This document describes the *identified need* for investment at Charleville. It includes description of the likely network options and to the extent possible, the characteristics of non-network options which may, either alone or in combination with network or other non-network options, represent a feasible solution for addressing the identified need.

Consultation starts: 17 January 2018
Consultation ends: 16 April 2018

Disclaimer
While care was taken in preparation of the information in this *Non Network Options Report*, and it is provided in good faith, Ergon Energy Corporation Limited accepts no responsibility or liability for any loss or damage that may be incurred by any person acting in reliance on this information or assumptions drawn from it. This document has been prepared for the purpose of inviting information, comment and discussion from interested parties. The document has been prepared using information provided by a number of third parties. It contains assumptions regarding, among other things, economic growth and load forecasts which may or may not prove to be correct. All information should be independently verified to the extent possible before assessing any investment proposal.
Executive Summary

Ergon Energy Corporation Limited (Ergon Energy) is responsible (under its Distribution Authority) for electricity supply to the Charleville area in southwest Queensland.

Charleville is located in the Maranoa area of the South West Region of Ergon Energy’s Network. The Charleville area is supplied via a single 276km 66kV sub-transmission Feeder from T83 Roma Bulk Supply Point and customers in Quilpie and Cunnamulla are supplied via separate 200km long 66kV feeders from Charleville. Charleville substation contains 1 x 66/11kV transformer, 1 x 66/22kV transformer, and also a 22/11kV transformer to link the 22kV and 11kV busbars and hence provide backup for each of the 66kV transformers. The MW07 Charleville zone substation contains a Static VAR Compensator (SVC) which is connected to its 11kV bus. The SVC is set up to control the 66kV bus voltage and has a range of 7MVAr inductive to 10MVAr capacitive.

The existing SVC is at the end of its design life. Ergon Energy has proposed to replace the existing SVC in 2019 in its submission to the AER. The SVC plays a critical role in maintaining stable voltage at both high and low load conditions. As a critical substation asset, Ergon Energy’s preferred internal solution is to replace the existing SVC with a new STATCOM / SVC.

This is a Non-Network Options Report, where Ergon Energy is seeking information about possible alternate solutions to address the identified need, which may be able to be provided by parties other than Ergon Energy.

Submissions in writing (electronic preferably) are due by 16 April 2018 and should be lodged to Ergon Energy’s “Regulatory Investment Test for Distribution (RIT-D) Partner Portal”. The portal is available at:


For further information and inquiries please refer to the “Regulatory Investment Test for Distribution (RIT-D) Partner Portal”.

# Table of Contents

Executive Summary ......................................................................................................................................... 1

1. Introduction .................................................................................................................................................. 4

2. Background .................................................................................................................................................. 5
   2.1. Existing Charleville SVC .................................................................................................................. 6
   2.2. Charleville Supply System ............................................................................................................... 7

3. Technical requirements of solution ............................................................................................................. 9
   3.1. Stability Requirements ..................................................................................................................... 9
   3.2. Negative Phase Sequence Capability ............................................................................................. 9
   3.3. Harmonics .......................................................................................................................................... 10
   3.4. Audio Frequency Load Control .................................................................................................... 10
   3.5. Voltage Fluctuations ....................................................................................................................... 10
   3.6. SVC Replacement Sizing ................................................................................................................. 10
   3.7. Land and proximity to Substation .................................................................................................. 11
   3.8. Detailed Technical Requirements .................................................................................................. 11

4. Feasible vs Non Feasible Options ................................................................................................................ 12
   4.1. Potentially Feasible Options ............................................................................................................ 12
   4.2. Options that are unlikely to be feasible ........................................................................................... 12
   4.3. Timing of feasible options .............................................................................................................. 13

5. Internal Options Identified ......................................................................................................................... 13

6. Submission and Next Steps ......................................................................................................................... 13
   6.1. Submissions from Solution Providers ............................................................................................. 13
   6.2. Next Steps ......................................................................................................................................... 14

7. Appendix A: Technical Specifications - STATCOMs .................................................................................. 15
List of Figures and Tables

Figure 1 – Charleville Subtransmission Network ................................................................. 5
Figure 2 – Location of Charleville Substation ..................................................................... 6
Figure 3 - Charleville Substation Basic Configuration ......................................................... 7
Figure 4 - EECL owned land ............................................................................................... 11

Table 1 – Ergon Energy's Internal Cost for the Preferred Option ........................................... 13
Table 2 – Future timetable for this RIT-D ............................................................................. 14
1. Introduction

This Non Network Options Report has been prepared by Ergon Energy in accordance with the requirements of clause 5.17.4(e) of the National Electricity Rules (NER).

This report represents the first stage of the consultation process in relation to the application of the Regulatory Investment Test for Distribution (RIT-D) on potential credible options to address the identified replacement expenditure in the distribution network that supplies the Charleville area.

This report:
- Provides background information on the network capability limitations of the distribution network supplying the Charleville area.
- Identifies the need which Ergon Energy is seeking to address, together with the assumptions used in identifying and quantifying that need.
- Describes the credible options that Ergon Energy currently considers may address the identified need, including for each:
  - Its technical definitions;
  - The estimated commissioning date; and
  - The total indicative cost (including capital and operating costs)
- Sets out the technical characteristics that a non-network option would be required to deliver in order to address the identified need.
- Is an invitation to registered participants and interested parties to make submissions on credible options to address the identified need.

In preparing this RIT-D, Ergon Energy is required to consider reasonable future scenarios. With respect to major customer loads and generation, Ergon Energy has, in good faith, included as much detail as possible while maintaining necessary customer confidentiality. Potential large future connections that Ergon Energy is aware of are in different stages of progress and are subject to change (including outcomes where none or all proceed). These and other customer activity can occur over the consultation period and may change the timing and/or scope of any proposed solutions.

Submissions in writing (electronic preferably) are due by 16 April 2018 and should be lodged to Ergon Energy’s “Regulatory Investment Test for Distribution (RIT-D) Partner Portal”. The portal is available at:


For further information and inquiries please refer to the “Regulatory Investment Test for Distribution (RIT-D) Partner Portal”.
2. **Background**

Charleville is located in the Maranoa area of the South West Region of Ergon Energy’s Network. The Charleville area is supplied via a single 276km 66kV sub-transmission Feeder from T83 Roma Bulk Supply Point and customers in Quilpie and Cunnamulla are supplied via separate 200km long 66kV feeders from Charleville. Distribution supply from Charleville and Cunnamulla is at 11kV for urban, and 22kV and 19.1kV SWER for more rural customers. Supply from Quilpie zone substation is exclusively 11kV with extensive 19.1kV SWER networks. Charleville substation contains 1 x 66/11kV transformer, 1 x 66/22kV transformer, and also a 22/11kV transformer to link the 22kV and 11kV busbars and hence provide backup for each of the 66kV transformers. The MW07 Charleville zone substation contains a SVC which is connected to its 11kV bus. The SVC is set up to control the 66kV bus voltage and has a range of 7MVAr inductive to 10MVAr capacitive.

The following diagrams (Figure 1 and Figure 2) provide an overview of the sub transmission network in the region and the location of Charleville Substation.
2.1. Existing Charleville SVC

The Charleville SVC is approaching the end of its design life and it is recommended for replacement on the basis of its age and reliability in 2019. The SVC performs the function of maintaining stable voltages at both high and low load times. At low load times, without the SVC in service, significant voltage rise would occur on the Charleville area network. Similarly, without the SVC’s capacitive support, voltage would become low during high load periods. The SVC also provides some Negative Phase Sequence (NPS) correction to address voltage balance issues associated with SWER networks. If the Charleville SVC fails, inductors and capacitors are manually switched. This switching however creates transients on the network, is difficult to manage, and also relies on some plant which is also approaching end of life. At peak load times, without the SVC in service, some loads may also need to be shed in order to maintain a suitable voltage. Figure 3 provides an overview of Charleville substation basic configuration.

Figure 2 – Location of Charleville Substation
2.2. Charleville Supply System

As described above, the Charleville area is supplied via a single 276km 66kV sub-transmission feeder from T83 Roma Bulk Supply Point and customers in Quilpie and Cunnamulla are supplied via separate 200km long 66kV feeders from Charleville. Distribution supply from Charleville and Cunnamulla is at 11kV for urban, and 22kV and 19.1kV SWER for more rural customers. Supply from Quilpie zone substation is exclusively 11kV with extensive 19.1kV SWER networks.

Charleville substation contains 1 x 66/11kV transformer, 1 x 66/22kV transformer, and also a 22/11kV transformer to link the 22kV and 11kV busbars and hence provide backup for each of the 66kV transformers. The MW07 Charleville zone substation contains a SVC which is connected to its 11kV bus. The SVC is set up to control the 66kV bus voltage and has a range of 7MVAr inductive to 10MVAr capacitive.

There are a number of operational challenges at Charleville substation associated with voltage control in the event that the SVC is out of service. This presents safety, voltage compliance and reliability risks.

The SVC is critical to the provision of ongoing voltage/VAR support, and to meet Ergon Energy’s corporate strategic objectives. Without reactive compensation, 66kV supply at Charleville and the far south western Queensland suffers from poor voltage regulation. It may be noted that although no customer minutes have been recorded against SVC outages, there remains a potential for outages due to increasing loads and either low or high voltages on the network which can lead to unwanted tripping of loads by protection or operator intervention. During SVC outages, a significant
amount of time is involved in maintaining volts on the 66kV busbar through reactor or capacitor switching and taps changing. The process is complex, slow and takes hours to manage by adjusting 66kV Roma bus volts and, on some occasions, even requesting Powerlink to lower the 132kV volts at Tarong and removing capacitor banks from service at Chinchilla. Despite these measures, the system voltage at Cunnamulla has become critically high on some occasions.

There are significant SWER schemes emanating from these remote townships, particularly Quilpie with a very extensive SWER scheme generating significant reactive VARs under light load.

Under light load, reactive VARs need to be continuously absorbed by the SVC to prevent system over voltages which would lead to unwanted VAR flows back from Charleville to Roma via the 66kV transmission line.

There is also some likelihood of multiple solar farms being developed in the far south western network, including Charleville substation. From a major customer perspective, solar MW injection into the grid may be maximised through a corresponding increase in VAR absorption, preferably at the same location using a compensator or reactor.

SVC failure may lead to voltage compliance issues, customer complaints, loss of revenue and operational constraints in the south west Queensland distribution network. Sub-transmission and distribution voltage levels may not be controlled within statutory limits, and the network will be at risk of over-voltages and under-voltages. Some load shedding is likely to occur either due to the voltage being excessively high or too low for the customers depending on the system load at the time.

The south west Queensland distribution network is characterised by relatively low fault levels with unacceptable voltage swings if large blocks of discrete capacitors or reactors are switched in and out for VAR compensation, hence the reason why a high reliability dynamic reactive compensator is necessary for voltage support.
3. **Technical requirements of solution**

A suitable replacement to meet Ergon Energy’s ongoing operational requirements in this system needs to be capable of providing the VAR support characteristics of a minimum of ±10 MVar. Ergon Energy seeks this solution to be split into a minimum of two ±5 MVar units on different substation circuit breakers to ensure that if there is a failure, risks are minimised. Ergon Energy’s studies indicate a cost effective solution may be to install a ±5 MVar unit on each of the 22kV bus and 11kV bus for a total substation capacity of ±10 MVar. It is highly desirable that these units have the capability to be expanded up to ±7.5 MVar, to cater for possible growth and changing voltage constraints beyond 2024. Ergon Energy however is also willing to consider other connection arrangements as may be proposed, such as connection at 66kV. Ergon Energy is also willing to consider other possible solutions which may be identified as part of the RIT-D process.

The following are some general parameters to which a non-network option must comply with. Also attached at Appendix A is Ergon Energy’s Specification for STATCOMs in Zone Substations – a technical standards guide to STATCOMs in Ergon Energy’s network.

It is expected that any proposed solution must be designed and or maintained in accordance with good electricity industry practice, such that a high reliability and availability solution is delivered.

### 3.1. Stability Requirements

Ergon Energy has the following stability requirements for any alternative technology installations:

1. Will not go out of service as a result of “inrush currents” on Charleville Zone Substation transformers or other substation transformers or devices
2. Will not go out of service if the steady state capacitive or inductive limits are reached. i.e. there is protection put in place such that it will remain operable, without causing damage to itself or adjacent plant and equipment
3. Will not simply trip as a result of reaching Negative Phase Sequence (NPS) limits, but will continue to correct voltage as much as possible at limit levels
4. Will not trip as a result of dips or transients in the network. It will instead look to minimise the impacts of these dips or transients as much as possible
5. Will remain operable if high or low voltages are seen and look to correct and stabilise these voltages as much as possible.
6. Will remain operational following a CB reclose event at Roma such that compensation is quickly provided to maintain stable voltage at Charleville.

### 3.2. Negative Phase Sequence Capability

The existing SVC at Charleville has the capability to provide negative phase sequence correction such that voltage balance across the three phases is maintained. The alternative solution must have NPS capability. This capability must maintain and correct voltage balance across the
3.3. **Harmonics**

The alternative solution must not cause harmonic problems on Ergon Energy’s network. It is expected that the alternative solution will meet the automatic access standard detail in S5.3.8 of the NER. Harmonic voltages at the SVC replacement’s connection point(s) must not exceed the levels determined in accordance with AS/NZS 61000.3.6.2001.

3.4. **Audio Frequency Load Control**

The alternative solution replacement and associated equipment must not cause attenuation or excessive magnification of the Audio Frequency Load Control signal. It is recommended that when impedance details of any proposed solution are known studies are completed to ensure no problems are introduced.

3.5. **Voltage Fluctuations**

The Roma network in the south west Queensland distribution system is characterised by relatively low fault levels with unacceptable voltage swings if large blocks of discrete capacitors or reactors are switched in and out for VAR compensation, hence the need for dynamic VAR compensator.

Under normal operation of the alternative solution, voltage fluctuations must not exceed 80% of the Threshold of Perceptibility as defined in AS 2279.

With significant rooftop photovoltaic generation, Ergon Energy is observing the nature of the network is becoming more dynamic. It will be critical that any solution is able to rapidly compensate for these dynamic changes and also the dynamic changes which may occur as part of any proposed renewable generation.

3.6. **SVC Replacement Sizing**

The alternative solution shall have a minimum VAR capability or ±10MVAr (2 of ±5MVAr) or equivalent and should ideally be able to be expanded to ±15MVAr (2 of ±7.5MVAr) or equivalent pending possible load or generation growth. This VAR requirement may vary depending on the proposal. For example, a larger solar farm may require additional inductive support to maximise real power export, whilst maintaining suitable voltage levels.

Any alternative solution must provide Ergon Energy with the capability and flexibility to manage 66kV voltage at Charleville. This may mean Ergon Energy will require direct control or some agreed level of control over the alternative solution, such that it integrates with Ergon Energy’s network requirements.
3.7. **Land and proximity to Substation**

Ergon Energy owns a parcel of land surrounding the Charleville Substation as indicated below. Ergon Energy is open to discussions around the use of this parcel of land as part of the alternative solution or part solution.

![Figure 4 - Ergon Energy owned land](image)

3.8. **Detailed Technical Requirements**

Respondents to this RIT-D must meet the Technical Requirements provided at Appendix A of this document. These are the minimum standards for STATCOMs in Ergon Energy zone substations. Respondents are advised to pay particular attention to the following requirements and sections of Appendix A: Specification for STATCOMs in Zone Substations, when proposing their solutions and options:
Environmental conditions in which the STATCOM is expected to operate, as detailed in section 7.2 of Appendix A
- Functional characteristics, section 7.3 of Appendix A
- Power system voltage, section 7.4 of Appendix A
- Power system frequency, section 7.5 of Appendix A
- Power system fault levels, section 7.6 of Appendix A
- Audio frequency load control blocking, section 7.7 of Appendix A
- Voltage unbalance, section 7.8 of Appendix A
- Auto-reclose, section 7.9 of Appendix A
- Computer models, section 8.2 of Appendix A
- Stability and ride through, section 8.4 of Appendix A
- Reactive power output, section 8.5 of Appendix A
- Short term overload capability, section 8.6 of Appendix A
- Negative phase sequence mitigation, section 8.7 of Appendix A
- Harmonics performance, section 8.8 of Appendix A
- Transient response, section 8.9 of Appendix A
- Control modes, section 8.10.5 of Appendix A
- Electromagnetic field (EMF), section 8.14 of Appendix A
- Audible noise, section 8.15 of Appendix A

4. Feasible vs Non Feasible Options

4.1. Potentially Feasible Options

The identified need presented in this RIT-D report is driven by the aging SVC which provides voltage management of the 66kV busbar during both low and high load periods. As such, solutions that cost-effectively address the voltage management at Charleville substation through reactive compensation, embedded generation or a combination thereof within the required parameters are likely to represent reasonable options.

A non-exhaustive list of potentially feasible options includes:

- Additional reactive compensation at Charleville zone substation
- New embedded dispatchable network generation
- Embedded energy storage systems

4.2. Options that are unlikely to be feasible

Without attempting to limit a potential proponent’s ability to innovate when considering opportunities, some technologies/approaches are unlikely to represent a technically or financially feasible solution. Unproven, experimental or undemonstrated technologies are unlikely to be feasible options.
Options that require completion beyond June 2020 are also extremely unlikely to be considered feasible.

Options that do not provide a significant level of redundancy in design and implementation are unlikely to be considered as feasible options given the need for a high reliability and availability solution.

Options that do not meet or are unable to demonstrate they can meet expected quality performance outcomes are unlikely to be considered as feasible options.

4.3. **Timing of feasible options**

The consequence of the SVC failing at Charleville is significant. As a result of this it is expected that for an option to be considered feasible it will be required to be completed, commissioned, accepted by Ergon Energy, and fully operational by June 2020.

5. **Internal Options Identified**

Ergon Energy’s preferred internal option at this stage is to replace the existing SVC, which is at the end of its design life, with an equivalent or better capacity STATCOM. The technical requirements have been provided under section 3 above. STATCOM standards are specified at Appendix A: Technical Specifications - STATCOMS. It is estimated that construction can commence in June or July 2018 and project completion is expected to be in June 2020.

The following table provides approximate anticipated costs for the proposed solution. It is noted at the time of writing the RIT-D more detailed cost estimates are being performed which may cause some change to the below figures.

<table>
<thead>
<tr>
<th>Internal option</th>
<th>Replace existing SVC with STATCOM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Approved value</td>
<td>$13,500,000</td>
</tr>
</tbody>
</table>

Table 1 – Ergon Energy’s Internal Cost for the Preferred Option

6. **Submission and Next Steps**

6.1. **Submissions from Solution Providers**

Ergon Energy invites written submissions on this report from registered participants and interested parties. With reference to Section 3 and Appendix A, all submissions should include sufficient technical and financial information to enable Ergon Energy to undertake comparative analysis of the proposed solution against other options. The proposals shall include, but are not limited to, at least the following:

- Full costs of completed works.
- Whole of life costs including losses.
- Project execution strategy including design, testing and commissioning plans.
- Engineering network system studies and study reports.
- Verified and approved engineering designs.
- Manufacture and supply of all plant, equipment and materials.
- Delivery to site, receiving and off-loading of all plant, equipment and materials.
- Assembly and installation on site.

Ergon Energy will not be legally bound in any way or otherwise obligated to any person who may receive this RIT-D report or to any person who may submit a proposal. At no time will Ergon Energy be liable for any costs incurred by a proponent in the assessment of this RIT-D report, any site visits, obtaining further information from Ergon Energy or the preparation by a proponent of a proposal to address the identified need specified in this RIT-D report. Submissions in writing are due by 16 April 2018 and should be lodged to Ergon Energy’s “Regulatory Investment Test for Distribution (RIT-D) Partner Portal” The portal is available at: https://www.ergon.com.au/network/network-management/network-infrastructure/regulatory-test-consultations.

### 6.2. Next Steps

Ergon Energy intends to carry out the following process to assess what action should be taken to address the identified need at Charleville:

<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
<th>Date Released:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step 1</td>
<td>Publish Non Network Options Report (this report) inviting non-network options from interested participants</td>
<td>17 Jan 2018</td>
</tr>
<tr>
<td>Step 2</td>
<td>Submissions in response to the Non Network Options Report and consultation period</td>
<td>17 Jan 2018 – 16 Apr 2018</td>
</tr>
<tr>
<td>Step 3</td>
<td>Review and analysis of proposals by Ergon Energy</td>
<td>Anticipated to be completed by: 14 May 2018</td>
</tr>
<tr>
<td>Step 4</td>
<td>Release of Draft Project Assessment Report (DPAR)</td>
<td>Anticipated to be released by: 28 May 2018</td>
</tr>
<tr>
<td>Step 5</td>
<td>Consultations in response to the Draft Project Assessment Report</td>
<td>Finalised by: 09 Jul 2018</td>
</tr>
<tr>
<td>Step 6</td>
<td>Publish the Final Project Assessment Report (FPAR)</td>
<td>23 Jul 2018</td>
</tr>
</tbody>
</table>

**Table 2 – Future timetable for this RIT-D**

Ergon Energy will take all reasonable efforts to maintain the consultation schedule listed above. Due to various circumstances the schedule may change, however, up-to-date information will be available on the Partner Portal.

During the consultation period, Ergon Energy will review, compare and analyse all internal and external solutions. At the end of the consultation and review process Ergon Energy will publish a final report which will detail the most feasible option and proceed to implement that option.
7. Appendix A: Technical Specifications - STATCOMs

Ergon Energy Corporation Limited

Specification for
STATCOMs in Zone Substations
# Specification for STATCOMs in Zone Substations

## Contents
1. **Purpose and scope**  
   1.1 Purpose 1  
   1.2 Scope 1
2. **References**  
   2.1 Legislation, regulations, rules, and codes 3  
   2.2 Standards 3
3. **Definitions, acronyms and abbreviations** 8  
   3.1 Definitions 8  
   3.2 Acronyms and abbreviations 9
4. **Security** 10
5. **Safety and environmental considerations** 10
6. **Drawings with specification** 10
7. **Service conditions** 10  
   7.1 Electrical clearances 10  
   7.2 Environmental conditions 11  
   7.3 Functional characteristics 13  
   7.4 Power system voltage 13  
   7.5 Power system frequency 14  
   7.6 Power system fault levels 15  
   7.7 Audio frequency load control blocking 15  
   7.8 Voltage Unbalance 15  
   7.9 Auto-Reclose 16  
   7.10 Protection details and operating times 16
8. **Design and construction** 16  
   8.1 Engineering studies 16  
   8.2 Computer models 17  
   8.3 Design reports and drawings 18  
   8.4 Stability and fault ride through 19  
   8.5 Reactive power output 20  
   8.6 Short term overload capability 21  
   8.7 Negative phase sequence mitigation 21  
   8.8 Harmonics performance 21  
   8.9 Transient response 22  
   8.10 Monitoring, control and indication 23  
   8.10.1 Communication equipment 23
8.10.2 SCADA and engineering access 23
8.10.3 Monitoring 23
8.10.4 Data logging 23
8.10.5 Control modes 26
8.10.6 Alarms and trips 27
8.10.7 Operator interface 28
8.11 Power electronics & inverters 28
8.12 Protection 29
8.12.1 Inverters 29
8.12.2 Coupling transformer (if required) 29
8.12.3 Reactors 29
8.12.4 Capacitor banks 29
8.13 Insulation coordination 30
8.14 Electromagnetic field (EMF) 30
8.15 Audible noise 32
8.16 Isolation, insulation and earthing 32
8.17 HV interconnections and plant 33
8.17.1 Power transformers 33
8.18 Cooling requirements 33
8.18.1 Air cooled 34
8.18.2 Liquid cooled 34
8.19 Auxiliary and control equipment 35
8.19.1 Protection against electric shock 35
8.19.2 Cables and wiring 35
8.19.3 Terminals 36
8.19.4 Fuses and links 36
8.20 Enclosures 37
8.21 Signage and labels 37
8.22 Power losses evaluation 37
8.23 Oil containment and fire separation 38
8.24 Asbestos 38
8.24.1 Definitions 38
8.24.2 Warranty 39
8.24.3 Certification and testing 39
8.24.4 Indemnity 40
8.25 Galvanizing 41
Specification for STATCOMs in Zone Substations

8.26 Anti-corrosion precautions 41
8.27 Painting and presentation 41

9. Spares, special test equipment, tools, options and accessories 42

10. Performance and testing 42
   10.1 STATCOM and associated plant testing 42
   10.2 Factory acceptance tests (FATs) 43
   10.3 Site acceptance tests (SATs) 43
   10.4 Commissioning tests 44
   10.5 System integration tests 44

11. Training 44
   11.1 Management and non-technical staff 45
   11.2 Design and asset management engineers 45
   11.3 Operating technicians 45
   11.4 Maintenance technicians 45
   11.5 Test and Commissioning staff 46

12. Maintenance & service agreement 46

13. Service history 46

14. Quality assurance 46

15. Risk assessment 47

16. Environmental considerations 47

17. Design life and warranty 47

18. Availability 47

19. Reliability 48

20. Traceability 49

21. Packaging and delivery 49
   21.1 Method of preservation and packaging 49
   21.2 Marking of goods for delivery 50

22. Deliverables 50
   22.1 Information to be provided by the Supplier 50
   22.2 Manuals 51
      22.2.1 Generic manual 51
      22.2.2 Site manual 51
   22.3 Drawings 52
      22.3.1 Drawings title block 52
      22.3.2 Drawing revisions 53
      22.3.3 Drawings in electronic format 53
Specification for STATCOMs in Zone Substations

22.4 Electronic nameplate  53
22.5 Dispatch advice email  53
A.1 General  55
A.2 Service performance  55
A.3 Reliability 56
A.4 Training  56
A.5 Environmental considerations  56
Specification for STATCOMs in Zone Substations

1. Purpose and scope

1.1 Purpose

This specification defines the technical requirements for the use of Static Synchronous Compensators (STATCOMs) in zone substation applications. It is intended for three phase STATCOMs connected to the HV network through coupling equipment. This specification covers the design, manufacture, testing and delivery for use across Ergon Energy zone substations and applies to 11, 22, 33, 66, 110, 132 & 220 kV voltages.

1.2 Scope

Site specific parameters and requirements for each project shall be included in the Project Scope Specification document.

The Supplier shall provide engineering design, plant, equipment, materials, onsite installation and commissioning services which shall include but is not limited to the following:

- Full costs of completed works.
- Whole of life costs including losses.
- Project execution strategy including design, testing and commissioning plans.
- Engineering network system studies and study reports.
- Verified and approved engineering designs.
- Manufacture and supply of all plant, equipment and materials.
- Delivery to site, receiving and off-loading of all plant, equipment and materials.
- Assembly and installation of the STATCOM system on site.
- Design, installation, and testing of the earthing system in the STATCOM site area and connection of the STATCOM earthing system to the substation earth grid in accordance with Ergon Energy Substation Earthing Standard (STNW3028/SS-1-7.1).
- Supervision and performance of final checks and commissioning tests of all STATCOM apparatus and controls to verify the STATCOM system is ready for operation.
- Availability, supply and cost of spare parts within and after warranty period expired (if ordered by the Purchaser).
- Special testing or maintenance equipment and tools (if ordered by the Purchaser).
- All drawings, design reports, test and commissioning reports, operating and maintenance manuals necessary to operate and maintain the STATCOM and associated equipment for its operational life.
- Training for the Purchaser’s personnel to enable them to operate and maintain the STATCOM for its operational life.
- Certification of the minimum Short Circuit Ratio (SCR) at which the STATCOM can reliably operate.
- PSS®E and Power Factory models for Steady State/RMS analysis and detail the minimum SCR for which these models are valid.
- Electromagnetic transient-type simulation model of the STATCOM compatible with PSCAD.
  - All PSCAD models shall be black boxed real code models.
Specification for STATCOMs in Zone Substations

- Model veracity must be demonstrated through; measurement results (from an equivalent facility and plant performance from other installations, lab tests, hardware in loop etc.) confirming the validity of the PSCAD vs PSS®E models using a set of benchmarking tests of faults and contingency scenarios.

The following material, equipment, services and facilities shall be provided by the Purchaser:

- A 240 / 415 V AC, 3 phase, 50 Hz, 4 wire supply for installation of the STATCOM system.
- A temporary 240 V AC, 50 Hz supply for construction shall be provided.
- A permanent DC supply for STATCOM system control power supply. Control system must be compatible with 32, 48, 110 & 125 V DC systems.
- Existing facilities and equipment to be interfaced with the STATCOM system including connection to the SCADA master station and Ergon Energy's communication network.
- Investigation of subsurface contamination conditions to determine if remedial work will be required to meet all applicable environmental laws.
- Design guidance for drawing development to ensure the Supplier is conforming to Ergon Energy standards.
- The supply-only of Ring Main Units (RMU's) were required up to 33 kV, suitable for the Supplier's design (4 switch or 3 switch)
- All primary plant other than the coupling transformer, including circuit breakers, disconnect switches, instrument transformers, surge arresters etc. If any primary plant is to be provided by the Supplier it shall be detailed in the Project Scope Specification document.

It is preferable that the successful supplier shall have existing plant and equipment installed in the National Electricity Market network and shall have an Australian agency or shall establish one following contract award.

Under the current National Electricity Market arrangements, Ergon Energy could incur significant liabilities if network constraints result in a total or partial failure to supply. Failure to complete these Works to specification could result in such constraints.

After the date of the Letter of Acceptance, the Supplier and Purchaser shall agree on a suitable start date and negotiate milestone dates detailed in the Project Scope Specification document.

In addition to a main conforming offer, Suppliers may offer alternative devices to the specification if they believe that such devices have technical and economic advantages to the Purchaser. Before such a device would be considered, Suppliers would need to prove to the Purchaser’s satisfaction that they would provide the dynamic range and performance equivalent to that of specified STATCOM.

2. References

STATCOM's shall be designed, manufactured and tested in accordance with all relevant Queensland Acts, Regulations, Safety Codes and Australian and International Standards and all amendments issued by the date of closing of tenders except where varied by this specification. Should inconsistencies be identified between standards and this specification the Supplier shall immediately refer such inconsistencies to the Purchaser for resolution.
2.1 Legislation, regulations, rules, and codes

This document refers to the following:

<table>
<thead>
<tr>
<th>Legislation, regulations, rules, and codes</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Queensland Environmental Protection Act, 1994) (Queensland Government)</td>
</tr>
<tr>
<td>(National Electricity Rules, 2016) (AEMC)</td>
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<tr>
<td>(Queensland Electricity Act, 1994) (Queensland Government)</td>
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<td>(Queensland Electricity Regulation, 2006) (Queensland Government)</td>
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<td>(Queensland Electricity Safety Act, 2002) (Queensland Government)</td>
</tr>
<tr>
<td>(Queensland Electrical Safety Regulation, 2013) (Queensland Government)</td>
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<tr>
<td>(Queensland Work Health and Safety Regulation, 2011) (Queensland Government)</td>
</tr>
</tbody>
</table>

2.2 Standards

This document refers to the following:

<table>
<thead>
<tr>
<th>Document number or location (if applicable)</th>
<th>Document name</th>
<th>Document type</th>
</tr>
</thead>
<tbody>
<tr>
<td>(AS 1100.101, 1992) (Standards Australia)</td>
<td>Technical drawing – Part 101: General principles</td>
<td>Standard</td>
</tr>
<tr>
<td>(AS 1101.3, 2005) (Standards Australia)</td>
<td>Graphical symbols for general engineering – Part 3 Welding and non-destructive examination</td>
<td>Standard</td>
</tr>
<tr>
<td>(AS 1102.101, 1989) (Standards Australia)</td>
<td>Graphical symbols for electrotechnical documentation – Part 101: General information and general index</td>
<td>Standard</td>
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<tr>
<td>(AS 1170, 2011) (Standards Australia)</td>
<td>Structural design actions (All parts)</td>
<td>Standard</td>
</tr>
<tr>
<td>(AS 1580) (Standards Australia)</td>
<td>Paints and related materials - Methods of test (All parts)</td>
<td>Standard</td>
</tr>
<tr>
<td>(AS 1627) (Standards Australia)</td>
<td>Metal finishing - Preparation and pretreatment of surfaces (All parts)</td>
<td>Standard</td>
</tr>
<tr>
<td>(AS 1767.1, 1999) (Standards Australia)</td>
<td>Insulating liquids - Part 1: Specification for unused mineral insulating oils for transformers and switchgear</td>
<td>Standard</td>
</tr>
<tr>
<td>(AS 1824.1, 1995) (Standards Australia)</td>
<td>Insulation co-ordination - Part 1: Definitions, principles and rules</td>
<td>Standard</td>
</tr>
<tr>
<td>Document number or location (if applicable)</td>
<td>Document name</td>
<td>Document type</td>
</tr>
<tr>
<td>------------------------------------------</td>
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</tr>
<tr>
<td>(AS 1931)</td>
<td>High Voltage Test Techniques (All parts)</td>
<td>Standard</td>
</tr>
<tr>
<td>(Standards Australia)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(AS 2067, 2016)</td>
<td>Substations and high voltage installations exceeding 1 kV AC</td>
<td>Standard</td>
</tr>
<tr>
<td>(Standards Australia)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(AS 2700, 2011)</td>
<td>Colour standards for general purposes</td>
<td>Standard</td>
</tr>
<tr>
<td>(Standards Australia)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(AS 4436, 1996)</td>
<td>Guide for the selection of insulators in respect of polluted conditions</td>
<td>Standard</td>
</tr>
<tr>
<td>(Standards Australia)</td>
<td></td>
<td></td>
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<tr>
<td>(AS 60146.1.1, 2002) (Standards Australia, 2002)</td>
<td>Semiconductor converters - General requirements and line commutated converters - Specifications of basic requirements</td>
<td>Standard</td>
</tr>
<tr>
<td>(AS 60270, 2001)</td>
<td>High voltage test techniques – Partial discharge measurements</td>
<td>Standard</td>
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<tr>
<td>(Standards Australia)</td>
<td></td>
<td></td>
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<tr>
<td>(AS 60417.1, 2004) (Standards Australia)</td>
<td>Graphical symbols for use on equipment - Part 1: Overview and application</td>
<td>Standard</td>
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<tr>
<td>(AS 60529, 2004)</td>
<td>Degrees of protection provided by enclosures (IP Code)</td>
<td>Standard</td>
</tr>
<tr>
<td>(Standards Australia)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(AS 61000.3.100-2011, 2011) (Standards Australia)</td>
<td>Electromagnetic compatibility (EMC) - Part 3: Limits - Steady State voltage limits in public electricity systems</td>
<td>Standard</td>
</tr>
<tr>
<td>(AS 62103-2006, 2006) (Standards Australia)</td>
<td>Electronic equipment for use in power stations</td>
<td>Standard</td>
</tr>
<tr>
<td>(Standards Australia)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Standards Australia)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(AS ISO 1000, 1998) (Standards Australia)</td>
<td>The international system of units (SI) and its application</td>
<td>Standard</td>
</tr>
<tr>
<td>(AS/NZS 1102.102, 1997) (Standards Australia)</td>
<td>Graphical symbols for electrotechnical documentation - Part 102: Symbol elements, qualifying symbols and other symbols having general application</td>
<td>Standard</td>
</tr>
<tr>
<td>Document number or location (if applicable)</td>
<td>Document name</td>
<td>Document type</td>
</tr>
<tr>
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<tr>
<td>(AS/NZS 1102.103, 1997) (Standards Australia)</td>
<td>Graphical symbols for electrotechnical documentation – Part 103: Conductors and connecting devices</td>
<td>Standard</td>
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<tr>
<td>(AS/NZS 1102.104, 1997) (Standards Australia)</td>
<td>Graphical symbols for electrotechnical documentation - Part 104: Basic passive components</td>
<td>Standard</td>
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<tr>
<td>(AS/NZS 1102.105, 1997) (Standards Australia)</td>
<td>Graphical symbols for electrotechnical documentation - Part 105: Semiconductors and electron tubes</td>
<td>Standard</td>
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<tr>
<td>(AS/NZS 1102.106, 1997) (Standards Australia)</td>
<td>Graphical symbols for electrotechnical documentation - Part 106: Production and conversion of electrical energy</td>
<td>Standard</td>
</tr>
<tr>
<td>(AS/NZS 1102.107, 1997) (Standards Australia)</td>
<td>Graphical symbols for electrotechnical documentation - Part 107: Switchgear, control gear and protective devices</td>
<td>Standard</td>
</tr>
<tr>
<td>(AS/NZS 2107, 2000) (Standards Australia)</td>
<td>Acoustics—Recommended design sound levels and reverberation times for building interiors</td>
<td>Standard</td>
</tr>
<tr>
<td>(AS/NZS 2310, 2002) (Standards Australia)</td>
<td>Glossary of paint and painting terms</td>
<td>Standard</td>
</tr>
<tr>
<td>(AS/NZS 2312.1, 2014) (Standards Australia)</td>
<td>Guide to the protection of structural steel against atmospheric corrosion by the use of protective coatings - Part 1: Paint coatings</td>
<td>Standard</td>
</tr>
<tr>
<td>(AS/NZS 3000, 2007) (Standards Australia)</td>
<td>Wiring rules</td>
<td>Standard</td>
</tr>
<tr>
<td>(AS/NZS 4383) (Standards Australia)</td>
<td>Preparation of documents used in electrotechnology (All parts)</td>
<td>Standard</td>
</tr>
<tr>
<td>(AS/NZS 4680, 2006) (Standards Australia)</td>
<td>Hot-dip galvanized (zinc) coatings on fabricated ferrous articles</td>
<td>Standard</td>
</tr>
<tr>
<td>(AS/NZS 4777.2:2015, 2015) (Standards Australia)</td>
<td>Grid connection of energy systems via inverters - Inverter requirements</td>
<td>Standard</td>
</tr>
<tr>
<td>(AS/NZS 60076.1, 2014) (Standards Australia)</td>
<td>Power Transformers Part 1: General</td>
<td>Standard</td>
</tr>
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</table>
### Specification for STATCOMs in Zone Substations

<table>
<thead>
<tr>
<th>Document number or location (if applicable)</th>
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<th>Document type</th>
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<tbody>
<tr>
<td>(AS/NZS 60076.6, 2013) (Standards Australia)</td>
<td>Power Transformers - Part 6: Reactors</td>
<td>Standard</td>
</tr>
<tr>
<td>(AS/NZS 60137, 2008) (Standards Australia)</td>
<td>Insulated bushings for alternating voltages above 1000V</td>
<td>Standard</td>
</tr>
<tr>
<td>(AS/NZS 60265.1, 2001) (Standards Australia)</td>
<td>High-voltage switches - Part 1: Switches for rated voltages above 1kV and less than 52kV</td>
<td>Standard</td>
</tr>
<tr>
<td>(AS/NZS 61000-2013) (Standards Australia)</td>
<td>Electromagnetic compatibility (EMC) – (All Parts)</td>
<td>Standard</td>
</tr>
<tr>
<td>(AS/NZS ISO 31000, 2009) (Standards Australia)</td>
<td>Risk management – Principles and guidelines</td>
<td>Standard</td>
</tr>
<tr>
<td>(AS/NZS ISO 9001, 2016) (Standards Australia)</td>
<td>Quality management systems - Requirements</td>
<td>Standard</td>
</tr>
<tr>
<td>(TB 663, 2016) (Cigre)</td>
<td>Guidelines for the Procurement and Testing of STATCOMs</td>
<td>Report</td>
</tr>
<tr>
<td>(IEC 60297-3-100, 2008) (IEC)</td>
<td>Mechanical structures for electronic equipment - Dimensions of mechanical structures of the 482.6 mm (19 in) series - Part 3-100: Basic dimensions of front panels, subracks, chassis, racks and cabinets</td>
<td>Standard</td>
</tr>
<tr>
<td>(IEC 60549, 2013) (IEC)</td>
<td>High-voltage fuses for the external protection of shunt capacitors</td>
<td>Standard</td>
</tr>
<tr>
<td>(IEC 60871-1, 2014) (IEC)</td>
<td>Shunt capacitors for AC power systems having a rated voltage above 1000V - Part 1: General</td>
<td>Standard</td>
</tr>
<tr>
<td>(IEC 61462, 2007) (IEC)</td>
<td>Composite hollow insulators - Pressurized and unpressurized insulators for use in electrical</td>
<td>Standard</td>
</tr>
<tr>
<td>Document number or location (if applicable)</td>
<td>Document name</td>
<td>Document type</td>
</tr>
<tr>
<td>---------------------------------------------</td>
<td>-------------------------------------------------------------------------------</td>
<td>---------------</td>
</tr>
<tr>
<td></td>
<td>equipment with rated voltage greater than 1000V - Definitions, test methods, acceptance criteria and design recommendations</td>
<td></td>
</tr>
</tbody>
</table>
### 3. Definitions, acronyms and abbreviations

#### 3.1 Definitions

For the purposes of this specification, the following definitions apply:

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capacitor bank</td>
<td>An assembly at one location of capacitors and all necessary accessories, such as protection equipment and controls, required for a complete operating installation. (P53H05R03, 2014)</td>
</tr>
<tr>
<td>Connection point</td>
<td>The network location where the STATCOM (via a coupling transformer) is physically connected to the Ergon Energy HV network.</td>
</tr>
<tr>
<td>DNP 3</td>
<td>The DNP 3 protocol structure, functions, and interoperable application options (subset levels) are specified. The simplest application level is intended for low-cost distribution feeder devices, and the most complex for full-featured systems. (IEEE Std 1815, 2012)</td>
</tr>
<tr>
<td>Flexible AC Transmission Systems</td>
<td>Flexible Alternating Current Transmission Systems incorporating power electronics-based and other static controllers to enhance controllability and power transfer capability</td>
</tr>
<tr>
<td>High voltage</td>
<td>Voltage exceeding 1000 V a.c. (AS 2067, 2016)</td>
</tr>
<tr>
<td>Insulated-gate bipolar transistors</td>
<td>Transistor having a conduction channel and a PN junction. The current flowing through the channel and the junction is controlled by an electric field resulting from a voltage applied between the gate and emitter terminals. (IEC 60747-9, 2007-09)</td>
</tr>
<tr>
<td>Manufacturer</td>
<td>An entity that makes goods through a process involving raw materials, components, or assemblies, usually on a large scale with different operations divided among different workers</td>
</tr>
<tr>
<td>Renewables</td>
<td>Renewable energy is energy which can be obtained from natural resources that can be constantly replenished</td>
</tr>
<tr>
<td>Purchaser</td>
<td>Person or entity that is a recipient of a good or service provided by a Supplier under a purchase order or contract of sale</td>
</tr>
<tr>
<td>Shall</td>
<td>Means mandatory</td>
</tr>
<tr>
<td>Should</td>
<td>Means advisory</td>
</tr>
<tr>
<td>Static Synchronous Compensator (STATCOM)</td>
<td>A static synchronous generator operated as a shunt connected SVC, whose capacitive or inductive output current can be controlled independently of the AC system voltage. (IEEE Std 1031, 2011)</td>
</tr>
<tr>
<td>Static Var Compensator (SVC)</td>
<td>A shunt-connected static var generator or absorber whose output is adjusted to exchange capacitive or inductive current to maintain or control specific parameters of the electrical power system (typically bus voltage). (IEEE Std 1031, 2011)</td>
</tr>
<tr>
<td>Supplier</td>
<td>An entity that supplies goods or services</td>
</tr>
</tbody>
</table>
### 3.2 Acronyms and abbreviations

The following abbreviations and acronyms appear in this standard.

<table>
<thead>
<tr>
<th>Abbreviation or acronym</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>AC or a.c.</td>
<td>Alternating Current</td>
</tr>
<tr>
<td>ADAS</td>
<td>Alternative Data Acquisition Service</td>
</tr>
<tr>
<td>ANSI</td>
<td>American National Standards Institute</td>
</tr>
<tr>
<td>AS</td>
<td>Australian Standard</td>
</tr>
<tr>
<td>BIL</td>
<td>Basic Insulation Level</td>
</tr>
<tr>
<td>CAD</td>
<td>Computer Aided Design</td>
</tr>
<tr>
<td>CT</td>
<td>Current Transformer</td>
</tr>
<tr>
<td>DC or d.c.</td>
<td>Direct Current</td>
</tr>
<tr>
<td>DNP</td>
<td>Distributed Network Protocol</td>
</tr>
<tr>
<td>EMT</td>
<td>Electromagnetic Transient</td>
</tr>
<tr>
<td>FAT</td>
<td>Factory Acceptance Test</td>
</tr>
<tr>
<td>HMI</td>
<td>Human Machine Interface</td>
</tr>
<tr>
<td>HRC</td>
<td>High Rupturing Capacity</td>
</tr>
<tr>
<td>HV</td>
<td>High Voltage</td>
</tr>
<tr>
<td>HVAC</td>
<td>Heating Ventilation &amp; Air Conditioning</td>
</tr>
<tr>
<td>IEC</td>
<td>International Electrotechnical Commission</td>
</tr>
<tr>
<td>IED</td>
<td>Intelligent Electronic Device</td>
</tr>
<tr>
<td>IEEE</td>
<td>Institute of Electrical and Electronics Engineers</td>
</tr>
<tr>
<td>IGBT</td>
<td>Insulated-Gate Bipolar Transistor</td>
</tr>
<tr>
<td>ISO</td>
<td>International Organization for Standardization</td>
</tr>
<tr>
<td>ITP</td>
<td>Inspection Test Plan</td>
</tr>
<tr>
<td>LCF</td>
<td>Local Control Facility</td>
</tr>
<tr>
<td>LV</td>
<td>Low Voltage</td>
</tr>
<tr>
<td>MV</td>
<td>Medium Voltage</td>
</tr>
<tr>
<td>MVA</td>
<td>Mega Volt Ampere</td>
</tr>
<tr>
<td>Mvar</td>
<td>Mega Volt Ampere Reactive</td>
</tr>
<tr>
<td>NARI</td>
<td>Network Asset Register Integration</td>
</tr>
<tr>
<td>NEMA</td>
<td>National Electrical Manufacturers Association</td>
</tr>
<tr>
<td>NZS</td>
<td>New Zealand Standard</td>
</tr>
<tr>
<td>OCC</td>
<td>Operational Control Centre</td>
</tr>
<tr>
<td>OTE</td>
<td>Operational Technology Environment</td>
</tr>
<tr>
<td>PDF</td>
<td>Portable Document Format</td>
</tr>
<tr>
<td>PVC</td>
<td>Polyvinyl Chloride</td>
</tr>
<tr>
<td>QA</td>
<td>Quality Assurance</td>
</tr>
<tr>
<td>RCD</td>
<td>Residual Current Device</td>
</tr>
<tr>
<td>RTU</td>
<td>Remote Terminal Unit</td>
</tr>
<tr>
<td>SAT</td>
<td>Site Acceptance Test</td>
</tr>
</tbody>
</table>
4. **Security**

Nil.

5. **Safety and environmental considerations**

Refer to Sections 7, 8.23, 8.24, 15 and 16.

6. **Drawings with specification**

Site specific parameters and requirements for each project shall be included the Project Scope Specification document.

7. **Service conditions**

7.1 **Electrical clearances**

All electrical clearances shall be in accordance with the minimum clearances detailed in the Ergon Energy Clearances in Air standard (STNW3013, 2010). See Table 3 below.

**Table 3 Minimum clearances**

<table>
<thead>
<tr>
<th>Nominal system voltage (Un) (kV)</th>
<th>Exclusion Zone (EZ) (mm)</th>
<th>Ground Clearance (G) (mm)</th>
<th>Section Clearance (S) (mm)</th>
<th>Horizontal Working Distance (H) (mm)</th>
<th>Vertical Working Distance (V) (mm)</th>
<th>Between energised parts and earth (mm)</th>
<th>Between energised parts (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>700</td>
<td>2440</td>
<td>3140</td>
<td>2600</td>
<td>2040</td>
<td>160</td>
<td>185</td>
</tr>
<tr>
<td>22</td>
<td>700</td>
<td></td>
<td>3140</td>
<td>2600</td>
<td>2040</td>
<td>280</td>
<td>325</td>
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<tr>
<td>33</td>
<td>700</td>
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<td>3140</td>
<td>2600</td>
<td>2040</td>
<td>380</td>
<td>440</td>
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<tr>
<td>66</td>
<td>1000</td>
<td></td>
<td>3440</td>
<td>2900</td>
<td>2340</td>
<td>630</td>
<td>725</td>
</tr>
</tbody>
</table>
Specifications for STATCOMs in Zone Substations

<table>
<thead>
<tr>
<th>Nominal system voltage (Un)</th>
<th>Exclusion Zone (EZ)</th>
<th>Ground Clearance (G)</th>
<th>Section Clearance (S)</th>
<th>Horizontal Working Distance (H)</th>
<th>Vertical Working Distance (V)</th>
<th>Between energised parts and earth</th>
<th>Between energised parts</th>
</tr>
</thead>
<tbody>
<tr>
<td>110</td>
<td>1400</td>
<td></td>
<td>3840</td>
<td>3300</td>
<td>2740</td>
<td>1100</td>
<td>1265</td>
</tr>
<tr>
<td>132</td>
<td>1500</td>
<td></td>
<td>3940</td>
<td>3400</td>
<td>2840</td>
<td>1300</td>
<td>1495</td>
</tr>
<tr>
<td>220</td>
<td>2300</td>
<td></td>
<td>4740</td>
<td>4200</td>
<td>3640</td>
<td>2100</td>
<td>2415</td>
</tr>
</tbody>
</table>

Definitions and illustrations of the safety clearances are in Standards Australia Substations and high voltage installations exceeding 1 kV AC (AS 2067, 2016).

When determining minimum clearance, due consideration shall be given to insulators considered as energised parts and cable termination lugs. Where these air clearances cannot be achieved, full insulation or protective barrier for plant highest voltage shall be provided.

Any equipment that requires maintenance while the installation is energized shall be outside the exclusion zone.

### 7.2 Environmental conditions

All materials supplied under this specification that are installed outdoors are required to withstand the following environmental conditions detailed in the Standard for Climatic and Seismic Conditions (STNW3007, 2011).

**Table 4 Environmental conditions**

<table>
<thead>
<tr>
<th>Particular</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Altitude</td>
<td>Less than 1000 metres above sea level</td>
</tr>
<tr>
<td>Ambient temperature</td>
<td>50°C summer daytime (maximum) -5°C winter night time (minimum)</td>
</tr>
<tr>
<td>Humidity</td>
<td>100% (maximum) 25% (minimum)</td>
</tr>
<tr>
<td>Isokeraunic level</td>
<td>40</td>
</tr>
<tr>
<td>Pollution</td>
<td>Level IV – Very Heavy in accordance with (AS 4436, 1996)</td>
</tr>
<tr>
<td>Precipitation</td>
<td>Tropical summer storms with high wind speed and annual rainfall in excess of 2000mm</td>
</tr>
<tr>
<td>Solar radiation (equivalent to a black body temperature of 80°C)</td>
<td>1100 W/m²</td>
</tr>
<tr>
<td>Wind velocity</td>
<td>Wind load in accordance with (AS/NZS 1170.2, 2011) as follows:</td>
</tr>
<tr>
<td></td>
<td>• Annual probability 1:2000</td>
</tr>
<tr>
<td></td>
<td>• Region C with V2000</td>
</tr>
<tr>
<td></td>
<td>• Terrain Category 2</td>
</tr>
<tr>
<td>Specification for STATCOMs in Zone Substations</td>
<td></td>
</tr>
<tr>
<td>-----------------------------------------------</td>
<td></td>
</tr>
<tr>
<td>• Shielding Multiplier 1.0</td>
<td></td>
</tr>
<tr>
<td>• Topographical Multiplier to suit site</td>
<td></td>
</tr>
<tr>
<td>• Wind gust speed 260 km/h (72 m/s)</td>
<td></td>
</tr>
</tbody>
</table>
7.3 Functional characteristics

The STATCOM should consist of power inverters with a common DC bus to inject reactive current (leading or lagging) into the power system to dynamically provide continuous regulation. Connection to the power system is via coupling equipment suitable for the applicable class of distribution, sub-transmission or transmission network voltage.

The STATCOM shall be capable of generating continuously variable inductive or capacitive shunt compensation up to the specified reactive power ratings of the STATCOM at the point of connection to the Ergon Energy network.

The STATCOM shall have high availability, reliability and shall remain stable in its operation in the presence of system disturbances and other dynamically real and reactive loads in the network it is connected to.

The STATCOMs shall be installed in exposed outdoor substations on pad-mounted slabs or in containerised enclosures. If oil filled transformers are used in the design, they shall adhere to all oil containment requirements as detailed in 8.23.

If a hybrid solution is proposed then any additional HV plant that is supplied shall meet the requirements of the relevant technical specifications provided by the Purchaser. When offering hybrid solutions they shall consider the following issues:

- Full dynamic support for expected contingencies without the use of overload.
- Primary purpose for fixed reactive plant shall be for loss reduction, long term steady state regulation, such as compensation for line susceptance.

The STATCOM system should allow the provision of future integration and connectivity of energy storage solutions.

The STATCOM shall be used for any of the following operational functions simultaneously:

- Bus voltage support
- Reactive power support
- Reduce the level of harmonics on the power system
- Reduce voltage unbalance on the power system
- Reduce the impact of oscillatory voltage transients
- Rapidly compensating for high or low voltage events such as system faults and load rejection
- Power factor correction

7.4 Power system voltage

Ergon Energy network voltages include 11, 22, 33, 66, 110, 132 & 220 kV. The voltage profile of the system is normally maintained between 0.95 and 1.05 per unit (pu). All power system equipment must be capable of continuous operation at voltages between 0.9 pu and 1.1 pu.

Site specific parameters shall be included in the Project Scope Specification document.
Specification for STATCOMs in Zone Substations

The STATCOM shall provide the rated three phase reactive power output range (leading and lagging currents), at the point of connection, without any degradation of performance, for power system Over-voltages and periods:

- 0.9 pu to 1.1 pu continuously
- 1.15 pu for 1800 seconds
- 1.2 pu for 30 seconds
- 1.3 pu for 2.0 seconds
- 1.5 pu for 0.2 seconds

This is required to ensure compliance with the AEMO Recommended Technical Standards For Generator Licensing In South Australia, Published: 31 March 2017 and the National Electricity Rules, Chapter 5 - Network Connection, Planning and Expansion, S5.1.a.4, as a consequence of a credible contingency event; the voltage of supply at a connection point should not rise above its normal voltage by more than a given percentage of normal voltage for longer than the corresponding period shown in NER v94 S5.1a.1 Figure 1 (Figure S5.1a.1) for that percentage and the voltage of supply at a connection point could fall to zero for any period.

### 7.5 Power system frequency

The STATCOM shall provide the rated three phase reactive power output range (leading and lagging currents), at the point of connection, without any degradation of performance, for power system frequencies from 46.5 Hz to 52.5 Hz for a period of at least 4 minutes.

This is required to ensure compliance with the AEMC Reliability Panel, “Application of Frequency Operating Standards During Periods of Supply Scarcity”, FINAL REPORT, 15 April 2009. Frequency characteristics for design purposes are shown in Table 5.

These requirements override those of section 6.3.2.2 of Standards Australia Electronic equipment for use in power stations (AS 62103-2006).

**Table 5 - NEM Mainland Frequency Operating Standards – interconnected system**

<table>
<thead>
<tr>
<th>Condition</th>
<th>Containment</th>
<th>Stabilisation</th>
<th>Recovery</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accumulated time error</td>
<td>5 seconds</td>
<td></td>
<td></td>
</tr>
<tr>
<td>no contingency event or load event</td>
<td>49.75 to 50.25 Hz, 49.85 to 50.15 Hz 99% of the time</td>
<td>49.85 to 50.15 Hz within 5 minutes</td>
<td></td>
</tr>
<tr>
<td>generation event or load event</td>
<td>49.5 to 50.5 Hz</td>
<td>49.85 to 50.15 Hz within 5 minutes</td>
<td></td>
</tr>
<tr>
<td>network event</td>
<td>49 to 51 Hz</td>
<td>49.5 to 50.5 Hz within 1 minute</td>
<td>49.85 to 50.15 Hz within 5 minutes</td>
</tr>
<tr>
<td>separation event</td>
<td>49 to 51 Hz</td>
<td>49.5 to 50.5 Hz within 2 minutes</td>
<td>49.85 to 50.15 Hz within 10 minutes</td>
</tr>
<tr>
<td>multiple contingency event</td>
<td>47 to 52 Hz</td>
<td>49.5 to 50.5 Hz within 2 minutes</td>
<td>49.85 to 50.15 Hz within 10 minutes</td>
</tr>
</tbody>
</table>
Conformance shall be demonstrated using a variable frequency source that is capable of sourcing and sinking the full reactive power output of the STATCOM while supplying the real power required for the STATCOM to operate.

7.6 Power system fault levels

All primary plant, secondary equipment or components in the STATCOM system should be capable of sustaining, without damage, any fault limited by the maximum design short-circuit level and duration of the system and the coupling equipment impedances.

The minimum and maximum fault levels at the point of connection to the Ergon Energy network shall be detailed in Project Scope Specification document.

The fault ratings for primary plant installed at the point of connection to the Ergon Energy network shall be detailed in Project Scope Specification document.

7.7 Audio frequency load control blocking

The Ergon Energy network uses Audio Frequency Load Control (AFLC) as a demand management tool for specific loads at certain times of the day, such as hot water systems and air conditioning. A ripple control frequency is modulated onto the 50 Hz waveform which varies depending on the region. The frequencies currently used by Ergon Energy are 167 Hz, 217 Hz, 225 Hz, 317 Hz and 425 Hz. The STATCOM system must not act as a sink to the AFLC signal otherwise demand management system will be compromised. The supplier shall detail how this is achieved in the design and prove during commissioning. The Purchaser shall include the AFLC frequency that is to be blocked in the Project Scope Specification document.

7.8 Voltage Unbalance

Voltage unbalance on the Ergon Energy network, expressed as the ratio of the Negative Phase Sequence Voltage to the Positive Phase Sequence Voltage, should not, under normal system conditions (i.e. no contingency) exceed:

<table>
<thead>
<tr>
<th>Nominal supply voltage (kV)</th>
<th>Maximum negative sequence voltage (% of nominal voltage)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Column 1</td>
<td>Column 2 Column 3 Column 4 Column 5</td>
</tr>
<tr>
<td></td>
<td>no contingency event credible contingency event or protected event general once per hour</td>
</tr>
<tr>
<td></td>
<td>30 minute average 30 minute average 10 minute average 1 minute average</td>
</tr>
<tr>
<td>more than 100</td>
<td>0.5 0.7 1.0 2.0</td>
</tr>
<tr>
<td>more than 10 but not more than 100</td>
<td>1.3 1.3 2.0 2.5</td>
</tr>
<tr>
<td>10 or less</td>
<td>2.0 2.0 2.5 3.0</td>
</tr>
</tbody>
</table>

These limits apply for normal and credible single contingency conditions as per the National Electricity Rules for Distribution Network Service Providers (DNPSs).
Although the National Electricity Rules state that the 1 minute voltage unbalance limit of 2% can be exceeded once per hour, they do not prescribe by how much. Large voltage unbalances, over 2%, may occur for short intervals of up to one minute due to faults, switching operations or transformer energisation. Ergon Energy sub-transmission and transmission lines are generally fully transposed.

For network operated STATCOMs it is likely within the distribution system that the STATCOM will be required to mitigate negative sequence unbalance therefore it is expected that the STATCOM is able to withstand unbalance equal to twice the system standard.

7.9 Auto-Reclose
The Ergon Energy network uses auto-reclosing on feeders. Dead-times of up to 10 seconds are typical with up to four shots to lockout if unsuccessful. The Purchaser shall include the auto-reclose details at the point of connection in the Project Scope Specification document.

7.10 Protection details and operating times
The Purchaser shall include the protection details and operating times at the point of connection in the Project Scope Specification document.

8. Design and construction

Site specific ratings, parameters and requirements for each project shall be included the Project Scope Specification document.

This should include:

- Project scope summary
- Project milestones
- Site location
- Contractual requirements
- STATCOM ratings and requirements
- Single line diagrams
- Site general arrangements and layouts
- Details of connected bus
- Details of regulated bus (if different from point of connection)
- Assumptions
- Exclusions

8.1 Engineering studies

System impedances and fault levels of the network relevant to the engineering studies required shall be provided by the Purchaser. These values shall be provided in the Project Scope Specification document.

The studies shall demonstrate that the STATCOM, coupling equipment and any fixed reactive plant such as capacitor banks and reactors included in the design solution shall meet all specified performance criteria.

Acceptance of the engineering studies by the Purchaser does not absolve the Supplier’s overall responsibility for the proper functioning of the STATCOM. The Supplier shall list in their offer all engineering studies.
Engineering studies shall outline general methodology, modelling approach and software employed and should include, but not be limited to the following:

- Insulation coordination studies with reference to section 8.13.
- Audible noise studies with reference to section 8.15.
- Dynamic performance studies (section 10) in accordance with Cigre Guidelines for the Procurement and Testing of STATCOMs (TB 663, 2016) with reference to section 10.
- Harmonic performance, resonance and harmonic amplification studies section 8.8
- Audio frequency load control (AFLC) signal absorption studies section 7.7.
- Availability studies with reference to section 18.
- Reliability studies with reference to section 19.

The events simulated shall use worst case situations and values including graphical results where appropriate. Conclusions shall be provided that confirm the offered STATCOM and its plant and equipment meet the specification requirements. Where this is not possible, detailed reasons why shall be provided along with recommended modifications to make the installation viable.

### 8.2 Computer models

The Supplier will develop various computer models for use in load flow analysis, dynamic stability and transient simulations. These models shall be provided to the Purchaser by the Supplier. These models shall be benchmarked throughout the various phases of the project, with a final validation being done against the actual installed system during the system integration tests as defined in section 10.5. For a suitable benchmark of any model, the Purchaser shall provide accurate power system data and contingency scenarios.

The Supplier shall provide PSS®E and Power Factory models for Steady State/RMS analysis and detail the minimum SCR for which these models are valid.

The Supplier shall provide an electromagnetic transient-type simulation model of the STATCOM compatible with PSCAD version 4.6.0 or later and with an Intel Fortran compiler version 11 or later to assess the impact and effect of connecting specific device the Ergon Energy network. This is required to facilitate stability analysis and the interaction of the STATCOM with other active electronic devices.

All PSCAD models shall be black boxed real code models including all control and protection functions and phase locked loop performance. Model veracity must be demonstrated through; measurement results (from an equivalent facility and plant performance from other installations, lab tests, hardware in loop etc.) confirming the validity of the PSCAD vs PSS®E models using a set of benchmarking tests of faults and contingency scenarios. All PSCAD models shall be programmable with any control modes available including adjustment settings such as; gains, set-points, limits, etc..

All STATCOM models are required to be made available to any connecting party through a methodology that is mutually agreeable to the Purchaser and the Supplier. The Purchaser’s preference is that all models can be included freely with the transmittance of the Purchaser’s system model. The provision of the Purchaser’s system models is either under an NDA or commercial in confidence as per relevant law, regulations, laws and guidelines.
8.3 Design reports and drawings

Design reports and drawings detailing STATCOM and associated substation design plant, components, physical layouts, electrical connections, protection, controls and communications shall be provided by the Supplier. Design reports shall contain full details of key considerations, assumptions made, calculations performed and reference materials used in the design. The design of the major aspects, systems, components, plant items and settings shall be addressed and detailed in the reports. Design reports may be submitted as a complete document or progressively.

Design reports and drawings should include, but not be limited to the following:

STATCOM Design and drawings:

- Main Component Design (determine L and C values and ratings of components)
- Harmonic Studies
- Transformer Design (for each different transformer)
- Reactor Design
- Capacitor Design
- Thyristor Valve Design
- Thyristor Valve Cooling System Design
- Reliability, Availability and Maintainability (RAM) calculation
- Loss Assessment

Substation Design and drawings:

- Insulation Coordination Study
- Lightning and surge protection
- Earthgrid Study and design
- EMF at 50Hz and harmonic frequencies
- Noise Level
- HV plant and equipment
- Bus bars and HV connections
- Conduits and cabling
- Lighting and power
- Fully dimensioned General Arrangement in plan and elevations

Civil Design and drawings:

- Transformer Foundation
- Landing Structures
- Support Structures for plant and bus bars
- Foundations & Footings
- Roads, Kerbs & Drainage
- Oil Containment
- Control Building & Building Systems

Secondary Systems Design and drawings:

- Auxiliary Supply Systems (AC & DC)
- Control Systems including Alarms and Indications (SCADA)
- Protection Systems
Specification for STATCOMs in Zone Substations

- Communications Systems
- Schematics, connection diagrams, cable schedules

Single Line Diagrams should include but not be limited to the following:

- Point of connection of STATCOM system to Ergon Energy network
- STATCOM detailing:
  - Reactive power rating
  - AFLC blocked frequency
  - Cooling method
- All circuit breakers disconnectors and earth switches
- All instrument transformers for metering and protection VTs and CTs detailing:
  - Ratios, ratings and class
- All surge arresters
- Power transformer detailing:
  - Power rating
  - Voltages of windings
  - Vector group and phase shift
  - Earthing arrangement
  - Nominal impedance in percent
  - Nominal turns ratio
- Fixed capacitor banks, detailing tuned branches:
  - Connection arrangements
  - Capacitance of capacitor banks in microfarads
  - Inductances of tuning reactors in milli-Henries
- Fixed Inductors with Inductance value of reactors in milli-Henries

General Arrangements fully dimensioned in plan and elevations should include but not be limited to the following:

- Size and location of STATCOM system with within zone substation
- Locations of any buildings
- Locations of major plant and auxiliary equipment
- Locations of busbars and connections
- Locations of foundations, cableways and conduits
- Lightning masts
- Earth grids

8.4 Stability and fault ride through

The STATCOM must remain stable and in operation throughout system events and disturbances where system voltage and frequency excursions may temporarily exceed expected normal operating conditions. The STATCOM shall be capable of uninterrupted operation during and following power system voltage, frequency and voltage/current waveform disturbances some of which may occur simultaneously. Severity and likelihood of these events should be considered when undertaking power system studies.

The STATCOM must be capable of withstanding any combination of voltage disturbances resulting in the voltage at the respective LV terminals of the equipment to drop below 85% of the nominal for a total duration of 1,800 ms within a 5 minute interval (moving window), regardless of disturbance type, duration, and residual voltage at the generating unit’s terminals.
Note that this requirement applies in addition to the voltage requirements in section 7.4. Examples of conditions where successful fault ride-through response is required include:

- 15 faults each cleared within 120 ms.
- 18 faults each cleared within 100 ms.
- 5 faults each cleared within 220 ms + 7 faults each cleared within 100 ms.

The STATCOM must be capable of returning to regulation within 10 ms of voltage recovery following a fault.

Multiple control modes for fault ride through include:

- Full capacitive
- Full inductive
- Settable partial reactive levels
- Online with no switching

As a result of a credible contingency event it is expected that the voltage at the STATCOM connection point could fall to zero. For such faults the STATCOM must ride through, including any reclose sequences.

Suppliers must guarantee that STATCOMs can meet specified availability and reliability and be stable in operation. If a STATCOM would not remain in uninterrupted operation for any of the specified system conditions, suppliers must state the limiting conditions. Suppliers must state any requirements in this Specification that they consider unachievable with a full explanation supplied together with alternative proposals.

### 8.5 Reactive power output

The reactive power output provided by the STATCOM shall be capable of being either leading (capacitive) or lagging (inductive). The rated reactive power output shall be provided over the full operating voltage range, frequency range and operating conditions detailed in Project Scope Specification document at the point of connection to the Ergon Energy network. The required rating shall apply under the environmental conditions detailed in section 7.2, for the design life in section 17 and availability in section 18.

The minimum operational three phase reactive power output range at the point of connection for the STATCOM, at normal operating frequency range 49.85 to 50.15 Hz and voltage operating range of 0.9 to 1.1 pu should be detailed in the Project Scope Specification document.

Redundancy design provisions of the STATCOM plant, equipment and critical spares shall be detailed to confirm the basis of the continuous capability. If further redundancy or duplication of the components may improve the availability of the STATCOM system, the Supplier may include this as an option in the offer.

Suppliers shall include a Reactive Capability Performance Characteristic, which shows voltage control versus Mvar output over the specified full operational reactive output range of the STATCOM. Suppliers shall guarantee the performance determined and documented in a Reactive Capability Performance Report shall be possible. The report will detail all values and calculations undertaken to compile the assessment including stability required in section 8.4.
Specification for STATCOMs in Zone Substations

The reactive power output as per the Project Scope Specification is required to be met with consideration for any derating, e.g. harmonic mitigation, negative phase sequence mitigation, etc.

If during commissioning or in service the STATCOM is incapable of the specified reactive capability Performance over the full operational range, the Supplier may be liable for liquidated damages.

8.6 Short term overload capability
The STATCOM should have a minimum overload capacity of 200% for a minimum of 2 seconds. This requirement is to aid in low or high voltage disturbances due to system fault transients, flicker and load rejection situations.

8.7 Negative phase sequence mitigation
The STATCOM must be capable of mitigating negative sequence current of a minimum of 10% of the full operational output rating. The requirement for negative phase sequence must not reduce the STATCOMs capability to meet the reactive power output or harmonic mitigation requirements.

8.8 Harmonics performance
The STATCOM shall be configured to avoid resonance with any existing power system components. The generation of harmonic voltages and currents on the Queensland system is strictly controlled. The maximum permissible harmonic voltages, as a combined result of all harmonic sources, are limited to the planning levels given in Table 2 of IEC Electromagnetic compatibility (EMC) Part 3.6: Limits - Assessment of emission limits for the connection of distorting installations to MV, HV and EHV power systems (IEC 61000-3.6).

To preserve the limits throughout the system, harmonic voltages arising from harmonic currents generated by the STATCOM shall be limited to one third of these planning levels. The limits are the target levels for continuous harmonic generation. It shall be considered that all characteristic STATCOM generated harmonics (i.e. the odd series) are continuously produced. Limits must be achieved for a system frequency range of 49.85 to 50.15 Hz.

The harmonic distortion shall be studied and verified through tests provided to the Purchaser. During commissioning the harmonic currents injected into the point of connection by the STATCOM over the full operational range of the unit shall be measured to verify the harmonic performance.

A Harmonic performance, resonance and harmonic amplification studies and report shall include:

- The general methodology, modelling approach and software employed
- The predicted highest harmonic currents up to the fiftieth (50th) injected into the point of connection by the STATCOM
- A summary of the highest system harmonic voltages up to the fiftieth (50th) appearing on the system
- A general description and outline of the design calculations including the voltage and current rating of the filter components
- Studies to check ability of filter components to withstand overvoltage and frequency variation conditions

The Supplier should propose a standardised or industry-accepted test method to verify harmonic performance including the performance of the audio frequency blocking filter. This study shall
Specification for STATCOMs in Zone Substations

include the effects of the STATCOM(s) on the electrical network and all existing plant. A detailed report of these studies shall be submitted to the Purchaser after award of the contract.

The STATCOM must be capable assisting in the reduction of system harmonics, e.g. active harmonic filtering, PWM switching algorithms, etc..

The requirement for harmonic mitigation sequence must not reduce the STATCOMs capability to meet the reactive power output or negative phase requirements.

8.9 Transient response

The STATCOM shall be capable of responding to changes of measured system values within 10 ms.

The change of measured system voltage to small disturbance should reach 90% of the desired total change within 60 ms of initiating a 5% step change of voltage reference.

The maximum overshoot shall not exceed 10% of the final value, and the settling time should not exceed 100 ms, after which the voltage shall be within ±5% of the final value defined as the settling band in Figure 5.

The response of the system voltage using the actual controller shall be validated on a real-time simulator. A Thevenin network equivalent is sufficient for this purpose.

![Figure 5 - Definition of Transient Response, Overshoot and Settling Time](image-url)
8.10 Monitoring, control and indication

The Supplier shall adhere to the requirements of the Purchaser's internal Operational Technology Standard for Data Collection (STNW3374, 2015) and the Standard for Intelligent Electronic Devices (STNW3383, 2015). These standards detail the requirements for the monitoring, collection and storage of operational data for the purposes of SCADA, metering or the Alternative Data Acquisition Service (ADAS) onto the Purchaser's Operational Technology Environment (OTE).

8.10.1 Communication equipment

The STATCOM control system shall include all communication equipment required to interface with the Purchaser's communication network.

8.10.2 SCADA and engineering access

The STATCOM system shall have an Ethernet 100base FX port that supports multiple access for DNP 3, IEC61850 Ed.2, engineering access and SCADA over Ethernet and be equipped for IP-based communications. All operational events and alarms shall be time stamped.

The Supplier shall provide remote communication capabilities for the STATCOM system. The STATCOM system shall be interfaced with the Purchaser's SCADA system via a RTU utilizing DNP 3 to enable operational control centres (OCC) at a remote location to monitor, start-up, adjust and shut down the STATCOM system. In addition, the STATCOM system shall provide performance data and alarms to the SCADA system.

8.10.3 Monitoring

Provision shall be made to allow internal control system signals to be monitored externally as analogue outputs. All channel outputs should be refreshed at least 6 times per 50 Hz cycle.

The minimum quantities to be provided shall be as below. Additional signals may be required up to a minimum of twelve in total:

- Connected bus voltage input magnitude
- Regulated bus voltage input magnitude
- STATCOM voltage set-point
- STATCOM Mvar output
- Voltage regulator output

Digital outputs are also required for external event recording and monitoring from logic signals within the STATCOM control system. A minimum of twelve digital outputs will be required.

8.10.4 Data logging

The system shall be capable of logging all events and alarms that the STATCOM system produces and store the information to be accessed later via the OTE.

Digital recordings of disturbances within the STATCOM and the power system shall provide two types of recordings:

- High speed recordings of waveforms, firing pulses, etc shall be taken at a user selectable recording rate between 1 and 2.5 kHz.
Specification for STATCOMs in Zone Substations

- Slower recordings of phasor quantities and time-based averages shall be taken at a maximum recording rate of 50 Hz to record ac quantities from the power system and analogue quantities from the SVC control system.

The Suppliers shall include details of the proposed disturbance monitoring and recording devices to be provided.

Recording devices shall be installed within the STATCOM building and be highly reliable to ensure successful recording of severe, infrequent disturbances such as voltage excursions and electromechanical oscillations. This shall be for the service conditions detailed in section 7 and stability in section 8.4.

Recording devices provided shall include:

- Self-monitoring, providing alarm indication to the Principal on failure
- Have remote reset facilities
- Powered off the auxiliary DC supply

The recording channels will be of several kinds, including but not limited to those listed in Table 7 below.

**Table 7 - Recording device minimum input channels**

<table>
<thead>
<tr>
<th>Input Channel Type</th>
<th>Minimum Number</th>
<th>Input Signals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alternating Voltage High Speed</td>
<td>3</td>
<td>Three phases of voltage Regulated Bus</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>Three phases of voltage Connected Bus</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>Spare</td>
</tr>
<tr>
<td>Alternating Voltage slow speed</td>
<td>6</td>
<td>Three phases of Regulated Bus voltage (Magnitude and angle)</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Spare</td>
</tr>
<tr>
<td>Alternating Current High Speed</td>
<td>3</td>
<td>Three phases of STATCOM primary current</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>Three phases of STACTCOM secondary current</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>three phases current of any fixed reactive devices</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Spare</td>
</tr>
<tr>
<td>Alternating Current slow speed</td>
<td>3</td>
<td>Three phases of STATCOM primary current</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>Three phases of STACTCOM secondary current</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>three phases current of any fixed reactive devices</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>Three phases of summated currents used for spare inputs (magnitude an angle)</td>
</tr>
<tr>
<td>other analogue slow speed</td>
<td>1</td>
<td>SVC voltage input magnitude</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>SVC voltage set-point</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>Voltage regulator output (per phase)</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>SVC Mvar output (per phase)</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>132kV NPS voltage</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>Frequency</td>
</tr>
<tr>
<td></td>
<td>14</td>
<td>Spare</td>
</tr>
<tr>
<td>Digital inputs</td>
<td>As required</td>
<td>All protection trips</td>
</tr>
<tr>
<td></td>
<td>As required</td>
<td>All alarms and faults</td>
</tr>
<tr>
<td></td>
<td>12</td>
<td>Spare</td>
</tr>
</tbody>
</table>
Recorders will continuously monitor inputs using digital signal acquisition channels. The quantities measured will be alternating voltage and current, control system signals and logic signals. In addition to storing the sampled waveforms, power system quantities will be calculated:

- Voltage and current phasors
- Real and reactive power
- Frequency

Averaged control system quantities shall be determined over the same period as the AC quantities are determined. These will be produced synchronously in real time, at a minimum rate of 20 times per second and a maximum rate of 50 times per second.

Recorders will sample continuously and record only when a trigger condition is detected. On triggering, the recorder will save the sampled waveforms and logic quantities at the high speed recording rate and the power system phasor quantities, frequency and control system quantities at the slower recording rate. These quantities will be saved to permanent mass storage. A certain number of pre and post trigger samples will be saved as configured by the user.

The recorder is not required to store real and reactive power quantities if these can be calculated from the phasor quantities. The recording devices provided shall be able to record voltage phasors, current phasors and frequency at a selectable fraction of the rate at which these quantities are produced. This will facilitate long recording times.

The triggering facilities provided with the equipment shall include the following.

- Maximum, minimum and maximum absolute value of rate of change triggers
- based on any or all of the following:
  - Frequency
  - RMS voltage magnitude
  - RMS current magnitude
  - Any phasor magnitude
  - Any phasor angle
  - Power flow
  - Reactive power flow
  - Electronic analogue quantities
- Event triggers, where any event channel input changes state either up or down, with selectable direction.
- Time triggers:
  - One shot, at a single selectable date/times
  - Daily, at selected times
  - On a weekly cycle, with selectable days and times
- Manual triggers both locally and remotely

All triggers must be selectable independently during normal operation of the recording device. For each trigger selected it shall be possible to specify:

- The kind of trigger
- The channel on which it operates
Specification for STATCOMs in Zone Substations

- The numerical data describing the trigger and the level at which it operates
- The rate at which data shall be saved to permanent mass storage upon triggering
- The length of pre-trigger and post-trigger period to be saved, in terms of numbers of saved samples.

It must be possible to save alternative trigger selections to permanent mass storage and to easily change between them.

The recorded data will be saved directly to permanent mass storage as a single file; the records for the separate channels shall not be split into separate files. It is not required to save both the high speed and slow speed recordings to the same file.

The file produced shall contain sufficient additional information to completely identify the data recorded therein, preferably as follows:

- Site identifier
- Recorder identifier
- Time/date of trigger, accurate to better than 1 millisecond compared with the actual
- trigger time
- Trigger identification
- Channel names, quantity types and units
- The recorded data

A sequence-of-events record shall be maintained which records the time, date, channel identification and transition direction whenever one of the event channels undergoes a voltage transition.

The mass storage device shall be sufficiently sized to hold at least 10 recordings of 12 analogue channels sampled at 2.5 kHz for 3 seconds duration. Any recorder provided shall include software capable of ensuring that there is always sufficient permanent mass storage space available to store data from a trigger. When this requires automatic deletion of recorded files, the order of deletion shall be oldest first. Note that it is the Purchaser's expectation that the volume of data stored for recent events should be in an efficient storage format and suitable for remote downloading as indicated above.

### 8.10.5 Control modes

Suppliers shall include a Dynamic Control and Regulation Performance Characteristic, which shows voltage control versus output over the specified full operational reactive output range of the STATCOM. Suppliers shall guarantee the performance determined and documented in a Control Assessment Report shall be possible. The report will detail all values and calculations undertaken to compile the assessment.

If during commissioning or in service the STATCOM is incapable of the specified dynamic control over the full operational range, the Supplier may be liable for liquidated damages.

The STATCOM system shall provide as a minimum the following control modes simultaneously:

- Voltage
- Voltage droop
- Constant var
- Power factor
- Capacitor & reactor switching
Specification for STATCOMs in Zone Substations

- Negative phase sequence unbalance (10% total current)
- A configurable/programmable gain option
- Power oscillation dampening
- Frequency droop

Suppliers shall provide a detailed description of start-up and shut-down sequences including flow diagrams and an indication of times required in each stage. The start-up and shut-down sequences shall minimise the reactive step during switch on and switch off of the STATCOM, except when the unit has tripped by protection systems as per section 8.12.

The Start-up control sequence shall:

- Be fully automatic following the start-up signal which may be locally or remotely applied
- Indicate ready to start or if not ready, list all reasons why a start is inhibited
- Set the voltage regulator to the level existing immediately prior to sending a circuit-breaker close allowed signal
- Indicate locally and at the remote operator’s location when the unit is fully regulating and ready to receive voltage set point instructions from the operator.

The Shut-down control sequence shall:

- Be fully automatic following the shut-down signal which may be locally or remotely applied
- Gradually adjust the STATCOM output to zero Mvar at an adjustable rate in order to mitigate voltage fluctuations.
- Indicate locally and at the remote operator’s location that the unit is fully shut-down and off line
- After the STATCOM circuit-breakers open, ensure that the energy stored in capacitors is discharged without any detrimental effect on STATCOM system components.

An Emergency Shut-Down shall be undertaken when the STATCOM must act to protect itself from damage due to faulty equipment and/or dangerous system conditions and if necessary, shall be tripped as fast as possible. The control system shall self-diagnosis and initiate immediate and appropriate actions such as shut-down or control system response blocked for an appropriate period. Suppliers shall provide details of their proposed self-diagnosis capability.

Suppliers shall provide a table of all protection trips triggered internally or externally to the STATCOM and shall indicate which trips are to be controlled in a stepped manner and which are to be instantaneous in accordance with section 8.12.

8.10.6 Alarms and trips

A central control unit shall monitor its own operation and the operations of the various STATCOM components. Two levels of status alert shall be provided. The first-level (alarm) indicates that a problem exists but that the equipment or its proper operation is not in immediate danger. The second-level (trip) initiates the immediate isolation or a controlled shutdown of the STATCOM due to equipment problems that might cause damage if left uncorrected.

Alarms include the following as a minimum:

- Auxiliary power supply failure; back-up supply in use
- Cooling system status and problems as per section 8.18
Specification for STATCOMs in Zone Substations

- Loss of redundant inverters
- Branch availability
- Loss of signal-measuring controlled busbar voltage, with the control continuing to maintain the last STATCOM operating point, unless the regulated busbar voltage is also the source of synchronizing voltage

Trips include the following as a minimum:

- Loss of all control power
- Loss of cooling system rated capabilities as per section 8.18
- Loss of synchronizing voltage source
- Excessive number of inverter failures

The central control unit should also have a built-in protective system for self-monitoring (watchdog).

Suppliers shall provide a table of all alarms and protection trips triggered internally or externally to the STATCOM and shall indicate which trips are to be controlled in a stepped manner, and which are to be instantaneous.

**8.10.7 Operator interface**

The STATCOM should provide a local control facility (LCF) and/or indication panel for local control and monitoring.

Hard-wired switches shall be included to enable auto-run, stop, system shutdown and local or remote/SCADA control where only one control point can be active at any one time. Indication LEDs shall also be used to indicate running status, selected control point and active alarms as a minimum.

The control modes shall be selectable and configurable either locally via the LCF or remotely by the OCC. The STATCOM system status and alarms shall be viewed and/or reset via the LCF or remotely by the OCC.

If a hybrid solution is implemented, capacitor banks and/or reactors shall be available to be switched independently if the STATCOM system is out of service.

**8.11 Power electronics & inverters**

The STATCOM inverter banks shall comprise of four quadrant IGBT inverter modules configured to meet the operating, performance and availability requirements. Each power inverter module shall be self-contained and include protection, isolation, charging circuits and sine filter network.

The inverter configuration shall be modular in design and allow the system to be expandable up to the rating of the coupling transformer (if required) or as otherwise stated in the Project Scope Specification document.

The inverter configuration shall provide a high level of redundancy and reliability. Failure of an individual module shall not prevent the operational capabilities of the STATCOM. If an individual module fails it shall automatically disconnect itself from the circuit and the remaining inverter modules shall continue to operate without interruption.
**8.12 Protection**

The protection relays shall receive their inputs from appropriately rated instrument transformers that are either supplied as part of the STATCOM system or by the Purchaser. Redundant protective functions should be included and demonstrated in the design. The use of common instrument transformers is acceptable.

All protection schemes shall be designed to ensure a high degree of reliability and be graded and coordinated to prevent mal-operation. Fail-safe principles should be applied throughout.

The following sections detail the minimum protection requirements for the STATCOM plant and equipment.

**8.12.1 Inverters**

Inverters shall have the following protection:

- Instantaneous overcurrent
- Time overcurrent
- Undervoltage
- Overvoltage
- Temperature supervision
- Reverse phase lockout supervision
- Ground fault supervision

**8.12.2 Coupling transformer (if required)**

Coupling transformers smaller than 6.3 MVA are typically fitted with HV fuses however for coupling transformers greater than 6.3 MVA, a duplicated differential protection scheme shall be employed.

The differential protection scheme shall have:

- Overcurrent and earth fault
- Restricted earth fault
- Differential protection
- Oil and winding temperature
- Gas accumulation and oil surge (Buchholz)
- Pressure relief relay

**8.12.3 Reactors**

Reactors shall have the following protection:

- Overcurrent and earth fault

**8.12.4 Capacitor banks**

Capacitor banks shall have the following protection:

- Overcurrent and earth fault
- Overload
- Unbalance
8.13 Insulation coordination
The Supplier shall be responsible for the Insulation Co-ordination design with respect to system or lightning over voltages within the STACTCOM area.

The Supplier shall design the STATCOM and associated equipment to comply with Ergon Energy Substation Insulation Coordination Standard (STNW3034, 2009) and Selection of Surge Arresters. (Ergon Energy, 2008).

All calculations and supporting documentation for the insulation co-ordination design shall be submitted to the Purchaser. The documentation shall include the Surge Arrestor details and appropriate calculations in determining their adequacy both in terms of current capacity and energy absorption.

Any inadequacies in the Suppliers' design shall be rectified at the Supplier's expense. The supply and installation of all surge arresters shall be included in the offer.

8.14 Electromagnetic field (EMF)
The Supplier shall include in the Design Report the details of models used and the results obtained from studies to determine the magnitude of the electric and magnetic fields associated with the STATCOM. Electromagnetic interference studies shall be in accordance with the Cigre Guidelines for the Procurement and Testing of STATCOMs (TB 663, 2016) for the STATCOM system and surrounding equipment that may be affected.

Ergon Energy practices a policy of prudent avoidance of excessive electromagnetic field (EMF) levels in regards to the placement of new electrical infrastructure.

The Australian Radiation Protection and Nuclear Safety Agency (ARPNSA), “Electricity and Health - Fact Sheet 19,” ARPANSA, 2011, states that there is no firm scientific evidence that exposure to EMF fields found near powerlines poses a hazard to human health. However, it is prudent to avoid excessive EMF levels where it can be achieved at a reasonable cost.

Energy imposes an additional requirement for special conditions (defined below) of a 4mG limit. The reason behind this limit was a study performed by Sir Richard Doll who found a small association between prolonged exposure to EMF above 4mG (equal to 0.4 µT) and leukaemia in children. However the ARPNSA notes that:

“The average level of 0.4 µT referred to in the conclusion to the Doll report is not an exposure limit or safe level. This exposure level was arbitrarily selected to distinguish ‘exposed’ and ‘unexposed’ participants in epidemiological studies.”

Taking the above into account, Ergon Energy uses the figures in Table 8 General Public limits for EMF levels outside the substation fence and the Occupational limits for EMF levels inside the substation fence.

### Table 8 Ergon Energy EMF Reference Levels

<table>
<thead>
<tr>
<th>Condition</th>
<th>Electric field (V/m)</th>
<th>Magnetic field (mG)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>General Public</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Up to 24 hours/day</td>
<td>5,000</td>
<td>2000, or 4 for special conditions</td>
</tr>
<tr>
<td><strong>Occupational</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Up to 24 hours/day</td>
<td>10,000</td>
<td>10,000</td>
</tr>
</tbody>
</table>

Special conditions are:

- Rooms in buildings (eg. residences, public buildings, etc.) which are regularly occupied for significant periods of time
- Public or private children’s playgrounds which have been designated as such under town planning schemes
- Location with special groups of people such as students in school, children in day-care and kindergarten centres
- Areas of undeveloped land where future utilisation is likely to include the above

The studies shall determine the maximum magnitude of the electric and magnetic fields produced by the STATCOM plant and equipment and shall determine the output that produces the maximum magnitude of electric field and output that produces the maximum magnetic field. The studies shall also determine the electric and magnetic fields at the maximum capacitive and reactive outputs of the STATCOM.

The studies shall show the magnitude of the field level distributions for the STATCOM plant and equipment (excluding the main transformer) for 50 Hz and the harmonic frequency of tuned filters. The electric and magnetic fields shall be calculated at one metre above ground over the entire STATCOM yard, control building and within five metres of the STATCOM perimeter fence.

Field plots for the air-cored reactors alone on a general arrangement drawing do not satisfy these requirements and will not be acceptable.

During commissioning, the Supplier shall measure the magnitude of the magnetic and electric fields to confirm compliance with the EMF design and confirm compliance with the ICNIRP limits in Table 8. The magnetic and electric field measurements shall be taken at 50 Hz and at the major harmonic filter frequencies of the tuned filters, 1 meter above ground and at no more than 5 meter intervals around the perimeter fence of the STATCOM, at no more than 2 meter intervals around the accessible interior of the control building and at all personnel operating points within the control building.

If testing shows levels to be higher than the specified EMF levels, then additional mitigation methods will be required and re-testing carried out, at the Supplier’s expense.

All calculations and full details of engineering design calculations / assumptions, basis, design of the models and the software code for the models and supporting documentation for electromagnetic field coordination design (including testing) shall be submitted to the Purchaser.
8.15 Audible noise

The Supplier shall design and construct/supply the STATCOM plant and equipment including the coupling transformer (if required) to limit the audible noise such that no overall audible noise increase occurs at the existing substation property boundary. Where this is not possible the Supplier shall discuss noise mitigation design options with the Purchaser including installing plant and equipment away from the boundary or by erecting noise barriers.

Audible noise studies shall be in accordance with the Cigre Guidelines for the Procurement and Testing of STATCOMs (TB 663, 2016) for the STATCOM system and surrounding equipment that may be affected.

To align with the Purchasers internal standards and the Environmental Guidelines for the Queensland Electricity Distribution and Supply Industry (Environmental Guidelines for the Queensland Electricity Distribution and Supply Industry, 1999), noise criteria for new plant or facilities shall be in accordance with Table 9.

<table>
<thead>
<tr>
<th>Time of Day</th>
<th>Maximum Noise Level for Steady State Noise</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Noise Sensitive Place</td>
</tr>
<tr>
<td>0700 hrs – 2200 hrs</td>
<td>Background + 5 dB(A)</td>
</tr>
<tr>
<td>2200 hrs – 0700 hrs</td>
<td>Background + 3 dB(A)</td>
</tr>
</tbody>
</table>

The Supplier and Purchaser shall negotiate who is responsible for establishing existing audible noise levels prior to construction of the facilities and for preparation of a report. The final report shall record audible noise levels prior to and after construction.

It should be noted that any noise emitted is also subject to the requirements within the (Queensland Environmental Protection Act, 1994), (Queensland Environmental Protection (Noise) Policy, 2008) or the local government planning scheme.

8.16 Isolation, insulation and earthing

The Supplier shall design the STATCOM and associated equipment to comply with Ergon Energy Substation Earthing Standard (STNW3028/SS-1-7.1, 2011) and Substation Insulation Coordination (STNW3034, 2009). Some specific requirements are listed below:

- The STATCOM system should be equipped with disconnect switches or circuit breakers as appropriate, to permit isolation between the primary plant and the secondary system (STATCOM)
- If HV disconnect switches or circuit breakers are included in the design, they shall be rated to break the maximum inductive and capacitive current output of the STATCOM system
- The coupling transformer (if required) basic insulation level (BIL) shall be detailed in the Project Scope Specification document to ensure BIL is not exceeded
- Surge protection equipment shall be used as required
- The switches and links shall be adequately sized to carry the maximum steady state and transient fault currents
Specification for STATCOMs in Zone Substations

- Grounding switches or equipment and grounding points shall be provided for access to allow maintenance and repairs to be undertaken
- The device enclosure shall be connected to the substation earth grid in at least two points as detailed in the Ergon Energy Substation Earthing Standard (STNW3028/SS-1-7.1)

8.17 HV interconnections and plant

In most cases, the primary equipment required as part of the design shall be provided by the Purchaser. However, if design and construction of any primary equipment is to be performed by the Supplier, it shall comply with the Purchasers relevant internal standards and specifications. Site specific parameters and requirements for each project shall be included the Project Scope Specification document.

8.17.1 Power transformers

STATCOM power transformers shall be designed with a low loss level (resistance) and have a core saturation range suitable for the full range of STATCOM operation. For further information refer to Ergon Energy power transformer for specification.

8.18 Cooling requirements

The cooling system should be able to maintain the full STATCOM rated output capacity or maximum device loss point at maximum ambient temperature. Cooling systems must be simple, reliable, easy to maintain and should have the minimum number of sensors to confirm operation and detect failures and defective parts.

Replacement of defective cooling equipment parts should be possible while the cooling system and STATCOM remain in uninterrupted service. If this is not the case the Supplier must clearly detail why in the offer.

The cooling system should provide full heat rejection capacity with redundancy for pumps, heat exchangers and fans, appropriate to the device availability requirements. Suppliers may provide redundancy options in the offer to eliminate full loss of system capacity due to cooling failures.

All components of the cooling system shall be clearly and permanently labelled with the name shown on a piping and instrumentation schematic diagram and suitably sized and durable version of the piping and instrumentation schematic diagram showing components in the correct physical location, shall be attached to the local control point for the cooling system.

Fan and pump motor speeds shall be selected to ensure long life, low noise and high reliability with at least 50,000 hours of operation without maintenance. Similar type and capacity devices shall have interchangeable parts. Motors shall be suitable for immediate restarting following loss of supply or accidental tripping after continuous operation without the temperature of any part of the windings rising to a value likely to cause damage. Motor ratings shall allow for the existence of out of balance in the supply voltage and preference is given to the use of a UPS or DC powered devices.

Design, selection of materials and manufacturing process shall ensure that the design life of heat exchangers match the operational life of the STATCOM. Tubes and fins shall be manufactured from compatible materials. Suppliers shall provide details of heat exchanger materials and corrosion protection, including details of the treatment to preclude corrosion at the tube to fin interface.
Specification for STATCOMs in Zone Substations

The Supplier shall describe the necessary maintenance actions and their frequency over the operational life of the system.

8.18.1 Air cooled

Cooling for semiconductors should be by natural convection or forced air. An air-cooling system should provide full heat rejection with redundancy in blowers, filtering, monitoring and heat exchangers (if required). The Supplier should describe the air filtering system and details of monitoring of the status of blowers, filters and other components. If filters are used, all air inlets should have exchangeable filters.

Air-cooled system monitoring should include, as a minimum, the following alarms:

- Blower transfer
- High exhaust air temperature or high heat sink temperature
- High differential pressure across the filter
- Low air flow

It should also include as a minimum the following trips:

- Excessive exhaust air temperature or high heat sink temperature
- Loss of air flow

8.18.2 Liquid cooled

A closed loop re-circulating system should provide full heat rejection capacity with redundancy for pumps, heat exchangers and fans appropriate to the device availability requirements.

Sufficient isolation valves shall be provided so components that require maintenance or form part of the STATCOM operational redundancy can be easily accessed while the cooling system and STATCOM remain in uninterrupted service.

Pump impellers, shafts, seals, glands and valves shall be of high quality, reliability and maximise maintenance cycles.

If high resistivity is required, a purifying loop to maintain liquid resistivity should be provided. The Supplier should state the design value of liquid resistivity and describe methods of detecting and responding to abnormal conditions.

If high resistivity is required, the quantity of de-ionizing material should be sufficient to operate correctly for a period 1½ times longer than the specified maintenance interval operation without replacement. De-ionizing materials should be replaceable without cooling system shut down.

Maintenance of closed loop systems and make up for loss of liquid should not be required more than once a year.

Liquid-cooled system monitoring should include, as a minimum, the following alarms:

- Depleted de-mineralised (de-ionizing) cell, if high resistivity is required
- Low water resistivity, if high resistivity is required
- Low coolant level
- Primary pump stopped
- Primary fan stopped
Specification for STATCOMs in Zone Substations

- High coolant temperature
- Failure of pump cycling scheme
- Leak detected

It should also include as a minimum the following trips:

- Extra high temperature
- Extra low coolant level
- Both pumps stopped or blocked flow

8.19 Auxiliary and control equipment

8.19.1 Protection against electric shock

The Supplier shall ensure that basic insulation and basic protection shall form part of the secondary wiring system as detailed in The Wiring Rules (AS/NZS 3000, 2007) to provide a minimum level of protection against electric shocks. Supplementary insulation shall be used where applicable to provide an increased level of protection including the use of Residual Current Devices (RCD) where required.

Where the nominal voltage of any circuit exceeds 50 V AC or 120 V ripple-free DC, the wiring shall be segregated from other wiring and all related terminals shall be shrouded.

Hinged panels carrying live terminals shall be fitted with a transparent rear safety cover, of suitable material, which completely surrounds all live parts, preventing access to live terminals without first removing the whole cover.

For 240 V AC circuits a barrier or enclosure shall be installed directly over the basic protection. The barrier or enclosure shall have a traffolyte or equivalent label stating “240 V AC” in white text on a red background.

8.19.2 Cables and wiring

All cables shall be stranded, copper, single insulated conductors to Standards Australia Electric cables - Polymeric insulated - Part 1: For working voltages up to and including 0.6/1 (1.2) kV (AS/NZS 5000.1, 2005) and Standards Australia Electrical installations - Selection of cables (Australian installation conditions) (AS/NZS 3008.1.1, 2009). The cable shall be constructed of thermoplastic material with a minimum V-90 thermal insulation and a minimum electrical insulation level of 0.6 kV / 1 kV unless specified otherwise. The insulation shall be halogen-free to reduce smoke emissions and flame propagation if a fire occurs.

Terminations of cables shall satisfy the electrical and mechanical requirements of the terminal block or sub-component to which it is attached. Conductor sizes shall not be less than 1.5 mm² or as stated below with the exception of items which are pre-wired and part of the factory assembly such as trip and close coil tails:

- Current transformer secondary wiring – 2.5 mm² for 1 Amp secondaries
- All conductors in series with trip and close coil circuitry – 2.5 mm²
- Earthing cables – green/yellow PVC insulated, 2.5 mm²
- All 240 V AC wiring shall be installed as per the wiring rules Australian Standard (AS/NZS 3000, 2007)
The wiring to any space heater shall be V105 or equivalent.

Seven stranded conductors may be terminated directly into terminal blocks. Multi-stranded conductors shall be terminated by means of solderless crimp lugs. All terminal blocks shall be accessible while the STATCOM is in service or energised.

Wiring shall be neatly bundled and tied together and, where possible, run in PVC ducting so as to avoid movement or fouling.

All cable, conductors and terminals shall be marked and identified in accordance with Preparation of Documents used in Electrotechnology (AS/NZS 4383). Individual conductors shall be permanently identified by the use of wire markers at both ends. The wire marker shall be non-deteriorating and capable of being renumbered without removal of the wire marker. Wire markers shall be printed; hand written wire markers shall not be accepted. Clip-on wire marks shall not be accepted. All cable, conductor and terminal numbers shall be readily identified from drawings.

**8.19.3 Terminals**

All terminals shall meet the requirements of the Australian standards for low-voltage switchgear and controlgear terminal blocks Standards Australia Low-voltage switchgear and controlgear (AS/NZS IEC 60947 All parts).

All items which Ergon Energy shall connect to remote equipment shall be wired to terminal blocks. These items include:

- All current transformer secondary connections
- All circuit breaker control and indication
- All alarm connections

These terminal blocks shall be of the tunnel type and capable of accepting up to 6 mm² control cable cores. Terminals blocks shall be suitable for DIN rail mounting.

The connections for purposes of remote status indication or alarms shall be terminated using ABB ZS6 Grey (PN. 1SNK 505 310 R0000) or equivalent.

Terminals for current transformer wiring shall be Weidmuller SAKC 10/35 2STB4 KRG (PN. 1404620000) with isolation plug bolts or equivalent. Current transformer terminals and link groups shall be separated by terminal block dividers.

Terminal types shall be ZS6 Grey (PN. 1SNK 506 010 R0000 or equivalent for all other terminals.

Where stud type terminals are used on any item, suitable spring washers shall be fitted.

A minimum clearance of 100 mm at the terminals shall be provided for external connections. A terminal block with a minimum of eight spare terminals shall be provided for Ergon Energy bay looping.

**8.19.4 Fuses and links**

Fuses shall be Alstom Type SC32 cartridge fuses or HRC equivalent and shall be black in colour.

Links shall be Alstom Type SC32 as above with a copper link instead of a fuse cartridge, and shall be white in colour. They shall be grouped according to their functions and suitably labelled.
Specification for STATCOMs in Zone Substations

Incoming voltage and current circuits, where necessary, shall be shrouded to prevent accidental contact.

Each fuse and link shall be labelled in accordance with circuit diagrams.

8.20 Enclosures

The device system shall be housed in enclosures appropriate to the application.

- For outdoor installations, all device system components shall be enclosed in an electrically grounded weatherproof (IP55 or higher) enclosure with provisions to securely anchor to the foundation.
- For indoor installations, all device system components shall be housed in electrically grounded metal enclosures designed to ensure that the opening of a door exposes no live parts. A dust proof enclosure (IP2X) is recommended for indoor installation.
- Energy storage in excess of 500 kJ usable capacitive energy storage, or rectifier, if appropriate, should be located in a suitable separate enclosure with mechanical and electrical interlocks provided to maintain a proper and safe operating sequence.

8.21 Signage and labels

All equipment, operating devices, relays etc. shall be suitably labelled such that they can be readily identified from drawings. Circuit breaker panels, control panels, relay panels etc. shall also be labelled. All labels shall be submitted to the Purchaser for approval.

Due to climatic conditions, adhesive backed plastic labels shall not be used. Labels shall be mounted using rivets or self-tapping screws. Indoor labels shall be engraved traffolyte or other approved material.

Labels shall be located such that they are easily read from normal operating positions and access ways around the equipment.

Cubicles and switchboard panels which have rear access shall also be labelled on the rear of the panel.

All labels and in particular those supplied on equipment of overseas origin, shall be submitted for approval prior to shipment of the equipment. All labels shall be in the English language.

The Supplier shall provide all the necessary warning and safety signs associated with the equipment supplied. Signs shall also be installed on the equipment advising correct operating procedures and safety requirements.

Warning signs shall conform to the relevant Australian Standard.

Details of all signs shall be submitted to the Purchaser for approval prior to manufacture.

The Purchaser shall supply and install operational signage.

8.22 Power losses evaluation

The Supplier shall specify the total system losses in idle mode, including transformer losses, in kW and in percentage of the device rating. In addition, the detailed losses should include all auxiliary loads including cooling fans and pumps, battery chargers, UPS systems, controls and other auxiliary loads and losses. The total losses of the system shall not exceed 5% of the system rating.

Suppliers shall include a Loss Performance Characteristic, which shows total STATCOM losses versus output over the specified full operational reactive output range. Suppliers shall guarantee
that losses determined and documented in a Loss Assessment Report shall not be exceeded. The report will detail all values and calculations undertaken to compile the assessment.

The Purchaser will assess offers with an economic evaluation of the capital cost of Suppliers by adding the cost of losses to the cost of capital investment.

The Supplier is able to propose hybrid solutions for the purpose of loss minimisation, ensuring the dynamic performance is not limited.

If the total STATCOM losses over the specified operational range exceed the guaranteed loss, the Supplier may be liable for liquidated damages.

8.23 Oil containment and fire separation
The entire STATCOM system including all coupling transformers or ancillary equipment shall comply with the Purchaser’s Oil Containment Standard (STNW3036, 2003) and Substation Fire & Explosion Protection Standard (STNW3035, 2013)

Throughout the design process in collaboration with the Purchaser, the Supplier should in particular be aware of:

- The requirements for bunded equipment and containment
- Separation between other transformers
- Separation between other plant and buildings

8.24 Asbestos

8.24.1 Definitions
In this 8.24.1:

(a) ‘Accreditation Entity’ means an entity which is a signatory to the International Laboratory Accreditation Cooperation Mutual Recognition Arrangement;

(b) ‘Approved Testing’ means laboratory testing which is undertaken by a NATA Accredited Laboratory in accordance with Australian Standard AS4964–2004 – Method for the qualitative identification of asbestos in bulk samples;

(c) ‘Asbestos Containing Materials’ means any material, object, product or debris that contains (in any quantity or percentage whatsoever) the asbestos form varieties of mineral silicates belonging to the serpentine or amphibole groups of rock forming minerals, including actinolite asbestos, grunerite (or amosite) asbestos (brown), anthophyllite asbestos, chrysotile asbestos (white), crocidolite asbestos (blue) and tremolite asbestos or a mixture of one or more of these minerals;

(d) ‘Asbestos Certification’ means, in relation to:
   (i) Prescribed Materials which are manufactured in Australia, certification from the supplier and/or manufacturer of the Prescribed Material that the relevant materials were manufactured by the party providing the certification in Australia; or
   (ii) Prescribed Materials which are not manufactured in Australia, certification from a NATA Accredited Laboratory located within Australia that:
(A) the laboratory has undertaken Approved Testing of the Prescribed Materials; and
(B) the Prescribed Materials are not Asbestos Containing Materials, where such certification must include:
(C) details of the accreditation of the laboratory;
(D) an outline of the approved method utilised by the laboratory; and
(E) the signature of the approved identifier,
and which, in either case, was issued no earlier than two (2) years prior to the date on which such certification is provided by the Contractor to an EQL Group Buyer in accordance with this 8.24.1.

(e) ‘NATA Accredited Laboratory’ means laboratory which has been accredited by the National Association of Testing Authorities; and

(f) ‘Prescribed Materials’ mean the following materials that have been, or are proposed to be, supplied under the Materials Contract:

(i) Zone substation outdoor STATCOMs; including incorporated parts and materials such as but not limited to:
(A) Paint or coatings
(B) Electrical wiring insulation
(C) Heaters
(D) Motors
(E) Porcelain insulator grout / cement
(F) Composite bushing material
(G) Insulated operating rods and linkages
(H) Electrical cloth and tapes
(I) Electrical panel partitioning
(J) Gaskets or seals
(K) Mastics, sealants, putties or adhesives
(L) Heat resistant sealing or caulking compounds

8.24.2 Warranty
The Contractor warrants that no Asbestos Containing Materials will be supplied under the Materials Contract. If the Contractor breaches this warranty, without limiting the Customer’s rights pursuant to the Materials Contract, the Customer may terminate the Materials Contract with immediate effect by giving notice in writing to the Contractor.

8.24.3 Certification and testing
(a) The Contractor must, at its cost, provide to Energy Queensland (on behalf of all EQL Group Buyers):

(i) Asbestos Certifications for each of the Prescribed Materials within 10 business days of receipt of a request by Energy Queensland, provided that Energy Queensland must not request such certifications more than once in any two year rolling period; and
(ii) if the supplier and/or manufacturer of any Prescribed Materials changes or there is a change in the manufacturing process relating to any Prescribed Materials, Asbestos Certifications for the affected Prescribed Material(s) within 10 business days of such change occurring.
(b) If the Contractor is unable to provide Asbestos Certification for any Prescribed Materials in accordance with 8.24.3 (a), the Contractor must notify Energy Queensland and may submit for Energy Queensland’s approval, certification from a laboratory approved by an Accreditation Entity, which certification must include:

(i) full accreditation details of the testing facility and the accreditation certifying entity; and
(ii) details of any mutual recognition arrangements with other accreditation entities.

Energy Queensland may approve or reject such certification in its absolute discretion.

(c) If the Contractor fails to provide an Asbestos Certification in accordance with 8.24.3 (a) and Energy Queensland has not approved any other certification in accordance with 8.24.3 (b), then without limiting the rights of each EQL Group Buyer pursuant to the Standing Offer and each Materials Contract, Energy Queensland may terminate the Standing Offer, and each Customer may terminate any Materials Contract to which it is party, with immediate effect by giving notice in writing to the Contractor.

(d) The Customer may at any time in its absolute discretion require any Materials that have been, or are proposed to be, supplied under the Materials Contract (including any Prescribed Materials) to be subject to Approved Testing by a NATA Accredited Laboratory located within Australia by giving notice to the Contractor.

(e) If the Customer gives notice to the Contractor in accordance with 8.24.3 (d), the Contractor must:

(i) provide assistance to the Customer to coordinate such testing, including by providing samples of the Prescribed Materials to the Customer and providing the Customer and its nominees with access to the Prescribed Materials; and
(ii) if specified in the relevant notice, suspend the supply of such Prescribed Materials under the Materials Contract until such time as the Approved Testing has been completed and the Prescribed Materials have been approved by the Customer for supply under the Materials Contract.

If the Customer exercises its rights pursuant to 8.24.3 (d) and (e), the Contractor is not entitled to an extension of time or any compensation in connection any delay or disruption caused by its compliance with this clause.

(f) The Customer will undertake the Approved Testing referred to in 8.24.3 (d) at its own cost, unless the results of the Approved Testing reveal that all or any part of the Prescribed Materials are Asbestos Containing Materials, in which case the cost of such testing will be a debt due and payable by the Contractor to the Customer and without limiting the Customer’s rights pursuant to the Materials Contract, the Customer may terminate the Materials Contract, with immediate effect by giving notice in writing to the Contractor.

8.24.4 Indemnity

Without limiting any other provision of the Materials Contract, the Contractor indemnifies the Customer against any action, claim, demand, cost, expense or other liability arising out of or as a consequence of a breach of the warranty in 8.24.2, including the cost of removing and replacing of the Asbestos Containing Material (including the decontamination of all surfaces and/or equipment deemed to be contaminated by the Asbestos Containing Material and disposal of such Asbestos Containing Material).
8.25 Galvanizing

Galvanizing shall be in accordance with Standards Australia Hot-dip galvanized (zinc) coatings on fabricated ferrous articles (AS/NZS 4680, 2006). Hot dip galvanizing of ferrous parts, including the threads and bolts and screwed rods shall be carried out after all machining; bending, cutting, drilling, punching, marking and welding operations have been carried out. Nut threads shall be lubricated by water-resisting rust-inhibiting oil after tapping. Surface preparing shall be in accordance with Standards Australia Metal finishing - Preparation and pretreatment of surfaces (All parts) (AS 1627).

8.26 Anti-corrosion precautions

Equipment offered shall be constructed of materials and be finished in such a way that corrosion is prevented to the maximum possible extent.

- All surfaces shall be self-draining and all air filled enclosures such as kiosk, terminal boxes shall have an insect-proof drain hole with diameter of 25 mm
- Current carrying parts shall be made from non-ferrous metal
- Materials and combinations of metals used in construction of the equipment shall be selected and arranged to prevent electrolyte corrosion in salt polluted atmospheres
- Pollution level 4 shall be specified for all plant insulators and bushings
- Aluminium and its alloys, whether used for current carrying or structural purposes, shall be resistant to auto-electrolytic and chemical action. The use of aluminium alloys containing magnesium or copper is not acceptable.
- Ferrous parts shall be hot dip galvanized or painted
- Surfaces to be galvanized or painted shall be sound, clean and free of harmful scale, rust, grease, moisture or any other foreign matter which will in any way detract from the life and usefulness of the coating

8.27 Painting and presentation

All parts required to be painted shall be thoroughly cleaned and stopped. Painting or varnishing shall begin within a short time of the completion of surface preparation.

The painting and preservation system for exterior surfaces shall satisfy the following requirements:

- Durability: Extra long term – 25+ years (Standards Australia Guide to the protection of structural steel against atmospheric corrosion by the use of protective coatings - Part 1: Paint coatings (AS/NZS 2312.1, 2014))
- Atmospheric Corrosivity Category: Category C5 – Very high Industrial (Standards Australia Guide to the protection of structural steel against atmospheric corrosion by the use of protective coatings - Part 1: Paint coatings (AS/NZS 2312.1, 2014))

Preferred colour is N42 Storm Grey to Standards Australia Colour standards for general purposes (AS 2700, 2011).

Special precautions shall be taken to ensure that all portions of plant difficult for access receive properly applied coatings of paint.

All interior surfaces of oil filled chambers shall be suitably treated to ensure that no rust, scale or other contaminant exists and shall be finished with an oil-resisting varnish or enamel.
9. **Spares, special test equipment, tools, options and accessories**

Suppliers shall submit separate details of any special test equipment, tools, gauges and jigs necessary for the installation, operation and maintenance of the plant.

Suppliers shall submit a spare parts strategy detailing costs of recommended spare parts and their storage. The spares strategy may form part of a service and maintenance agreement offered by the Supplier.

10. **Performance and testing**

Tests and procedures described in all parts of section 10 Performance and testing shall be in accordance with Cigre Guidelines for the Procurement and Testing of STATCOMs (TB 663, 2016).

Some tests may not be able to be performed due to power system constraints or limitations imposed by the operational control centre during the commissioning period.

10.1 **STATCOM and associated plant testing**

The testing of all STATCOM related primary equipment consists of Type Tests and Routine Tests. The Factory Acceptance Test (FAT) of the Control and Protection system consists of functional and dynamic performance testing.

All equipment must be subjected to and pass the specified type tests. All type test reports shall be provided.

All equipment must be subjected to and pass the specified routine tests in the factory of manufacture. Routine tests required shall be negotiated and carried out on all supplied equipment as part of the Suppliers quality assurance procedure.

Prior to commencing testing and commissioning the Supplier shall produce Quality system documentation including a comprehensive list of required tests that shall be agreed with the Purchaser.

The Purchaser or representative shall be allowed to witness any or all type tests, and all routine tests performed as part of the Contract.

Typical equipment type tests as part of the STATCOM solution may include:

- Inverter modules
- Coupling transformer
- DC capacitors
- Phase reactors

Other plant, secondary equipment and components should be type tested according to relevant standards and Purchasers specifications. This includes:

- Power transformers
- Circuit breakers
Specification for STATCOMs in Zone Substations

- Disconnector switches
- Earthing switches and devices
- Instrument transformers
- Surge arresters
- Protection devices
- Controls and communications
- Metering equipment and data recorders
- Onsite earthing design must be verified via testing

Equipment such as the inrush resistors and discharge resistors are design dependent. Type testing shall be to the relevant Australian or International Standards. Where such standards are not available, type testing requirements shall be agreed between the Supplier and the Purchaser.

### 10.2 Factory acceptance tests (FATs)

The STATCOM control and protection systems must be factory tested before being delivered to site. This is to ensure that the control and protection hardware and software meets all the specified requirements.

Verification of actual control & protection hardware and software shall be performed by running the real control systems together with a real-time simulator. The real-time simulator shall accurately represent the steady-state and dynamic behaviour of the power electronic devices (including any power electronic device or inverter protection algorithms). A network equivalent together with the STATCOM must be modelled on the real-time simulator. Functional performance tests may be done using a reduced network model. This shall be benchmarked against the PSCAD and PSS®E models.

### 10.3 Site acceptance tests (SATs)

SATs are completed on site following the erection and assembly of the equipment and the installation and connection of field cabling and main circuit connections. SATs shall be completed for all the items in an associated subsystem before energisation and testing of the subsystem.

The correct operation of each specific subsystem should be verified at site before proceeding to undertake commissioning tests.

Each field installed cable path needs to be checked end to end for electrical continuity and correct termination according to the circuit diagram. Where a mixture of factory and field installed connections exist within an electrical circuit the overall circuit shall be checked, not just the field terminations.

Particular attention shall be paid to earthing design as site installation may inadvertently create magnetic loops.

Primary and secondary circuit injections shall be required to confirm functionality.
**10.4 Commissioning tests**

Commissioning tests shall be done on site and can only proceed following FAT and SAT.

Commissioning tests requiring connection to the power system shall be conducted once necessary arrangements have been made with the operational control centre. These tests shall to be planned well in advance as they require coordination of many different entities including the operational control centre, switching operators, Supplier’s and Purchaser’s engineers.

At this stage of the commissioning process, the Purchasers staff should be fully involved with all tests to gain as much “hands-on” experience as possible which forms part of the training program detailed in section 11.

**10.5 System integration tests**

The system integration tests are required by the Purchaser to validate the operation of the STATCOM and the impact on the AC system. These tests are dependent on the requirements of the STATCOM and the availability of the AC system to perform these tests. The following tests are the minimum tests that shall be performed and can be expanded as required.

- Start-up and shutdown test
- Constant reactive power control test
- Voltage control mode test
- Dynamic performance test
- STATCOM operating range test
- STATCOM redundancy test
- STATCOM overload test
- AC system fault test
- STATCOM remote control capabilities
- Black start for network auto-reclose
- R2 model validation tests and report (S5.2 NER)

**11. Training**

A comprehensive training program shall be provided by the Supplier and is required for all levels of personnel in the Purchaser’s organization. This is to provide a solid basis for operation and maintenance over the operational life of the STATCOM.

The training program shall cover all equipment as supplied by the Purchaser, including: inverter modules, cooling, control and protection, transformers, auxiliary systems, switchyard equipment, measurement, interlocking and safety.

The training program shall include classroom instruction on the theory and operation of the STATCOM equipment provided by the Supplier with particular emphasis placed on inverter modules, system cooling and the associated control and protection equipment.
Specification for STATCOMs in Zone Substations

The Supplier shall be responsible for providing the appropriate level of training to ensure that the requirements for health and safety and environmental standards can be achieved at the site for all equipment covering the construction period, testing, commissioning and maintenance.

The Supplier shall provide training manuals associated with the formal courses. The training program provided by the Supplier shall include formal training as well as hands-on training and participation by Purchaser’s personnel in all stages of the project including, the design stage, FAT and SAT tests and commissioning.

The formal program should provide appropriate training to all levels of the Purchaser’s staff, including:

11.1 Management and non-technical staff
This program should be designed to help the participants achieve an overview understanding of the STATCOM including purpose, system benefits, and operation.

11.2 Design and asset management engineers
The objective is to provide training to staff from the Purchaser’s design office to obtain an understanding of STATCOM technology in the areas of system studies, inverter modules, control and protection equipment and any other equipment special to the STATCOM. This program can include participation of the designers in the carrying out of studies at the Supplier’s premises.

The program should train control engineers in the commissioning, operation and maintenance of protection and control systems including training on how to view and modify all system parameters. Details of SCADA integration and remote engineering access shall also be provided.

11.3 Operating technicians
The operator training program should thoroughly familiarize the operating personnel with the characteristics and requirements of steady-state and transient operation of the STATCOM, in the performance and operation specifications of all equipment, the principles of control and protection, the performance of control and protection systems, especially the operator control and SCADA system, the operation specification given by the Supplier and other aspects.

For the operators, the training shall be completed prior to commissioning to allow operation by the Purchaser.

11.4 Maintenance technicians
A maintenance training program is essential to completely familiarize the maintenance personnel with the various facets of the STATCOM system. Maintenance training should include preventive maintenance as well as trouble-shooting and safety requirements. Maintenance of inverter modules, cooling, transformers, auxiliary systems and solid state controls and microprocessor control systems used in the converter station shall be emphasized. The program should train control technicians in the commissioning, operation and maintenance of microprocessor systems for the controls.

The use of any special tools and test equipment should also be covered.
Specification for STATCOMs in Zone Substations

The program should include hands-on instructions using the supplied equipment in the factory and/or the sites.

At the completion of the training, the maintenance personnel shall be able to completely and properly maintain the STATCOM equipment without Supplier assistance.

11.5 Test and Commissioning staff

The Supplier shall provide a program and schedule with the objective of having staff (including supervisors) nominated by the Purchaser sufficiently trained to participate in the commissioning on the scheduled start dates, under the direction of the Supplier’s commissioning supervisors.

12. Maintenance & service agreement

In addition to the inclusions of the offer the Supplier shall provide comprehensive details of any additional service agreement options, maintenance plans or spares strategies that can be negotiated upon award of the contract.

As a minimum the Supplier shall provide details of the following:

- The standard warranty period and options for an extended warranty period
- Remote service capabilities including 24/7 telephone support capabilities
- On site corrective and preventative maintenance options
- Cost breakdown of recommended maintenance activities for the operational life of the STATCOM solution, including estimated labour hours and replacement parts
- Spare parts and storage thereof
- Software updates / upgrades
- Methods to minimise outages
- Cyber security

13. Service history

Potential first time Suppliers to Ergon Energy shall state:

- The period of service of typical items offered within the Australian environmental conditions
- Australian electricity authorities that have a service history of the types of STATCOMs offered
- Contact names and telephone numbers of relevant employees of those supply authorities who can verify the service performance claimed

14. Quality assurance

Design and manufacture of the items shall be in accordance with Standards Australia Quality management systems – Requirements (AS/NZS ISO 9001, 2016). Documentary evidence shall be provided concerning the level of Quality System Certification associated with the Supplier and/or Manufacturer including the associated Capability Statement.
Specification for STATCOMs in Zone Substations

If the Supplier is a non-manufacturing Supplier, the documentary evidence shall include the quality system certifications of both the Supplier and the Manufacturer.

Once accepted, any deviations from the Project Scope Specification or the Specification for STATCOMs in Zone Substations shall not be implemented without submission of relevant Quality Assurance documentation and re-qualification test certificates that are acceptable to the Purchaser and approved in writing by the Purchaser prior to delivery of goods.

15. **Risk assessment**

Suppliers and their Manufacturers shall comply with the requirements of the (Queensland Work Health and Safety Act, 2011), (Queensland Electrical Safety Act, 2002) and associated Regulations and Codes of Practice and compliance with any applicable advisory standards.

Supplied items shall be subjected to a formal risk assessment meeting Standards Australia Risk management - Principles and guidelines (AS/NZS ISO 31000, 2009) prior to acceptance. Suppliers shall provide risk assessment documentation.

The risk assessments shall identify hazards to personnel, public and property associated with:

- Transport, handling and storage of the plant
- The installation of the plant
- The operation and maintenance of the plant during life expectancy
- Dismantling and the disposal of plant at end of life
- Effects of environmental conditions on the equipment

16. **Environmental considerations**

Suppliers shall provide documentation detailing the whole of life environmental soundness of the plant including design, materials, manufacturing, operation, maintenance, recyclability and disposal at end of service life.

17. **Design life and warranty**

The STATCOM primary plant shall have a design life of 40 years and the secondary equipment shall have a design life of 20 years.

Warranty for the STATCOM systems shall be a minimum of five (5) years. This is due to the complexity of this type equipment and expected level of support required from the Manufacturer and Supplier.

18. **Availability**

Ergon Energy requires a high level of availability equal to 99.5% or greater in one year, including planned and unplanned outages.
Specification for STATCOMs in Zone Substations

The system is considered to be available for service only if it is able to perform the whole of the specified duty. Operation with limited control functions or within a limited range of outputs due to a subsystem failure is to be treated as unscheduled servicing downtime.

The percentage % Availability can be calculated as follows:

\[
\text{%Avail} = \left( \frac{\text{Total Time System is able to Perform Specified Duty}}{\text{Total Time Period}} \right) \times 100
\]

Total Downtime within a Total Time Period is defined as the sum of the following times:

Minor Service Downtime:

- Minor scheduled servicing according to instructions aligned with conditions, lifecycle or operations. This includes checks of operation, adjustments to control, protection and communication devices. It also includes measurements of the characteristics of insulation, cleaning, lubricating, tensioning and replacing worn parts such as filters.

Major Service Downtime:

- Major scheduled servicing according to instructions aligned with lifecycle or operations. This includes detailed examinations of all parts. It also includes the measurement of characteristics of plant, secondary equipment or components.

Unscheduled Servicing Downtime:

- Unscheduled servicing downtime is the time taken to restore the STATCOM to service following an outage necessitated by failure of plant, secondary equipment or components.

The Percentage % Downtime can be calculated as follows:

\[
\text{%Downtime} = \left( \frac{\text{Total Downtime}}{\text{Total Time Period}} \right) \times 100 \text{ or } \text{%Downtime} = 100 - \text{%Availability}
\]

19. Reliability

Ergon Energy requires a high level of reliability equal to 4000 hours or greater mean time between unplanned outages.

Suppliers shall provide evidence in support of the reliability and performance claimed including information relating to Mean Time Between Failures (MTBF), Mean Time To Restore System (MTTRS) and Failure Mode and Effect Analysis (FMEA).

The Reliability is the probability of the STATCOM performing its specified duty within a defined time period, where the defined time period must be less than the total time period used to determine the Percentage Availability of the STATCOM.

The reliability can be determined as a percentage, but would be easily confused with the percentage availability. It is considered that the most appropriate measure of the reliability of the STATCOM is the mean time between failures.
Mean Time Between Failures (MTBF):

- This is the mean length of time for which the system will operate without failure of any component of sub system during the useful life of the system after the commissioning period

Mean Time To Restore System (MTTRS):

- This is defined as the mean time taken to perform corrective action to restore the system to the specified duty and includes location of a failure, disassembly, replacement or repair, reassembly, adjustment and test. It excludes time for off-system maintenance and repair of components or equipment which have been replaced by a spare item and also excludes call-out time and travelling time to the substation.

The mean time to restore system for failures which cannot be rectified using a spare item shall include the time taken to either repair on site, or transport and repair at a central workshop or obtain a replacement item and reinstall test and re-commission the STATCOM.

20. Traceability

Suppliers shall determine which plant components require traceability. The criteria for traceability shall be based on previously identified failure modes which may necessitate the recall of plant from service for rework or replacement should they occur either in the field or during manufacture or testing at works.

21. Packaging and delivery

All equipment shall be at the Supplier’s risk until delivered and unloaded by the Supplier’s agents.

21.1 Method of preservation and packaging

The plant shall be packed in weatherproof cases where necessary and be suitable for the nominated mode of transport; by sea, rail or road.

Special precautions in the way of packing and bracing shall be taken to prevent damage to any sections of the equipment. External battenning shall be arranged to permit slings to be passed underneath plant for lifting. All cases shall be marked with a sign, prohibiting the use of hooks.

Packaging or crating shall be assembled in a way that allows for easy removal of the equipment for inspection upon delivery and reassembly of the packaging or crate.

Should any timber packaging be supplied from overseas Manufacturers, then it shall meet all conditions and inspections required by the Australian Quarantine Act and all associated costs shall be included in the tendered price.

All items separated for transport shall each be fitted at the Manufacturer’s works and then marked with non-deteriorating tags showing the serial number of the unit so that they can be refitted identically during erection at site.
Specification for STATCOMs in Zone Substations

Each item shall be individually packaged and delivered with fittings, hardware and associated manuals and test reports.

All bright and polished parts and screw threads shall be treated with petroleum jelly or other suitable rust preventative.

21.2 Marking of goods for delivery
The following information shall be clearly marked on the surface of each individual container:

- Purchaser details
- Contract number
- Purchaser's stock code
- Purchase order number
- Ergon Energy structured plant number
- The applicable system voltages
- Name of Manufacturer or trademark
- Manufacturer serial number
- Manufacturer model number
- Gross weight
- Case number with total number of cases (example, 1 of 4)

The Supplier shall mark all cases of plant which cannot be safely stored outside with the words “FOR INSIDE STORAGE ONLY”.

The Supplier shall detail in writing and on packaging the delivery and storage requirements.

22. Deliverables

22.1 Information to be provided by the Supplier
All drawings and documentation supplied under this specification shall be in English and dimensioned in metric units in accordance with Standards Australia, The international system of units (SI) and its application (AS ISO 1000, 1998).

The Purchaser shall review drawings and/or documentation supplied under this Technical Specification in relation to how the plant interfaces with the Purchaser's design, construction, operation, maintenance and other requirements. Alterations and/or modifications may be requested to meet these requirements. The Supplier shall remain responsible for the safety and reliability aspects of the plant or equipment supplied. The Purchaser shall not be liable for expenses incurred due to alterations or modifications to the plant during the manufacture and/or supply without prior written approval from the Principle Representative.

The Supplier shall supply within two weeks of the date of the formal execution of the Agreement, a comprehensively detailed program of works indicating timing for all activities required to achieve contract performance.
Within six weeks from the date of the formal execution of the Agreement, the Supplier shall provide a copy of drawings and generic manuals necessary to enable the Purchaser to examine the design and general arrangement.

Prior to dispatch, the Supplier shall provide the following:

- A final copy of all drawings listed in this section of the specification.
- A certified copy of routine test reports verifying compliance with this specification.
- Final inspection report including the manufacturing, packaging procedures, dispatch and all transport handling activities from Manufacturer’s works to site.

### 22.2 Manuals

The generic and site specific manuals shall be suitable for use by installation and maintenance technicians.

#### 22.2.1 Generic manual

The cover page of each generic manual shall include:

- Contract number
- Contract item number/s
- Purchaser’s stock code number
- Name of Manufacturer or trademark
- Manufacturer model number

Each generic manual shall include:

- Transport, storage, installation, commissioning, operation, maintenance and disposal instructions
- Guaranteed electrical and mechanical performance characteristics of plant
- Type test reports
- Example of routine test reports
- Example of final inspection report
- Approved contract drawings as per Section 22.3
- Illustrated parts breakdown of plant (exploded view) with all parts identified
- List of recommended spare parts, tools, gauges, lubricants and equipment

#### 22.2.2 Site manual

One hard copy site manual shall be dispatched with each item of plant. This site manual shall contain all generic manual items with the inclusion of the specific item routine test reports and final inspection report in place of the examples.

In addition to the information provided on the cover page of the generic manual, the cover page of the site manual shall include:

- Purchase order number
Specification for STATCOMs in Zone Substations

- Ergon Energy Structured Plant Number
- Manufacturer serial number

22.3 Drawings

Drawings shall be supplied to the following standards:

- Standards Australia Technical drawing - Part 101: General principles (AS 1100.101, 1992)
- Standards Australia Graphical symbols for electrotechnical documentation - Part 101: General information and general index (AS 1102.101, 1989)
- Standards Australia Graphical symbols for electrotechnical documentation - Part 102: Symbol elements, qualifying symbols and other symbols having general application (AS/NZS 1102.102, 1997)
- Standards Australia Graphical symbols for electrotechnical documentation - Part 103: Conductors and connecting devices (AS/NZS 1102.103, 1997)
- Standards Australia Graphical symbols for electrotechnical documentation - Part 104: Basic passive components (AS/NZS 1102.104, 1997)
- Standards Australia Graphical symbols for electrotechnical documentation - Part 105: Semiconductors and electron tubes (AS/NZS 1102.105, 1997)
- Standards Australia Graphical symbols for electrotechnical documentation - Part 106: Production and conversion of electrical energy (AS/NZS 1102.106, 1997)
- Standards Australia Graphical symbols for electrotechnical documentation - Part 107: Switchgear, controlgear and protective devices (AS/NZS 1102.107, 1997)
- Standards Australia Preparation of documents used in electrotechnology (All parts) (AS/NZS 4383)

The Supplier shall provide the following drawings as a minimum to the Purchaser:

- Rating plate
- General arrangement plan and elevations
- Mechanical loading
- Footing details
- Schematics
- Connection diagrams
- Logic diagrams
- Materials list
- Cubicle/terminal box layout

22.3.1 Drawings title block

The drawing title shall be a concise description of the contents of the drawing.

The title shall be designed so that it reads from the general to the particular, top to bottom, as indicated in the following example:

- Contract number
Specification for STATCOMs in Zone Substations

- Model number
- Drawing function (manufacturing / installation)
- Engineering approval signature and date

### 22.3.2 Drawing revisions

The revision block for each revision shall contain:

- The revision letter in prominent display
- A brief description of the revision
- Engineering approval signature and date

### 22.3.3 Drawings in electronic format

Initial copies of drawings submitted for approval purposes may be supplied in PDF format.

Once approved by the Purchaser, electronic drawings shall be provided. Electrical drawings shall be drawn in the sheet space (Microstation) or paper space (AutoCAD). Ergon Energy has a preference for MICROSTATION V8i format however will accept AutoCAD (2007) format.

Each electronic file shall only contain one drawing to conform with the Purchaser’s electronic document system.

Physical drawing of the plant shall be drawn in the design space (Microstation) or model space (AutoCAD) at 1:1 and then referenced into the sheet space (Microstation) or paper space (AutoCAD) at the appropriate scale. Preference is given to three dimensional models.

### 22.4 Electronic nameplate

The Ergon Energy Network Asset Register Integration (NARI) process is used to capture and maintain plant life cycle data. The Ergon Energy Structured Plant Number (SPN) is a unique identifier to describe a single item of plant based on its serial number and purpose. The Electronic Nameplate is a spreadsheet sent to the Supplier after formal execution of the Agreement.

The Supplier shall complete the plant specific information in the spreadsheet each time a Purchase Order is received with an SPN. The Supplier shall email the spreadsheet to inventory.nameplatedata@ergon.com.au prior to dispatch of order.

### 22.5 Dispatch advice email

The purchaser requires an email notification for each item of plant to be dispatched.

This dispatch advice email shall contain:

- Electronic Nameplate
- PDF of the routine test reports
- Final inspection reports

This email shall be sent to:
Specification for STATCOMs in Zone Substations

- The originator of the Purchase Order
- inventory.nameplatedata@ergon.com.au
- ergon.library@ergon.com.au
- The contract Principles Representative

Test reports shall be emailed with the completed library transmittal. Library transmittal shall be provided to the Supplier after formal execution of the Agreement.
Specification for STATCOMs in Zone Substations

A.1 General
The specific technical requirements for each item offered shall be as stated in the Project Scope Specification with all data guaranteed.

In addition to the completed Project Scope Specification, Suppliers shall submit with their tender a complete description of the plant/equipment offered including:

- Dimensioned general arrangement plan and elevation drawings
- Dimensioned rating plate drawings
- Dimensioned mechanical loading drawings
- Dimensioned footing details drawings
- Schematics drawings
- Connection diagrams drawings
- Materials list drawing
- Dimensioned cubicle/terminal box layout drawings
- Generic manuals
- Type test certificates for the items offered
- Example routine test certificates
- Example final inspection report
- List of all departures from this Technical Specification
- Documentation to enable an assessment to be made of the Suppliers and their Manufacturer’s ability to conform with the Quality Assurance (QA) requirements of this specification in regard to design, manufacture, inspection, testing, supply, storage, erection and commissioning
- Details of any quality program audits carried out on the Supplier’s works shall be in accordance with the Standards Australia Quality management systems – Requirements (AS/NZS ISO 9001, 2016) standard or equivalent internationally recognised quality program standards
- Documentation covering material safety data for every hazardous substance used for construction, insulation, impregnation, finish, or for any other purpose

The Purchaser may require additional information to be provided for tender evaluation purposes.

The Supplier shall append additional descriptions, drawings, technical data sheets with properly authorised and documented certification from an appropriate NATA accredited testing laboratory, where applicable.

A.2 Service performance
The Supplier shall provide a statement detailing the following:

- The period of service achieved by the items offered within Australian conditions
- Australian electricity supply authorities who have a service history of the items offered
- Contact names and phone numbers of relevant employees of those supply authorities who can verify the service performance claimed
A.3 Reliability
Suppliers shall provide service life statements and include evidence of the reliability and performance claimed as detailed in section 19.

A.4 Training
Proof of ability to deliver training requirements as detailed in Section 11 shall be provided as part of the offer.

A.5 Environmental considerations
All materials supplied under this specification may be installed in marine coastal areas with direct and constant salt spray. The Supplier shall provide information on how materials will perform in this extreme environment. The environmental conditions that shall be complied with are detailed in section 7.2.