Substation Primary Design Standard

TransGrid

Summary

This document outlines the primary design standard for TransGrid substations.

TransGrid publishes this information under clause 5.2A.5 of the National Electricity Rules.

Document Control

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1. Introduction

The substation design responsibilities are broadly divided into primary and secondary systems. The primary systems are the high voltage, civil and structural and building elements. The secondary systems are the protection, communication and control, auxiliary supplies and the automation systems that integrate the operation of the substation. This document deals with the design of the primary system of the substation.

2. Reference Documentation

The items below that have also been published on TransGrid's website under 5.2A.5 of the National Electricity Rules, form part of this document and should be read in conjunction with this document:

- Plant List – HV Switchgear and Accessory Items;
- Breaker and a Half - Generic Substation Layout;
- Mesh Connection - Generic Substation Layout;
- Loop In - Loop Out - Generic Substation Layout;

3. Safety in Design

Designs shall be in accordance with the Safe Work Australia Safe Design of Structures Code of Practice as per the WHS Act 2011 and meet the requirements of the Electricity Supply (Safety and Network Management) Regulation 2014 (NSW).

4. Drawing and Documentation Requirements

4.1 Drawing numbering

Drawings shall be numbered as follows.

<site code>-<sequence number>/<sheet number>

<site code>Site specific three letter code

<sequence number>Six digit number within the series specified in table below

<sheet number>Number starting at 1

Sheet numbers shall be used for drawing continuations and drawing sets representing a single item.

High Voltage design	
Sub package	**Drawing number series**
Single line diagrams	100001
General arrangements	100101
Sections	100201
Conduits	100301
Earthing	100401
Miscellaneous	100501

Building layouts and services	100601
Civil and Structural design	
Sub package	**Drawing number series**
Earthworks	200001
Roads	200101
Drainage	200201
Cable trenches and pits	200301
Footings	200401
Structures	200501
Fencing	200601
Miscellaneous	200701
Building architectural and structural	200801
Survey	200901

Table 1: Drawing sheet numbering

Drawing file names shall be as specified in TransGrid CAD standards.

4.2 CAD Guidelines

High voltage, civil and structural design drawings shall be as per drafting guidelines STD-848530 and STD-848531 which will be provided upon request:

4.3 Documentation

The Connection Applicant is required to uniquely identify all items of equipment and handover the TransGrid all information required for the continued safe operation, maintenance, de-commissioning and disposal of the identified equipment and any system handed over to TransGrid.

All documentation shall be provided in an electronic format, but all of the required documentation shall be provided in one identified package and the contents of the package shall be fully described.

Such documentation and information is expected to include but not be limited to:

- Drawings of individual items
- System Drawings (such as operational diagrams, switching instructions and interlocking)
- Setting information and facilities for any configurable device. This also includes the means by which settings are changed.
- Instruction and Operation Manuals (of both equipment and systems generated by the Connection Applicant)
- Test Reports. In the case of Type Testing of Equipment, Type Test Summaries are acceptable in the first instance. All other Test Reports are to be provided.
- SID information and Residual Risks
- Software and firmware information including licences and media.
- Commercial information that may be of interest to TransGrid such as Defects Liability Periods and other similar responsibilities and commitments.
- The function, size, type and description of any valve or fitting.

5. High Voltage Design

5.1 General

The substation high voltage design shall be to AS 2067 with the additions and clarifications specified in this document. All documents referenced by AS 2067 such as Australian Standards, also apply.

5.2 General design and equipment parameters

General design parameters shall be as follows.

1	Design life: 50 years
2	Maximum ambient air temperature: 40°C (Plant items: 45^{O}C)
3	Minimum ambient air temperature: -5°C (lower for Alpine sites based on historical weather data)
4	Maximum solar radiation: 1100W/m2
5	Pollution level: default is Medium but, should be reviewed to suit site location and environment
6	DC – station battery - 125 V nominal with voltage variation 88 V – 137.5 V
7	AC - three phase, four wire - 415/240V ±10% (this applies to existing substations but also covers the new requirement of 400/230 V -5+10%)
8	Auxiliary Switches Suitable for duty at 125 V DC 10 A slightly inductive
9	Auxiliary Contacts (a) Trip 1 A make at 125 V DC (b) Alarm and indication 50 mA at 125 V DC slightly inductive
10	Minimum height of lowest part of HV support insulators from ground level: 2,440 mm
11	Requirements for Control Cubicles a) Distance from ground level of any gauge or indicator: 1,200 to 1,800 mm b) Distance from ground level of all user accessible devices including switches, fuses, contactors, terminals etc. 1,000 to 1,800mm c) Distance from ground level to base of cubicle: 600mm minimum d) Distance from ground level of OLTC manual crank axis: 1,000 to 1,600mm
12	Protection for Outdoor Equipment a) Degree of protection for sealing cubicles, enclosures and terminal boxes against the ingress of water, foreign particles and insects: IP55 b) Degree of protection for electric motors not enclosed in a cubicle: IP56D c) Degree of protection for fans: IP2X
13	Altitude: ≤1,000m (subject to review for the installation location)

5.3 Single line diagram

Phases shall be identified as red, white and blue (RWB).

Equipment identification on single line diagram shall be as per following TransGrid standards STD-171831 and STD-813409-1 to 5.

All new substation designs shall include an Initial and Ultimate Single Line Diagrams. The Single Line Diagram shall be laid out to match the physical arrangement of the equipment on site.

All Single Line Diagrams shall use drawing symbols in accordance to STD-142374.

All Single Line Diagrams shall reference an Equipment Schedule which identifies each item of HV equipment.

Phasing arrangements busbars, transformer and line bays within the high voltage switchyard shall be as shown in the diagrams below:

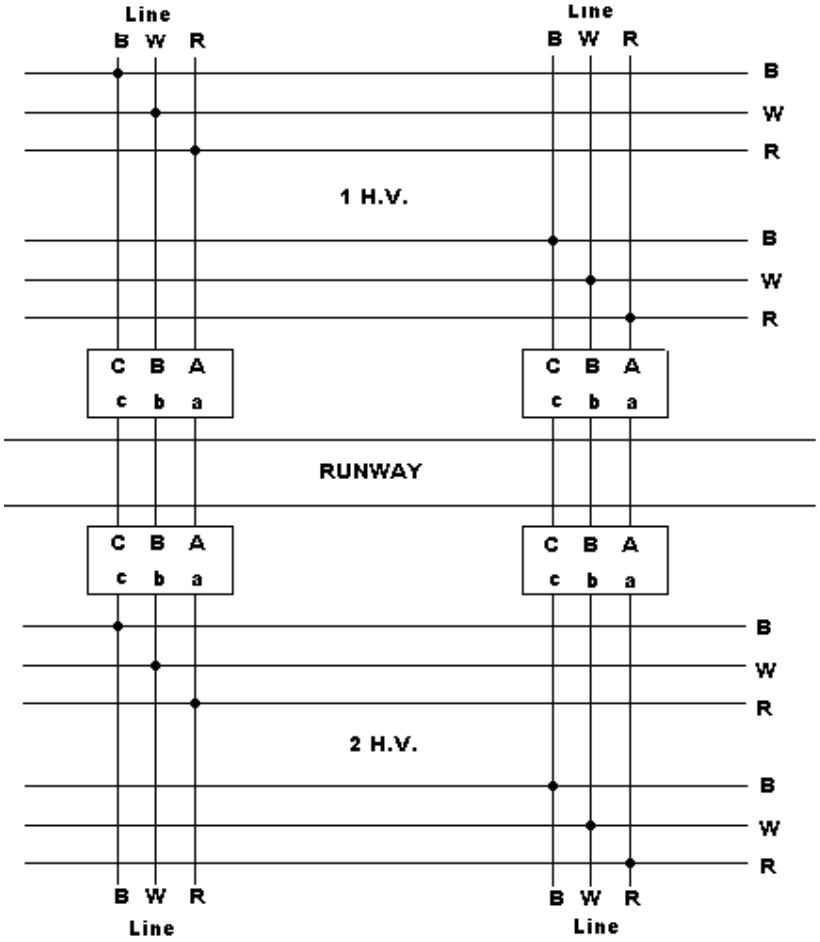

Figure 1: Single busbar, double busbar and breaker and a half switchyards up to 330kV

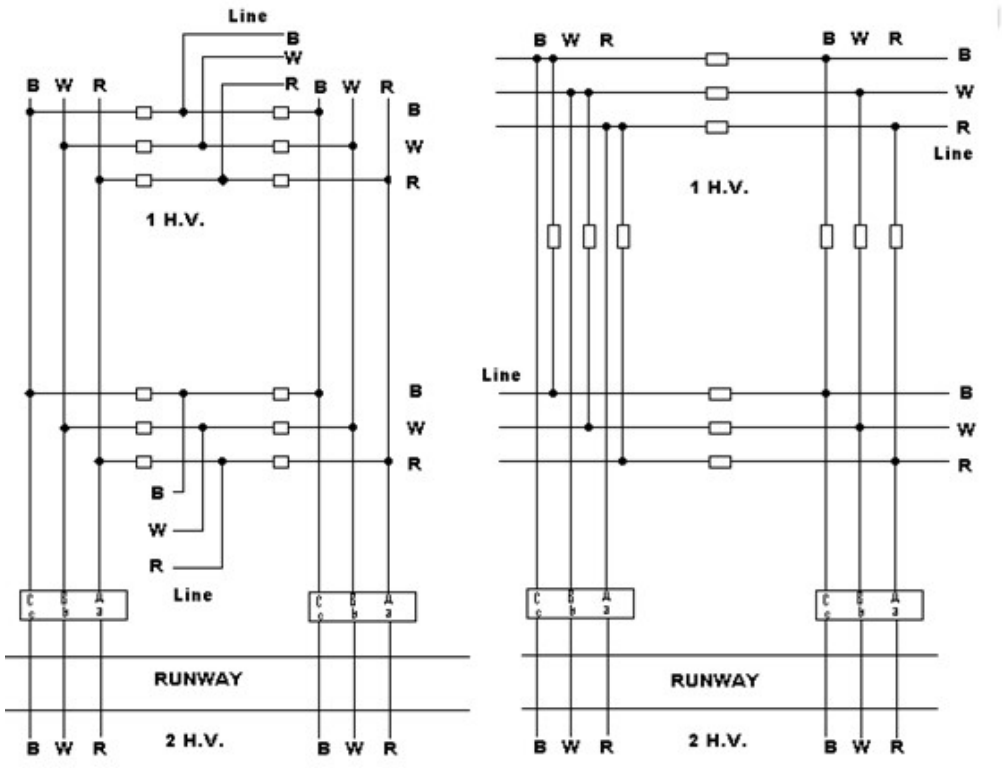

Figure 2: Mesh switchyards up to 330kV

Disconnectors shall be located to provide isolation on both sides of equipment and each end of lines for maintenance.

Earth switches shall be located on:

- Line side of line disconnectors;
- Equipment side of equipment disconnectors for 330kV and above;
- Equipment side of equipment disconnectors below 330kV and greater than 40kA;
- Substation side of line disconnectors for line entry bays for 330kV and above;
- Substation side of line disconnectors for line entry bays below 330kV and greater than 40kA;
- Capacitor side of capacitor circuit breaker/current transformer;
- Reactor side of reactor circuit breaker/current transformer;
- Bus side of bus disconnector (one earth switch per bus).

Disconnectors below 220kV are not required to be motorised except for safety or manual handling reasons or if it is a system disconnector. A system disconnector is a disconnector in a circuit branch that does not have a circuit breaker (motorised in the general case).

5.4 General arrangement

The substation general arrangement shall generally be as shown in the typical general arrangements also published on TransGrid's website under 5.2A.5 of the National Electricity Rules as follows:

- Breaker and a Half - Generic Substation Layout;
- Mesh Connection - Generic Substation Layout;
- Loop In - Loop Out - Generic Substation Layout;

The substation earthworks bench shall extend at least 500mm past the perimeter fence external earth grid conductor to protect the conductor from erosion.

Maintenance vehicle access shall be provided to prevent multiple outages for maintenance.

Cable trench crossings shall be provided as required.

Landing gantries and poles shall allow for future rearrangement, as follows:

- 330kV - 100m span of twin olive conductor;
- 220kV - 70m span of twin olive conductor;
- 132kV - 50m span of twin olive conductor.

Design of the general arrangement in initial development shall allow for future expansion of the substation if specified in project specifications without major augmentation and or unnecessary outages.

Land acquisition shall allow for 20m buffer zone, the buffer zone is measured perpendicular from the centreline of the perimeter security fence, around the perimeter of the substation external fence to allow for:

- Maintenance access;
- Bushfire protection of the substation asset;
- Earthwork and drainage;
- Earthing system transferred potential to neighbouring properties.

The buffer zone can be reduced subject to risk assessment and approval.

The areas and assets which, will not be owned and operated by TransGrid shall, be fenced off from rest of substation.

Design of the general arrangement shall allow for following external amenities in vicinity of auxiliary and secondary building unless noted otherwise in project agreement:

- Storage container (size 6m (L) x 2.5m (W) unless agreed otherwise);
- Water tank;
- Septic tank;
- Toilet;
- Diesel Generator, if required.

5.5 Electrical clearances

Electrical clearances shall be to AS 2067. Voltage range I and II shall be used. Voltage range II shall only be used by risk assessment. Highest voltage 36kV clearances shall be used for highest voltages below 36kV.

Section safety clearance from ground level, access platforms and elevated surfaces that can be easily walked on (e.g. transformer bund walls, footings) shall be the greater of AS 2067 and TransGrid Power System Safety Rules (PSSR) safe approach distance (SAD) +2440mm.

Electrical clearances for vehicle movement on designated access ways shall be to AS 2067 and PSSR with a safety observer. Electrical clearances for vehicle movement in all other areas shall be to PSSR with a safety observer. The vehicle size shall be fit for purpose (e.g. transformer transporter, EWP for accessing gantries for landing span stringing).

The highest point on a vehicle a person can sit or stand on designated access ways is 1.5m above the access way surface level. The maximum overhang from the designated access way of the highest point on a vehicle a person can sit or stand is 0.35m.

5.6 Insulation co-ordination

An insulation co-ordination study shall be performed to determine surge arrester locations and specifications. Surge arresters shall be provided for each transformer winding as close as possible to the transformer.

Mean Time Between Failure (MTBF) of 400 years for air-insulated substations and 800 years for gas-insulated substations shall be used in insulation the co-ordination study.

5.7 Earthing system

The substation earthing system shall be designed for the worst case fault levels, X/R ratios and fault clearing times for the design life of the substation. The substation earthing system shall be designed to meet both AS 2067 and IEEE 80 safety criteria.

The earthing system for the substation or switching station completed by the Connection Applicant shall be designed to function and meet the safety criteria in isolation from any customer earthing systems (e.g. solar farm or wind farm earth grids).

Soil resistivity testing shall be conducted as part of earthing system design. The Wenner method is preferred. Probe spacing of up to equal or greater than the length of substation shall be used as minimum.

Portable earthing fittings shall be provided for maintenance.

Functional earth safety (e.g. transformer neutrals, high voltage cable screens, earth switches) shall be considered particularly. Functional earths shall connect to two independent sections of earth grid.

Switchyard fences shall be earthed every 10m maximum.

The earthing system shall be tested before energisation to confirm safety compliance.

5.8 Electric and magnetic fields

Electric and magnetic fields shall be determined at 1.0m above ground level.

Electric and magnetic fields shall be tested after energisation to confirm safety compliance.

5.9 Conductors and fittings

Conductors and fittings and conductor and fitting arrangements shall be selected to achieve the required current ratings, limit mechanical loads and limit corona and radio interference voltage (RIV).

Conductor mechanical loads shall be limited to conductor, equipment and structure mechanical load ratings.

Corona shall be limited to 16kV/cm for 132kV and below and 19kV/cm above 132kV.

5.10 Switchyard high voltage cables

High voltage cable design parameters shall be as follows:

- Ambient air temperature - (refer section 3.2 general design parameters);
- Ambient soil temperature - 25°C;
- Soil and backfill moisture content - 0% (fully dry);
- Load factor - 1.0;
- Screen bonding - Double point preferred.

High voltage cable cover shall be 750mm to the top surface of the mechanical protection (excluding gravel surface layer) minimum.

Unbonded screen ends shall be placed out of reach or shrouded to prevent contact in service but be accessible for testing.

5.11 Switchyard lighting

The minimum requirement for Switchyard lighting:

- Lights shall be provided for walking in open areas likely to be accessed;
- Lights shall be provided near the substation security fence in areas unlikely to be accessed as a deterrent only;
- Lights shall be provided for walking in closed or constrained areas (e.g. equipment enclosures, stairs) for increased safety only;
- Lights shall not obstruct access for operation and maintenance.

Lights shall be manually controlled and automatically controlled by the substation security system.

5.12 Switchyard lightning protection

Switchyard lightning protection shall use lightning masts or overhead earth wires using the rolling sphere method with a 24m sphere radius. At a minimum Lightning protection should be applied to:

- High voltage conductors;
- High voltage equipment (including transformer radiators);
- Buildings (air terminals mounted on buildings may be used);

The switchyard fence may be used for lightning protection.

5.13 Switchyard fire protection

Passive fire protection (e.g. spacing, oil containment) is preferred over active fire protection (e.g. fire hydrants). Fire protection requirements shall be determined by risk assessment. The risk assessment shall consider bushfire attack and bushfire start.

5.14 Switchyard security

Switchyard security requirements will be dependent on a security criticality assessment to be completed by TransGrid. Switchyard security shall include motion detectors, cameras and a card reader at each external entrance minimum.

5.15 Acoustic noise

The substation shall comply with relevant local, national and state acoustic noise requirements. Acoustic noise shall be tested after energisation to confirm compliance.

5.16 Documentation

As a minimum the following documentation shall be provided:

- Initial single line diagram;
- Ultimate single line diagram;
- Equipment schedule;
- Initial site layout;
- Ultimate site layout;
- Initial general arrangement;
- Ultimate general arrangement;
- Bay and bus plan and elevations;
- Conductor and fittings schedule;
- Earth grid and riser layout;
- Conduit layout;
- Conduit sections;

- Miscellaneous equipment layout
- High voltage design parameters design report;
- Electrical clearances design report;
- Insulation coordination design report;
- Earthing system design report;
- Conductor and high voltage cable design report;
- Equipment and structure conductor mechanical loads design report;
- Lighting design report;
- Lightning protection design report;
- Fire protection design report;
- Acoustic design report;
- Earthing system test report;
- Electric and magnetic fields test report;
- Acoustic test report.

6. High Voltage Equipment Requirements

6.1 General Equipment Requirements

TransGrid's HV network is designed to provide very long term reliable operational service and high availability. This is achieved by a total design concept that allows the operation and maintenance of the Network without interruption to supply and in accordance with the Principal's Power System Safety Rules and operating procedures.

This includes the provision of access and facilities for operation; the ability to carry out maintenance on any item of plant or equipment with no or minimal disturbance to other systems; facilitate emergency response at any time and in all weather conditions and efficient fault finding for restoration purposes.

As part of the Safety in Design process, the Supplier's design shall be assessed to ensure these concepts are not compromised.

6.2 Design Life

The Supplier's design must incorporate such materials, features and components as necessary and appropriate to:

- Minimise the extent, frequency, duration and cost of maintenance for each Item throughout its design life, and
- Ensure ease of use and safety for personnel whilst installing, operating and maintaining each Item.

TransGrid requires that all information provided in support of the above extends to and includes subcomponents and sub-suppliers, and that account of the design life and maintenance requirements of sub-components has been made for the published design life and maintenance requirements for the Item.

6.3 Reinforced Security and Explosion Proof Design

All HV equipment insulation is required to have composite insulation, except for post insulators.

The equipment design shall include features intended to reduce the safety risk in the event of an internal insulation failure. The Connection Applicant shall provide details of these features and/or supporting test data in the relevant handover documentation.

6.4 Direct Earthing

TransGrid adopts a philosophy of 'Direct Earthing' of equipment. Earthing terminals shall be directly connected to the earth grid (general mass of earth) via suitably sized copper strap. Examples of earthing terminals requiring direct earthing are:

- The neutral / earth terminal of Items such as Instrument transformers, bushings and surge arresters
- Disconnectos and earthing switches
- Control cubicles

It is not acceptable to 'earth through the tank'.

6.5 Accessibility of User Features

Operator accessible components such as any fuse, link, switch, contactor, indicator, handle, operation counter etc. shall be at a height greater than 1000mm but not exceeding 1500mm from ground level or operating platform such that the user does not have to crouch down or otherwise adopt a contorted stance to perform the action.

Any point required to be accessed for operation, maintenance or repair shall be readily viewable and readily accessible.

All indicators shall be readily visible from the ground such that position, status or value information can be easily determined. Examples include:

- Equipment oil level or pressure gauge indicators
- Position indicators

6.6 Disconnector and Earth Switch Design Requirements

The general arrangements of the equipment shall be as stated following:

- Disconnector: Horizontal Double Break (HDB)
- Earthing Switch: Single Vertical Break (SVB) with blade horizontal in open position

Each disconnector shall be designed so that an associated earthing switch may be mounted on either or both ends of the phase beam. Each associated earthing switch shall be designed so that it may be mounted on either end of the phase beam.

It is preferred that the direction of operation of the associated earthing switch blades is such that the open blades remain in the plan view shadow area of the disconnector.

Easy adjustment facilities shall be provided for alignment of insulators and contacts.

All disconnectors and earthing switches shall be capable of being locked by means of a 45mm standard shank padlock in both the open and the closed positions.

It is required that for the full manual operation of both power and manually operated mechanisms that the operator does not have to leave the earth mat.

Manual operating handles shall be free of any insulating covering. Manual operating mechanisms for earthing switches shall comply with the specifications tabulated in the following:

	Manual Operating Mechanism for Disconnector	Manual Operating Mechanism For Earthing Switches
Acceptable mechanisms	Horizontal lever, hand-wheel, hand-crank, geared device	Preferred: horizontal lever Alternative: spade type handle, crank handle.
Plane of movement	Horizontal	Preferred: horizontal Alternative: vertical, crank handle
Direction of movement from open to closed position	Clockwise (when viewed from above) and not exceeding 110º	Horizontal Lever: either direction Spade type handle: upwards

The following shall also apply:

- Maximum length of simple horizontal motion bar type handle or lever shall be 1200mm.
- Maximum height from ground level of simple horizontal motion bar type handle or lever shall be 1200mm.
- Maximum operating force using simple horizontal or spade type handle shall be 250N.
- Maximum operating force for using a geared device shall be 90N.

Manually operated disconnectors shall be designed such that inadvertent operation of the disconnector is not possible. This may involve the provision of a latching mechanism that prevents the inadvertent operation of the disconnector operating handle.

6.7 Mounting and Handling of Current and Voltage Transformers

For interchangeability purposes, CTs are required to be able to be provided with mounting arrangemnets which are compatible with TransGrid's standard support structures as outlined in the following standard drawings (which will be provided up request):

a. For 362 kV CTs - Drawing No. STD-352537
b. For 145 k V CTs - Drawing No. STD-352541
c. For 72.5 kV CTs - Drawing No. STD-352540

If adaptor plates are required to meet the required mounting arrangements they must be approved by TransGrid and shall be fitted to the CT prior to the dispatch of plant.

All mounting arrangements shall be clear of secondary cable runs and allow ready connection of cables to terminal boxes.

The VTs shall have four (4) 20 mm diameter holes on a 660 mm square for mounting.

6.8 Quality of Supply Requirements

The Connection Applicant shall provide the performance requirements of the relevant instrument transformers.

6.8.1 Harmonic Distortion Testing

This test shall be performed in accordance with the requirements specified in TransGrid documentation. A copy can be provided on application.

The method employed for the harmonic distortion testing shall be described in the documentation package along with some details of the associated test equipment and experience of the testing contractor in carrying out harmonic distortion testing.

6.8.2 Frequency Response Testing

This test shall be performed in accordance with the requirements specified in TransGrid documentation. A copy can be provided on application.

The method employed for the frequency response testing shall be described in the documentation package along with some details of the associated test equipment and experience of the testing contractor in carrying out frequency response testing.

6.9 FUSES, MINIATURE CIRCUIT BREAKERS AND LINKS

All fuses shall be HRC cartridge type and the cartridges shall comply with AS 60269 “Low-voltage fuses”, “Part 1: General requirements” and “Part 2: Supplementary requirements for fuses for use by authorised persons (fuses mainly for industrial application)”.

Miniature circuit breakers may be used instead of fuses and shall comply with AS 3111 “Approval and test specification - Miniature overcurrent circuit-breakers”.

Where two independent LV supplies are specified, all miniature circuit breakers shall be either 2 pole (single phase – active + Neutral) or 4 pole (three phase + Neutral) as in these cases TransGrid requires a switched Neutral for protection grading purposes.

Independent isolation facilities shall be provided on each side of all trip and close coils and shall be located adjacent to their respective fuse or miniature circuit breakers on the front of the main control panel. Suitable points of isolation shall be provided such that it shall be possible to de-energise and isolate every circuit so that every circuit can be made safe for work.

Within any cubicle, independent electrical isolation links shall be provided:

- on each side of all trip and close coils and operating mechanisms and,
- on either side of any fuses or miniature circuit breakers.

All links shall be physically located on the front of the main control panel and, where feasible, adjacent to the associated fuse or circuit breaker such that the isolation of the circuit device is clearly established.

Links shall be mounted in a white cartridge type fuse carrier, complying with AS 60269 “Low-voltage fuses”, “Part 1: General requirements” and “Part 2: Supplementary requirements for fuses for use by authorised persons (fuses mainly for industrial application)”, for AC applications.

Links for all other circuits shall be of the Phoenix URTK/S type of size appropriate to the cable size and must include a hexagonal head link-securing screw in lieu of the standard screw supplied.

Links shall be positioned either horizontally or vertically and shall fall to the closed position when in vertical orientation. For a vertically mounted link, the incoming / outgoing wires (the X terminal side) shall be connected to the bottom of the link.

Fuses, miniature circuit breakers and links shall be grouped together and clearly identified with a description of their function on a plate mounted nearby inside the control cubicle.

6.10 Pressure Vessels Approval

The designs of all compressed gas pressure vessels shall be to the approval of the Workcover Authority of NSW and evidence shall be provided of the approval process.

Inspection of equipment shall also be to the requirements of the Workcover Authority of NSW.

6.11 Spare Parts, Tools and Appliances

The Connection Applicant shall list, package for long term storage and handover to TransGrid any Spare Parts, Tools and Appliances necessary for the operation, maintenance and disposal of the equipment.

Any spare part, tool or appliance requiring indoor storage must be clearly and permanently labelled on all four vertical sides of the crate or clearly on any package with the words “Must Be Stored Indoors” or a globally accepted equivalent symbol.

7. Civil and Structural Design

7.1 Standards

The designs shall be based on TransGrid's performance requirements specified in this document, the applicable Australian Standards and industry best practice. Refer Appendix A.

7.2 Geotechnical investigations

Where geotechnical investigations are to be undertaken by the Connection Applicant, the Connection Applicant shall ensure the investigations provide all the parameters and information required to design all the civil components of the switchyard and, where applicable, the access road.

The purpose of the investigation is to identify the soil and rock types and profiles and other matters that may influence the civil design and construction of the substation. Where contamination of soil is possible, the geotechnical investigation should undertake all appropriate chemical analyses of the soils on the site.

7.3 Erosion and sediment control

A Soil Management Plan is required for all substation work involving earthworks. Soil conservation and erosion prevention measures shall be in accordance with Landcom, 2004, *Managing Urban Stormwater: Soils and Construction* (Volume 1) (The Blue Book) NSW. The plan shall have a cover sheet that outlines the verification measures employed in preparing the plan as well as the justification of the plan itself.

The Contractor shall plan and carry out the whole of the works to minimise erosion, sedimentation and pollution of the site, watercourses and surrounding areas according to the following principles:

- Avoid unnecessary ground disturbance;
- Control underwater flow paths, volumes and velocities;
- Utilise progressive rehabilitation techniques.

Such measures shall be temporary or permanent, as proposed by the Connection Applicant.

Temporary controls are measures required to provide erosion and sediment control in construction areas.

The Connection Applicant is to comply with Local Government Authority requirements for sustainable stormwater and wastewater management strategies.

7.4 Bench design

Electricity supplies are an essential service and a switchyard should not be affected by flooding.

A switchyard should be located at least 500 mm above the 1:100 flood levels and should not be impeded when the flood level is at the 200 year Return Period where levels are unavoidably less than the 1:100 year level, mitigation measures should be implemented to minimise the effect of flooding.

The switchyard site needs to be accessible under most circumstances to allow fault response and access for operational reasons. The switchyard bench is to provide a stable, dry weather trafficable and free-draining structure and provide a safe platform for personnel, vehicles, cranes and trucks in order to facilitate the maintenance and operation of the switchyard for the duration of its operational life.

Eliminate uneven surfaces and tripping hazards in the switchyard area generally where possible and minimise otherwise. Provide handrails and barriers as needed to minimise hazards associated with steps.

Slopes to earthworks batters that require maintenance, should be such that personnel, equipment and vehicles can safely traverse the area.

The switchyard shall be surfaced with 20 mm crushed, quarried blue metal laid to a depth as required for spill oil control and earthing requirements. This applies to all areas of the switchyard that are not otherwise sealed e.g. roads and pavements. The depth of coverage of the blue metal is subject to earthing studies.

The general arrangement of the switchyard is to take into account the need for vehicle and crane access to all plant. Corridors for vehicle access are to be allowed for between switchbays (including future switchbays), or within the space between the switchbays and other high voltage plant.

7.5 Earthworks

Excavation and filling shall be designed and the compaction specified such that ground settlements are acceptable and will not affect the performance of the substation throughout its service life.

The field dry density of finished earthworks in the switchyard area, generally, will not be less than the value recommended in the Geotechnical Report

The Geotechnical Report will make recommendations on the slope of cut and fill earthworks and embankment slopes in the substation.

The drawings shall show finished earthworks levels, including transition points and sufficient cross-sections to ascertain cut and fill requirements. The existing surface cut and fill lines shall be clearly shown.

An Earthworks Plan is a document generated by the bulk eartworks contractor which details how they propose undertaking scope of works and is required for any significant earthworks on the site.

7.6 Roadways and pavements

7.6.1 General

The substation roads and pavements shall be designed and detailed to provide general vehicular access to, and within, the Substation.

The road design parameters to allow for traffic conditions after the completion of the works, including the installation of all plant associated with the substation.

The design of the area around any building shall allow for delivery, unloading and installation of equipment.

The drawings for roadways and pavements shall show:

- Vertical and horizontal alignments
- Long section on the centre line of the road, including chainage
- Sufficient cross sections to determine cut and fill quantities
- Reduced Level (RL) to Australian Height Datum (AHD) of existing surface, finish level, etc. all drainage requirements adjacent, or under roads, including invert levels

7.6.2 Access road

The alignment, grade, width and strength of the access road shall be designed and constructed to allow for safe transport and delivery of equipment and personnel.

The design parameters for the access road shall be as required by the Local Council and RMS if appropriate, but not less than follows:

- Construction traffic during the works
- Design traffic after completion of all construction works of not less than 200,000 Equivalent Standard Axles (ESA).

The road shall be designed to be maintenance free for a minimum of 20 years after Practical Completion.

The road shall have a minimum width of 5 metres, or as required to allow two large vehicles to pass without running into soft ground on the side of the road. This may require gravel shoulders to be constructed on both sides of the sealed section of the road.

The road shall be designed to drain such that it meets the Drainage section of this document.

Where a wearing surface is specified, the wearing surface shall be a Double/Double seal type in accordance with RMS Form 106 unless otherwise required by the Local Council.

7.7 Parking and hardstand areas

The drainage design shall satisfy the requirements of the Drainage section of this document. Runoff from these areas shall connect to the switchyard drainage systems.

Where supply and installation of secondary system buildings (SSB) form part of the scope, allowance shall be made for hardstands to each of the SSB. The hardstand area to each of the SSB shall be of a size and geometry to allow for access and parking alongside the SSB in all weather conditions for two domestic size vehicles at any one time without obstructing access paths. The hardstands should as a minimum incorporate the full footprint of the SSB including a 2 m wide perimeter all around the building and 2.5 m in front of the veranda at the major access end of the building. The pavement shall be designed to adequately support expected vehicular and heavy vehicular traffic. The hardstand areas shall be sealed. The wearing surface shall be a Double/Double seal type in accordance with RMS Form 106. Runoff from these areas shall connect to the switchyard drainage systems.

The extent of the hardstand area shall be indicated on the bulk earthwork drawings.

7.8 Cable trenches and conduits

The design of cable trenches shall allow sufficient space for cabling for the ultimate development of the substation.

The walls and base of cable trenches shall be of reinforced concrete. Precast concrete units may be used. All cable trenches shall have effective shear keys between adjoining sections. The shear key may utilise galvanised steel dowel bars, or other methods approved by TransGrid. Joints between sections shall be sealed against water leakage.

Non-trafficable trench covers shall not require more than two persons to safely remove. These trench covers shall be so dimensioned such that the weight of individual panels does not exceed 32 kg and comply with the guidelines specified in the Hazardous Manual Tasks Code of Practice.

Trafficable trench covers shall be designed for the traffic loads specified at the following locations:

- All designated roadways;
- All plant access corridors;
- For sites that do not have kerbed perimeter roads a corridor of 6 m from the security fence towards the bays.

The drainage of cable trenches shall comply with the Drainage section of this document..

Conduits shall be laid straight in all planes between conduit pits and shall be self-draining. The spacing of pits should suit the requirements for installing cable to both the initial and final development and must consider typical cable installation constraints.

Cable pits shall be sized to accommodate the bending radius of cables and to allow physical access to install the cables. All pits deeper than 600 mm shall have minimum internal plan dimensions of 900 mm by 600 mm, or greater as required. Step rungs shall be provided where depth of pit is greater than 900 mm. Step rungs may be galvanised steel or plastic encapsulated steel. All step rungs shall comply with the requirements of AS 1657.

Conduits shall be provided with bellmouths at pit entries.

All pits shall have removable covers. The covers shall not require more than two persons to safely remove and comply with the guidelines specified in the Hazardous Manual Tasks Code of Practice by Safe Work Australia. Steel covers shall be free of distortion after fabrication and galvanising to within +/- 2 mm measured across the cover in any direction.

7.9 Drainage

The drainage system shall be designed to efficiently collect and discharge surface and subsoil water that would impair or be the cause of failure of foundations, roads, slopes, retaining walls or drainage structures. The drainage system shall also separately drain oil and oil contaminated water to the appropriate containment structures.

The design of the drainage system shall be based on the Institution of Engineers (Australia) ‘Australian Rainfall and Runoff: A Guide to Flood Estimation’ Volumes 1 and 2 and AS 3500.3.

Runoff from outside the switchyard shall be intercepted and diverted around the switchyard by catch or table drains and concrete boundary drains. The drains shall be designed for rainfall corresponding to a 50 year average recurrence interval and designed to counter erosion and remain functional due to effects of siltation.

The switchyard stormwater drainage system shall be designed for a rainfall corresponding to a 10 year average recurrence interval. The drainage structures shall not surcharge when subjected to the design rainfall intensity. The runoff coefficient shall be based on commercial development with a runoff coefficient of not less than 0.6 for the unpaved areas and 0.9 for paved areas.

Subsoil drains shall not be used to capture surface runoff when other drainage methods are practical.

Switchyard stormwater drainage design shall comply with the requirements of AS 3500 part 3. The minimum grade on all drains shall be 1%.

All conduit pits shall be drained. The drain pipe shall be a graded at slope of not less than 1:150 between pits. The pit drainage shall connect into the substation drainage system. Where the pit floor is lower than the cable conduit a separate drain pipe shall be installed.

Any surface drainage structures located in trafficable areas shall be designed to accommodate the appropriate to the wheel loads. Reinforced sections shall have dowel bars at joints between sections. Flow in V drains shall be intercepted at regular intervals by pits which shall drain into the stormwater drainage system.

Ponding in localised areas shall be prevented by grading of the switchyard in those areas, or installing appropriate drainage structures. Surface rainwater shall be intercepted and prevented from flowing over switchyard embankments except where contained in appropriate drainage structures.

The runoff from the switchyard, except for potentially oil contaminated water, shall be diverted to the natural watercourse in accordance with EPA guidelines and requirements. Dispersion structures and other measures satisfying the requirements of Erosion and Sediment shall be implemented.

The drainage system of switchyard areas that contain oil-filled equipment and from the bunded areas shall be kept separate from the stormwater drainage system. The design of drainage for the oil containment system shall comply with the applicable requirements of this Section, AS 2067 and AS 1940.

Subsurface drains shall be constructed where permeable water bearing strata are intersected by the earthworks. Where a roadway's performance may be affected by groundwater, sub-soil drains shall be constructed parallel to the roadway to intercept groundwater. Subsoil drains may also be required to mitigate the effects of groundwater on foundations, retaining walls, drainage structures.

Cable trenches shall drain into the switchyard drainage system either directly into the stormwater system or to the secondary dam or tank, as appropriate. Where a cable trench impedes surface or groundwater flows, subsoil drains shall be constructed adjacent to the cable trench to capture the water. Where a subsoil drain is constructed the cable trench may incorporate drainage weep-holes to the subsoil drain to assist removal of the water from the cable trenches laid across the slope. Water captured in cable trenches shall be prevented from entering the control room underfloor area.

7.10 Pits

All pits shall be accessible and have removable covers. The covers shall not require more than two persons to safely remove. Steel covers shall be free of distortion after fabrication and galvanising to within +/- 2 mm measured across the cover in any direction.

The internal plan dimensions of pits shall not be less than the following:

- Deeper than 0.6 m: 900 mm by 600 mm;
- Deeper than 1.2 m: 900 mm by 900 mm;
- Deeper than 2.4 m. 900 mm by 1200 mm.
- Less than 0.6 m deep: 600 mm by 600 mm, or smaller subject to the approval of the Superintendent.

Step rungs shall be provided where the depth of a pit is greater than 900 mm. Step rungs may be of galvanised steel or plastic encapsulated steel. All step rungs shall comply with the requirements of AS 1657.

7.11 Oil containment

7.11.1 General

A substation oil containment system shall be provided in accordance with the requirements specified in AS 2067.

Design and detailing of oil containment and drainage to comply with AS 2067 and AS 1940.

7.11.2 Bunded areas

Bund walls shall be of reinforced concrete. Suitable construction/control joints, including water stops as necessary, shall be installed to prevent the cracking of bunds. The area inside the bunds shall slope to the drainage points.

7.12 Structure and foundation design

7.12.1 General

The substation structure design requirements specified herein are for equipment and conductor support structures.

Structure and footing types listed for the substation are, for convenience, divided into Minor and Major Structures. TransGrid's substations have a post-disaster function. Accordingly, the structure loads are based on Importance Level 4 and a 50 years design working life (Refer AS/NZS 1170.0 – 2002)

The design of steel structures shall be based the requirements of AS 4100 (Steel Structures) except lattice steel structures which may designed to the requirement of AS 3995 (Design of steel lattice towers and masts).

All steel structure designs utilising base plates shall provide for grouting between the base plate and the concrete footing. The base plates shall be supported using setting nuts or packer plates. The steelwork drawings for major structures shall indicate the permitted support methods for base plates.

The design of concrete structures shall be based on the requirements of AS 3600 (Concrete Structures) unless otherwise specified herein.

7.12.2 Design loads

Load Types

The loads considered in the design of structures and foundations shall include the following:

- Dead loads;
- Live loads;
- Wind loads;
- Ice loads;
- Short-circuit loads;
- Soil loads and pressures;
- Earthquake loads;
- Construction loads, including the stringing of buswork and conductors.

The plant and structures are to be designed for the wind loading specified in AS 1170.2, 'Structural design actions Part 2: Wind actions'. A minimum C_d of 1.2 for insulators shall be used.

Ultimate Loads

Structural elements are to be designed to withstand the following load combinations without permanent distortion and in accordance with the relevant material and design Standards.

- 1.35G
- 1.25G + Q
- 1.2G + W_u + Q
- 1.2G + F_{eq} + Q
- 0.9G + Q
- 0.9G + W_u + Q

- $0.9G + F_{eq}$
- 1.5G + 2.0M (refer notes)
- 0.8G + 2.0M

Where

G = force due to weight of conductors and structure ie permanent actions.
F = Conductor tensions
Q = Live Loads
W_u = wind loads to AS 1170.2 (a minimum C_d of 1.2 for insulators shall be used)
F_{eq} = earthquake loads to AS 1170.4
M = maintenance loads including workmen, conductor tension, etc.

Notes

Design load combinations are applied as follows:

- The loads due to weight and conductor tension, if applicable, shall be factored by 1.35 and applied in the combinations (e.g. vertical, longitudinal and transverse directions) that produce the most adverse forces on the structures;
- The initial conductor tension is factored by 1.25. The effect of the short circuit force is calculated for that tension;
- The initial conductor tension is factored by 1.2. The effect of wind and the short circuit force is calculated for that tension. As the wind has much longer duration than the SC force, it is assumed that conductor tensions will be calculated for the design wind pressures and the effect of SC currents will be based on the wind-tension. As the load combinations are extreme, the load factor for wind and SC are 1.0;
- As maintenance loads have a safety element where personnel may be working on, or close to the structure, the factor reflects the potential consequences of a failure. Hence, loads due to maintenance operations shall be factored by 2.0. Note that the factor applies to the conductors or equipment affected by the operation. In this instance it is considered that the factor of 2.0 is adequate to allow for initial stringing errors and that the initial tension may be assumed to be as specified;
- When considering short circuit loading, the load combinations shall be in accordance with AS 2067 and AS 7000.

Serviceability loads

The serviceability limit state is based on the permanent loads and wind loads corresponding to a 25 year recurrence interval. The load factor to be used is unity. Structures shall be designed to limit deflections to the most severe of the following:

- The limits specified by the equipment manufacturers;
- The limits imposed by the strength of adjacent equipment or structures;
- Under serviceability limit states 1/180 of the span or height of the structure, or for masts, 1/100 under every-day conditions and 1/50 under serviceability loads (provided that electrical clearances are not infringed in any circumstance).

7.12.3 Durability

All structural elements shall be designed and constructed such that they do not require repairs for corrosion during the design life of the Substation.

The Designer must consider if the subsoils have aggressive elements and select materials to withstand these elements.

Concrete poles, where used, shall not crack under serviceability loads.

7.12.4 Fire resistance

Materials and construction shall have fire resistance ratings of 2 hours, or as specified. The design fire rating should be indicated on the relevant drawings.

7.12.5 Footing design

Foundation design (each type and size of foundation and permissible soil pressures) shall be based on the ultimate load combinations.

Footings should be designed based on soil properties identified in geotechnical investigations and appropriate standards.

The maximum short and long term settlement and movements of footings is not to have a deleterious effect on the supported structure and equipment, or any connection to other structures or equipment. Foundation settlements shall be such that claddings and linings do not crack or sag and building elements do not open up allowing wind and/or water in (particularly under serviceability conditions). The surface of all footings shall drain freely.

An estimate of foundation movements shall be made. The Geotechnical report will identify soils that are prone to shrinkage and swelling, or are dispersive. If such soils are identified the soils properties are to be modified and/or the foundations design modified accordingly.

Piled foundations shall comply with AS 2159. Reinforced concrete piled foundations are preferred from durability consideration, but other types may be suitable in some circumstances.

The assumed bearing capacity shall be indicated on the drawings.

Reinforcement for crack control in slabs shall be based on the exposure environment applicable to the site, but not less than 'moderate' in accordance with AS 3600 Clause 9.4.3. Slabs with thickened edges shall be treated as restrained unless appropriate measures have been implemented to reduce restraint from the soil or other sources of restraint.

The pavement in the transformer compound and reinforced concrete slabs for capacitor banks etc. shall be designed to adequately support the expected loads including loads arising from installation, removal, commissioning and maintenance of the transformer.

8. Building Design

8.1 General

Buildings shall be fully self-contained that utilise materials and structural systems that are suitable for site specific conditions and required design life with all fixings and components being composed of compatible materials with low corrosion rates for the environmental conditions for the specific site.

The soffit/ceiling height to suit the cubicle specific design including, making provision for the installation or removal of cables as required.

The building structure shall be designed in accordance with the following requirements:

- Nactional Construction Code (NCC) requirements for class 8 as per Building Classification in the NCC buildings;
- Durable design that ensures the building remains fully serviceable for its design life;
- Building Ingress Protection Rating detailed in the International Standard EN60529 of minimum IP54, dust sealed and vermin proof for 20 years;
- Insulated against varying temperature conditions;
- Designed in a manner to minimise potential fire hazards;
- Designed to be able to be installed on sloping ground as applicable;
- The maximum deflection allowed shall be the lesser of that permitted by the equipment manufacturer for the equipment installed in the switchroom, or the Australian Standards;

- Sufficient space must be allowed for the installation of cable ladders and associated cables in a safe manner. The clearance shall provide sufficient personnel access complying with WHS legislation;
- Ensure adequate working space around equipment within the building;
- The building shall be designed to be of compact floor area, while making provision for the substation's ultimate development;
- The building shall be located in a position that allows for adequate parking and safe access without having to enter the outdoor switchyard areas;
- Foundations shall be constructed in accordance with the NCC and relevant standards for a site classified in accordance with AS 2870, as Class A;
- Building to be constructed of non-combustible materials. The materials and design of the walls shall take into account the loadings for cabinets, cable trays and other equipment that may be mounted on them.

8.2 Design loads

8.2.1 General

The building and all associated structures shall be designed to adequately resist all applied loads i.e. dead, live, wind, earthquake, equipment loads, etc. in accordance with the referenced standards and the load and other structural requirements specified herein.

The building structure shall be considered as being of Importance Level 4 – 'Building or structures that are essential to post-disaster recovery' in accordance with NCC Table B1.2 a – Importance Levels of Buildings and Structures.

Live and dead loads shall be developed in accordance with AS 1170 – Structural design actions.

Consideration shall be given to the support of any loads suspended from the roof or walls such as cubicles, false ceilings, cable ladders, air-conditioning equipment, ductwork, light fixtures, distribution boards, and cable.

Wind, snow and earthquake loading shall be developed in accordance with AS 1170.2, AS 1170.3 and AS 1170.4 respectively, and shall be site-specific.

8.2.2 Floor

The floor loading capabilities shall allow for the following as a minimum:

- Equipment loads as defined in the concept design;
- External cable ladders that may be suspended;
- The floor shall be designed to support the control and protection panels along the length of each wall;
- SSB access walkways shall be designed for equipment loads when installing or removing equipment;
- Floors in the building shall be designed to be able to support the movement, installation or removal of all future electrical cubicles and equipment. The floor joists shall be designed to allow transportation and lifting all electrical equipment installed.

8.2.3 Roof

The roof frame shall be designed to resist applied loads including but not limited to:

- Roof live load in accordance with Australian Standards;
- Cable ladders;
- Ceilings;
- Light fittings;
- Air-conditioning;
- Snow loads where applicable;

- The building shall be insulated against hot and cold conditions through insulation batts or equivalent. The thermal efficiency of the walls, roof and floor must be compatible with the air conditioning requirements.

8.2.4 Transportation

Transport loads and carriage impulse loads imposed on the structure or its equipment shall be designed for and furthermore shall be negated wherever possible by temporary or permanent structural bracing. Fit out of cubicles and other equipment/items to be included in transportation loads.

8.2.5 Structural rigidity

The structure shall be sufficiently rigid to ensure that installed equipment is not damaged during transportation and on-site installation of the unit.

8.3 Drainage systems

Drainage to comply with requirements stipulated in AS 3500.

8.4 Wastewater treatment

Where connections to town sewage systems are available, the building wastewater drains shall be connected to the town sewage system. Where this is not possible, the wastewater drains shall be connected to a suitable disposal system, such as a septic tank or a treatment plant with the chlorinate treated water pumped into a suitable area of the landscaped area for irrigation.

The wastewater treatment systems shall comply with the requirements of the Board of Health of New South Wales and the Local Authority.

8.5 Mechanical services

8.5.1 Air-Conditioning plant

Air conditioning shall be installed as per Australian Standard AS 1668.

The air conditioning plant shall provide a suitable environment for staff and the protection relays, communications, metering and other control equipment.

The air conditioning controllers shall be interfaced to the SCADA control system with a series RS 232 communication using MODBUS protocol to provide room and outside air temperatures, air conditioning status and alarm monitoring.

Air conditioning plant shall automatically shut down in the event of a fire signal from the room fire detectors.

Units shall also be designed to take into account temperature conditions at blind spots and be sized to meet the site's local maximum and minimum ambient temperatures outside conditions.

8.5.2 Battery room ventilation

A natural ventilation system is preferred to ensure that the hydrogen concentration in the air does not exceed 2% and shall be provided in accordance with AS 2676.

The low level inlet and high level outlet vents are to be sized for natural ventilation and be located at opposite ends of each Battery Room. The rate of ventilation, air flow rate and sizing of inlet/outlet apertures shall be designed in accordance with AS 2676.

8.6 Fire protection

8.6.1 Portable fire protection equipment and storage

The Connection Applicant shall supply and install portable fire extinguishers to the Battery Room in accordance with AS 2676.

8.6.2 Fire protection

Each building shall comply with all the current requirements of the National Construction Code, including relevant installer's statements for compliance certification, as well as relevant Australian Standards.

The Gas Fire Suppression System shall be designed and installed in accordance with AS ISO 14520.1 Gaseous fire-extinguishing systems-Physical properties and system design-General requirements.

Where a VESDA system is required it shall be designed and installed to provide coverage of the whole building.

Details of the systems proposed shall be included in the Technical Schedules.

8.7 Domestic water

Domestic water services shall be sourced from town water mains, or where these are not available, from a Water Tank to be provided.

The domestic water system shall supply water to the locations in Buildings as required.

8.8 Internal lighting requirements

8.8.1 Luminaires

All AC systems are to follow the principles defined in Australian Standard AS 3000 and AS 3008. The location of the light fittings shall be subject to the equipment layout.

With the exception of the battery rooms, the luminaires inside each room of each building shall be located to provide a level of illumination in accordance with the requirements of AS1680. Interior & exterior luminaires shall be located to provide a level of illumination that is at least in accordance with the requirements of AS 1680.

The light fittings in Battery Rooms shall be flame proof fluorescent and comply with the requirements of AS 2676.1.

8.8.2 Emergency evacuation lighting

The emergency evacuation lighting system shall comply with the requirements of Australian Standard AS 2293.1 and must switch on automatically on loss of AC supply.

8.9 Electrical requirements

8.9.1 General

The Connection Applicant shall design and install all the AC and DC systems necessary for the building lighting, power, security systems, and any other purpose required to complete the works.

All electrical installations shall be carried out in accordance with the latest edition and amendments of AS 3000 and other relevant Australian standards such as AS 3008. AC wiring for the SSB shall be chased through internal walls and no exposed conduits or wiring shall be used.

8.9.2 Power outlets

External power outlets shall be provided on the building as follows:

- One off weatherproof double 10 A GPO on the wall adjacent to the switchyard door;
- One off three phase 415 V, 32 A continuous rated switchplug outlets (5 pin) located adjacent to Battery Room door and/or cable access holes.

8.9.3 Earthing and surge protection

The Connection Applicant shall design, supply, install and connect the earthing system required for the safe and effective earthing of the distribution boards, equipment and building structure.

The building installation shall be earthed in accordance with AS 3000 and AS 2067 via the Substation earth grid.

Appendix A – Civil and Structural Design Standards

The following Australian Standards (and RMS forms for roads) are applicable to the specified design requirements, or materials and construction requirements for the substation.

A.1 General

AS 1170	Structural Design Actions
AS 2067	Substations and High Voltage Installations exceeding 1kV AC
AS 3600	Concrete Structures
AS 4100	Steel Structures
AS 5577	Electricity Network Safety Management Systems
AS 7000	Overhead line design
ENA 15	Energy Network Australia - National Guideline for Prevention of Unauthorised Access to Electricity Infrastructure
ENA 18	Energy Network Australia - Fire protection of Electricity Substations
COP	Code of Practice - Safe Design of Structures
COP	Code of Practice - Hazardous Manual Task

A.2 Geotechnical site investigations

AS 1726	Geotechnical Investigations

A.3 Concrete

AS 1012	Methods of testing concrete
AS 1141	Methods for sampling and testing aggregates
AS 1379	The Specification and Supply of Concrete
AS 1478	Admixtures for concrete
AS 2530	Methods for testing Portland, blended and masonry cements.
AS 2758	Aggregates and rock for engineering purposes
AS 3582	Supplementary cementitious materials for use with Portland and blended cement.
AS 3600	Concrete Structures
AS 3610	Formwork for Concrete
AS 3972	Portland and Blended Cements
AS 3799	Liquid membrane-forming curing compounds for concrete
AS/NZ 4671	Steel Reinforcing Materials

A.4 Clay bricks and concrete blocks

AS 3700	Masonry Structures
AS/NZS 4455	Masonry units and Segmental pavers
AS/NZS 4456	Masonry units and Segmental pavers. Method Test
AS 2701	Methods of sampling and testing mortar for masonry construction

A.5 Earthworks

AS 1141	Methods for sampling and testing aggregates
AS 1289	Methods for testing soils for engineering purposes
AS 3798	Guidelines in earthworks for commercial and residential developments
AS 4678	Earth-Retaining Structures
AS 2870	Residential slabs and footings – construction

A.6 Roadworks

AS 1141	Methods for sampling and testing aggregates
AS 1152	Specification for Test sieves
AS 1160	Bitumen emulsions for construction and maintenance of pavements
AS 1289	Methods for testing soils for engineering purposes
AS 1507	Road tars for pavements
AS 2008	Residual bitumen for pavements
AS 2150	Hot Mix Asphalt – A guide to good practice
AS 2157	Cutback bitumen
AS 2758	Aggregates and rock for engineering purposes
AS 2891	Method of testing and sampling asphalt
AS 3798	Guidelines in earthworks for commercial and residential developments
AS/NZS 4671	Steel reinforcing material
AS/NZS 4680	Hot-dip galvanised (zinc) coatings on fabricated ferrous articles
AS/NZS ISO 9000	Quality Management Systems. Fundamentals and vocabulary
AS/NZS ISO 9002	Quality Systems. Model for quality assurance in production, installation and servicing.
RMS Form 76	Supplement to AUSTROADS 1992 Guide
'AUSTROADS'	Pavement Design – A guide to the Structural Design of Road Pavements (1992)
RMS Guide	Sprayed Sealing Guide (October, 1991)
RMS 106	Sprayed Bituminous Surfacing (with Cutback Bitumen)
RMS 116	Asphalt (Dense Graded and open Graded)
RMS T166	Test method 166. Relative Compaction of Road Construction Materials
RMS 3051	Unbound and Modified Base and Sub base Materials for Surface Road Pavements.
RMS Form 400	Bituminous Surfacing Daily Record

A.7 Concrete pavements

AS 3600	Concrete Structures
AS 4671	Steel Reinforcing Materials
AS 4680	Hot-dip galvanised (zinc) coatings on fabricated ferrous articles

A.8 Water services

AS 1345	Identification of the contents of pipes, conduit and ducts.
AS 1432	Copper tubes for plumbing, gas fitting and drainage applications

AS 1463	Polyethylene pipe extrusion compounds
AS 1477	Unplasticised PVC (UPVC) pipes and fittings for pressure applications
AS 1627	Metal finishing
AS 2280	Ductile iron pressure pipes and fittings
AS 2419	Fire Hydrant installations
AS 2441	Installation of fire hose reels
AS 2544	Grey iron pressure fittings
AS 2941	Fixed fire protection installations
AS 3680	Polyethylene Sleeving for Ductile Iron Pipelines
AS 3681	Guidelines for the application of polyethylene sleeving to ductile iron pipelines and fittings
AS 3688	Water Supply – Metal fittings and end connectors
AS/NZS 4129	Fittings for polyethylene pipes for pressure applications
AS/NZS 4130	Polyethylene pipes for pressure applications
AS/NZS 4158	Thermal-bonded polymeric coatings on valves and fittings

A.9 Drainage

AS 1074	Steel tubes and tubulars for ordinary services
AS/NZS 1254	Unplasticised PVC (UPVC) pipes and fittings for storm and water applications.
AS/NZS 1260	UPVC pipes and fittings for sewerage applications
AS 1289	Method of testing soil for engineering purposes
AS 1477	Unplasticised PVC (UPVC) pipes and fittings for pressure applications
AS 1597	Precast reinforced concrete box culverts
AS 1657	Fixed platforms, walkways and ladders
AS 1646	Elastomeric seals for waterworks purposes
AS 1741	Vitrified clay pipes
AS1940	Storage and handling of flammable and combustible liquids
AS 2053	Non-metallic conduits and fittings
AS 2280	Ductile iron pressure pipes and fittings
AS 2439.1	Perforated Drainage Pipe and Associated Fittings
AS 2544	Grey iron pressure fittings
AS 2876	Concrete kerbs and channels (gutters) - Manually or machined placed.
AS 3735	Concrete structures for retaining liquids
AS/NZS 3500	Plumbing and drainage
AS 4058	Precast concrete pipes (pressure and non-pressure)
AS/NZS 4680	Hot dipped galvanised coatings or ferrous articles
AS 3996	Metal access covers and frames
BS 1256	Malleable Cast Iron Screwed Pipe Fittings
RMS R63	Geotextiles (Separation and Filtration)
RMS R62	Subsurface Drainage – Materials
RMS 3553	Seamless tubular filter fabric

A.10 Concrete pipelines

AS/NZS 4058	Precast concrete pipes
AS/NZS 3725	Design for installation of buried concrete pipe

A.11 Cable conduits

AS 2053	Non-metallic conduits and fittings
AS 3000	Rules for the electrical equipment of buildings, structures and premises

A.12 Footings

AS 1289	Methods for testing soils for engineering purposes
AS 2159	Piling - Design and installation.
AS 2870	Residential slabs and footings – construction

A.13 Fencing

Unless otherwise specified; materials supplied shall comply with the following Standards.

BS 1722-14	Specification for Welded Mesh panel Fences
AS 1725	Chain Link security fencing and gates
AS 4680	Hot Dip Galvanised (Zinc) Coatings on Fabricated Ferrous Articles
AS 4100	Steel Structures
AS 1554	Structural Steel Welding
AS 3016	Electrical Installation – Electric Security Fences
AS 3550.2.76	Safety of Household and Similar Electric Appliances – Electric Fence Energisers
AS 1074	Steel tubes and tubulars for ordinary service
AS 1163	Structural Steel Hollow Sections
AS/NZS 4680	Hot dipped galvanised coatings on ferrous articles
AS 2423	Coated Steel Wire Products

A.14 Structures and footings

The Building Code of Australia – as applicable

AS 1170	Structural Design Actions
ESAA NENS 05 –	National Fall Protection Guidelines for the Electricity Industry
AS 4100	Steel structures
AS 3600	Concrete structures
AS 3995	Design of steel lattice towers and masts
AS/NZS 4600	Cold formed steel structures
AS/NZS 1554.1	Structural Steel welding
AS/NZS 1559	Hot dipped galvanised steel bolts and associated nuts and washers for tower construction.
AS 1074	Steel tubes and tubulars for ordinary service
AS 1111	ISO metric hexagon bolts and screws
AS 1112	ISO metric hexagon nuts

AS/NZS 3678	Structural Steel. Hot rolled plates, floor plates and slabs
AS/NZS 3679	Structural Steel. Hot rolled bars and sections
AS/NZS 4680	Hot Dip Galvanised (Zinc) Coatings on Fabricated Ferrous Articles