Network Standard

Document No.
NS186

Title:
Major Substations Civil Works Design Standard

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4	27/06/2025	Update and conversion to the new template	Joseph Metti	Jacob Bayley

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List of Annexures

Scope

This Network Standard provides the performance and design criteria for the civil works design of major substations with the voltages of 132kV, 66kV, 33kV and 11kV.

Refer to NS185 for details of the performance and design criteria for the architectural and structural design of buildings for major substations.

Refer to also the relevant network standard for the requirements for active and passive fire mitigation, fencing and security.

This document does not include detailed information for yard structures in substations, nor does it include provisions or information for distribution substations, kiosks or pole top equipment such as transformers, regulators or capacitors.

Reference Documents

All work covered in this document shall conform to all relevant Legislation, Standards, Codes of Practice and Network Standards.

Ausgrid Documents

NS001 Glossary of Terms

Bush Fire Risk Management Plan

EG 320 Major Substation Environmental Sustainability Initiatives

HS018-P0200 Lifting Operations

NEG SM04.25 Switchyard Steelwork

NEG SM05 Site Assessment Process for Major Projects

NEG SM08 Noise Assessment

NS130 Laying Underground Cables Up to and Including 11kV

NS158 Labelling of Mains and Apparatus

NS171 Fire Stopping in Substations

NS174 Environmental Procedures

NS184 Fences for Zone and Subtransmission Substations

NS185 Major Substations Building Design Standards

NS187 Passive Fire Mitigation Design of Substations

NS189 Oil Containment for Major Substations

NS203 Telecommunications Network: Master Policy Document

NS210 Documentation and Reference Design Guide for Major Substations

NS212 Integrated Support Requirements for Ausgrid Network Assets

NS222 Major Substation Earthing Design

T0007 NEG SM04.21 Light & Power

T0037 Network Access and Security – Locks and Keys

T0053 Design and Construction of Power Cable Conduits in Major Substations

T0059 NEG SM07 Active Fire Systems for Substations

Tree Safety Management Plan

Other Standards and Documents

ANZECC & ARMCANZ – Australian and New Zealand Guidelines for Fresh and Marine Water Quality.

AS/NZS ISO 14040: Environmental management - Life cycle assessment - Principles and framework.

AS/NZS 1158 Lighting for roads and public spaces (Set)

AS/NZS 1170 Structural design actions (Set)

AS 1319 Safety Signs for the occupational environment

AS 1530.4 Methods of fire tests on building materials, components and structures - Fire-resistance test of elements of construction

AS 1657 Fixed platforms, walkways, stairways and ladders – Design, construction and installation

AS 1940 The storage and handling of flammable and combustible liquids

AS 2159 Piling – Design and Installation

AS/NZS 2699 Built-in components for masonry construction (Set)

AS 2865 Confined Spaces

AS 2870 Residential slabs and footings

AS/NZS 2890.1 Parking facilities – Off-street car parking

AS/NZS 3500 National Plumbing and Drainage (Set)

AS 3600 Concrete structures

AS 3700 Masonry structures

AS 3745 Emergency control organisation and procedures for buildings

AS 4100 Steel Structures

AS 4678 Earth-retaining structures

AS 5100 Bridge Design (Set)

Australian Rainfall and Runoff - A Guide to Flood Estimation

Department of Environment and Heritage – Coastal Risk Management Guide.

Department of Environment and Heritage – Flood Risk Management Guide

Department of Environment & Heritage – Managing Urban Water Series.

Department of Planning & Infrastructure – Hazardous Industry Planning Advisory Paper No 1 – Emergency Planning

Department of Climate Change, Energy, the Environment and Water – National Strategy for Ecologically Sustainable Development

ENA Doc 001 - 2019 National Electricity Network Safety Code

ENA Doc 015 - 2006 National Guideline for Prevention of Unauthorised Access to Electricity Infrastructure

ENA Guideline - Seismic Security of Power Systems ND/S/-01 (ESAA, ESC158 January 1994) (For Information only)

ENA Guideline - Substation Seismic Design Application Guide ND/S/-02 (ESAA, ESC156 September 1994) (For Information only)

Environment Protection Authority (EPA), NSW Noise Policy for Industry

Environment Protection Authority (EPA), Specification of Supply of Recycled Materials for Pavements, Earthworks and Drainage

Mobile Crane - Code of Practice 2024 - Workplace Health and Safety Queensland

National Construction Code Series (NCC)

Pavement Design: A Guide to the Structural Design of Road Pavements (Austroads)

RMS document: RTA 45070666E Heavy Vehicle Mass, Loading and Access

Water Sensitive Urban Design (WSUD) - Landcom.

Acts and Regulations

Electricity Supply (General) Regulation 2014 (NSW)

Electricity Supply (Safety and Network Management) Regulation 2014

Environmental Planning and Assessment (EP&A) Regulation 2000

Protection of the Environment Administration Act 1991 (NSW)

Protection of the Environment Operations Act 1997 (NSW)

Work Health and Safety Act 2011 (NSW)

Work Health and Safety Regulation 2017 (NSW)

Clause	Standard Requirements

1 General

1.1 All materials and equipment used for construction of Ausgrid's assets shall be free from Asbestos and/or Asbestos related products.

1.2 Refer to NS174 for Environmental Planning, licensing and/or approval requirements associated with major substation civil works.

2 Functional requirements

2.1 Design life

2.1.1 Design Life refers to the ability of the substation civil works to maintain functionality and operation in a safe, effective and cost-efficient manner. All substation civil works shall be designed to withstand the loads and other forces to ensure the required Design Life is attained.

2.1.2 Ausgrid shall determine and advise the required Design Life for each substation, based on criteria related to calculated load, system reliability and criticality. Three classifications are used for the design of major substations:

- 100 year Design Life;
- 50 year Design Life;
- 20 year Design Life.

2.1.3 The applicable Design Life for each substation is project specific and shall be included in the Design Brief issued to the Designer by Ausgrid.

2.2 Design standards

Substation civil works shall be designed to comply with all relevant legislation, Australian Standards, Codes of Practice, the National Construction Code (NCC / BCA), relevant statutory and approving authorities and any other requirements as directed by Ausgrid.

2.3 Design life of components

2.3.1 General

The Design Life of all components shall be assessed when designing the overall civil works to ensure compliance with, and achievement of, the specified Design Life.

2.3.2 100 year and 50 year design life

2.3.2.1 For major substations classified as 100 year or 50 year Design Life, the following requirements shall apply:

- The Architectural, Civil and Structural design shall ensure all structural components of the civil works are designed for the relevant Design Life, as applicable to the project;
- Replacement of nominated non-structural components during the Design Life is allowed. Refer to Clause 2.4; and
- Components which do not have the required design life, unless maintained, shall be included in the schedule of required maintenance works. Preliminary Maintenance Procedures and Operation Schedules (PMPO) shall be included in the Compliance Certificate (CC) submission and Tender documentation.

2.3.2.2 Where a Design Life of 100 years is required, the following additional requirements shall apply:

- The Designer shall provide details of measures used to achieve the extended Design Life to Ausgrid for approval, prior to the design proceeding; and
- The durability requirements in AS 5100:5 Bridge Design - Concrete shall be utilised in the designs.

2.3.3 20 year design life

For temporary substations, or equipment, required as a means of supplementing the Network, or required for emergency situations whilst other work is undertaken for a more permanent solution, the following requirement shall apply:

- The Architectural, Civil and Structural design shall ensure all structural components of the civil works are capable of a minimum Design Life of 20 years.

2.4 Replacement of components

2.4.1 For a Design Life of 100 years or 50 years, replacement of components is allowed for accessible and replaceable non-structural elements. These may include, but are not limited to, the following items:

- Aesthetic or outer protective materials.
- Exposed external metalwork such as guardrails, ladders, trench covers etc.
- External finishes
- Flexible roadway pavements.
- External security fencing, gates etc.

2.4.2 Replacement may also be reasonably practicable for external switchyard steelwork, some of which may be accessible under restricted access or controlled outage conditions.

2.4.3 All replacement of components during the substation Design Life shall be subject to a Life Cycle Cost assessment in accordance with Clause 2.5.

2.5 Life cycle costing (LCC)

2.5.1 LCC assessment

2.5.1.1 LCC techniques shall be applied to projects as specified in the Design Brief documentation, or otherwise where requested in writing by Ausgrid.

2.5.1.2 LCC shall assess the capital and recurrent costs involved with the ownership and operation of the asset. Recurrent costs include, but are not limited to, maintenance, on-going operation, refurbishment and disposal.

2.5.1.3 The Designer shall provide information illustrating the use of LCC techniques in the selection of designs, construction options/activities, materials and finishes. This information shall form part of the design and options recommended to minimise overall LCC of the asset components and structure.

2.5.2 Mid-term refurbishment

2.5.2.1 All options for design of 100 year and 50 year Design Life substations shall take into account the re-equipping of switch rooms, control rooms and replacement of transformers in an operational substation.

2.5.2.2 The Design shall allow for the efficient and cost-effective replacement of components and shall include a Life Cycle Cost assessment incorporating all replacement costs. Where applicable, the cost of any necessary power outages to enable replacement shall be factored into the Life Cycle Cost assessment.

2.5.2.3 The Life Cycle Costing shall include the cost of complying with all Ausgrid requirements for work undertaken in an operational substation.

2.6 Design statement and certification

Substation designs shall be accompanied by a Design Statement for the specified Design Life. Refer to Annexure F.

2.7 Preliminary maintenance procedures

As part of the design documentation, the Designer shall provide Preliminary Maintenance Procedures and Operation Schedules (PMPO) to Ausgrid. Refer to Annexure F.

2.8 Ecologically sustainable development

2.8.1 The design of the substation civil works shall take into account the principles of ecologically sustainable development (ESD).

2.8.2 Ecologically sustainable development can be achieved through the implementation of the principles and programs as outlined in Annexure B.

2.8.3 Refer to EG 320 for guidance on the initiatives that may be applicable in reducing embodied impacts associated with major substation projects.

3 Site requirements

3.1 Site investigation

3.1.1 The requirements for site inspection and investigation are described in NEG SM05. The site investigations are divided into two stages:

- Stage 1 – Preliminary Site Assessment (Property Acquisition). Ausgrid shall undertake the applicable activities during the site acquisition and concept design phase.
- Stage 2 – Detailed Site Assessment (Design Stage). The Designer shall undertake the applicable activities during the detail design phase.

3.1.2 Site investigation for the substation civil works shall assess site conditions including both the previous and proposed land use. Investigations shall be carried out to ensure compliance with all relevant standards and all project specific requirements.

3.2 Site topography

3.2.1 Except where approved in writing by Ausgrid, the final level of the substation site shall be at, or above, the 1 in 100 year (1% Annual Exceedance Probability) flood level or as per Local Council requirements whichever is the higher in level.

3.2.2 Sufficient falls shall be provided across the site to facilitate gravity drainage for both stormwater flows, and for any oil containment pipelines on the site. Refer to NS189 for oil containment requirements.

3.2.3 Where a site does not have adequate falls for gravity drainage systems, cut and/or filling of the site shall be investigated.

3.2.4 Ausgrid approval in writing shall be obtained prior to any design which incorporates pumping of stormwater or oil containment from the site. Such approval shall require the submission of a full hydraulic design and a review of all options.

3.2.5 A substation site layout drawing shall indicate the existing and the finished ground levels. The Designer shall assess the site conditions and determine the method of site preparation, and the footings required for installation of all structures and specified equipment.

3.2.6 For sites in low-lying areas near coastal locations, an allowance shall be made for potential future sea-level rise in accordance with the relevant NSW Government policies, guidelines and management programs.

3.2.7 Reference shall be made to the “CoastAdapt” datasets, developed by the National Climate Change Adaptation Research Facility (NCCARF) in conjunction with the CSIRO, which provide sea-level rise information for coastal councils.

3.2.8 The need for groundwater ingress management and additional oil containment controls shall be assessed for low-lying substation sites.

4 Materials in substations

4.1 All materials shall be assessed with regard to their Design Life, Life Cycle Cost, strength and aesthetics.

4.2 All materials used in substation civil works shall be non-combustible, except with the written approval of Ausgrid.

4.3 Where required by the substation design, materials shall be designed to achieve the necessary fire resistance level (FRL).

4.4 Recycled materials may be utilised for the construction of roadways, drainage systems and site work platforms. The use of recycled materials shall comply with:

- EPA - Specification of Supply of Recycled Materials for Pavements, Earthworks and Drainage;
- the Protection of the Environment Operations Act;
- the recycled aggregate order 2014 and recycled aggregate exemption 2014;
- the excavated natural material order 2014 and excavated natural material exemption 2014; and
- the recovered fines order 2014 and the recovered fines exemption 2014.

4.5 The proposed use of any recycled materials shall be subject to an assessment of the relevant performance criteria and shall require the review and approval of Ausgrid.

5 Substation design requirements

5.1 General

5.1.1 The site and civil works to be completed at the substation site shall be as follows:

- excavation, benching, backfilling and consolidation of the entire site to cater for the ultimate development of the substation;
- final levelling, consolidation, surfacing and compaction of entire switchyard area with crushed rock (where required) to cater for the ultimate development of the substation;
- installation of retaining walls, as necessary, to cater for the ultimate development of the substation;
- installation of an all-weather access road and a substation roadway for motor vehicles and all items of plant and equipment,
- security fencing and a landscaping buffer to cater for the ultimate development of the substation;
- installation of a water supply, drainage, oil containment and sewage facilities;
- installation of footings and bunding for all main transformers and associated coolers;
- environmental management facilities including oil separation, oil containment and site run-off control to cater for the ultimate development of the substation;
- installation of conduits or ducts;
- provision of pulling pits as necessary to facilitate the installation of cables;
- installation of footings and structures for all plant and equipment;
- provision of safe access to routine operating and visual monitoring locations;
- installation of a substation earth grid; and
- construction of a switch room/control room building (refer to NS185).

5.1.2 The Designer shall allow for safe work at heights by providing adequate space around equipment to ensure that ladders, scaffolding, elevated work platforms etc, can be utilised when required.

5.2 Durability

5.2.1 Materials and applied finishes for substation civil works shall be low maintenance. Applied finishes shall comply with the requirements in Annexure A and Clause 2.3.

5.2.2 Applied finishes that require re-application during the Design Life of the substation shall be subject to a Life Cycle Cost assessment in accordance with Clause 2.5. Where applicable, the cost of any necessary power outages shall be factored into the Life Cycle Cost assessment.

5.2.3 The durability requirements for all concrete structures shall comply with AS 3600 and the requirements of Clause 2.3.

5.2.4 The durability requirements for masonry construction shall be in accordance with AS 3700 and AS/NZS 2699, plus the following additional requirements:

- Exterior unprotected concrete blocks shall have a salt attack resistance at “Exposure” grade, when used on sites within 2 km of a surf coast or within 1 km of a non-surf coast; and
- The reinforcement for concrete block walls shall be galvanised where it may be continually wet or in exposed locations. This requirement shall apply to retaining walls and exposed walls in all coastal or industrial areas.

5.2.5 Refer to NS187 for limitations on the materials used within substations.

5.3 Noise and vibration

5.3.1 The design of substation civil works and equipment layout shall ensure all equipment which generates noise is orientated away from sensitive receivers.

5.3.2 Equipment location, orientation and local topography shall be used to minimise the line-of-sight exposure of noise sources to neighbouring properties.

5.3.3 A noise and vibration assessment shall be carried out during the design stage using realistic operating conditions and including maintenance activities. Refer to NEG SM08 for noise assessment requirements.

5.3.4 Operational noise levels shall comply with the EPA NSW Noise Policy for Industry. Refer to NS174.

5.3.5 Where the noise assessment shows that mitigation measures are required for realistic operating conditions, these measures shall be incorporated into the substation design.

5.3.6 Where the noise assessment shows that mitigation measures may be required for more severe (but less likely) operating conditions, suitable allowances shall be provided for the future installation of sound barriers, enclosures or other methods of mitigation.

5.3.7 Penetrations in walls such as air ducts, ventilators and grills shall be minimised in areas facing sensitive receivers. Openings in surfaces facing sensitive receivers may require appropriate acoustic louvres to baffle or redirect noise generated from the substation.

5.3.8 Where required, outdoor transformer enclosures shall be treated to minimise reverberant noise, consistent with fire rating requirements.

5.3.9 The use of acoustically rated walls for reduction of noise from transformers or equipment onto nearby sensitive receivers shall require prior acoustic testing of the area.

5.4 Site services

5.4.1 General

The Designer shall design all civil earthworks and site services including stormwater, groundwater, oil containment, fire and associated hydraulic services.

5.4.2 Fire services

5.4.2.1 Fire services shall be installed in accordance with the requirements of the Network Standards and local authorities.

5.4.2.2 Passive fire system requirements shall be in accordance with NS187.

5.4.2.3 For active fire system requirements, including detection systems and alarms, refer to T0059.

5.4.2.4 For the design of substations in bushfire prone areas, special provisions may need to be included as detailed in NS187.

5.4.2.5 A fire hydrant service, connected to water supply (and electrically isolated for earthing purposes), shall be provided for coverage of the substation area where a significant fuel source exists or where asset protection is required.

5.4.2.6 Each main transformer bay within the substation shall have fire hydrant coverage from two directions to facilitate the protection of adjacent assets.

5.4.2.7 Fire hydrants inside the substation area can be omitted for sites that are adequately served by external fire hydrants or street hydrants.

5.4.2.8 Where fire hydrants are provided inside the substation area, a fire hydrant booster connection, in line with local authority requirements, shall be installed external to the security fence in a readily accessible location for fire service vehicles.

5.4.3 Hydraulic services

5.4.3.1 The hydraulic services for the substation are site specific, and will include of some or all of the following:

- Sanitary plumbing.
- Sewer or septic drainage.
- Trade waste plumbing.
- Trade waste drainage.
- Domestic cold water.
- Domestic hot water.
- Non-potable / recycled water.
- Fire hydrant service connected to water supply.
- Fire hydrant booster connection.

5.4.3.2 Refer to the requirements of AS/NZS 3500 National Plumbing and Drainage (Set).

5.4.3.3 Where a septic tank is employed, it shall be installed outside the substation intruder resistant fence.

5.4.4 Stormwater and other services

The stormwater and other services for the substation are site specific, and will include of some or all of the following:

- Stormwater collection, detention and drainage.
- Oil containment drainage.
- Subsoil groundwater drainage.
- Roadway drainage.
- Surface water drainage.

5.5 Oil containment

5.5.1 Environmental management facilities, including oil separation, oil containment provisions and site run-off control for the ultimate development shall be provided.

5.5.2 The designer shall provide calculations to support the basis of sizing of the equipment offered. The oil containment facilities shall be installed in accordance with NS189.

5.6 Segregation of transformers

5.6.1 Separation distances between transformers and between transformers and buildings shall meet the requirements of NS187.

5.6.2 Where fire segregation is required and the necessary separation distances cannot be satisfied, Fire Separation Walls (FSW) shall be used to meet the requirements of NS187.

5.7 Designer safety reports and CHAIR

5.7.1 The Designer shall prepare a Designer Safety Report in accordance with the WHS Regulation. The report shall comply with NS210 and shall be prepared at the completion of the design phase.

5.7.2 A Construction Hazard Assessment & Implementation Review (CHAIR) shall be undertaken in accordance with the WHS Regulation. A copy of the CHAIR review documentation shall be provided to Ausgrid for review and approval prior to completion of the design phase.

5.7.3 The Designer shall include sufficient resources and staff, across the range of design disciplines involved in the project, to coordinate advice and participate in the CHAIR process. The aim shall be to enable a full assessment of the civil works and the construction methodology.

6 Civil design requirements

6.1 Civil design criteria

Substation civil works shall be designed with an Importance Level of 4, in accordance with the NCC and relevant Australian Standards. The substation wind and earthquake design shall be based on this Importance Level.

6.2 Permanent and imposed loads

6.2.1 Permanent and imposed loads shall be in accordance with AS/NZS 1170.1 unless advised otherwise in writing by Ausgrid.

6.2.2 Permanent loads shall be maximum foreseeable loads over the entire Design Life of the substation.

6.3 Wind loads

6.3.1 Wind loads applicable to the substation structures shall be in accordance with AS/NZS 1170.2 and shall not be less than the value derived from Table 1.

Table 1: Wind loads

Substation Category	Regional Wind Speed (m/s)
100 year	≥ V_{2500} (Note 1)
50 year	V_{2500}
20 year	V_{1000}

[1] Risk Analysis required. Refer to AS/NZS 1170.0 Annexure F – Annual Probability of Exceedance.

6.3.2 For structures covered by the NCC, AS/NZS 1170.0 requires the design loads to comply with the annual probability of exceedance as given in the NCC. For these structures the relevant requirements of the NCC shall apply where they are more severe than the values given in Table 1.

6.4 Earthquake loads

6.4.1 Earthquake loads shall be obtained from AS/NZS 1170.4.

6.4.2 The Designer shall reference ENA guidelines Seismic Security of Power Systems ND/S/-01 and Substation Seismic Design Application Guide ND/S/-02 for earthquake design.

6.4.3 The annual probability of exceedance and the probability factor (kp) for earthquake loading shall not be less than that shown in Table 2.

Table 2: Earthquake Loading Probability of Exceedance

Substation Category	Annual Probability of Exceedance	Probability Factor (kp)
Ultimate Loads		
100 year	≤ 1/2500	Risk Analysis (Note 1)
50 year	1/2500	1.8
20 year	1/1000	1.3
Serviceability Loads		
100 year	≤ 1/250	Risk Analysis (Note 1)
50 year	1/250	0.75
20 year	1/100	0.50

[1] Risk Analysis required. Refer to AS/NZS 1170.0 Annexure F – Annual Probability of Exceedance.

6.4.4 The serviceability load requirements in Table 2 are intended to ensure acceptable performance of the structure after a moderate earthquake. The main structure shall not require significant repair after the serviceability limit state earthquake and shall remain in an acceptable condition for operational continuity.

6.4.5 For the serviceability limit state, the design requirements shall include the following:

- Probability Factor (kp) as per Table 2.
- Structural Ductility Factor (μ) = 1.15, to reflect realistic damping for an elastic structure.
- Structural behaviour to remain within the elastic range (i.e. no yielding of reinforcement).
- Allowable lateral movement not to exceed 1.0% of height, to minimise damage to the non-structural components.

6.4.6 For the ultimate limit state, the structural design shall:

- use an appropriate Structural Ductility Factor (μ) in accordance with AS/NZS 1170.4;
- aim to reduce the risk of a complete structural collapse, where reasonably practicable; and
- for framed structures, any plastic hinges formed during a major earthquake shall occur preferentially in the beams, rather than the columns, to reduce the potential for collapse of the entire structure.

6.4.7 For structures covered by the NCC, AS/NZS 1170.0 requires the design loads to comply with the annual probability of exceedance as given in the NCC. For these structures the relevant requirements of the NCC shall apply where they are more severe than the values given in Table 2.

6.5 Vibration limits

6.5.1 Equipment installed in substations may have specific vibration profiles which affect the structure and sensitive equipment on the structure.

6.5.2 Where required, the structure shall be designed to reduce the impacts involved with vibration of equipment.

6.5.3 Substation sites which are proposed to be located near existing or identified future mine blasting activities shall be designed for the impacts of ground vibration and air blast overpressure, as negotiated between Ausgrid and the mine/quarry operator.

6.5.4 Mine blasting activities may require additional protective measures to prevent flyrock from entering the substation site or damaging the associated overhead transmission lines.

6.6 Differential settlement

6.6.1 Differential settlement shall be limited or managed to prevent structural damage to the substation civil works and to limit detrimental impact on plant and equipment.

6.6.2 The design of switchyard structures, busbars and insulator connections for sites with reactive soils shall be subject to the review and approval of Ausgrid.

7 Transformer and access roadways

7.1 General

An access road and substation roadway inside the substation shall be established to cater for the ultimate development of the substation. The substation roadway shall provide sufficient clearance between plant items and the switch room / control room to accommodate for large transport vehicles and cranage access.

7.2 Design and performance criteria

7.2.1 Substations shall be designed to enable efficient equipment change-over and general vehicular access for maintenance and operations.

7.2.2 All transformer and access roads shall comply with this standard and all local and statutory authority requirements including all Development Approval, Construction Certificate conditions and NSW RMS requirements.

7.2.3 All roadways leading into and within substation areas shall be designed with slopes and falls to facilitate access during all weather conditions and allow for efficient replacement of transformers and/or emergency access for works in the yard or substation buildings.

7.2.4 Road designs shall incorporate turning circles, changes in grade and maximum grades to ensure the access roadway suits the proposed equipment transport and delivery procedures for all substation equipment.

7.2.5 The designated transformer roadway shall allow for site access of an articulated low loader transformer float. The transformer roadway shall be designed to meet specified manoeuvring and loading requirements. Ausgrid shall provide the site-specific loading requirements.

7.2.6 Transformer and access roadways inside the substation can be designed using unsealed, flexible or rigid pavements depending on the length of roadway, the site-specific conditions and the likely wear on the surface over its expected life. The selected roadway design shall meet the relevant design requirements of this standard.

7.2.7 The use of unsealed or flexible pavements in truck turning areas shall be subject to approval by Ausgrid.

7.2.8 Reinforced concrete roadways near or inside the substation area shall be bonded to the site earth grid. To reduce the potential for steel reinforcing to corrode if exposed, the Designer shall ensure strict adherence to AS 3600 or AS 5100 requirements, as appropriate, when specifying the minimum concrete cover of steel reinforcing.

7.2.9 The Designer shall review and satisfy local and statutory authority requirements with regard to associated street works, connections to utilities, footpath crossings and general town planning matters.

7.2.10 Amendments to the Ausgrid Site Layout Plan to suit site topography and geology, construction practicalities, town planning requirements or other architectural and road engineering requirements shall require the approval of Ausgrid.

7.3 Roadway design loads

7.3.1 Ausgrid shall provide the maximum transformer loadings for each substation site, and specific manufacturer’s drawings of the transformer arrangement.

7.3.2 Actual transformer weights, installation methods and crane loads, where available, shall be used in the design of the transformer roadway.

7.3.3 Typical design loadings are provided in Tables 3 and 4 and shall be used in conjunction with the loading schedules and the transformer manufacturer’s drawings.

7.3.4 Road pavements shall be designed for the expected number of equivalent standard axles (E.S.A.), up to a maximum of 10^4 E.S.A., as defined in the document "Pavement Design: A Guide to the Structural Design of Road Pavements (Austroads)".

Table 3 – Wilson Transformer Company - Typical New Transformer Loads[1]

Tx size	15/19 MVA	20/33 MVA	25/37.5 MVA	30/50 MVA	60 MVA	72/120 MVA
Usage	Typical Zone Bushing	Typical Zone Bushing	Typical Zone	Typical Zone	Typical STS	Typical STS
Reference Drawing	Wilson 879-2212C	Wilson 879-2039C	Wilson 879-1807C	Wilson 879-1729C	Wilson 879-2108C	Wilson 879-2016C
Transformer Main Tank	N/A[2]	N/A[2]	N/A[2]	N/A[2]	N/A[2]	1,248 kN
Radiator	N/A[2]	N/A[2]	N/A[2]	N/A[2]	N/A[2]	210 kN
Transport weight of Tx (main tank)	295 kN	278 kN	390 kN	565 kN	560 kN	930 kN
Total load in service	378 kN	480 kN	665 kN	785 kN	915 kN	1,459 kN

[1] Older transformers may be used as spares. These transformers may be heavier, and in some cases may be used in new substations.

[2] Main tank and radiator come in one piece.

Table 4 – Typical Transformer Roadway Loads (50MVa transformer)

Load Type	Load
Roadway Blanket Imposed Load	15kPa
Roadway Dynamic Loads	As per AS 5100 series.
Transporter Loading -Transformer:	
Wheel Loadings	Transporter plus transport weight of Transformer (Refer to specific vehicle loading diagrams).
Max Axle Load	Austroads '92 - HLP 320 – 200kN/axle (permit required).
Max Wheel Load	When the dolly is removed the axle loads exceed the RMS maximum for 2.5 m width.

7.4 Transformer installation loads

7.4.1 Transformers can be installed by either skating or mobile crane methods depending upon substation layout, site constraints and transformer specifications.

7.4.2 Road pavements for the transformer roadway shall be designed to support and distribute the infrequent but highly concentrated loads associated with skating or mobile crane installation.

7.4.3 The design of the road pavement as an equivalent pad footing, or other methodology, shall be evaluated by the Designer to determine an economical design for the roadway at these locations.

7.4.4 The design for transformer installation loads shall be in accordance with Annexure C.

7.5 Pulling eyes

7.5.1 Pulling eyes are not mandatory for the installation of main transformers and other large items of plant within major substations.

7.5.2 Where required by the Design Brief, or where otherwise specified in writing by Ausgrid, the design shall allow for the inclusion of pulling eyes to the transformer access road, in accordance with the intent of Ausgrid Drawing No. 49802.

7.5.3 Pulling eyes shall be designed for 10% of the transformer transport weight.

7.6 Transformer roadway layout and design

The design of transformer roadways shall meet the following requirements:

- The maximum grade on a substation road used for transformer movement shall be 1:10 unless otherwise approved by Ausgrid. The maximum change in slope shall be no more than 500mm from an 18m long straight edge to allow for adequate low loader clearance.
- Transformer roadways adjacent to the transformer bays shall have maximum gradients of 1:20 and 1:50 maximum cross fall for drainage. Reverse gradients for loaded vehicles shall be calculated.
- For skated installation procedures for transformers, the roadways immediately in front of transformer bases shall be at the same level as the finished transformer base slab, where site conditions allow.
- The locations of transformer pulling eyes built into the roadway or adjacent structure, where these are required, shall be shown on the Ausgrid Site Layout Plans. Pulling eyes shall be designed in accordance with Clause 7.5.
- Oil resistant joint sealant (equivalent to 'Fireban 1' with “Hydrocore”) shall be used within 10 metres of the transformer areas.
- Kerbs between the transformer roadway and gravel covered switchyards shall be mountable.
- The transformer and access road layouts shall incorporate the necessary allowances for clearance and access including:
  - Initial construction activities;
  - Installation of the designed transformers;
  - Mid-term refurbishment including replacement of transformers and switch equipment;
  - Maintenance vehicles; and
  - Conduits and cabling under the road.

7.7 Minimum transformer roadway dimensions

7.7.1 All transformer access roads shall comply with the dimensions in Table 5.

Table 5 – Minimum Transformer Roadway Dimensions

Transformer Access Road Details	Dimensions
Maximum surface deviation of road surface is to be	10 mm in 4 metres
Width of transformer road for outdoor transformers up to 50MVA (excl. kerbs and gutters)	5 metres
Width of transformer road for outdoor transformers up to 120MVA (excl. kerbs and gutters)	6 metres
Width of transformer road for indoor transformers up to 50MVA (excl. kerbs and gutters)	6 metres
Kerb width	150 mm – 200 mm
Gutter width excluding kerb width	300 mm – 600 mm

7.7.2 External to switchyard areas, a 5 metre wide roadway shall be provided unless otherwise approved by Ausgrid. This shall be increased for turning circles or vehicle paths which require additional width.

7.8 Clearances and turning circles

7.8.1 All transformer and access roads (including kerb and gutter sections of roads) shall have a minimum of 500mm clearance from any boundary line or boundary fence.

7.8.2 Refer to Table 6 for the minimum diameter of turning circles.

Table 6 – Minimum Design Vehicle Turning Circles

Vehicle Details	Turning Circle
Construction trucks	5 metres inside radius
Low loaders	10 metres inside radius minimum
Test Vehicle	26 metres wall to wall

7.9 Access roadways and parking area design

7.9.1 Design for substation access roads shall be in accordance with the RMS document: RTA 45070666E for vehicle axle loadings. Access over driveways and parking areas shall be provided for a 15T total mass limit “General Access Vehicle”.

7.9.2 All substation access and maintenance roads shall have a minimum width of 4 metres excluding any kerb or gutter sections and at bends or curves. Access and maintenance roads shall be able to withstand site specific point loads where required.

7.9.3 Fencing along all substation access and maintenance roads shall comply with NS184 for access requirements and distances from fences.

7.9.4 General access to the site shall comply with AS/NZS 2890.1 for off-street parking facilities.

7.9.5 As a minimum, provision shall be made to accommodate the following vehicles and not affect access to the transformer roadway:

- Three standard cars; and
- A single 15 tonne GVM rigid vehicle.

7.9.6 The Designer shall assess the requirements for turning circles and access in the provision of parking for vehicles.

7.10 Access for test vehicles

Ausgrid’s Test Vehicle will occasionally access switchyards. Provision shall be made to allow access for this vehicle to undertake testing procedures. The Test Vehicle uses a Mercedes-Benz Arocs 3243 Chassis, with access requirements as shown in Table 7.

Table 7 – Access requirements for Ausgrid Test Vehicles

Vehicle Details	Capacity
Turning circle	23.2 m (11.6m radius)
Sweep path	24.6 m
Max vehicle mass	32,000 kg
Max front axle mass	12,600 kg
Max rear axle mass	20,000 kg
Max vehicle payload	**8,550 kg**

8 Switchyard foundations

8.1 General

This Section applies to the various elements that make up a substation switchyard area, and associated structures. Information on switchyard steelwork is contained in NEG SM04.25.

8.2 Footing systems

8.2.1 The requirements of AS 2870 shall be the minimum for switchyard footing systems.

8.2.2 The footings for standard yard structures shall be designed for a bearing pressure that does not exceed the maximum allowable bearing pressure as determined from a geotechnical assessment of the actual site conditions. This assessment may include detailed site investigations and soil testing if required.

8.2.3 A Geotechnical Engineer shall check the bearing capacity prior to the concrete being poured. Alternatively, yard structure footings may be supported on piles in accordance with Clause 8.3.

8.2.4 Settlement criteria for yard structures shall be provided by Ausgrid. Refer to Clause 6.6 for differential settlement limitations.

8.2.5 The design of footing systems shall consider the location and entry points of all cables into the substation. Refer to NS185 for requirements where cables enter buildings.

8.2.6 For substations (except temporary substations) where rock is within 3 m of the surface, and a geotechnical assessment deems that the surface soil conditions are unsuitable, the affected structures shall be founded on rock.

8.2.7 Founding on rock at depths greater than 3 m shall be as determined by a Geotechnical Engineer. Notwithstanding, all switchyard structures shall be founded on material of uniform strength.

8.3 Piles

8.3.1 Piles shall be designed and installed to the requirements of AS 2159.

8.3.2 Piles shall be designed for the Design Life of the substation, except where required by Clause 8.3.3 or specified otherwise in writing by Ausgrid.

8.3.3 For sites where difficult, aggressive or uncertain ground conditions lead to a significant risk of accelerated pile deterioration, or where it is demonstrated that the incremental cost of an extended Design Life is minimal, piles may be designed for up to a 100 year Design Life, subject to written approval by Ausgrid.

8.3.4 For temporary substations, all piles shall be designed for the substation's 20 year Design Life.

8.3.5 Due to excavations for trenching and cabling on site, the top 1.5 m of pile length shall not be considered to contribute to the load carrying capacity of the pile.

8.3.6 The design and installation of piles shall include an assessment of the following items:

- ground conditions;
- acid sulphate soils;
- contamination;
- disposal of spoil;
- installation difficulties and limitations; and
- vibration and impact on equipment and buildings.

8.3.7 Refer to Table 8 for limitations on the use of various piling systems.

Table 8 – Limitations on Piling Systems

Pile Type	Appropriate use
Concrete Bored Pier	All substation types.
Grout Injected / Continuous Flight Auger	All substation types.

Pile Type	Appropriate use
Concrete displacement or partial displacement piles	All substation types.
Steel Piles	Temporary substations only.
Steel Screw Piles	Temporary substations only. Not to be used in fill areas and not to be used where rock is expected to be encountered.
Timber	All substation types - subject to Ausgrid review and approval.

8.3.8 The use of timber piles may be well suited for those locations where water saturated ground is encountered, or where friction piling is required.

8.3.9 For all pile systems, sufficient geotechnical information shall be obtained to confirm adequate foundation capacity. Installation logs shall be provided to Ausgrid on a drawing for inclusion into Ausgrid's Drawing Management System (DMS).

8.3.10 Piling shall be tested where required, as determined by the project Geotechnical Engineer's requirements.

9 Switchyard design

9.1 General

9.1.1 The switchyard grade shall provide sufficient falls for drainage and shall be designed to facilitate the installation and operation of all yard structures and equipment including transformers, air-insulated switchgear, oil containment systems etc.

9.1.2 The required falls to facilitate operation of any gravity oil separation facilities shall be provided by Ausgrid. Refer to NS189 for the minimum falls for oil containment gravity drainage.

9.2 Equipment handling plans

Equipment Handling Plans shall be prepared for each substation site, in conjunction with the Electrical Layout Plan for the site.

9.3 All weather access

The switchyard platform shall be designed to provide all weather access to all sections of the yard for vehicles with a 9 tonne axle load or a 3 tonne wheel load, whichever is greater.

9.4 Switchyard surface

9.4.1 The switchyard shall be topped with 75 to 100 mm of crushed rock to Ausgrid specification and requirements.

9.4.2 The step down from a yard structure footing to the top of the yard crushed rock shall be at least 50mm and not more than 300mm.

9.5 Earthing

The substation earth grid shall be established for the ultimate development of the substation. Earth connections shall be provided to all plant and equipment items in accordance with NS222.

9.6 Cable trenches and covers

9.6.1 Cable trenches shall have concrete bases with brick, reinforced block or concrete sides and removable trench covers.

9.6.2 Cable trenches shall provide easy access to cables and shall be installed in accordance with Ausgrid Drawing No. 49806 or 125623, as applicable. Special design provisions shall be included for sites with reactive soils and for mine subsidence areas.

9.6.3 The top of the cable trench shall be 50 mm above the level of the crushed rock in the yard to minimise gravel falling into the trench.

9.6.4 Cable trenches shall allow for a suitable bending radius for cables and other services installed in the trench.

9.6.5 Where required, provision shall be made for the installation of fibre optic cables which may have larger bending radii than other services within the cable trench. Refer to NS185 for requirements relating to data and communications facilities.

9.6.6 The design shall ensure that cable trenches do not have exposed sharp edges or corners which may cause damage to cables during installation works.

9.6.7 Cable trench covers shall provide protection for control and other cables installed in the cable trenches and shall provide non-slip trafficable access for personnel working within switchyards.

9.6.8 The design of cable trench covers shall meet the following requirements:

- A Design Life matching the substation, using low maintenance materials that do not require frequent reapplication of applied finishes.
- A maximum edge deflection of 10mm under pedestrian loading.
- A mass of 20 kg maximum for individual trench covers required to be lifted by hand.
- Manufactured from materials resistant to corrosion and aging.
- No sharp edges and securely located.
- Not be subject to brittle fracture.
- Minimise the damage to cables if dropped.
- Not prone to misalignment, dislodgement or movement due to wind.
- Not prone to WHS issues regarding lifting and trips.
- Resistant to the effects of potential external fires.
- At locations specified by Ausgrid, are fire rated to address identified external fire risks.

9.6.9 Refer to NS187 for limitations on materials to be used in areas exposed to external fires.

9.6.10 Compressed fibre cement materials shall not be used for cable trench covers.

9.6.11 Vehicles shall not be driven over cable trenches or cable trench covers.

9.7 Switchyard services

9.7.1 The following services shall be reticulated in conduits or cable trenches, which shall be installed between all major plant items and the substation building:

- Control and protection;
- SCADA;
- communications;
- 415V AC power; and
- DC power cables.

9.7.2 At least one additional spare conduit of equivalent size and type, identified at each end and fitted with a draw rope, shall be installed for each major plant item.

9.7.3 Feeder cables shall be installed in conduits. Where the use of TSB backfill is required it shall be installed in accordance with T0053.

9.7.4 All conduits and cable trenches shall be blocked to prevent the entry of vermin in accordance with NS171.

9.8 Communications conduits

Provision shall be made within the substation for the required data and communication installation works and for suitable access via communications conduits. Refer to NS185 for requirements relating to data and communications facilities.

9.9 Power cable conduits

All underground power cables shall be installed in conduits in accordance with T0053. The size and bending radius of the conduits shall be in accordance with the cable manufacturer's recommendations.

9.10 Slopes and batters

9.10.1 Where retaining walls are not provided, the top of batter slopes shall be at least 1m beyond the extremities of the substation building, yard access, yard fence or yard structure.

9.10.2 To enable safe pedestrian access, the maximum slope in switchyards shall be 1:8, except as indicated in this Section.

9.10.3 The switchyard slope may be increased to 1:6 with approval from Ausgrid following a detailed design review.

9.10.4 Batter slopes may be increased beyond a slope of 1:6 at locations where pedestrian access and regular maintenance access is not required.

9.10.5 Stepped yards may be required where the slope of the site exceeds 1:6, and these designs shall be subject to written approval from Ausgrid.

10 Retaining walls

10.1 Construction of buildings or switchyard structures above retaining walls shall not be within 3m of the retaining wall, or within a distance equal to the maximum height of the retaining wall, whichever is greater.

10.2 Alternatively, the proposed structure shall be supported on piles to a depth specified and approved by a Geotechnical and Structural Engineer.

10.3 Retaining walls, other than basement walls, shall not rely on the substation building or yard structures to provide stability. Any propped retaining walls shall be designed for at-rest earth pressures.

10.4 Retaining walls shall be designed for full hydrostatic pressures, except where the design ensures that maintenance free drainage can be achieved for the Design Life of the structure.

10.5 Retaining walls shall have the same Design Life as the substation building or yard structure, except where the loss of the retaining wall will not impact that structure. An impact is deemed to occur if, when the retaining wall fails, the retained materials could fall onto, against or undermine any building or yard structure.

10.6 The base of retaining wall footings shall be founded a minimum of 500mm below ground level, or 500mm below any cable trenches, cables or other yard structure footings adjacent to the wall.

10.7 Retaining walls shall be designed in accordance with AS 4678.

10.8 Refer to Table 9 for the various types of retaining wall systems and the locations for acceptable use.

Table 9 – Acceptable use of Retaining Walls Construction Types

Retaining Wall System	Acceptable Use
Reinforced Concrete	All substations
Reinforced Concrete Blocks	All substations
Reinforced Soil Structures (RSS)	All substations
Gravity Walls (stone or masonry)	All substations

Retaining Wall System	Acceptable Use
Concrete Crib	All substations
Timber Crib	Temporary substations
Treated Timber	Temporary substations
Recycled Tyres (Ecoflex)	Temporary substations

10.9 Where security fences are used in conjunction with retaining walls, the fence type may determine the type of wall selected. Refer to NS184.

11 Ground anchors

11.1 The design of ground anchors within the substation, where these are deemed to be required, shall account for the following aspects:

- Existing and future cable locations;
- Stray currents and accelerated corrosion;
- Durability, including a Design Life of up to 100 years as for piles (refer to Clause 8.3);
- Earthing requirements; and
- Access for inspection and maintenance.

11.2 The proposed use of ground anchors shall be reviewed and approved by Ausgrid prior to design or installation.

12 Stormwater drainage

12.1 General

12.1.1 Stormwater drainage shall be designed for the Design Life of the substation.

12.1.2 The design of drainage systems shall assess, but not be limited to, the following aspects:

- potential ground movement;
- loading from expected traffic;
- access for maintenance;
- silt inflows and flushing;
- slope stability; and
- earthing.

12.1.3 The drainage system design shall comply with all authority requirements, conditions and practices including the provision of on-site detention.

12.1.4 Refer to Australian Rainfall and Runoff and AS 3500.3 for the design requirements of stormwater drainage systems.

12.1.5 Subsoil drains shall be installed within the site area to allow effective groundwater drainage behind retaining walls, at the base of batters and for other structures. Subsoil drains shall discharge any groundwater in accordance with the requirements of Clause 13.2.

12.1.6 Areas containing oil filled equipment may require special treatment to reduce the risk of site contamination. Refer to NS189 for oil containment and drainage requirements.

12.1.7 Site drainage provisions shall ensure that the all-weather access for motor vehicles and plant is achieved to the entire substation site.

12.1.8 All drainage water shall be collected and reticulated in drains of suitable capacity, to a point of discharge off the site in a manner that complies with local Council and Water Authority Regulations.

12.2 Water quality objectives

12.2.1 The water quality objectives for stormwater discharges leaving the site shall be based on the following:

- Australian and New Zealand Guidelines for Fresh and Marine Water Quality, Australian and New Zealand Environmental Conservation Council.
- Water Sensitive Urban Design (WSUD) - Landcom.
- Managing Urban Water Series - Department of Environment & Heritage.

12.2.2 The water quality objectives adopted for stormwater discharges shall assess the receiving environment associated with each site.

12.3 On-site stormwater detention

12.3.1 An on-site stormwater detention (OSD) system may be required by local Council requirements for locations which drain directly to a public stormwater drainage system.

12.3.2 The need for an OSD system on a specific site shall be critically assessed and negotiated with the local Council in each case. An exemption shall be sought where required due to site constraints, electrical hazards or other conditions on site.

12.3.3 Where an OSD system is deemed to be necessary, the key design requirements shall be reviewed and agreed with the local Council.

12.3.4 Refer to Annexure D for OSD system design options and design requirements.

13 Groundwater drainage

13.1 General

13.1.1 Where site conditions allow, substation civil works shall be located above the groundwater table to minimise the potential impact of groundwater.

13.1.2 In situations where substation civil works are below the surrounding groundwater table, an assessment of groundwater impacts, drainage and water quality shall be made. Where required, the affected civil works shall drain by gravity to a suitable discharge point or collection pit.

13.1.3 An appropriately designed groundwater drainage system, certified by a practising Civil or Hydraulic Engineer, shall be submitted by the Designer to satisfy the design requirements. All proposed groundwater drainage systems shall be subject to the review and approval of Ausgrid.

13.1.4 Any discharge to stormwater shall be in accordance with Section 120 of the Protection of the Environment Operations Act. In practice, this requires ensuring all discharges are in accordance with the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC Guidelines).

13.1.5 The ANZECC Guidelines provide water quality “trigger values” that, if exceeded, indicate a potential environmental impact and will require further investigation to determine whether the discharge water would pose a risk of harm to the receiving water body.

13.1.6 The ANZECC investigation and water quality assessment shall determine if the groundwater is suitable to be discharged to local stormwater, or otherwise requires collection or on-site management.

13.2 Discharge of groundwater

13.2.1 Discharge of groundwater to local Council or Water Authority stormwater infrastructure shall only occur where a water quality assessment against the ANZECC Guidelines has been completed. The assessment shall confirm the discharge water would not pose a risk of harm to the receiving water body.

13.2.2 All approved groundwater discharges shall be external to any substation buildings, using gravity drainage or an automatic pumping system, as required. Any pumping system shall be installed to the appropriate Australian Standard and use an independent control system.

13.3 Collection and management of groundwater

13.3.1 Where a water quality assessment has determined that groundwater is not suitable for discharge to stormwater, an investigation of alternative options shall be undertaken.

13.3.2 Alternative options may include, but are not limited to, the following:

- Options for re-use on-site;
- Infiltration structure (i.e. absorption trench/zone);
- Discharged to an unsealed area (i.e. grassed area, garden bed);
- Collection and treatment on-site;
- Collection via tanker for off-site management.

14 Landscaping and surface works

14.1 Driveways

14.1.1 The layout and design of substation driveways and switchyards shall include provision for access by transformer floats. An equipment delivery and handling area shall be provided to suit the substation layout and the Equipment Handling Plan.

14.1.2 Refer to Section 7 for the civil design requirements of transformer and access roadways.

14.2 Personnel access paths

14.2.1 External concrete paving shall be provided for personnel access points into the substation buildings. Other locations around the building perimeter shall be sealed or provided with a granular topping (e.g. blue metal) to cater for infrequent access as required.

14.2.2 The access paving, seal or topping shall have a minimum width of 1200 mm and be drained away from the building to the site stormwater system. For locations designed to collect roof or site stormwater run-off, additional erosion control may be required.

14.3 Access to towers, power poles and landing span structures

14.3.1 Provision shall be made for vehicle access (e.g. EWP) to high voltage towers, power poles and landing span structures located within the substation yard.

14.3.2 Access to these structures is required during initial installation and for future operations and maintenance.

14.4 Embankment retention

The use of retaining walls for landscaping works shall be minimised by incorporating stable banks wherever site conditions allow.

14.5 External landscaping

14.5.1 There shall be no landscaping inside the live switchyard area.

14.5.2 The Ausgrid Tree Safety Management Plan shall be consulted to determine the appropriate species to be planted. The plan outlines Ausgrid's approach to vegetation management near the electricity network and specifies plants both suitable, and unsuitable, for use near the network.

14.5.3 Low maintenance landscaping shall be provided for substation areas.

14.5.4 Refer to Annexure E for landscaping requirements and materials.

15 Perimeter security

15.1 The perimeter of live substation switchyards and the substation building shall be secured to minimise the risk of unauthorised entry.

15.2 The live switchyard security fence enclosing live outdoor electrical equipment, and the substation building, shall be designed to be secure against opportunistic intruders without the aid of tools or keys. The design shall provide an intruder resistant and tamper-evident barrier. The barrier shall be resistant to covert attack.

15.3 For further details of the substation building security requirements, refer to NS185.

15.4 Specific attention shall be paid to personnel and vehicular entry gates within the security fencing, and these shall be fitted with Ausgrid padlocks.

15.5 The switchyard security fence and gates shall be designed in accordance with the requirements of NS184 and ENA Doc-15.

15.6 Concealed spaces outside the live switchyard security fence shall be minimised where reasonably practicable.

15.7 Boundary fencing shall be provided in accordance with the requirements of NS184 as an initial level of security and to define the site boundary.

15.8 The height and type of boundary fence shall depend on the initial level of security required, the degree of screening necessary (both determined by Ausgrid) and the fencing type permitted by the Local Planning Authority, if applicable.

15.9 Where site conditions allow, the boundary fence shall be of open style design, such as a tubular fence, to allow for the principles of CPTED (Crime Prevention Through Environmental Design).

15.10 In community sensitive areas, where the need for an upgraded boundary fence has been agreed in writing by Ausgrid, the fence may be of timber, brickwork, blockwork or decorative mesh or a combination of each.

15.11 Where metallic or conductive fencing material is used for the boundary fence, it shall have sufficient separation from the switchyard fence to ensure that no contact occurs in the event of a boundary fence collapse.

15.12 No storage areas or rooms, other than those required for approved substation equipment, shall be provided within the substation site.

15.13 All substation building and fencing locks shall be installed in accordance with the requirements of T0037.

16 Substation signage

16.1 General

Standard external substation signs shall be installed in accordance with Ausgrid Drawing No. A1 127950 and NS184 and shall include:

- substation name, number and contact details.
- substation fence safety signs.
- Statutory signage as required by NCC and Australian Standards.

16.2 Emergency drainage diagram

16.2.1 An emergency drainage diagram shall be prepared for the completed substation in accordance with NS185. The diagram shall incorporate details of the oil containment and stormwater drainage and any operational requirements for the oil tank in an emergency.

16.2.2 Emergency drainage diagrams shall include volume information, including liquid and oil capacity, where an oil containment system is shown. The diagram shall indicate the oil containment system with red marking and the stormwater system with green marking.

16.2.3 An additional copy of the emergency drainage diagram shall be located at the oil containment tank, where the tank is located internal to the building.

Annexure A: Architectural Finishes

A1 External and internal finishes

External finishes shall comply with this Network Standard and the specific urban design requirements for the locality of the substation.

External and internal finishes to the different areas of the substation shall comply with the requirements in Table A1.

Table A1: External and Internal Finishes[1]

Room/Area	Ceiling	Walls	Floors
Transformer Bays	N/A	Acoustic Blocks where required or unpainted off-form concrete or masonry.	Concrete Monolithic Slab with Broom Finish
Transformer Roadway	N/A	N/A	For Concrete Monolithic Slab – Broom Finish For Unsealed or Flexible Pavement – No additional finish
Oil Containment Tanks (Concrete)	Unpainted off-form concrete	Unpainted off-form concrete	Steel Trowel Monolithic Slab
Bunded Areas	N/A	Unpainted off-form concrete	Steel Trowel Monolithic Slab with Concrete Sealer

[1] The required internal finishes in Table A1 may vary for ceilings, walls and floors that use alternative types of substrate materials.

A2 Off-form concrete finishes

The off-form concrete finishes shown in Table A2 shall be specified for substation works.

Table A2: Off-form Concrete Finishes

Type	Internal Finish	External Finish
Exposed off-form concrete	Class 2	Class 2
Non-exposed off-form concrete	Class 3	Class 4

Annexure B: Ecologically sustainable development

B1 Key principles

B1.1 Ecologically sustainable development (ESD) can be achieved through the implementation of the following principles and programs:

- The precautionary principle - if there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation.
- In the application of the precautionary principle, public and private decisions should be guided by:
  - careful evaluation to avoid, wherever practicable, serious or irreversible damage to the environment; and
  - an assessment of the risk-weighted consequences of various options.
- Inter-generational equity - the present generation should ensure that the health, diversity and productivity of the environment are maintained or enhanced for the benefit of future generations.
- Conservation of biological diversity and ecological integrity - conservation of biological diversity and ecological integrity should be a fundamental consideration.
- Improved valuation, pricing and incentive mechanisms - environmental factors should be included in the valuation of assets and services, such as:
  - Polluter pays - that is, those who generate pollution and waste should bear the cost of containment, avoidance or abatement.
  - The users of goods and services should pay prices based on the full life cycle of costs of providing goods and services, including the use of natural resources and assets and the ultimate disposal of any waste.
  - Environmental goals, having been established, should be pursued in the most cost-effective way, by establishing incentive structures, including market mechanisms, that enable those best placed to maximise benefits or minimise costs to develop their own solutions and responses to environmental problems.

B1.2 For additional guidance on ESD refer to the Department of Climate Change, Energy, the Environment and Water website shown below:

https://www.dcceew.gov.au/environment/epbc/publications/criteria-determining-esd-relevance

B1.3 The National Strategy for Ecologically Sustainable Development provides the broad strategic directions and framework for governments to direct policy and decision-making.

Annexure C: Transformer installation loads

C1 General

Transformers can be installed by either skating or mobile crane methods depending upon substation layout, site constraints and transformer specifications.

C2 Skated transformer loadings

For skated installation, the roadway in front of the transformer base shall be designed for a rolling load on 4 transformer “skates” containing rollers of approximately diameter 33mm x 125mm wide. The transport weight shall be used for design installation loads.

The Designer shall allow for jacking of the transformer to position and remove the skates. Four jacks are required, but it shall be assumed that any jack may take up to half of the transport weight of the transformer. The bearing area used in accommodating the jacking loads, and the quantum of the jacking loads used in design, shall be stated on the drawings.

Loads on the jacks and skates shall attract an imposed load factor of 1.5 and a dynamic factor of 1.4 for design purposes.

Bunds or falls across the site may require the use of a jacking and beam arrangement for the skated installation.

C3 Mobile crane loadings

For transformer installation using mobile cranes in outdoor substations, the crane shall not be permitted to lift materials over exposed live electrical apparatus, except where approval is granted in writing by Ausgrid.

The design of the transformer roadway for mobile crane loading shall account for the following aspects:

- Actual crane loadings and crane positions shall be determined for the site whenever reasonably practicable;
- Load factors shall be adjusted to appropriately reflect the low load cycle and well defined loading;
- The roadway design and underground services drawings shall indicate the various loading zones and design load capacity;
- The installation contractor shall be required to submit a lift plan and crane loading diagram to demonstrate design compliance; and
- The use of a staged roadway construction approach to minimise potential damage to the roadway and final pavement shall be assessed.

For mobile crane installation, the roadway in front of the transformer base and the transformer base itself shall be designed for the actual crane loads appropriate for the substation but not less than the loads in Table C1. The extent of the various loading zones shall be indicated on design drawings.

Table C1 – Minimum Transformer Roadway Crane Loadings

Typical Crane Details	Load
Axle (6 off @1.7m centres)	13.0T
Wheel	6.5T min. Check loadings for each installation.
Outrigger Pad (sized for 150 kPa contact pressure).	0.65 x (weight of crane, rigging and the transformer)[1]

[1] Based on Mobile Crane - Code of Practice 2024 - Workplace Health and Safety Queensland.

A lift plan, developed in accordance with HS018-P0200, shall be used to determine the actual crane outrigger loads for the site using the largest transformer to be installed. Typical mobile crane outrigger loads are shown in Table C2, for information purposes only.

The lift plan for the transformer shall ensure that the crane outrigger load spreading structures are designed for the available design load capacity on site.

Table C2 – Typical Mobile Crane Outrigger Working loads

Tx size	15/19 MVA	20/33 MVA	25/37.5 MVA	30/50 MVA	60 MVA	72/120 MVA
Usage	Typical Zone Bushing	Typical Zone Bushing	Typical Zone	Typical Zone	Typical STS	Typical STS
Reference Drawing	Wilson 879-2212C	Wilson 879-2039C	Wilson 879-1807C	Wilson 879-1729C	Wilson 879-2108C	Wilson 879-2016C
Transport weight of Tx (main tank)	295 kN	278 kN	390 kN	565 kN	560 kN	930 kN
Outrigger load for Crane with 6m radius lift[1]	80 Tonne crane	80 Tonne crane	80 Tonne crane	N.A.	N.A.	N.A.
	620 kN	-	680 kN	-	-	-
Outrigger load for Crane with 10m radius lift[1]	100 Tonne crane	100 Tonne crane	150 Tonne crane	300 Tonne crane	300 Tonne crane	360 Tonne crane
	780 kN	-	890 kN	1,370 kN	1,370 kN	1,600 kN

[1] For information purposes only.

Annexure D: On-site stormwater detention systems

D1 Design options

At site locations where an OSD system is to be installed, the following hierarchy of design options shall be applied:

1) Incorporate the OSD function into existing water detention facilities, such as EGOWS tanks, to the fullest extent possible.
2) Adopt surface detention basins where there is ample space available on-site located away from electrical mains and apparatus.
3) Provide Council with the option of rainwater harvesting for local re-use as an alternative to an OSD system.
4) Use above ground tanks where the site can accommodate them. Lightweight, removable covers shall be provided to facilitate access.
5) Use in-ground tanks with suitable internal heights. Hatches and/or trafficable removable covers shall be provided to facilitate access.

D2 Design requirements

The key design requirements for OSD systems installed at Ausgrid sites shall be as follows:

- The OSD flowrate and detention capacity shall be determined by Ausgrid's hydraulic designer and based on site-specific requirements. The key design parameters shall be reviewed and agreed with the local Council.
- All OSD tanks shall have 1.8m internal head clearance or otherwise shall have suitably designed removable covers along the entire length.
- Tanks with fixed roofs shall have suitably designed access hatches located at opposite ends of the tank. Tanks which are longer than 15m shall have hatches midway at spacings not exceeding 10m.
- All OSD tanks shall have a suitable inspection opening in the roof (250mm diameter nominal) located above, or near, the discharge outlet.
- Handrails shall be provided for accessible above ground tanks where required.
- Enclosed OSD tanks are confined spaces and will require signage, entry permits, standby personnel, gas detectors, training and rescue/escape procedures in accordance with AS 2865 and WHS Regulations. A suitable fall arrest device may be required where vertical ladders are provided for normal access / egress.
- An OSD system that is designed to retain water for re-use shall be provided with suitable pumps or drainage lines to enable emptying of the system.
- All OSD systems shall be located to allow for removal of covers or hatches and to enable ready access by maintenance crews and cleanout tankers.

For enclosed OSD tanks, personnel shall enter the tank wearing a full harness and, where conditions allow, shall remain attached to a mechanical retrieval mechanism which can be operated from outside the tank. Class 3 fall arrest devices provide both fall arrest and retrieval functions.

Fall arrest protection is required when climbing vertical ladders where the fall distance may exceed 2m.

Annexure E: Landscaping requirements

E1 Landscaping principles

The purpose of landscaping is to provide low level screening for aesthetic relief in line with environmental requirements from the Approving Authority. The landscaping shall have minimal maintenance requirements.

The design shall incorporate screening opportunities and the careful placement of equipment to reduce the visual impact on local residents. However, any landscaping shall not screen the switchyard and/or Ausgrid buildings from sight.

Selected trees and shrubs shall be of a type and variety that do not support climbing of any sort, particularly within a 3 metre distance of any part of the substation fence.

Selected trees and shrubs shall not have invasive root systems and shall be located as to avoid all underground cabling, ductlines and the Ausgrid earthing grid.

Low or minimal maintenance ground cover is preferred to any lawn, turfed or grassed areas that may require maintenance.

Irrigation systems shall not be provided, and the selected plant materials shall not require ongoing maintenance beyond an initial 12-month period.

A ground cover zone of 1 metre width shall be provided adjacent to transformer and access roadways between the switchyard security fencing and the boundary of the Ausgrid site.

The design shall comply with provisions and clearances required in NS184.

All landscaping design shall comply with this Network Standard, Local Authority requirements, Development Application requirements and Development Approval conditions.

Landscaping shall be provided as low-level screening where new buildings are located adjacent or near to neighbouring properties or facing public roads.

All landscaping areas shall have a minimum 3 metres setback from substation yard area.

The maximum expected normal growth height of any landscaping component shall be less than 3 metres if within 3 metres of a fence, structure or building.

Landscaping components shall be designed to ensure there is no access provided by landscaping components to the fences or gates of any Ausgrid yard or building.

Landscaping components shall not to allow or provide access as a climb point.

There shall be minimal likelihood of any loose or flying debris from plants, shrubs or trees being dropped or blown into the substation yard area, up against or near fences. The intent is to avoid:

- shorting of electrical equipment caused by a branch or limb dropping onto or near equipment; and
- branches dropped near fences allowing access into the yard area by unauthorised persons.

The design shall ensure landscaping components do not provide screening of unauthorised persons who may enter or be within the switchyard or serve as a visual barrier. Casual surveillance of the switchyard is part of the Ausgrid strategy for substation security.

Landscape design shall not support the spread of fire. Landscape design shall comply with all Local Authority requirements for bush fire, spread of fire and Local Fire Brigade codes, requirements or recommendations.

The maximum tree height adjacent to or near overhead feeders shall comply with the Ausgrid Tree Safety Management Plan.

E2 Landscaping materials

Landscaping materials and plants shall be indigenous to the locality and procured where possible from suitably qualified local suppliers and sources. Landscape materials shall be appropriate for the site soil types and the required visual character of the neighbourhood.

The selected plants, shrubs or trees shall, where practicable, not increase the heat or fuel load to a fire, to reduce the spread of fire near a substation yard or building.

E3 Additional requirements

The finished surface levels shall direct run-off or stormwater away from all substation yards and buildings.

A fully designed stormwater and subsoil drainage system shall be provided to ensure surface and groundwater is directed away from all substation yards and buildings.

Landscaping levels shall not allow access or provide a climbing point to the substation building, yard or fence. Refer to the restriction of access measures contained in NS184.

Annexure F: Substation design documentation

F1 Design statement and certification

Substation designs shall be accompanied by a Design Statement for the specified Design Life and adequacy, prepared by the appointed Architects, Structural Engineers and Civil Engineers prior to acceptance of the design drawings for review by Ausgrid.

The Design Statement shall detail the standards, codes, practices or other literature and information which supports the recommendation of materials, products or finishes utilised to achieve the required Design Life.

The certification of the civil works being designed for the required Design Life shall be referenced in the Design Certificates required from the Designer as part of the Compliance Certificate process.

The Design Certificates shall specifically:

- Refer to the Design Life of the substation civil works;
- Include full referencing to the standards utilised for the design;
- State the design has assessed and is in accordance with relevant codes and standards to achieve the Design Life specified by Ausgrid;
- Be approved by Ausgrid prior to submission of the Compliance Certificate documentation to the Local Approval Authority; and
- Contain approved Preliminary Maintenance Procedures and Operation Schedules (PMPO).

F2 Preliminary maintenance procedures

As part of the design documentation, the Designer shall provide Preliminary Maintenance Procedures and Operation Schedules (PMPO) to Ausgrid.

The PMPO Schedules shall include expected time frames and procedures to enable maintenance to be planned in compliance with the manufacturer's and Designer's requirements, and any recommendations to achieve the required Design Life.

The PMPO Schedules shall include information on the suitability of all components to achieve Design Life including finishes, maintenance procedures and inspection regimes.

The PMPO Schedules shall accompany the documents submitted for project approval.

F3 Maintenance procedures and operating manuals

The Designer documentation shall specify that the Maintenance Procedures and Operating Manuals shall:

- Be prepared based on information contained in the Preliminary Maintenance Procedures and Operation Schedules provided by the Designer;
- Be submitted to Ausgrid for review and approval prior to an application being submitted for Practical Completion;
- Include recommended procedures for all maintenance and operation activities;
- Ensure the specified Design Life to comply with Life Cycle Costing requirements;
- Include information regarding operation and replacement instructions for items which have been amended during construction;
- Include all items added to the project due to revised construction, design, security or organisational issues encountered in the design and construction phases;
- Comply with the relevant requirements of NS210 and NS212; and
- Be in a format and structure that is suitable for uploading into the Ausgrid record management system (HPRM).

The Designer documentation shall also specify that:

- within four weeks of Practical Completion of the construction of the substation, the Final Maintenance Procedures and Operating Manuals detailing all the inspection, maintenance and operational requirements shall be provided; and
- where the Final Maintenance Procedures and Operating Manuals are not provided within four weeks, Ausgrid may arrange to prepare these documents at the Contractor's cost which shall be deducted from the retention monies.