Part of Energy Queensland

Substation Standard

Substation Construction Manual

These standards created and made available are for the construction of Energy Queensland infrastructure. These standards ensure meeting of Energy Queensland's requirements. External companies should not use these standards to construct non-Energy Queensland assets.

If this standard is a printed version, to ensure compliance, reference must be made to the Energy Queensland internet site www.energyq.com.au to obtain the latest version.

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Abstract: This document is a reference for the constructors of Energex and Ergon Energy substations, and it covers all aspects of substation construction for both Greenfield and Brownfield substation projects to meet the performance expected by Energy Queensland.

Keywords: substation, construction

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1 Overview

1.1 Purpose

This document is a reference for the constructors of Energex and Ergon Energy substations and it covers all aspects of substation construction for both Greenfield and Brownfield substation projects to meet the performance expected by Energy Queensland.

1.2 Scope

The standard is applicable for all substation projects regardless of internal/external construction delivery mode. Whilst this document refers to Energy Queensland policies and work practices, contractors performing substation construction shall comply either with these policies or have their own similar policies and procedures, except where Energy Queensland policies and procedures are mandatory (eg Safe Access High Voltage).

The Substation Construction Manual is not intended to replace Health, Safety and Environment (HSE) policies and standards, Substation Standards and Work Practices, but rather to act as a reference document that cross-references existing policy, standards and process documentation and plug any gaps where documentation does not exist.

2 References

2.1 Legislation, regulations, rules, and codes

Electrical Safety Code of Practice – Works, 2020 (Queensland Government)

Environmental Protection Act, 1994 (Queensland Government)

Queensland Electricity Act, 1994 (Queensland Government)

Queensland Electricity Regulation, 2006 (Queensland Government)

Queensland Electrical Safety Act, 2002 (Queensland Government)

Queensland Electrical Safety Regulation, 2013 (Queensland Government)

Queensland Work Health and Safety Act, 2011 (Queensland Government)

Queensland Work Health and Safety Regulation, 2011 (Queensland Government)

Professional Engineers Act 2002 (Queensland Government)

Queensland Workplace Health and Safety Scaffolding Code of Practice 2009 (Queensland Govt)

Queensland Workplace Health and Safety Confined Spaces Code of Practice 2011 (Qld Govt)

2.2 Controlled Documents

Apply and Remove Overhead Portable Earthing Devices (PED) - 2968297

Asbestos SWMS R324 - 1887806

Asbestos Removal and Control Plan - for Working with and Removing Friable / Non-Friable Asbestos Items Located within High Voltage Equipment - 2985704

Barrier Systems for Work in Outdoor Substations (Bulk Supply or Zone) - 2885278

Confined Space SWMS R329 - 1887630

Construction Work Activities R245 - 692444

Contaminated and Flammable Atmospheres SWMS R332 - 1887894

Cultural Heritage Discovery Process - 2860861

Electrical Safety Rules 2022 - 6503074

Environmental Management of Spills - 2855014

Environmental Management Standard - 2947192

Fire Protection Systems at EQL Sites - 3322520

Greenlining and Bluelining of Ergon Energy Substation Drawings - 2597658

Health and Safety Policy - 692225

HSE Incident Management Framework R073 - 690160

Hazardous Manual Tasks R243 - 692111

Pressurised Gas, Chemical and Fuel Lines SWMS R331 - 1887586

Queensland Electricity Entity Standard Safe Access HV Electrical Apparatus - 2904212

Safe Entry High Voltage Enclosures - 2888222

Safe Working at Heights on Substation Structures - 2945282

Safety Observer Roles and Responsibilities - 3333651

Scratch Brushing for Conductors - 3016702

SF6 Gas Maintenance and Handling - 2857761

Standard for Communications Equipment Installations - 2920282

Standard for Personal Protective Equipment (PPE) S031 - 691352

Storm Water and Erosion Control - 2857719

Substation and REG Drawing Management Process - 20487340

Test and Commissioning Manual - 2877081

Trenching and Excavations SWMS R328 - 1887982

Tools and Equipment Safe Operating Procedures - 3070197

WCS34 - Earthing Systems - 692197

WCS61 - Underground Civil Construction - 3070584

WCS100 - Substation Site Construction - 3066470

WCS105 - Fibre Optic Cable System Installation and Maintenance - 12561819

Working with Secondary Systems Switching - 21579677

Working with Substation Wiring and Circuitry - 13764022

2.3 Substation Standards

Network Physical Security - Design Reference - 13158190 (STNW3039)

Standard for Audible Noise in Substations - 22968176 (STNW3041)

Standard for Busbar Conductor Selection - 3062690 (STNW3014)

Standard for Clearances in Air - 3054141 (STNW3013)

Standard for Cables and Cable Installation - 12737281 (STNW3018)

Standard for Panel Wiring - 2938164 (STNW3021)

Standard for Oil Containment - 3062359 (STNW3036)

Standard for Substation Design Requirements - 20468486 (STNW3003)

Standard for Substation Direct Lightning Strike Shielding - 20389422 (STNW3032)

Standard for Substation Earthing Devices - 3057007 (STNW3029)

Standard for Substation Equipment Identification - 2947172 (STNW3001)

Standard for Substation Fire and Explosion Protection - 3058013 (STNW3035)

Standard for Substation Lighting - 2949685 (STNW3040)

Standard for Substation Metering - 3061818 (STNW3114)

Standard for Substation Signage - 2941554 (STNW3037)

2.4 Other Documents

Substation Workflow SP005

Substation Earthing STNW3028

Substation Standard AC Supplies STNW3023

3 Definitions and Abbreviations

3.1 Definitions & Abbreviations

For the purposes of this document, the following definitions apply.

AMO	Asset Management Officer
Authorised Person	A person who is permitted to work closer to electric lines than an untrained person due to their knowledge and competencies. They either have an electrical mechanic licence, or have completed training on Working on or Near Electrical Network Infrastructure in Qld.
Brownfield Site	An existing energised site
Constructor	Substation Operations (internal project) or external substation contractor (DCT project)
EWP	Elevated Work Platform
Exclusion Zone	A prescribed safety zone around exposed live electrical plant that no person, vehicle or operating plant may encroach until the conditions for safe work take place. Different zones exist for trained and untrained persons.
FAT	Factory acceptance testing
GIS	Gas insulated switchgear
Greenfield Site	Is a term used to describe undeveloped land in a city or rural area.

Hazchat	Hazard identification and management tool
HVE	High Voltage Entry
HV	High Voltage (greater than 1000 V a.c.)
ITP	Inspection and Test Plan
LV	Low Voltage (Exceeding 50 V a.c., but not exceeding 1000 V a.c.)
NAR	Network Access Restrictions
PC	Principal Contractor
PICW	Person in Control of Work
PPE	Personal Protective Equipment
QMP	Quality Management Plan
RPEQ	Registered Professional Engineer Queensland
Safety Observer	A trained and competent worker to implement control measures in an emergency, and be able to rescue and resuscitate a worker who is carrying out work. Safety observers can be appointed for mechanical tasks, electrical tasks and to maintain an exclusion zone for non-electrical tasks.
SAT	Site acceptance testing
SID	Safety in Design
SIT	Site integration testing
SPRMP	Simple Project Risk Management Plan
SWMS	Safe Work Method Statements
SWP	Standard Work Practice
WHSMP	Work Health & Safety Management Plan

4 Safety Legislation and Policies

4.1 Workplace Health and Safety Policy

Energy Queensland is committed to working in a way which ensures the health and safety of its Employees, Contractors, Customers and Members of the Public via its Health & Safety Policy (P009).

Refer also to the Standard for the Management of Alcohol and Other Drugs S008.

4.2 Queensland Safety Legislation

The Qld Electrical Safety Act 2002 provides that an electricity entity has an obligation to ensure that its works:

a) are electrically safe, and

b) are operated in a way that is electrically safe

This obligation includes the requirement that the electricity entity inspects, tests and maintains the works.

The Act also places obligations in regards to electrical safety on all persons, including employers, self-employed persons, designers, manufacturers, importers, suppliers, installers, repairers, persons in control of electrical equipment, workers and other people at a place where electrical equipment is located.

The Queensland Work, Health and Safety Act 2011 provides the framework to protect the health, safety, and welfare of all workers at work, and of all other people who might be affected by the work.

Under the WH&S Act everyone has duties (obligations), and the duties for a person conducting a business or undertaking are defined and involve:

- Management or control of workplaces
- Management or control of fixtures, fittings or plant at workplaces
- Design of plant, substances or structures
- Manufacture of plant, substances or structures
- Importation of plant, substances or structures
- Supply of plant, substances or structures
- Installation, construction, commissioning of plant or structures
- Officers, workers and all other persons also have duties to work and act in a manner which contributes positively to the protection of the health, safety and welfare of themselves and all others who might be affected by the work. In particular, personnel must comply at all times with all workplace health and safety directions, rules and guidelines given.

Site offices, accommodation, sanitary facilities, water etc., must meet the requirements of the latest issue of the Act and Regulations.

All construction work must be carried out under a Work, Health and Safety Management Plan or a Site Safety Plan, as required by the Queensland Work, Health and Safety Regulation 2011. This Plan must be complementary to Energy Queensland requirements for entering and working in substations.

4.3 Safety in Design (Risk Management)

Section 17 Management of Risks of the Work Health and Safety Act 2011 states -

“A duty imposed on a person to ensure health and safety requires the person—

a) to eliminate risks to health and safety, so far as is reasonably practicable; and

b) if it is not reasonably practicable to eliminate risks to health and safety, to minimise those risks so far as is reasonably practicable.”

During design development, the Designers will assess and document any hazards or risks associated with the design, construction, ongoing operation and maintenance, or decommissioning of the various parts and components of the substation. Any residual risks assessed as higher than low risk and not covered by a relevant SWMS, SWP, or Work Instruction will be documented by the Designer in a Safety in Design Report.

All Constructors must refer to the Safety in Design (SID) report provided by the Design group, prior to commencing any construction work.

4.4 Construction Work

All construction work activities shall conform to Energy Queensland Standard R245. A Principal Contractor (PC) shall be appointed for each construction project or construction work activity valued at $250,000 or more.

A Person in Control of Construction (PICC) shall ensure the Workplace Health and Safety Management Plan is kept up to date, consult and co-ordinate with other workgroups and ensure the workplace is secured from unauthorised access.

All construction crews must complete a hazard identification Hazchat prior to commencement of any work on site. This task requires careful review and identification of the likely hazards involved, plus the controls to be used in managing risk during the site activities.

4.5 Personal Protective Equipment (PPE)

The minimum PPE required for construction sites and particularly for substations can be found in Standard for Personal Protective Equipment (PPE) - S031. Particular attention should be given to the requirement to remove all metallic jewellery and eyewear, as well as any other metallic or non-metallic item that might get caught in panels, on structures, machinery, etc. (eg. watches, rings, necklaces, key chains, neck ties, etc.).

Note that some tasks may require additional PPE to the minimum requirements, particularly with regards to hazards associated with live work and potential arc flash hazards. Arc flash clothing and protective equipment sized for the potential incident energy shall be worn for the duration of these tasks.

4.6 Site Inductions

It is an Energy Queensland requirement that any worker who is undertaking construction activities has completed the General Construction Induction training. If the worker has not carried out construction work in the preceding two years they will be required to undertake the General Construction Induction training again before commencing construction work.

All workers on a construction project shall; be inducted by person in control of the construction site and made aware of the WHS Management plan and its content.

4.7 Barrier Systems for Work in Outdoor Substations

Barrier Systems for Work in Outdoor Substations (2885278) contains a table listing barriers, temporary fences, bunting, tapes and signage associated with substation works and delineation of work areas.

4.8 Incident Reporting and Emergency Contacts

For guidance on reporting incidents, refer to HSE Incident Management Framework 690160.

Emergency Contacts and lines of communication must be established prior to commencement of work on site.

4.9 Working in Energised Substations

All personnel must at all times comply with the Electrical Safety Rules and Regulations as set out by Energy Queensland when working on, or in the vicinity of electrical apparatus that is live or is capable of being made live from any source of supply.

Energy Queensland reserves the right to evict any personnel from the site at any time should their presence on-site be considered to constitute a hazard.

4.9.1 Substation Entry

In a Commissioned HV Substation, all personnel must comply with Work Practice 2888222: Safe Entry to High Voltage Enclosures at all times. This document must be read in full and strictly adhered to as well as the site specific requirements in the project documents.

Only those Personnel who have successfully completed the required Technical Training - Working Safely On or Near Electrical Network Infrastructure and have been duly authorised are allowed entry to the site, unless accompanied at all times by an Authorised Person. These requirements also apply to an uncommissioned construction site, as soon as any HV Conductor (including earthing conductors) becomes connected to, or within approach distance of a commissioned HV network.

In the event of a work crew containing a number of unauthorised persons (eg. civil contractor), there should not need to be one authorised person for every unauthorised person, but there must be a sufficient number of authorised personnel to ensure that the unauthorised persons are accompanied and supervised by an authorised person at all times.

On arrival at the substation prior to entering, it is essential that a check be done for any Network Access Restrictions (NAR). Contractors should seek advice from their relevant contact person. Ie. Superintendent, Technical Representative, etc.

Particular attention must be given to the requirements for locking of gates and keeping them locked, except during entry and exit. At all times when gates are unlocked (eg. to receive deliveries), they must be manned.

For guidance in relation to management of non GCWI/unauthorised specialist workers who come onto site for very short, infrequent durations (eg. plumbers, concrete cutters, crane drivers, delivery drivers, etc.), refer to Contractor WHS Management Guidelines.

4.9.2 Exclusion Zones, Authorised Persons, Safety Observers

The Exclusion Zones for trained and untrained persons can be found in Schedule 2 of the Queensland Electrical Safety Regulations. The Exclusion Zones are specified in two different categories, as follows:

a) Exclusion Zones for Authorised Persons and Instructed Persons (ie. under the supervision of an Authorised Person)

b) Exclusion Zones for Untrained Persons (neither Authorised nor Instructed)

Authorised Persons and their required competencies are defined in the Queensland Electrical Safety Regulations. In general, an Authorised Person must be able to demonstrate competence in recognising communication, low voltage and high voltage conductors, understand the dangers involved in live high voltage substations and be familiar with the appropriate Exclusion Zones.

A Safety Observer is required where it is possible that an Exclusion Zone may be compromised. The person appointed to be a Safety Observer must be an Authorised Person and also have the knowledge and competencies indicated in the above Work Instructions, so generally will need to have had adequate experience working in similar situations in live HV substations. However, a formal electrical qualification is not essential.

4.9.3 Training and Authorisations

To be authorised for unaccompanied entry into a HV substation, personnel must have successfully completed the training course Working Safely on or Near Electrical Infrastructure.

For personnel who require further authorisations, such as Individual of a Workgroup, Access Permit Recipient, Switching Operator Assistant, etc., further training courses are necessary and are available through the Technical Training Department.

4.9.4 Access to Substation Entry Keys/Swipe Cards

Only authorised personnel may hold substation entry keys or swipe access card, and such keys are issued subject to strict conditions of use. Following completion of the required training, personnel may apply for a key if required, by completing a Network Keys – Substation Request in Service Now.

4.9.5 Site Hygiene, Protection of Property, Final Cleaning

At all times during the course of work on a substation site, whether greenfield or brownfield, the site must be maintained in as clean and tidy a state as possible, according to the state of the work, so as to minimise the risk of injury or illness, enable efficient and safe access for construction vehicles and personnel, etc. and otherwise meet Work, Health and Safety requirements. Appropriate bins shall be provided and used for disposal of waste, and arrangements made for appropriate removal of the waste from the site regularly, in accordance with local regulations.

Particular care must be taken not to cause any damage to public and private properties, land, streets, including public utilities and the soil and space beneath such properties abutting and/or adjacent to the works. The constructor must make good any loss or damage caused.

On completion of the works, all rubbish, waste, excess material, plant and temporary work, including sanitary conveniences, offices, sheds, hoardings, protective covers etc., must be taken down and cleared away as appropriate, unless otherwise agreed with the Project Manager. Any damage done to the substation buildings, structures, plant, earth grid, substation surfaces (driveways, access roads, gravel surfacing, etc.), drainage, or property must be made good, before departing the site. All gravel surfacing must be raked and graded to even-finished levels.

All doors, windows, etc., must be checked and eased to ensure proper operation and closure. The complete works must be cleaned, including but not limited to the work described below:

- Thoroughly clean all porcelain insulators and bushings immediately prior to testing.
- Sweep all building floors and dispose of rubbish.
- Check outdoor concrete slabs and roads for soil/gravel and sweep if necessary.
- Check and clear all drains.
- Check any other services not already done.

5 Hierarchy of Standards

All construction work, and the associated supply of materials and equipment, must be undertaken in accordance with all relevant Legislative and Regulatory requirements, Substation Work Practices, relevant Energy Queensland Substation Standards, Specifications and standard drawings, manufacturer’s instructions, and the relevant Australian Standards.

Where no Australian Standard exists, then the latest revision of the relevant International Electrotechnical Commission (IEC) Standard, British Standard (BS), or the NATSPEC BASIC Standard (in that order of preference) applies.

Any deviations from the Energy Queensland Standards and Specifications must be with the approval of the Substation Designer. A documented and approved risk assessment must be produced in consultation with the relevant SME’s in instances where the Project Scope Statement or Project Sponsor directs work to be undertaken which is not in accordance with the standards.

A list of Energy Queensland Substation Standards is provided in Section 3.3 of this standard. These standards provide reference to the applicable Australian Standards.

Safety legislation and policies are outlined in Section 3.1 of this standard. Electrical safety requirements are not negotiable and must be strictly complied with at all times.

6 Quality Management

6.1 Workmanship & Materials

Work must be done by appropriately qualified, competent tradespersons in an entirely sound, secure, neat, efficient and tradesman like manner, complying with the relevant Energy Queensland Standards and Work Practices. Where materials or work methods are included in the published standards of Standards Australia, the materials and workmanship used must not be inferior to those in the relevant Standard.

Unless otherwise specified, all materials used must be entirely suitable for the intended application, whether stated or implied, and be free from defects. Where materials bearing the Australian Standards mark are available, these materials must be the minimum standard for use. All manufactured materials must be used strictly in accordance with the manufacturer's instructions and recommendations.

6.2 Quality Management Plan

All construction work must be covered by a Quality Management Plan (QMP) in accordance with AS ISO 10005, which ensures the work is carried out in accordance with the project documents and the relevant Energy Queensland standards. Inspection and Test Plans must be included in the QMP.

The ITPs must clearly show all inspection witness and hold points, testing requirements and how the work will comply with the project documentation.

6.3 Inspection and Test Plan

All Constructors must carry out sufficient inspection and construction testing of the works installed by them using ITPs, to confirm correct and adequate installation in accordance with the drawings and relevant Energy Queensland standards.

The Constructor is to use EQL ITPs. If no standard ITP is available, the constructor will contact Engineering Field Support to produce one. Inspection hold points and any additional tests required by the Certifying RPEQ must be integrated into the ITPs and discussed in the pre-start meeting.

Form 16 Inspection Certificate shall be provided for assessable building works on completion.

6.3.1 Electrical Works

The minimum requirements for electrical construction testing are described in Section 17 of this Standard.

Specialist testing of HV plant and functional testing of the secondary systems (protection, control, etc.) is the responsibility of the test groups, but is dependent on adequate construction testing being completed first by the constructors.

6.3.2 Civil Works

Refer to project specifications - Civil Works for testing frequency and acceptance criteria. The Constructor must have a training plan showing each workers qualifications, inductions, training, licences, competencies and authorisation status. This also includes workers of subcontractors that have been engaged by the Principal Contractor.

7 Project Delivery

The workflow and responsibility for project delivery can be found in:

- Substations Workflow – SP005.
- Design, Construct & Transfer Workflow – SP006
- EQL Complex Projects – SP010

7.1 Project Documentation and Deliverables

The project specification will define the specific requirements for a particular project, however the tables below summarise the minimum requirements for constructors during the Implementation and Finalisation stages of a project.

Table 1 – Implementation Phase

Construction Discipline	Deliverable
Principal Contractor/ Project Manager	Quality Program • Quality Assurance program. • Project Quality Plan. • Environmental and Cultural Heritage Management Plan • Work, Health and Safety Management Plan. • Register of records (objective quality evidence). • Technical Data as required by Specification (eg. Thermal Backfill data)
Substation Design	Printed, stamped design drawing sets issued to relevant construction groups
Workshop Construction	• Pre-start meeting. • Completed modular building & panels, including point to point testing of wiring. • Building footing design details provided to Project Manager or delegated officer for use of site civil construction group. • Building(s) installed on site. • As-built drawing markups on Return copy drawing set forwarded to Project • Manager or delegated officer for use of site construction groups. • Copies of checked circuitry drawings forwarded to Project Manager or delegated officer, confirming precise point to point testing completed, for reference of site construction & test groups.
Civil Construction	Meetings & Coordination • Pre-Start Meeting. • Project progress meetings. • Coordination with other work groups on site or preparing to come to site.

Construction Discipline	Deliverable
	Construction Work • All civil work defined in the project documentation completed in accordance with the Energy Queensland standards, procedures and this Standard. • As-built drawing markups transferred to the Return copies of the drawings. Inspection and Testing • Test Results and Certificates returned to Design engineer.
Substation Construction	Meetings & Coordination • Pre-Start Meeting. • Project progress meetings. • Coordination with other work groups on site or preparing to come to site. • Confirm material orders/delivery. Construction Work • All structures & HV plant installed & connected. • Secondary systems cabling & panels, earthing, etc. completed. • ·Construction testing of electrical installations (except that already done by workshop on panels). Construction Testing • Prepare construction test tools. • Certification of test equipment. • Test result sheets & supplementary sheets. • Problem or non-conformance reports. • List of outstanding work and defects. • Remedial work reports. • Completed Commissioned /De-commissioned Substation Primary Plant Data Capture Forms & associated plant nameplate photographs. Drawings • As-built drawing markups transferred to Return copies and made available for reference of other groups, including Communications, SCADA, Test, etc. • Checked working copies of schematic drawings, indicating construction testing completed. • File compression/decompression software, where necessary. Clearances & Certification • Competency and authorisation records.

Construction Discipline	Deliverable
	• Request for approval to subcontract work. • Notice of intention to commence supply or manufacture. • Notice of Inspection or Test. • Construction Authority • Construction Safety Clearance - High voltage Apparatus • Certificate of Practical Completion. • Variations.
Control Systems Construction	Meetings & Coordination • Pre-start meeting. • Project progress meetings. • Coordination with other work groups on site or preparing to come to site. SCADA Works • IED programmed (may occur off site before installation in panel). • All points from the IED to the RTU tested and commissioned. • PowerOn & IED communicating correctly. Miscellaneous configuration requirements.
Telecomms Construction	Meetings & Coordination • Pre-start meeting. • Project progress meetings. • Coordination with other work groups on site or preparing to come to site. Communications Works • MUX configurations loaded. • Stride MUX and Cable drawings changed from Planned to existing during commissioning. • New cross-connects added. • Coordination with other work groups on site or preparing to come to site. • As-built drawing markups on Return copies forwarded to Communications Design group for finalising of drawings.
Test	Meetings & Coordination • Pre-start meeting. • Project progress meetings.

Construction Discipline	Deliverable
	• Coordination with other work groups on site or preparing to come to site • Pre-commissioning & Commissioning Test Works/Tools • Control/protection panels & building services FAT tested. • HV plant, earthing, etc. SAT tested. • Functional testing of all secondary systems, including integration with existing systems (eg. Bus Zone, AC & DC Supplies), Network Operations and remote end substations completed. • Completed works switched into live service & carrying load as intended. • As-built drawing markups transferred to Site Initial Record copies to be kept on site. • As-built drawing markups transferred to Return copies and forwarded to Substation Design group for finalising of drawings. Training • Onsite handover/training session, as required.
Commissioning Co-ordinator	Meetings & Coordination • Pre-start meeting. • Project progress meetings. • Coordination with other work groups on site or preparing to come to site. Commissioning Works • Works program/schedule (MDCP) • Project commissioning plan & schedule completed. • Coordination of all internal and external work groups associated with project commissioning. • Field Test and HV plant manufacturers' test results audit checked. • Authority to Energise form completed and submitted. • AFW's and other documents required for commissioning submitted. • Completed works switched into live service & carrying load as intended.

Table 2 – Finalisation Phase

Construction Discipline	Deliverables
Substation Construction	• Final Release (as-built) drawings (including Civil & Communications) placed in the substation, with marked up copies and old revisions replaced.
Test	• Final Release (as-built) drawings (including Civil & Communications) filed in the Test office, with marked up copies and old revisions replaced. • Test results & signed off Protection Setting Requests (PSR's) filed in Test office (and copy forwarded to Design Manager).

8 Drawings, Documentation & Records

8.1 General

In the event of conflict between the requirements of the issued construction drawings and the Work Specification or any other relevant document, the relevant Design Engineer must be contacted for clarification. In the case of an externally designed and constructed project, the Contractor's Construction group should seek clarification first from their own Design Engineer. If the issue appears to be a conflict in Energy Queensland's requirements, the Contractor's Design Engineer or Representative will then contact the Energy Queensland Technical Representative (Design Engineer) for clarification.

8.2 Drawings (Physical, Schematic, Schedules)

Construction must be carried out only in accordance with drawings which:

- Have been signed off by the relevant RPEQ who is either carrying out or directly supervising the design work, and
- Have been transitioned to Released for Construction status in Autodesk Vault

Earlier issues of the drawings must not be used for construction, even if bearing a Contractor's "Released for Construction" stamp, as the release of the drawings for construction is to be controlled by Energy Queensland. This ensures that the drawings are issued for construction only after all requirements have been satisfied, as well as locking the construction version in the Autodesk Vault, to ensure consistency for all work groups that may need to access the drawings.

Following Gate 3 approval for the project, the originating Substation Design group will print and collate the required number of construction sets of the drawings, appropriately stamped in accordance with the Substation Controlled Drawings process documents. The collated sets of printed drawings will be issued via the Project Manager, to all involved Constructors.

Workpack Communications must accompany the issued drawings to confirm the correct drawings and their revisions to be used.

The Return copy set of the drawings will be issued to the first group in each of the Civil and Electrical disciplines to commence construction of the works. Use of the Return copy drawings is described in more detail in Section 9.4, but the Return copy set must be passed on to the next

appropriate work group. (eg. Panel Construction group passes on marked up Return copies to Field Construction group, then to Test group, etc.).

8.3 Interpretation of Revision Clouding on Drawings

Anything shown within the boundaries of the revision clouding on a drawing issued for construction must be interpreted as either new or modified in relation to the existing installation.

If any doubt or uncertainty exists, the Constructor must check against the previous Final Release version of the drawing to confirm exactly what is already existing and what has to be added or modified. The previous revisions are available for viewing in the Drawing Management System, otherwise copies can be obtained on request to the Substation Design Engineer.

8.4 Greenlining of Electrical Drawings (Ergon)

Refer to Section 17 of this Standard for details of Electrical Construction Testing to be carried out. During the process of continuity testing and associated visual checking of secondary wiring, the Greenlining Test copy of each relevant schematic must be greenlined and marked up with corrections, in accordance with Greenlining and Bluelining of Ergon Energy Substation Drawings – 2597658. This provides a record not only of the as-built state of the works, but also of the progress of construction testing, for the benefit of both the Construction and the following Test groups.

All markups (corrections, additions, deletions) on the Greenlining Test Copy, but not the greenlining, must be transferred to the Return copy set as indicated in Section 9.4. (Bluelining is for functional testing to be carried out by the relevant Test Group). The Greenlining Test copy set must then be returned to the Project Manager, for forwarding to the appropriate Test group for Site Integration Testing (SIT). This is the reason why it is essential that the greenlining process be done on the Set 6 copy of the drawings.

8.5 As Built Drawings

All construction and test changes to the issued drawings must be marked up, firstly on the workgroup's working copy of the drawings, then transferred to the Return copy on site prior to departure from site (or earlier if a significant time period has elapsed since the changes were made and other workgroups on site are dependent on the up to date Return copy also).

The Return copy drawings provide the source of the latest information for each work group on commencement on-site, as well as the collation of all changes to be forwarded back to the Design Office on completion of commissioning. Refer to the reference documents 20487340 Substation & REG Drawing Management Process.

9 Environment

9.1 General

Energy Queensland is committed to responsible Environmental Management ensuring that all business activities associated with the supply of electricity are carried out with as little adverse impact on the environment as possible. Refer to the Environment and Cultural Heritage P058 - 691101.

All activities carried out on the site must comply with the project Environmental and Cultural Heritage Management Plan and the environmental requirements of substation standard STNW3003 Substation Design Requirements. Refer also to the Queensland Environmental Protection Act.

Constructors must comply with all By Laws and Regulations of Local and other Statutory Authorities having jurisdiction over the work.

9.2 Noise

Noise emanating from substations may be of concern in sensitive environments eg. residential, rural, adjacent to schools, hospitals, etc. Substation Standard STNW 3041 Audible Noise, in conjunction with the various Legislation, Standards and other documents referenced therein, sets out Energy Queensland requirements in relation to management and limitation of substation noise. In addition, the Local Authority may have some specific requirements and some specific noise level limits may be included in the Construction specification for a particular project.

Noises created by substation plant such as transformers (hum, tap changer, fans, etc.), CT's, VT's, circuit breakers (tripping/closing) are generally addressed through appropriate design, such as appropriate positioning/alignment of plant, acoustic walls or screens, or in some cases specifying low noise HV plant. The constructors must ensure that the design features provided to manage noise level are implemented correctly to a high standard. For example, improperly fastened metallic fittings on structures or busbars may be a source of additional vibration noise; gaps left around the base or other part of acoustic screens are likely to reduce their effectiveness, etc.

Construction noises need to be managed through restriction of noise producing activities to the allowable working hours as specified by Energy Queensland and the Local Authority, use of well maintained, low noise vehicles and construction equipment, scheduling particularly noisy activities to the time of day with highest background noise level if possible, use of noise shielding where possible (eg. within site workshop), etc. Refer also to AS 2436 for guidance on control of construction noise and vibration.

9.3 Oil Handling

Substation sites contain a considerable quantity of oil in transformers, CT's, VT's, switchgear, vehicles and other operating equipment, which can pose a significant environmental & fire hazard risk, if not handled appropriately.

All handling of oil on site must be carried out in accordance Standard for Handling and Storage of Insulating Oil - 2946173.

Any oil or chemical spills must be contained and the resultant waste, including contaminated soil disposed of in a manner consistent with the Environmental Protection requirements and Standards referred to above.

Power transformers will generally require oil containment systems, consisting of bund walls, drainage & oil/water separation facilities to prevent transformer oil entering the environment in the event of any small or large loss of oil from the transformer. Refer to Standard STNW3036 Oil Containment for the requirements for oil containment systems.

9.4 SF6 Gas Handling

Sulphur Hexafluoride (SF6) gas has a very high global warming potential, and its toxic, corrosive by-products produced in the event of an arc due to an equipment fault, need to be handled carefully following strict procedures, to avoid or at least minimise the potential for environmental damage or personnel contamination.

The gas and its by-products must be handled, tracked and reported in accordance with AS 62271.4 and Work Instruction SF6 Gas Maintenance and Handling - 2857761, using appropriate PPE, as specified in that Instruction.

9.5 Erosion & Sediment Control

Reference document Environmental Management Standard - 2947192 sets out the Energy Queensland obligations and requirements in relation to Soil Erosion and Sediment Control Document. Document Storm Water and Erosion Control - 2857719 tabulates a range of control measures available for field crews to mitigate potential environmental and cultural heritage risks.

Specific control measures/mitigation strategies required for the site will be set out in the site Erosion and Sediment Control Plan (ESCP) and the Environmental Management Plan.

9.6 Cultural Heritage

In the event of discovery of items/areas of possible cultural heritage, work must be stopped immediately and the procedure of Cultural Heritage Discovery Process - 2860861 (Field Instruction) followed to ensure that the cultural heritage value is protected from harm as far as possible. Refer also to the other cultural heritage documents referred to in the Field Instruction.

10 Civil Works

10.1 General

This section is a reference guide on how to comply with the minimum standards required by Energy Queensland for civil construction work inside or immediately adjacent to electrical substations. Civil construction work may include but not be limited to new substations, upgrade of existing substations and survey or geotechnical investigations.

This Section 11 must be read in conjunction with the other relevant sections of this document, the Energy Queensland Standards, the Reference documents and the project documents.

10.2 Civil Construction Work

Civil construction work includes but is not limited to Demolition, Earthworks, Roadworks, Footings, Buildings, Bunds, Oil/Water Separation, Hydraulics, Structures, Electrical Conduits, Cable Pits and Ducts, Earth Grids and Tails, Fences and Switchyard Surfacing. Relocating HV or LV cables is considered electrical construction work and shall be undertaken by suitably qualified personnel.

All civil construction work must comply with the following documents:

- The project documents and the ‘Work May Start’ drawings
- The Referenced Australian Standards and Codes
- The Energy Queensland Safe Work Practices (SWP)
- Queensland Workplace Health and Safety Code of Practices for Construction
- All sections of this document.

Inspection requirements and acceptance criteria can be found in the project documents.

Standard Work Practice WCS100: Substation Site Construction and WCS61: Civil Works detail the requirements for performing civil works inside a substation. These documents must be read in full and strictly adhered to. Special attention must be given to the requirements for the safety of workers on roofs and high areas, in excavations and working in and around live electrical equipment.

All dimensions and levels must be verified on site prior to the commencement of construction work. Dimensions must not be scaled from drawings.

10.2.1 Asbestos

Every Energy Queensland site has an Asbestos Register that must be reviewed before carrying out any work on-site. The following documents are a reference to guide Constructors on the requirements for managing asbestos:

- 690840: Asbestos Management Plan R077
- 690519: Contractor Asbestos Related Work or Asbestos Removal Work Reference Guide

- 2983534: Manage Asbestos Quick Reference
- 1887806: Asbestos SWMS R324

10.2.2 Safe Work Areas

The Safe Work Areas and the Builders Area (or Builder Storage Areas) are typically nominated on the plan but must be verified with the Substation Work Group Leader (internal) or Operational Contracts Officer (DCT project) during the pre-start meeting.

The Safe Work Areas must be demarcated by the appropriate barrier (i.e. fences, bunting, flags) as defined in 2885278: Queensland Electricity Supply Industry Substation Barrier Chart and the project documents. Civil works typically require steel mesh panels and green flags. Refer to the Temporary Fence Drawings for construction and earthing details. The Constructor must not hinder the operation of the substation and site access must be made available to Energy Queensland crews at all times to respond to power outages or emergencies. In the Constructor's absence, measures must be implemented to inform the Energy Queensland crews of potential hazards within the site.

Builders areas are typically outside the substation and must be away from site access and where no harm can come to the public.

10.2.3 Exclusion Zones

The Energy Queensland Substation Work Group Leader (internal), Operational Contracts Officer (DCT project) or the Electrical Constructor in control of the site must identify exclusion zones, safe work areas and no go areas to the Civil Constructor as part of the site induction. Refer also to Section 5 of this document.

10.2.4 Excavations

Extreme caution must be exercised when excavating inside or adjacent to substations to avoid damage to or contact with existing underground services.

Works involving excavation in Substations now require individuals to manage the hazards associated with excavation by considering the Safe Work Method Statement – Trenching & Excavations R328 prior to commencement of work. Additional requirements have been updated in the SWMS to reflect the previous controls applied through the Permit to Dig which is no longer applicable.

10.2.5 Star Pickets

If authorised, a risk assessment must be performed prior to the use of star pickets in substation yards. Once approved, the star pickets must be driven no further than 300mm deep and a marker or obstruction must be placed on the star picket to prevent overdriving.

10.2.6 Earth Grid

The substation earth grid installation must meet the requirements of Sections 13.1 and 13.2 of this Standard, WCS34 Earthing Systems and the project Specification. The electrical materials required for the earth grid will be identified in the Bill of Materials prepared by the electrical designers and generally provided as free issue by Energy Queensland (except that backfill materials remain the responsibility of the Civil Constructor).

The Civil Constructor must advise the Design Engineer or other appropriate contact person in writing when the earthing materials will be required. Arrangements will then be made to provide the materials for pickup by the Constructor. Pickup location, date of availability and any other specific detail required will be provided in the Specification.

10.2.7 Confined Spaces

Working in confined spaces must be avoided wherever possible. If this is not possible, the work must comply with the Queensland WHS Confined Spaces Code of Practice, AS 2865 and the documents below.

- 1909592 Confined Space Management Plan R233
- BS001409F101/1023 Confined Space Entry Permit
- 1887630 Confined Space SWMS R329

10.2.8 Hot Works

Any hot works performed on-site (welding, grinding etc.) requires a permit and must comply with the following documents:

- 2857807 Working in a Hot Work Area
- 2906148 Hot Work Permit

Welding must only be performed by experienced personnel who are certified in accordance with AS1796.

10.2.9 Scaffold Certificate

Where scaffolding is used on-site a Certificate of Compliance is required in accordance with AS/NZS 4576 and the Queensland WHS Scaffolding Code of Practice.

10.3 Mobile Plant

Refer to 1887762 Movement of Powered Mobile Plant SWMS R327 for guidance of Energy Queensland's requirements for movement of mobile plant in substations.

10.4 Other References

Other references include

- 2945282 Safe Work at Heights on Substation Structures
- 690539 Working on Roadways Manual R236

11 Primary Plant

11.1 General

Typically, primary plant consists of the high voltage equipment, associated structures and the cable and busbar interconnections, that make up the high voltage installation of the switchyard, as indicated in the following sections.

All items of primary plant must be located and installed with the orientations shown on the General Arrangement and Section Drawings and must be erected strictly in accordance with the appropriate manufacturer's detailed Installation Manual.

Generally, primary plant must not be installed until all erection of poles, towers, termination structures and overhead works (landing spans, strung busbars, overhead earthwires) have been completed, unless absolutely necessary and agreed by the Project Manager or Design Engineer.

All HV plant will be purchased by Energy Queensland under period contracts and received into the Logistics system. Except for power transformers (refer section 12.2), all requisitioned items must

be collected from the appropriate Energy Queensland storage depot as advised and transported to site, by the Constructor.

As soon as possible following arrival of plant at site, the Constructor must open all crates sufficiently to enable inspection and checking that all required components have been received and are in good condition. Any equipment damage or deficiencies must be reported promptly in writing to the Project Manager and/or relevant standards department with a material non-conformance report for follow up. This action will help to minimise potential construction delays in the event that the equipment manufacturer needs to be contacted for supply of missing components or rectification of damage.

The Constructor must provide all galvanised bolts, nuts, washers, etc. required for mounting the equipment to the support structures, unless supplied by the Manufacturer. Bolts and nuts, etc. must be ISO metric of the appropriate size in accordance with AS1111 and AS1112 and galvanised in accordance with AS1214.

11.2 Power Transformers

Supply, delivery to site, installation and testing of any power transformers required for the substation is generally the subject of a separate contract between Energy Queensland and the Transformer Supplier (excluding station service transformers).

A Representative from the Transformer Supplier will conduct a pre-delivery site visit to review the site access and discuss with the Constructor any requirements or co-ordination necessary before and during transformer delivery.

Prior to delivery of a power transformer, the following site works must be completed:

- The base course of the substation driveway must be completed. This does not require the concrete edging, kerb and channelling, or bitumen to be completed, but a solid compacted road base which allows transformer delivery to proceed safely, independent of weather conditions.
- The transformer footing and bund wall must be complete and have had sufficient time to cure, so as to achieve a significant percentage of the design strength. (Typically 28 days – If a shorter lead time is absolutely necessary due to unavoidable project constraints, this must be negotiated with the project team, including civil and electrical SME's). Sealing of the slab and bund can be done at any suitable time after curing of the concrete is complete as above, either before or after delivery of the transformer, dependent on the urgency of transformer delivery. (Allow two to three days to complete painting).
- Ensure all of the conditions as agreed at the pre-delivery site meeting are in place.
- Installation and test of the 415V, 63A AC supply for use by the Transformer Installation Crew.

The Transformer Supplier will not deliver the power transformers if the conditions are not met. To avoid the possibility of delays and disruption due to the site not being ready when required, the Constructor and Project Manager must liaise regarding the site preparedness and the transformer delivery schedule.

During assembly and testing of the transformers, the following conditions must be observed:

- Earthworks or any dust producing activity must not be carried out in the vicinity of the transformer assembly area at this time, so as to avoid dust entering the transformers or oil.
- Clear access to the transformer assembly area must be maintained to enable the transformer installation crew to complete the work safely and efficiently. Generally as there

will be some crane work and oil filling and whilst this work is being undertaken, it is generally unsafe for other activities to be happening in the area.

- During testing, no other work can take place on or around the transformer.

Following completion of transformer installation and testing and subsequent hand-over of the transformer by the Transformer's Installation Crew, external HV, LV and multi-core cable connections can be installed on the transformer, in accordance with the relevant Design Drawings.

11.3 HV Circuit Breakers (Outdoor)

HV circuit breakers must be erected on their support stands and assembled, in accordance with the Manufacturer's Installation Manual. In general there shall be sufficient information contained in the supplier's manuals to allow for installation and commissioning of the breaker. The Substation Constructor shall note the requirements for gas in the breaker, whether SF6, dry air or another specialty gas, and ensure they have suitable filling equipment for evacuating and filling the breaker. See Section 10.4 for further information around gas handling.

Some specialised aspects of the assembly and testing (e.g. commissioning point of wave controller) may be required to be completed by the Circuit Breaker Supplier, or other person Trained and Authorised by the Supplier. This requirement depends on the Manufacturer of the circuit breaker and may change from time to time, therefore should be checked for each project.

Responsibility for sourcing appropriately qualified personnel for all aspects of the circuit breaker installation lies with the Substation Constructor, unless specified otherwise in the project documentation.

11.4 Current Transformers and Marshalling Boxes

Current transformers are generally fully assembled and filled with insulating oil ready to be erected on their support structures. CT's must be stored on-site and handled strictly in accordance with the Manufacturer's Instruction Manual.

Spare CT secondary cores must be earthed at the marshalling box, as should be indicated on the Project Design Drawings.

Cable screens and other earth connections must be bonded to the earthing bar internal to the marshalling box.

Cables must be fitted with approved glands at the entry point through the gland plate in the bottom of the marshalling box.

11.5 Voltage Transformers and Marshalling Boxes

Voltage transformers are generally fully assembled and filled with insulating oil ready to be erected on their support structures. VT's must be stored on-site and handled strictly in accordance with the Manufacturer's Instruction Manual.

Cable screens and other earth connections must be bonded to the earthing bar internal to the marshalling box.

Cables must be fitted with approved glands at the entry point through the gland plate in the bottom of the marshalling box.

11.6 Disconnectors and Earth Switches

Disconnectors and earthing switches must be erected strictly in accordance with the erection instructions in the Manufacturer's Instruction Manual.

Care must be taken to ensure that all disconnectors and earthing switches are erected with the correct orientation, as indicated on the Switchyard General Arrangement and Section Drawings issued for the Project. i.e. The earthing switches must be at the correct end of their associated disconnectors and the operating mechanisms must be on the correct side of their structures, as indicated on the design drawings. Adjustments may be necessary to main contacts and flicker blades to ensure correct alignment during operation. Generally, the objective will be to facilitate easy viewing of operating number plates and handles by an Operator walking from the control building towards the switchyard.

11.7 Surge Arresters and Station Post Insulators

Surge diverters and station post insulators must be erected strictly in accordance with the Manufacturer's Instruction Manual.

In the event that surge diverters or station post insulators are supplied in more than one section, these sections must be joined together to form one unit before being erected onto the support structure.

11.8 Audio Frequency Load Control Equipment

The load control equipment must be assembled and installed as indicated in the Load Control Drawings, plus the Manufacturer's Assembly Instruction Manual.

Erection and installation includes (but is not necessarily limited to) the following activities:

- Erection of suitably designed structures and surrounding safety enclosure for the coupling cell.
- Connection of high voltage conductors to the coupling cell
- Installation of the internal cubicles housing the ripple control transmitter, controller, etc.
- Cabling and connections between the external coupling cell and the internal transmitter and controller
- Auxiliary supply connections
- Control cabling and connections to the RTU.

The Construction Workgroup will perform on-site testing and pre-commissioning of the plant.

11.9 Capacitor Banks

Capacitor banks (either cubicle enclosed or outdoor type) must be installed and erected in accordance with the Project Design Drawings and the Manufacturer's Instruction Manual, as required.

Erection of support structures and an enclosure fence may be required for outdoor type capacitor banks.

HV connections, auxiliary supply and control cable connections must be made in accordance with the relevant Project Design Drawings.

11.10 Statcoms and SVCs

This plant will generally be installed and commissioned with supervision from the manufacturer.

11.11 HV Switchboards and GIS

Switchboards may be supplied pre-installed by Workshops in a transportable building, or packaged as individual panels as supplied by the Switchgear Supplier, to be installed in a building on site.

In the case of switchboards requiring on-site installation, the panels must be requisitioned and collected from the appropriate Energy Queensland storage depot and transported to site, as for most other items of HV plant.

Before installation of a switchboard in a building on-site, the following requirements must be met:

- The switchroom floor must be prepared to the Switchboard Manufacturer's Specification. The preferred method and finish are supplied with the switchboard drawings and data.
- The substation building and vehicle access must be sufficiently completed and clear to enable the installation to proceed unhindered.
- The switchroom must be sealed, air-conditioners or other ventilation systems operational (as installed), and a power supply suitable to run the individual switchboard panel heaters must be available.

These requirements are to provide a dust free and secure environment to ensure the longevity of the equipment. This is a hold and inspection point. Installation must not proceed if the conditions are not met.

For a HV GIS, a representative from the manufacturer shall be present to witness and supervise correct assembly. A HV test is required after assembly, and provision shall be made for the appropriate test set and connections to be available to conduct the testing.

Installation of the switchboard and GIS must be carried out in accordance with the Manufacturer's Installation Manual.

11.12 HV Cables

11.12.1 General

Installation and termination of HV and LV cables must be carried out in accordance with STNW 3018 Cables and Cabling.

The Constructor must supply all tools and equipment, plus minor materials required for the installation, termination and testing of the HV power cables. All supplied items must be entirely satisfactory for the service conditions and intended operational requirements, whether such conditions or operational requirements are directly specified or not.

Cable-laying must also meet the following requirements:

- Conduits must be spaced to ensure required current ratings are met (in accordance with the Cable Rating Design Report).
- Cables to be installed so as to exclude cable wastage and cable damage.
- The finished cable routes must not undermine foundations of substation equipment or encroach on any other substation works.
- HV power cables must be supported and clamped as the cables rise into the Control Building or onto the transformer. Cable clamps must not cause circulating current problems (e.g. trefoil cleats, separation of the cable clamp from a steel bracket by a non-metallic spacer or similar; use of non-magnetic cable clamps).
- Cable glands to be installed at entry to air insulated boxes. Refer also to STNW 3018 Cables and Cabling.
- The HV power cable drum must be placed at an appropriate location to ensure that the cable can be pulled / installed efficiently. Generally the cable drum can be placed at the

transformer and the cable can then be pulled from somewhere in the vicinity of the Control Building.

- Refer also to Civil Works drawings for further information on laying of conduits.

11.12.2 Thermal Backfill

If thermal backfill is required to reach the specified Soil Thermal Resistivity in the cable trench, the material data must be forwarded to the Design Engineer, for checking and confirmation by the Network Rating and Utilisation Engineer, before backfilling commences. The material data must include the following:

- Thermal dry out curve
- Compaction Test Results from a Geotechnical Soils Laboratory to determine compaction ranges, compaction methods including layer thickness, minimum moisture level, and number of passes for the chosen compaction method.
- Demonstration of compliance with the project specific requirements.

Refer also to the Energy Queensland Cable Trench Installation Specification. Backfilling of the trench must be in accordance with the Geotechnical Soils Laboratory recommendations and the requirements in the Civil Works drawings.

11.12.3 Cable Marking and Identification

All cables from the power transformers must be permanently marked according to phase with appropriately coloured heat shrink PVC sleeving at four locations:

a) Inside the transformer cable boxes.

b) Immediately outside the transformer cable boxes (single core cables).

c) Inside the indoor switchgear or the outdoor Ring Main Units.

d) Immediately outside the indoor switchgear or outdoor Ring Main Units (single core cables).

In addition, all HV cables from the power transformers must be permanently labelled T1 or T2 etc. at location (a) and feeder name/number at location (d).

For auxiliary transformer cables, the marking and labelling must be at locations (c), (d) and at or immediately beneath the cable outdoor terminations, permanently labelled Aux Transformer 1 or 2. PVC tape shall not be placed directly over the HV termination.

11.12.4 Cable Terminations

Cable terminations must be done in accordance with the relevant manufacturer's instructions and standard STNW 3018 Cables and Cabling. High voltage cable connection lugs must comply with AS 62271.301-2022 – Dimensional Standardisation and Terminals.

HV cable screens must be earthed at one or more ends, in accordance with STNW 3018 Cables and Cabling and any project specific requirements of the design drawings and/or specification. The stranded copper screen must be brought out under the heat shrink termination, the strands twisted together and inserted into an appropriately sized crimp lug with ring termination. The size of the crimp lug must be consistent with the total screen conductor area. The screen tail must be of appropriate length to allow connection to the earth point without the need for any additional linkage and routed so that phase to earthed metal clearances are not compromised. Labels and signs need to be installed where single core HV cable screens are single point bonded.

Indoor switchboards and circuit breakers are subject to partial discharge testing prior to commissioning and must be free of any external cable connections during testing. Therefore the timing of cable termination works and testing needs to be co-ordinated between the Construction and Testing groups. In some cases, the cables may be terminated and connected to the switchboard, then unbolted from the switchboard terminals later for testing purposes.

11.12.5 As constructed cable location drawings

Prior to backfilling, direct buried HV cables or conduits for HV cables shall be recorded in terms of depth and alignment from permanent structures so they can be accurately located in the future. These details shall be returned to substation design so they can be recorded on a record of cables drawing for the substation.

11.13 Busbars and Conductors

11.13.1 Overhead Conductors

Landing spans, strung busbars and overhead earth wires must be installed in accordance with the Substation General Arrangement and Section Drawings, plus the relevant Standard Assembly Drawing(s). The conductors must be strung to the correct sags and/or tensions as specified on the appropriate drawing.

Conductor drums must be stored on level ground with the axis horizontal and must not be dropped off vehicles or distorted in any way which might lead to difficulty in running off the conductor. The protecting battens must remain in place on the drums as long as possible to prevent damage to the outer layers of conductors.

After being run off the drum, the conductor must be supported above the ground on rollers or similar, until erected. The conductor must not be driven over or walked on by pedestrians. Every precaution must be taken to ensure that the conductors when erected are left without any scratches, cuts, protruding strands, bird caging, rough welds, deposits of grease or dirt, deformation or adhesions.

Only conductor which is free of imperfections must be used for compression terminations. All grease and foreign matter must be wiped away and any light scratches must be removed by rubbing down with fine emery cloth. Steel wool must not be used.

EWP Operators must have successfully completed the appropriate training and assessment and properly secured harnesses must be worn at all times while working in the EWP.

11.13.2 Rigid Busbars

Rigid aluminium tubular busbars must be fabricated in accordance with the relevant Fabrication Drawings and erected as indicated on the Substation General Arrangement and Section Drawings.

Busbar supports must be expansion, sliding or fixed type, and busbar joints must be either butt or expansion type, as indicated on the Substation General Arrangement and Section Drawings and the relevant Assembly Drawings. For sliding busbar supports, metalwork shall have a flexible bonding lead between them to equalise potentials and reduce partial discharge/radio interference voltage at these connections.

All welding of aluminium must be carried out by a skilled Welder using the Metal Inert Gas (MIG) process. The weld filler alloy to be used on all B6101 aluminium alloy must be aluminium alloy B4043.

Individual weld runs must be completed as quickly as possible and time for cooling must be allowed between successive runs to limit distortion and loss of strength in the weld zone. When

welding terminal palms, earth loops, etc. to tubular busbars, the cross-sectional area of the welds must be at least equal to the cross-sectional area of the palm, loop, etc. or the busbar, whichever is less.

Vibration damping conductors must be laid loosely along the whole length inside the busbar tube and tack welded at one end to prevent migration along the bus.

11.13.3 Droppers and Flexible Connections

Droppers and flexible conductor connections between HV plant must be installed as indicated on the Substation General Arrangement and Section Drawings and the relevant Assembly Drawings.

All conductor ends must be cleaned with a wire brush, imperfections smoothed with fine emery cloth and coated with jointing compound before insertion into the compression or bolted connectors.

Compression must be continued until the two halves of the compression die meet solidly. Multiple, overlapping compressions must be carried out over the whole of the available compression length. Where compression connector detail drawings specify a dimension across the flats after compression, the compression must be continued until this dimension is achieved.

Where it is necessary to bolt an aluminium terminal lug onto a copper equipment terminal palm (or vice versa), the copper palm must be tinned and positioned underneath the aluminium. This is to minimise the risk of any corrosive copper salts being washed onto the aluminium by moisture.

Bolted electrical joints must be made using stainless steel bolts, nuts and washers. For aluminium to aluminium connections, a load spread washer must be placed on each side of the connection, with the addition of a spring washer between the nut and the load spread washer on that side. For tinned copper connections, the load spread washer can be replaced by a standard flat washer. An anti-seize compound such as Locktite 767 or equivalent must be added to each nut and bolt prior to assembly. Suitable jointing compound shall be applied to the faces of terminal palms to be connected.

All bolted connections must be made in accordance with Australian Standard AS 62271.301: High Voltage Switchgear and Controlgear – Dimensional Standardisation of Terminals. The torque applied to each bolted connection must be in accordance with the relevant table in the Standard.

11.14 Clearances

Energy Queensland Standard STNW 3013 Clearances in Air sets out all Safety and Electrical Clearances that must be observed through both Design and Construction Practices.

Table 1 of the above Standard, sets out the minimum phase to earth and phase to phase clearances that must be observed for all parts that will become energised at some time. Flexible conductor connections between HV plant, droppers, and HV cable terminations and lugs must be installed so as to avoid compromise of those clearances through bending, sagging or swaying of conductors, or protrusion of cable termination lug bolts towards each other. Generally, it is desirable to arrange HV flexible conductors to curve upwards between two items of plant, using the natural curve of the conductors, if possible.

The arrangement of overhead strung bus, droppers and flexible connections must also ensure that the appropriate section clearances (also in Table 1) are achieved.

In 3 phase HV cable termination boxes, the cable lugs and bolts should preferably be installed with all the lugs on the same side of the equipment terminal palm for each phase and the bolts facing in the same direction, with the toes of the bolts pointing into the larger clearance gap. This is not always possible (e.g. in switchgear panels, etc.), so may have to be modified on site for particular cases, but the principle is always to arrange so as to obtain the largest possible phase to earth and

phase to phase clearances in all parts of the cable termination box (subject to achieving the minimum values in Table 1 of STNW 3013 Clearances in Air).

In exposed outdoor situations, at the lower voltages, consideration needs to be made of the possibility of infringement of the minimum clearances by birds, reptiles, or climbing animals. Insulation of exposed live terminals may need to be provided to prevent contact by vermin, whether specified in the design or not.

11.15 Lightning Protection

Lightning protection, consisting of an integrated combination of lightning masts and overhead earthwires above the incoming feeder landing spans must be installed in accordance with the Substation General Arrangement and Section Drawings, plus the relevant Standard Assembly Drawing(s) and Substation Standard STNW3032 Substation Lightning Protection.

In the event of any lighting fixtures, or other LV auxiliary circuits needing to be installed on lightning towers, care needs to be taken to achieve sufficient clearance and insulation between the lightning current circuit and the LV circuit to prevent lightning current causing any back flash-over in the LV system of the substation.

11.16 Phasing

Phasing shall be in accordance with substation design drawings and standards for phasing. When interfacing with existing network, phasing tasks shall be incorporated into the switching sheet to prove correct prior to energisation.

12 Earthing

12.1 General

The substation earthing system must be constructed and commissioned strictly in accordance with Energy Queensland Standards STNW 3028 Substation Earthing and STNW 3029 Safety Earthing and the relevant Australian Standards and Guidelines: Refer to:

- IEEE 80-2000 Guide for Safety in AC Substation Grounding
- ENA EG1-2006 Substation Earthing Guide
- AS 2067 Switchgear Assemblies and ancillary equipment for alternative voltages above 1kV.
- Queensland Electrical Safety Code of Practice 2010: Works

The work shall be carried out by an Electrical Fitter Mechanic possessing a current Queensland Electrical Workers and Contractors Board Certificate of Competency.

12.2 Main Earth Grid

Earth grid conductor crimp connections, including lugs must be well compressed such that all conductor strands make solid contact with other conductors and the outer strands are solidly compressed into the inner surface of the surrounding crimp connector. Gaps between conductors must be minimal.

Quality of crimp connections is dependent on factors such as crimp type, compression pressure, calibration and serviceability of compression tool and dies, care and skill of the operator. Prior to commencement of the earth grid connections, the Design Engineer (or Representative) may require to inspect a random sample of three (3) to five (5) completed earth grid joints of each type and may request to view a small number of further samples on a random basis during the course

of the work, to ensure consistency is maintained. These samples must be cut through by hacksaw to expose the cross-section of the joint, for the approval of the Design Engineer (or Representative). Refer to the specification on a particular project for project specific requirements.

Back-filling of the earth grid conductor excavations must not be carried out until the Design Engineer (or Representative) has been notified and had time for Final Inspection of the laid earth grid conductor and jointing.

All earth grid connections must be ductored as part of the Construction Testing, as described in Section 17 below.

Other earth grid testing, including measurement of the resistance of the buried earth grid system to the general mass of the earth, Step and Touch Potentials, Earth Potential Rise (EPR), etc. will be carried out during final commissioning.

To prevent the transfer of dangerous voltages outside the substation, all conducting services leaving the earth grid area (metallic pipes, fences, control, protection and communication cables, etc.) must be isolated as specified in STNW 3028: Substation Earthing.

12.3 Extending Fences & Earth Grids in Energised Substations

When erecting a fence inside or near the outside of an energised substation, the construction procedures must ensure that no connection is made between the substation earth grid and any remote earth. There must also be no possibility of any Personnel (Staff or Public) being able to contact both the substation earth potential and remote earth potential at the same time, as the substation earth grid potential may be considerably different from that of remote earth.

Suitable protective measures shall be taken when constructing fences or working on the earth grid in and near a HV substation. Supply of insulation mats, gloves, temporary jumper leads, and other safety equipment required is the responsibility of the relevant Constructor.

When constructing a new section of earth grid in an area adjacent to the existing earth grid of the substation, due consideration must be given to the risks associated with transferred potentials in the event of an earth fault occurring during installation of the new earth grid. Following are the minimum requirements:

(a) A Work Method Statement must be prepared indicating how the risks will be minimised.

(b) Prior to commencement of installation of conductors, a 3 metre isolation zone must be cordoned off with tape, measured from the existing metal fence or other defined boundary between the existing earth grid and the new work area.

(c) Installation and connection of the new section of earth grid must be carried out in two stages, as described in (d) and (e) below.

(d) The new earth grid conductors must be installed, commencing at the boundary of the work area furthest from the existing grid and working back towards that existing grid, until the boundary of the isolation zone is reached. No conductive material is permitted to breach the Isolation Zone, including earthing conductors, fencing materials, construction AC supply cabling (unless electrical isolation provided), etc. No special safety requirements such as insulating gloves and mats are required at this stage, provided the Isolation Zone is not breached.

(e) Following completion of the work in (d) above, including making of connections, backfilling and compacting, the task of connecting the conductors across the Isolation Zone to the existing grid can be commenced, subject to the following safety requirements:

- The principle of working towards the existing grid must be adhered to as much as possible.
- Whenever conductors are handled, 00 insulated gloves must be worn.
- When connections are made to the existing earth grid, insulating mats must be used also.

- Temporary jumper leads must be applied between the existing and new earth grid conductors, before the final connection is made.
- A new fence must not be extended across the Isolation Zone until the earth grid is completely finished.

12.4 Support structures, Equipment

All support structures, equipment earth points, marshalling boxes and exposed metalwork must be connected to the main earth grid, in accordance with Energy Queensland Substation Standard Earthing Drawings.

The earthing tails from the earth grid must be fitted neatly into the provided slots in the foundation, shaped to the structure earth connection point, cut to length and fitted with the appropriate compression terminal lug.

Bare copper strap and lugs must be tinned over the whole connection area where earth connections are made to equipment and structures.

The Constructor must supply all compression tools and dies, plus minor materials such as hot dip galvanised bolts, nuts, etc. required for jointing and fastening the earthing conductors to structures and equipment. All fasteners must be both non-corroding and non-corrosive.

Portable earthing device attachment saddles must be fabricated in accordance with relevant drawings, then fitted at each point indicated by an asterisk “*” on the relevant Substation Elevation Drawings and indicated generally in the Standard Earthing Drawings.

Electrical plugs/sockets, etc. installed in the switchyard should have the earth pin connected to the substation earth grid as near as practicable to the outlet.

12.5 Panels and Building Equipment

Project Drawings should indicate the main earthing requirements for the building equipment, but may miss some of the detail, due to the complexity that arises from the number of connections required. Hence, some guidelines are provided for the assistance of the Construction Workgroup.

All control and protection panels, switchboards, battery chargers, cable trays and ladders and sundry metalwork in the Control Building must be connected to the main earth grid.

Each separate HV Switchboard or GIS must have at least two earthing tails connected directly back to the main earth grid in the ground, one at each end of the switchboard or GIS. In a Control Building Room containing a single row of control/protection panels, exactly the same arrangement must be applied to the row of panels. Where there are two or more sets of panels, including some possibly along the walls (AC and DC supply panels, etc.), the earth bars of the different sets of panels must be bonded together via the earth bar in the overhead cable tray and again two connections made directly back to the grid, one from either end of the cable tray earth bar.

Cable tray and other sundry metalwork may be earthed via tails off any of the main earth connections indicated above.

Each individual switchboard panel or control/protection panel must be connected to the main earth bar run in the cable tray above. The earth bars at the top and bottom of each panel must also be connected together with an insulated green/yellow earthing conductor of equivalent cross-sectional area to the earth bars themselves.

Bare copper strap and lugs must be cleaned up over the connection area where earth connections are made to panels, switchboards, battery chargers, cable trays, etc.

Earthing of the Control Building itself – walls, roof, etc. – must be separate from the internal substation equipment earthing and have its own direct connections to the main earth grid, so that the equipment earthing is not dependent on the building earthing or vice versa.

12.6 Cable Screens

Cable screens are to be earthed at either one or both ends, dependent on the function of the cable, as specified in Energy Queensland Substation Standards STNW 3018 Cables and Cabling and STNW 3028 Substation Earthing.

The Constructor must prepare the cable and provide all necessary materials required for effective connection of the screen, including the required length of earthwire.

The cable screen must be bonded to an earth strap where available, otherwise to the appropriate earthing terminal of the panel, marshalling box, etc.

For both HV and multicore cables, the cable termination/screen earthing arrangement must provide sufficient clearance in air from the live parts to ensure that the rated impulse withstand and power frequency withstand levels are not compromised.

Stranded copper screens (generally on HV cables) must be earthed in accordance with Section 12.12.4. Brass tape screens on multicore cables must be earthed to a suitable earth bar via a stranded copper conductor earth tail, of minimum cross section of 2.5mm2, with standard green-yellow insulation. Connection to the double brass tape can be by constant force spring or soldering.

13 Steelwork

13.1 General

Tolerancing shall be in accordance with design drawings, or if not specified then to standard drawings for fabrication quality.

Welding of steel structures and re-inforcing steel shall be to relevant parts of AS/NZS 1554. Welding of aluminium structures to be in accordance with AS/NZS 1665. All burrs, welding pits and sharp edges to be removed.

Structures to be galvanised shall be hot dipped in accordance with AS/NZS 4680 with a minimum coating thickness of 84 microns. Centrifuged work (unless otherwise deemed unacceptable) to AS/NZS 4792 to a minimum of 42 microns.

Fasteners shall be to the associated Australian Standards, shall have metric coarse thread to AS1275 with thread fit – tolerance class 6H/8g (commercial quality fasteners).

13.2 Erecting Steel Structures

A lifting plan and suitable rigging shall be used for erecting steelwork. Clearances shall be maintained during lifting to any live conductors. Use only bolts and nuts for mounting as per the design drawings. The height of steel structures to be adjusted to meet design heights and the height of rigid busbars. After final adjustment, grouting to occur between steel structure mounting plate and concrete footing.

14 Secondary Systems

14.1 Protection and Control Panels

Protection and Control Panels are supplied as single panel cubicles which must be installed in the locations indicated on the relevant Building Layout Drawings, bolted together using the joining brackets provided at the top of each panel and dyna-bolted securely to the floor. Four dyna-bolts (minimum 12mm diameter) plus square washers (approx. 25mm) are required per panel.

Panels must be lifted only by the eye bolts provided at the top of each panel.

Earthing of panels is covered in Section 13.5.

Lift-off rear panel doors must be removed and placed out of the way during internal fit-out and wiring of the panels to provide safe passage and exit for Personnel in the event of an emergency.

Relays and other panel equipment must be mounted in the panels and wired in accordance with the approved design drawings, which should be based on the latest versions of the relevant Relay Application Guides and drawings. Wiring construction work must meet the detailed requirements and standards in STNW 3021 – Panel Wiring.

Where a modular building is specified, the substation control/protection panels and other building equipment, including MV switchboards and overhead cable tray, etc. will be constructed and installed off site as part of the building construction, whereas for a brick/block building, installation of panels and equipment will need to be done on site, following sufficient completion of the building construction (subject to agreement with the building constructor).

14.2 Remote Terminal Units and Human Machine Interface (HMI)

The SCADA Remote Terminal Unit (RTU) racks must be installed in the panel locations indicated on the relevant Design Drawings for the Project.

The Local Control Facility (LCF) (also referred to as a HMI –Human Machine Interface) must be installed either on the desktop or in the allocated panel, as indicated on the Drawings, dependent on which type of LCF is provided.

Any spare cards in an RTU rack must be fully wired out to terminals, as indicated on the Design Drawings for the RTU, so as to be readily available in the future if needed.

Loading of RTU configuration files into RTU's and functional testing will be carried out by the appropriate Secondary Systems Group and programming of the LCF will be carried out by Energy Queensland SCADA Group.

14.3 Communications

Communications and signalling requirements are generally designed, supplied and installed by Communications work groups, but some associated work is generally the responsibility of the substation constructor. Specifically,

- Installation of completed communications equipment cubicles, including the 48V DC supply panel (where required), supplied by Communications work group.
- Provision of AC & DC power supplies from the appropriate Distribution panels to the Communications panels.
- Installation of fibre optic raceways, cable ducts and termination enclosures
- Installation of a concrete communications antenna pole based on the standard Communications pole drawings supplied by the Communications designers. – Orientation is to be in accordance with the site specific layout drawing.
- Supply and installation of public telephone services and telephone isolation equipment, if required by the design.

The DC power supply cabling from the substation 110V DC Distribution Panel, or from the 48V DC Supply Panel as required, must be installed in accordance with the design drawings, Ergon Substation Standards STNW 3022 DC Supplies and STNW 3018 Cables and Cabling and 2920282 Standard for Communications Equipment Installation.

The location and type of the outdoor conduits, pits, termination enclosures and splice enclosures will depend on the incoming optical fibre cable type and location of the terminating structure.

Where more than one fibre optic cable enters the substation, the conduits for each cable must follow diverse paths into the substation control building and not use common pits or ducts or termination enclosures. The internal OFS 800 termination enclosure must be mounted on the wall of the equipment room as close as practicable to the communications equipment cubicles and in accordance with AS/ACIF S009:2001 – Installation Requirements for Customer Cabling (Wiring Rules). The final position of conduits, cable pits, termination enclosures, etc. must be determined in conjunction with the Communications workgroup.

The required orientation of the communications antenna and of any future microwave dish to be mounted on the concrete pole must be double-checked before installation of the pole. Orientation is to be in accordance with the site specific layout drawing, as is the antenna mounting arrangements.

If a direct connection to the NBN is required, it must be installed to the substation. This includes telecommunications conduits from the property boundary to the substation control building, and, in consultation with the Carrier's contractor, from the property boundary to the public network connection point. All materials used must be in accordance with AS/ACIF S008:2010 – Requirements for Customer Cabling Products. All telecommunications equipment must be installed in accordance with AS/ACIF S009:2006 – Installation Requirements for Customer Cabling (Wiring Rules).

Where a coaxial connection is made to the NBN, a telephone Line Isolation Unit (LIU) must be installed in the substation building to isolate the NBN from the network equipment installed in the substation.

The telephone line isolation unit must be equipped with sufficient high voltage isolation links to allow for termination and isolation of the 10 pair lead-in cable, as well as sufficient optical isolation modules to isolate two PSTN telephone lines, with capability of expansion to four telephone lines by the addition of isolation modules.

The exchange side of the isolation unit must be powered from the Carrier's network. The subscriber side of the isolation unit must be powered from the substation DC supply.

During any work on the network side of the LIU, any accessible exposed earthed metal within two metres of the LIU must be covered with insulating rubber mats of appropriate rating (10kV), to prevent any inadvertent personnel contact with the earthed metal. This is to protect personnel against potentially dangerous touch potentials between the substation earth grid and the external public telephone network.

Telecommunications conduits and cables within the substation must be unbroken between the

property boundary and the telephone line isolation unit. The use of PSTN telecommunications pits within the substation boundary is not permitted.

14.4 Metering

All metering must be installed in accordance with Substation Standard STNW 3114 Metering, the Queensland Electricity Connection and Metering Manual (QECMM) and the relevant Design Drawings.

Revenue metering circuits must be sealable at the locations as indicated in STNW 3114 Metering.

Metering VT and CT loads must be balanced on all three phases as far as possible. For any 3 phase installation, the least loaded metering winding must carry not less than 80% of the load experienced by the most heavily loaded metering winding. Transducers and meters must be connected to the preferred phases as indicated in the Manufacturers' Installation Guides. In the event of contradiction with the Project Design Drawings, the Designers must be consulted for clarification.

14.5 LV Cabling, Secondary Wiring and Terminals

14.5.1 General

This Section describes the general requirements for all LV cables, secondary wiring and terminals for all AC and DC circuits, CT and VT secondary circuits, control, alarm and protection circuits. All secondary wiring must comply with the following common requirements, in addition to the specific requirements of other relevant Sections of this Standard:

- 0.6/1kV halogen free insulated conductor conforming to AS/NZS 5000.1
- Stranded Conductors
- All Control and Protection Panel wiring must be grey.
- Cables exiting a building to have a double brassed tape (DBT) screen. Cables contained solely within the building do not require DBT.

14.5.2 LV & Multicore Cable Installation

- All LV cables and wiring must be installed and terminated in accordance with Standards STNW 3018 Cables and Cabling and STNW 3021 Panel Wiring.
- In order to minimise induced voltages, cable runs must, wherever possible, be at right angles to the busbars. Where parallel runs are unavoidable, the multicore cables must be separated from the busbars by as large a distance as practicable.
- Within the Control Building, so far as is possible, cables which extend outside the Control Building must be physically separated from internal cabling and particularly from those cables containing low level signals.
- Where cables enter the building adequate vermin proofing must be installed.
- AC and DC circuits must be run in separate cables.
- Where Prot 1 and Prot 2 protections are used, their secondary circuits must also be run in separate cables.
- Cables exiting the Control Building must be laid neatly in concrete trenches, then, exit the trenches at appropriate points in electrical grade PVC conduits to reach the switchyard equipment, as indicated on the appropriate Cable Route Diagrams and other Associated Drawings. Control cables must not be direct buried and must not be run in the same ducts or conduits as HV cables. Cable segregation distances between LV AC power cables, control cables and instrumentation cables must be maintained in accordance with STNW 3018 Cables and Cabling.
- Due care must be taken to avoid damage to cables during laying. Large heavy cables may need to be supported on rollers when running across other cables, but winches should not be used, unless absolutely necessary. Cables must be laid parallel with one another as far as possible, not bunched or crossed, so that each cable may be identified throughout its entire length.
- Where cables exit from conduits, or enter equipment cubicles for termination, they must be adequately protected against mechanical damage and adequately supported by clamps attached either to the panel or the structure. Cables not enclosed within ducts or conduits must be clamped at intervals not exceeding 300mm (approximately).

- Suitable plastic zip ties can be used for bundling and securing control cables that are not exposed to the sun. In outdoor situations non ferrous steel straps shall be used.
- Upon installation of cables, both ends must be suitably sealed to prevent ingress of moisture, dirt, or vermin (until glanded and terminated).
- Any exposed outdoor wiring between terminal boxes and cubicles must be protected from ultraviolet light.
- Each cable must be fitted with a permanent non-corroding cable marking tag at each end just before the cable gland, stamped with the unique cable number, as per the Cable Schedule and appropriate Connection Diagram.
- Cable screens of multicore cables must be connected to the substation earth grid at only one end of the cable. Refer also to Section 13.5 of this standard and STNW 3018 Cables and Cabling.

14.5.3 Cable Cores and Termination

- All Switchyard cables into marshalling boxes to have appropriate cable glands. Brass glands to be used on outdoor boxes.
- Cable cores must be labelled strictly in accordance with the numbering specified on the relevant Connection Diagrams.
- Wire number ferrules must be interlocking, non-rotating type, fitted firmly over the insulation at both ends of each conductor, as close as possible to the terminals and indelibly marked with non-deteriorating black lettering on a white background. Clip-on type ferrules are not acceptable.
- Earthing of equipment generally requires that each item be individually connected to the earth bar. Should looping of earth wires be unavoidable, it must be arranged such that disconnection of any item of equipment from its earth connection during test or maintenance will not interrupt the earthing connections to other plant remaining in service.
- Terminals in 400V and 230V AC circuits must be protected by inherent design features or an insulated cover to protect against inadvertent contact. All such terminals and surrounding barriers must be identified by red colouring and be marked in red "400/230V AC" by means of a label attached to the terminal barriers or covers.
- All fuse holders must be installed at the front of the terminal boards and no live metal is to be exposed at the back.
- All fuses and links must be clearly labelled with the circuit function and fuse size or ‘Link’ as per the approved Design Drawings.
- All cable cores must be terminated as indicated in the approved Design Drawings. Spare cores can be left inside duct with a heatshrink cap.
- Connections to equipment terminals must be made with appropriate crimp lugs to suit the particular equipment, as generally indicated by STNW3021 – Panel Wiring. Circular lugs must be used where possible, rather than forked lugs. The latter are to be used only where the type of equipment dictates that these are the most suitable type of lug.
- STNW 3021 indicates the minimum required Standards for termination of cores and crimping of lugs. The lug manufacturer’s recommendations must also be followed.

- Design drawings and STNW 3021 – Panel Wiring will prescribe recommended links and terminals. These shall not be substituted with alternative links and terminals without approval from the Design Engineer.
- All live terminals behind equipment door to be made IP2X touchproof.
- When working live in panels, refer to Work Practice Working with Substation Wiring and Circuitry - 13764022

14.5.4 Optical Fibre Cables

Optical fibre cables must be run in white conduits or raceways, as specified in the design and segregated from all other cables. The optical fibre conduit may be run in the main cable duct or cable ladder, but must be clamped to the side of the duct or ladder to be kept clear of the other cables.
Refer also to 2920282 Standard for Communications Equipment Installation and Section 15.3 of this standard for other essential requirements in relation to installation of optical fibre cables.

14.5.5 Decommissioning and Removal

- Cables that are no longer required must be isolated, proven de-energised, and disconnected.
- All cables that have been disconnected must be completely removed and not left in cable trays, conduits, and cable ducts.
- To facilitate the identification of cables to be removed after being disconnected and/or cut away, the ends of the cable must be covered with a red insulation tape, and using a white paint pen mark the cable with the cable identifier and “to be removed”.
- Where cables have been disconnected, left in an outdoor cable duct/tray, or will not be removed during the current project being worked on, then a more permanent system of marking and insulating must be used. This should consist of the application of a heat shrink cap over the cable end, and the application of a suitable indelible label detailing the Cable Identifier, Project no., Date, Disconnected by, and “To be removed”. As a secondary measure, the cable identifier must also be marked using an indelible pen or paint on the side of the cable as a precaution against longer term deterioration of the label.
- Where a cable is no longer required and has been identified as being direct buried, it is highly recommended that the cable be removed. If it is deemed not practical or high risk to excavate for its removal, then it is still a requirement to identify and mark the cable ends in the manner described above for outdoor cables not being removed for 12 months or later. A record of the decommissioned direct buried cable must be kept on substation plan drawings (eg. identified and notes included on General Arrangements, Foundation Plans etc.) and the cable is to be retained on the cable schedule drawing with appropriate decommissioning notes.

15 Miscellaneous

15.1 Substation Auxiliary AC Supplies

This Section describes the General Construction requirements of the low voltage 400V AC supply system for the substation equipment and services plus the on-site construction power needs, within the earth grid area only. It is not intended to apply to the constructor's site office, workshop and amenities AC supply, which must be installed as a separate system, where these facilities are outside the substation earth grid area.

The major AC supply equipment, as required by the design, will be specified and procured by the appropriate design team and will be available for collection by the constructor.

All items must be entirely satisfactory for the service conditions and intended operational requirements, whether such conditions or operational requirements are directly specified or not.

The AC supply system must be installed and tested in accordance with AS/NZS 3000 Wiring Rules. Additional RCD protection must be installed on LV circuits if required by AS/NZS 3000, and as indicated on the Design Drawings.

The station supply ground, pad mounted or pole mounted 11kV/415V transformers, RMU's, associated HV and LV cables, the 400V AC three phase main switchboard and sub-boards must be installed and tested as indicated on the relevant Design Drawings and in accordance with Energy Queensland Substation Standard STNW 3023 AC Supplies.

Prior to commissioning of the 11kV/415V station supply transformers, a temporary source of LV AC supply for on-site construction, operation and testing purposes (eg. battery chargers, fans, tap changers, etc.) will be needed. The Substation Constructor must arrange either:

(a) Sufficient LV generating capacity, or

(b) LV Supply to the site from the Energy Queensland Distribution Network, if readily available.

The temporary connection is to be requested for the duration of the Construction/Commissioning period. This connection will be subject to Energy Queensland Standard Terms and Condition for supply and will be metered and charged accordingly.

The following conditions apply to the use of temporary supplies:

- The temporary supply must be connected to the substation AC supply panel, so as to function, as far as possible, in the same manner as the final permanent supply will do.
- The temporary supply must remain wholly within the substation earth grid area and not be used to supply equipment outside that area, so as to avoid the possibility of touch potential problems due to transference of the substation earth potential to an area that might be at a different earth potential.
- Access to all live parts must be restricted in accordance with the requirements of AS/NZS 3000 and any related document, to minimise the risk of accidental contact by personnel.
- All outstanding and/or uncompleted works must be made safe at all times, including the cutover from temporary to permanent arrangement.
- A written statement detailing the status of the temporary AC supply and associated isolations, locks and tags must be provided in handing over to the next work group (Test/Commissioning, etc.)

Within a live substation site (brownfield), power supply for on-site construction, office and facilities purposes may be available directly from the existing AC supply system for the site, provided the

tools and equipment connected do not overload the relevant circuits used, or otherwise impact on the supply to the live substation equipment.

15.2 DC Supply Systems

This Section describes the General Construction requirements of the batteries, battery chargers, battery stands, DC isolation and test panels, DC/DC converters, DC/AC inverters, and DC distribution boards for the Substation DC Supply Systems and the Communications DC Supply System.

The major DC supply equipment items as indicated above are selected (by the Designer) from the standard Energy Queensland inventory items sourced on the Energy Queensland Period Contract for DC supply equipment.

All items, whether sourced from the Period Contract or elsewhere (for non-contract items) must be entirely satisfactory for the service conditions and intended operational requirements, whether such conditions or operational requirements are directly specified or not.

Installation of the DC Supply Systems, including all cabling between battery banks, isolation and test panels, DC distribution board, battery charger, DC/DC converter and DC/AC inverter must be carried out as described in Energy Queensland Substation Standard STNW 3022 DC Supplies.

Bolts, nuts, washers and inter-connections must be of an inherently corrosion resistant material or otherwise protected against corrosion and must be supplied by the Construction Workgroup.

Racks, signage and inter-cell/inter-tier/inter-row connectors are supplied by the Battery Manufacturer, together with the batteries and must be installed in accordance with the Instruction Manual supplied.

The Battery and Battery Charger Instruction Manuals (supplied with the equipment) also contain Factory Acceptance Test results. The batteries and chargers must be inspected, installed and tested in accordance with the requirements of the Instruction Manuals.

15.3 Lighting

All switchyard and building lighting must be installed in accordance with Energy Queensland substation standards STNW 3040 Substation Lighting and STNW 3003 Substation Design Requirements, in locations and orientations as shown on the relevant design drawings.

All switchyard lights must be able to be maintained without need for an outage of any HV equipment. For example, swing-down lights and their counter-balances must not encroach within the relevant exclusion zones for nearby HV plant, at any point of their swing-down paths.

Cabling to each light must be connected as indicated on the relevant Design Drawings. Minor materials required to complete the connections are to be supplied by the Constructor.

15.4 Nameplates, Signage and Labelling

15.4.1 General Requirements

Rating plates, nameplates, signs and labels installed on outdoor equipment must be of stainless steel or non-ferrous metal, with etched or engraved lettering and fixed with stainless steel screws or monel rivets. Indoor labels must be engraved traffolyte or other approved material.

Rating plates, nameplates, signs and labels must be located such that they can be easily and safely read from normal operating positions and access ways around the equipment, at ground or floor level.

Full details of all signs, labels, etc. required, including content, sizes and details of lettering, in accordance with the respective Template Drawings will be provided in the Project Design, for ordering purposes. All fasteners required must be supplied by the Construction Workgroup.

15.4.2 Rating Plates

All CT and VT marshalling boxes must incorporate rating plates showing all relevant rating data of the associated HV plant. A second set of rating plates is usually sourced from the CT or VT Manufacturer for installation on the appropriate marshalling box.

All switchyard operational signs must align with the approved Operating Single Line Diagram. The Standards for content, sizing, and layout of operational signs are indicated on typical Drawings.

Switchyard Operational Number signs are required on each HV operational point only. i.e. circuit breakers, disconnectors, earthing switches, voltage transformers, power transformers (all ratings), HV fuses, disconnectors and earthing switches in RMU's and HV switchboards. Current transformers and surge diverters are not operating points and therefore must not be allocated Operating Numbers, although they may have been shown on the Operating Diagram for information.

15.4.3 Labels

All equipment, operating devices, relays, etc. must be suitably labelled such that they can be readily identified from drawings. Circuit breaker and transformer control cubicles, control panels and relay panels must also be labelled. Cubicles and switchboard panels with rear access must also be labelled on the rear of the panel.

On manufactured equipment, most labels should be supplied and installed by the Equipment Manufacturer, however, some additional labelling may be provided by the Project Designer to match the equipment identifications shown on the Project Drawings. e.g. bay numbering, device identification, etc.

All labels must be in the English language.

15.4.4 Safety Signs

Warning and Safety Signs must be installed around and within the substation, as specified in the Energy Queensland Standard STNW 3037 Substation Signage.

These signs warn Personnel of dangerous voltage levels, correct operating procedures and safety requirements within the substations.

Warning signs must conform to the relevant Australian Standard and Work Health and Safety Act 2011. The required signs and locations will be provided in the Project Design Drawings, however the Constructor should still double check that all the necessary signs have been provided and that the specified locations are suitable.

15.5 Painting

All surfaces of structures and equipment must be finished with an appropriate coating system which will provide the necessary protection against corrosion for the design life of the equipment.

Minimum coatings for all exterior surfaces not specified as hot dip galvanised must be one coat of primer, one undercoat and two finishing coats of an approved colour and quality paint. The top coat must be single pack epoxy.

The interior of outdoor control cubicles, cabinets must receive the same number of coats as the exterior. The Constructor must make good any damage to the paint incurred during delivery, erection or commissioning, before completion of the works.

15.6 Locks, Keys, Operating Equipment, Building Furniture

Where building locks are required, they must be flush mounting types, suitable for Energy Queensland's master key system.

Locks must be constructed and located on equipment so that they remain serviceable in the whole range of Queensland climatic conditions for an indefinite lifetime, including continuous periods of up to two years without operation or maintenance.

Building entry & internal door lock barrels are to be replaced by the appropriate lock barrels, according to the substation region.

All HV operating points (circuit breakers, disconnectors, earthing switches, VT secondary fuses) must be capable of being locked out with the appropriate switching padlock (again according to the substation region).

Panel, cubicle and miscellaneous equipment keys, equipment operating handles and the like must be hung on a shadow board(s) mounted in the control building, in the same room(s) as the associated equipment. The control building must also include a plan desk, chair, drawing hanger for storage of substation drawings and two drawer filing cabinet (to fit under desk).

Operating equipment such as portable earthing devices (PED's), HV test sticks, DNOB's, HV gloves, etc must be neatly stored in an efficient manner that ensures the equipment remains in serviceable condition and is readily accessible when required. PED's must be hung neatly and singly on smoothly curved brackets, either in the control building, or in an external operating equipment shed, as specified by the designers. Circuit breaker trolleys for MV switchboards should be stored in the switchboard room in readily accessible position, but parked neatly so as to be clear of personnel access paths. A substation sign-in/out log book must be placed on the control room desk, near the telephone.

Switching padlocks, door lock barrels and operating equipment as listed above are available as Energy Queensland stores stock. Quantities and voltage/current ratings as appropriate, will be specified by the designers for the specific project.

15.7 Control Building Electrical Services

This includes control building lighting and power circuits, air conditioning, fire protection and security systems as required.

All materials supplied and all work carried out must comply with the requirements of the latest addition of the Australian/New Zealand Wiring rules (AS/NZS 3000) and amendments thereto, the Queensland Electrical Safety Act and Regulations, other relevant SAA Codes, Energy Queensland Standards and the design drawings provided for the project.

All light switches and GPO's must be flush mounted on blockwork, except that outlets of 63A capacity or greater rating (single or three phase) may be surface mounted. Where blockwork is required to be core filled, the Contractor must install conduits into flush mounted wall boxes, to allow drawing in of cables after core filling.

Each electrical socket outlet must be engraved or labelled to indicate its respective circuit number. In some cases, labels may be fixed to the wall adjacent to the switch, if fixing to the switch is not suitable.

The control building electrical circuits must be cabled and connected to the appropriate circuit breakers on the AC Distribution Board, as indicated on the project electrical design drawings.

The AC Distribution Board will be provided as free-issue to the building constructor for installation as indicated on the building layout drawings, to enable the connection of the building electrical circuits as in the paragraph above.

The final installation must ensure that the loads are as evenly balanced as possible across the three phase supply.

Equipment Manuals provided by equipment suppliers must include full operating instructions, as constructed drawings, test results, manufacturer's product data and safety instructions for the safe installation and use of the equipment.

The air-conditioning system must be supplied, installed and commissioned in accordance with the requirements of the project Specification, STNW 3003 Substation Design Requirements, the design drawings and the relevant SAA Codes and other relevant Regulations.

A fire protection system must be installed in accordance with STNW 3035 Substation Fire Protection, the project Civil Specification (where supplied), the Workplace Health and Safety Act and Regulations, the appropriate Australian Standards referenced in STNW 3035 Substation Fire Protection and the design drawings. The system must include Fire Alarm Panel, detectors, cables, conduits, accessories and fire extinguishers.

The fire protection system must include an air conditioning shutdown signal from the Fire Alarm Panel to the relevant circuit on the AC Distribution Board, in the event of a fire. Fire extinguishers must be mounted securely on suitable brackets, enabling ready access to the extinguishers if required, with appropriate identification signs in accordance with the Regulations and located as indicated on the design drawings.

A building security system, including Intruder Alarm Panel where required, must be supplied, installed and commissioned in accordance with the project specification, STNW 3039 Substation Physical Security and Monitoring and the relevant Standards and Regulations, etc references therein.

15.8 Commissioned/De-commissioned Plant Data Capture Forms

Following installation of each item of new HV plant or protection relay into its correct position in the substation, a Commissioned Substation Primary Plant Data Record Form NA000403F189 (Ergon) and Form 1392 (Energex) must be completed for each item and a clear, readable photograph of the nameplate(s) attached.

Similarly, for any existing items of plant de-commissioned and removed from their service positions, a De-Commissioned Substation Plant Data Record Form NA000403F190 must be completed and nameplate photo attached.

The form(s) should be completed prior to issue of the Construction Release/Authority, in case access to HV plant is still needed to view and photograph plant details. As well as the nameplate photograph (essential), a general photograph of the item of plant is also useful.

As well as major HV plant items, completed forms will be required for items such as transformer bushings, CT's, oil pumps, cooling fans, surge diverters and HV links. Secondary items needing to be recorded include protection relays, battery banks, chargers, revenue and statistical meters, metering CT's, RTU cards, etc.

A single form can be used for a set of 3 single phase items of plant (eg. CT's, VT's, surge diverters). The completed forms and nameplate photos must be forwarded to the AMO (Asset Maintenance Officer) through the Project Manager, as early as possible prior to commissioning of the plant.

16 Electrical Construction Testing

16.1 General

All construction groups must monitor and ensure the quality of their completed work, by carrying out Construction Testing and rectifying any deficiencies found, prior to handover to the Test group.

The construction work & testing must be verified by completion of the relevant Substation Construction Tools or test forms.

The extent of Construction Testing done must be indicated in the completed Construction Tools or test forms and include (but not be limited to):

(a) Continuity testing of all field wiring and cables in marshalling cubicles and site primary plant. Point to point testing of panel and primary plant internal wiring will generally have been completed by the relevant Suppliers and accordingly does not need to be repeated, unless the wiring has been modified since completion of the FAT. In the event that the Field Construction group are also responsible for wiring of the control, protection and other panels (either directly or by sub-contract), then that group will also be responsible for continuity testing of the panel wiring.

(b) Continuity testing of all cables (and connections) entering the Control/Communications Buildings and any additional inter-panel wiring, DC/AC supplies and any other wiring in the Building that has not been checked during FAT Testing of Control/Protection Panels. (Unchecked wiring should be readily determined from the greened-out copies of Schematics marked up during FAT Testing).

(c) Insulation Resistance Testing of all 230/400 V wiring installed on site including control cables, panel wiring and inter-panel wiring.

(b) “Ductoring” of all earth mat connections. Refer Maintenance Acceptance Criteria (MAC) for test current. Resistance is measured to a common reference point (the No 1 Transformer 11kV neutral connection point). Results must be recorded on Earth System Continuity Test Report or equivalent.

(c) “Ductoring” of HV connections to primary plant.

All construction works must be verified by the Substation Work Group Leader or equivalent Contractor representative supervising and coordinating the work, through a combination of checking the completed Construction Tools and adequate inspection of the completed work.

At the completion of construction, a verified electronic copy of all relevant completed Construction Tools must be saved to the nominated Network Storage drive for maintenance and quality records and a copy forwarded to the Project Manager. Where the constructor does not have suitable access to the network drive, the Project Manager will arrange for saving of the electronic copy on the network drive.

16.2 Specific Requirements for Secondary Systems

Within Ergon area, Quality Document MN000301R167: Green-lining and Blue-lining of Ergon Energy Substation Drawings provides further details of the requirements for Continuity Testing and Visual

Identification of Cabling, Wiring and Terminations. A working copy of each relevant Schematic must be green-lined progressively, in accordance with the procedure outlined in the same document. (Blue-lining is for Functional Testing to be carried out by the relevant Test Workgroup).

All cabling, wiring and termination of wiring must meet the Requirements and Standards of STNW 3021 – Panel Wiring.

Check that all equipment is mounted securely and that all electrical connections, including cable screens are properly crimped, with the correct type of lugs and tightened properly (tug test).

Check connection and insulation of cable screens in accordance with Design Requirements. i.e. Are they connected correctly and earthed at the correct end(s).

For Insulation Resistance Testing of Cables, each core is to be meggered individually, with every other core in the cable earthed.

With all cores in a cable shorted together at one end, megger the insulation of the whole cable to earth.

Megger the insulation between different sources of supply in panels. Care must be taken to disconnect or short out terminals of equipment which may be damaged during this testing and to restore any disconnected items to their exact original state.

Check cable entries, fuses, links, indicating lamps and any other equipment.

16.3 Construction Authority and Handover

The management of not electrically connected assets ready for energisation (including roles, responsibilities and forms) is covered by the Management of Not Electrically Connected Apparatus – Procedure.