

STATIC COMPENSATOR - STATCOM

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TABLE OF CONTENTS

PURPOSE AND SCOPE	1
PART 1 – PROCEDURAL	1
1 GENERAL REQUIREMENTS	1
2 PRIMARY PLANT	8
3 SECONDARY EQUIPMENT	16
4 AUXILIARY SYSTEMS	16
5 INSULATION CO-ORDINATION	19
6 PERFORMANCE REQUIREMENTS	21
7 TEST REQUIREMENTS	28
8 SYSTEM STUDIES AND NETWORK MODELS	32
9 TYPE REGISTRATION PROCEDURE	34
10 FORMS AND RECORDS	35
11 DEFINITIONS	35
12 ACRONYMS	35
13 AMENDMENTS RECORD	36
14 IMPLEMENTATION	36
PART 3 - GUIDANCE NOTES AND APPENDICES	37
15 REFERENCES	37
APPENDIX A - TYPICAL STATCOM SINGLE LINE DIAGRAM	41
APPENDIX B - TYPICAL OPERATING CHARACTERISTIC FOR A STATCOM	42
APPENDIX C - LIMITS OF RADIO FREQUENCY EMISSIONS	44
APPENDIX D - DYNAMIC RESPONSE TESTING	45
APPENDIX E - LIST OF STUDIES AND REPORTS TO BE SUBMITTED	47
APPENDIX F - SITE SPECIFIC DATA TO BE INCLUDED IN THE ENQUIRY DOCUMENTATION	48
APPENDIX G - SCHEDULES OF DATA TO BE SUPPLIED BY THE SOLUTION PROVIDER	51

PURPOSE AND SCOPE

This Technical Specification (TS) defines the functional, performance and testing requirements for a Static Compensator (STATCOM) for connection to the National Grid Electricity Transmission (NGET) system. This includes all types of Voltage Source Converter (VSC) based compensator technology.

The detailed Protection and Control (P&C) requirements for the STATCOM bay are defined separately in TS 3.24.99.

It does not include the switchgear connections to the High Voltage (HV) system, which are specified separately in TS 2.2.

PART 1 – PROCEDURAL

1 GENERAL REQUIREMENTS

1.1 Introduction

- 1.1.1 The STATCOM shall be used to provide continuously variable reactive power on the electricity transmission system. The reactive power is primarily required to provide fast automatic response for dynamic voltage control during the post fault recovery period, and to maximise reactive current injection across the period itself to support commutation and voltage stability of nearby sources affected by the network disturbance.

- 1.1.2 A typical STATCOM single line diagram is given in Appendix A.
- 1.1.3 The STATCOM shall be suitable for independent and autonomous operation. The STATCOM shall be capable of monitoring and communicating the availability of its capability in real time operation such that this may be captured by both control telemetry and any co-ordinated voltage control scheme
- 1.1.4 Where the STATCOM is required to operate as part of a coordinated voltage control scheme, the control requirements shall be defined in the Enquiry Documentation.
- Informative : Throughout this TS, reference is made to further information or requirements being defined within the Enquiry Documentation. Appendix F provides a summary of these items.*
- 1.1.5 STATCOM equipment shall comply with the scheme requirements specified in the Enquiry Documentation, all relevant TS's and the British, European or International standards listed in this specification. With regard to the hierarchy of requirements given in these documents, the order of precedence shall be the Grid Code, Enquiry Documentation, National Grid Technical Specifications, British Standards, European Standards and International Standards.
- 1.1.6 Where a requirement in a TS exceeds or is more onerous than that of the British, European or International standard, the most onerous condition shall be considered appropriate.
- 1.1.7 The Solution Provider shall note that the design of the STATCOM must comply with the requirements of UK legislation. Attention is drawn to the provisions of the Health and Safety at Work Act, the Construction (Design and Management) Regulations, the Electricity at Work Regulations, the Manual Handling Operations Regulations, the Work at Height Regulations and the Workplace (Health, Safety and Welfare) Regulations.
- 1.1.8 The Solution Provider shall be responsible for the design of the compensation equipment and its components such that no damage shall be caused to it and the equipment within it as a consequence of primary equipment failures, remote faults in the network and malfunction of P&C functions.
- 1.1.9 The Solution Provider shall complete the schedules of technical data provided in Appendix G of this specification to support his Tender submission. Once a contract has been awarded, the Solution Provider shall review the schedules, update and resubmit them should any of the details change as a result of detailed design.

1.2 Environmental Conditions

- 1.2.1 The STATCOM design shall comply with the environmental requirements of TS 1.
- Informative: TS 1 specifies the normal and abnormal environmental conditions, including Ingress Protection (IP) rating, maximum and minimum operating temperatures, ice coating and pollution class, in which STATCOM equipment shall be expected to operate at its specified current, voltage and frequency ratings.*
- 1.2.2 The effect of solar gain shall be considered by the overall design. An average of solar gain of 1000W/m² and no wind shall be used in the design and calculations. Further guidance is given in BS EN 61936-1 clause 4.4.2.2.
- Informative: Particular considerations should be given to equipment or cooler banks that may be located in a sun trap.*
- 1.2.3 The STATCOM design shall comply with the mechanical loading requirements of TS 3.1.4.
- Informative: TS 3.1.4 specifies the dead, wind, ice and short circuit mechanical loadings to be considered.*
- 1.2.4 The site pollution class in accordance with TS 2.1 and IEC/TS 60815-1 shall be specified in the Enquiry Documentation.
- 1.2.5 Electronic equipment shall comply with the requirements of TS 3.24.15 applicable to its location.
- 1.2.6 The environmental conditions for the P&C equipment are specified in TS 2.24 and TS 3.24.99.

1.3 Power System Characteristics

1.3.1 The STATCOM design shall comply with the normal and abnormal power system conditions defined in TS 1.

Voltage and frequency disturbances can be coincident. Combined voltage and frequency disturbances shall be withstood by the design, not either one on its own.

Informative: The Solutions Provider's attention is drawn to document 'CI 01 – Technical and Operational Characteristics of the Transmission System' which provides historical background information of the power system requirements as set out in TS 1.

1.3.2 System Voltage

The nominal, maximum continuous, minimum continuous and short term maximum system voltages for plant and equipment are specified in TS 1 and CC6.1.7 of the Grid Code (Figures B2 & B3 in Appendix B). The STATCOM performance requirements during voltage disturbances are given in section 6.6.

The primary system connection voltage shall be specified in the Enquiry Documentation.

1.3.3 System Frequency

The STATCOM design shall remain stable and comply with the rated, maximum continuous and minimum continuous frequency ranges specified in TS 1 (and Grid Code CC6.1.2 and CC.6.1.3) and the excursions detailed below in Table 1.

Following a system frequency excursion outside the range 49 - 51 Hz detailed in TS 1, system frequency shall stabilise to a value between 49 - 51 Hz. No consideration therefore need be given to consecutive frequency excursions outside the range 49.0 – 51.0 Hz.

System frequency variations and durations shall be in accordance with Table 1:

System frequency (Hz)	Duration
47.0 - 47.5	20 seconds
47.5 – 49.0	90 minutes
49.0 - 51.0	Continuous
51.0 - 51.5	90 minutes
51.5 - 52.0	15 minutes

Table 1: Duration of frequency excursions

For guidance it shall be assumed that the incidents given in Table 1 will occur once every five years.

1.3.4 Short Circuit Rating

TS 1 specifies the short circuit rating for plant and equipment and the associated fault clearance times. Any deviation from these requirements shall be specified in the Enquiry Documentation.

The minimum and maximum short-circuit levels will be defined in the Enquiry documentation.

Solution Providers shall note that the minimum short-circuit levels relate to compliance with performance requirements of this specification; lower short-circuit levels may exist as the result of abnormal system conditions and Solution Providers shall declare the minimum short-circuit level for safe operation, including switching of the STATCOM.

1.3.5 Insulation Levels

TS 1 specifies the standard insulation levels for power frequency, switching impulse and lighting impulse withstand voltages.

Further details for insulation co-ordination and Creepage are given in Section 5 of this Specification.

1.3.6 Maximum levels of NPS on the existing National Grid system

The STATCOM shall be able to operate and withstand a negative phase sequence component of phase voltage up to 2% continuously for the purposes of rating, without enabling a Phase Locked Loop function, and be robust to short term peaks above this as will occur following or during faults as per Grid Code obligations (CC.6.1.7).

1.4 Dynamic Shunt Compensation Characteristics

1.4.1 Mvar Rating

The required Mvar rating for the device shall be specified in the Enquiry Documentation. This is the value to be continuously available at the connection point to the transmission network.

The STATCOM shall be capable of varying the output continuously. The device shall be capable of a step change to maximum Leading or Lagging output in 50 ms or less (upon receipt of a control signal), unless modified in the Enquiry Documentation. Further details are given in TS 3.24.99.

1.4.2 Continuous Current Rating

TS 1 specifies the nominal continuous current ratings for plant and equipment. Section 6.2 of this specification provides further details.

The step sizes and the frequency of steps shall not exceed the acceptable levels prescribed in Grid Code clause CC6.1.7. (i.e. below ERP28 equivalent).

1.4.3 Short Term Rating

TS 2.1 specifies the short term ratings (overload factors) for plant and equipment. Section 6.2 of this specification provides further details along with TGN(E) 26, TGN(T) 29, TGN(E) 66 and TGN(T) 67.

1.4.4 The Fault Duty Cycle

As a minimum the device shall meet the requirements of Grid Code CC6.3.15 and be able to ride through and respond across its full range and capability including the following requirement;

The STATCOM shall be capable of repeated transient response performance, in accordance with Grid Code clause CC.A.7.2.3.1(i),(ii), (iii), (iv), (vi) and across the reactive range (0.95PF leading to 0.95PF lagging) at 15 second intervals. A minimum sequence shall be 5 repetitions in 2 minutes which under worst case conditions would each be 15 seconds apart. A maximum of 5 such sequences may occur in any 24 hour period, after which the Control System should send an alarm to the control room any restriction to reactive capability. The full reactive capability as defined under clause CC.6.3.2 of the Grid Code shall be fully restored as soon as possible and within 6 hours of the final event unless otherwise agreed.

Any further Fault Duty Cycle shall be specified in the Enquiry Documentation.

1.5 Site and Plant Safety Hazards

Informative: UK legislation requires the Solution Provider to declare all safety hazards relating to the equipment offered.

1.5.1 A register of the hazards shall be submitted and shall include those hazards associated with the physical arrangement of the equipment (e.g. trip/fall hazards) which may pose a danger during off-load maintenance access, and those associated with the in-service operation of the equipment (e.g. stray magnetic fields, high temperatures, fluid leaks, presence of dangerous voltages.).

1.5.2 Access shall be prevented to parts that might represent a hazard (due to voltage, temperature, mechanical movement, etc.). Activities involving working at height or manual handling shall be eliminated by design where reasonably practicable. Where not reasonably practicable to eliminate such activities, the Solution Provider shall propose a safe system of work to be agreed with NGET and provide associated risk assessments and method statements.

1.6 Workplace Noise

- 1.6.1 In normal operation of the facility, it shall not be necessary for any person to work in, or enter an area on a regular basis, where the steady state or peak noise levels exceed the relevant exposure action values specified in The Control of Noise at Work Regulations 2005.
- 1.6.2 The Solution Provider shall identify any areas that are to be designated as Hearing Protection Zones.

1.7 Installation

- 1.7.1 The design of the STATCOM shall take into account all aspects of safety associated with construction, commissioning, operation, maintenance (including any mid-life refurbishment), decommissioning and disposal.
- 1.7.2 The available land shall be detailed in the Enquiry Documentation.
- 1.7.3 The STATCOM shall be designed to occupy the minimum land area required to permit adequate space for all foreseeable inspection, maintenance and repair requirements including safe access and egress. Where practicable this shall be through the use of a Mobile Elevated Work Platform (MEWP). The Solution Provider shall supply detailed MEWP access drawings identifying MEWP access routes.
- 1.7.4 The space requirements around the components installed in the compound shall take into consideration all foreseeable inspection, maintenance and repair activities. This shall include the allowance of sufficient room to work with tools (including any special tools) and facilitate safe movement around the components. TS 2.1 Section 7.101 'Maintenance access' further defines these requirements and provides anthropometric data, which is derived from those set out in BS EN 547-3.

Informative: These should be considered as the minimum requirements and where specific activities require additional space; this shall be taken in to consideration during the design and layout of the compound.

- 1.7.5 Safety clearances shall comply with the requirements of TS 2.1 Section 5.101 'Electrical safety clearances' unless the equipment is fenced off and access is prevented by a suitable interlocking scheme whenever the equipment is either;
 - (a) energised, or
 - (b) de-energised and unearthed.
- 1.7.6 Access to the primary plant shall be possible without the need to remove any structural member or support including insulators, main connections, busbars or any other normally fixed equipment. The Solution Provider shall confirm their compliance with this requirement by supplying detailed layout drawings in the Tender submission.
- 1.7.7 Where the equipment is fenced off, access for inspection or operation of all ground mounted equipment (e.g. marshalling kiosks, circuit breakers, disconnector/earth switch mechanism cabinets, P&C and cooling plant) shall be possible from outside the compound to prevent the need to isolate and earth the STATCOM in order to access these items.
- 1.7.8 Where the equipment is fenced off, the access gates to the installation's compound shall be designed to allow access by any prescribed plant or vehicles (such as a MEWP) required for inspection, maintenance or repair activities.
- 1.7.9 Where the equipment is fenced off, it shall only be possible to gain access to the compound while the equipment is both isolated from the transmission system and earthed. Under these circumstances it shall be possible to walk within the STATCOM compound without danger. A Safety Interlocking scheme shall be provided to facilitate this in accordance with TS 3.1.1.

Informative: Access to the plant within the compound, during in-service operation shall not be required.
- 1.7.10 Where required, fences shall be supplied in accordance with Section 4.5 of this specification and shall not restrict visual inspections of the equipment contained within the compound when viewed from outside the compound perimeter.

- 1.7.11 Over-sailing Hazards shall be avoided (or designed out) during the design stage which may prevent or restrict access to equipment for maintenance or component replacement activities.

Informative: Further guidance regarding safety clearances and the avoidance of over-sailing can be found in TGN(T) 186, 'Guidance for working in proximity to live conductors – reducing the risks'.

- 1.7.12 All busbars shall be constructed at a minimum height of 2.4m to allow persons to walk underneath unimpeded.
- 1.7.13 Cables, pipework etc. shall not be surface laid without prior agreement by NGET.
- 1.7.14 Cables, pipework, earth tape or supporting structures shall not be placed less than 2.4m above the ground without prior agreement by NGET. The Solution Provider shall ensure there is adequate access to all cubicles and for removing cooling motors, air conditioning / Heating, Ventilation and Air Conditioning (HVAC) units and associated filters etc. – minimum passageway width is 1.1m in TS 2.1. Access to valve cooling fans needs to be stated as well as cooling valves.
- 1.7.15 The design of the foundation rebar within any magnetic field generated by the STATCOM such as reactor(s) shall avoid closed loops to reduce heating and corrosive effects. Further details are given in TS 3.10 and Design Handbook (DH) 10.
- 1.7.16 The Solution Provider shall provide general layout drawings of all equipment configurations to verify compliance of the design with the specified land area requirements as detailed in the Enquiry Documentation.

1.8 Lifetime and Availability

- 1.8.1 The STATCOM primary equipment and associated civil works shall have a minimum design life of 40 years. The P&C systems associated with the STATCOM shall have a minimum design life of 15 years as detailed in TS 2.24. The power electronic devices shall have a minimum design life of 25 years. The Solution Provider may offer additional design life where it demonstrates an overall cost benefit and complies with the reliability, availability and maintainability requirements.
- 1.8.2 Details shall be supplied during the Tender stage on how to facilitate the design life, including replacement of shorter lifetime components such as the P&C and power electronic systems / devices with the minimum of down time for the STATCOM installation.
- 1.8.3 The STATCOM and its control system are required to have 100% of its capacity available for 98% (excluding planned maintenance outages) of the service life. While the overall availability shall exceed 95% (including activities required during warranty periods and any other planned maintenance activity).
- 1.8.4 The Solution Provider shall supply a detailed reliability, availability and maintenance study demonstrating compliance with this requirement inclusive of primary, secondary and auxiliary system performance. The Solution Provider shall identify the consequences of unreliability in their STATCOM design and propose mitigation measures to provide partial availability until the next scheduled outage.
- 1.8.5 A Failure Mode, Effects and Criticality Analysis (FMECA) shall be performed on the complete STATCOM solution offered by the Solution Provider. The FMECA shall highlight failure modes with their probabilities and severity of consequences to demonstrate where effort and design considerations have been directed to minimise any potential consequences of a failure or to identify where further effort may be required in the detailed design stage. The FMECA shall be used to support the reliability, availability and maintenance study.
- 1.8.6 Reference is also made to Section 2.2.12 of this specification in respect of the specific availability requirements for valve equipment.
- 1.8.7 Where equipment requires mid-life refurbishment in order for the STATCOM to achieve its anticipated asset life, the scope of the refurbishment activity shall be clearly indicated by the Solution Provider in their Tender response. Provision shall be made to permit pre-outage work to minimise outage requirements should equipment require mid-life refurbishment, such as space for installation and testing of replacement P&C cubicles.

- 1.8.8 Consideration shall be given to minimising outage requirements for operation and maintenance (including any mid-life refurbishment or replacement) activities through, for example, provision of redundancy of critical systems and components and appropriate positioning of components to which access may be required.
- 1.8.9 With NGET's assistance, the Solution Provider shall monitor the availability of the STATCOM equipment following take-over of the STATCOM by NGET. One year prior to the end of any warranty, a report shall be presented to NGET demonstrating that the STATCOM has met the specified availability figures as defined above. Where the actual availability performance is measured to be less than specified, remedial action shall be agreed and taken to rectify any shortfalls in performance. A penalty shall apply. The nature and value of this penalty will be detailed in the Enquiry Documentation.

1.9 Duplication

- 1.9.1 To achieve the required performance, the design of the STATCOM shall ensure that no single failure of the following systems may cause a fault to remain connected to the primary system. To implement this, independent and duplicated systems shall be considered by the Solution Provider for the following items.
- (a) Digital controllers and relays
 - (b) Power supplies
 - (c) Control signals (including optical fibres)
 - (d) Measurement transformers and current sensors signals
 - (e) Cooling system components such as pumps

1.10 Redundancy

- 1.10.1 For the following items, redundancy shall be provided to prevent any single sub-module failure to cause the STATCOM to be switched out of service.
- (a) Capacitor units in service
 - (b) Power electronic modules in service
 - (c) Cooling system components such as fans.

1.11 Maintenance Requirements

- 1.11.1 A maintenance regime shall be provided which minimises the need for outage related inspections. Best industry practice shall be adopted to provide non-intrusive inspection methods and asset monitoring activities to identify the need for any preventative or corrective maintenance activity.
- 1.11.2 Routine maintenance that requires an outage of the STATCOM shall be minimised and shall not be required more than once every three years. The warranty shall take this into account.
- 1.11.3 All items that require regular inspection and/or maintenance shall be listed in the Tender submission, together with the recommended inspection intervals to achieve the required service life.
- 1.11.4 At the Tender stage the Solution Provider shall supply fully documented method statements for the inspection, maintenance and replacement procedures for major plant items, equipment and auxiliary systems.
- 1.11.5 Any special tools or equipment that may be required to carry out routine maintenance or repairs shall be identified by the Solution Provider and shall be provided for each STATCOM installation with the agreement of NGET.
- 1.11.6 The maintenance requirements for the P&C equipment are detailed in TS 3.24.99.

1.12 Spares

- 1.12.1 The provision of Spares and Transmission Manuals 'T-Manuals' shall be in accordance with UKBP/TP 112 – Spares Procedure.

1.12.2 The Solution Provider shall maximise the use of common component designs across the solution to allow for a common spares holding.

1.12.3 The Solution Provider shall recommend to NGET during the Tender stage through the provision of a spare parts list, the quantity and type of components that should be held as spares for both maintenance activities (consumables) and as strategic replacements.

1.12.4 Sufficient spare components shall be provided through the contract to allow for the rapid replacement of failed units up to the design lifetime.

Informative: This shall include reference to auxiliary components such as cooling and HVAC etc. not just the valves and primary plant.

1.12.5 Strategic spares requirements shall be specified in the Enquiry documentation.

1.13 Training

1.13.1 The Solution Provider shall make provision for a training programme to include operator/dispatch and maintenance training for engineering, operating and maintenance personnel.

1.13.2 The solution Provider shall make provision for a training programme to include Power system modelling training and how to use this in power system studies within NGET's standard suite of modelling tools/applications. See section 8.4 for further detail on the model data requirements.

1.13.3 The content of the programme, timing of delivery and the location(s) of training shall be mutually agreed between NGET and the Solution Provider.

1.13.4 The use of video and web based media shall be considered to supplement any relevant training material and requirements.

1.14 Requirements for Portability & Relocation

1.14.1 The requirement for portability and relocation shall be specified in the Enquiry Documentation.

2 PRIMARY PLANT

This section addresses the STATCOM main components and the technical requirements.

2.1 General

2.1.1 All plant, equipment and apparatus shall comply with the general conditions specified in TS 1.

2.1.2 Individual items shall also comply with the relevant level 2 and level 3 TS's, British, European and International standards or specifications, including the requirements detailed below.

2.1.3 All equipment and auxiliary systems directly associated with plant items (i.e. mechanism boxes, marshalling kiosks, termination boxes and associated wiring), in addition to complying with Section 2.1.1 and 2.1.2 of this specification, shall comply with the relevant requirements of TS 2.19.

2.1.4 Interlocking shall be provided and must be hard wired to TS 3.1.1. It shall be fail safe to ensure and demonstrate firing pulses are disabled, TS 3.24.99 further defines.

2.1.5 The nameplates for each item of plant, equipment and apparatus shall meet the minimum requirement as detailed in TS 2.1 and UKBP/TP 109.

2.1.6 Full account of any allowances required for the effects of harmonics, as detailed in this specification and the Enquiry Documentation, shall be taken in to consideration by selecting the appropriate ratings of all components and shall consider the minimum of;

- (a) Any harmonics generated by the STATCOM itself.
- (b) The supply system harmonic impedance loci ("rating" conditions) for the 275 kV and/or 400 kV systems detailed in the Enquiry Documentation.
- (c) The maximum continuous fundamental frequency voltage on the HV system.

- (d) The levels of pre-existing harmonic voltage distortion on the system up to the limits prescribed in ER G5/4-1.
- (e) Any resonances arising as a result of interactions with adjacent or nearby primary plant such as cables, filters, Mechanically Switched Capacitor – Dampening Network (MSC-DNs) reactors etc.

The Solution Provider shall provide details of their sub-component rating methodology to demonstrate compliance.

2.1.7 External Insulation

Unless otherwise specified in section 1.2.4, the minimum Creepage distance of all external porcelain insulation shall be based on the values given in IEC/TS 60815 Part 1 and Part 2 for the selected equipment rated voltages, as follows;

- (a) Insulation shall meet the requirements of TS 3.1.7.
- (b) For equipment mounted in the vertical/upright position, pollution class d
- (c) For equipment mounted in any other spatial orientation, pollution class e
- (d) Where necessary, this Creepage distance shall be increased to take into account the allowances for harmonics as detailed in the Enquiry Documentation.
- (e) Porcelain insulators shall comply with, TS 3.2.9, IEC 60273 and BS EN 60168.

The selected insulator configurations and supporting steelwork shall not result in insulation failure due to heavy wetting conditions.

2.2 Power Electronic Valves

- 2.2.1 This includes thyristor, Insulated Gate Bipolar Transistor (IGBT) based valves and other types of power electronic devices.
- 2.2.2 All valves, whenever used and of whatever type, shall comply in general with the applicable sections and principles of BS EN 60146, BS IEC 60747-1 and BS IEC 60747-1.
- 2.2.3 It shall be possible to exchange discrete power semiconductor assemblies with the minimum disassembly of any power or water cooling circuit and with the minimum dismantling of any overall convertor module (if supplied).
- 2.2.4 Special tools required for the replacement of these parts shall be provided under the contract. Points for attaching earthing devices for the control of trapped charge, induced voltages or inadvertent re-energisation of the valves should be provided.
- 2.2.5 The in-service failure of any single valve component shall not prevent the continued operation of the STATCOM at any point on its continuous operating characteristic. If a fault occurs, the control system will automatically notify the existence of the fault and log the date and time of its occurrence. A clear indication of the fault location shall also be provided. The Solution Provider shall provide full details as to how this requirement for redundancy will be implemented and how the voltage stresses applicable to the non-bypassed components are affected.
- 2.2.6 A sufficient level of redundancy shall be provided to achieve 99.5 % availability (excluding planned maintenance) and allow valves to operate for a period of three years between scheduled maintenance. At least 10% redundant sub-modules or 2 redundant sub-modules (whichever is greater) shall be provided.
- 2.2.7 The Solution Provider shall provide details of the provisions for valve protection.
- 2.2.8 The purpose and configurations of any semiconductor snubber and associated circuits shall be summarised by the Solution Provider in their Tender submission.
- 2.2.9 A detailed design report covering all aspects of the valve design shall be provided by the Solution Provider at the contract stage.

- 2.2.10 Any control or fibre optic cabling must be protected from inadvertent contact by personnel. The cabling must also be adequately protected from vermin damage or any adverse environmental effects i.e. moisture, humidity etc.
- 2.2.11 The Solution Provider shall demonstrate at the Tender stage that the selection of component materials used in the valve design and any interfaces to the cooling system will not lead to any form of electro-chemical reaction, corrosion or the accumulation of scaling within the valve or cooling system.
- 2.2.12 Power Electronic Valve Availability. The minimum requirements for overall STATCOM availability are specified in Section 1.8.3. Within these values, the availability figures specific to the power electronic valves (including associated cooling plant) shall be 99.5% (excluding planned maintenance) and 99% (including planned maintenance) respectively.
- (a) A statistical availability study shall be supplied by the Solution Provider with the Tender submission (in addition to that requested in Section 1.8) demonstrating compliance with the above requirement.
 - (b) The source of component failure rate statistics shall be included with this submission. Particular attention should be drawn to the configuration and performance of the components of the valve cooling system and the associated pumps, transducers, controllers, etc.

2.3 Valve housing and associated enclosures

- 2.3.1 The STATCOM valve hall/housing and any other associated outdoor enclosures/connections shall be designed and tested to provide adequate protection and weather proofing to withstand the full range of environmental conditions detailed within this specification and shall be suitable for the British climate.
- 2.3.2 Particular attention shall be paid towards temperature ranges, humidity levels and the risk of condensation developing inside the housings/enclosures. The design shall limit moisture ingress below a level which may cause damage or lead to a flashover in either the Valve Housing or any of its connections to ground potential.
- 2.3.3 Where HVAC is employed to control the climate in the valve accommodation the performance, operation and maintenance shall be included in the overall STATCOM performance and lifetime costing.
- 2.3.4 Outdoor enclosures for valves should be similar to portable protection and plant accommodation with respect to lifetime etc. – see TS 2.10.10. These housings shall be designed to a minimum IP rating of IP55 in accordance with BS EN 60529. Supporting test evidence shall be supplied to NGET.
- 2.3.5 All thermal insulating materials used in areas where temperature and humidity control are critical shall be of the 'closed cell' design to prevent moisture being retained within the insulation materials.
- 2.3.6 The housing shall also be designed to meet the relevant electrical and mechanical stresses it will be exposed to under normal and abnormal operating conditions.
- 2.3.7 An assessment of, and provisions for, a pressure relief system shall be included in the accommodation design such that in the event of a flashover within the housing, damage is limited and any excess pressure is released in a controlled manner.
- 2.3.8 The Solution Provider shall demonstrate that the design of the Valve and its enclosure meet the general recommendations of IEC/TR 62757 and follows industry best practice in managing the risk of fire.
- 2.3.9 Fire protection and climate monitoring are covered in Section 4.

2.4 Valve Cooling

- 2.4.1 The cooling plant shall be arranged to minimise the auxiliary power requirements of the STATCOM throughout its entire operating characteristic and during periods whilst the STATCOM is shutdown.

- 2.4.2 The cooling plant shall be located on the external side of any interlocked compound to allow access to the cooling plant for any routine inspections, without the need to isolate and earth the primary plant.
- The cooling system control system, enclosures, wiring and components on the cooling system skid (or equivalent) shall comply with the requirements of section 4.1 and TS 2.19.
- 2.4.3 Isolation valves shall be provided and accessible from ground level and without having to climb into the skid. These shall be padlockable or equivalent locking facility to meet requirements of National Safety Instruction (NSI) 17 – Pressure systems.
- 2.4.4 There shall be provision of venting valves at the highest point and drain valves at the lowest point of the cooling system to enable fluids, where necessary, to be fully drained from the system prior to any intrusive access or maintenance.
- 2.4.5 The cooling fluid shall not freeze when exposed to the minimum ambient temperature specified in TS 1. To achieve this, pipework may be thermally insulated or the cooling fluid may contain an additive to prevent the risk of freezing.
- 2.4.6 The Solution Provider shall demonstrate that the cooling fluid shall operate over the full ambient temperature range stated within this specification.
- Informative: The cooling fluid may consist of deionised water due to the electrical potential difference between the valves and the cooling plant.*
- 2.4.7 External piping shall be stainless steel. The design shall minimise the number of joints and opportunities for leaks to develop.
- 2.4.8 A report shall be provided by the Solution Provider detailing the required flow rates, pressures, temperatures, number of external coolers in operation and other parameters as appropriate in respect of the cooling system relating to the float Mvar condition (i.e. zero Mvars) and also the Mvar value which corresponds to maximum cooling load. This information shall be calculated assuming the maximum ambient temperature external to the valves given in TS 1. Indicative cooling plant ratings shall also be provided at the Tender stage.
- 2.4.9 Evidence shall be provided by the Solution Provider to demonstrate that any coolant mixture used in the cooling circuit is fully compatible with the pipework and all other materials into which it will come into contact for all conditions of temperature, pressure and flow rate that will be experienced in service. As a minimum, data sheets and other supporting documentation (e.g. compatibility test evidence demonstrating non-corrosion performance, etc.) shall be provided to confirm compliance with this requirement.
- 2.4.10 The cooling design shall ensure that no cross contamination of separate cooling sub-systems (e.g. a pure water system to a water/glycol mixture system) is possible. The growth of algae and bacteria within the cooling system must be prevented.
- 2.4.11 The Solution Provider is reminded that, depending on the design, the valve cooling system or a part thereof may be required to comply with the Pressure System Safety Regulations 2000. The Solution Provider is responsible for assessing whether the regulations do apply and if not, should state why the regulations do not apply. If the regulations do apply, the Solution Provider shall produce a Written Scheme of Examination (WSE) and ensure that the WSE is in place before the valve cooling system is put into operation for the first time.
- 2.4.12 Sufficient on-site coolant storage shall be provided, either in expansion tanks or in supplementary tanks to ensure a 6 month standby for normal operating losses.
- 2.4.13 Any spillage or losses of coolant which may contain a pollutant or contaminant must be appropriately contained to allow proper disposal. Any coolant losses should be minimised and shall not require operator intervention (e.g. topping up) any more frequently than once every 2000 hours of operation.
- 2.4.14 Evaporative coolers are not permitted.
- 2.4.15 The average annual cost of components and labour resources for replacing all components in the valve cooling system scheduled to be replaced periodically (such as exchangeable resin cylinders, if used) shall be stated at the Tender stage.

- 2.4.16 Redundancy shall be provided to ensure that the STATCOM can continue in operation throughout its entire continuous operating characteristic at maximum ambient temperature with a pump (primary and secondary), fan, 3 way valve or heat exchanger (as applicable) out of service.
- 2.4.17 All redundant equipment must be provided with a means of local isolation for maintenance purposes in accordance with NGET Safety Rules and the Electricity at Work regulations.
- 2.4.18 To maximise lifetime and cooling plant availability the apportionment of running hours between the cooling system's rotating plant shall be controlled automatically by the control system. The criteria used by the Solution Provider to achieve the pump rotation optimisation shall be stated at the Tender stage. Changeover between cooling pumps shall be achieved in a smooth manner enabling the cooling plant to continue in operation without reduction in performance whilst the changeover is occurring.
- 2.4.19 Where the cooling plant comprises one or more items of equipment that is only required to operate infrequently or at certain times of the year (such as a chiller/refrigeration unit utilised when the ambient temperature is relatively high), the Solution Provider shall detail the provision made in the cooling plant design to ensure that such components will satisfactorily operate when required following a long duration of inactivity. It is expected that this will take the form of some periodic running as deemed necessary.
- 2.4.20 If the STATCOM is not required to be in service for extended periods of time, to save the running costs associated with the cooling system and to reduce unnecessary wear and tear on the cooling system components (pump running hours etc.), a Maintenance mode for the cooling system control shall be provided at the control system to switch the cooling system off (in addition to the normal on/off/auto/manual modes that may exist).
- 2.4.21 The Maintenance mode shall enable an auto-run feature for the cooling system pumps and any other recommended components. The auto-run feature shall be at intervals, and for durations as recommended by the cooling system manufacturer. For example, 1 hour of running per month for each pump etc.
- 2.4.22 The Maintenance mode shall provide alarms, indications and events as appropriate. The STATCOM shall be prevented from entering in to service while the cooling system is in Maintenance mode.
- 2.4.23 Instrumentation for coolant flow pressure, temperature and conductivity shall remain within calibration for a minimum period of two years and shall be arranged to be fail safe. Transient indications and alarms associated with these devices must be stored / logged before resetting.
- 2.4.24 Once the cooling system, cross-site pipework and connections to the valve have been installed and assembled on site, the fully assembled system shall be subjected to an over pressure test to prove the system. The duration and over pressuring level shall be agreed with the Solution Provider.

2.5 Valve Protection

- 2.5.1 The requirements for valve control and protection are detailed in TS 3.24.99 and shall be satisfied. Where devices with turn-off capability are supplied and connected in series, the means by which the satisfactory turn-on and turn-off performance of the series string will be achieved shall be detailed by the Solution Provider. This shall include details of the effects of component equipment manufacturing tolerances and the effects of variations in the performance characteristics of individual semiconductor devices (e.g. turn-on and turn-off delays, etc.).

2.6 D.C. Capacitors

- 2.6.1 Where supplied, d.c. capacitors shall comply with BS EN 61071. The Solution Provider shall provide full details with their Tender submission of the methodology used in determining the choice of d.c. capacitor rating and resultant stress levels including the effects of any harmonics.

- 2.6.2 Where d.c. capacitors are installed in a cabin or housing, the Solution Provider shall demonstrate that their mounting arrangement and cooling facilities are suitable for the chosen capacitor environmental temperature category and rated voltage.
- 2.6.3 It shall be possible to replace individual capacitors without the need to dismantle d.c. bus-work. For maintenance purposes, a suitable method shall be provided to enable the short-circuiting, discharging and connecting to earth of the d.c. capacitors and d.c. bus-work. This shall be in accordance with NSI 11.
- 2.6.4 The impregnant shall be low fire hazard, biodegradable and be PCB free. The Solution Provider shall supply the relevant Control of Substances Hazardous to Health (COSHH) Data sheet for the impregnant.
- 2.6.5 The capacitors shall be of self-healing type, so designed to ensure minimal energy release should a fault occur within the capacitor unit.
- 2.6.6 The upper limit of the capacitor unit case temperature, Operating temperature (Θ_{max}), shall be specified by the capacitor manufacturer. The nominal range of values is given in clause 4.1.2 of BS EN 61071:2007. The manufacture shall demonstrate that the selected Θ_{max} takes in to consideration the most onerous operating conditions of the STATCOM (system voltage, STATCOM output, harmonics etc.) and the most onerous environmental conditions, and that the selected Θ_{max} provides an adequate safety factor between the expected case temperature and the selected rating of the case temperature.
- 2.6.7 In accordance with clause 5.13.1 in BS EN 61071, test Nb shall be performed as described in BS EN 60068-2-14.
- 2.6.8 In accordance with clause 7.1 in BS EN 61071, a discharge resistor shall be installed within each capacitor unit, capable of meeting the stated discharge duty of 75 V or less in 10 minutes.
- 2.6.9 Where d.c. capacitors are supplied which exceed a rating of 1500 Vdc, NGETs standard requirements for Creepage distances and air clearances shall apply.
- 2.6.10 The relevant sections of TS 3.11.1 shall also apply to d.c. capacitors.
- 2.6.11 The relevant Appendices and schedules of data within TS 3.11.1 shall also apply to d.c. capacitors. Where the schedules of data are not appropriate for d.c. capacitors, the capacitor supplier shall provide relevant alternative data items to support the capacitor design and selection of key parameters.

2.7 A.C. Capacitors

- 2.7.1 Where supplied, a.c. capacitors and associated equipment shall comply with the requirements of TS 3.11.1.
- 2.7.2 The required capacitor voltage rating (U_N) shall be determined according to the procedure detailed in TS 2.11 Appendix M.
- 2.7.3 High frequency a.c. earthing capacitors, where supplied, shall comply with the requirements of BS EN 60358 & TS 3.11.1 as applicable.

2.8 Phase Reactors

Informative: Phase reactors may also be known as Coupling Reactors.

- 2.8.1 Where dry type reactors are supplied they shall be designed and tested in accordance with IEC 60076-6 and TS 3.3.2.
- 2.8.2 Where oil filled reactors are provided they shall comply with the relevant parts of TS 2.3.
- 2.8.3 The design of the phase reactor shall be capable of withstanding the mechanical and thermal stresses associated with the discharge and short circuit currents it shall be exposed to.
- 2.8.4 Special attention is required to the design of an unshielded air core reactor with respect to the stray magnetic fields it will produce and the impact they may have on nearby metallic parts. Further guidance for stray magnetic field limits is given in section 6.4 of this specification.

- 2.8.5 Where reactors that do not fall within the general scope of either TS 2.3 or TS 3.3.2 are provided, the Solution Provider shall provide full details of the specifications to which these reactors are designed and tested.

2.9 Resistors

- 2.9.1 Air insulated resistors, where supplied, shall comply with the requirements of TS 3.11.2.
- 2.9.2 The data and information required by and detailed in TS 3.11.2 shall be provided.

2.10 Filter Banks

- 2.10.1 Filter banks, where supplied, shall comply with the requirements of TS 2.21 where appropriate.
- 2.10.2 The data and information required by and detailed in TS 2.21 shall be provided.

2.11 Compensator Transformer

- 2.11.1 The HV compensator transformer shall comply with the relevant requirements of TS 2.3. The neutral ends of the HV windings shall be directly earthed.
- 2.11.2 Single phase units may be specified to achieve the required availability and reliability.
- 2.11.3 Cooling of the compensator transformer shall be as specified in TS 2.3, except as follows:
- (a) No Oil Natural Air Natural (ONAN) rating is required. As a result of a step load change from float to maximum rated STATCOM output, no part of the winding shall exceed the temperature attained when operating at full rated output.
 - (b) The operation of fans and pumps shall be automatic with a manual override facility provided to allow the operation of each component of the cooling system separately or in combination.
 - (c) The STATCOM must be capable of maximum rated power with a minimum of one fan and one pump out of service.

2.12 Auxiliary / Earthing Transformer

- 2.12.1 An earthing transformer, where required, shall earth the secondary side of the compensator transformer. It may also be used to provide the STATCOM auxiliary supplies (see section 4.7). The neutral end of the HV windings of the earthing transformer shall be solidly earthed unless the Solution Provider can justify why this should not be the case and an alternative means of earth fault protection is provided.
- 2.12.2 An earthing transformer, where required, shall comply in general with the requirements of BS EN 60076 (all applicable parts) & TS 2.3.

2.13 Circuit Breakers

- 2.13.1 Circuit breakers, where supplied, shall comply with the requirements of TS 3.2.1.
- 2.13.2 The Solution Provider shall identify and declare at the Tender stage the switching duties required during energisation sequences or fault interruption as a result of the STATCOM architecture.
- 2.13.3 The data and information required by and detailed in TS 3.2.1 shall be provided.

2.14 Disconnectors and Earth Switches

- 2.14.1 Disconnectors and earth switches shall comply with the requirements of TS 3.2.2.
- 2.14.2 Earth switches shall be provided to earth each separate section of conductor including the main Low Voltage (LV) busbars.
- 2.14.3 The data and information required by and detailed in TS 3.2.2 shall be provided.
- 2.14.4 All disconnector and earth switches associated with the installation shall be mounted outside any interlocked boundary fence or building room (where provided) to enable operational access to their mechanisms without infringing safety distances.

Informative: this includes applications on the LV side of the compensator transformer.

2.15 Voltage Transformers

- 2.15.1 Voltage Transformers (VTs) shall comply with the requirements of TS 3.2.5
- 2.15.2 The data and information required by and detailed in TS 3.2.5 shall be provided.
- 2.15.3 The rating, voltage class, transformation ratio, output, and accuracy class for any VT located within the STATCOM shall be selected by the Solution Provider to satisfy the requirements of the specific application.
- 2.15.4 Test and isolation facilities for VT secondary circuits shall be in accordance with TS 2.19.
- 2.15.5 Three, single phase, high accuracy wound VTs of the relevant rated voltage will be installed. These will be connected, one per phase, to the load (i.e. transformer) side of the HV circuit breaker and their secondary outputs will be available for compensator control purposes.
- 2.15.6 In addition an existing lower accuracy, single phase signal representing nominal busbar voltage (i.e. source side of circuit breaker) will be made available if required.
- 2.15.7 HV VTs shall be specified as Power Quality (PQ) quality measurement class and enable measurement up to 100th harmonic.
- 2.15.8 Low Power Instrument Transducers (LPITs) may also be employed; however the performance and functionality shall be agreed with NGET at the Tender evaluation stage.

2.16 Current Transformers

- 2.16.1 Current Transformers (CT's) shall comply with the requirements of TS 3.2.4.
- 2.16.2 The data and information required by and detailed in TS 3.2.4 shall be provided.
- 2.16.3 The rating, transformation ratio, output, and accuracy class for any CT located within the STATCOM shall be selected by the Solution Provider to satisfy the requirements of the specific application. Where possible this should aim to minimise the number of variants used across the whole STATCOM solution. This will help in testing and spares management etc.
- 2.16.4 Test and isolation facilities for CT secondary circuits shall be in accordance with TS 2.19 and DH 01.
- 2.16.5 LPITs may also be employed; however the performance and functionality shall be agreed with NGET at the Tender evaluation stage.

2.17 Other Transformers/Wound Components

- 2.17.1 Transformers and other wound components not covered in this specification shall comply with the appropriate sections of BS EN 60076.

2.18 d.c. measuring devices

- 2.18.1 d.c. currents and voltages shall be determined directly by measurement. The accuracy and performance of d.c. current and voltage measuring devices shall be sufficient to meet the specified control and protection requirements. The performance and functionality shall be agreed with NGET at the Tender evaluation stage.

2.19 Optical Fibres

- 2.19.1 Optical Fibres shall comply with the requirements of TS 3.8.33, BS EN 60794-1-1 and BS EN 60794-1-2.
- 2.19.2 When installed and terminated, the fibres shall have sufficient spare length to permit at least three re-terminations at each end of the fibre. This extra length shall be available within the termination cubicle.
- 2.19.3 Each fibre cable supplied shall have 100% fibre cores available as spare. (i.e. if 10 operational cores are required, an additional 10 shall be supplied as spares).
- 2.19.4 Where optical fibres are connected between equipment at earth potential and equipment at some other voltage potential i.e. connected to the Valve Base Electronics (VBE) (or similar), the Solution Provider shall demonstrate how the optical fibres are protected from any possible partial discharge damage which may ultimately lead to a flashover of the equipment.

2.20 Substation Post Insulators

- 2.20.1 Substation post Insulators shall comply with the requirements of TS 3.2.9.
- 2.20.2 The data and information required by and detailed in TS 3.2.9 shall be provided.
- 2.20.3 General insulation levels and Creepage requirements are defined in TS 1 and TS 2.1.

2.21 Busbars and Connectors

- 2.21.1 Busbar systems shall comply with the requirements of TS 3.1.4.
- 2.21.2 LV busbars and connectors and their safety clearances shall conform to TS 2.1 unless the equipment concerned is fenced off and access prevented (by an interlocking scheme to the approval of NGET) whenever the equipment is unearthed. They shall be suitably rated to match the full capabilities of the STATCOM.
- 2.21.3 For d.c. busbar systems, the amplitude and duration of the current to be used when calculating the short circuit load of conductors shall be determined by the Solution Provider.
- 2.21.4 The Solution Provider shall provide details of the method used to calculate the short circuit load of conductors.
- 2.21.5 The data and information required by and detailed in TS 3.1.4 shall be provided.

2.22 Bushings

- 2.22.1 a.c. bushings shall comply with the requirements of TS 3.2.7.
- 2.22.2 d.c. bushings shall comply with BS EN 62199.
- 2.22.3 The data and information required by and detailed in TS 3.2.7 shall be provided.
- 2.22.4 Bushings penetrating into the valve housing shall be either gas filled or of the dry type to reduce fire risk. Oil filled bushings shall not be used.

2.23 Surge Arresters

- 2.23.1 All surge arresters shall comply with the requirements of TS 3.2.3.
- 2.23.2 The data and information required by and detailed in TS 3.2.3 shall be provided.

2.24 Cables

- 2.24.1 All power cables shall comply with the requirements of TS 2.5 and associated level 3 specifications.
- 2.24.2 The data and information required by and detailed in TS 2.5 shall be provided.
- 2.24.3 Where cables fall outside the scope of the TS, they shall comply with the relevant sections of BS 6622. Continuous extruded metallic sheath cables shall be provided with an extruded insulation screen. Particular attention is drawn to BS 6622 in respect of the requirements for earthing of armour and/or screens.
- 2.24.4 Where multiple cables per phase are required, the Solution Provider shall ensure that the current rating of any cable is not exceeded under any continuous operating condition due to current sharing effects.

3 SECONDARY EQUIPMENT

- 3.1.1 STATCOM P&C systems shall comply with the requirements of TS 3.24.99.
- 3.1.2 The data and information required by and detailed in TS 3.24.99 shall be provided.
- 3.1.3 At the Tender stage the Solution Provider shall supply details of the P&C system.

4 AUXILIARY SYSTEMS

4.1 General

- 4.1.1 All auxiliary systems shall comply with the requirements of TS 2.19 where applicable.
- 4.1.2 At the Tender Stage the Solution Provider shall supply adequate details of all auxiliary systems.

- 4.1.3 Marhalling and secondary multicore cables shall meet the requirements of TS2.19 with the following qualifying statement - XLPE, LSF, SWA, LSF – BS 6724 or equivalent shall be used for all cross site cabling. All cables including optical fibres in cable trenches or subfloor internal or external shall have protection either SWA or a suitable protective conduit (such as copex) or as agreed by NGET.

4.2 Air Drying / Air Conditioning systems

- 4.2.1 Where an air drying or conditioning system is provided to control the climate of enclosures, housings, ducts or other systems that contain equipment connected to the HV system (either directly, e.g. a Valve in a Valve house, or indirectly e.g. the optical fibres connected to the individual valve control units in a Valve house), the Solution Provider shall demonstrate through a design report that the system is capable of performing adequately in the full range of climatic conditions experienced in the UK, guided by the environmental conditions given in TS 1.
- 4.2.2 The design report shall contain sufficient detail and calculations regarding operating temperatures, expected air flows and air pressures, maximum permissible humidity levels, dew point calculations and ambient measurements to demonstrate the system performance. The calculations, sizing of components and duplication (where appropriate) shall also take in to consideration the required system reliability in relation to the individual components that make up to the air drying system.
- 4.2.3 The Solution Provider shall detail the actions that will be taken by the STATCOM to protect its self if the air drying system fails, becomes faulty or if a sensor becomes faulty or gives a spurious reading.
- 4.2.4 As a minimum, Temperature, Humidity and Air Pressure Sensors shall be located in each enclosure etc. that is to have its climate controlled by the system. Where phase segregated equipment is provided, the sensors shall monitor all three phases of the installation.

4.3 Climate Monitoring System

- 4.3.1 To provide additional security to the Air Drying / Air Conditioning system, if required, the Solution Provider shall provide an additional climate monitoring system to monitor the climatic conditions from the air outlet of the air drying system and within the enclosures, housings, ducts or other systems that contain equipment connected to the HV system (either directly, i.e. a Valve house or indirectly i.e. the optical fibres connected to the individual valve control units) where the climate is closely controlled or conditioned.
- 4.3.2 As a minimum, the monitoring system shall monitor, temperature, relative humidity and air pressure (differential pressure where a permanent positive pressure is required within an enclosure) within each enclosure and housing along with ambient temperature, ambient humidity, ambient air pressure and wind speed/direction.
- 4.3.3 Where sensors are installed in close proximity to HV equipment (e.g. within the Valve house) the sensors shall be tested and demonstrated to function in the worst possible electromagnetic conditions. TS 3.24.15 gives further supporting requirements.
- 4.3.4 The Climate Monitoring system shall interface to the main STATCOM control system where supervision and alarms of the monitoring system sensors will be provided. If the Climate Monitoring System is designed to take protective actions for the STATCOM if the climate exceeds recommended conditions the Solution Provider shall state what actions shall be taken. Appropriate alarms shall be generated by the system. Analogue trending values for all measured parameters shall be recorded in a data logging system for historical analysis.
- 4.3.5 All sensors shall be supervised so that the monitoring system can detect if a sensor becomes faulty or gives a spurious reading. The Solution Provider shall state what actions shall be taken under these conditions.
- 4.3.6 A dew point calculation shall be made by the monitoring system to estimate the risk for condensation forming in the controlled climate. The Solution Provider shall state what actions shall be taken under these conditions.

4.4 Equipment Fire Protection

- 4.4.1 Fire protection and control, including limitation of fire risk shall comply with TS 3.1.3.

- 4.4.2 All armoured cables used shall comply with BS 6724 regarding the level of smoke emitted during combustion and the concentration of acid gas emitted during combustion.
- 4.4.3 All small wiring cables used shall comply with TS 2.19 regarding the level of smoke emitted during combustion and the concentration of acid gas emitted during combustion.
- 4.4.4 The Solution Provider shall show, to the approval of NGET, that the walls and roof, both internal and external, of any buildings used have been tested in accordance with the procedure set out in BS 476 Part 7 (surface spread of flame) and the results of these tests shall be within the limits defined for a classification of Class 1 (see BS 476 Part 7 Table 2).

4.5 Fences

- 4.5.1 Where an extension to an existing perimeter fence is required to accommodate a STATCOM installation, the requirements of TS 2.22 and DH 10 shall be met. The Risk Category of the extension shall be to the same requirements as the existing perimeter fence.
- 4.5.2 Where the STATCOM installation is outside an existing perimeter fence and it is not practical to extend an existing perimeter fence, a new perimeter fence around the STATCOM installation shall be supplied in accordance with TS 2.22.
- 4.5.3 The Risk Category for a new perimeter fence shall be determined on a site-by-site basis and shall be specified in the Enquiry Documentation.
- 4.5.4 Safety fencing shall be provided in accordance with the requirements of TS 3.10 and DH 10. The specific requirements in DH 10 for Mechanically Switched Capacitor / Mechanically Switched Capacitor Damping Network Compounds, shall also apply to STATCOM installations where electrical safety clearances are not adhered to by the STATCOM installation.

4.6 Buildings and Housings

- 4.6.1 Where required, the provision of Buildings and Housings shall be in accordance with TS 3.10 and DH 10.
- 4.6.2 Oil-filled equipment shall be excluded from the valve accommodation.
- 4.6.3 Climatic condition monitoring shall be employed and shall provide alarms as part of the STATCOM control system.

4.7 Auxiliary Supplies

- 4.7.1 Auxiliary supplies shall comply with the requirements of TS 2.12.
- 4.7.2 Low Voltage Alternating Current (LVAC) supplies shall comply with the requirements of TS 3.12.3.
- 4.7.3 Low voltage direct current (d.c.) supplies shall comply with the requirements of TS 3.12.4.
- 4.7.4 The STATCOM shall be self-sufficient for all its a.c. power requirements, except for start-up and shut down, when a changeover system, to be supplied as part of the STATCOM contract, may be employed to connect to the existing substation supplies. At the Tender stage the Solution Provider shall supply adequate details of auxiliary power requirements. The requirements of the changeover system will be specified in the Enquiry Documentation.
- 4.7.5 The overall supervision of the auxiliary supply system shall be carried out by the STATCOM P&C system TS3.24.99.
- 4.7.6 Full details of the auxiliary power rating requirements shall be provided for the STATCOM. This shall define the capacity at float condition and full output and any other state which defines the maximum capacity.
- 4.7.7 P&C Power supplies shall consist of two independent 110 V d.c. supplies. TS 3.24.99 details these requirements.

4.8 Earthing System

- 4.8.1 An earthing system shall be provided in accordance with TS 3.1.2.
- 4.8.2 All switchgear and compensator equipment, structures and enclosures shall be connected to the existing substation earthing system as specified in TS 2.1 and associated specifications.

5 INSULATION CO-ORDINATION

5.1 A.C. Insulation Co-ordination

- 5.1.1 Valve System Insulation Co-ordination shall be in accordance with BS EN 60071-1, BS EN 60071-2 and BS EN 60071-5 where appropriate.
- 5.1.2 The STATCOM shall be capable of withstanding the transient and temporary overvoltage conditions as defined in TS 1 as well as any surges generated by the operation of the STATCOM and other reactive compensation devices or sources of overvoltage including tripping of the STATCOM circuit breaker, or adjacent circuit breaker, followed immediately by re-energisation and tripping of the circuit-breaker. The completed assembly, including any surge arresters and control system actions, must comply with the requirements of TS 1, TS 2.1 and TS 2.3.
- 5.1.3 In each case (STATCOM and neighbouring VSC devices) the solution shall withstand the transient overvoltages. This shall include not only the primary equipment withstand but also ensure the control system of the device actively suppresses, within its capability, to levels no higher than those maximums defined.
- 5.1.4 The STATCOM shall be capable of withstanding the maximum nominal system operating voltage, the transient and temporary overvoltage conditions as defined in section 1.3 of this specification as well as any surges generated by operation of the STATCOM including;
- a) A double exponential full wave of 1200 kV peak (400 kV system) or 1050 kV (275 kV system) with 8/50 μ s wave shape, followed by a temporary overvoltage on the primary side of the compensator transformer of 1.45 p.u for a duration of 1 s linearly decaying to 1 p.u over 5 s. The STATCOM shall be in operation or temporarily blocked and then immediately returned in to operation following the above sequence.
 - b) A chopped double exponential wave of 1750 kV peak (400 kV system) or 1300 kV (275 kV system) with 1.2/50 μ s wave shape chopped at 10 μ s, followed by a temporary overvoltage on the primary side of the compensator transformer of 1.45 p.u for a duration of 1 s linearly decaying to 1 p.u over 5 s. The STATCOM shall be in operation or temporarily blocked and then immediately returned in to operation following the above sequence.
- 5.1.5 The electrical withstand voltages required for the secondary side of the compensator transformer shall be determined by the Solution Provider. The selection of these withstand voltages shall be supported by a design report and the use of appropriate IEC standard insulation class(es). Where the selected secondary voltage does not correspond directly to one of the IEC U_m values the electrical withstand voltages shall be those for the next highest value of U_m . The design shall cater for an induced voltage to correspond to primary winding test but in any case not less than $2 \times$ nominal voltage. Lower withstand voltages may be proposed where surge arresters are employed subject to the submission of insulation co-ordination studies and acceptance of these by NGET. The electrical clearances applied to the secondary side of the compensator transformer shall meet the general requirements of TS 1, TS 2.1 or TS 2.29 for the rated secondary voltage selected by the Solution Provider. The next highest rated secondary voltage shall be selected if the secondary voltage does not correspond directly to one of the nominal system voltages quoted in TS 1, TS 2.1 or TS 2.29.
- 5.1.6 Where a physical barrier (such as a Glass Reinforced Plastic (GRP) container wall) is introduced between high voltage conductors and areas accessible by personnel, one of the following requirements shall be met:-
- (a) The clearance between the high voltage conductors and the physical barrier shall comply with the safety distances specified in TS 2.1
 - (b) The clearance between the high voltage conductors and the physical barrier shall comply with the minimum basic electrical clearance specified in TS 2.1.
 - (c) The equipment configuration shall be subject to type and routine tests to BS EN 62271-1.

- (d) Additionally, if option (b) or (c) above is followed, the barrier shall be capable of carrying the appropriate fault current. This capability shall be demonstrated to NGET.

5.1.7 Reference should be made to BS EN 62271-1, BS EN 62271-103 and BS EN 62271-203 for withstand voltages for longitudinal insulation for switchgear, disconnectors, etc.

5.1.8 All surge arresters connected at the secondary voltage shall have a minimum energy absorption capability equivalent to at least line discharge Class 3 unless the Solution Provider's insulation co-ordination studies indicate for a higher energy absorption class.

5.1.9 The protective level of the surge arresters shall be such that the Rated Lightning Impulse Withstand Voltage (RLIWV) and Rated Switching Impulse Withstand Voltage (RSIWV) of the secondary side insulation is a factor of at least 1.25 and 1.15 respectively of the highest possible relevant surge arrester residual voltage.

5.2 D.C. Insulation Co-ordination

5.2.1 The Solution Provider shall perform a full study demonstrating the suitability of the insulation co-ordination system applicable to any d.c. voltage source converter system. Insulation Co-ordination shall be in accordance with BS EN 60071-1 and BS EN 60071-2 and BS EN 60071-5 where appropriate.

5.2.2 The requirements for minimum clearances of live parts on the d.c. side shall be similar to the a.c. values, except that the minimum electrical clearance shall be stated by the Solution Provider and shall be fully consistent with the results of the insulation coordination study. The electrical clearances shall not be less than the minimum air clearance given in Table A.1 of BS EN 60071-2 for lightning impulse withstand voltage or in Table A.2 for switching impulse withstand voltage except where it has been proven by test that the standard impulse withstand voltages are met under all applicable environmental conditions.

5.2.3 Electrical safety clearances

- a) For live parts on the a.c. side of the converter, the requirements for electrical safety clearances specified in TS 2.1 shall apply.
- b) The requirements for electrical safety clearances on the d.c. side of the converter shall be similar to the a.c. values, except that the Safety Distance shall be stated by the Solution Provider and shall be fully consistent with the results of the insulation coordination study.
- c) The Safety Distance shall be greater than the electrical clearance by a margin of at least 0.3m.

5.3 Insulation Co-ordination Report

5.3.1 The Solution Provider shall submit an insulation co-ordination report covering the entire STATCOM installation.

5.3.2 As a minimum, the report shall describe the performance of the STATCOM under energisation conditions and its response to Rated Lightning Impulse Withstand Voltage (RLIWV) and Rated Switching Impulse Withstand Voltage (RSIWV) as defined in TS 1 and the sequences of a) and b) in section 5.1.4.

5.3.3 The Solution Provider shall provide an indicative report on the insulation coordination studies for Tender purposes outlining the following as a minimum:

- a) Design assumptions and risks
- b) Insulation withstand voltages for equipment
- c) Transient current stresses for equipment
- d) Surge arrester locations
- e) Surge arrester protective levels
- f) Surge arrester energy handling requirements
- g) Earthing/surge capacitors if required

- h) Insulation clearances for equipment
- i) Creepage distances for insulation.

5.3.4 The Solution Provider shall provide a comprehensive report on the insulation coordination studies at the detailed design stage confirming the performance, ratings and selection of components for manufacture and assembly.

6 PERFORMANCE REQUIREMENTS

6.1 General

6.1.1 The STATCOM shall be designed to withstand the specified continuous rated current, emergency overloads, power system faults, harmonic voltages and harmonic currents specified in this document and the Enquiry Documentation.

6.1.2 As a minimum, the STATCOM shall provide active support to meet the relevant requirements for reactive compensation as defined in the Grid Code, the System Operator – Transmission Owner Code (STC) and the Security and Quality of Supply Standard (SQSS) unless modified by the requirements in this TS.

6.2 Continuous and Short Term Current Rating

6.2.1 Continuous and controllable operation shall be possible according to the operating characteristic detailed in Appendix B. The Mvar output capability and the design points defining the operating characteristic of Appendix B are specified in the Enquiry Documentation.

6.2.2 This shall take into account the harmonic levels defined in the Enquiry Documentation.

6.2.3 The effects of worst case tolerances for individual components (e.g. transformers, capacitors and reactors), supply system frequency variations and the relevant environmental conditions stated in this TS and TS 1 shall be taken into account in the design.

Allowances for self-heating effects or the proximity of other plant shall also be included by the Solution Provider.

6.2.4 A study report with full calculations which demonstrates these requirements are satisfied by the Tendered design shall be provided with the Tender submission.

6.3 Electromagnetic Compatibility

6.3.1 The STATCOM shall meet all of its performance requirements in the substation environment detailed in TS 3.24.15. The STATCOM shall be immune to substation interference and self-generated interference.

6.3.2 The STATCOM shall be demonstrated to comply with the European Council Directive 89/336/EEC on electromagnetic compatibility with respect to the limitation of Radio Frequency Emissions.

The radiated radio interference fields, measured at 250 meters from any point on the STATCOM outer boundary, shall not exceed the levels shown in the drawing in Appendix C.

6.4 Electric and Magnetic Fields

6.4.1 Occupational exposure

In normal operational conditions, it shall not be necessary for staff to enter any area where the limits given in Table 2 below for time-varying fields can be exceeded.

The Solution Provider shall provide plans showing areas (if any) where this magnetic field level is exceeded for operation of the STATCOM at any maximum continuous operating point for all of the site layouts listed in the Enquiry documentation and proposals for any barriers necessary.

6.4.2 Public exposure

Outside of the boundary fence, in normal operational conditions, it shall not be possible for members of the public to enter any area where the limits given in Table 2 below for time-varying fields are exceeded. If operational constraints or significant additional costs would be

incurred to achieve this, the Solution Provider shall notify NGET and act on any instructions given.

	Occupational Exposure limit	Public Exposure Limit
	External field strength corresponding to the basic restriction	
Magnetic field	6000 μ T	360 μ T
Electric field	20 kV/m	9 kV/m

Table 2 : External field strengths corresponding to ICNIRP basic restrictions for public and occupational exposures at 50 Hz

- 6.4.3 The Solution Provider shall provide plans and magnetic field plots to demonstrate the criterion above has been met for the STATCOM installation. To enable NGET to carry out an assessment of the impact of staff with medical devices these plots shall additionally show the 100 μ T contour. This is not, however, a limit that shall be applied to the design.

6.5 Environmental Operational Noise Control

- 6.5.1 The Solution Provider shall include a noise model for the proposed STATCOM equipment using an industry standard noise modelling package. The noise studies shall include;
- Tables of raw sound power data to enable independent noise modelling
 - Tables of equipment operating modes and associated sound powers
 - Details of proposed acoustic mitigation and insertion loss
 - Incorporation of site layout and equipment design including heights and dimensions of principal noise sources
 - Details of the source input data used
 - Tables of contributions at residential receivers
 - Details of key assumptions made in the noise modelling
 - A statement specifying whether or not a dB penalty for tonality has been applied (and if so, at source or at receiver) in accordance with BS 4142:2014
 - Clear noise contour maps with contours to below background
- 6.5.2 Site specific noise requirements shall be detailed within the Enquiry Documentation.
- 6.5.3 The noise model shall consider float, full output, any lifetime load profile detailed in the Enquiry Documentation as operational scenarios for the equipment and any operating points that the Solution Provider considers to be more onerous for Environmental Noise.
- 6.5.4 Design of the proposed STATCOM equipment shall aim to achieve the lowest practicable (below background) BS 4142 assessment level at the most sensitive receivers.
- 6.5.5 NGET aims to achieve a 0 dB assessment level at sensitive receivers. The Solution Provider should note that the local planning authority may impose a more stringent condition for audible noise.
- 6.5.6 The noise performance data required for air-cored reactors shall be determined in accordance with BS EN ISO 3746 or BS EN 9614. The Solution Provider is reminded that where air-cored reactors are utilised, calculations shall take full account of the maximum continuous rated fundamental and harmonic currents as declared in TS 3.3.2. For transformers and iron-cored reactor noise requirements see TS 2.3.
- 6.5.7 The Solution Provider shall provide details at the Tender stage of the methodology they intend to follow to demonstrate compliance of their installed equipment against the noise model.