ADDENDUM

Date Addendum Issued:	

	Originated by	**Approved by**
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ORIGINAL DOCUMENT DETAILS

DOCUMENT TITLE	Substations
DOCUMENT NUMBER	TS 2.01
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ADDENDUM DETAILS

The above document shall be read in conjunction with the following amendments:

Check appropriate boxes below

Addition		**Replacement**	**X**	**Deletion**	

Replace Note 4 to Table 5 with the following text:

Note 4. This is the minimum clearance between the lowest part of any high voltage insulator within the substation and any point to which pedestrian access is permitted. Examples include high voltage equipment support insulators and insulator strings forming part of down-leads connected to anchor blocks.

TECHNICAL SPECIFICATION ADDENDUM

DOCUMENT TITLE	SUBSTATIONS
DOCUMENT NUMBER	TS 2.1
ISSUE NUMBER	5
ISSUE DATE	01/06/07

This Technical Specification shall be read in conjunction with the following amendments:

Check appropriate boxes below

Addition	**X**	**Replacement**		**Deletion**	

AMENDMENTS

Handling and monitoring facilities for SF_6 and SF_6 gas mixtures

All filling, sampling and isolation facilities shall be accessible and usable from ground level or from a fixed platform and shall be outside the relevant safety distance defined in Table 5 of this specification.

Monitoring equipment which requires no routine maintenance, calibration or other intervention (e.g. directly coupled pressure/density transducers) may be excluded from this requirement provided that a safe means of access for replacement/repair is provided and that the expected maintenance free period exceeds 15 years.

Access shall be provided to allow gas filling & handling equipment to be placed adjacent to filling points.

Gas filling, handling and sampling shall be able to be undertaken safely by an unaccompanied individual.

All pressure monitoring & measuring devices shall be removable without reducing the pressure in the main gas volume. This requirement may be achieved by a lockable shut-off valve between the main volume and the device or by the use of a self sealing coupling behind the removable device. In the latter case the coupling shall be lockable when the coupled device is removed or shall have the facility to fit a lockable blanking piece to prevent unauthorised interference. The presence of self-sealing couplings and their intended function shall be clearly indicated locally on the equipment.

Date Effective From	07/10/2009

	Originated by	**Authorised by**	**Approved by**

Name	Mark Waldron		
Job Title	Applied policy team Manager		
Department	ENI, Asset Policy		
Date	07/10/09		

SUBSTATIONS

PURPOSE AND SCOPE

This Specification covers all National Grid substations with equipment installed for use on 66, 132, 275 and 400kV, 50 Hz systems. Substations operating at other voltages are expected to comply with the general provisions of this specification. It is applicable to both open-terminal air-insulated (AIS) and metal-enclosed gas-insulated (GIS) substation constructions (including hybrids thereof) and covers equipment operated at lower voltages on the same substation site. It also applies to new construction and extensions to existing installations.

PART 1 – PROCEDURAL

Refer to sub document TS 2.1 Part 1.

This sub document follows the format and numbering convention of IEC 61936-1, Power Installations Exceeding 1kV – Common Rules.

Any sections numbered 101 onwards refer to additional information added by National Grid.

1 FORMS AND RECORDS

Not applicable.

PART 2 - DEFINITIONS AND DOCUMENT HISTORY

2 DEFINITIONS

Not applicable.

3 AMENDMENTS RECORD

Issue	Date	Summary of Changes / Reasons	Author(s)	Approved By (Inc. Job Title)
1	March 1993	New document		Mike Humphries Technology and Science
2	May 1995	Complete rewrite		Mike Humphries Technology and Science
3	Sept 2002	Complete rewrite	Mark Waldron Asset Policy	Mike Dean Asset Strategy Manager
4	December 2003	Policy & procedure removed. Busbar loading spec relocated to dedicated level 3 NGTS. Conductor jointing and oversailing guidelines relocated to TGN's. Minor aspects of TPS 2.1.1 incorporated.	Mark Waldron Asset Policy	Mike Dean Asset Strategy Manager
5	May 2007	Introduction of standard single line diagrams, pollution performance (moved from TS 1), overload ratings & maintenance access requirements. Modified portable earthing req. Format & numbering aligned with IEC 61936-1.	Mark Waldron Asset Management	Edgar Goddard Electricity Network Investment Manager

PART 3 - GUIDANCE NOTES AND APPENDICES

Not applicable.

SUBSTATIONS - PART 1 - PROCEDURAL

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1 Scope

This Specification covers all National Grid substations with equipment installed for use on 66, 132, 275 and 400kV, 50 Hz systems. Substations operating at other voltages are expected to comply with the general provisions of this specification. It is applicable to both open-terminal air-insulated (AIS) and metal-enclosed gas-insulated (GIS) substation constructions (including hybrids thereof) and covers equipment operated at lower voltages on the same substation site. It is applicable to new construction and extensions to existing installations.

Where a 'CEGB Standard' substation is to be extended the project specification may also refer to obsolete Transmission Plant Specifications which are available from National Grid.

All National Grid plant and apparatus wholly within the substation and not covered more specifically by other National Grid Technical Specifications (TS) is within the scope of this document.

This document follows closely the format and content of IEC 61936-1, *Power installations exceeding 1kV – common rules*, and should be read in conjunction with BS 7354*, Design of high-voltage open terminal stations*. Regarding the hierarchy of requirements given in these documents, specific requirements detailed in National Grid Technical Specifications shall take precedence over guidance of BS 7354 which in turn shall take precedence over the general provisions of IEC 61936-1.

2 Normative references

In addition to the references detailed in IEC 61936-1, the following are referred to in this document.

IEC 61936-1	Power installations exceeding 1kV – common rules
IEC 60060-1	Guide on high-voltage testing techniques. General
IEC 60815	Guide for the selection of insulators in respect of polluted conditions
BS EN 547-3	Safety of machinery. Human body measurements. Anthropometric data
BS EN 60335-2-76	Specification for safety of household and similar electrical appliances. Particular requirements for electric fence energisers.
BS EN 60507	Artificial pollution tests on high-voltage insulators to be used on a.c. systems
BS EN 60529	Specification for degrees of protection provided by enclosures (IP code)
BS EN 60694	Common specifications for high-voltage switchgear and controlgear standards
BS EN 60865-1	Short-circuit currents. Calculation of effects. Definitions and calculation methods
BS EN ISO 14122 (Parts 1 to 4)	Safety of machinery - Permanent means of access to machinery

BS 1710	Specification for Identification of Pipelines and Services.
BS 5395	Stairs, ladders & walkways.
BS 7354	Design of high-voltage open terminal stations
BS 7671	Requirements for electrical installations. IEE Wiring Regulations. Sixteenth edition.
TS 1	Ratings and General Requirements for Plant, equipment and apparatus for the National Grid System
TS 2.3	Power transformers and reactors
TS 2.5	Cable systems
TS 2.10	Generic Technical Specification for Civil Engineering Works
TS 2.12	Substation auxiliary supplies
TS 2.13	Electronic Equipment
TS 2.19	Ancillary light current equipment
TS 2.20	Oil containment at substations & other operational sites
TS 2.21	400kV and 275kV mechanically switched capacitor banks and damping networks
TS 2.22	Perimeter security fencing for new substations and extensions to existing substations.
TS 2.24	Substation information, control, protection and metering
TS 2.26	132kV mechanically switched capacitor banks and damping networks
TS 3.1.1	Substation Interlocking Schemes
TS 3.1.2	Substation Earthing
TS 3.1.3	Fire Protection of National Grid Substations
TS 3.1.4	Busbar systems for AIS substations
TS 3.1.5	Busbar clamps and components
TS 3.2.1	Circuit-breakers
TS 3.2.2	Disconnectors and Earthing Switches
TS 3.2.3	Metal oxide surge arresters
TS 3.2.4	Current transformers for protection and general use
TS 3.2.5	Voltage transformers
TS 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
TS 3.2.8	Line traps for use on 275kV and 400kV systems (archived)

TS 3.2.9	Solid core post insulators for substations
TS 3.2.10	Voltage grading capacitors for circuit-breakers
TS 3.2.11	Air systems incorporating
TS 3.2.14	Gas Insulated Switchgear
TS 3.7.11	Software Based Interlocking
TS 3.11.1	Capacitors and capacitor banks
TS 3.24.15	Environmental and test requirements for electronic equipment
TS 3.24.43	Interlocking
PS(T) 003	Type registration
PS(T) 005	Sulphur Hexafluoride gas
PS(T) 006	Earthing switches
PS(T) 007	Disconnectors
PS(T) 008	Asset health – condition monitoring systems
PS(T) 021	Surge arresters for substations
PS(T) 022	Design and operation of combined disconnector-earthing switches
PS(T) 068	LVAC supplies for transmission substations
PS(T) EPS 11.0	Maintenance policy
TGN(T) 27	Application guidelines for overvoltage protection in substations using surge arresters
TGN(T) 86	Control of ferroresonance
TGN(T) 176	Sequential disconnection
TGN(T) 186	Guidance for working in proximity to live conductors
TGN(T) 187	Guidance for conductor jointing in substations
TP 106	Equipment commissioning and decommissioning
TP 109	Numbering and nomenclature of HV apparatus
HS(G)38	Lighting at Work
National Grid Safety Rules	
The Horlock Rules	NGC substations and the environment :Guidelines on siting and design
NSI 1	Operational & Safety Switching
NSI 2	Earthing High Voltage Equipment

3 Definitions

The definitions of IEC 61936-1 apply without modification.

4 Fundamental requirements

Clause 4 and the associated sub-clauses of IEC 61936-1 are applicable with the following modifications.

Substations shall meet the system requirements detailed in TS 1.0 and shall be designed & constructed in accordance with BS7354.

Substation primary plant shall have an anticipated asset life of not less than 40 years unless an alternative value is agreed with National Grid prior to installation & commissioning.

4.1 General

No specific requirements.

4.2 Electrical requirements

4.2.1 Methods of neutral earthing

Neutral earthing of the National Grid system at various voltages is defined in TS 1.0.

4.2.2 Voltage classification

Rated voltages (highest voltages for equipment) and the associated dielectric withstand requirements are defined in TS 1.0.

4.2.3 Current in normal operation

Rated normal currents are defined in TS 1.0.

In additions to these requirements, substation plant shall also be capable of withstanding the overload conditions detailed in Table 1 where rated normal current = 1.0.

4.2.4 Short-circuit current

Rated short-circuit currents and rated durations of short-circuit are defined in TS 1.0.

Calculation of short-circuit currents shall take into account Energy Networks Association, Engineering Recommendation (ENA, ER) G74.

4.2.5 Rated frequency

The rated frequency is defined in TS 1.0

4.2.6 Corona

No specific requirements.

Table 1: Overload factors for application to rated normal current

Ambient temp'		10^0C	20^0C	30^0C
Pre fault continuous current		1.013	0.958	0.900
Post-fault continuous current		1.206	1.140	1.072
Overload currents				
pre-load (%age post fault)	**Overload duration**			
84	20	1.307	1.236	1.162
	10	1.462	1.383	1.300
	5	1.746	1.652	1.553
	3	2.000	1.966	1.848
75	20	1.356	1.282	1.206
	10	1.578	1.492	1.403
	5	1.971	1.865	1.753
	3	2.000	2.000	2.000
60	20	1.424	1.347	1.266
	10	1.736	1.642	1.543
	5	2.000	2.000	2.000
	3	2.000	2.000	2.000
30	20	1.519	1.437	1.350
	10	1.945	1.840	1.729
	5	2.000	2.000	2.000
	3	2.000	2.000	2.000
0	20	1.555	1.471	1.383
	10	2.000	1.915	1.800
	5	2.000	2.000	2.000
	3	2.000	2.000	2.000

Note: Table 1 has been derived to exploit reduced ambient temperatures to ensure that the maximum allowable temperature of materials defined in IEC 60694 (IEC 62271-1) are not exceeded.

4.3 Mechanical requirements

Mechanical loading studies shall be undertaken in accordance with TS 3.1.4.

Calculations or tests shall be performed to demonstrate the mechanical suitability of equipment terminals for specified loading combinations of conductor systems in which the equipment is to be applied.

The effects of short-circuits on busbar systems and plant shall be assessed using the procedures and loading combinations detailed on TS 3.1.4.

4.4 Climatic and environmental conditions

Climatic and environmental conditions are defined in TS 1.0.

4.4.101 Pollution performance requirements for ceramic insulation

External insulation shall be in accordance with the relevant requirements and recommendations of IEC 60815

For ceramic insulation, test conditions to prove this performance level shall be as defined in Tables 2 & 3. Service experience offered in lieu of artificial pollution testing shall be identical to that detailed for composite insulation in clause 4.4.102.

Insulation, including composite insulation, shall have a minimum specific creepage of 25mm/kV for Class III pollution environments and 31mm/kV for Class IV pollution environments. Account shall be taken of the factor k_D

Ceramic insulation for vertical application meeting the following criteria is deemed to meet the requirements of Tables 2 & 3 without further testing.

Alternate Long Short (ALS) profile.
$(p_1 – p_2) \geq 15$ mm
$s \geq 70$mm

Where the parameters p_1, p_2 and s are as defined in IEC 60815.

Table 2: Pollution, Salt Fog and Heavy Wetting Test Requirements

Insulation	IEC 60815 pollution class	IEC 60507 salt fog withstand test specification kg/m^3	NGT heavy wetting test specification kg/m^3
Indoor	I	No test withstand required	No test withstand required
Outdoor	III	80	80
Outdoor (special)	IV	>160	> 160
Outdoor Horizontal	III & IV	80	80

Note 1: Pollution Class IV may be specified for sites which are judged to be subject to severe coastal or industrial pollution.

Note 2: Details of the heavy wetting specification can be found in Annex A.

The application of an anti-pollution palliative coating to the external surface of ceramic insulation in order to satisfy the requirements of this specification is not acceptable.

Products consisting of internally graded insulation contained within an external AIS insulating enclosure or weather-shield, such as bushings, instrument transformers or grading capacitors, shall be considered a single item for the purposes of pollution and heavy wetting tests.

Phase to earth insulation connected in parallel and having a shed-to-shed separation distance of less than 0.5 times the phase-to-earth clearance shall be considered as a single item for the purposes of pollution and heavy wetting tests.

Table 3: Test Voltage Levels for Pollution, Salt Fog and Heavy Wetting Tests

Rated Voltage of Insulation	17.5	72	145	300	420
Test Voltage (phase-to-earth)	10	42	84	173	242
Test Voltage (phase-to-phase)	17.5	72	145	300	420
Test voltage for other insulation	The maximum power frequency voltage to which the insulation may be stressed in service. For insulation enclosing a switchgear interrupting gap, or if insulation is specified for enclosures for isolating gaps, or for insulation connected in parallel with such an interrupting or isolating gap, this test voltage shall be the out-of-phase voltage.				

Horizontally oriented insulation and insulation intended for mounting > 15^0 from the vertical shall meet the pollution and heavy wetting requirements in its intended orientation.

The insulation shall be mounted at the orientation intended for service during pollution and heavy wetting tests.

Note 3: Typically 2 to 5 years test station experience or 5 to 10 years power system experience in lieu of testing will be sufficient to meet these requirements depending on actual severity of climatic conditions during the test period. Where such evidence is unavailable, monitoring of initial installations on the National Grid System may be considered. Such consideration will be in the form of a risk assessment taking into account factors such as expected pollution levels at the proposed location, system risks associated with failure and predicted equipment population.

4.4.102 Pollution performance requirements for composite (non-ceramic) insulation

As mentioned in IEC 61462, the pollution test procedures defined in IEC 60507 are not applicable for non-ceramic insulation and standard test procedures remain under consideration.

Composite external insulation shall be supported by satisfactory service experience equivalent to at least two years in a heavily polluted environment similar to that experienced at UK coastal locations. All relevant aspects of this experience shall be fully documented.

4.4.103 Environmental protection of outdoor plant and equipment

Equipment shall be adequately protected from the corrosive effects of its intended operating environment taking into account the anticipated operating life (not less than 40 years for primary equipment). The supplier shall define a periodic, preventive maintenance regime which will ensure that the equipment remains in good overall condition for its anticipated asset life.

Material construction and/or applied protective coatings shall, as far as reasonably practicable, keep the equipment in operational condition for the anticipated operating life without preventive maintenance. As a minimum, intervals of at least 20 years shall be achievable between preventive maintenance.

4.5 Special requirements

4.5.1 Effects of small animals and micro-organisms

No additional requirements are specified.

4.5.2 Noise level

Impulse and steady state noise shall not exceed the relevant action levels specified in the UK noise at work regulations.

5 Insulation

Clause 5 and the associated sub-clauses of IEC 61936-1 are applicable with the following modifications.

5.1 Selection of insulation level

Insulation level requirements are detailed in TS 1.0

5.2 Verification of withstand values

No additional requirements are specified.

5.3 Minimum clearances of live parts

The layout of AIS equipment shall ensure the integrity of the air space between live parts and other conductors (including earthed conductors) for the rated voltage conditions for which the substations is designed.

Equipment configurations which have not been dielectrically tested shall meet the minimum operational clearances defined in Table 4.

Table 4: Minimum electrical clearances

Nominal voltage (kV)	Phase-to-earth clearance (m) Note 2 *(IEC values in brackets)*	Phase-to-phase clearance (m)
33	0.5 *(0.32)* Note 1	0.43 *(0.32)*
66	0.7 *(0.63)*	0.78 *(0.63)*
132	1.1 *(1.3)*	1.4 *(1.3)*
275	2.1 *(2.4 rod-structure, 1.9 conductor structure)*	2.4 *(3.1 rod-conductor, 2.6 conductor-conductor)*
400	2.8 *(3.4 rod structure, 2.6 conductor structure)*	3.6 *(4.2 rod-conductor, 3.6 conductor-conductor)*

Note 1: A minimum clearance of 500 mm is specified to cover vermin and bird interference.

Note 2: Under some circumstances temporary infringement of phase to earth clearances during earthing switch operation may be permitted. Refer to TS 3.2.2.

Note 3: Table 1 lists MINIMUM clearances and an appropriate additional allowance should be made for constructional tolerances, effects of short-circuit, wind effects etc.

Note 4: The minimum clearances which are in widespread use in the UK differ from those recommended in IEC 61936-1. On the basis of long term satisfactory service experience and familiarity of operational staff these clearances are maintained in preference to the IEC values.

5.4 Minimum clearances between parts under special conditions

No additional requirements are specified.

5.5 Tested connection zones

No additional requirements are specified.

5.101 Electrical safety clearances

Safety to persons shall normally be achieved by the provision of adequate safety clearance to live parts taking into account the need for construction, modification, maintenance and vehicular and pedestrian access.

Where adequate safety clearances to live parts cannot be maintained without limiting access, fixed barriers or fences shall be provided.

The safety clearances to be maintained in AIS installations are listed in Table 5.

Table 5: Substation Safety Clearances/Distances

Nominal System Voltage	Safety Distance (From National Grid Safety Rules)	Design Clearance for Safety (vertical) D_S	Design Clearance for Safety (horizontal) D_{SH}	Insulation Height (pedestrian access)
kV	M (Note 1)	M (Note 2)	M (Note 3)	M (Note 4)
≤ 33	0.8	3.2	2.3	2.4
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 5 lists MINIMUM clearances and an appropriate additional allowance should be made for constructional tolerances.

Where the design of the substation requires the use of mobile equipment working platforms the design clearances for safety D_S and D_{SH} shall be increased by 2m.

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

Note 2: This is 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 up-stretched hand), which is taken to be 2.4 m, to the appropriate Safety Distance.

Note 3: Where practicable the vertical design clearance should be applied in all directions.

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

All structures installed in substations shall be designed such that they deter climbing.

Note 5: The use of anti-climbing guards in substations is not normally acceptable unless they can be shown to pose no significant risk during planned activities requiring access to equipment.

5.102 Oversailing conductors and conductor in proximity

Designers are obliged to comply with all relevant health and safety legislation, however particular attention is drawn to the designers' duties under the Construction (Design and Management) Regulations (CDM). In applying the principles of prevention and protection in the reduction of risk, particular attention is drawn to the hazards of working in proximity to exposed live HV conductors (including 'oversailing' conductors) during construction, operation, maintenance, repair, replacement or demolition of electrical/mechanical equipment and civil structures.

If the designer does not eliminate hazards presented by exposed live HV conductors from the design, there is an obligation on said designer to demonstrate, by risk assessment, that the design has complied with the principles of prevention and protection, as required by CDM. The hierarchy of risk control should be considered when selecting alternative control measures.

Oversailing conductors shall be eliminated from the design as far as is reasonably practicable.

Note 1: Oversailing conductors are exposed HV conductors above or in proximity to any reasonably foreseeable work area and which would normally remain energised during such work activities. Guidelines on meeting the requirement of this clause are detailed in TGN (E) 186.

Conductors in proximity shall be eliminated from the design.

Note 2: Conductors in proximity are exposed HV conductors with insufficient clearance to a reasonably foreseeable work area to avoid danger and which would normally remain energised during work activities. Guidelines on meeting the requirement of this clause are detailed in TGN (E) 186 .

Situations where work activities must be carried out above exposed HV conductors that are live shall be eliminated from the design.

6 Equipment

Clause 6 and the associated sub-clauses of IEC 61936-1 are applicable with the following modifications.

6.1 General requirements

Substation civil requirements are detailed in TS 2.10.

Requirements for ancillary light current equipment are detailed in TS 2.19.

6.1.1 Selection

Existing plant, civil structures and foundations may be re-used providing that adequate strength and capability is demonstrated and that the residual anticipated asset life is appropriate for National Grid's plans for the installation.

6.1.2 Compliance

Equipment shall comply with all relevant National Grid Technical Specifications and shall be Type Registered as required by PS(T)003.

6.1.3 Personnel safety

No additional requirements are specified.

6.1.101 Maintenance regimes

National Grid's maintenance policy is detailed in PS (T) EPS 11.0.

Maintenance recommendations, including details of procedures, equipment and spares shall be provided for all substation plant. For closely integrated equipment, such as GIS, compact AIS or hybrid assemblies, the maintenance recommendations shall include procedures for replacing major sub-components.

Substation equipment shall be designed & installed to minimise the need for system access (outages) for maintenance. Maintenance requiring system access shall not be required at less than 6 yearly intervals or at less than 2000 mechanical operations.

The supplier shall indicate where basic recommended maintenance intervals can be safely extended by the application of techniques such as condition monitoring, in service diagnostic testing or equipment "exercising".

Note The application of condition monitoring should be in accordance with PS (T) 008

Within individual bays, equipment maintenance regimes shall be aligned such that a co-ordinated bay maintenance strategy can be adopted.

6.1.102 Mid-life refurbishment

Where sub-components require mid-life refurbishment in order for the equipment or installation to achieve its anticipated asset life, the scope of this activity shall be clearly indicated by the supplier in the maintenance recommendations for the equipment. Consideration shall be given to minimising the outage requirements to achieve the necessary re-furbishment.

Note: For example, equipment utilising electronic controls or fluid based mechanisms may require mid-life refurbishment activities which would preferable be undertaken by use of off-line refurbishment & exchange.

6.2 Specific requirements

Phase-to-phase AIS solid external insulation is not acceptable.

6.2.1 Switching devices

Specific requirements for circuit-breakers are detailed in TS 3.2.1

Specific requirements for disconnectors and earthing switches are detailed in TS 3.2.2, PS(T)006, PS(T)007 and PS(T)022.

Requirements for sequential disconnection are detailed in TGN (E) 176.

Substations shall have sufficient earthing provision to enable the safe maintenance of any item of primary equipment including fixed earthing switches. Sufficient earthing switches shall be provided to enable the application of a primary earth between all foreseeable points of work and all potential infeeds.

As a minimum, earthing switches in accordance with TS 3.2.2 shall be provided at circuit entries ('line' earth switches) and at one position on each section of busbar. Further earthing provision may be by means of other types of interlocked motorised earthing device which meet the specified rating.

Note: For GIS installations the number of busbar earthing devices may be reduced by reference to the "30m rule" detailed in National Safety Instruction 2. For all but the largest GIS installations a single earth switch on each section of busbar will meet this requirement.

Where high level earthing switches are employed, e.g. on high level busbars, specific procedures for maintenance of these devices must be agreed with National Grid.

6.2.2 Power transformers and reactors

Specific requirements for power transformers and reactors are detailed in TS 2.3

6.2.3 Gas insulated metal enclosed switchgear (GIS), metal-enclosed switchgear, insulation-enclosed switchgear and other prefabricated type-tested switchgear assemblies

Specific requirements for gas insulated switchgear are detailed TS 3.2.14

GIS substations shall be equipped with surge arresters in accordance with PS(T)21 and TGN(T)27.

An audible alarm scheme to warn operators of a major loss of SF_6 gas shall be provided in indoor substations. This shall operate at the low pressure alarm setting of each gas zone and shall fail safe i.e. shall not fail in such a way that correct alarms are suppressed.

Controls shall be provided at the substation control point to reset and isolate the audible alarm.

Visual indication(s) shall be provided in the switch-house to show that the audible alarm is in service.

Visual indication(s) shall be provided outside the main entrances to the switch-house to indicate that the alarm has operated.

SF_6 detection and alarms should be installed in substations where a slow leak may result in a build up of gas e.g. in basement areas.

A diagram of the gas system shall be displayed at the Local Control Cabinet or at any point where gas service connections are grouped together.

6.2.4 Instrument transformers

6.2.4.1 Current transformers

Specific requirements for current transformers are detailed in TS 3.2.4

The accommodation of current transformers shall be as specified in Annex B.

The location of current transformers shall be as specified in Annex C.

6.2.4.2 Voltage transformers

Specific requirements for current transformers are detailed in TS 3.2.5

6.2.4.3 Current Transformers, Voltage Transformers and Combined Instrument Transformers for Settlement Metering

Specific requirements for settlement metering instrument transformers are detailed in TS 3.2.6

6.2.5 Surge arresters

Specific requirements for surge arresters are detailed in TS 3.2.3.

Guidance regarding the application of surge arresters is detailed in PS(T)21 and TGN(T)27.

6.2.6 Capacitors

Specific requirements for capacitors are detailed in TS 3.11.1 (capacitors & capacitor banks), TS 2.21 (400kV and 275kV mechanically switched capacitor banks and damping networks) and TS 2.26 (132kV mechanically switched capacitor banks and damping networks).

6.2.7 Line traps

Power line carrier communications, and hence line traps, are only applied as replacements for existing legacy equipment. In such cases specific requirements for line traps are detailed in TS 3.2.8 (archived).

6.2.8 Insulators

Specific requirements for insulators are detailed in TS 3.2.9

6.2.9 Insulated cables

Specific requirements for insulated cables are detailed in TS 2.5 and the associated level 3 specifications.

6.2.10 Conductors and accessories (busbar systems)

Specific requirements for conductors and accessories are detailed in TS 3.1.4 and TS 3.1.5.

Guidance regarding jointing of current carrying conductors is given in TGN(E)187.

6.2.11 Rotating electrical machines

No additional requirements are specified.

6.2.12 Static converters

No additional requirements are specified.

6.2.13 Fuses

No additional requirements are specified.

6.2.101 Portable earthing equipment

The need to use portable primary earthing equipment shall be minimised as far as reasonably practicable. Where primary earthing is to be achieved using portable earthing leads, consideration should be given to safe application positions and compliance with the Manual Handling Regulations.

Where the use of portable earthing is foreseen, e.g. to permit maintenance of fixed earthing, provision shall be made to employ National Grid's standard portable earthing equipment.

The substation design shall cater for a maximum earthing clamp size of 90mm. The application of portable primary earths to larger diameter busbars and flexible conductors shall be by means of earthing stubs or equivalent primary attachment points. Primary attachment points shall be adequately dimensioned for the attachment of sufficient earth leads to match the substation short-circuit rating. Consideration should be given to safe application positions and compliance with the Manual Handling Regulations

Points for attachment of the earth end of portable earthing leads shall be provided at each switchgear structure and shall be adequately dimensioned for the attachment of sufficient earth leads to match the substation short-circuit rating. .

Each portable earthing lead attachment point shall be connected to the substation earthing mat by a fully rated conductor system.

The application of portable earthing at heights exceeding 4.8m is unacceptable.

7 Installations

Clause 7 and the associated sub-clauses of IEC 61936-1 are applicable with the following modifications.

7.1 General requirements

The manner in which plant and equipment is designed and installed as a system shall allow that system and its components to be operated and maintained in accordance with all relevant statutory requirements.

The siting and design of new substations shall take into account the guidelines known as the Horlock Rules.

The substation installation including busbars, connections, insulators, structures foundations & all other infrastructure shall be designed for an anticipated life of 40 years subject to periodic preventive maintenance being carried out in accordance with manufacturers or suppliers instructions.

Lifting beams or fixed overhead travelling cranes of adequate capacity shall be provided where their use is required to assist with maintenance, repair or dismantling of switchgear. Fixed cranes shall not be provided in outdoor substations or indoor AIS substations except where specifically required for maintenance or repair purposes.

Provision shall be made to inspect beams or cranes for insurance purposes and to fit lifting tackle.

The substation layout and surfaces shall be adequate to allow the access and use of any powered access equipment, cranes or similar equipment which may be required for foreseeable maintenance activities

Access in the form of a road/path of minimum 1m width which is suitable for gas handling equipment shall be provided to all equipment containing SF_6.

Roads shall be provided to access substation main buildings, relay rooms and heavy items of plant (e.g. transformers) in accordance with TS 2.10. All other surfaces shall also be in accordance with the relevant requirements of TS 2.10.

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

Requirements of electronic interlocking schemes provided as part of substation control systems are specified in TS 3.24.43.

As a minimum the following facilities shall be provided at all new 400 kV, 275 kV and National Grid owned 132kV substations.

The extent to which this Clause shall apply to extensions to existing installations shall be specified by National Grid in the Project Enquiry.

- Adequate toilet and washing facilities for operation and maintenance staff taking into account National Grid's equal opportunities policies.

- Standby control room(s) with 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 prevent ingress of SF_6 decomposition products in the event of a switchgear fault.

- At sites where SF_6 gas-filled equipment is installed a standing area and suitable water and drainage connections for a mobile changing/shower facility shall be provided. It shall, as a minimum, comprise a rectangular reinforced concrete slab having minimum dimensions of 6m x 4m projecting 50mm above the surrounding finished substation level. The slab shall be laid to minimum falls for drainage purposes with surface water running off to the surrounding areas (unless the site topography and geology dictate a positive drainage system is necessary). The washdown area shall be provided with electricity and water supplies as follows:

    - three phase 32 A integrated isolator/socket (IP 67 rating)

    - single phase 16A integrated isolator/socket (IP 67 rating)

    - insulated water supply with out door tap.

  A manhole chamber with 100mm (minimum) outlet pipe and 5 tonne (minimum) wheel load solid top cover and frame shall be provided adjacent to the slab to accept waste water discharges from the mobile facility. Such waste may discharge into a foul sewer or alternatively a dedicated cesspool having a minimum capacity of 4500 litres. SF_6 gas waste shall not be discharged into a sewage treatment plant or septic tank. Where a dedicated cesspool is used the drainage system shall be sealed against rainwater ingress.

- A small mess room with sink, worktop, electrical outlets and facilities for the supply of drinking quality water.

- An equipment store (including earth storage facilities) / small workshop.

- Vehicle parking.

7.1.1 Circuit arrangement

Substation bays shall be in accordance with the functional (single line) diagrams presented in Annex D. These diagrams represent the standard construction of commonly used bay types and deviation from these arrangements shall be agreed with National Grid. Less common or non-standard circuit designs are not covered and separate agreement shall be reached regarding the most appropriate arrangement.

The design of a substation shall permit installation, extension, operation and maintenance (preventive and corrective) with a maximum of one circuit (including any circuit requiring intervention) and one section of busbar out of service simultaneously.

Note: A section of busbar is taken to be a part of either the main or reserve busbars or a mesh corner. Associated busbar section and busbar coupler circuits may be considered to be part of the busbar section.

The height of the highest component of outdoor substations should be kept to a practical minimum to achieve a low substation profile.

On new sites the maximum height of equipment shall not exceed the values listed in Table 6.

At existing sites the height of existing equipment shall not be exceeded.

Table 6: Maximum Equipment Heights in Substations

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

The substation shall be designed to minimise the land area required.

Equipment design and layout shall facilitate extension of the substation with minimum disruption to normal operation.

Circuit arrangements where a wound VT may become connected to the power system via the grading capacitors of a circuit-breaker shall be avoided.

Transformer feeder circuits (including transformers banked with line circuits at mesh substations) with an overhead line circuit length greater than 15 km shall be fitted with ferroresonance detection and quenching equipment. Further guidance can be found in TGN (T) 86.

7.1.2 Documentation

Documentation requirements are defined in TS 1.0

7.1.3 Transport rules

No additional requirements specified.

7.1.4 Aisles & access areas

No additional requirements specified.

7.1.5 Lighting

Adequate lighting shall be provided in accordance with HS(G)38.

7.1.6 Operational safety

No additional requirements specified.

7.1.7 Labelling

Numbering and nomenclature of HV apparatus shall be in accordance with Tramsmission Procedure (TP) 109.

7.2 Outdoor installations of open design

7.2.1 Protective barrier clearances

No additional requirements specified.

7.2.2 Protective obstacle clearances

No additional requirements specified.

7.2.3 Boundary clearances

Exposed live conductors that cross perimeter fences shall, under worst-case conditions, be at a height no less than the minimum height above ground of overhead lines as defined in the Electricity Safety Quality and Continuity regulations, 2002 (including all subsequent amendments).

Designers must allow for the specified maximum ambient temperature and temperature rise due to passage of rated normal current when determining maximum conductor temperature.

Subject to agreement with National Grid a reduced horizontal clearance may be acceptable provided clearances of D_S and D_{SH} (as appropriate) are maintained from the top of the perimeter fence (but excluding any electrified wires). See Figure 1 based on 400kV clearances.

Exposed live conductors that do not cross perimeter fences shall be a distance of at least D_S (measured horizontally) from a substation compound perimeter fence.

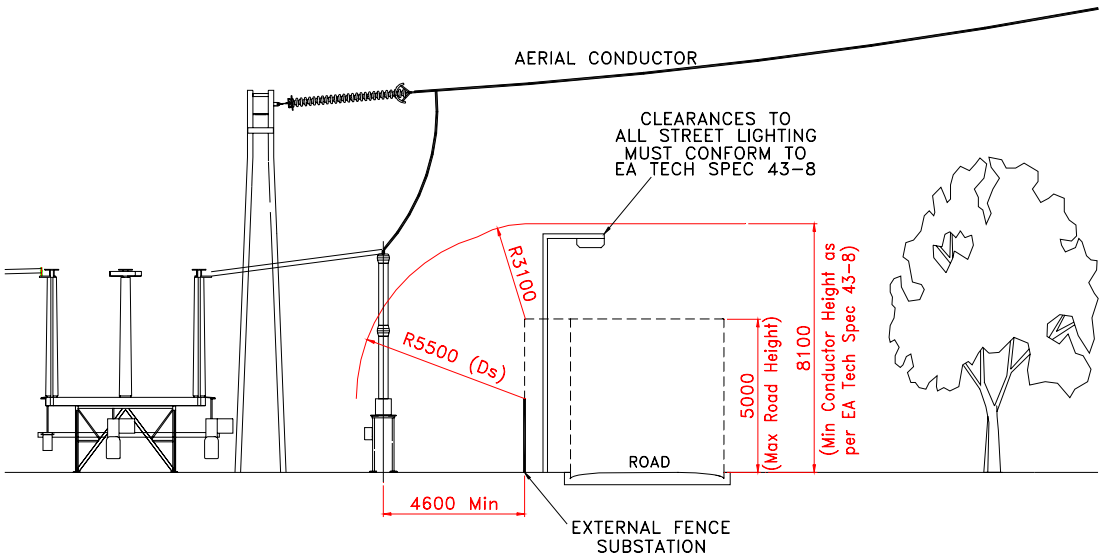

Figure 1: Reduced Clearance to Substation Perimeter Fence (400kV Clearances Shown)

7.2.4 Minimum height over access areas

The minimum vertical clearance from exposed live conductors to internal substation roadways or recognised maintenance access routes to which vehicular access is required shall be the greater of:

Minimum height above ground of overhead lines as defined in the Electricity Safety Quality and Continuity regulations, 2002 (including all subsequent amendments).

or

Maximum agreed vehicle height + 0.5m margin + Safety Distance

Where the latter criterion is used the maximum vehicle height used for the design shall be clearly marked at all vehicular access points.

The horizontal clearance from defined roadways to exposed live conductors shall be sufficient to ensure that:

Safety distance is not infringed by any part of a vehicle.

and

D_{SH} (Ref' Table 5) is maintained from the driving and/or riding position of any vehicle.

Note: The second of these requirements caters for the case where the driving and/or riding position falls outside (above) the envelope of the vehicle.

Lockable 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.

7.2.5 Clearance to buildings

7.2.6 External fences or walls and access doors

Perimeter security fencing shall be in accordance with TS 2.22. Additional security provisions (if any) will be specified on a site specific basis pending inclusion in TS 2.10.

Perimeter fences meeting statutory 2.4m height requirements and incorporating electric pulse security systems will be considered for lower priority sites if it can be demonstrated that there is a lifetime cost benefit compared to the use of National Grid standard fencing.

Electric pulse security fences (BS EN 60335-2-76) are required for sites requiring high security.

No equipment within the substation shall be installed within 2m of the security fence.

7.3 Indoor installations of open design

No additional requirements specified.

7.4 Installation of factory built, type-tested enclosures

7.4.1 General

No additional requirements specified.

7.4.2 Additional requirements for gas-insulated metal-enclosed switchgear

7.4.2.1 Design

Specific requirements for GIS are detailed in TS 3.2.14

7.4.2.2 Erection on site

No additional requirements specified.

7.4.2.3 Protection against overvoltages

GIS substations shall be equipped with surge arresters in accordance with TGN(T)27.

7.4.2.4 Earthing

No additional requirements specified.

7.5 Requirements for buildings

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

Fixed crane(s) shall be provided in indoor GIS substations unless the supplier can demonstrate that they are not required for dismantling or removing any part of the substation for maintenance or repair purposes.

Specific requirements for oil containment are detailed in TS 2.20.

7.6 High voltage/low voltage prefabricated substations

No additional requirements are specified.

7.7 Electrical installations on pole, mast & tower

No additional requirements are specified.

7.101 Maintenance access

Safe means of access and egress shall be provided, or be identified in the design, for all foreseeable activities.

Provision of access to plant, equipment and apparatus for maintenance, repair and operation shall take into account the intended activity, the expected frequency that access will be required and the anthropometric data of the human body. For the purposes of this document the anthropometric data detailed in BS EN 547-3 shall be used. For parameters where percentile values are given, assessments should be undertaken using the 5th and 95th percentile as boundary conditions.

Note: Example clearances meeting these requirements are as follows:

Minimum vertical clearance for walking/standing access :	2100mm
Minimum passageway width for walking/standing access:	750mm
Minimum passageway width for work in a kneeling position:	1100mm
Height range for work in standing position:	900-1500mm
Height range for work in kneeling position:	600-1200mm
Height range for work in sitting position:	300-900mm

Access for operation, routine periodic inspection shall be from ground level or a fixed platform.

Access for routine preventive maintenance, repair, erection, extension, replacement and demolition may be from:

- ground level or a fixed platform (preferred)
- temporary fixed height access equipment (<= 3.6m)
- mobile elevated working platform (MEWP) (>3.6m)

Note: Further guidance on this topic can be found in TGN (E) 186.

The provision of fixed access platforms shall take into account the expected frequency of the planned activity e.g. activities expected to occur at >12 yearly intervals are unlikely to justify provision of fixed access arrangements.

The choice of fixed access means shall be in accordance with BS EN ISO 14122-1.

The need to work at height, particularly for routine activities, should be eliminated where it is reasonably practicable to do so.

It shall be possible for an unaccompanied individual to undertake routine operational & frequent maintenance activities such as isolation, earthing and routine inspection.

Isolation facilities or locking devices shall be between 1 m and 1.8 m above either the floor level or a platform provided for access and shall be not further than 750 mm horizontally from the edge of a platform.

Isolation facilities shall be accessible from ground level or from fixed platforms and shall permit the application of isolation procedures defined in National Safety Instructions (NSI) 1 and 2.

Where movement of equipment within the substation would be restricted by the presence of ladders it is acceptable that these are removable. Removable ladders and mobile platforms shall be easily handled and used on the finished substation surface by one person.

Fixed access facilities shall comply with BS EN !SO 14122-2, 14122-3 or 14122-4 as appropriate and their arrangement shall be agreed with National Grid to suit site requirements.

Fixed ladders should not be provided in circumstances where it would be practical to install a staircase.

Fixed platforms need not be provided for corrective or infrequent preventive maintenance so long as access can be gained by the use of pre-formed scaffolding or powered access equipment.

All displays of pressure/density or level shall be readable from the substation floor level or from fixed access walkways.

Voltage transformer secondary isolation links, or equivalent means of positive isolation, 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 National Grid's standard padlock type.

8 Safety measures

Clause 8 and the associated sub-clauses of IEC 61936-1 are applicable with the following modifications.

It is intended that National Grid substations are as safe an environment as is reasonably practicable. This specification contains many detailed requirements intended to facilitate this however, due to the complex nature of substation design and construction, no single specification, or suite of specifications, can guarantee to address all potential dangers in the optimum way. As part of a collaborative approach it is vital that National Grid and our substation suppliers take a “best practice” approach to substation design safety at all times. In particular constructional issues such as tripping hazards, sharp edges, labelling and poor access which are difficult to specify effectively should be eliminated wherever possible in the design.

Substations shall be designed and installed with due regard to the National Grid safety rules and the associated National Safety Instructions (NSIs).

8.1 Protection against direct contact

No additional requirements specified.

8.2 Means to protect persons in case of indirect contact

No additional requirements specified.

8.3 Means to protect persons working on electrical installations

No additional requirements specified.

8.4 Protection from danger resulting from arc fault

No additional requirements specified.

8.5 Protection against direct lightning strokes

No additional requirements specified.

8.6 Protection against fire

8.6.1 General

Fire protection shall be in accordance with TS 3.1.3.

Buildings housing GIS shall have a 30 minute fire resistance in accordance with the requirements of the UK building regulations. Where such buildings share walls or other dependent elements with control buildings these must be designed such that they do not compromise the 1 hour fire resistance of the latter.

8.6.2 Transformers & reactors

No additional requirements specified.

8.6.3 Cables

No additional requirements specified.

8.6.4 Other equipment with flammable liquids

No additional requirements specified.

8.7 Protection against leakage of insulating liquid and SF_6

No additional requirements specified.

8.7.1 Insulating liquid leakage and subsoil water protection

8.7.1.1 General

Specific requirements for oil containment are detailed in TS 2.20.

8.7.1.2 Containment for indoor equipment

No additional requirements specified.

8.7.1.3 Containment for outdoor equipment

No additional requirements specified.

8.7.2 SF_6 leakage

Specific details regarding the use of SF_6 gas are detailed in TS 1.0 and PS (T) 005.

8.7.3 Failure with loss of SF6 and its decomposition products

No additional requirements specified.

8.8 Identification and marking

8.8.1 General

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

a) Each circuit-breaker, disconnector and earthing switch mechanism box shall carry a label giving the operational reference of the device.
b) Each pressure gauge or pressure readout device shall carry a label identifying the parameter it is monitoring.
c) Each valve (including self-sealing gas filling valves) shall carry a label identifying its function.
d) Each SF_6 filling valve shall be provided with a label identifying the mass of gas contained within the gas compartment to which it is fitted (at normal filling density). The volume of the compartment and normal filling density shall also be marked.
e) Each control handle or switch for plant operation shall carry a label identifying its function.
f) Each point of LV isolation associated with plant shall carry a label identifying its function.
g) Each cabinet, cubicle or kiosk shall carry a label identifying all of the equipment contained within it.

Labels shall be sufficiently durable for the application and the environment in which they are to be used taking account of the expected operational lifetime of the equipment. They shall remain in place and legible for the design lifetime of the equipment.

Note: Experience indicates that this requirement can be met by the use of UV resistant engraved labels with mechanical fixings. National Grid will require demonstration that alternative labelling systems are adequate

The fixing of labels shall not compromise the degree of protection (IP rating) of the equipment.

All pipework shall be identified in accordance with BS 1710.

The ownership of equipment shall be clearly labelled particularly where National Grid and Users equipment or isolation facilities are located in close proximity.

8.8.2 Information plates & warning plates

No additional requirements specified.

8.8.3 Electrical hazard warning

No additional requirements specified.

8.8.4 Installations with incorporated capacitors

No additional requirements specified.

8.8.5 Emergency signs for emergency exits

No additional requirements specified.

8.101 Safety from pressurised systems

Pressurised systems, such as hydraulic and/or pneumatic pipework, shall be adequately protected to prevent danger arising from external damage. If such pipework is installed in shared ducts/trenchs with other equipment (e.g. cabling), mechanical segregation/protection shall be provided.

8.102 Safety from moving mechanical parts

Parts of equipment which move during normal operation and which are accessible from fixed or temporary access facilities e.g. drive linkages, shall be guarded to prevent inadvertent contact and injury. The principles outlined in the following documents shall be adopted in the design.

- ISO 12100-1 Safety of machinery- Basic concepts, general principles for design Part 1 and part 2.
- BS EN 811 Safety of machinery – Safety distances to prevent danger zone being reached by the lower limbs
- BS EN 294 Safety of Machinery - Safety distances to prevent danger zones being reached by upper limbs
- L22 - Safe use of work equipment – Provision and use of work equipment regulations 1998.

9 Protection, control and auxiliary systems

Clause 9 and the associated sub-clauses of IEC 61936-1 are applicable with the following modifications.

Equipment panels may be located in the switchgear building either adjacent to the switchgear or in an annexe. Such equipment, together with its accommodation, shall meet the requirements of Class IP 54 of BS EN 60529.

Electronic equipment shall be located in accommodation commensurate with its environmental performance which is classified in TS 2.13, TS 2.24 and TS 3.24.15 as appropriate.

Light current accommodation shall meet the requirements of TS 2.13 Class C (minimum ambient temperature -10°C, relative humidity 10-100%) under all ambient conditions.

Fixed heating 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 16°C without causing condensation on the equipment.

All panels housing secondary equipment which are sited in equipment rooms or accommodation shared with equipment owned by other users shall be padlockable.

All substation auxiliary cabling between substation buildings, relay rooms, common marshalling points and substation primary equipment shall, as far as reasonably practicable, be installed in buried cable ducts. Where cable trays (or similar) are used these shall not present a risk of injury and shall be suitably finished to prevent degradation due to environmental conditions. Auxiliary cables shall be installed such that they do not present a tripping hazard.

The installation of substation auxiliary cabling should minimise hazards such as tripping and sharp edges (cable trays). 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.

The location of all buried cables and ducts shall be clearly recorded on site.

All metallic cables shall be of low smoke, low fume, zero halogen, armoured design. Installation shall be in accordance with BS 7671.

Substation auxiliary supplies shall be designed and installed in accordance with TS 2.12 and the associated level 3 specifications.

Protection relays and circuits associated with equipment owned by Users (e.g. generating companies, distribution companies or directly connected consumers) shall be accommodated in separate panels from those associated with equipment owned by National Grid. This requirement shall also apply to multi-core cable terminations, marshalling facilities and jumper fields.

Ideally all National Grid owned equipment should be physically segregated from that owned by Users however it is accepted that this is not always possible/practical in which case the following clauses are applicable.

Where switchgear local controls are grouped on a bay control panel (or similar) then control of National Grid owned plant shall be segregated from that of User owned plant. Separate individually lockable local/remote control selector switches shall be provided for National Grid and User equipment such that staff with authority to operate only User equipment are unable to access control of National Grid owned equipment.

Facilities provided for substation level control of Users equipment shall have no facilities to operate National Grid owned equipment.

Any electrical/mechanical supplies which are provided by National Grid to Users equipment shall be equipped with segregated, clearly labelled isolation facilities.

Common compressed air, hydraulic or other motive power systems supplying both National Grid and Users equipment are unacceptable.

9.1 Monitoring and control systems

No additional requirements specified.

9.2 DC and AC supplies

9.2.1 General

Specific requirements for dc and ac supplies are detailed in PS(T)068, TS 2.12 and the associated level 3 specifications. The use of dangerous voltages (>50V ac or >120V dc) shall be avoided as far as reasonably practicable. Where dangerous voltages are utilised appropriate warning labels and guarding shall be employed to ensure personnel safety.

48V DC, 110V DC and 400/220V AC auxiliary supply isolation facilities shall be located in the equipment local control cubicle (LCC) or, where installed in a common panel, shall be clearly segregated from isolation facilities for National Grid owned equipment. LCC's and common panels should be sited in areas to which access will be permitted to non-National Grid staff.

9.2.2 AC supply

Alternating current control systems are not acceptable for the control of circuit-breakers, switches, disconnectors or earthing switches.

400V AC supplies to significant User loads, such as transformer coolers, shall be supplied from separate circuits on the substation LVAC supplies board and provision shall be made for the installation of metering. Isolation facilities shall be provided at the load end of the circuit such that isolation at the LVAC board is not normally required during maintenance.

9.2.3 DC supply

The rated supply voltage of the DC system at National Grid substations is 125 V. Closing and opening releases and operating devices shall operate over the voltage ranges, measured at their terminals during operation, given in Table 7.

The Supplier shall declare the characteristics of the current required by the closing and opening releases and operating devices when operating at the minimum operating voltage.

Table 7: Rated Supply and Operating Voltage Range for D.C. Systems and Operating Devices

		D.C. System	Closing and Opening Releases and Operating Devices	
			Close	Open
Maximum Operating Voltage	Volts	137.5	137.5	137.5
Minimum Operating Voltage	Volts	93.5	87.5	77

9.3 Compressed air systems

Specific requirements for compressed air systems are detailed in TS 3.2.11.

9.4 SF_6 gas handling plants

No additional requirements specified.

9.5 Basic rules for electromagnetic compatibility of control systems

No additional requirements specified.

10 Earthing systems

10.1 General

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

Particular attention should be paid to requirements for high frequency earthing.

10.2 Fundamental requirements

No additional requirements specified.

10.3 Design of earthing systems

No additional requirements specified.

10.4 Construction of earthing systems

No additional requirements specified.

10.5 Measurements

No additional requirements specified.

10.6 Commissioning

No additional requirements specified.

10.7 Maintenance

No additional requirements specified.

11 Inspection and testing

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

Routine Tests shall normally be performed at the point of manufacture.

Commissioning tests and routine tests which are performed at site shall be fully documented taking into account the requirements of TP 106.

Detailed commissioning procedures and acceptance values shall be provided by the Supplier

Diagnostic tests shall be incorporated into the commissioning test programme and be performed on all equipment to establish its correct operation.

Annex A HEAVY WETTING TEST SPECIFICATION

A.1 General Test Requirements

A.1.1 The Heavy Wetting Test is used to establish the performance of a polluted insulator when exposed to the sudden application of heavy wetting.

A.1.2 The general test requirements are as in BS EN 60507 Clauses 5 and 6.

A.2 Preconditioning Process

A.2.1 The insulator shall be preconditioned as required by BS EN 60507 Clause 10 before performing the test.

A.3 Heavy Wetting Test

A.3.1 The intention of the test is to confirm the specified heavy wetting withstand salinity of the insulator at the specified test voltage.

A.3.2 Referring to clauses in BS EN 60507 the test shall start when the test insulator and the chamber conditions fulfill the requirements of Clause 9, and after the preconditioning of the insulator according to Clause 10.

A.3.3 A series of tests shall be performed on the insulator as detailed below. Each test consists of three stages.

A.3.3.1 Stage 1 Salt Fog

The specified test voltage, in accordance with Table 3 of this document shall be applied to the insulator which shall be exposed to a salt fog using a salt solution having the specified test salinity in accordance with Table 2 of this document. Flashovers during this stage do not constitute a failure of the heavy wetting test. After a flashover, the insulator shall immediately be re-energised at a voltage level 5% below the flashover voltage. This process may be repeated if further flashovers occur. The total period of application of salt fog shall be 15 minutes.

A.3.3.2 Stage 2 Drying

The insulator is allowed to dry initially at the voltage level reached at the end of Stage 1. During the drying period the test voltage shall be increased if necessary to the specified test voltage. Flashovers during this stage do not constitute a failure in the test. After a flashover the insulator shall be immediately re-energised to continue the drying process. The total drying period shall be 15 minutes.

A.3.3.3 Stage 3 Heavy Wetting

Immediately following Stage 2 and at the specified test voltage, the insulator shall be sprayed with water as specified in the IEC 60060-1 Standard Wet Test Procedure except that the water conductivity shall be 100 $\mu S.mm^{-1}$. The wetting shall continue until flashover or until the discharge activity has decreased to a stable level at which flashover cannot occur. If this cannot be determined then the wetting shall continue for 15 minutes.

A.3.3.4 Acceptance Criteria for the Heavy Wetting Test

The insulator complies with this specification if no flashover occurs during the Stage 3 Heavy Wetting tests in a series of three consecutive tests with. A single test consists of the complete sequence of all 3 stages in accordance with the above

procedure. Washing of the insulator is permitted between each, 3 stage, test procedure. If only one flashover occurs, a fourth test shall be performed and the insulator then passes the test if no flashover occurs in this final test.

Annex B CURRENT TRANSFORMER (CT) ACCOMMODATION

B.1 INTEGRATED DIGITAL PROTECTION/CONTROL

The requirements specified in sections B2 to B8 of this Appendix are applicable to substations where conventional protection & control equipment is installed.

The introduction of integrated digital protection & control equipment has eliminated the requirement to provide separate CT cores for busbar and feeder protections and to segregate metering functions from protection. There is still, however, a requirement to maintain two independent measurement and communication systems for analogue data.

The minimum provision shall be:

- Two independent current sensors per phase on each circuit. These shall be designed and constructed in such a way that the risk of common mode failure is, as far as reasonably practicable, minimised.

- Two independent communication channels for transmitting analogue data to protection and control equipment. These shall be designed and constructed in such a way that the risk of common mode failure is, as far as is reasonably practicable, minimised.

Where the measurement or transmission of analogue data is dependent on an auxiliary power supply then each sensor/communications channel shall be supplied from an independent source (e.g. 110V DC supplies 1 and 2).

Where transmission of analogue data relies on the operation of active components to process this data (e.g. integrators, A/D converters, opto-electric converters) then facilities shall be provided for protection relays to use a secondary data source in the event of failure of the primary source. Typically, relays using data channel 1 would revert to data channel 2 in the event of failure and vice versa.

In designing the changeover system, the following hierarchy of preference shall be considered (most preferred first, least preferred last):

1. Automatic changeover on failure of primary data channel.

2. Manual changeover by unskilled staff on failure of primary data channel.

3. Manual changeover by skilled staff on failure of primary data channel.

Changeover facilities shall be designed so that, as far as is reasonably practicable, they do not introduce any additional risks of common mode failure.

B.2 CURRENT TRANSFORMER MOUNTING AND POLARITY REQUIREMENTS

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

For CT's which are integral to circuit-breakers and for separately mounted CT's which are directly associated with circuit-breakers all P1 markings shall be electrically nearer to the circuit-breaker than the corresponding P2 markings.

For CT's which are integral to transformers, reactors or generators the P1 markings shall be electrically nearer to the windings than the corresponding P2 markings.

For separately mounted current transformers which 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.

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 A3 to A8 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.

B.3 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 TS 3.2.6.

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

B.3.1 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.

B.3.2 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.

B.4 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.

B.5 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 A3.1 or A3.2.

B.6 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.

B.7 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.

B.8 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:

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

2. Neutral current transformer housings shall provide accommodation for one Measurement/Protection current transformer.

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

C.1 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.

C.2 BUSBAR STATIONS

C.2.1 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.

C.2.2 Bus Section and Bus Coupler Circuits

Current transformers for busbar protection shall be installed on both sides of the circuit-breaker with 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.

C.3 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 e.g. 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 shall be located on the side of the circuit breaker remote from that zone.

C.4 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 shall be located on the side of the circuit-breaker remote from that zone.

ANNEX D STANDARD SUBSTATION BAY FUNCTIONAL (SINGLE LINE) DIAGRAMS

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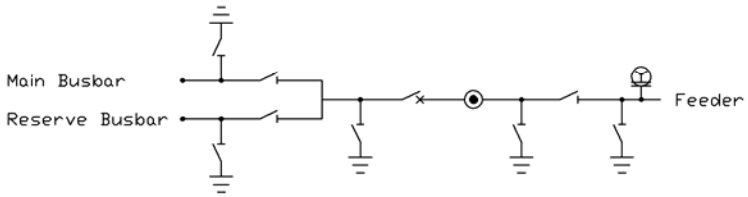
DOUBLE BUSBAR AIS

OVERHEAD LINE FEEDER BAY



Notes

a) Where a single Earth Switch is not fitted at the busbar side of the Circuit Breaker then an Earth Switch shall be fitted on both sides of each Busbar Selector Disconnectors.

b) Where Power Line Carrier communications are to be retained a line trap shall be required, normally mounted on the CVT.

c) Where an Overhead Line circuit has a cable entry in to the substation the need to provide cable fault detection protection (and associated CTs) should be considered as per cable protection policy.

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TS 2.1
STANDARD SINGLE LINE DIAGRAM
DOUBLE BUSBAR AIS
OVERHEAD FEEDER BAY

Station			ISSUE A
Circuit			
Drg. No. 41/177344	Sht No 1	No of Shts 16	
SCALE:- N/A	Work Ref		

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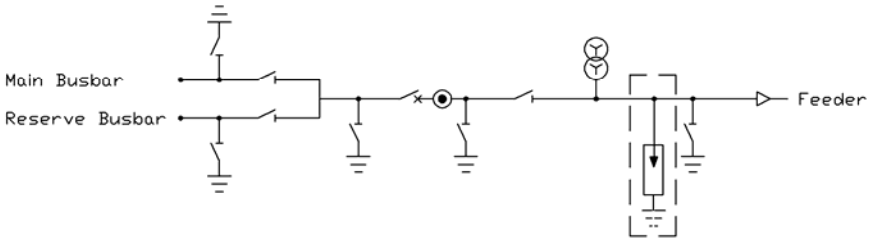
DOUBLE BUSBAR AIS

CABLE FEEDER BAY



Notes

a) Where a single Earth Switch is not fitted at the busbar side of the Circuit Breaker then an Earth Switch shall be fitted on both sides of each Busbar Selector Disconnectors.

b) The Wound VT is for cable discharge duty and is only required at one end of the Cable Circuit.
The VT arrangement at the remote end shall be shall be in accordance with protection policy.

c) The use of Slip-over CT's at the cable termination is non-preferred unless DAR lockout facilities are required.

d) A Surge Arrester may be required but should be determined on a circuit basis. See TGN(E)27 for further guidance.

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DOUBLE BUSBAR AIS
CABLE FEEDER BAY

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Circuit				
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SCALE:- N/A		Work Ref		

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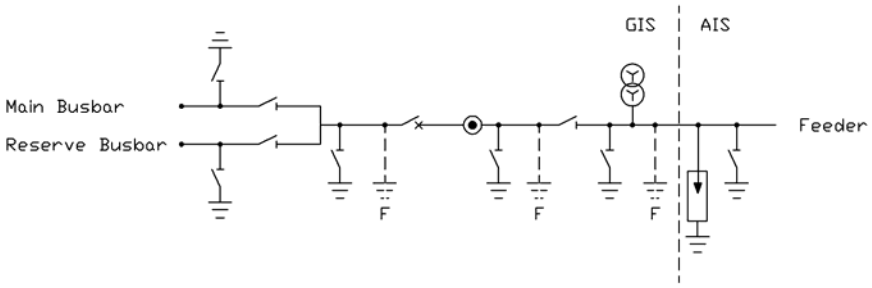
DOUBLE BUSBAR GIS

OVERHEAD LINE FEEDER BAY



Notes

a) The Surge Arrester is shown in the preferred location but may be within the GIS boundary.

b) Where the requirements of NSI 2 can be met by the use of Busbar Earth Switches located at the end of each section of busbar and by the use of Portable Earthing Devices, then Busbar Earth Switches in every bay are not required.

c) Preferred location of Portable Earthing devices shown by the dotted Earth Symbol and designated 'F'.

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TS 2.1
STANDARD SINGLE LINE DIAGRAM
DOUBLE BUSBAR GIS
OVERHEAD LINE FEEDER BAY

Station			ISSUE A
Circuit			
Drg. No. 41/177344	Sht No 3	No of Shts 16	
SCALE:- N/A	Work Ref		

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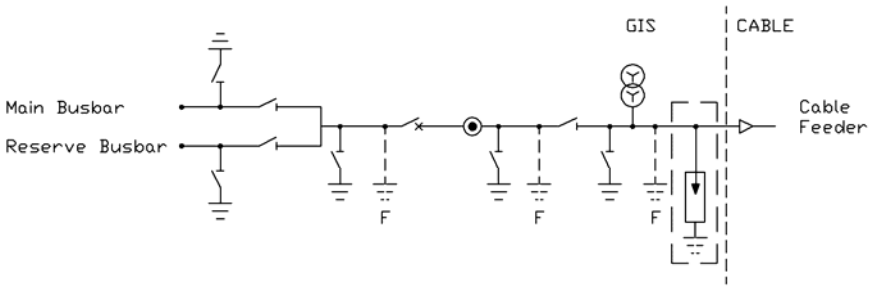
DOUBLE BUSBAR GIS

CABLE FEEDER BAY



Notes

a) Preferred location of Portable Earthing Devices shown by the dotted Earth Symbol and designated 'F'.

b) A Surge Arrester may be required but should be determined on a circuit basis. See TGN(E)27 for further guidance.

c) Where the requirements of NSI 2 can be met by the use of Busbar Earth Switches located at the end of each section of busbar and by the use of Portable Earthing Devices, then Busbar Earth Switches in every bay are not required.

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STANDARD SINGLE LINE DIAGRAM
DOUBLE BUSBAR GIS
CABLE FEEDER BAY

Station			ISSUE A
Circuit			
Drg. No. 41/177344	Sht No 4	No of Shts 16	
SCALE:- N/A	Work Ref		

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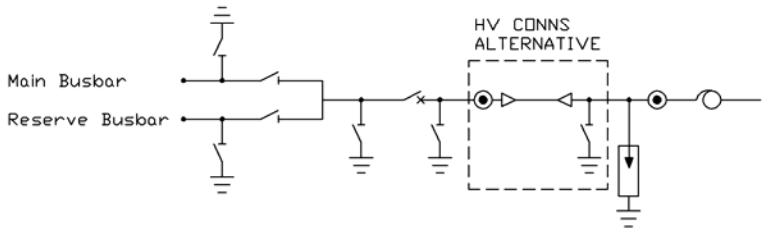
DOUBLE BUSBAR AIS
TRANSFORMER BAY (HV SIDE) / SVC BAY/ REACTOR



Notes

a) Where a single Earth Switch is not fitted at the busbar side of the Circuit Breaker then an Earth Switch shall be fitted on both sides of each Busbar Selector Disconnectors.

b) Turret CT's within the transformer bushing have been assumed in this arrangement.

c) HV Conns shown in this drawing are representative of the situation when the connected equipment is remote from the busbars.

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STANDARD SINGLE LINE DIAGRAM
DOUBLE BUSBAR AIS
TRANSFORMER BAY (HV SIDE) / SVC BAY/REACTOR

Station				ISSUE A
Circuit				
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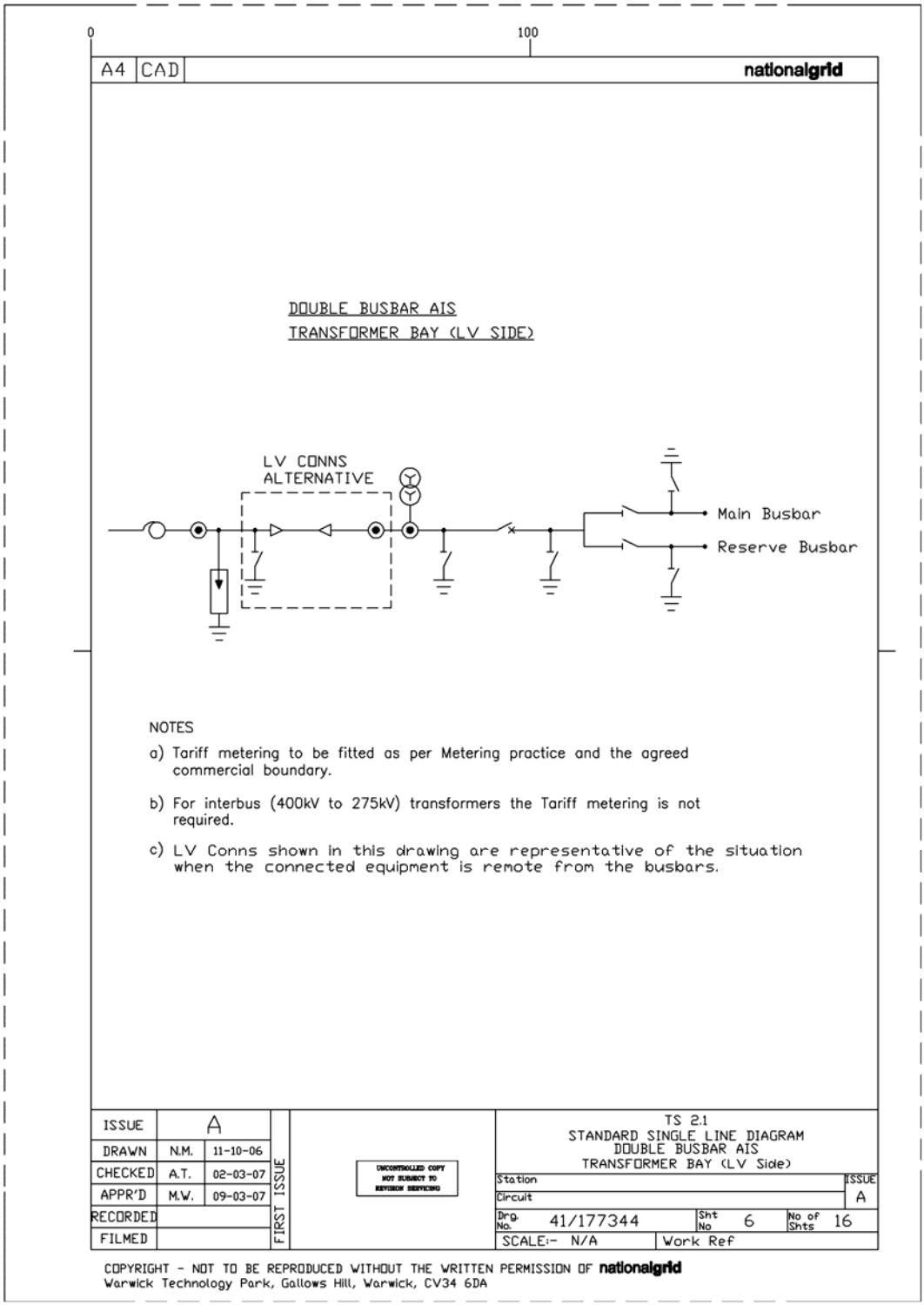
SCALE:- N/A		Work Ref		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DOUBLE BUSBAR AIS
TRANSFORMER BAY (LV SIDE)
LV CONNS
ALTERNATIVE
Main Busbar
Reserve Busbar
NOTES
a) Tariff metering to be fitted as per Metering practice and the agreed commercial boundary.
b) For interbus (400kV to 275kV) transformers the Tariff metering is not required.
c) LV Conns shown in this drawing are representative of the situation when the connected equipment is remote from the busbars.
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STANDARD SINGLE LINE DIAGRAM
DOUBLE BUSBAR AIS
TRANSFORMER BAY (LV Side)
Station
Circuit
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Drg. No. 41/177344
Sht No 6
No of Shts 16
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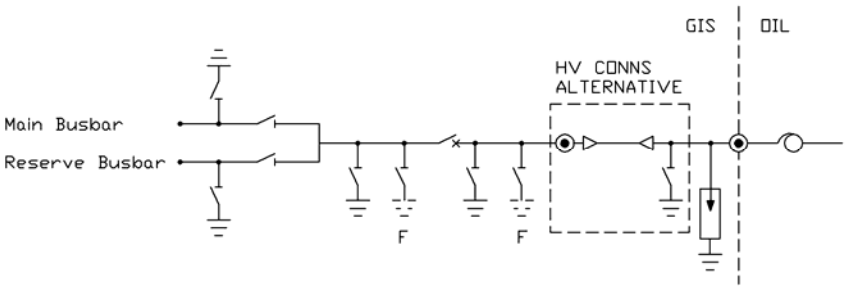
DOUBLE BUSBAR GIS
TRANSFORMER BAY (HV SIDE) / SVC BAY / REACTOR BAY



NOTES

a) Turret CT's within the transformer bushing have been assumed in this arrangement.

b) HV Conns shown in this drawing are representative of the situation when the connected equipment is remote from the busbars. The use of cable is indicative and alternatives (e.g. GIB) maybe appropriate.

c) Where the requirements of NSI 2 can be met by the use of Busbar Earth Switches located at the end of each section of busbar and by the use of Portable Earthing devices, then Busbar Earth Switches in every bay are not required.

d) Preferred location of Portable Earthing Devices shown by the dotted Earth Symbol and designated 'F'.

ISSUE	A			TS 2.1 STANDARD SINGLE LINE DIAGRAM DOUBLE BUSBAR GIS TRANSFORMER BAY (HV Side)/SVC BAY/REACTOR
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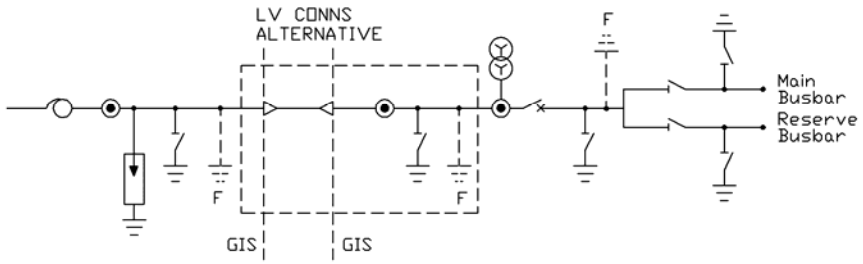
DOUBLE BUSBAR GIS
TRANSFORMER BAY (LV SIDE)



NOTES

a) Tariff metering to be fitted as per Metering practice and the agreed commercial boundary.

b) For interbus (400kV to 275kV) transformers the Tariff metering is not required.

c) LV Conns shown in this drawing are representative of the situation when the connected equipment is remote from the busbars. The use of cable is indicative and alternatives (e.g. GIB) maybe appropriate.

d) Where the requirements of NSI 2 can be met by the use of Busbar Earth Switches located at the end of each section of busbar and by the use of Portable Earthing devices, then Busbar Earth Switches in every bay are not required.

e) Preferred location of Portable Earthing Devices shown by the dotted Earth Symbol and designated 'F'.

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STANDARD SINGLE LINE DIAGRAM
DOUBLE BUSBAR GIS
TRANSFORMER BAY (LV Side)

Station				ISSUE A
Circuit				
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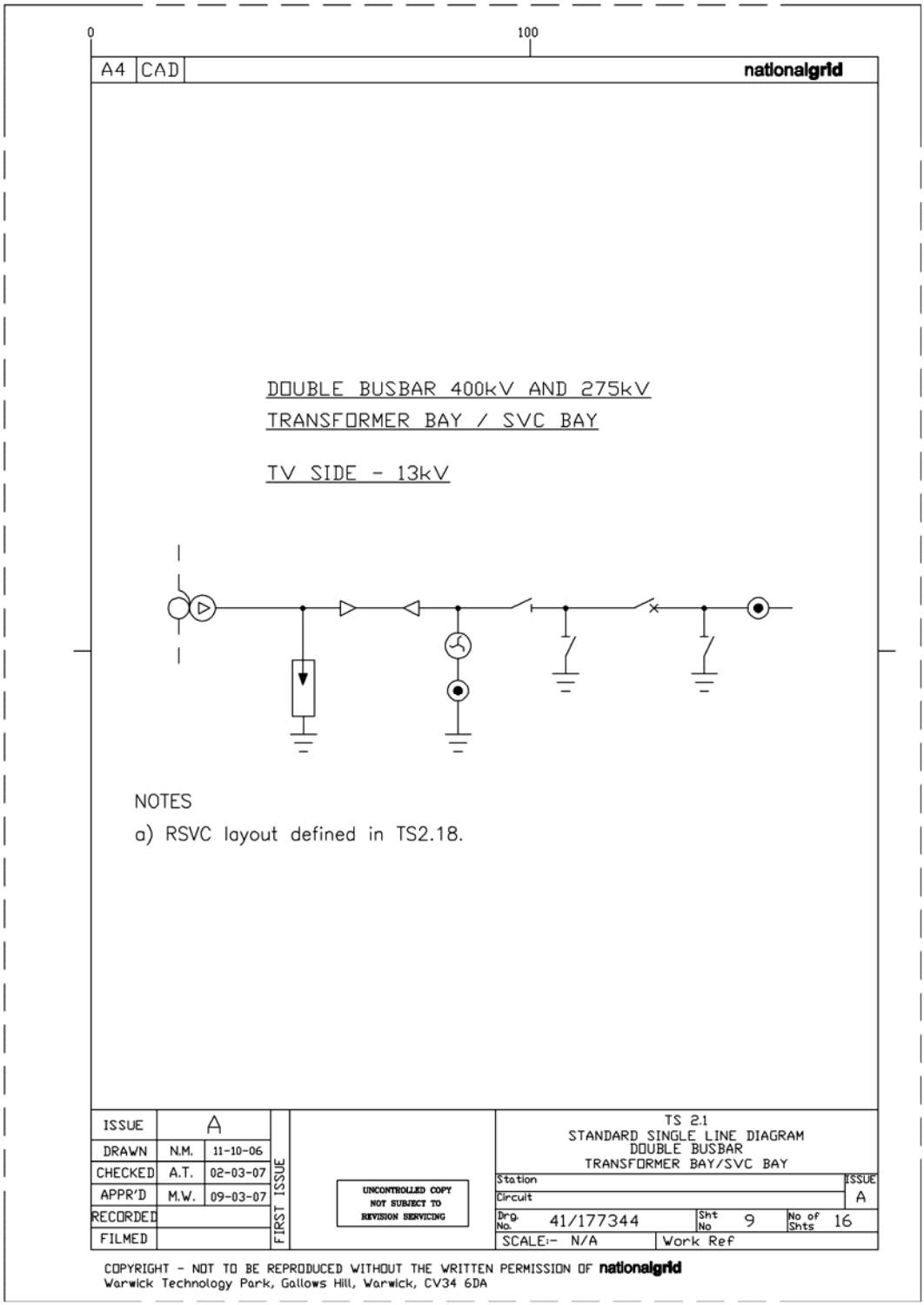
SCALE:- N/A		Work Ref		



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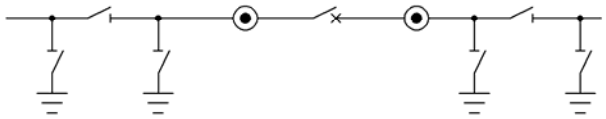
DOUBLE BUSBAR AIS & GIS
COUPLER / SECTION BAY

MAIN BUSBAR



NOTES

a) The outer Earth Switches may be installed at the ends of the busbars for a GIS substation.

b) Earth Switches are not required for bus couplers in GIS substations.

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STANDARD SINGLE LINE DIAGRAM
DOUBLE BUSBAR AIS & GIS
COUPLER/SECTION BAY

Station				ISSUE A
Circuit				
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SCALE:-	N/A	Work Ref		

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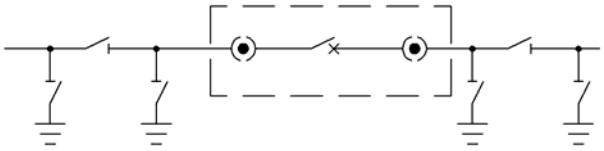
DOUBLE BUSBAR AIS & GIS
SECTION BAY

RESERVE BUSBAR



NOTES

a) The circuit breaker and current transformers may be omitted by agreement with National Grid.

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DOUBLE BUSBAR AIS & GIS
SECTION BAY

Station				ISSUE A
Circuit				
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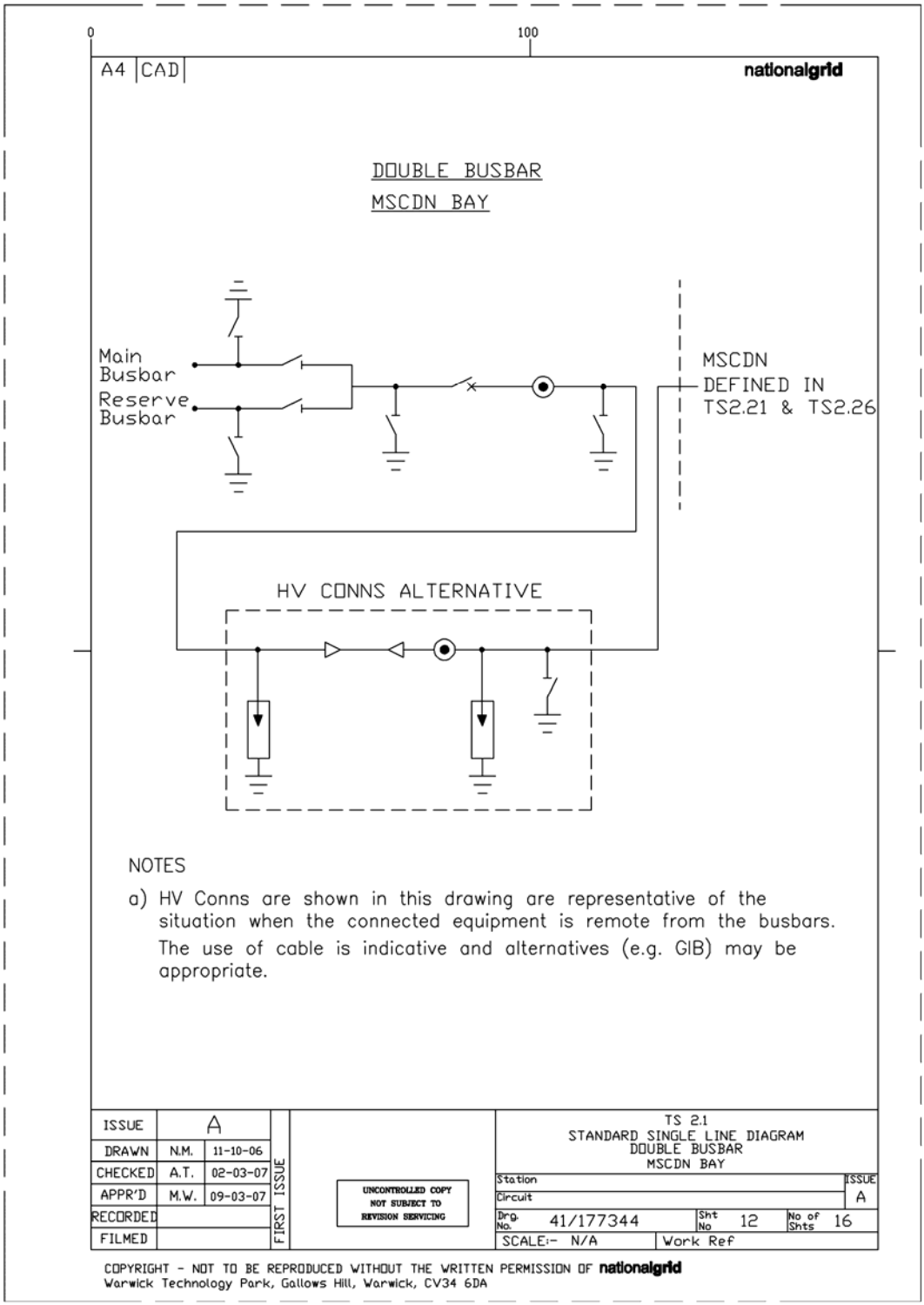
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nationalgrid
DOUBLE BUSBAR
MSCDN BAY
Main Busbar
Reserve Busbar
MSCDN
DEFINED IN
TS2.21 & TS2.26
HV CONNS ALTERNATIVE
NOTES
a) HV Conns are shown in this drawing are representative of the situation when the connected equipment is remote from the busbars. The use of cable is indicative and alternatives (e.g. GIB) may be appropriate.
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TS 2.1
STANDARD SINGLE LINE DIAGRAM
DOUBLE BUSBAR
MSCDN BAY
Station
Circuit
ISSUE A
Drg. No. 41/177344
Sht No 12
No of Shts 16
SCALE:- N/A
Work Ref
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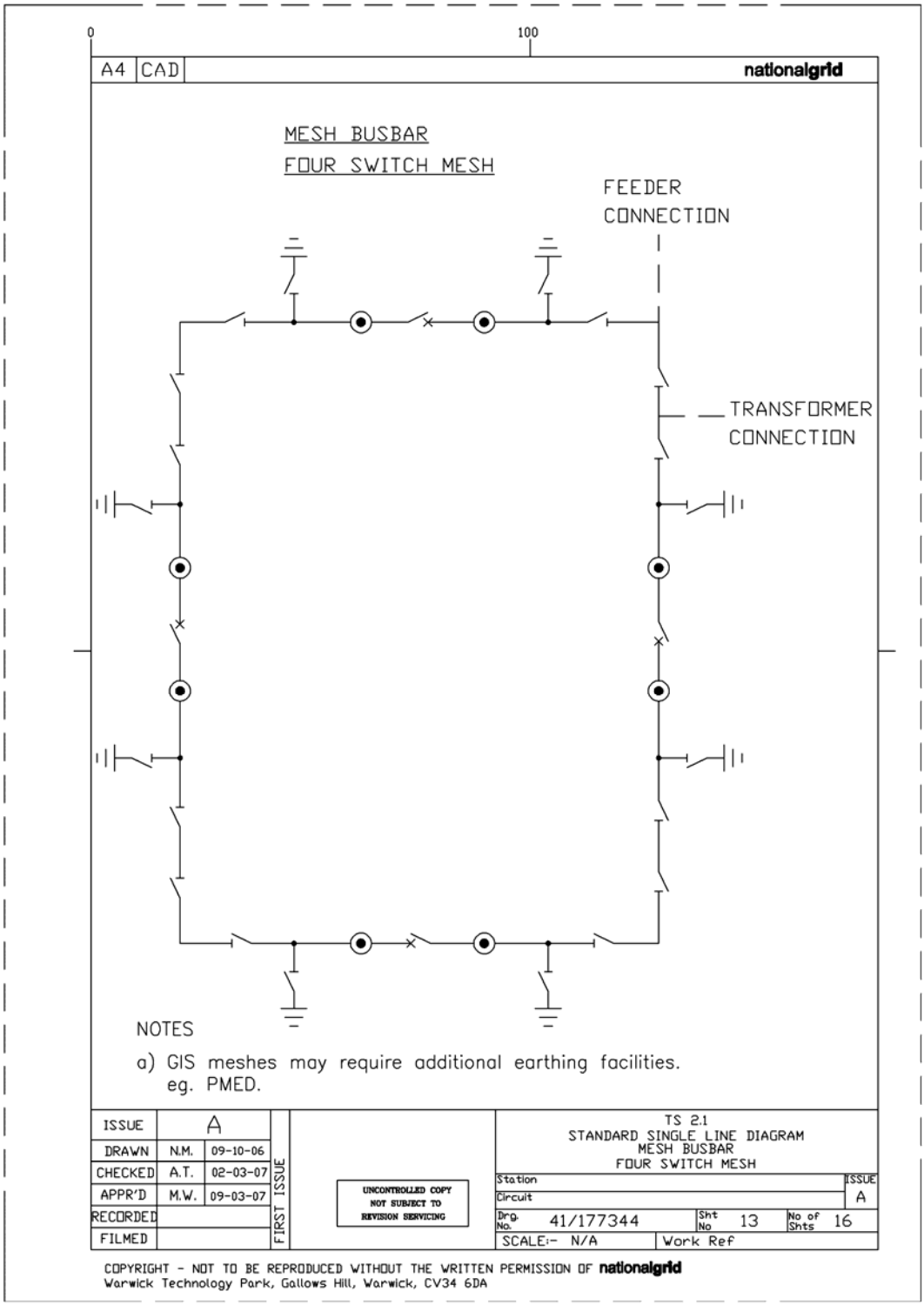
0
100
A4
CAD
nationalgrid
MESH BUSBAR
FOUR SWITCH MESH
FEEDER
CONNECTION
TRANSFORMER
CONNECTION
NOTES
a) GIS meshes may require additional earthing facilities.
eg. PMED.
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TS 2.1
STANDARD SINGLE LINE DIAGRAM
MESH BUSBAR
FOUR SWITCH MESH
Station
Circuit
ISSUE A
Drg. No. 41/177344
Sht No 13
No of Shts 16
SCALE:- N/A
Work Ref
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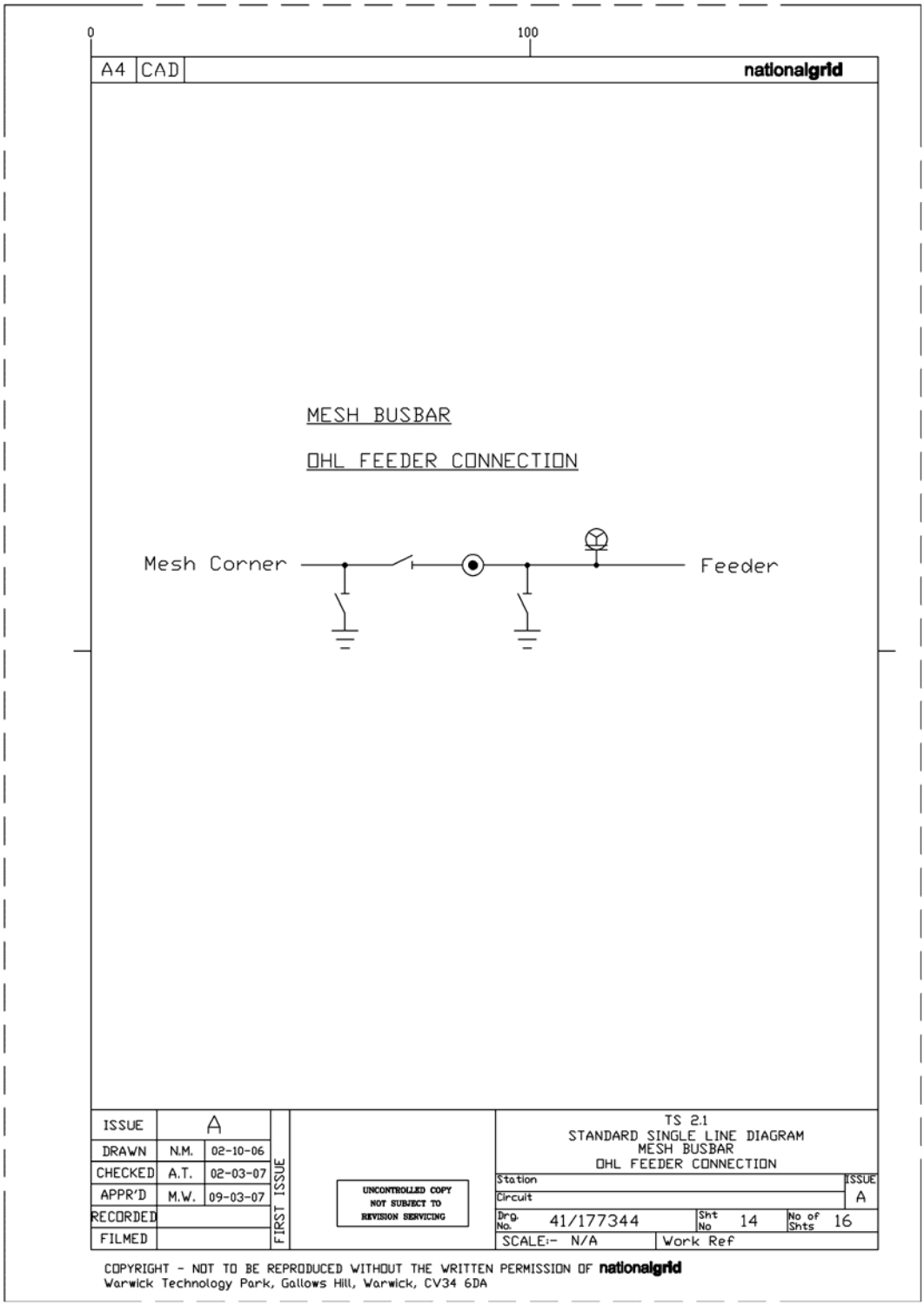
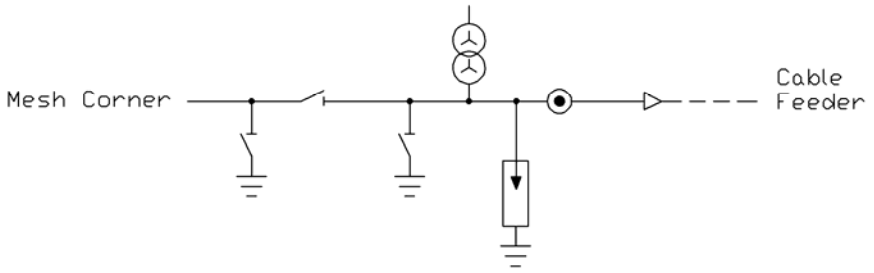
Warwick Technology Park, Gallows Hill, Warwick, CV34 6DA



0 100

A4 CAD nationalgrid

MESH BUSBAR
CABLE FEEDER CONNECTION



Notes

a) The Wound VT is for cable discharge duty and not generally required for protection purposes.
A Wound VT is only required at one end of the Cable circuit.
The remote end may be a single phase VT.

b) CT location may be as a conventional feeder bay if practicable.
Slip-over CT's have been assumed in this drawing.

c) A Surge Arrestor may be required but should be determined on a circuit basis.
See TGN(E)27 for further guidance.

ISSUE	A		
DRAWN	N.M.	19-09-06	FIRST ISSUE
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TS 2.1
STANDARD SINGLE LINE DIAGRAM
MESH BUSBAR
CABLE FEEDER CONNECTION

Station			ISSUE A
Circuit			
Drg. No.	41/177344	Sht No 15	No of Shts 16
SCALE:- N/A		Work Ref	

0 100

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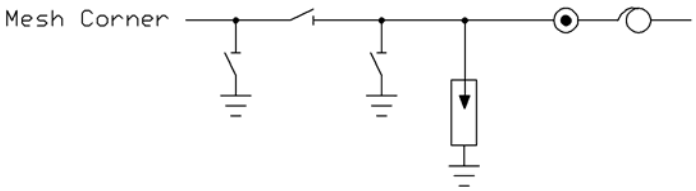
MESH BUSBAR

TRANSFORMER CONNECTION



NOTES

a) Ferro–resonance quenching earth switch may be required.

ISSUE	A			TS 2.1 STANDARD SINGLE LINE DIAGRAM MESH BUSBAR TRANSFORMER CONNECTION
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