

VOLTAGE GRADING CAPACITORS FOR CIRCUIT BREAKERS

TABLE OF CONTENTS

PURPOSE AND SCOPE	1
PART 1 – PROCEDURAL	1
1 GENERAL REQUIREMENTS.....	1
2 PERFORMANCE REQUIREMENTS.....	2
3 TYPE TEST REQUIREMENTS	2
4 ROUTINE TESTS	4
5 TYPE REGISTRATION PROCEDURE	4
6 FORMS AND RECORDS	5
PART 2 - DEFINITIONS AND DOCUMENT HISTORY	5
7 DEFINITIONS	5
8 AMENDMENTS RECORD.....	5
9 IMPLEMENTATION	5
PART 3 - GUIDANCE NOTES AND APPENDICES.....	6
10 REFERENCES	6
APPENDIX A: TYPE REGISTRATION DATA SHEET	7
APPENDIX B: TYPE TEST INDEX	8

PURPOSE AND SCOPE

This document defines the technical requirements for voltage grading capacitors which are to be applied to circuit-breakers for use on, or directly connected to, the National Grid Transmission System at 420kV, 300kV, 145kV, 66kV and 13kV (tertiary). The principles of this document also apply to equipment connected at other voltages.

PART 1 – PROCEDURAL

1 GENERAL REQUIREMENTS

1.1 General Requirements for Voltage Grading Capacitors

- 1.1.1 The capacitor manufacturer shall assign a value of U_N for each design of capacitor. For application purposes the supplier shall take into account the ratings of TS 1 and the intended use (e.g. voltage sharing resulting from series application). Appropriate dielectric withstand levels shall be derived on the basis of U_N , the intended use, capacitor tolerances and the general requirements of TS 1.
- 1.1.2 In cases where National Grid purchases grading capacitors directly for replacement or retrofit purposes acceptable characteristics and parameter tolerances shall be agreed as part of the Type Registration process.
- 1.1.3 Voltage grading capacitors shall be fitted with a rating plate based on the requirements of BS EN 60871-1 and containing the following information:
 - Manufacturer.
 - Identification number.
 - Year of manufacture.
 - Capacitance.
 - Rated voltage.
 - Rated frequency.
 - Operating temperature range.
 - Chemical or trade name of impregnant.
 - Applicable Standards & Specifications.

1.2 General Requirements for Externally Mounted (AIS) Voltage Grading Capacitors

- 1.2.1 Protective enclosures of externally mounted capacitors shall be demonstrated to meet the requirements for external insulation specified in TS 2.2.
- 1.2.2 The supplier shall declare the maximum acceptable working cantilever load and the minimum cantilever failure capability of protective enclosures of externally mounted capacitors. The deflection under these loads shall also be declared (See 3.3). The application of the capacitors shall be such that handling procedures and methods of mounting do not introduce excessive cantilever loads and that a suitable margin exists between the maximum service mechanical stress and the ultimate failure value.

1.3 General Requirements for Internally Mounted (GIS) Voltage Grading Capacitors

- 1.3.1 Voltage grading capacitors intended for use in a pressurised atmosphere shall not suffer ingress of the surrounding medium. Testing shall be in accordance with Clause 3.7 of this document however other test procedures may be considered.

2 PERFORMANCE REQUIREMENTS

- 2.1 Voltage grading capacitors shall be suitable for use over an ambient temperature range of +40°C to -25°C as defined in TS 1. Relevant testing procedures shall take into account any additional temperature effects resulting from the intended application. See 3.6.

3 TYPE TEST REQUIREMENTS

3.1 General

- 3.1.1 Any series of type tests on individual capacitor units shall be preceded and followed by routine testing as detailed in Clause 4 of this document. There shall be no significant change in the measured values as a result of the type tests other than due to any anticipated conditioning effects. The maximum partial discharge on completion of testing shall not exceed the maximum specified value for a new capacitor unit. The maximum value is expected to be no greater than 10 pC as specified in IEC 60358 unless otherwise agreed by National Grid.

3.2 Mechanical Type Tests

- 3.2.1 Voltage grading capacitors shall be subjected to a circuit-breaker mechanical operations test in accordance with TS 3.2.1 or an equivalent test procedure.
- 3.2.2 In addition to the test procedure of 3.2.1 voltage grading capacitors shall be subjected to the following test procedure.
- 3.2.3 The capacitor shall be clamped at one end in a horizontal orientation. The opposite end shall be raised by the declared maximum acceptable working deflection and released from this position. This procedure shall be repeated a total of 2000 times. After every 500 operations the capacitor shall be rotated on its longitudinal axis by 90° such that 4 distinct orientations are tested.

3.3 Cantilever Load Type Tests

- 3.3.1 The capacitor shall be subjected to a mechanical failure load bending test in accordance with the requirements of IEC 60358. The load/deflection characteristics shall be measured and recorded in the test report.

3.4 Electrical (Dielectric) Type Tests

- 3.4.1 Unit testing of individual capacitors shall take account of the intended use and the maximum stresses on a single unit due to voltage division, capacitor tolerances etc.
- 3.4.2 A one minute power frequency voltage withstand test shall be applied at not less than the appropriate value derived from IEC 62271-1, Table 2a.

- 3.4.3 Lightning and switching impulse tests shall be in accordance with the requirements for complete circuit-breakers as detailed in TS 3.2.1. These tests may be undertaken as an integral part of the testing of the circuit-breaker or may be undertaken separately. A complete series of test impulses shall be applied to each terminal of the capacitor with the opposite terminal earthed.
- 3.4.4 Chopped lightning impulse tests, based on the principles of IEEE C37.06 shall be applied as detailed below. The impulse voltage peak values for the complete circuit-breaker are as specified in TS 1.

Chop at 2 μ s with a minimum peak of 1.29 times rated Lightning Impulse Withstand Voltage

Chop at 3 μ s with a minimum peak of 1.15 times rated Lightning Impulse Withstand Voltage

A minimum of 3 impulses of each polarity shall be applied to each terminal of the capacitor with the opposite terminal earthed.

3.5 Short-Circuit Type Tests

- 3.5.1 The capacitor shall be subjected to an external short-circuit, normally via a parallel rod-rod gap with an applied power frequency voltage of not less than the appropriate one minute withstand value derived from Table 2a of IEC 62271-1. This test shall be applied to each terminal of the capacitor with the opposite terminal earthed. The test procedure shall be that of IEC 60358 which requires two short-circuits to be applied in a 5 minute period. The capacitor shall be demonstrated to be undamaged as a result.

3.6 Environmental Type Tests

The following test procedure demonstrates the environmental performance of capacitors, as detailed in Clause 2.1, where there are no significant additional heating or cooling effects resulting from the intended application. Where such effects exist these should be taken into account and the temperature limits in the following test procedure suitably modified.

- 3.6.1 High and low temperature performance of the capacitor shall be demonstrated by application of the following test programme or a demonstrably equivalent alternative.
- (i) Rated voltage measurement of capacitance, loss angle and partial discharge at ambient temperature.
 - (ii) Cool the capacitor to $\leq -25^{\circ}\text{C}$ allowing sufficient time for stabilisation.
 - (iii) Rated voltage measurement of capacitance, loss angle and partial discharge at a temperature $\leq -25^{\circ}\text{C}$.
 - (iv) 1 minute application of power frequency withstand voltage at $\leq -25^{\circ}\text{C}$.
 - (v) Rated voltage measurement of capacitance, loss angle and partial discharge at $\leq -25^{\circ}\text{C}$.
 - (vi) Allow capacitor to return to ambient temperature.
 - (vii) Rated voltage measurement of capacitance, loss angle and partial discharge at ambient temperature.
 - (viii) Raise the capacitor temperature to $\geq +40^{\circ}\text{C}$.
 - (ix) Rated voltage measurement of capacitance, loss angle and partial discharge at $\geq +40^{\circ}\text{C}$.
 - (x) 1 minute application of power frequency withstand voltage at $\geq +40^{\circ}\text{C}$.
 - (xi) Rated voltage measurement of capacitance, loss angle and partial discharge at $\geq +40^{\circ}\text{C}$.
 - (xii) Continued application of rated voltage for a minimum of three hours and for sufficient time to demonstrate normal recovery (or stability) of capacitance and loss angle.