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SHUNT CAPACITORS AND CAPACITOR BANKS

TABLE OF CONTENTS

PURPOSE AND SCOPE.....	1
PART 1 – PROCEDURAL	1
1 GENERAL REQUIREMENTS	1
2 PERFORMANCE REQUIREMENTS.....	3
3 TEST REQUIREMENTS	6
4 FORMS AND RECORDS	8
PART 2 - DEFINITIONS AND DOCUMENT HISTORY	8
5 DEFINITIONS	8
6 AMENDMENTS RECORD	8
7 IMPLEMENTATION.....	8
PART 3 - TECHNICAL GUIDANCE NOTES AND APPENDICES.....	9
8 REFERENCES	9
APPENDIX A - SELF-CERTIFICATION CHECK SHEET	10
APPENDIX B - ADDITIONAL INFORMATION REQUIRED WITH TENDER SUBMISSION.....	13
APPENDIX C - SCHEDULE OF TECHNICAL DATA - PLANT PERFORMANCE.....	14
APPENDIX D - SCHEDULE OF TECHNICAL DATA - MAINTENANCE AND SPARES.....	19

PURPOSE AND SCOPE

This Specification outlines the functional and performance requirements for shunt capacitors and capacitor banks for use within items of plant to be connected to the National Grid UK Transmission System (Electricity) or Third Party networks. It does not include bank protection schemes or switchgear connections to the HV system which can be found in the National Grid Technical Specifications listed in Section 8. The rating requirements shall be specified in the Enquiry Document or other National Grid Technical Specifications.

PART 1 – PROCEDURAL

1 GENERAL REQUIREMENTS

1.1 Overall

The capacitors, including all their component parts, shall be designed for a minimum operating life of 40 years. Where maintenance is required to meet the lifetime requirement, details shall be declared.

1.2 Racking

The racking shall be designed to carry safely all the required capacitor units, conductors, insulators and other fittings. Allowance for additional loading during erection, equipment maintenance and access shall be made. It is also probable that there may be a need to mount resistors or air-cored reactors on the top of the racks. In such circumstances the Principal Contractor shall co-ordinate the requirements.

Where metal racking is used, galvanised steel racking is preferred. Alternative materials may also be considered. Where additional plant is to be mounted on the racks (refer to above para), the surface shall be smooth and defect free.

All metal mechanically fixed to the racking and all joints within the racking, shall be electrically connected as specified in TS 2.1.

Each rack shall be uniquely numbered in a secure and permanent manner and in a way that is readable from a point on the ground to which access is permitted with the bank energised.

Each rack shall be labelled in such a way that the position of every capacitor unit within a rack can be identified. The labelling shall be permanent and shall be readable from a point on the ground, to which access is permitted with the bank energised.

Each rack shall have a boss to which National Grid approved field equipment earths can be connected.

1.3 Maintenance Facilities

The layout of the capacitor banks shall be such as to allow suitable access for maintenance or repair using a Mobile Work Elevated Platform (MWEF), eg performing capacitor measurements or assisting in the replacement of a failed capacitor unit or fuse. Access shall be possible without the need to remove any structural member or support including insulators, main connections, busbars, corona rings or any other normally fixed equipment.

Safety equipment approved by National Grid shall be provided to assist in the removal and refitting of failed units and their fuses (where applicable) in accordance with National Safety Instruction (NSI) 11. This equipment shall include:

- a) Four purpose-built and insulated leads, or Temporary Short Circuit Leads, to apply a temporary short to a unit while its connections are being broken.
- b) Nine purpose-built and insulated leads, or Bolted Short Circuit Leads, which can be applied securely to an isolated unit, short circuited by a Temporary Short Circuit Lead, to allow safe movement.
- c) Two Discharge Sticks which are suitable to safely short circuit a unit before the commencement of work, for example performing capacitor measurements on the unit. For design purposes, the unit shall be assumed to be charged to the voltage specified for the unit short circuit discharge type test.

The insulation of the cable included in the above equipment shall be coloured a bright red.

- d) Equipment to assist the manoeuvring of a capacitor unit into and out of the rack. One type of this equipment per substation shall be provided for all capacitor units supplied on a contract. The equipment shall be tested and certified in the UK for its duty to the satisfaction of National Grid and shall be provided prior to commissioning of the capacitor installation. This apparatus shall enable the removal and replacement of any capacitor unit irrespective of its position in the bank and shall not depend upon the capacitor unit retaining its shape as manufactured and shall reasonably allow for the consequences of any internal and/or external damage sustained by the capacitor unit. The tenderer shall provide full details of the lifting equipment offered and its manner of operation with his submission.

1.4 Spares

The tenderer shall state the recommended spares holding to achieve a life of 40 years (the specified life) and a life of 25 years.

1.5 Busbars and Clearances

A fully rated set of conductors and connections shall be supplied to connect the capacitor bank equipment together. Busbars shall conform to TS 2.1. Where externally fused capacitors are used, the required electrical clearances between the fuse tail and any other parts of the capacitor bank shall be maintained in normal operation, during operation of the fuse and with the fuse tail hanging following fuse operation.

All connections between individual capacitor units and connections between the capacitor bank and other equipment shall be such to allow the use of the safety equipment (as defined in section 1.3) to be applied in accordance with NSI 11.

1.6 Bushings and Outdoor Insulators

All insulation within the capacitor bank installation (eg unit bushings, inter-rack, base and busbar support insulators etc) shall comply with the following performance requirements:

- a) Have a minimum creepage distance of 25mm/kV based on the voltage across that insulation (derived from U_n).
- b) Have a power frequency short duration ac withstand voltage of at least 2.15 times the voltage across that insulation (derived from U_n).
- c) Satisfy the minimum lightning impulse levels, both HV to LV terminals, HV terminal to earth and LV terminal to earth as specified by the Principal Contractor (where applicable) or in other associated Level 2 (NG)TS.

All bushings and outdoor insulators shall also conform to NGTS 3.2.7 and NGTS 3.2.9 as applicable. All of the relevant parts of Appendix A of NGTS 3.2.7 and Appendix B of NGTS 3.2.9 shall be completed for each different bushing or insulator used.

1.7 Protection

The protection of the capacitors and the capacitor bank shall be in accordance with NGTS 2.24, NGTS 3.24.11, NGTS 3.24.13 and NGTS 3.24.77 as applicable. The detailed requirements for the power circuit components will be found in the relevant (NG)TS.

Where VTs are provided for capacitor out of balance measurement, the design of the bank shall allow a field equipment earth to be applied between the capacitor bank and the VT primary connection(s). This is required by the Safety Rules to prevent inadvertent back energisation from the VT secondary during maintenance.

The out-of-balance - or fuse failure protection - shall not give a false alarm, particularly due to inrush currents even if any point-on-wave switching device, if provided, is not operational and results in the circuit breaker closing at peak voltage.

1.8 Technical Data

The Tenderer's attention is drawn to the information requested in PART 3, Appendix C of this Specification. This information shall be provided at the time of Tender Submission.

2 PERFORMANCE REQUIREMENTS

2.1 Main Requirements

The following Clauses of IEC 60871 1: 2005 are relevant and shall apply.

- a) Definitions. Clause 3 and its sub-clauses. In addition, a Capacitor Rack is defined as an individual framework containing capacitor units connected together.
- b) Service conditions. Clause 4. The ambient air category will be a standard range that encompasses the range defined in the site conditions, refer to TS 1.
- c) Insulation Levels. Section 18 Tables 3, 4 and 5 give the standard insulation levels. TS 1 defines the system insulation levels.

- d) Maximum Permissible Voltages. Clause 19 gives the long duration voltages and the switching voltages that the capacitor installation shall withstand. The achievement of these levels by capacitor units both endurance and type tested to this specification will be accepted without additional evidence. If enhanced capability is claimed for the capacitor units, test evidence for the unit involved shall be submitted to National Grid.
- e) Maximum Permissible Current. Clause 20 gives the long duration currents that the capacitor installation shall withstand.
- f) Internal Discharge Devices shall be provided.
- g) Container Connections. Clause 22 gives the requirement.
- h) Markings of the Unit. Clause 25 defines the requirements for the markings on the units.
- i) Markings of the bank. Clause 26 defines the markings of the bank that shall be provided on a rating plate mounted externally on the compound fence containing the capacitor bank. Where the capacitor bank is mounted above ground level to allow personnel access around the bank whilst energised, the rating plate shall be fixed to the capacitor bank supporting structure. In addition, the nameplate shall state that:
 - (i) "ACCESS TO THE CAPACITOR BANK SHALL NOT BE GAINED WITHIN 10 MINUTES OF THE BANK BEING DE-ENERGISED" AND
 - (ii) "THE REQUIREMENTS OF NATIONAL SAFETY INSTRUCTION 11 (HIGH VOLTAGE STATIC CAPACITOR BANKS) SHALL BE FOLLOWED WHEN PERFORMING WORK ON THIS EQUIPMENT".

2.2 Additional Requirements

The capacitor bank and its units shall additionally meet these requirements.

IEC 60871 – 1 allows capacitors to be operated at overloads, both long and short duration voltages and currents. In particular, it permits operation at $1.1 \times U_n$ for 12 hours in every 24 hours. National Grid permits this 10% margin to be used both for operation of the bank with the alarm-level number of external fuses operated, and for harmonic contributions to rating. This allowance recognises that the system may not operate at maximum system voltage continuously, the harmonics existing on the system and those generated by the sub-system are not always at their maximum possible values, and that the capacitors themselves may not be energised continuously.

If capacitor bank is star connected, the star point shall be connected to earth.

Where an internally fused capacitor bank has more than one capacitor unit connected in series, there shall be at least two units connected in parallel in every series group.

The impregnant shall be biodegradable, to the approval of National Grid, and be PCB free.

The required tests on the capacitors are defined in Section 3 of this Specification.

The tenderer shall supply a graph of how the capacitance of the unit varies with temperature, and how capacitance and tan delta vary with time energised.

2.3 Unit Fusing Requirements - General

The units shall be supplied with either internal or external fuses or be of fuseless type.

The fuse shall only operate when the capacitor unit/element it is protecting fails. The fuse shall not operate when the protected unit/element discharges into a faulted parallel connected unit/element. The fuse shall not operate due to the inrush or outrush currents when the bank is energised or de-energised, or when a parallel connected bank is energised or de-energised.

The fuse shall be able to operate on the 50 Hz current that flows in the event of a unit/element failure at a voltage zero.

The operation of the number of internal fuses that corresponds to the alarm level shall not increase the voltage on the remaining parallel connected elements above 1.3 times the Nominal voltage rating of each element.

The operation of the number of internal fuses that corresponds to the 1st trip level shall not increase the voltage on the remaining parallel connected elements above 1.8 times the Nominal voltage rating of each element.

The operation of the first external fuse shall not increase the voltage on the remaining parallel connected units above a level equal to 1.1 times the unit voltage derived from the relevant element endurance test data.

An external fuse failure which causes the voltage on the parallel connected units to exceed 1.1 times the unit voltage derived from the relevant element endurance test data shall initiate a trip.

In respect of fuseless type capacitors, the failure (to short circuit) of the number of capacitor elements that corresponds to the alarm level shall not increase the voltage on the remaining elements within the 'unhealthy' unit, nor increase the voltage on any other units above a level equal to 1.1 times the unit voltage derived from the relevant element endurance test data.

In respect of fuseless type capacitors, the failure (to short circuit) of the number of capacitor elements which causes the voltage on the remaining elements within the 'unhealthy' unit and / or the voltage on any other units to exceed 1.1 times the unit voltage derived from the relevant element endurance test data, shall initiate a trip.

All internally fused capacitor units supplied shall have their fuses intact prior to their initial energisation at site.

2.4 Internal Fusing Requirements

The following clauses of IEC 60871-4: 1996 are relevant and shall apply.

- a) General requirements. Clause 4.1.
- b) Disconnecting Requirements. Clause 4.2, but the voltage limits shall be as defined below.
- c) The fuse may be required to operate at a voltage based on the minimum continuous voltage of the system to which the capacitor is connected (refer to TS 1) and with no allowance for harmonic voltages. This level shall be agreed with National Grid. Where this voltage, the Minimum Normal Operating Voltage U_{α} , is defined, the lower limit u_1 shall be the lower of:-

$$0.98 \times \sqrt{2} \times U_{\alpha} \text{ and } 0.9 \times \sqrt{2} \times U_N.$$

- d) If the Minimum Normal Operating Voltage is not defined, the lower limit u_1 shall be:-

$$0.9 \times \sqrt{2} \times U_N, \text{ as defined in clause 4.2.}$$