

SUBSTATIONS - PART 1 - PROCEDURAL

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1 Scope

This document describes the technical requirements for User's equipment directly connected to the England and Wales Transmission system and located within NGET's busbar protection zone operating at nominal voltages of 400 kV, 275 kV, 132 kV and 66 kV unless otherwise agreed with the user as defined in the Bilateral agreement. The principles of this document applies to equipment connected at other voltages.

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 NGET 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 60815	Guide for the selection of insulators in respect of polluted conditions
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 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.
ENA (ER) G74	The calculation of short circuit currents in three-phase AC power systems
ENA (ER) G5	Planning levels for harmonic voltage distortion and the connection of non-linear equipment to transmission systems and distribution networks in the UK.
ENA TS 41-24	Eathing Requirements
TS 1 (RES)	Ratings and General Requirements for Plant, equipment and apparatus for the NGET System
TS 2.12 (RES)	Substation auxiliary supplies

TS 2.19 (RES)	Ancillary light current equipment
TS 3.1.1 (RES)	Substation Interlocking Schemes
TS 3.1.2 (RES)	Substation Earthing
TS 3.2.1 (RES)	Circuit-breakers
TS 3.2.2 (RES)	Disconnectors and Earthing Switches
TS 3.2.4 (RES)	Current transformers for protection and general use
TS 3.2.9 (RES)	Solid core post insulators for substations
TS 3.2.14 (RES)	Gas Insulated Switchgear
TS 3.24.15 (RES)	Environmental and test requirements for electronic equipment
HS(G)38 (RES)	Lighting at Work
NGET Safety Rules	

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 (RES) and shall be designed & constructed in accordance with BS7354.

4.1 General

No additional requirements specified.

4.2 Electrical requirements

4.2.1 Methods of neutral earthing

Neutral earthing of the NGET 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.

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.

4.3 Mechanical requirements

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.

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

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.

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.

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.

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 1.

Table 1: 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 (RES)

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 2.

Table 2: Substation Safety Clearances/Distances

Nominal System Voltage	Safety Distance (From NGET 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 2 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.

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

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

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

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 Users's plans for the installation.

6.1.2 Compliance

Equipment shall comply with all relevant Technical Specifications (RES).

6.1.3 Personnel safety

No additional requirements are specified.

6.1.101 Maintenance regimes

No additional requirements specified.

6.1.102 Mid-life refurbishment

No additional requirements specified.

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 (RES)

Specific requirements for disconnectors and earthing switches are detailed in TS 3.2.2 (RES),

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.

6.2.2 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

An audible alarm scheme to warn operators of a major loss of SF₆ 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.

SF₆ 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.

6.2.3 Instrument transformers

6.2.3.1 Current transformers

Specific functional and performance requirements for current transformers for protection and general use are detailed in TS 3.2.4 (RES)

The accommodation of current transformers shall be as specified in 0A.

The location of current transformers shall be as specified in 0B.

No additional requirements specified.

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

No additional requirements specified.

6.2.4 Surge arresters

No additional requirements specified.

6.2.5 Capacitors

No additional requirements specified.

6.2.6 Line traps

No additional requirements specified.

6.2.7 Insulators

Specific requirements for insulators are detailed in TS 3.2.9 (RES)

6.2.8 Insulated cables

No additional requirements specified.

6.2.9 Rotating electrical machines

No additional requirements are specified.

6.2.10 Static converters

No additional requirements are specified.

6.2.11 Fuses

No additional requirements are specified.

6.2.12 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.

Portable primary earths 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

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

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.

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

Substations shall be provided with a full interlocking scheme as specified in TS 3.1.1 (RES)

7.1.1 Circuit arrangement

NGET Substation bays shall be in accordance with the functional (single line) diagrams presented in 0. These diagrams represent the standard construction of commonly used bay types and deviation from these arrangements shall be agreed with NGET. 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 3.

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

Table 3: Maximum Equipment Heights in Substations

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

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

No additional requirements specified.

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.

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 may 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

No additional requirements specified.

7.2.6 External fences or walls and access doors

No additional requirements specified.

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 (RES)

7.4.2.2 Erection on site

No additional requirements specified.

7.4.2.3 Protection against overvoltages

No additional requirements.

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. 'Plug and switch' systems such as PASS M00 bay type solutions are excluded from this requirement. 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.

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

For general access around the substation, a safe means of access and egress shall be provided, or be identified in the design, for all foreseeable activities

8 Safety measures

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

It is intended that NGET/User 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 NGET and User ensure that 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 NGET & User safety rules (where relevant).

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

Where fire protection is required to be installed, the design shall be site specific.

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 SF₆

No additional requirements specified.

8.7.1 Insulating liquid leakage and subsoil water protection

8.7.1.1 General

No additional requirements specified.

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 SF₆ leakage

Specific details regarding the use of SF₆ gas are detailed in TS 1.0. (RES) and section 6.22.

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.

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.

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 NGET 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/trenches 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 or an adjacent building. 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 3.24.15 (RES) as appropriate.

Fixed heating shall be thermostatically controlled.

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 and a copy of the records stored on site.

Substation auxiliary supplies shall be designed and installed in accordance with TS 2.12 (RES).

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 NGET. This requirement shall also apply to multi-core cable terminations, marshalling facilities and jumper fields.

Ideally all NGET 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 NGET owned plant shall be segregated from that of User owned plant. Separate individually lockable local/remote control selector switches shall be provided for NGET and User equipment such that staff with authority to operate only User equipment are unable to access control of NGET ational Grid owned equipment.

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

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

Common compressed air, hydraulic or other motive power systems supplying both NGET 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 TS 2.12 (RES). 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 NGET owned equipment. LCC's and common panels should be sited in areas to which access will be permitted to non-NGET 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.

9.3 SF₆ gas handling plants

No additional requirements specified.

9.4 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. (RES)

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

The User's earthing system shall be integrated with that of NGET's substation earthing system and shall, as a minimum, meet the standard ENATS 41-24.

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

No additional requirements specified.

ANNEX A - CURRENT TRANSFORMER (CT) ACCOMMODATION

A.1 INTEGRATED DIGITAL PROTECTION/CONTROL

The requirements specified in sections A2 to A8 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.

A.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.

A.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 (RES).

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

A3.1 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.

A3.2 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.

A.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.

A.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.

A.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.

A.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.

A.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 B - LOCATION OF CURRENT TRANSFORMERS ASSOCIATED WITH 420, 300 AND 145 kV CIRCUIT BREAKERS

B.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.

B.2 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 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.

B.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.

B.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 C - STANDARD SUBSTATION BAY FUNCTIONAL (SINGLE LINE) DIAGRAMS

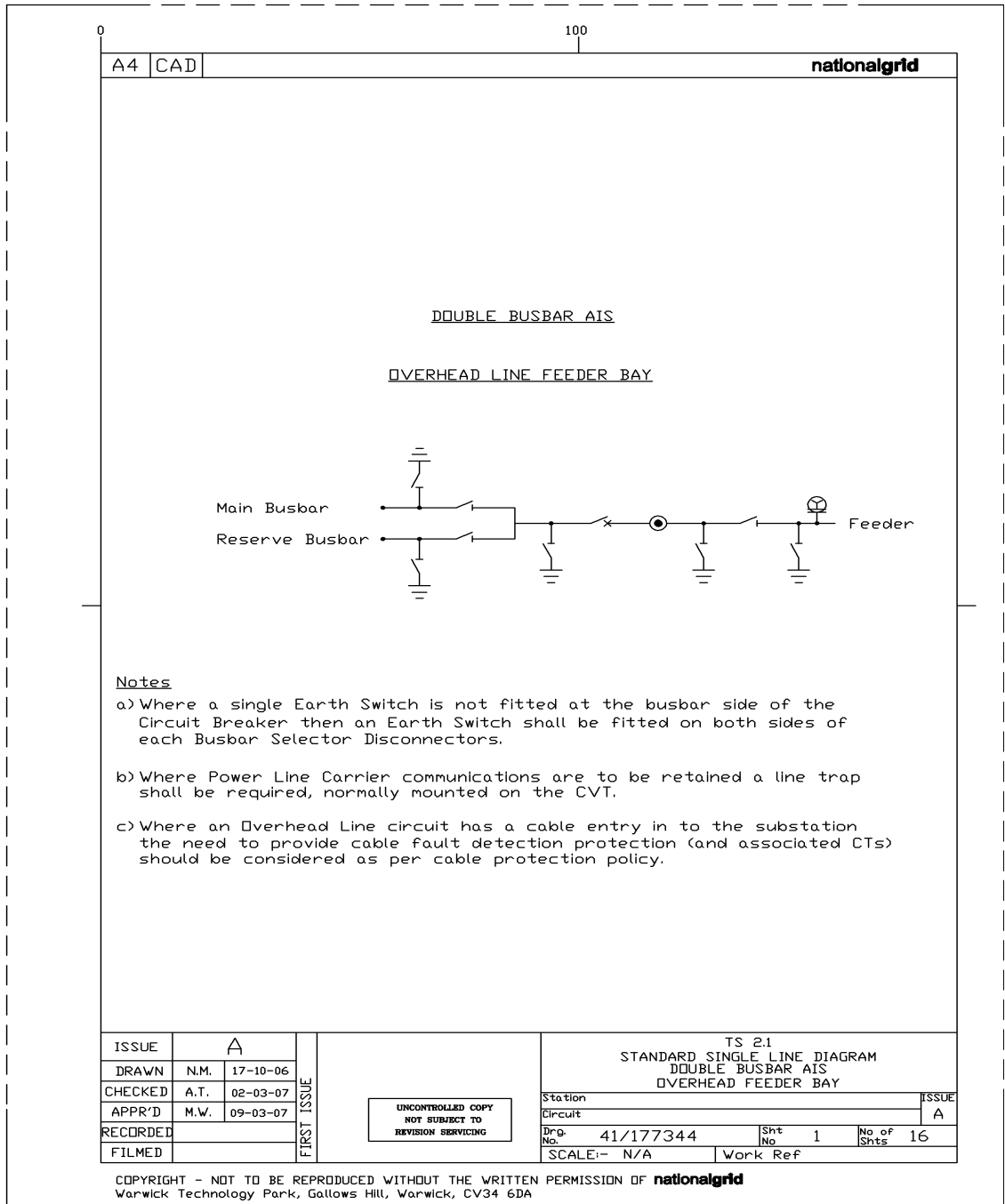
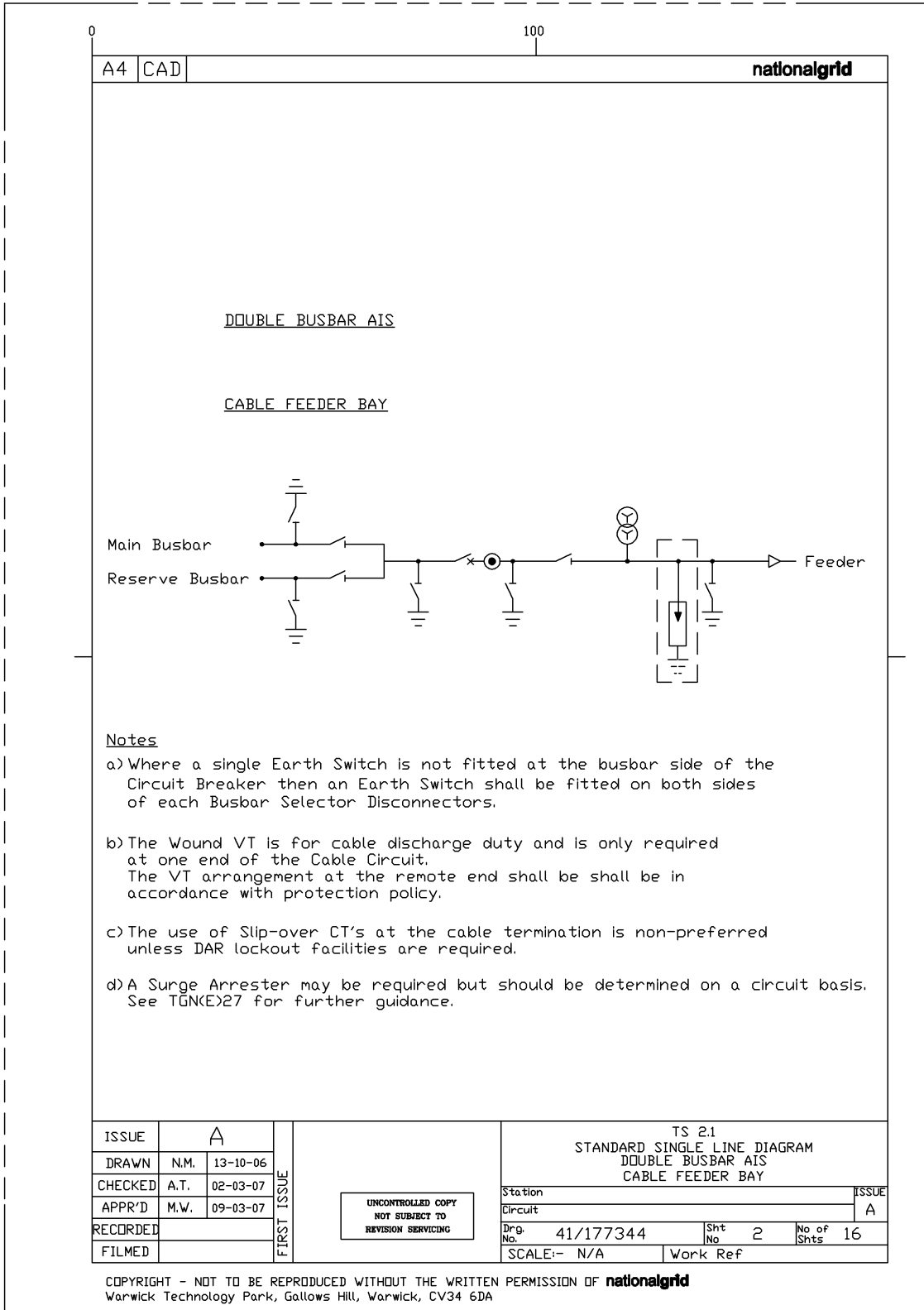
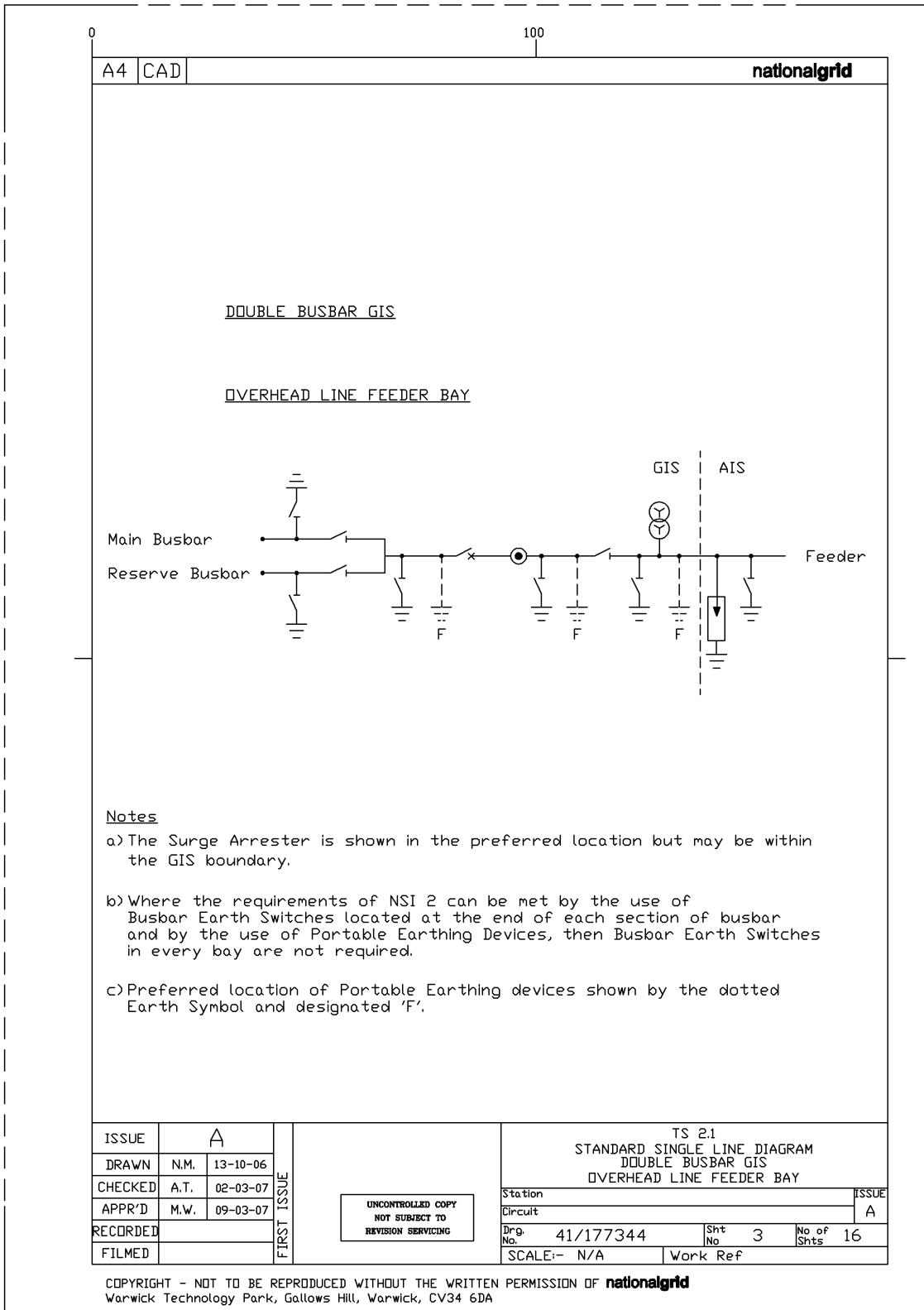
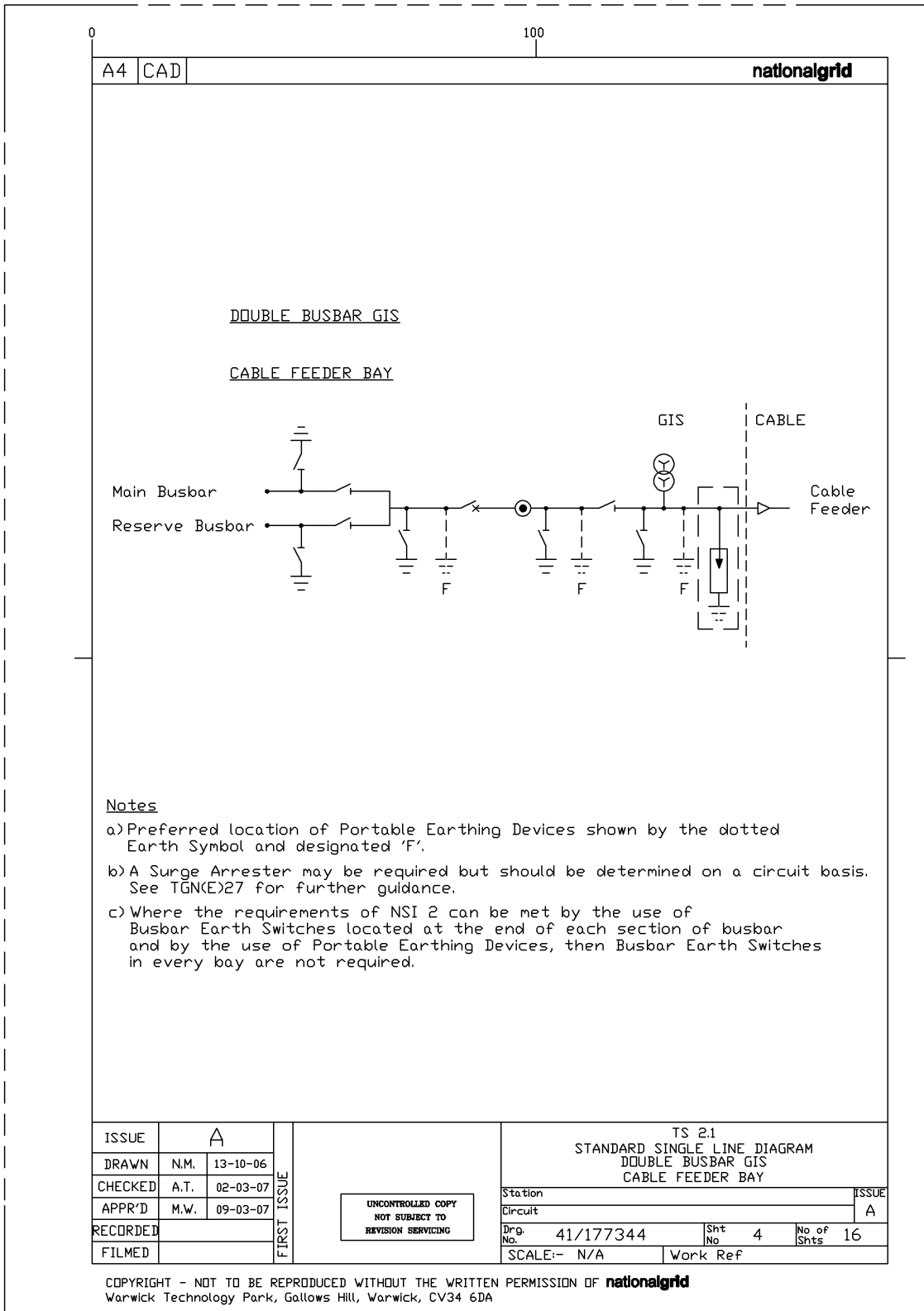
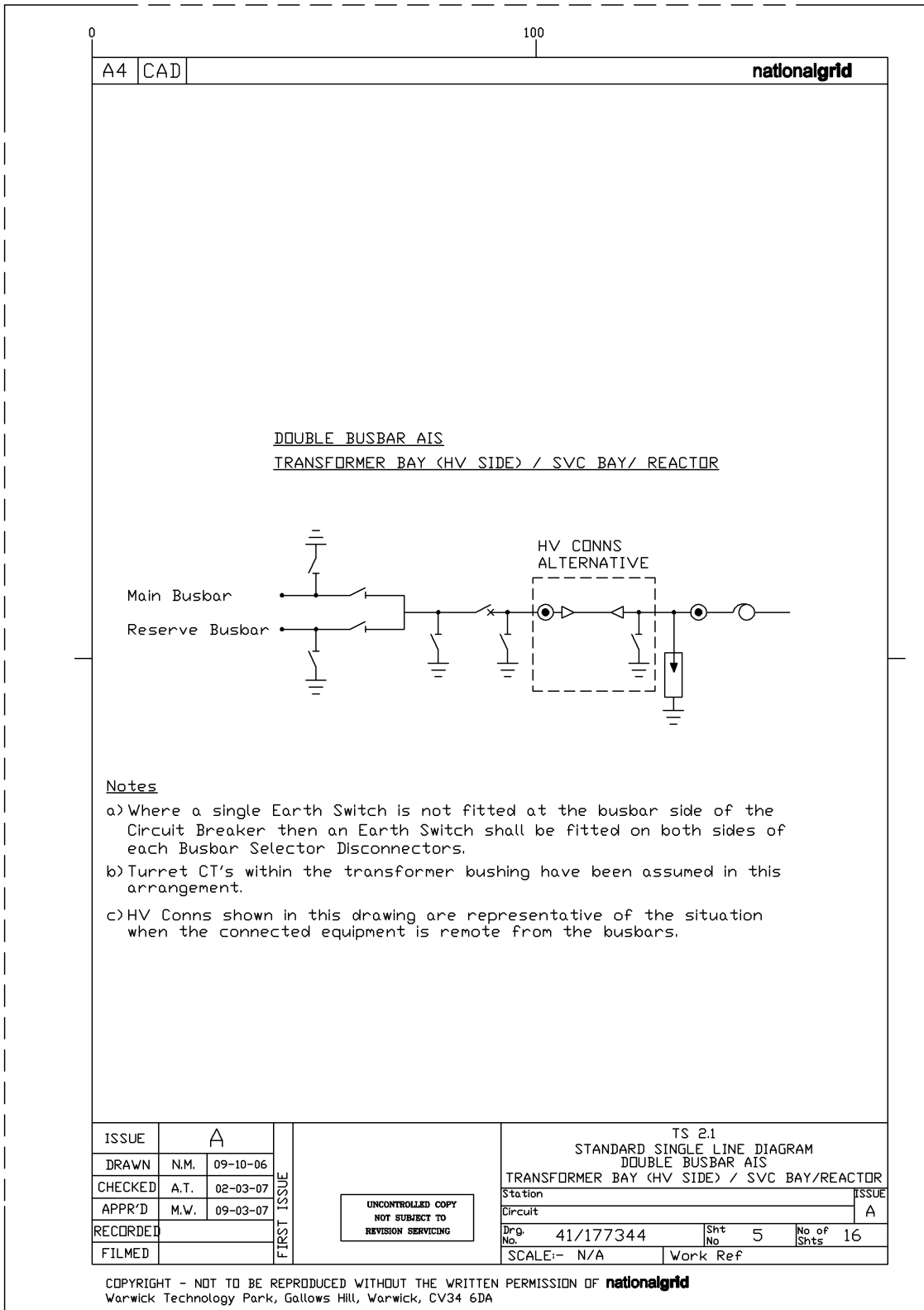


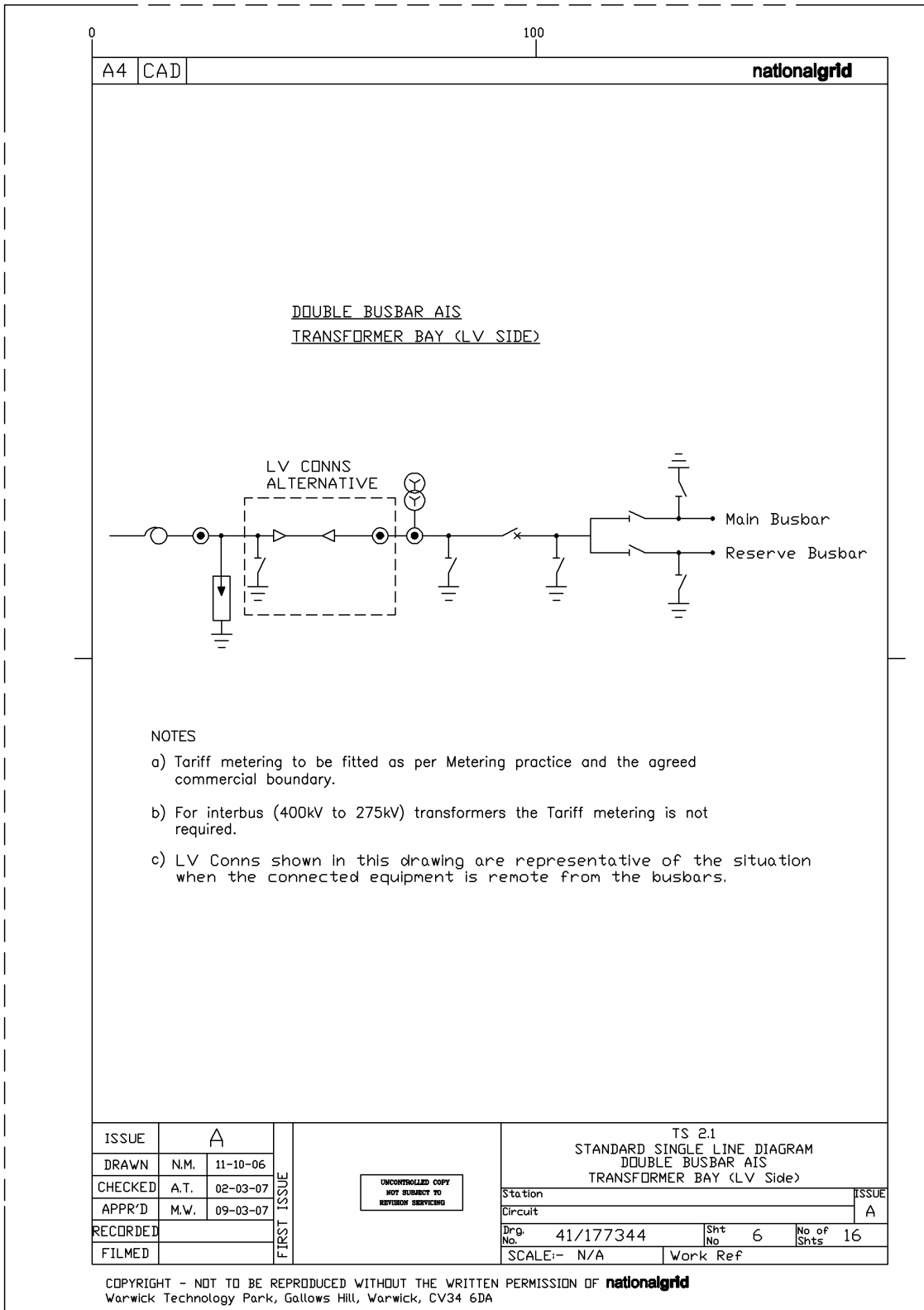
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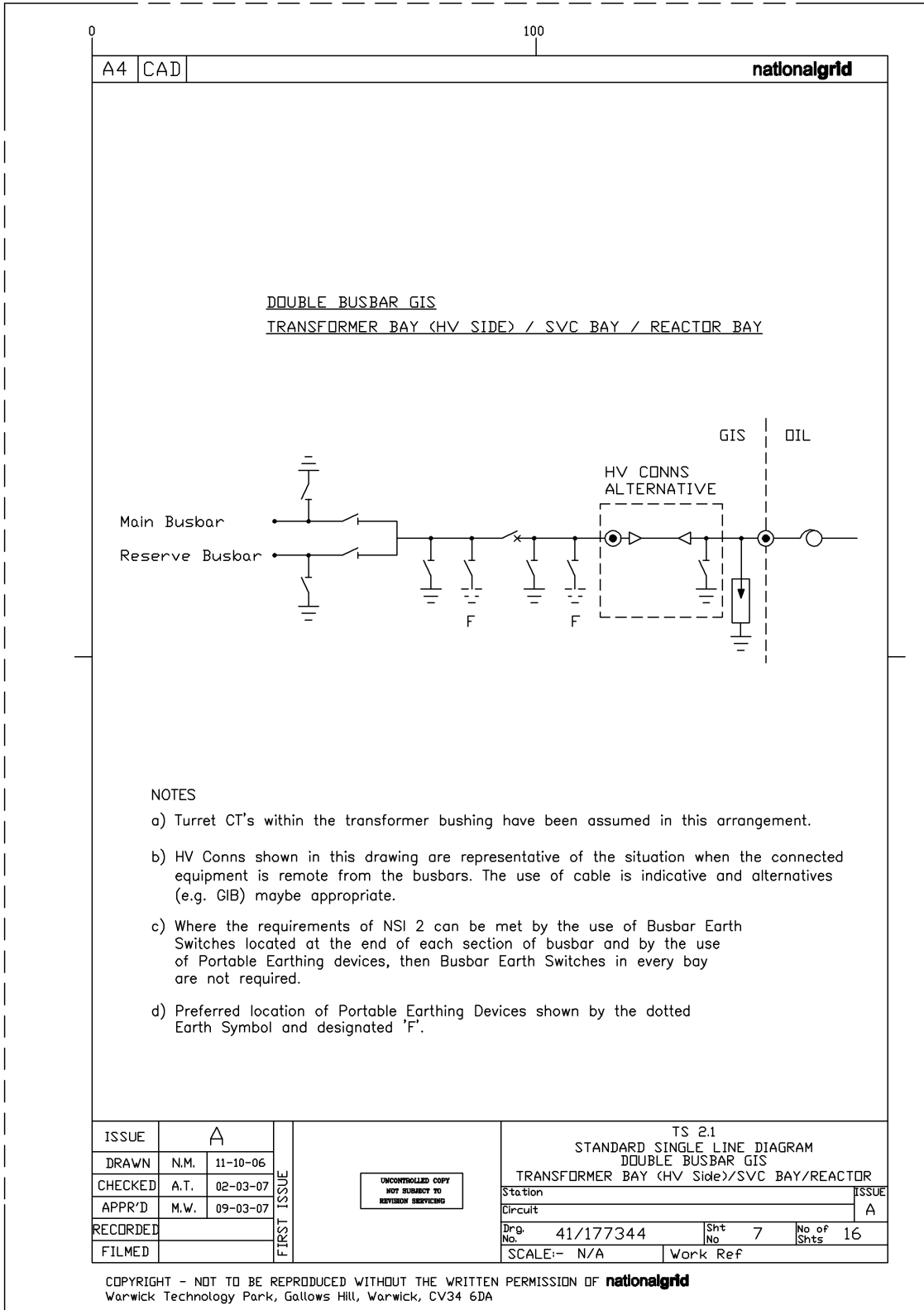


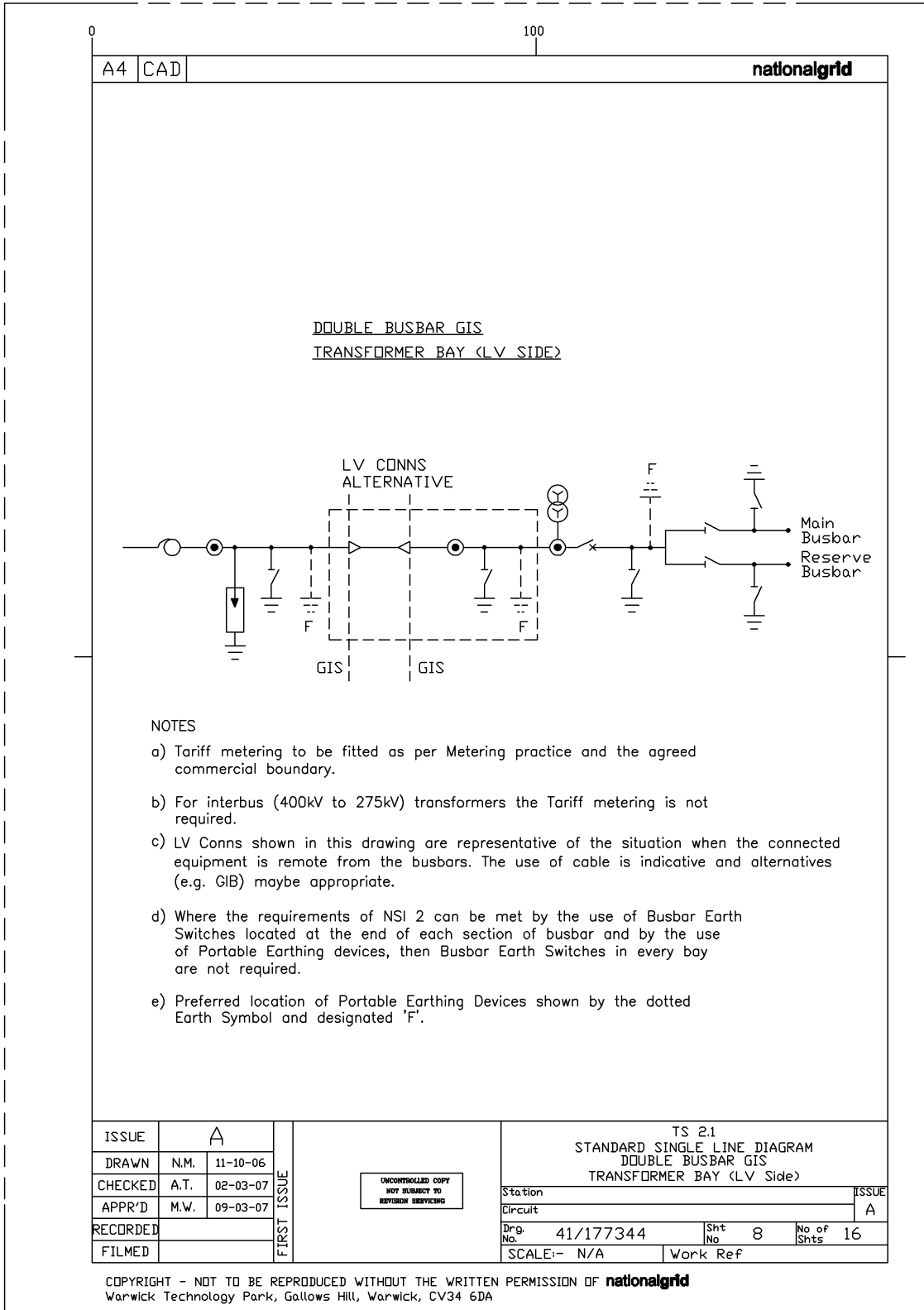


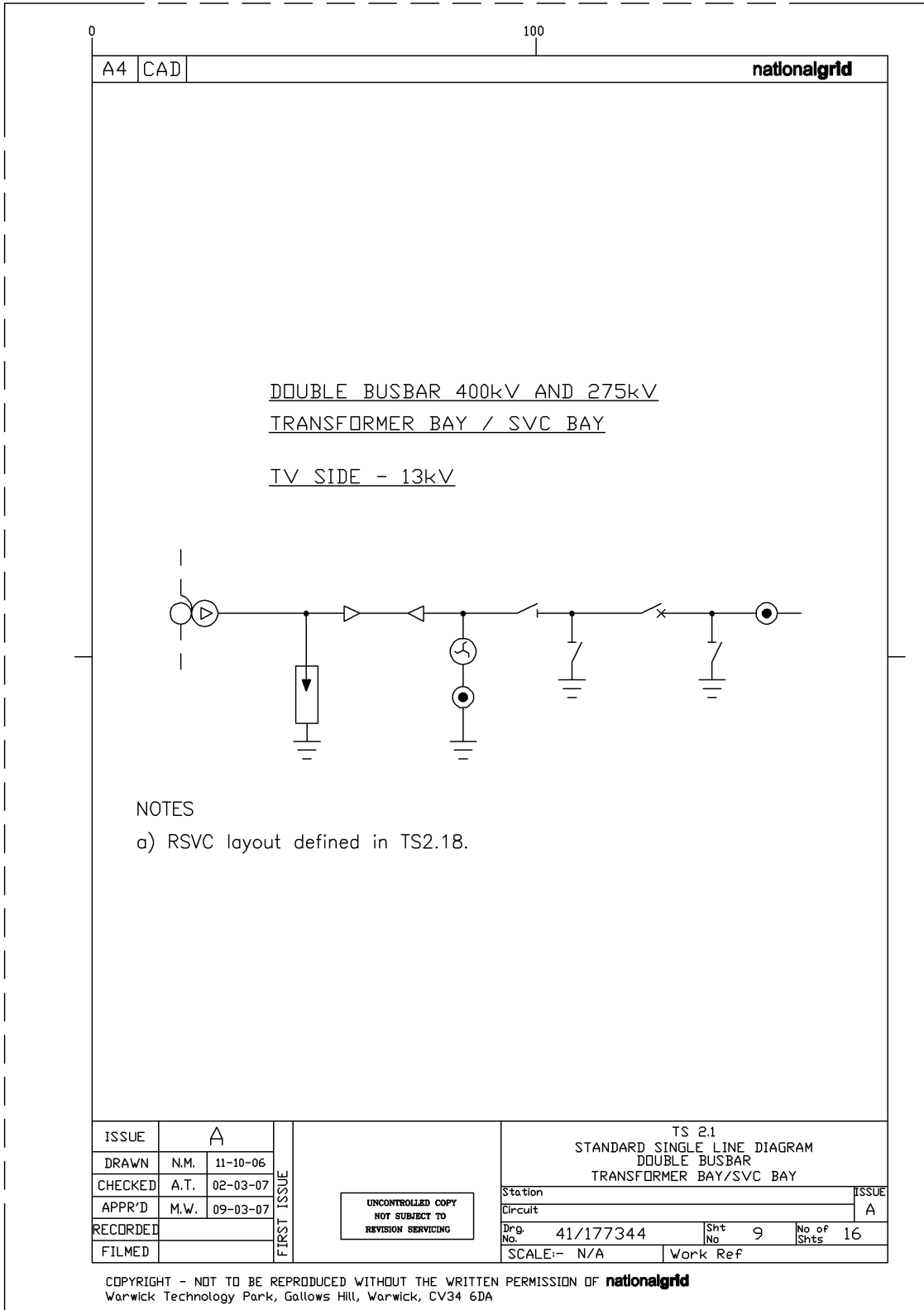


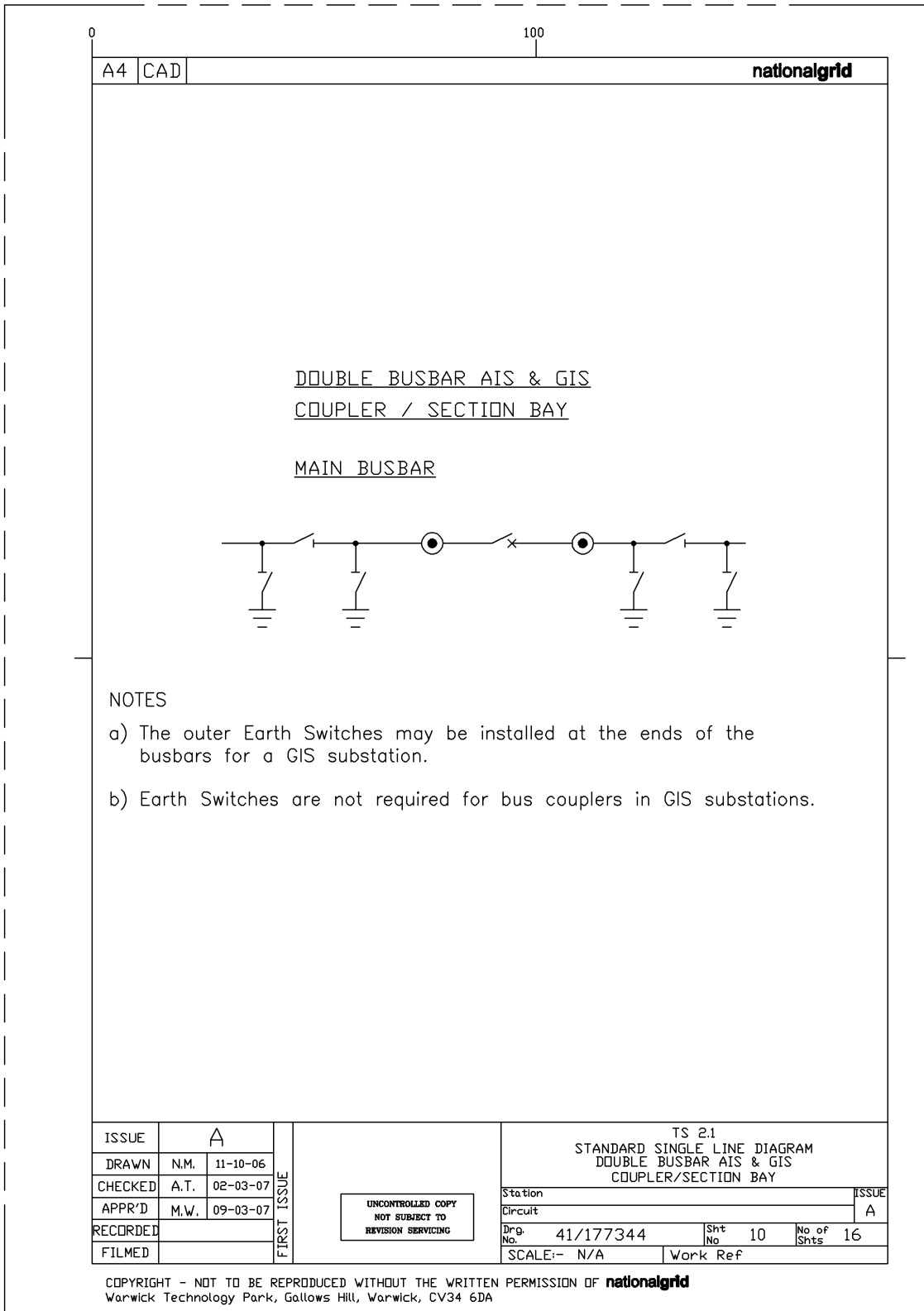


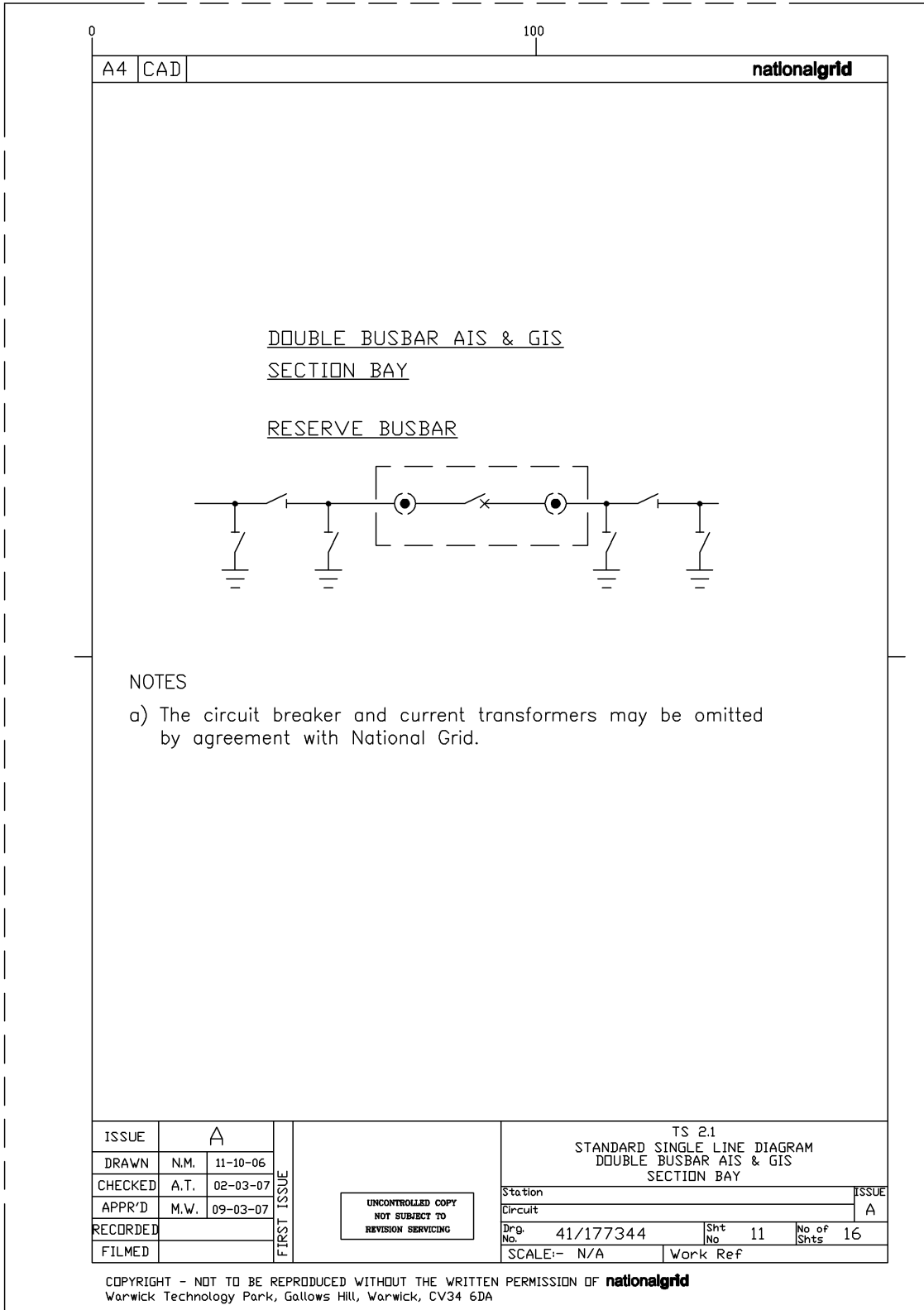


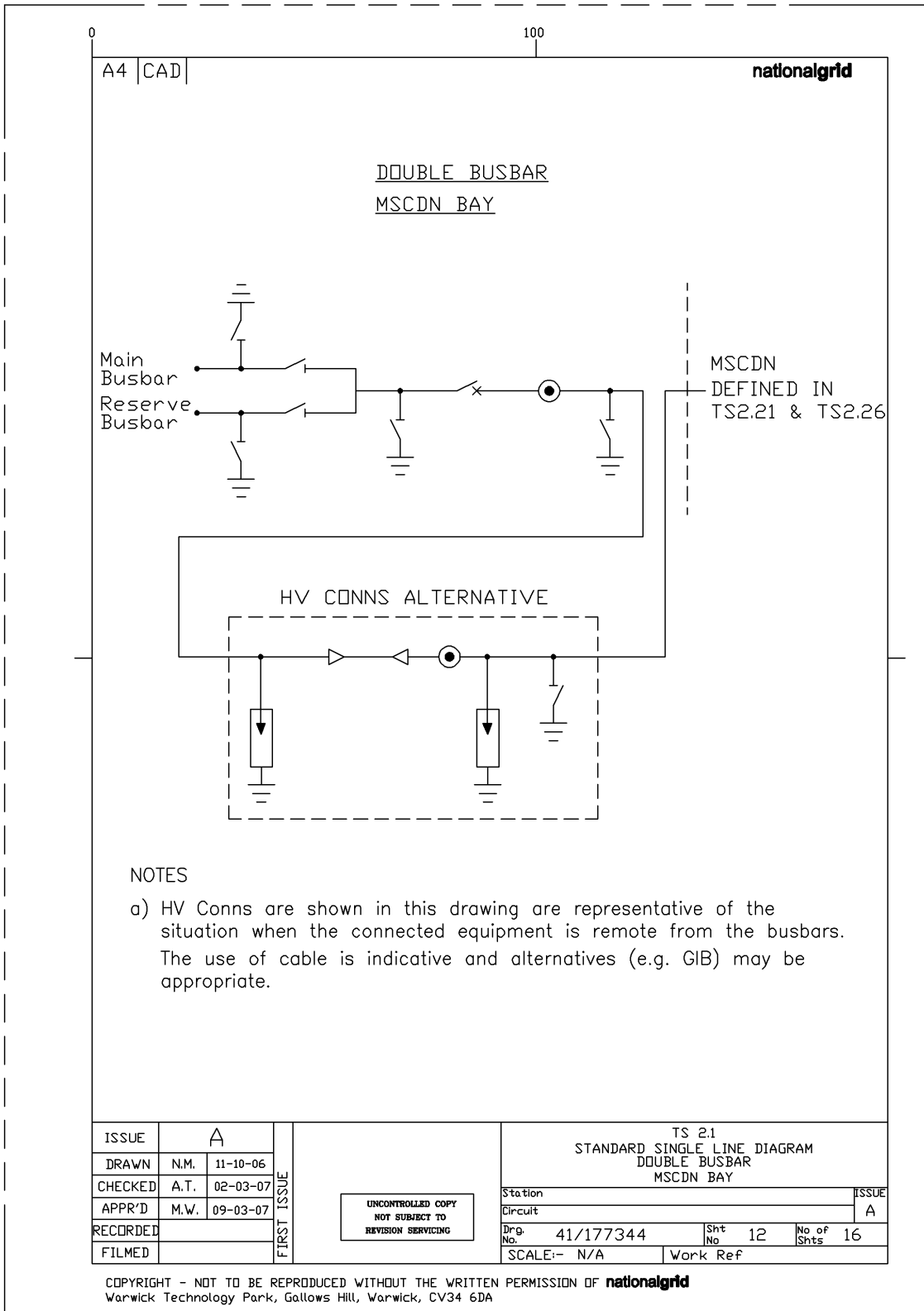


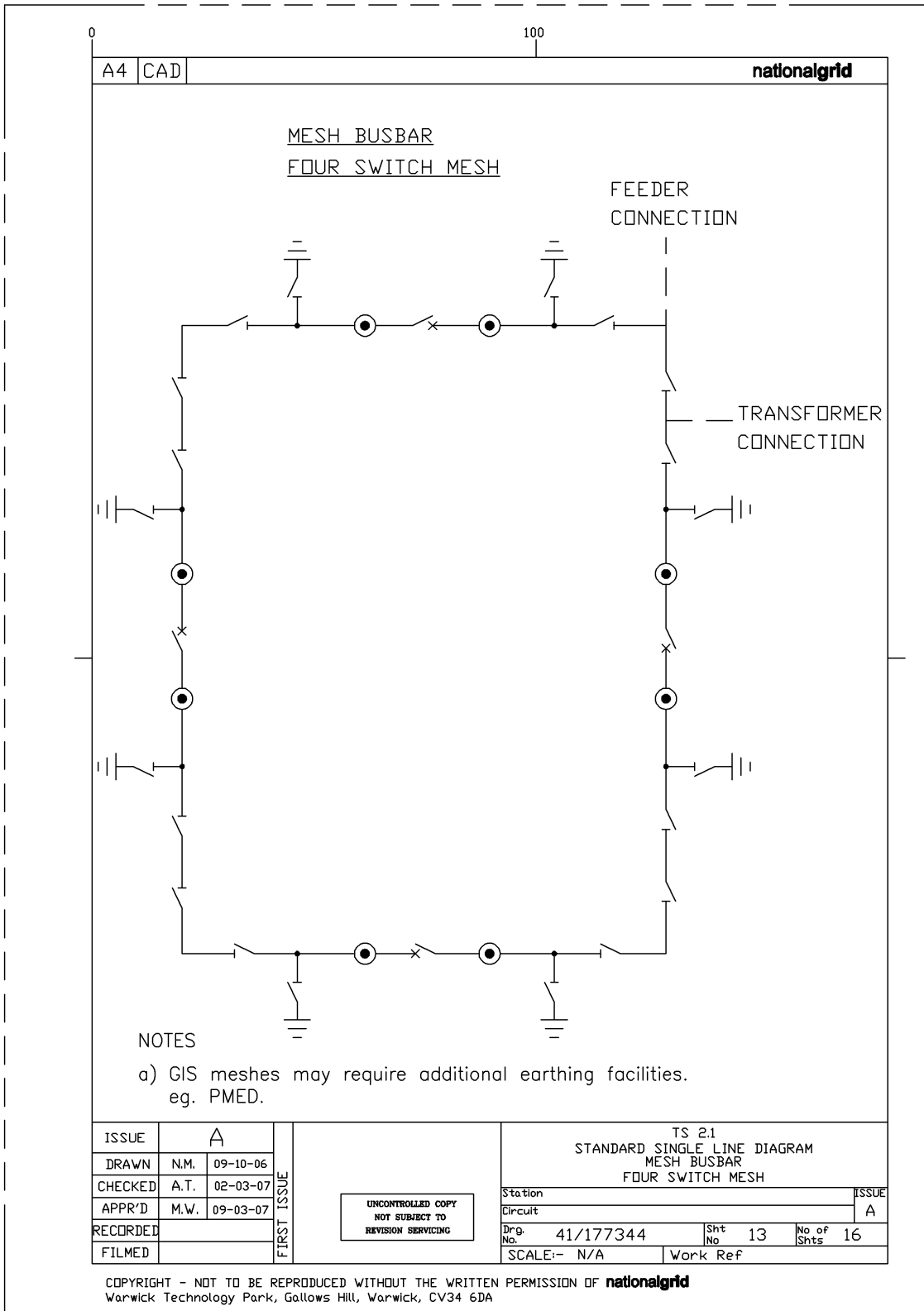


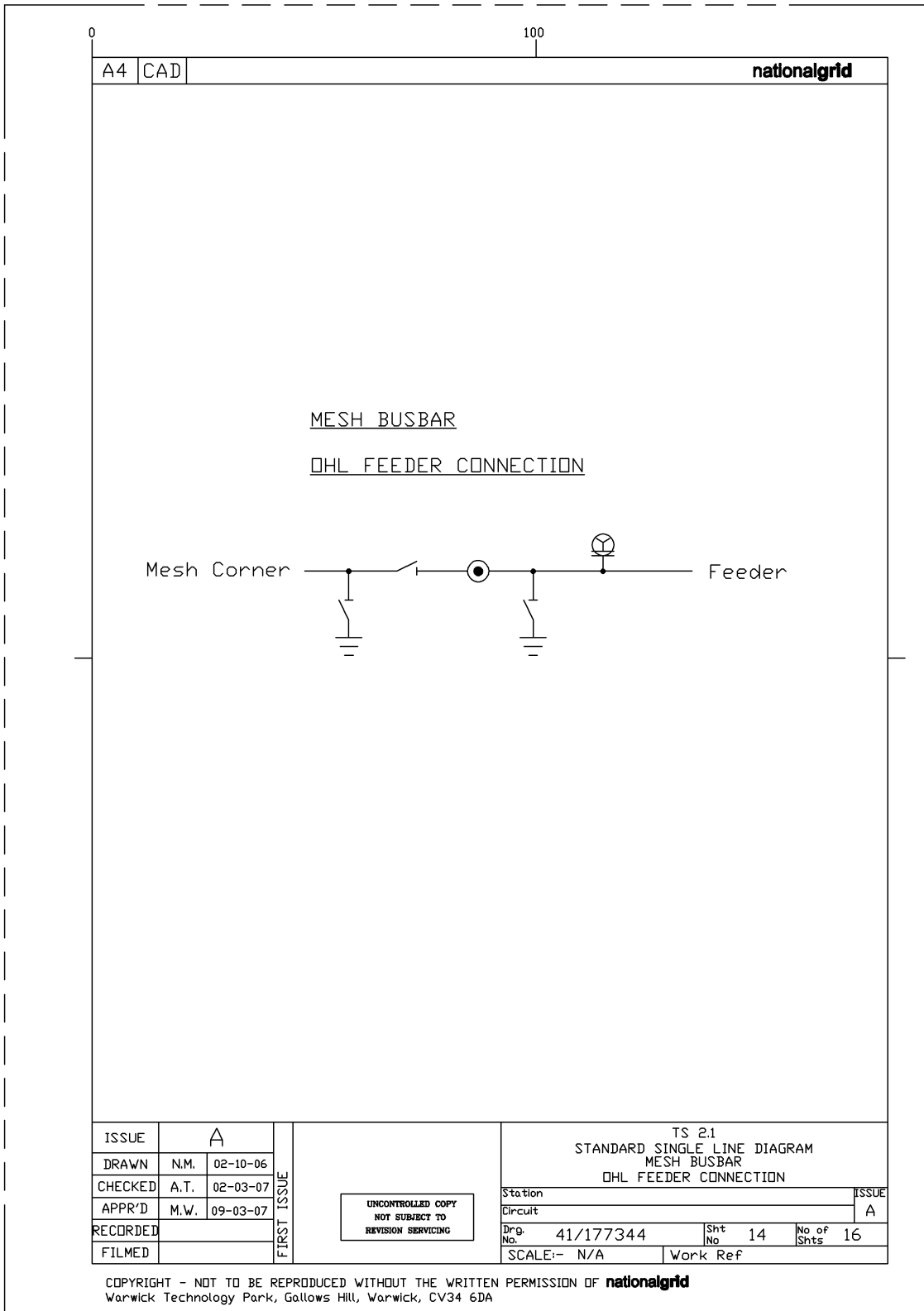


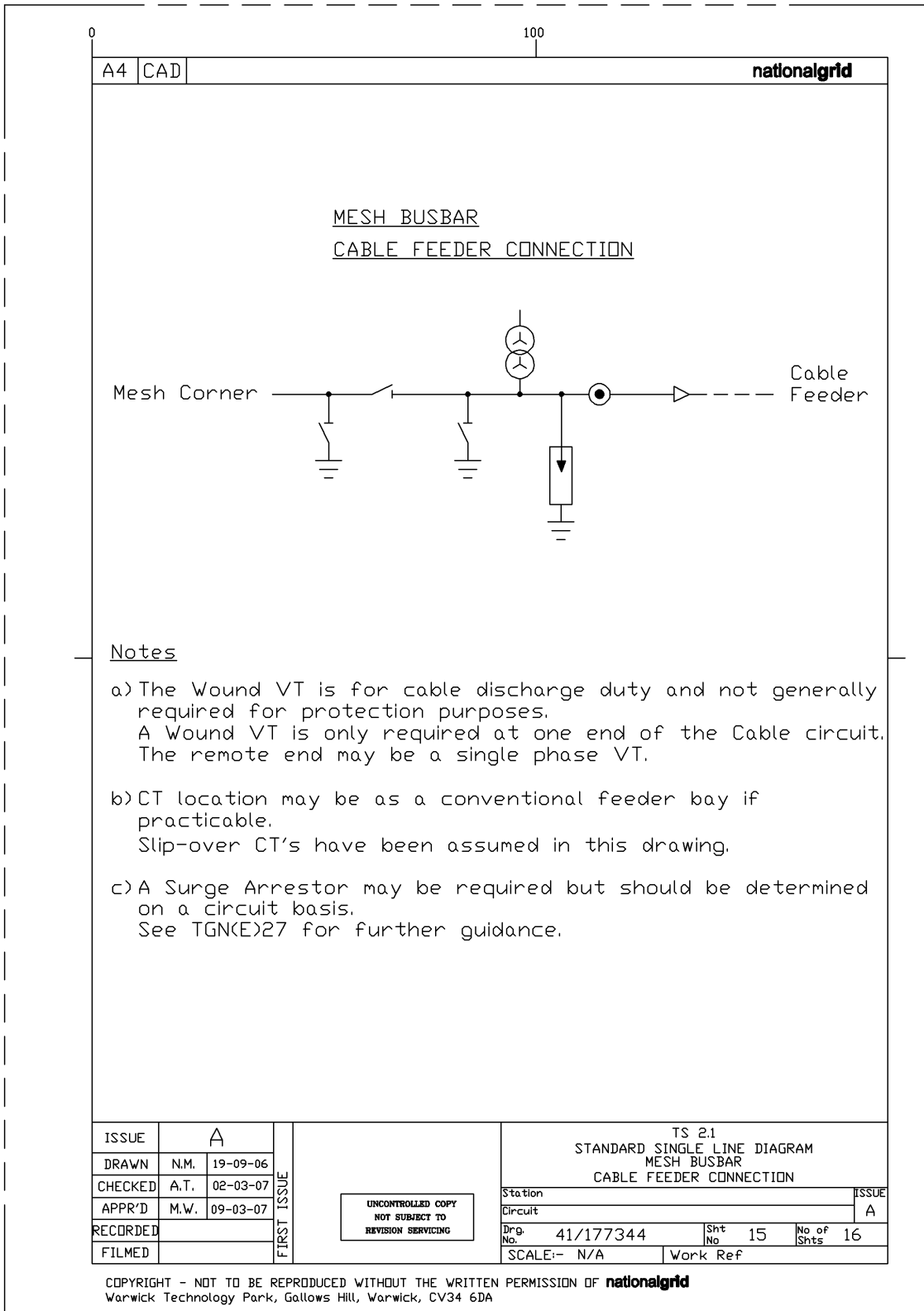


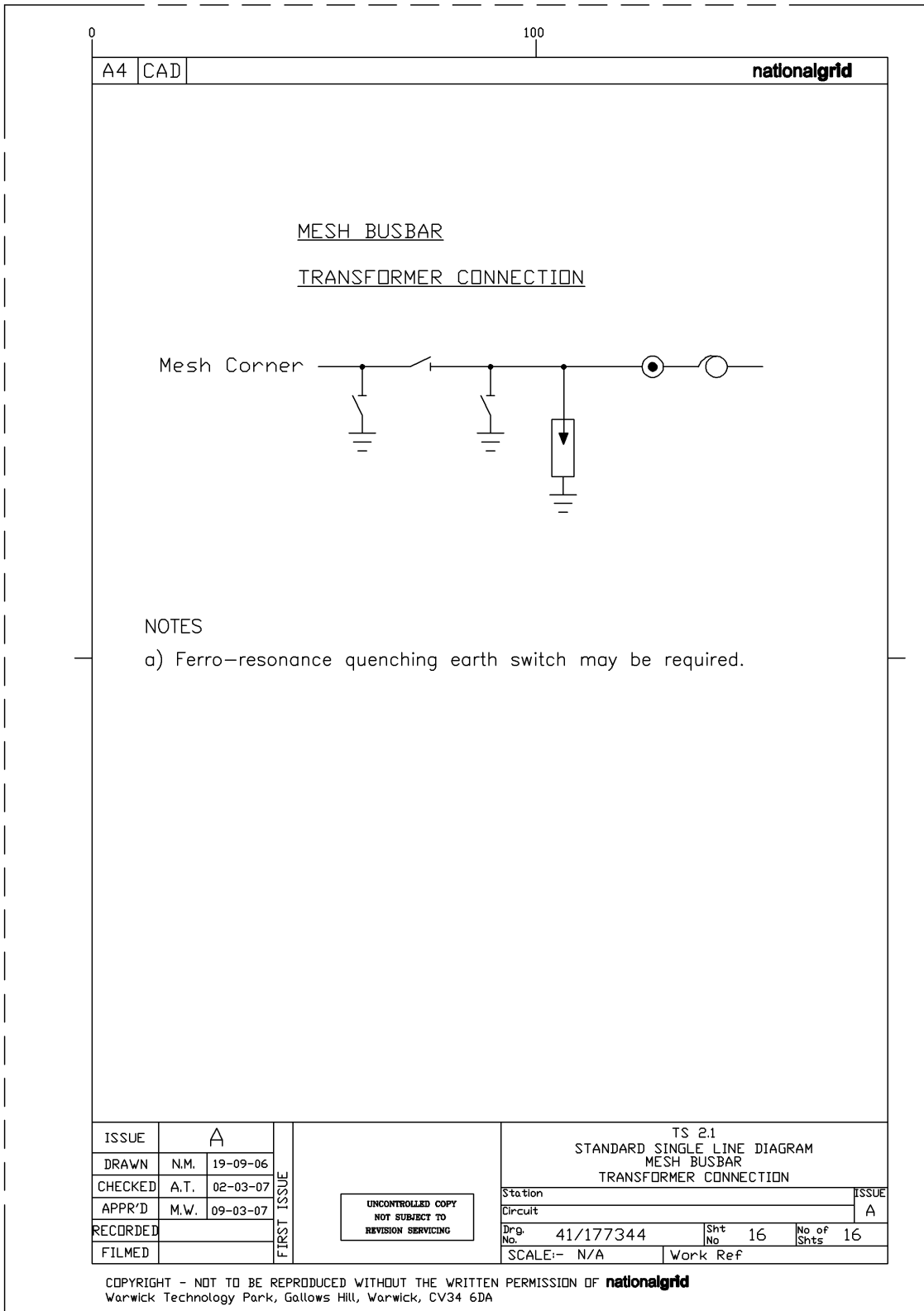












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 Warwick Technology Park, Gallows Hill, Warwick, CV34 6DA

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