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**National Grid
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Specification**

**NGTS 3.2.5
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**Voltage Transformers
for use on the 132 kV,
275 kV and 400 kV
Systems**

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Authorised for Issue by:

A handwritten signature in black ink, appearing to read "M B Humphries".

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VOLTAGE TRANSFORMERS FOR USE ON THE 132 kV, 275 kV AND 400 kV SYSTEMS

FOREWORD

This Specification defines the functional requirements for voltage transformers for protection, monitoring or general purpose application of maximum voltage rating 145 kV, 300 kV and 420 kV connected to the National Grid Company (NGC) Transmission System. It supports the more general conditions defined in the companion documents NGTS 1 and NGTS 2.2.

1 SCOPE

This is a functional specification for electromagnetic and capacitor voltage transformers.

Functional requirements for settlement metering voltage transformers are separately specified in NGTS 3.2.6.

2 REFERENCES

This document makes reference to or must be read in conjunction with:

BS 7625 (HD 554 S1)	Voltage Transformers
BS 7578 (HD 597 S1)	Coupling Capacitors and Capacitor Dividers
IEC 694	Specification for Common Requirements for High Voltage Switchgear and Controlgear Standards
NGTS 1	Overview, National Grid System
NGTS 2.1	Substations
NGTS 2.2	Switchgear for the National Grid System
NGTS 2.6	Protection
NGTS 3.2.6	Current and Voltage Measurement Transformers For Settlement Metering of the 33 kV, 66 kV, 132 kV, 275 kV and 400 kV Systems
NGTS 3.6.10	PLC Coupling Equipment
NGTS 3.12.2	110 V D.C. Supplies

3 GENERAL REQUIREMENTS

In addition to the requirements of NGTS 1 and NGTS 2.2 the following clauses apply:

3.1 General (For All Types of Voltage Transformer)

3.1.1 Voltage transformers shall comply with BS 7625 (HD 554 S1) and the requirements herein.

3.1.2 Voltage transformers shall be designed for a minimum service life of 40 years as detailed in NGTS 2.2 clause 3.1.1.

3.1.3 External porcelain insulation and insulation co-ordination shall meet the requirements of NGTS 2.2.

3.1.4 Voltage transformers shall be provided with one secondary winding of rating and accuracy class detailed in clauses 4.2 and 4.3.

3.1.5 Both ends of the voltage transformer secondary winding shall be brought out to permit connection to links or fuses external to the voltage transformer.

3.1.6 A single terminal box shall be mounted on each voltage transformer to accommodate necessary alarm equipment, secondary terminal connections, fuses and links. Each secondary wire to the terminal block shall be identified in accordance with BS 7625 (HD 554 S1). Suitable secondary terminals and connections shall be provided. Means shall be provided for the secondary isolation of the voltage transformer in accordance with NGTS 2.1 clause 3.1.12. Suitable fuses or MCBs shall be provided for the purpose of protecting the voltage transformer windings.

3.1.7 For oil-filled equipment, the supplier shall declare the type of insulating oil used and shall provide evidence demonstrating that the oil is suitable for the required application.

3.1.8 For oil-filled equipment fitted with an external oil expansion system, means shall be provided to give a permanent visual indication of position.

3.1.9 For oil-filled equipment where the oil expansion system is internal, ie gas cushion or diaphragm, and/or where an external indicator is impractical, means shall be provided to permanently display the internal oil pressure.

3.1.10 Oil-filled equipment shall be provided with a means of taking oil samples for dissolved gas analysis. For post-type equipment, the oil sampling point shall be positioned on the earthed metal base unit of the transformer. Sampling points are not required on the capacitor units of capacitor voltage transformers.

3.1.11 Gas filled equipment shall also comply with the general requirements of NGTS 2.1 for GIS and pressurised SF₆ equipment.

3.2 Additional Requirements for Capacitor Voltage Transformers (CVTs)

3.2.1 CVTs for use on the 275 kV and 400 kV systems shall be provided with the coupling capacitor facility for power line carrier application. The capacitors of the CVTs shall comply with BS 7578 (HD 597 S1).

3.2.2 300 kV rated CVTs may be required as the supporting insulator for line trap mounting, and this shall be specified in the contract.

3.2.3 CVT support structures shall be suitable for accommodating a PLC coupling device at a height to permit access with the equipment live.

3.3 Additional Requirements for Electromagnetic Voltage Transformers (EVTs)

3.3.1 An insulation test tap shall be provided for open-terminal EVT's for the purpose of performing capacitance and dielectric loss angle ($\tan \delta$) measurements on the internal insulation during routine maintenance. The purpose of this terminal and its connection shall be clearly identified in the terminal box.

3.3.2 A terminal shall be provided for the purpose of earthing the neutral connection of the EVT primary winding and test tap connections.

3.3.3 Oil-filled EVT's shall normally be fitted with a Gas Detection Device (GDD). Requirements for the GDD are detailed in Appendix B. Alternative methods of protecting the EVT and its windings may also be considered.

4 PERFORMANCE REQUIREMENTS

Note: For the purposes of this section, U_m is as defined in BS 7625 (HD 554 S1) clause 4.18.

4.1 General

4.1.1 All voltage transformers shall comply with the requirements of BS 7625 (HD 554 S1) for the primary ratings detailed in NGTS 1 and NGTS 2.2.

4.1.2 EVT's may be required to perform discharge duties for capacitor bank (SVC/MSVC) applications. The discharge voltage duty requirement shall be $(2.5 \times U_m / \sqrt{3})$. The value of capacitance to be discharged, the minimum number of successive discharges and the maximum rest period between each series of successive discharges shall be stated in the contract. The number of successive discharges, however, shall not be less than two.

4.1.3 Where EVT's are connected to line or cable circuits, and will perform circuit capacitance discharge duties, the supplier shall declare any thermal or mechanical limitations of the EVT which will limit the normal operational capability of the circuit, ie number of de-energisations due to manual switching or auto-reclose. Unless specifically amended in the contract, for 400 kV and 275 kV systems the maximum discharge voltage shall be $(1.1 \times \sqrt{2} \times U_m / \sqrt{3})$. For 132 kV systems, the corresponding voltage shall be $(2.5 \times \sqrt{2} \times U_m / \sqrt{3})$.

4.1.4 The supplier shall state any conditions under which ferroresonance may occur and thereby any restriction on the application of EVT's. Devices to suppress ferroresonance, when supplied as part of the EVT equipment, shall not impair the performance of the EVT. Their effectiveness shall be subject to evaluation and testing.

4.2 Voltage Transformers for Protection and General Instrumentation

Voltage transformers for protection and general instrumentation shall meet the following performance requirements :-

Maximum Primary Voltage (kV)	Accuracy Class (BS 7625)	Rated Burden (VA) (BS 7625)	Rated Voltage Factor pu (BS 7625)	Transformation Ratio (kV/V)
420	1.0/3P	100 or 50	1.5, 30 secs	$396/\sqrt{3} : 110/\sqrt{3}$
300	1.0/3P	100 or 50	1.5, 30 secs	$275/\sqrt{3} : 110/\sqrt{3}$
145	1.0/3P	100 or 50	1.5, 30 secs	$132/\sqrt{3} : 110/\sqrt{3}$

Note: The rated burden shall be selected for the required application from the above BS 7625 rated burden values. The performance of the voltage transformer shall be fully demonstrated for the selected rated burden value.

4.3 Voltage Transformers for Monitoring System Voltage

Voltage transformers for the monitoring of system voltage shall meet the following performance requirements :-

Maximum Primary Voltage (kV)	Accuracy Class (BS 7625)	Rated Burden (VA) (BS 7625)	Rated Voltage Factor pu (BS 7625)	Transformation Ratio (kV/V)
420	0.2	25	1.5, 30 secs	$396/\sqrt{3} : 110/\sqrt{3}$
300	0.2	25	1.5, 30 secs	$275/\sqrt{3} : 110/\sqrt{3}$
145	0.2	25	1.5, 30 secs	$132/\sqrt{3} : 110/\sqrt{3}$

Note: The performance of the voltage transformer shall be fully demonstrated for the rated burden value above.

5 TESTING REQUIREMENTS

5.1 Type Tests

5.1.1 All Voltage Transformers

All voltage transformers shall be tested in accordance with BS 7625 (HD 554 S1). In addition, the following apply:

- (i) Temperature Rise - The thermal time constant of all equipment shall be determined on both rising and falling temperature.
- (ii) Radio Interference - Radio interference voltage tests to IEC 694 are to be performed on open-terminal voltage transformers.
- (iii) Accuracy Tests - (a) These shall be performed in a laboratory giving traceability to National/International Standards. The overall accuracy and uncertainty of the measurement shall be demonstrated prior to testing and shall be commensurate with the accuracy class of the transformer under test. (b) Full accuracy type tests to BS 7625 (HD 554 S1) shall be performed for the selected rated burden value.
- (iv) Cantilever Test - The cantilever/bending moment performance of post-type voltage transformers shall be verified by a type test. The 1-minute cantilever test force shall be declared by the supplier.
- (v) Leakage Test on Oil System - For transformers using an oil insulation system, the supplier shall demonstrate leak-free performance of the transformer.
- (vi) Leakage Test on Gas System - For transformers using a gas insulation system, the supplier shall demonstrate compliance with clause 4.7.3 of NGTS 2.2.

Routine tests shall be performed before and after all type tests and no significant changes between the results shall occur.

For oil-filled equipment, dissolved gas analysis shall be performed before and after dielectric type tests. No changes between the DGA measurements shall be permitted within the declared repeatability of the measurement.

5.1.2 Additional Requirements For EVTs

- (i) EVTs shall be tested together with their associated GDD and, where applicable, with their associated ferroresonance damping device.
- (ii) If the EVT is fitted with a ferroresonance damping device, the supplier shall demonstrate, by test, the satisfactory performance of the complete equipment to meet the requirements of clause 4.1.4 of this specification.

5.2 Routine Tests

5.2.1 All Voltage Transformers

All voltage transformers shall be tested in accordance with BS 7625 (HD 554 S1). Additionally the following apply:

- (i) Capacitance and dielectric loss ($\tan \delta$) measurements of the primary insulation over the voltage range 10 kV to rated voltage shall be performed.
- (ii) Accuracy Tests - (a) These shall be performed in a laboratory giving traceability to National/International standards. The overall accuracy and uncertainty of the measurement shall be demonstrated prior to testing and shall be commensurate with the accuracy class of the transformer under test. (b) Full accuracy routine tests to BS 7625 (HD 554 S1) shall be performed for the selected

rated burden value.

5.2.2 Routine Tests for EVTs

In addition to the tests detailed in 5.2.1 above, the following apply:-

- (i) Where applicable, power frequency withstand tests in accordance with BS 7625 (HD 554 S1) clause 16.3.1 (Method I) shall be performed.
- (ii) A measurement of the VT primary resistance shall be made.

5.2.3 Routine Tests for CVTs

In addition to the tests detailed in 5.2.1 above, a ferroresonance test using the procedures of BS 7625 (HD 554 S1) clause 51 shall be performed. Ten short-circuit applications at 120 % of rated primary voltage and five applications at 150% of the rated primary voltage shall be performed. Acceptance criteria shall be as per BS 7625 (HD 554 S1) clause 45(a). This test shall be performed before the accuracy routine tests and permanent records of the results shall be maintained.

5.2.4 Routine Test Reports

Routine test reports shall include details of all routine measurements made in accordance with this specification. The information required in clause 5.2.1(ii) regarding the overall accuracy and uncertainty of the accuracy measurements shall also be recorded.

Specifically for the partial discharge (PD) test, the values of measured PD at the specified test voltage shall be recorded together with PD inception and extinction voltages. Inception voltage is defined as the voltage level at which the first trace of measurable PD is detected upon increasing test voltage. Extinction voltage is defined as the voltage level at which measurable PD is completely extinguished upon decreasing test voltage.

6 APPROVAL PROCEDURE

Requirements for the approval for voltage transformers are as detailed in NGTS 2.2. Where required, Appendix A of this document shall be completed by the supplier in support of approval.

APPENDIX A

INFORMATION TO BE SUPPLIED BY THE TENDERER

A1 GENERAL DETAILS

1	Manufacturer	
2	VT type and reference Drawing reference (s)	
3	Production commencement date	
4	Type test report number (s)	
5	Test specification (s)	
6	Category and date of approval	

A2 TECHNICAL DATA

1	Rated primary voltage	kV	
	Maximum operating voltage	kV	
	Rated secondary voltage	V	
	Intermediate voltage (CVTs only)	kV	
2	Rated transformation ratio	V/V	
	Maximum number of secondary windings		
3	Rated secondary burden	VA	
	Accuracy class		
	Accuracy testing: Overall accuracy and uncertainty of measurements		

4	Voltage factor / time Thermal current rating	pu/sec A	
5	Capacitance / dielectric loss ($\tan \delta$)	pF	
6	Power frequency withstand voltage (dry/wet) Lightning impulse withstand voltage (dry) Switching impulse withstand voltage (dry/wet)	kV kV kV	
7	Admissible static load (primary terminals) Admissible dynamic load (primary terminals) Cantilever test load (primary terminals) Declared porcelain breaking strength	kN kN kN kNm	
8	Insulation test tap (Yes/No) Porcelain insulator creepage distance Porcelain insulator arcing distance	mm mm	
9	Details of the capacitors used (CVTs only): (a) Manufacturer (b) Type (c) Number of capacitor units (d) HV capacitance, C_1 (e) LV capacitance, C_2 (f) Equivalent capacitance, C_e	pF pF pF	
10	Gas detection device (oil-filled EVT) (a) Electrical or mechanical (b) Contact rating (trip) (c) Contact rating (alarm)	A A	

11	Insulation details: (a) Insulating medium (b) Quantity (c) Type of insulating oil (if applicable) (d) Gas insulation (if applicable): (i) Maximum operating pressure (ii) Minimum operating pressure (iii) Normal operating pressure (iv) Leakage rate (v) Maximum permissible dew point temperature	 MPa MPa MPa torr /s °C	
12	Total weight	kg	

APPENDIX B

REQUIREMENTS FOR GAS DETECTION DEVICES (GDDs)

B1 REFERENCE DOCUMENTS

In addition to the references specified in NGTS 2.6 the following documents apply:

- | | |
|-----------|---|
| IEC 801-3 | Electromagnetic Compatibility for Industrial Process Measurement and Control Equipment (Part 3) |
| IEC 801-4 | Electromagnetic Compatibility for Industrial Process Measurement and Control Equipment (Part 4) |

B2 GENERAL REQUIREMENTS

B2.1 Means shall be provided such that the function of the GDD can be verified during routine maintenance.

B2.2 Where functional testing of the gas detection equipment requires the introduction of gas or air into the instrument transformer, suitable fixed access points shall be provided. Dismantling of fixed pipework for testing purposes is not acceptable.

Note: Test sets and any other special equipment necessary for maintenance testing of the function of the equipment, including the testing of all alarm/trip output functions of the GDD, shall be provided by the supplier.

B2.3 Secondary terminals shall be provided for the supply input and relay output circuits. These terminals shall be located in the secondary terminal box of the instrument transformer and shall provide withdrawable links and/or fuses, as appropriate, to enable the device to be isolated from the supply voltage, and from the alarm/trip circuit energising voltages, for the purposes of commissioning and maintenance testing.

B2.4 Supply to the GDD

B2.4.1 Electronic GDDs shall normally be electrically supplied from a VT secondary winding.

B2.4.2 As an alternative to B2.4.1 above, electronic GDDs shall be capable of being electrically supplied from an external D.C. supply which shall be in accordance with NGTS 3.12.2. The auxiliary supply will be given from a tripping battery supplied under another contract. The battery will be earthed by one of two methods, each incorporating earth fault protection. In the first method, a resistor is connected across the battery with a relay connected between the centre point of this resistor and the earth terminal. This limits the earth fault current to 5 mA or less. In the second method, the positive terminal is biased to 30-35 volts negative with respect to earth.

B2.4.3 The supply to electronic GDDs shall incorporate suitable overcurrent protection which shall be fully supervised. In the case of GDDs deriving supply from an external D.C. source this protection shall be in the positive leg of the supply.

B2.4.4 Sub-fuses shall be fully supervised by the electronic equipment which shall provide an alarm in the event of failure. Any sub-fuses shall be accessible without dismantling of the GDD.

B3 PERFORMANCE REQUIREMENTS

B3.1 The functional requirement of the equipment is that it shall detect the occurrence of free gas within the oil-filled instrument transformer and provide an output tripping signal which will normally be used by NGC to automatically de-energise a defective instrument transformer. The alarm and tripping contacts shall normally be open and shall close to initiate an alarm or trip. In the absence of gas, the contacts shall remain in the open position whether the instrument transformer is energised or de-energised.

B3.2 Electronic GDDs shall function without maloperation under all system voltage variation and transient conditions. Spurious or transient operation of the contacts during de-energisation of the instrument transformer is not permitted.

(i) Electronic GDDs drawing their supply from a VT secondary winding shall function without maloperation over the range 80% to 150% of nominal voltage.

(ii) Electronic GDDs drawing their supply from an external D.C. source shall function without maloperation over the operative range of the supply (as detailed in NGTS 2.6 clause 4.1.3(i)).

B3.3 Electronic GDDs shall be self-monitoring in service, and shall provide an output alarm in the event of failure of the GDD, or operation of its protection.

B3.4 The alarm and tripping contacts shall be suitable for making and breaking 150 VA with an L/R = 0.04 sec, between the limits of 30 volts and 250 volts A.C. or D.C. and of making 500 VA between the limits of 110 volts and 250 volts D.C.

B4 TESTING REQUIREMENTS

B4.1 Type Tests - Electronic Type

GDDs that employ electronic components or modules mounted within the primary equipment shall be tested to verify their performance.

In the absence of international specifications for electronic equipment situated immediately adjacent to primary plant, testing shall follow the principles of IEC Recommendations for indoor equipment. The supplier shall propose test parameters taking into account the increased severity of interference, electrical stress, temperature and humidity experienced by outdoor equipment.

The following tests shall be regarded as the minimum criteria for performance assessment and should be supplemented by additional tests, as required, subject to the mutual agreement of the supplier and NGC, to verify specific design or constructional features of the device.

B4.1.1 Electrical Interference and Insulation Tests

- (i) Dielectric Tests in accordance with NGTS 2.6 clause 4.1.4.
- (ii) Insulation Resistance Measurement, 500 V d.c. ($\geq 100 \text{ M}\Omega$)
- (iii) High Frequency Disturbance Test in accordance with NGTS 2.6 clause 4.1.5.
- (iv) Fast Transient Test to IEC 801-4. Test level to be Level 3.
- (v) Radio Frequency Interference Test to IEC 801-3. Test level to be Level 3. Tests to be performed over the frequency range 27 MHz - 1 GHz.

B4.1.2 Environmental Tests

Tests in accordance with NGTS 2.6 clause 4.1.1.

B4.1.3 Performance Tests

The following operational performance tests shall be made to demonstrate the correct functioning of the GDD.

(i) For devices deriving their supply from the VT secondary winding

(a) At 80%, 100% and 150% of nominal supply voltage, the correct functional operation of the gas detection system shall be demonstrated.

(b) The supply shall be varied slowly ($60 \text{ sec} \pm 15 \text{ sec}$) over the range $0 - 150\% V_{\text{nominal}} - 0$ volts. There shall be no false operation of the GDD.

(c) At nominal voltage, the supply shall be subject to interruptions of 10 ms, 100 ms and 500 ms. There shall be no false operation of the GDD.

(ii) For devices deriving their supply from an external D.C. source

(a) At the limits of supply and at nominal voltage (as detailed in NGTS 2.6 clause 4.1.3(i)), the correct operation of the GDD shall be demonstrated.

(b) The auxiliary D.C. supply shall be varied slowly ($60 \text{ sec} \pm 15 \text{ sec}$) from $0 - 137.5 - 0$ volts and switched on and off at the nominal voltage and at the extremes of the operating voltage range. There shall be no false operation of the GDD.

B4.2 Type Tests - Non-Electronic Type

B4.2.1 Non-electronic GDDs shall be subjected to the dielectric tests of B4.1.1(i).

B4.2.2 The correct functional operation of the GDD shall be demonstrated.

B4.3 Routine Tests

B4.3.1 Electronic GDDs shall be subject to the dielectric tests of B4.1.1(i) and the appropriate functional performance tests of B4.1.3(i).

B4.3.2 Non-electronic GDDs shall be subject to the tests of B4.2.