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National Grid
Technical
Specification

NGTS 2.1
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Substations

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SUBSTATIONS

FOREWORD

This Document defines the technical requirements for substations connected to The National Grid Company plc (NGC) system and with equipment rated at 145, 300 or 420 kV. It is supported by the more specific NGTS documents at Level 3.

This Specification is applicable to new construction and extensions to existing installations. It should however be noted that where a 'Central Electricity Generating Board (CEGB) Standard' substation is to be extended the Contract may refer to obsolete Transmission Plant Specifications.

1 SCOPE

This functional Specification covers all types of substation with equipment installed for use on 132, 275 and 400 kV 50 Hz systems. It is applicable to both open-terminal air-insulated (AIS) and metal-enclosed gas-insulated (GIS) substation constructions and covers equipment operated at lower voltages on the same substation site.

All NGC plant and apparatus wholly within the substation and not covered more specifically by other NGTS's is within the scope of this document.

2 REFERENCES

The Health and Safety at Work Act 1974.

The Factories Act 1961.

The Electricity at Work Regulations 1989.

IEC 694 (BS 6581) Common Clauses for High-Voltage Switchgear and Controlgear Standards.

IEC 865 Calculation of the Effects of Short-Circuit Currents.

EN 50-052 High-Voltage Switchgear and Controlgear for Industrial Use. Cast Aluminium Alloy Enclosures for Gas-Filled High-Voltage Switchgear and Controlgear.

EN 50-064 Wrought Aluminium and Aluminium Alloy Enclosures for Gas-Filled High-Voltage Switchgear and Controlgear.

BS EN 50-068 Wrought Steel Enclosures for Gas-Filled High-Voltage Switchgear and Controlgear.

BS EN 50-069 Welded Composite Enclosures of Cast and Wrought Aluminium Alloys for Gas-Filled High-Voltage Switchgear and Controlgear.

BS EN 50-089 Cast Resin Partitions for Metal Enclosed Gas-Filled High-Voltage Switchgear and Controlgear.

BS EN 60-529 Classification of Degrees of Protection Provided by Enclosures.

BS EN 61011 Safety Requirements for Mains Operated Electric Fence Energizers.

BS 1710 Specification for Identification of Pipelines and Services.

BS 5395: Part 3 Code of Practice for the Design of Industrial Type Stairs, Permanent Ladders and Walkways.

BS 7354 Code of Practice for Design of High-Voltage Open-Terminal Substations.

NGTS 1 Overview, National Grid System.

NGTS 2.2 Switchgear for the National Grid System.

NGTS 2.13 Electronic Equipment.

NGTS 2.19 Ancillary Light Current Equipment .

NGTS 3.1.1 Substation Interlocking Schemes.

NGTS 3.1.2 Substation Earthing.

NGTS 3.1.3 Substation Auxiliary Supplies (Publication Mid 1995).

NGTS 3.2.2 Disconnectors and Earthing Switches.

3 GENERAL REQUIREMENTS

3.1 Requirements for all Substations

3.1.1 Statutory Requirements

In addition to the requirement specified in Clause 4.1 of NGTS 1, the manner in which plant and equipment is installed as a system shall allow that system and its components to be operated and maintained within the requirements of principally The Health and Safety at Work etc Act 1974, The Factories Act 1961, The Electricity at Work Regulations 1989, The Provision and Use of Work Equipment Regulations 1992 and The Electricity Supply Regulations 1988 as amended 1990 and 1994. Particular attention shall be paid to safe access/egress from places of work and provision of a safe place of work.

3.1.2 Design Life of Installation

Unless otherwise specified by NGC, the substation installation including busbars, connections, insulators and structures shall be designed for a life of 40 years subject to periodic preventive maintenance being carried out in accordance with manufacturers or suppliers instructions.

Where part of the installation would require replacement or mid-life refurbishment to achieve the specified design life then this shall be stated at the time of tendering. Tenderers shall declare the life cycle costs of equipment on request.

3.1.3 Outage Constraints

Unless otherwise specified or agreed by NGC the design of the substation shall permit installation, extension, operation and maintenance (preventive and corrective) with a maximum of one circuit and one busbar section out of service simultaneously. A busbar section is taken to be a part of either the main or reserve busbars. Associated busbar section and busbar coupler circuits may be considered to be part of the busbar section.

NGC shall be advised at the Tender stage of any areas in which the requirements of this clause cannot be met.

The line conductors of different outgoing circuits shall not be crossed unless otherwise agreed by NGC.

3.1.4 Switchgear Local Control

The installation of switchgear shall comply with the requirements of Clause 3.3 of NGTS 2.2.

3.1.5 Operational Access

Reasonable access shall be provided to the isolation facilities of each disconnecter and earthing switch, including the locking device, where fitted. Access shall comply with Clause 3.1.1 and shall be suitable for use by an unaccompanied person.

Unless otherwise agreed with NGC the isolation facilities or locking devices shall be between 1 m and 1.8 m above the floor level or platform provided for access and shall not be further than 750 mm horizontally from the edge of a platform.

Access above ground level shall be from mobile or fixed platforms (though the latter may be accessed by ladder). Where movement of equipment within the substation would be restricted by the presence of ladders it is acceptable that these should be removable. Removable ladders and mobile platforms shall be easily handled and used on the finished substation surface by one person.

Ladders and permanent platforms shall, where applicable, comply with BS 5395: Part 3. Other Standards may be acceptable by agreement with NGC.

3.1.6 Requirements for Maintenance

The substation layout shall make allowance for preventive or corrective maintenance within the outage constraints specified in Clause 3.1.3 and using procedures compliant with Clause 3.1.1.

Access for maintenance shall be provided as follows:

(i) The substation layout and surfaces shall be adequate to allow the access and use of powered access equipment, cranes and similar equipment required for any normal maintenance operation (circuit-breaker interrupter change, disconnecter contact change, insulator cleaning etc). Suitable sealed surface roads shall be provided to substation main buildings and heavy items of plant (eg transformers), other surfaces should be finished in accordance with NGTS 2.10.

(ii) Fixed platforms need not be provided for preventive or corrective maintenance requirements so long as access can be gained by the use of pre-formed scaffolding, portable ladders or, in outdoor substations, powered access equipment.

Arrangements of any fixed platforms provided shall be to the approval of NGC and shall meet the requirements of BS 5395: Part 3. Other Standards may be acceptable by agreement with NGC.

Maintenance shall be taken to include the replacement of any component or sub-component within the substation including GIS enclosures.

Suppliers shall, on request, provide a written procedure for carrying out any proposed maintenance procedure in accordance with these requirements.

3.1.7 Interlocking

Substations shall be provided with a full interlocking scheme as specified in NGTS 3.1.1.

Requirements of electronic interlocking schemes provided as part of substation control systems are specified in NGTS 3.7.11.

3.1.8 Cranes & Lifting Equipment

Fixed cranes should not be provided in indoor AIS substations except where specifically required for maintenance or repair purposes. Fixed cranes shall be provided in indoor GIS substations except where the supplier can demonstrate specifically that they are not required for dismantling or removing any part of the substation for maintenance or repair purposes.

Lifting beams or overhead cranes of adequate capacity shall be provided, where necessary, to assist in dismantling switchgear. Provision shall be made to inspect beams or cranes for insurance purposes and fit lifting tackle within the outage constraints specified in Clause 3.1.3.

3.1.9 Facilities

The following facilities shall be provided at all new 400 kV and 275 kV substations.

- (i) Adequate toilet and washing facilities for NGC operation and maintenance staff.
- (ii) A standby control room, this shall have provision to be equipped as a permit office and to be used for on-site drawing/record storage. At indoor GIS substations access to the control room shall not be through the switchgear hall and the room shall be designed to prevent ingress of SF₆/arc products in the event of a switchgear fault.
- (iii) At sites where SF₆ gas-filled equipment is installed, a standing area and suitable water and drainage connections for a mobile changing/shower facility. Such facilities are required to comply with NGC safety codes of practice for work on SF₆-filled equipment that has been exposed to power arcing.
- (iv) A small mess room with sink.
- (v) An equipment store/small workshop.
- (vi) Vehicle parking.

The size of the mobile changing/shower facility and workshop will be specified by NGC.

The extent to which this Clause shall apply to 132 kV and lower voltage substations and extensions to existing installations shall be specified by NGC.

3.1.10 Plant and Equipment Identification

Labels shall be provided to allow identification of all plant and equipment and associated operating facilities and points of isolation. The following are normally required:

- (i) Each circuit-breaker, disconnector and earthing switch mechanism box shall carry a label giving the NGC operational reference (to be specified by NGC) of the device.
- (ii) For GIS equipment each partition between gas zones shall carry labels giving the identifier of the gas zone at each side of the partition.
- (iii) Each pressure gauge or pressure readout device shall carry a label identifying the parameter it is monitoring.
- (iv) Each valve (including self-sealing gas filling valves) shall carry a label identifying its function.
- (v) Each control handle or switch for plant operation shall carry a label identifying its function.
- (vi) Each point of LV isolation associated with plant shall carry a label identifying its function.
- (vii) Each cabinet, cubicle or kiosk shall carry a label identifying the equipment contained within it.

The detailed wording of labels shall be to the approval of NGC. The labels shall be sufficiently durable for the application and environment in which they are to be used. Stencilling of items which may require repainting during the life of the substation shall not be acceptable.

3.1.11 Current Transformers

Unless otherwise agreed with NGC, the accommodation of current transformers shall be as specified in Appendix A and their location shall be as specified in Appendix B.

3.1.12 Voltage Transformer Secondary Isolation

Voltage transformer secondary isolation links, or other means of positive isolation to the approval of NGC, shall be provided in a separate isolation box mounted between 1 m and 1.8 m above substation floor or access platform level. The door of the isolation box shall be padlockable by means of NGC's standard padlock type.

3.1.13 Compressed Air Storage Systems

Where required, a central compressed air storage system shall be provided, the technical requirements will be specified in the Contract.

3.1.14 Substation Auxiliary Cable Routing

Cable trenches shall be used between main substation buildings and dispersed relay rooms or, in the case of a central relay room, between the relay room and the common marshalling point for each primary circuit. Cables between dispersed relay rooms or circuit marshalling points and local plant may be buried direct where armoured cables are used; in all other circumstances cable ducts may be used. In relay rooms and control rooms cables shall be run in overhead racks and computer floors shall not be provided. The location of all buried cables and ducts shall be adequately recorded.

3.1.15 Light Current Equipment

Electronic equipment shall be located in accommodation commensurate with its environmental performance which is classified in NGTS 2.13 and NGTS 2.6 as appropriate. Where reasonably practicable, co-location of protection, control and measurement systems in a common room is preferred.

Heaters and/or dehumidifiers shall be provided in light current accommodation in order to meet the requirements of NGTS 2.13 Class C (minimum ambient temperature -10°C , relative humidity 10-100%) under all ambient conditions. Where fixed heating is provided it shall be thermostatically controlled.

Where no fixed heating is provided, provision shall be made for raising the air temperature in the vicinity of all equipment associated with any one circuit to 15°C without causing condensation on the equipment.

All panels housing secondary equipment sited in equipment rooms shall have provision to be padlocked.

3.1.16 Substation Earthing

Substation earthing systems shall be designed and installed in accordance with NGTS 3.1.2.

3.1.17 Substation Auxiliary Supplies

Substation auxiliary supplies shall be designed and installed in accordance with NGTS 3.1.3.

3.1.18 Environmental

The guidelines for substation siting and design given in Appendix C shall be followed, with particular attention paid to Clause C2.2 and Sections C3 and C4.

3.1.19 NGC will specify requirements for site security provisions and equipment on a site by site basis. The use of electric pulse security fences to BS EN 61011 is the preferred option for sites requiring high security. Perimeter fences meeting statutory 2.4 m height requirements, incorporating electric pulse security systems on lower security sites, will be considered if it can be demonstrated that there is a cost benefit over the use of NGC standard fencing over the life of the substation.

3.2 Requirements for AIS Substations

The layout of AIS shall be arranged to ensure the integrity of the air space between live parts and other conductors (whether earthed or at different potential) for the rated voltage conditions for which the

substation is designed. Safety to persons shall be maintained by the provision of adequate clearance to live parts for maintenance, vehicular and pedestrian access. Where adequate safety clearances cannot be maintained, barriers or fences shall be provided to limit access, these barriers or fences shall be to the approval of NGC. The need to extend substations with the minimum of disruption to normal operation shall be considered in the design and layout of the equipment. The extent of possible future extension will be defined in the Contract.

3.2.1 Electrical Clearances

Where equipment configurations have not been subject to type or routine tests in accordance with IEC 694 the electrical clearances listed in Table 1 shall be applied.

Table 1 Substation Electrical Clearances

Nominal System Voltage	BIL/SIL	Basic Electrical Clearance (phase to earth)	Phase-to-Phase Clearance
kV (rms)	kV (p)	m (Notes 2,3)	m
11	(Note 1)	0.5	0.25
22	(Note 1)	0.5	0.33
33	170	0.5	0.43
66	325	0.7	0.78
132	550/650	1.1	1.4
275	1050/850	2.1	2.4
400	1425/1050	2.8	3.6

Note 1 To be specified by NGC in the Contract.

Note 2 Minimum clearance of 500 mm specified to cover vermin and bird interference.

Note 3 Under some circumstances temporary infringement of phase to earth clearances during earth switch operation may be permitted. Refer to NGTS 3.2.2.

It should be noted that Table 1 lists MINIMUM clearances and an appropriate additional allowance shall be made by the Supplier for constructional tolerances, effects of short-circuit, wind effects etc.

3.2.2 Safety Clearances/Distances

The safety clearances to be maintained in all AIS installations are listed in Table 2.

Table 2 Substation Safety Clearances/Distances

Nominal System Voltage	Safety Distance (From NGC Safety Rules)	Design Clearance for Safety (vertical)	Design Clearance for Safety (horizontal)	Insulation Height (pedestrian access)
kV	m (Note 1)	m (Note 2)	m (Note 3)	m (Note 4)
11/22/33	0.8	3.2	2.3	2.4

Nominal System Voltage	Safety Distance (From NGC Safety Rules)	Design Clearance for Safety (vertical)	Design Clearance for Safety (horizontal)	Insulation Height (pedestrian access)
66	1.0	3.4	2.5	2.4
132	1.4	3.8	2.9	2.4
275	2.4	4.8	3.9	2.4
400	3.1	5.5	4.6	2.4

It should be noted that Table 2 lists MINIMUM clearances and an appropriate additional allowance shall be made by the Supplier for constructional tolerances.

Note 1 Persons shall not allow any part of their body or any object to infringe this distance to exposed conductors operated at high voltage.

Note 2 The minimum clearance from a live conductor to a point to which pedestrian access is permitted.

These figures are derived by adding the 'personal reach' (the vertical reach of a person with upstretched hand), which is taken to be 2.4 m, to the appropriate Safety Clearance.

These figures should be taken as the 'section clearance' when this dimension is considered in the substation design.

Note 3 These figures may be used by agreement with NGC. In general the vertical design clearance should be applied in all directions.

Note 4 The minimum clearance from the lowest insulation part of a support insulator to a point to which pedestrian access is permitted.

3.2.3 Clearance to Roadways

The clearances to roadways to which vehicular access is required shall, unless otherwise agreed by NGC, allow unrestricted movement of a 2.4 m high vehicle. To comply with NGC safety codes of practice and obviate the need to use temporary earthing the clearances from live conductors to a 2.4 m high vehicle spanning the full width of the roadway shall be as listed in Table 2, Design Clearance for Safety (vertical).

Height barriers shall be provided at entrances to the substation and/or within the substation to restrict access for vehicles exceeding the maximum height for which unrestricted access is allowable. These barriers shall be designed to be opened and shall have a facility to apply a padlock to secure them in the closed position.

3.2.4 Substation Profile

To limit the environmental impact of the substation the height of the highest component of outdoor substations should be kept to a practical minimum to achieve a low substation profile. Unless otherwise agreed by NGC, on new sites maximum heights of equipment shall not exceed the values listed in Table 3. At existing sites the height of existing equipment shall not be exceeded.

Table 3 Maximum Equipment Heights in Substations

Nominal System Voltage	Maximum Equipment Height
kV	m
132	7.5
275	10
400	12.5

3.2.5 Substation Area

Unless otherwise specified, the substation shall be designed to minimise the land area required.

3.2.6 Earthing Devices

The required locations of earthing devices will be specified by NGC.

Earthing switches in accordance with NGTS 2.2 shall be provided at circuit entries ('line' earth switches) and at one position on each section of busbar.

At remaining locations, other types of interlocked earthing device which meet the specified rating may be used (for example, Fixed Earthing Devices in accordance with NGC Transmission Plant Specification (Application) TPS 3/4).

3.2.7 Portable Earthing

Provision shall be made to employ NGC's standard portable earthing equipment. This equipment is designed for use with tubular conductors with diameters in the range 10-90 mm, or with diameters of 127 mm, 140 mm or 190/200 mm. Further details are available, on request, from NGC. Where flexible conductors are used as substation conductors or where tube sizes are incompatible with the earthing equipment then earthing stubs shall be provided. The number and location of earthing stubs shall be to the approval of NGC.

Points for attachment of the earth end of portable earthing leads shall be provided at each switchgear structure. This may be by 'D' loops or by other means approved by NGC. Each attachment point shall be connected to the substation earthing mat by a fully rated conductor/conductors. Allowance shall be made for the attachment of sufficient leads at each point to match the switchgear rating.

3.2.8 Relay Rooms

Central or dispersed relay rooms may be provided to meet the protection performance requirements stated in NGTS 2.6. If a central relay room is to be supplied at 400 kV double busbar substations, the supplier shall demonstrate to NGC that the protection performance requirements can be achieved. Dispersed relay rooms shall be transportable with facilities for ease of site connection, eg heavy duty plug and socket connectors and the protection and control equipment shall be pre-wired, factory assembled and factory tested.

3.3 Requirements for GIS Substations

The following requirements apply to phase-segregated GIS designs with a rated voltage of 300 or 420 kV. They shall also apply, where appropriate, to lower voltage designs, however in this case the extent of compliance required shall be subject to agreement with NGC.

3.3.1 Buildings

GIS installations comprising two or more circuit breakers shall be housed in a building so as to minimise erection and life cycle maintenance costs. The building shall be of minimum cost construction consistent with environmental and planning requirements.

3.3.2 AIS Connections

Where AIS connections are associated with a GIS substation then the requirements listed under 3.2 shall apply to those connections.

3.3.3 Segregation of Gas Zones

The equipment shall be segregated into sufficient independent gas zones to allow the requirements of Clause 3.1.6 to be met. Unless otherwise agreed with NGC, circuit-breakers shall be accommodated in separate gas zones from other equipment.

3.3.4 Gas Zone Barriers

Gas zone barriers (partitions) shall be designed to withstand the differential pressures to which they may be subjected during preventive or corrective maintenance. A reduction of the dielectric properties of adjacent gas zones containing live high-voltage conductors by lowering gas pressures will not be acceptable.

3.3.5 Portable Maintenance Earthing Devices

Provision shall be made for fitting Portable Maintenance Earthing Devices (PMED's) where these are required to permit maintenance/testing. The principal applications of PMED's are to allow an earthing switch that would normally be the point of earthing, to be itself maintained and to earth cable sealing ends with the isolation link removed.

The PMED's shall be rated in accordance with the requirements of NGTS 2.2.

Proposals for the location of PMED positions shall be submitted to NGC for approval before the substation design is finalised.

Positions at which PMED's may be fitted shall be identified by painting the access covers green. The PMED's shall be identified by painting in a red/white striped pattern externally so that they can be clearly seen when in position. Other alternative means of identification may be employed to the approval of NGC.

Two three-phase sets of PMED's shall be supplied for each substation or, if the PMED's are of more than one type, two three-phase sets of each type shall be supplied.

3.3.6 Disconnecter Lock-Out

If the GIS disconnectors supplied cannot be demonstrated to perform their rated duties when filled with SF₆ gas at atmospheric pressure then arrangements shall be made to prevent operation when gas density is lower than the 'low' alarm setting.

3.3.7 SF₆ Gas Service Connections

The gas service connection for each gas zone shall be readily accessible without the use of special access equipment. Proposed access arrangements shall be to the approval of NGC.

A schematic diagram shall be provided showing the gas zones within a bay and their relationship to the

primary plant of that circuit or busbar section. Where gas service connections are grouped together the diagram shall be displayed adjacent to this point, otherwise it shall be displayed at the Local Control Cabinet (LCC).

Filling points shall be fitted with self-sealing valves of a design to the approval of NGC. Gas service valves, lockable by means of NGC's standard padlock type, shall also be provided at each filling point. Alternatively, where self-sealing valves are fitted directly to the enclosures, a lockable cover to prevent unauthorised access to the valve shall be provided. This cover shall be lockable by means of NGC's standard padlock.

Provision shall be made for the use of an in-line dust filter at each filling point, either by permanently installing a filter at each point or providing a separate filter that can be fitted between the gas service hose and the self-sealing valve.

3.3.8 Pressure/Density Indication

Facilities for indicating the gas pressure or density in each gas zone shall be provided. Systems offering facilities for remote indication are preferred. Where the indication is of density this shall be displayed as an equivalent pressure at a reference temperature. The equipment shall be permanently installed and all displays shall be readable from the substation floor level or from access walkways.

3.3.9 SF₆ Gas Alarm Scheme

Each gas zone shall be fitted with a density monitor with two falling alarm settings. These shall be set to the switchgear manufacturers recommended 'falling' and 'low' alarm densities and shall be connected to the substation alarm scheme. The grouping of 'low' alarms at the normal substation control point shall be such that the section of equipment which requires isolation from the system can be readily identified.

Where leakage of gas from a high pressure gas zone to an adjacent lower pressure gas zone may result in the rupture of the pressure relief device of the lower pressure zone before a falling pressure alarm is received from the high pressure zone then the lower pressure zone shall be fitted with a high density alarm.

For indoor substations, an audible alarm scheme shall be provided in the substation building to warn operators of a major loss of SF₆ gas. This shall be connected to operate at the low pressure alarm setting of each gas zone. Controls shall be provided at the substation control point to reset and isolate the audible alarm. Visual indications shall be provided in the switchhouse, to show that the audible alarm is in service and outside the main entrances to the switchhouse, to indicate that the alarm has operated. Provision shall be made to isolate the alarm contact of each gas zone independently so that individual alarms can be disabled during maintenance, such isolation shall not prevent the receipt of a 'low' pressure alarm at the control points.

Each density monitor shall be provided with a means of checking initiation of the 'falling' and 'low' density alarms without reducing the pressure in the main compartment. The method of providing this facility shall be to the approval of NGC.

3.3.10 Bursting Discs & Explosion Vents

Bursting discs and explosion vents shall be installed so as to eject debris away from normally accessible areas. They shall be set to minimise danger to personnel.

3.3.11 Identification of Pipework

Fixed gas and hydraulic pipework shall be identified in accordance with BS 1710.

3.3.12 Identification of Gas Zone Barriers

The position of each non-breathing gas zone partition shall be clearly identified by painting the flange of the GIS enclosure where the partition is fitted in a distinctive colour.

Labels shall be fixed to the enclosure at each non-breathing gas zone partition showing the identifier of the gas zones at each side of that partition.

3.3.13 Cable Testing

Where high voltage cables are terminated directly in GIS enclosures then provision must be made for D.C. cable testing.

The point of disconnection for cable testing and the connections between it and the cable shall be demonstrated to meet the requirements of NGTS 2.2 for D.C. withstand voltage.

In all cases a fixed or temporary earthing device shall be provided for applying an earth between the point of isolation and the cable sealing end. It shall be possible to apply this earthing device using an insulated tool to the approval of NGC and leave it in place while making or breaking the point of isolation.

Where specified, provision shall be made for installing a D.C. test bushing to allow cables to be tested from the substation end. Where a test bushing is not supplied as part of the Contract then the installation shall be designed to permit the use of one of NGC's existing bushings. Details of available bushings will be supplied on request.

Suppliers shall provide details of proposed cable testing arrangements with Tenders.

3.3.14 Primary Injection Testing of CT's

Provision shall be made for carrying out primary injection tests on all current transformers without requiring internal access to any chamber.

3.3.15 Partial Discharge Measurement

Capacitive couplers for diagnostic monitoring of the GIS equipment and transient voltage measurements are required to be located in all phases at the sealing ends of each cable connected circuit, at the SF₆ side of each transformer bushing and adjacent to the SF₆/air bushings of each circuit connected to AIS equipment. In addition couplers shall be located in all phases at approximately 20 m intervals between these points such that all parts of the GIS equipment are between two couplers and no more than 20 m from either of these couplers. Proposals shall be to the approval of NGC.

To facilitate the use of couplers for in-service monitoring, coupler signal connections shall be cabled to ground level and suitable test boxes provided at locations agreed with NGC. Signal connections in the test box shall be N series 50 ohm sockets. To limit interference, cables between the couplers and test boxes shall be double screened co-axial.

3.3.16 Desiccant

All gas zones shall have desiccant material provided in each phase to assist in the absorption of water vapour and gaseous acidic products.

3.3.17 Location of Light Current Equipment

Equipment panels may be located in the switchgear building either adjacent to the switchgear, generally conforming to bay widths, or in an annexe. Such equipment, together with its accommodation, shall meet the requirements of Class IP 54 of BS EN 60 529.

3.4 Requirements for Earthing Systems and Earthing of Plant

The requirements for earthing systems and earthing of plant are defined in NGTS 3.1.2.

4 PERFORMANCE REQUIREMENTS

4.1 Requirements for all Switchgear

4.1.1 Jointing of Current Carrying Conductors

The method of jointing site-assembled current carrying conductors (except those internal to GIS equipment) shall be such as to avoid electrochemical reactions or the effects of corrosion. Such joints shall be expected to have a service life of at least 40 years. Jointing methods shall be to the approval of NGC.

4.2 Requirements for AIS

4.2.1 Mechanical Design

Equipment shall be designed to withstand the maximum force to which it may be subjected in its lifetime. In order to establish the total mechanical forces acting on equipment and supporting structures it is necessary that consideration be given to forces resulting from:

- (a) Short-circuit current
- (b) Wind loading
- (c) Deadweight
- (d) Ice covering
- (e) Conductor tension

These forces shall be calculated in accordance with Section 3.2 of BS 7354:1990 and factors of safety applied in accordance with Section 3.3.

Other internationally recognised Specifications or Standards may be acceptable as an alternative to BS 7354 subject to the agreement of NGC.

Where the design of equipment imposes additional forces to those listed above, then the Supplier shall take account of these forces in his design.

4.2.2 Busbars, Connections & Connectors

These shall be rated for normal current, short time withstand current and maximum radio interference voltage in accordance with NGTS 2.2 and IEC 694.

Table 6 of IEC 865: Recommended Highest Temperatures for Mechanically Stressed Conductors during a Short Circuit

Type of conductor	Maximum recommended conductor temperature during a short circuit
Bare conductors, solid or stranded: Cu, Al or Al alloy	200°C
Bare conductors, solid or stranded: steel	300°C

Table 4 Recommended Highest Temperatures for Non-Mechanically Stressed Conductors During a Short Circuit

Type of conductor	Maximum recommended conductor temperature during a short circuit
Bare conductors, solid or stranded: Cu	405°C
Bare conductors, solid or stranded: Al or Al alloy	325°C
Bare conductors, solid or stranded: steel	300°C

The maximum conductor temperature after passage of rated short time current shall not exceed the recommended values given in table 6 of IEC 865 for mechanically stressed conductors and Table 4 above for non mechanically stressed conductors. The initial conductor temperature shall be taken to be the rated maximum ambient temperature for the equipment. Table 6 of IEC 865 is reproduced on the preceding page for clarity.

4.3 Requirements for GIS

4.3.1 Pressurised Gas-Filled Enclosures

These shall be designed and manufactured in accordance with the following CENELEC Standards:

EN 50-052
EN 50-064
BS EN 50-068
BS EN 50-069

4.3.2 Cast Resin Partitions

Cast resin partitions (barriers) shall be designed and manufactured in accordance with CENELEC Standard EN 50-089.

4.3.3 Internal Arcing

In principle, the gas zones, when at design pressure, shall show no external effect resulting from an internal arc of rated short-time current for a duration not less than the maximum main protection fault clearance time. On small gas zones, operation of the safety device may occur within main protection fault clearance time. When gas zones are subjected to an internal arc of rated short-time current for a duration not less than the back-up or breaker-fail protection fault clearance time, the resulting effect shall be restricted to operation of the safety pressure relief device(s) or the appearance of a hole, provided there is no ejection of fragmented parts.

The fault clearance times to be used in assessing this performance are as follows:

Rated Voltage (kV)	Main Protection (ms)	Back-Up or Breaker Fail Protection (ms)
420	140	300
300	160	500
145	180	1000

Compliance with this requirement shall be demonstrated by means of calculations or tests. On equipment having three phases in a common enclosure, or gas zone, allowance shall be made for the possibility of

faults evolving to include two or more phases.

4.3.4 Couplers for Partial Discharge Measurement

Partial discharge couplers (the requirement for which is specified in Clause 3.3.15) shall be sensitive to all frequencies in the range 0.1 - 1.5 GHz and shall give an output signal suitable for a spectrum analyser.

Couplers shall have a linear response in the frequency range 50 Hz - 300 MHz and a capability to make D.C. 'trapped charge' measurements.

5 TEST REQUIREMENTS

5.1 Type Tests

5.1.1 Busbars, Connections & Connectors

Electrical type tests shall be performed in accordance with IEC 694.

Tests of mechanical performance shall be subject to agreement between the Supplier and NGC dependant on the application.

5.1.2 Pressurised Gas-Filled Enclosures

These shall be tested, where applicable, in accordance with the following CENELEC Standards:

EN 50-052
EN 50-064
BS EN 50-068
BS EN 50-069

5.1.3 Cast Resin Partitions

Cast resin partitions (barriers) shall be tested in accordance with CENELEC Standard EN 50-089.

5.2 Routine Tests at Manufacturers Works

5.2.1 Pressurised Gas-Filled Enclosures

These shall be tested in accordance with the following CENELEC Standards:

EN 50-052
EN 50-064
BS EN 50-068
BS EN 50-069

5.2.2 Cast Resin Partitions

Cast resin partitions (barriers) shall be tested in accordance with CENELEC Standard EN 50-089.

5.3 Routine Tests at Site

5.3.1 Current Carrying Conductors

Where joints between current carrying conductors are made on site then the joint electrical resistance shall be measured and recorded.

5.3.2 Partial Discharge Tests (GIS)

Partial discharge activity shall be monitored throughout the site power-frequency high voltage tests of GIS equipment.

Suppliers shall state the maximum acceptable partial discharge level during the site test at $1.1 U/\sqrt{3}$. This measurement shall be made on reducing voltage following the power frequency withstand test. The partial discharge level at nominal voltage shall also be recorded.

APPENDIX A

CURRENT TRANSFORMER ACCOMMODATION

A1 CURRENT TRANSFORMER MOUNTING AND POLARITY MARKINGS

The following conventions shall be adopted for the physical mounting of current transformers with respect to their terminal markings:

- (i) In circuit-breakers, all P1 markings shall be electrically nearer to the circuit-breaker than the corresponding P2 markings.
- (ii) In transformers, reactors or generators, the P1 markings shall be electrically nearer to the windings than the corresponding P2 markings.
- (iii) For separately mounted current transformers, if they are associated with the circuit-breaker, they shall be considered as though they were an integral part of the circuit-breaker. If separately mounted current transformers are not associated with the circuit-breakers, the P1 markings shall be electrically nearer to the junction of the primary connections or busbars than the corresponding P2 markings.
- (iv) In the run of busbars, and not associated with a circuit-breaker, the current transformers will usually be in the same housing or chamber. In this case the P1 marking should be electrically nearer the section of busbars with the higher number. If there are two housings or chambers (per phase), the P1 markings of each shall be electrically nearer the adjacent housing or chamber.

The current transformer accommodation normally available for use is as detailed in A2 to A7 below. In each case the current transformer cores are listed in the preferred order with the housing, Core 1 being positioned nearest to the P1 terminal.

A2 POST TYPE CURRENT TRANSFORMERS AND THROUGH WALL AIR/AIR BUSHINGS

All 420, 300 and 145 kV post type measurement/protection CTs and through wall air/air bushings shall have accommodation for a minimum of four current transformer cores using one of the arrangements listed below. Accommodation for CTs for high accuracy metering purposes shall be as detailed in NGTS 3.2.6.

The following 'standard' configurations of CT cores are commonly used by NGC. Alternative configurations may be accepted or specified on a contract basis:

A2.1 Five Core Arrangement

A full complement of five secondary windings as follows:

- Core 1 Protection Type A
- Core 2 Protection Type A
- Core 3 Measurement/Protection
- Core 4 Protection Type B
- Core 5 Protection Type B

This arrangement will be required where older types of high-burden protection/instrumentation are installed.

A2.2 Four Core Arrangement

A complement of four secondary windings as follows:

Core 1 Protection Type A
Core 2 Protection Type A
Core 3 Protection Type B
Core 4 Protection Type B

This is the preferred arrangement for circuit CT's in new substations with digital protection/instrumentation systems.

A3 AIS DEAD-TANK AND GIS CIRCUIT-BREAKERS

Circuit-breaker bushings, bushing turrets or CT enclosures on the line side of the circuit-breaker shall be capable of accommodating four or five secondary windings in arrangements A2.1 or A2.2, as required by the application. For busbar coupler and section applications CT accommodation shall be provided on each side of the circuit-breaker.

A4 GIS BACK PARTS

In switchgear making up a mesh, or single switch substation additional accommodation is required for four or five current transformers in each feeder circuit connection, the arrangement being as A2.1 or A2.2.

A5 TRANSFORMER AND SHUNT REACTOR BUSHING TURRETS

The accommodation available in the turrets of bushings shall allow for a maximum of four current transformer windings, excluding those which may be required for winding temperature indicators, as follows:

Core 1 Protection Type B
Core 2 Measurement/Protection
Core 3 Protection Type A
Core 4 Protection Type A

The allocation of current transformer cores to particular transformers will depend upon the protection requirements of the local primary systems to which the transformer is connected.

A6 SLIP-OVER, NEUTRAL AND OTHER SEPARATELY MOUNTED CURRENT TRANSFORMERS

Accommodation requirements for such applications are to be examined individually to establish that sufficient accommodation exists for the current transformer types required.

A7 THE NEUTRAL AND NEUTRAL END CONNECTIONS OF TRANSFORMER AND SHUNT REACTORS

For neutral current transformers associated with double-wound grid transformers and supergrid auto-transformers, and neutral end current transformers associated with supergrid auto-transformers, accommodation shall be provided as follows:

(i) Neutral current transformer housings shall provide accommodation for at least three current transformer windings as follows:

Core 1 Protection Type B
Core 2 Measurement/Protection
Core 3 Measurement/Protection

(ii) Neutral end current transformer housings shall provide accommodation for one Protection Type B current transformer winding per phase.

(iii) Combined neutral and neutral-end current transformer housings shall provide accommodation for at least two neutral current transformer windings as follows:

Core 1 Protection Type B (one current transformer per phase)
Core 2 Measurement/Protection (one only - on neutral conductor)
Core 3 Measurement/Protection (one only - on neutral conductor)

For neutral and neutral end current transformers associated with supergrid shunt reactors, accommodation shall be provided as follows:

(i) Neutral end current transformer housings shall provide accommodation for one Protection Type B current transformer per phase.

(ii) Neutral current transformer housings shall provide accommodation for one Measurement/Protection current transformer.

APPENDIX B

LOCATION OF CURRENT TRANSFORMERS ASSOCIATED WITH 420, 300 AND 145 kV CIRCUIT BREAKERS

B1 GENERAL

In all installations where current transformer housings are associated with circuit-breakers such housings shall be mounted as close as possible to the circuit-breaker concerned.

B2 BUSBAR STATIONS

B2.1 Circuits Other than Bus Section or Bus Coupler

All current transformers associated with a given circuit-breaker shall be installed on the circuit side of the circuit-breaker.

B2.2 Bus Section and Bus Coupler Circuits

Current transformers for busbar protection shall be installed on both sides of the circuit-breaker; the current transformer for a particular zone of protection being located on the side of the circuit-breaker remote from the zone.

Current transformers for commissioning overcurrent and back up earth fault protection shall be installed on the reserve busbar side of the bus coupler circuit-breaker and on the lower numbered main or reserve busbar side (as appropriate) of the bus section circuit-breaker.

Current transformers for system back-up protection shall be installed in the bushings or housings on the reserve busbar side of the bus-coupler circuit-breaker and on the lower numbered main or reserve busbar side (as appropriate) of the bus-section circuit-breaker. The current transformers shall preferably be of the Measurement/Protection type but, where there is only one set of such current transformers in the correct location, Type A current transformers shall be used instead; this will normally only apply where post-type current transformers are employed.

Current transformers for instrumentation purposes and circuit-breaker fail protection shall be installed on the main busbar side of the bus-coupler circuit-breaker and on the higher numbered main or reserve busbar side (as appropriate) of the bus-section circuit-breaker.

B3 MESH TYPE STATIONS

Current transformers for feeder protection, feeder instrumentation purposes and for system back-up protection shall be installed in the line current transformer housing.

Current transformers for bus section instrumentation purposes and circuit-breaker fail protection shall be installed in the bushings or housings on the side of the circuit-breaker which connects to the mesh corner having the corresponding number eg mesh corner four side of S40 etc.

Current transformers for mesh-corner protection shall be installed in the line current transformer housing, in the HV bushing turrets of the associated transformer(s) and on both sides of the circuit-breakers, the current transformer for a particular zone of protection being located on the side of the circuit-breaker remote from that zone.

B4 SINGLE SWITCH STATIONS

Current transformers for feeder protection and for feeder instrumentation purposes shall be installed in the line current transformer housings.

Current transformers for system back-up protection shall be installed in the line current transformer housings and in the bushings or housings on the higher numbered side of the bus section circuit-breaker; the current transformer for system back-up protection shall also be used for circuit-breaker fail protection.

Current transformers for bus section instrumentation purposes shall be installed in the bushing or housings on the lower numbered zone side of the bus section circuit-breaker.

Current transformers for mesh corner protection shall be installed in the line current transformer housings, the HV bushing turrets of the associated transformer(s) and in the bushings or housings on both sides of the bus section circuit-breaker, the current transformer for a particular zone or protection being located on the side of the circuit-breaker remote from that zone.

APPENDIX C

NGC SUBSTATIONS AND THE ENVIRONMENT: EXTRACT FROM GUIDELINES ON SITING AND DESIGN

C1 OVERALL SYSTEM OPTIONS AND SITE SELECTION

In the development of system options including new substations, consideration must be given to environmental issues from the earliest stage to balance the technical benefits and capital cost requirements for new developments against the consequential environmental effects in order to keep their adverse impact to a reasonably practicable minimum.

C2 LOCAL CONTEXT, LAND USE AND SITE PLANNING

C2.1 The siting of substations, extensions and associated proposals should take advantage of the screening provided by land form and existing features and the potential use of site layout and levels to keep intrusion into surrounding areas to a reasonably practicable minimum.

Notes:

- 1 A preliminary study should be undertaken to identify the extent of land required to meet both operational and environmental needs.
- 2 In some instances it may be possible to site a substation partially or fully enclosed by existing woodlands.
- 3 Topographical information should be obtained at an early stage. In some cases a geotechnical survey may be required.

C2.2 The proposals should keep the visual, noise and other environmental effects to a reasonably practicable minimum.

Notes:

- 1 Allow sufficient space for screening of views by mounding or planting.
- 2 Consider appropriate noise attention measures where necessary.
- 3 Use security measures which minimise visual intrusion from lighting.
- 4 Consider appropriate on site water pollution prevention measures.
- 5 Consider adjoining uses and the amenity of local inhabitants.

C2.3 The land use effects of the proposal should be considered when planning the siting of substations or extensions.

Notes:

- 1 Issues for consideration include potential sterilisation of nationally important land, eg Grade 1 agricultural land and sites of nationally scarce minerals.
- 2 Effects on land drainage.

C3 DESIGN

C3.1 In the design of new substations or line entries, early consideration should be given to the options available for terminal towers, equipment, buildings and ancillary development appropriate to individual locations, seeking to keep effects to a reasonably practicable minimum.

Notes:

- 1 With outdoor equipment, a preference should be given normally to a low profile design with low height structures and silhouettes appropriate to the background.
- 2 Use lightweight narrow section materials for taller structures especially for gantries over 6 metres in height.
- 3 Commission exterior design and colours appropriate to the surroundings.
- 4 Materials and colours for buildings, equipment and fencing should be chosen to harmonise with local surroundings.
- 5 Where possible, avoid the use of prominent insulators by consideration of available colours appropriate to the background.
- 6 Where possible site buildings to act as visual screens for switchgear.
- 7 Ensure that the design of high voltage and low voltage substations is coordinated by early consultation between NGC and its customers.
- 8 Where there are particular technical or environmental constraints, it may be appropriate to consider the use of Gas Insulated Switchgear (GIS) equipment which occupies less space and is usually enclosed within the building.
- 9 Early consideration should be given to the routing of utility service connections.

C3.2 Space should be used effectively to limit the area required for development consistent with appropriate mitigation measures and to minimise the adverse effects on existing land use and rights of way, whilst also having regard to the future extension of the substation.

Notes:

- 1 Assess the benefit of removing redundant substation equipment from existing sites where this would improve their appearance.

C3.3 The design of access roads, perimeter fencing, earthshaping, planting and ancillary development should form an integral part of the site layout and design to fit in with the surroundings.

C4 LINE ENTRIES

C4.1 In open landscape especially, high voltage line entries should be kept, as far as possible, visually separate from low voltage lines and other overhead lines so as to avoid a confusing appearance.

C4.2 The inter-relationship between towers and substation structures and background and foreground features should be studied to reduce the prominence of structures from main viewpoint. Where practicable the exposure of terminal towers on prominent ridges should be minimised by siting towers against a background of trees rather than open skylines.

RECORD OF REVISION

NGTS 2.1

This issue (Issue 2) has been revised and amended as follows:

REV	DATE	DETAILS OF REVISION	AUTHORISATION
	May 1995	Numerous Revisions (Identified in document Margin) as a result of major review	