Standard

High Voltage (HV) Shunt Capacitor Bank Standard

R522695

Version 1.0, June 2018

Authorisations

Action	Name and title	Date
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Review cycle	30 months	

Responsibilities

This document is the responsibility of the Asset Strategy Team, Tasmanian Networks Pty Ltd, ABN 24 167 357 299 (hereafter referred to as "TasNetworks").

Please contact the Asset Strategy Leader with any queries or suggestions.

- Implementation All TasNetworks staff and contractors.
- Compliance All group managers.

Minimum Requirements

The requirements set out in TasNetworks' documents are minimum requirements that must be complied with by all TasNetworks team members, contractors, and other consultants.

The end user is expected to implement any practices which may not be stated but which can be reasonably regarded as good practices relevant to the objective of this document.

Record of revisions

Section number	Details
Entire doc	Copied over verbatim from superseded Transend to TasNetworks template. Updated Transend to TasNetworks document reference numbers where known including Australian Standards.

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1 General

1.1 Purpose

To define the requirements for high voltage shunt capacitor banks under the responsibility of Tasmanian Networks Pty Ltd (hereafter referred to as 'TasNetworks').

1.2 Scope

This standard applies to all high voltage shunt capacitor banks under the responsibility of TasNetworks.

This standard contains requirements for design, engineering, manufacture, construction, testing at manufacturer's works, secured packaging, supply, transportation, delivery to site, testing and commissioning with complete documentation of the capacitor bank and is to be applied to new installations as well as redevelopment of part or all of existing installations.

1.3 Objective

TasNetworks requires design, construction, installation and commissioning of equipment and services be covered by this standard to ensure:

(a) that relevant Australian legal requirements are met;

(b) that the requirements of the National Electricity Rules are met;

(c) personnel and public safety hazards are identified and control measures adopted;

(d) risk to TasNetworks' assets is assessed;

(e) ease of operation and maintenance;

(f) reliability and continuity of electricity supply;

(g) that the requirements of the TasNetworks business plan are met;

(h) that the exposure of TasNetworks' business to risk and loss is minimised; and

(i) that TasNetworks' responsibilities under connection agreements are met.

1.1 Certificate of conformance

(a) Before any new and/or modified capacitor bank is put into service in TasNetworks' system, a certificate of conformance with this standard must be submitted to TasNetworks. The certificate of conformance must be duly supported with documents, drawings, test results, test reports, test certificates, completed check-lists and other documents as applicable. Where TasNetworks has approved deviation to specific requirements of this standard, all such approvals must be included with the certificate of conformance.

(b) TasNetworks will supply a blank form for certificate of conformance, to be completed by the Contractor.

(c) A capacitor bank will be put in service only after TasNetworks has accepted the certificate of conformance.

1.1 Precedence

Any conflict between the requirements of the codes, specifications, drawings, rules, regulations and statutory requirements or various sections of this standard and other associated documents must be brought to the attention of TasNetworks for resolution. The most onerous requirement will normally be applied.

1.2 Deviation

Special approval for a deviation to this standard may only be accorded, if it does not reduce the quality of workmanship and does not deviate from the intent of the standard. A request for a deviation must follow a designated procedure that involves approval from TasNetworks. Deviations if any, must be specifically requested, and approved in writing by TasNetworks prior to award of Contract.

1.3 References

As a component of the complete specification for a system, this standard is to be read in conjunction with other standards and documents as applicable. In particular this includes the project specifications and the following:

1.3.1 TasNetworks standards

Substation Civil Design and Construction Standard	R590634
Substation Lightning Protection and Earthing Standard	R522692
General Substation Requirements Standard	R522687
High Voltage System Standard	R565983
Testing, Commissioning and Training Standard	R246497
Security Fences and Gates Standard	R579297
SCADA System Standard	R246439
HV & LV Cable Systems Standard	R590630
HV Shunt Capacitor Bank Schedule	R579292
HV Shunt Capacitor Bank Deliverables	R579291
Asset Nomenclature Standard	R684808
Metering Standard	D11/86620

1.3.2 Other standards

Power capacitors – Shunt – Rated voltages above 660 V ac	AS 2897 – 1986 (IEC/TS 60871-2 Ed. 2.0)
Power transformers - reactors	AS/NZS 60076.6:2003

2 General Requirements

Project specific requirements for the capacitor bank will be listed in the project specifications.

2.1 Service Conditions

Service conditions will not exceed the limits stated in AS 2897 – 1986, together with the particulars of the system stated in Table 1 of this standard.

Specific environmental conditions and any specific design, installation, operation or maintenance criteria for particular works will be stated in the project specifications, such as availability of space, switchyard, switchboard and SCADA arrangements and any power quality performance criteria.

2.2 Performance

(a) A capacitor bank and its individual components must provide reliable performance.

(b) The performance of the capacitor bank must meet all specified electrical, mechanical and environmental criteria under both normal and abnormal system conditions.

(c) The selection of equipment, design and all works associated with the capacitor banks must conform to the requirements as specified in document R522687 and meet or exceed the specified design criteria and performance stated within this standard.

(d) Details of maintenance items, their accessibility and the frequency of maintenance must be provided with the tender.

3 Capacitor banks

Capacitor banks are to be arranged in an unearthed double star configuration.

Conceptual diagrams for high voltage capacitor banks, with associated busbar connection equipment are attached, as follows:

- Figures 1 to 4 Power circuit one line diagrams.
- Figures 5 to 8 Metering and protection one line diagrams.
- Figure 9 to 10 General arrangement – plan and sections.

3.1 Application of capacitor banks

Shunt capacitor banks are installed to provide reactive power compensation to support voltages within the National Electricity Rules requirements and to mitigate voltage collapse in specific regions. An additional advantages is power factor correction, and a subsequent reduction in transmission losses, with the potential for postponement of transmission or distribution investment.

Shunt capacitor banks are applied at various locations within the network. To ensure rationalisation of requirements, TasNetworks has standardised on specific types of high voltage shunt capacitor banks dependent on the rated voltage of the connection, as follows:

(a) Type One (1) – 24 kV, 5 MVAr outdoor.

(b) Type Two (2) – 24 kV, 5 MVAr indoor.

(c) Type Three (3) – 12 kV, 2.5 MVAr outdoor.

(d) Type Four (4) – 12 kV, 2.5 MVAr indoor.

The service location shall be indoor (Type 2 or Type 4), unless stated differently within the project specifications.

3.1 Capacitor bank concept

Each capacitor bank shall comprise of:

(a) three only, single-phase reactors to both limit inrush current and detune harmonics, with each reactor. Where iron-core reactors are utilised they must be mounted at ground level on a common frame. Alternatively, where air-core reactors are utilised they must be stacked above each other and mounted on a common structure;

(b) an assembly of capacitor units arranged in parallel/series phase connected groups, with each phase on a separate mounting structure; and

(c) two insulated double-star, unearthed neutral connections;

(d) single-phase, neutral current transformer located between the star-point neutral connections for unbalance condition detection.

3.1 General design requirements from capacitor banks

Materials and components must be selected to ensure safe and reliable operation for at least 45 years, with minimum inspection and maintenance.

The capacitor bank must be designed to:

(a) permit operational earthing to be applied effectively without compromising safe work clearances and to allow effective capacitor discharge;

(b) enable maintenance of the capacitor bank, including protection and control systems to be performed safely and efficiently;

(c) allow filters and ventilation grills to be inspected, cleaned and replaced without the need for isolating and earthing;

(d) demonstrate the incorporation of modern design and insulation material, together with intelligent, multi-function protection, control and monitoring technology;

(e) work in parallel with one or more existing or future capacitor banks in close electrical proximity;

(f) interface with existing dc supplies, SCADA, mimic, alarm annunciator and bus-zone and circuit breaker failure scheme;

(g) ensure heating and ventilation is provided to ensure a capacitor bank can operate at rated capacity within rated temperature limits;

(h) ensure position indicators, pressure monitors and rating plates are visible from ground level;

(i) where outdoor, provide lightning protection (mast only) to shield the installation; and

(j) provide ac lighting and power supplies, with at least one single phase 10 A double GPO, to facilitate maintenance.

3.1 Design requirements for capacitor banks

Capacitor banks must be designed such that:

(a) individual capacitor units are appropriately sealed and finished to permit outdoor operation, exposed to both direct sunlight and wet weather conditions;

(b) the impregnant fluid must be biodegradable and must not contain polychlorinated-biphenyl (PCB) or any derivatives;

(c) capacitor units must utilise aluminium foil with folded edges and polypropylene di-electric film with a 'hazy' surface;

(d) the capacitor bank, individual components and earthing system must be of robust construction and capable of withstanding the mechanical forces from thermal expansion and contraction;

(e) the capacitor bank's switchboard, circuit breaker and earthing system must be appropriately rated to withstand the specified minimum short-circuit withstand current rating for at least one second. Power cables, capacitor cans and reactors must be appropriately rated to at least withstand the short-circuit currents that can be supplied by the existing high voltage system;

(f) capacitor units, conductors and fittings must have over-voltage, over-current and overload capabilities to withstand continuous operation at above rated voltage as per AS 2897 Section 4; and

(g) detuned capacitor bank reactors must be rated for continuous duty as per AS/NZS 60076.6.

4 Shunt capacitor and reactor

4.1 Capacitor and reactor design and installation

System particulars, specific requirements and parameters for shunt capacitors and reactors are detailed in Table 1 of this standard and any additional criteria specific to a project will be stated in the project specifications.

To ensure utilisation of common equipment and minimise spares holdings, equipment for operation at a nominal voltage of 11 kV must be insulated for operation at a nominal voltage of 22 kV.

Table 1 Parameters for capacitors and reactors

Sr. No.	Parameter	Unit	Requirement			
			Type One (1)	Type Two (2)	Type Three (3)	Type Four (4)
1	Particulars of the System					
1.1	Number of phases	-	3			
1.2	Frequency	Hz	50			
1.3	Normal operating frequency excursion band	Hz	48.8 to 52			
1.4	Power system frequency range	Hz	44.8 to 52			
1.5	Nominal voltage	kV	22		11	
1.6	Highest voltage	kV	24		12	
1.7	Lightning Impulse Withstand Voltage (LIWV) of equipment	kV_p	150		95	
1.8	Power Frequency Withstand Voltage (PFWV) of equipment	kV_{rms}	50		28	
2	Particulars of Capacitor Bank					
2.1	Number of phases	-	3			

Sr. No.	Parameter	Unit	Requirement			
2.2	Rated voltage of equipment	kV	24		24	
2.3	Rated reactive power @ nominal voltage	MVar	5		2.5	
2.4	Minimum short-circuit withstand	kA	25			
2.5	Minimum short-time	s	1			
2.6	Neutral connection	-	double star			
2.7	Earthing arrangement	-	ungrounded			
2.8	Service location	-	outdoor	indoor	outdoor	indoor
2.9	Cooling	-	air natural	forced ventilation	air natural	forced ventilation
2.10	Degree of protection by enclosure of building	IP	-	44	-	44
2.11	Maximum sound pressure level, measured in accordance with AS 2374 Part 6	dBA	20	46	20	46
2.12	Support structure material	-	fully welded, galvanised mild steel			
2.13	Portable earth lead connection points	-	• one on each neutral star point; • one on each phase between capacitor and reactor; and • one on each phase between reactor and power cable termination.			
3	Particulars of Capacitor					
3.1	Rated capacitance	µF	31.3		62.6	
3.2	Tolerance on capacitance	%	+/- 5			
3.3	Capacitor quantity in series in each parallel connection	-	2		1	
3.4	Capacitor fusing	-	internal			
3.5	Discharge resistors	-	internal			
3.6	Temperature range	ºC	• 10°C/B, in accordance with AS 2897			
3.7	Maximum dielectric losses	W/ kVAr	0.2			
3.8	Duty cycle	-	Continuous			
3.9	Minimum creepage distance	mm/ kV	20			
3.10	Bushings on capacitor can	-	double, porcelain, N24 'silver-grey' to AS 2700 (to conform to AS 1265)			
3.11	Capacitor can material	-	304 grade stainless steel, with leak-proof seams, welds and studs			
3.12	Surface treatment of cans	-	enamel paint N24 'silver-grey' to AS 2700			
3.13	Lifting lugs	-	required			

Sr. No.	Parameter	Unit	Requirement			
4	Particulars of Reactor					
4.1	No. of phases	-	three, single-phase units			
4.2	Rated voltage of equipment	kV	24		24	
4.3	Rated reactance	mH	16		8	
4.4	Tolerance on inductance	%	+/- 2			
4.5	Reactor quantity in series		2		1	
4.6	Reactor inductance (at rated frequency and current)	%	5			
4.7	Nominal tuning frequency	Hz	225			
4.8	Rated current	A	145			
4.9	Reactor core	-	air	iron	Air	iron
4.10	Reactor function		detuning and damping			
4.11	Cooling method	-	forced air			
4.12	Maximum sound pressure level, measured in accordance with AS/NZS 60076.6:	dBA	20	65	20	65
4.13	Lifting lugs	-	required			
4.14	Arrangement	-	vertically stacked	side-to-side	vertically stacked	side-to-side
4.15	Support insulators	-	porcelain, silver-grey, with anti-vibration mounts, as required			

4.1 Neutral current transformer

Specific requirements and parameters for neutral current transformers are detailed in Table 2. System parameters remain as per Table 1.

The neutral current transformer must be fully insulated to rated voltage from the primary connection and conform to AS 60044.1.

Table 2 Parameters for neutral current transformers

Sr. No.	Parameter	Unit	Requirement	
	Particulars of Current Transformers			
1	Number of phases	-	single	
2	Installation	-	outdoor	indoor
3	Mounting arrangement	-	Free-standing	free-standing
4	Construction type	-	post, bar	block
5	Number of cores	-	1	
6	Insulation medium	-	composite polymeric bushing	cast-resin
7	Rated voltage	kV	24	
8	Rated short-time thermal current	kA	25	
9	Rated dynamic current	kA	63	
10	Rated short-time	S	1	
11	Nominal secondary current	A	5	
12	Rated secondary continuous thermal current	A	10	
13	Number of protection cores	-	nil	
14	Number of metering cores	-	1	
15	Order of assembly (core 1)	-	$P_1 - P_2$	
16	Location of core 1	-	adjacent to primary terminal P_1	
17	Duty of each core	-	metering	
18	Transformation ratio of each core	-	5/5	
19	Accuracy Class of each core	-	1.0	
20	Test taps	-	No	
21	Degree of protection by enclosure	IP	66	
22	Degree of protection by enclosure of secondary terminal box	IP	54	
23	Lifting lugs	-	not required	

4.2 Capacitor bank installation

(a) The building, kiosk or enclosure must be positioned to minimise the length of power cabling between the associated feeder circuit breaker and capacitor bank, including switchgear.

(b) The building, kiosk or enclosure must be arranged to minimise interference with and allow continued maintenance access to existing substation infrastructure, such as, switchgear and transformers. Buildings, kiosks or enclosures must not positioned above underground control cables, incoming

transformer and outgoing feeder power cables, oil containment system, storm water, fire-fighting water and general water supply pipes.

(c) The internal layout, material and location of the capacitor bank building, kiosk or enclosure must be clearly marked on the substation general arrangement drawing and provided to TasNetworks for review and approval.

(d) The capacitors, reactors and neutral current transformer must be effectively screened off from any switching or operating area.

(e) The reactors must be positioned with adequate clearance to minimise the heating and loss effect of magnetic fields on adjacent electrical equipment and metallic structures.

(f) The switchgear, capacitors, reactor and neutral current transformer must be installed within a free-standing building, or kiosk, with concrete floor and cable ducts, with cladding and roof to conform to TasNetworks' Substation Civil Infrastructure Standard, R590634, suitable for a service life of at least 45 years without replacement of structural material and at least 30 years without the need for replacement of cover panels. The cladding and roof must not require repainting for the duration of the service life.

(g) All necessary connections, cabling, post-insulators, clamps, nuts, bolts and washers shall be supplied to complete the erection of the capacitor bank, ready for service.

(h) Separate compartments must be provided for each capacitor bank step (module 'C') and for the switchgear (module 'S'), with separate external access doors for each module 'C' and for module 'S'. Door fittings must be provided to allow safe egress from all compartments.

(i) Alternatively, where an outdoor installation is specified, the capacitors, reactors and neutral current transformer must be installed on support structures on a concrete plinth within a safety fence enclosure. A concrete pad must cover all areas within the enclosure to minimise maintenance requirements. Where an outdoor installation is specified, a building or kiosk must be always be provided for the switchgear (module 'S').

(j) A compartment or an enclosure for each capacitor bank step must not be utilised for installation of any other equipment other than the associated reactor, capacitor and neutral current transformer.

(k) The capacitor compartment must be lockable, leak-proof and vermin-proof and have ventilation, heating, lighting and access doors for safe and reliable operation and all-weather maintenance, including doors or removable panels to allow for ease of removal and repair of capacitors, reactors and switchgear. Pressure-relief vents must be provided and positioned at a minimum height of 2.4 m to direct any arc fault pressure upwards.

(l) Climatic control must conform to TasNetworks' Substation Civil Design and Construction Standard, R590634

(m) Hinged access doors must be fitted with an automatic closing device and a restraint to hold the door in the fully open position of at least 120 degrees in the presence of high winds.

(n) Access doors to the capacitor compartment or access gates to an enclosure must be lockable and interlocked with the earthing switch to prevent access to the capacitor bank equipment and associated conductors, while the capacitor bank is unearthed, and to prevent the earth switch from opening whilst the door or gate remains open.

(o) Adequate access and clearance must be provided for safe application of portable earth leads.

4.1 Special tools

Any special tools required for the operation or maintenance of the capacitor bank must be provided.

4.2 Documentation requirements

(a) Dimensional plan and section drawings for the capacitor bank and its associated accessories must be produced and submitted for approval by TasNetworks. The drawings must show the final outline dimensions, total mass, centre of gravity, details of insulators, primary and earth terminals, foundation plan, attachment points, lifting lugs, other fittings and accessories, and the materials utilised.

(b) Separate nameplate and warning label drawings must be produced and submitted for approval by TasNetworks.

(c) Separate schematic and wiring diagrams must be produced and submitted for approval by TasNetworks.

(d) A Material Safety Data Sheet (MSDS) for the insulating material must be provided.

(e) Details on packaging and handling the equipment during transport and erection must be provided and submitted for approval by TasNetworks.

(f) Operation and maintenance manual must be provided and submitted for approval by TasNetworks.

(g) Separate construction drawings must show recommended foundations, cable ducts and entry points and all detail required to install the equipment, including minimum clearances in air (between phases and to earth), structural calculations, rated static and dynamic mechanical terminal loads.

(h) All documents and drawings must be clear, legible and free from errors or omissions.

(i) All documents and drawings must be in the English language ONLY.

(j) Only SI system of units must be used. Units must be stated for all values.

(k) Scales, wherever used, must be as per the applicable Australian Standards.

(l) All drawings that are made to scale must include a scale block.

(m) Electronic copies of drawings must be supplied on CD-rom in both Adobe Acrobat 'pdf' and AutoCad Release 14 format.

(n) Only information relevant to the supplied capacitor bank must be shown in the documentation and drawings.

(o) Painting and galvanising

(p) Metallic inside and outside surfaces, excluding capacitor cans, reactor windings and fans, must be galvanised or painted in accordance with the requirements detailed within R522687.

(q) The surface preparation must include grit blasting to a Class 2.5 finish to AS 1627.4

(r) The primer must comprise one (1) coat ethyl silicate inorganic primer (Dulux zinc galv. 16 or similar) to a minimum thickness of 75 micrometers and maximum thickness of 100 micrometers.

(s) The paint finish must comprise at least two (2) coats Dulux exterior gloss acrylic, colour Silver Grey N24, or similar, to AS 2700

(t) Alternative paint systems may be submitted to TasNetworks for approval. Alternative paint systems must offer a superior paint or application method.

4.1 Labels

(a) Warning labels are to be traffolyte, with black text on yellow background.

(b) Danger labels are to be traffolyte, with black text on red background.

(c) Device number labels are to be traffolyte, with black text on white background.

4.1 Nameplates

(a) The capacitor bank, capacitors and reactors must be provided with nameplates that are:

(i) legible and in the English language;

(ii) permanently and indelibly marked;

(iii) securely fixed in position to the body of the equipment or to the enclosure for the capacitor bank;

(iv) weather proof and corrosion-proof;

(v) made of brass, stainless steel or material of equal durability; and

(vi) readable from ground level.

(b) In addition to the requirements of Section 6 of AS 2897 and clause 8.8 of AS/NZS 60076.6, the following information must be included on the equipment nameplate:

(vii) Mass of the device (in kg).

(viii) Rated continuous thermal current (A).

(ix) Purchaser: TasNetworks Networks Pty Ltd.

(x) Purchaser's contract number: refer to project specifications.

5 Capacitor bank switching, protection and control equipment

Each capacitor bank shall be connected to a busbar through the following:

(a) A three-pole, withdrawable, vacuum circuit breaker, suitable for capacitive switching and frequent operation.

(b) Three, single-phase, three-toroid current transformers with one toroid for capacitor bank protection and one toroid for metering. An additional protection toroid must be included. Where required, this toroid must be utilised to limit the zone of any existing high-impedance bus-zone protection scheme.

(c) A three-pole earth switch for effective capacitor bank discharge on de-energisation.

(d) Free-standing post insulators for conductor support, where required.

(e) Three, single-phase voltage transformers, or where available, existing busbar voltage transformers must be utilised for abnormal voltage detection.

(f) Three, single-phase surge diverters.

(g) Three, single-phase capacitive voltage indicators.

(h) Three-phase, high voltage XLPE cable, as required.

The following switching arrangements may be utilised and are listed in order of preference. The switching arrangement will be indicated within the site specific requirements of the project specifications:

- A 'dedicated' feeder circuit breaker capable of capacitive switching and frequent operation on the existing high voltage switchboard using either:
    - a spare feeder circuit breaker; or

- new switchgear within an extension to the existing high voltage switchboard, where the existing high voltage switchboard has the capacity for extension within the existing switchroom dimensions; or

- A 'shared' feeder circuit breaker, with new switchgear capable of capacitive switching and frequent operation within a new building or kiosk.

The Contractor must submit the capacitor bank's bus connection and switching equipment configuration to TasNetworks for TasNetworks' review and approval.

5.1 General arrangement

The high voltage switching equipment must be designed to:

(a) conform to TasNetworks' High Voltage System Standard, R565983;

(b) have a rating of at least 1250 A for the incoming bus riser and 2000 A for busbars;

(c) be fully fault rated and designed and tested to withstand an internal arc due to a short-circuit current of the same level as the maximum short-time withstand level; and

(d) provide an operating platform within the switchgear compartment, module 'S', comprised of at least the width of the high voltage switchboard and a minimum distance of 1500 mm in front of the high voltage switchboard.

5.1 Circuit breaker

The circuit breaker utilised for switching and isolating the high voltage capacitor bank must:

(a) conform to TasNetworks' High Voltage System Standard, R565983; and

(b) provide the specific parameters listed in Table 3.

Table 3 Parameters for circuit breakers

Sr. No.	Parameter	Unit	Requirement
	Particulars of Circuit Breakers		
1	Switching medium	-	Vacuum
2	Operating cycles of mechanism prior to maintenance (C/O at I_n)	cycles	10 000
3	Service life of mechanism prior to replacement (C/O at I_n)	cycles	30 000
4	Mechanical and electrical service life of vacuum interrupter prior to maintenance and replacement (C/O at I_n)	cycles	30 000

5.1 Earth switch

The earth switch utilised for earthing the high voltage capacitor bank must:

(a) conform to TasNetworks' High Voltage System Standard, R565983;

(b) be provided with castell key or solenoid interlocking to permit the operation of any access doors to the capacitor bank enclosure. Where required, a castell key exchange box must be provided; and

(c) be interlocked with any access doors to the capacitor bank enclosure.

5.1 Instrument transformers

The instrument transformers, including voltage transformers and current transformers utilised for protection and metering of the high voltage capacitor bank must:

(a) conform to TasNetworks' High Voltage System Standard, R565983.

5.1 Surge diverters

The surge diverters utilised for protection of the high voltage capacitor bank must conform to TasNetworks' Substation Lightning Protection and Earthing Standard, R522692.

5.2 High voltage power cables and conductors

Power cables from HV switchboard to the capacitor bank and associated switchgear must:

(a) conform to TasNetworks' HV & LV Cable System Standard, R590630;

(b) comprise 120 mm2, three-phase copper conductors in a single three-phase cable;

(c) have the cable sheath earthed at the switchboard end only, with the screen looped back through any core-balance current transformers;

(d) be provided with phase identification on each cable termination;

(e) be insulated for operation at a nominal voltage of 22 kV; and

(f) be within conduits.

High voltage conductors between reactor and capacitor and between capacitor cans must be fully covered with at least 1.6 mm thick PVC sheathing. Any outdoor bushing terminals must be protected by 'bird-caps' covering all live fittings.

5.1 Protection and control

The protection and control of the high voltage capacitor bank must:

(a) conform to TasNetworks' High Voltage System Standard, R565983;

(b) as a minimum, provide over-current, earth-fault, over-voltage, harmonic overload, under-voltage, neutral unbalance protection, under-current detection and initiate circuit breaker fail. Voltage protection must be applied to all three phases;

(c) be arranged to trip the capacitor bank circuit breaker for an associated high voltage bus-zone or feeder protection operation;

(d) where required, provide interlocking between the associated feeder circuit breaker and the capacitor bank switching breaker;

(e) be provided with automatic control functions to switch the high voltage capacitor bank based on the reactive power of the associated load; and

(f) where required, provide transducers and/or current transformers on the associated supply transformers' HV incomer circuits to provide current signals to determine the reactive power of the associated load.

5.1 Metering

As a minimum, metering must be provided for the following:

(a) operational metering, to conform to TasNetworks' High Voltage System Standard, R565983; and

(b) revenue metering, to conform to TasNetworks' High Voltage System Standard, R565983 and the Metering Specification, D11/86620. Revenue metering must be installed within the substation's existing metering cubicle.

5.1 Alarms and events

In addition to the requirements of TasNetworks' High Voltage System Standard, document R565983, the controls, alarms and status indications, as shown in Tables 4, 5 and 6, must be provided to the substation's local alarm annunciator and mimic, respectively.

Table 4 Controls for capacitor bank from mimic

Sr. No.	Control Description	Local	Remote
1	Circuit breaker open/closed	Required	Required

Table 5 Alarm and event indications from capacitor bank to annunciator

Sr. No.	Alarm Description	Local	Remote
2	Ventilation fail	Required	Required
3	Anti-condensation heating fail	Required	Required
4	Protection relay fail	Required	Required
5	Protection relay operated	Not required	Required
6	AC supply fail	Not required	Required

Table 6 Status indications from capacitor bank switching equipment to mimic

Sr. No.	Status Description	Local	Remote
1	Circuit breaker open/closed	Required	Required
2	Earth switch open/closed	Required	Required

5.2 Connections to SCADA and NOCS

The capacitor bank's switchgear, ventilation, heating, ac and dc supply, protection and control devices must be connected to local station SCADA system and remote NOCS. All works associated with SCADA must be as per TasNetworks' SCADA System Standard, R246439. Signals and connections to be provided for position indication, control, metering, alarms and events must comply with the requirements of this standard.

6 Cable systems

All junction box wiring, cubicle wiring, cables and cable systems associated with the capacitor bank must be in accordance with TasNetworks' Check title HV & LV Cable Systems Standard, R5990630.

7 Civil works

All civil works associated with capacitor bank must be in accordance with document TasNetworks' Substation Civil Design and Construction Standard, R590634.

8 Earthing

Earthing of all equipment and works associated with capacitor bank must be in accordance with TasNetworks' Check Title Substation Ancillary Systems Standard,

Frames of all equipment supplied must be provided with reliable earth connections and comply with relevant Australian Standards.

Earthing terminals must be suitable for connecting copper earthing strip size 40 mm x 3 mm using a minimum of 2 x 13 mm bolts with 44 mm centres.

9 Data for Asset Management Information System

(a) TasNetworks maintains a comprehensive 'Asset Management Information System' (AMIS) that contains all design, test results and the condition of all TasNetworks assets. The AMIS also contains maintenance regimes for all assets.

(b) The supplier must provide information required to maintain the currency of AMIS for each asset on standard forms. TasNetworks will provide the asset data sheets to the selected supplier. Forms are required to be filled in for all new assets.

10 Maintenance procedures and plans

(a) Detailed maintenance procedures covering the entire life of the capacitor bank and its components must be provided, including installation, commissioning, maintenance and decommissioning procedures.

(b) Blank inspection and test plans for commissioning, maintenance and routine testing, for use by TasNetworks maintenance personnel, must be provided.

11 Testing

(a) Testing, installation and commissioning must comply with the requirements of the TasNetworks' Testing, Commissioning and Training Standard, R246497.

(b) All components of high voltage shunt capacitor bank and associated switching, protection and control equipment must be duly tested in accordance with relevant applicable Australian and international standards. Where tests are optional in the standards, it will be considered that these tests are required by TasNetworks, unless otherwise requested by Contractor and agreed in writing by TasNetworks before the award of Contract.

(c) All test reports must be forwarded to TasNetworks. The tests will be considered as completed only after an approval and acceptance of the test results is provided by TasNetworks in writing. A list of the tests to be conducted on the high voltage capacitor bank is given below.

11.1 Type tests

(a) Type tests are intended to prove the soundness of design of all components of the high voltage shunt capacitor bank and the associated switching, protection and control equipment and their suitability for operation under the conditions detailed in the standards. Type tests must be carried out before delivery. A test report, detailing the results of such tests along with the procedures followed, must be provided to TasNetworks. These tests must have been applied to all components of the shunt capacitor bank of identical design with that offered, or on a shunt capacitor bank of a design which does not differ from that offered in any way which might influence the properties to be confirmed by the type test.

(b) Where such tests have already been performed, a copy of type test report that qualifies for the exemption from conducting these tests must be provided with the tender.

(c) Type tests must be performed to the relevant Australian and International Standards. Where type tests differ from the requirements under the relevant Australian Standards, the Contractor/Supplier must detail and submit a list of non-conformances to TasNetworks for consideration.

(d) Type tests on capacitors and reactors must include all type tests and all special tests specified in AS 2897 and AS/NZS 60076.6. Type tests for switching, protection and control equipment must conform to the requirements of TasNetworks' High Voltage System Standard, R565983. Type tests for current transformers must include all type tests specified in AS 60044.1.

11.1 Routine tests

(a) The routine tests must be conducted on the complete system to prove quality of manufacture and conformance with the relevant performance requirements of the applicable standards. Splitting of routine tests into separate phases for individual components of the system is not acceptable. Routine testing must be performed at the manufacturer's works prior to delivery.

(b) Procedures for routine tests with supporting documentation must be submitted to TasNetworks for approval and acceptance. Routine tests must not be conducted unless the routine test procedures have been accepted and approved by TasNetworks.

(c) Routine test results and certificates must be submitted to TasNetworks for approval and acceptance. Routine tests will be considered as completed only after TasNetworks approves and accepts the test results.

(d) Routine factory test results must be approved and accepted by TasNetworks prior to dispatch of equipment to site.

(e) Routine tests for capacitors and reactors must include all routine tests specified in AS 2897 and AS/NZS 60076.6. Routine tests for switching, protection and control equipment must conform to the requirements of TasNetworks' High Voltage System Standard, R565983. Routine tests for current transformers must include all routine tests specified in AS 60044.1.

(f) Test equipment and the test laboratory utilised for accuracy error tests must have certification from the 'NATA, Australia' or their mutually recognised test accreditation authority to perform tests for revenue metering measurement applications as per the Rules and the certification number, description and serial numbers of test equipment must be recorded on the test certificate for each current transformer.

11.1 Pre-commissiong and Commissioning tests

(a) Pre-commissioning and commissioning tests must be conducted on the installed system after erection on site and before it is put into service to prove that it has not been damaged during transportation or

erection. The pre-commissioning and commissioning testing procedures must be submitted to TasNetworks for approval.

(b) Power quality tests on the power system must be conducted for at least 1 week prior to the system being put into service and for at least 1 week after the system is put into service. Power quality tests must be performed on all phase voltages, transformer incomer currents and capacitor bank currents and include waveform recording, measurements to the 13th harmonic, total harmonic distortion, voltage unbalance and flicker.

(c) Electrical tests on the complete capacitor bank and associated power cables must be performed to conform to the requirements of TasNetworks' High Voltage System Standard, R565983.

(d) Sound pressure tests must be performed on the energised capacitor bank to AS 2374 Part 6, with all ventilation in service. Where sound pressure levels are greater than the levels stated in Table 1, noise containment measures are to be introduced by the contractor to reduce the noise to an acceptable level at the site boundary. This may include, but not limited to, the installation of ducts or the installation of noise containment walls.

(e) On-load checks must be carried out on all protection and metering circuits and must also include recording of phase angles.

(f) Commissioning test reports must be submitted to TasNetworks for approval and records.

12 Packaging

(a) The supplier is responsible for ensuring that adequate packaging and external signage is provided to minimize the risk of damage to equipment during delivery and removal from packaging. The packaging must be suited to the particular methods of delivery and provide protection against damage from all foreseen hazards.

(b) Packaging must be externally labelled for ease of identification of the capacitor bank and its components.

(c) Details of packaging methods must be submitted to TasNetworks for review.

13 Information to be provided with tender

Requirements for information to be submitted as part of the tender are outlined in document R579292 High Voltage Shunt Capacitor Bank Schedule.

Addition requirements for information to be submitted as part of the tender for switching, protection and control equipment are outlined in document R586383 High Voltage Systems Schedule.

14 Deliverables

Requirements for project deliverables are outlined in document R579291 High Voltage Shunt Capacitor Bank (Deliverables). Additional requirements for project deliverables for switching, protection and control equipment are outlined in document R586382 High Voltage Systems (Deliverables).

15 Hold points

The requirement of documentation is listed in the deliverable schedule in R586382.

The hold points for each capacitor bank are:

(a) "Critical design information documentation" must be submitted four weeks after letter of acceptance for TasNetworks' review, comments and approval prior to procurement of equipment;

(b) "Detailed design documentation" must be submitted prior to manufacturing of equipment, for TasNetworks' review, comments and approval. A face-to-face design review must be held at the earliest opportunity after the electrical design has been finalised and an early draft of the outline drawing is available. Information must be provided in good time before the meeting to permit study of the detailed design aspects.

(c) "Inspection and Test Plan" must be submitted one month prior to "Factory Acceptance Testing (FAT)", for TasNetworks' review, comments and approval;

(d) Draft "Operations and Maintenance manuals (O&M manuals)" must be provided at least one month prior to FAT, for TasNetworks' review, comments and approval;

(e) "Invitation to witness testing" must be submitted prior to any equipment testing, for TasNetworks' arrangements to witness. A minimum of two weeks notice must be given;

(f) Complete updated O&M manuals must be submitted one week prior to FAT for TasNetworks' preparation to attend FAT;

(g) Final training manuals must be provided at least two weeks prior to training, for use of training team;

(h) "FAT" must have been witnessed by TasNetworks and FAT results approved by TasNetworks, prior to dispatch of the capacitor bank from the factory;

(i) All non-conformances as identified during FAT or other inspections must have been completed prior to dispatch of the capacitor bank from the factory;

(j) Information required for AMIS pertaining to design information and maintenance regimes must be submitted to TasNetworks prior to commencing installation;

(k) "Pre-commissioning tests" must have been witnessed by TasNetworks and test results approved by TasNetworks, prior to "commissioning tests";

(l) All non-conformances as identified during pre-commissioning tests must have been completed before commencing any commissioning tests;

(m) Results of commissioning tests must have been approved by TasNetworks and relevant testing authorities as per the requirements of the Rules, prior to commissioning;

(n) "Commissioning tests" must have been witnessed by TasNetworks and test results approved by TasNetworks, prior to "energisation";

(o) All non-conformances as identified during commissioning tests must be completed before commencing any energisation;

(p) "Training" must have been completed prior to energisation;

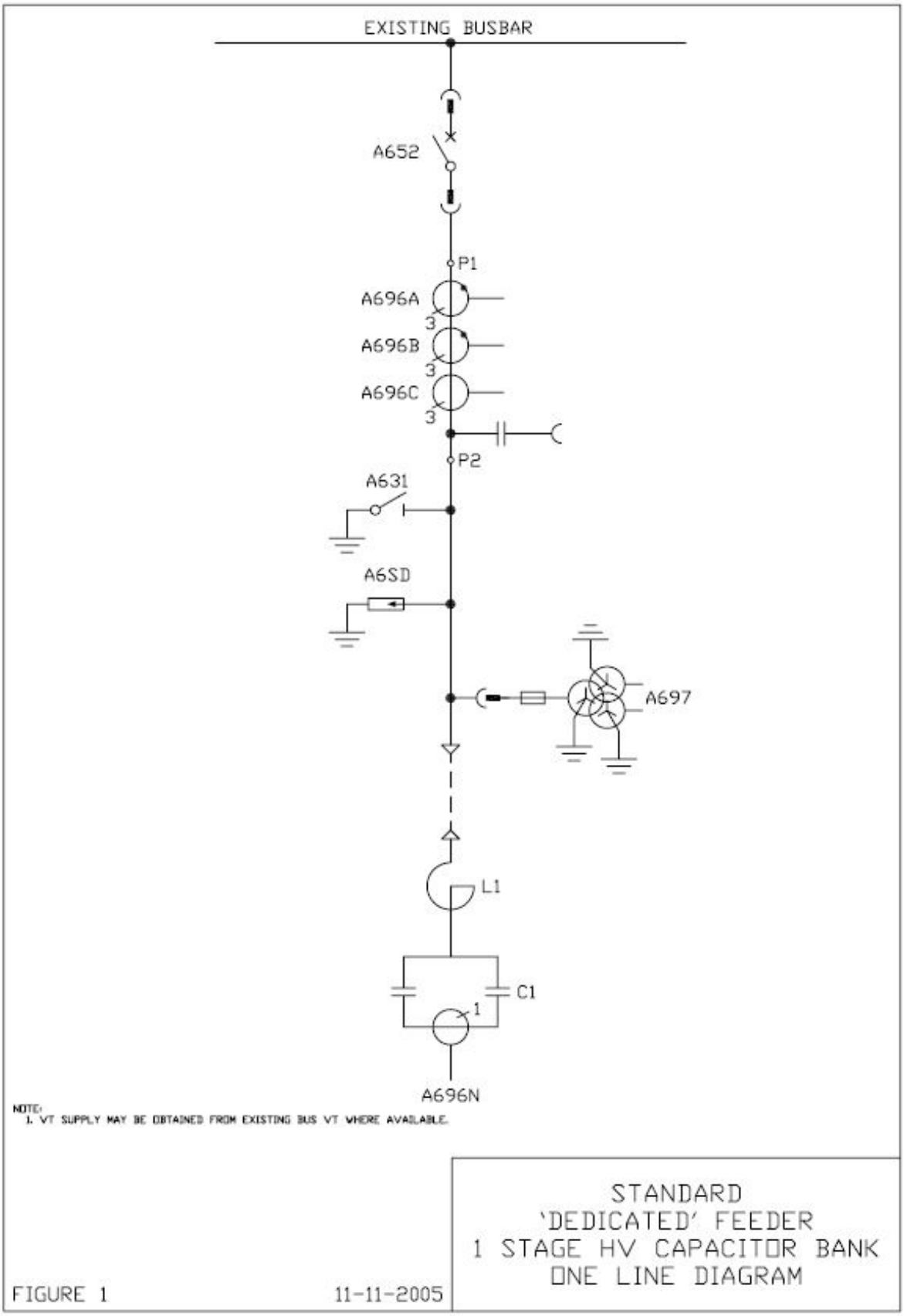
(q) Information for AMIS pertaining to test results must have been submitted to TasNetworks prior to energisation;

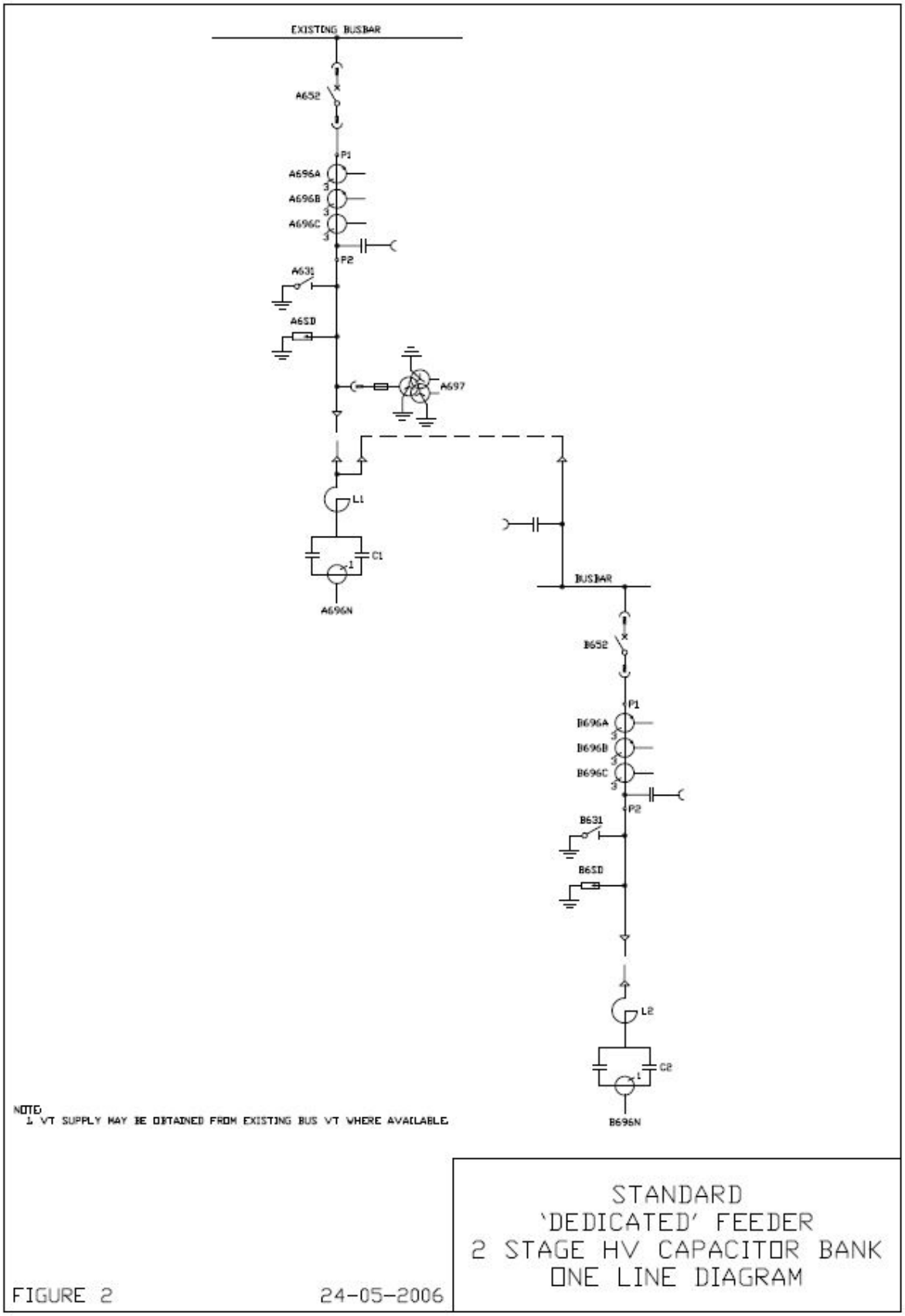
(r) Certificate of conformance with contract specifications, standard specifications, codes and standards with associated documents, drawings, test results, test reports, test certificates, completed check lists and other documents must be submitted and must have been accepted and approved by TasNetworks prior to energisation;

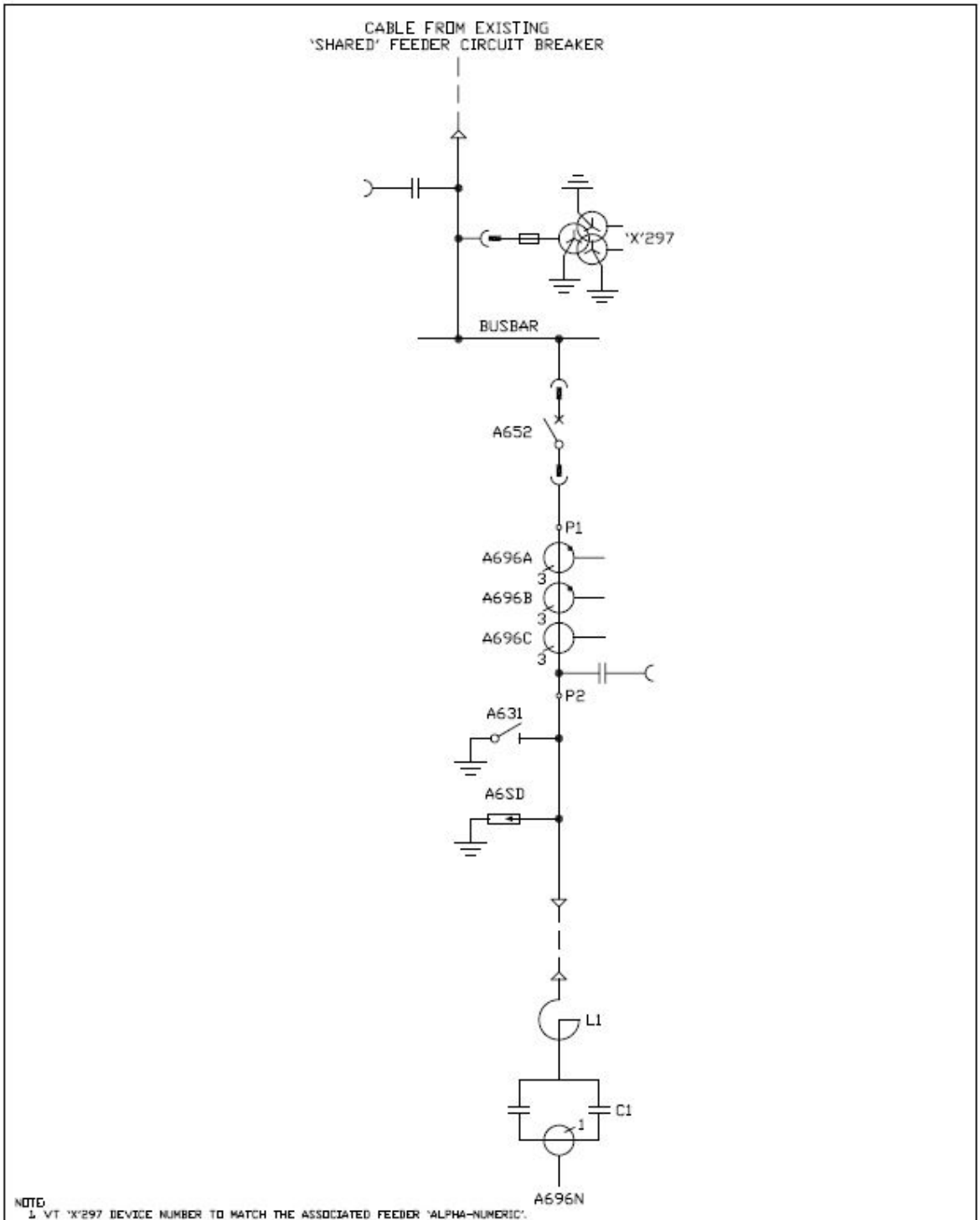
(s) TasNetworks must have completed the inspection of each asset prior to its energisation; and

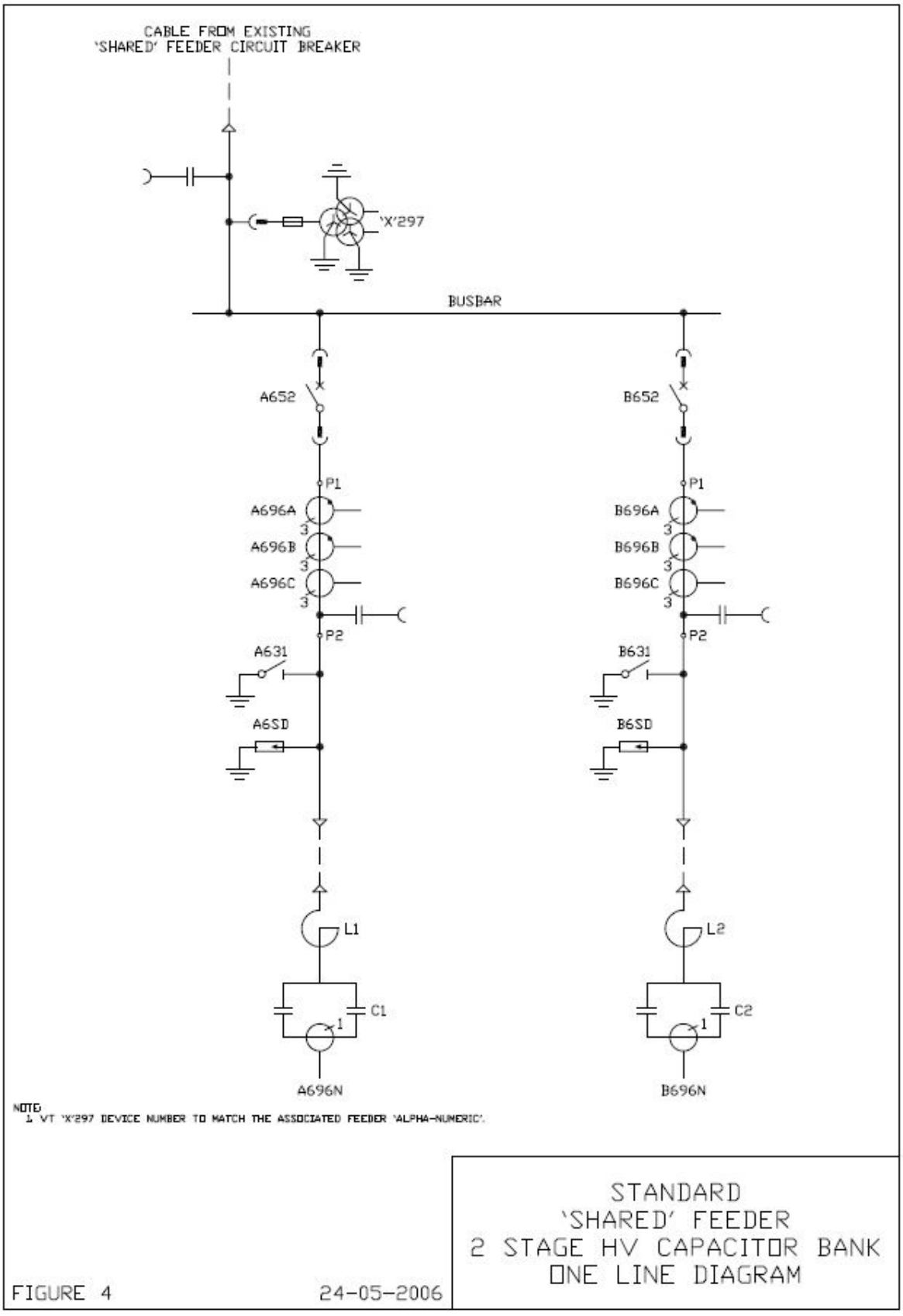
(t) All as-built documentation, software licences, O&M manuals, test results and test certificates must be submitted to TasNetworks and be accepted by TasNetworks prior to practical completion.

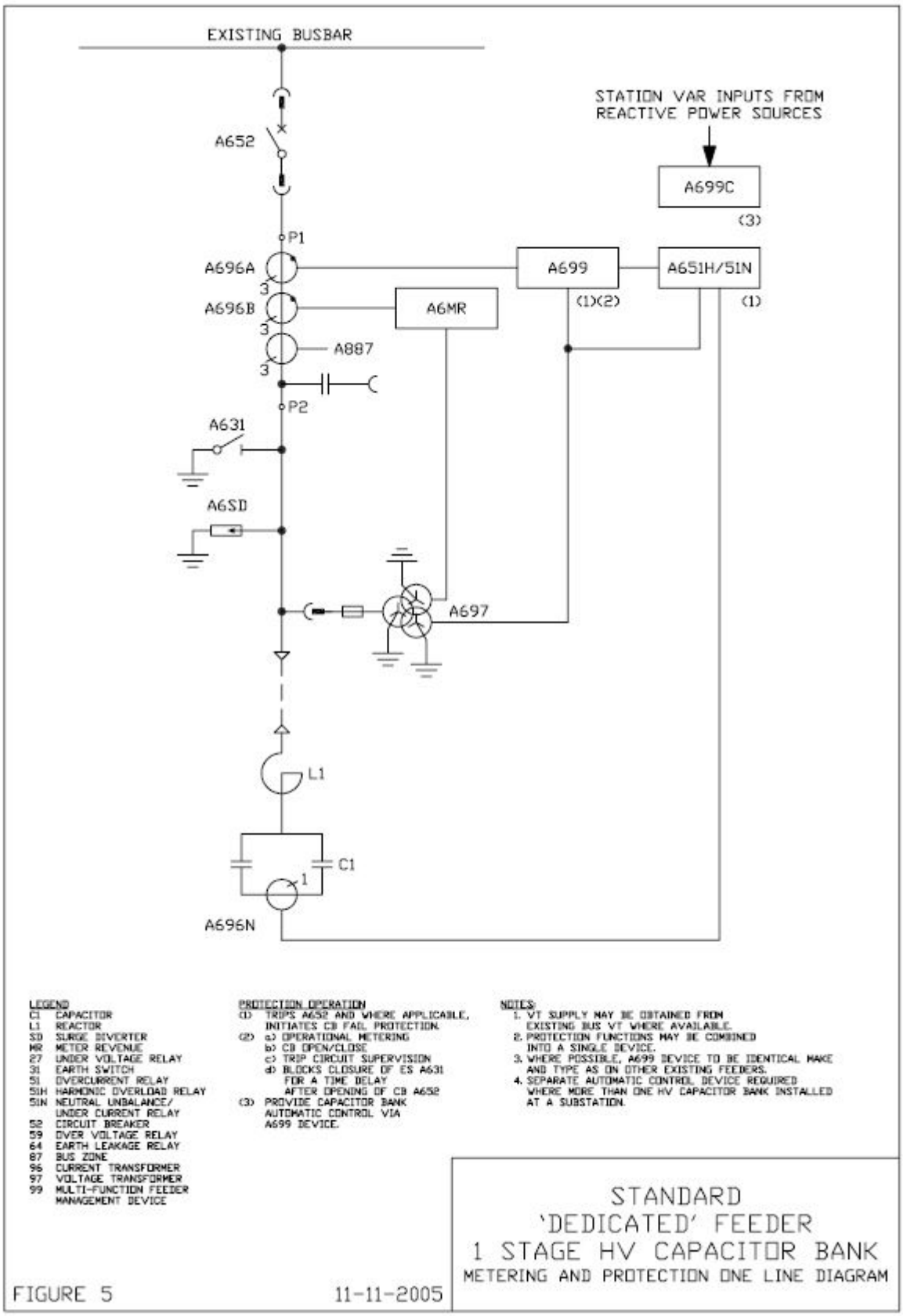
Appendix A – Typical Capacitor Bank details for reference purposes.

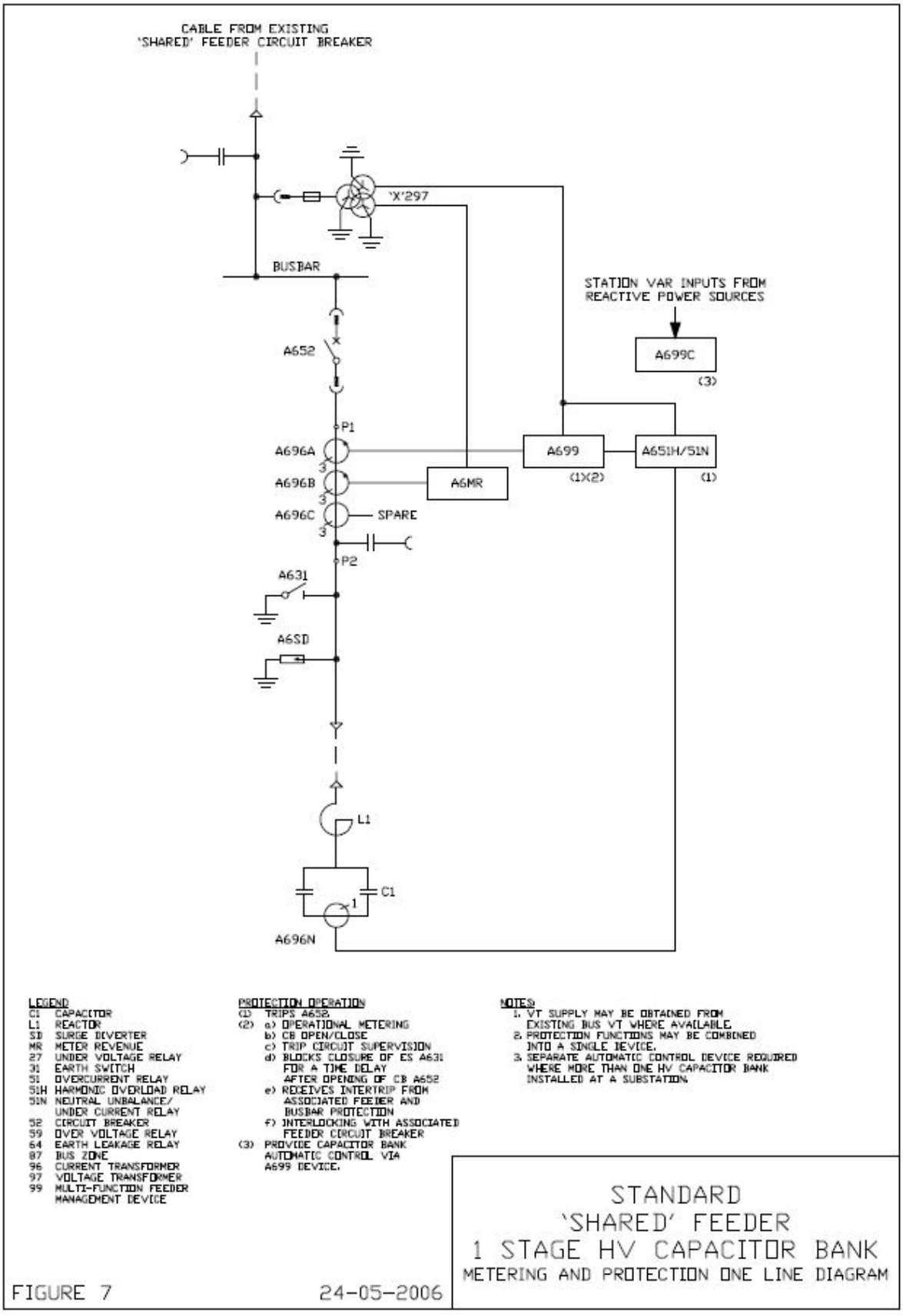

EXISTING BUSBAR
A652
P1
A696A
3
A696B
3
A696C
3
P2
A631
A6SD
A697
L1
C1
1
A696N
NOTE:
1. VT SUPPLY MAY BE OBTAINED FROM EXISTING BUS VT WHERE AVAILABLE.
STANDARD
'DEDICATED' FEEDER
1 STAGE HV CAPACITOR BANK
ONE LINE DIAGRAM
FIGURE 1
11-11-2005

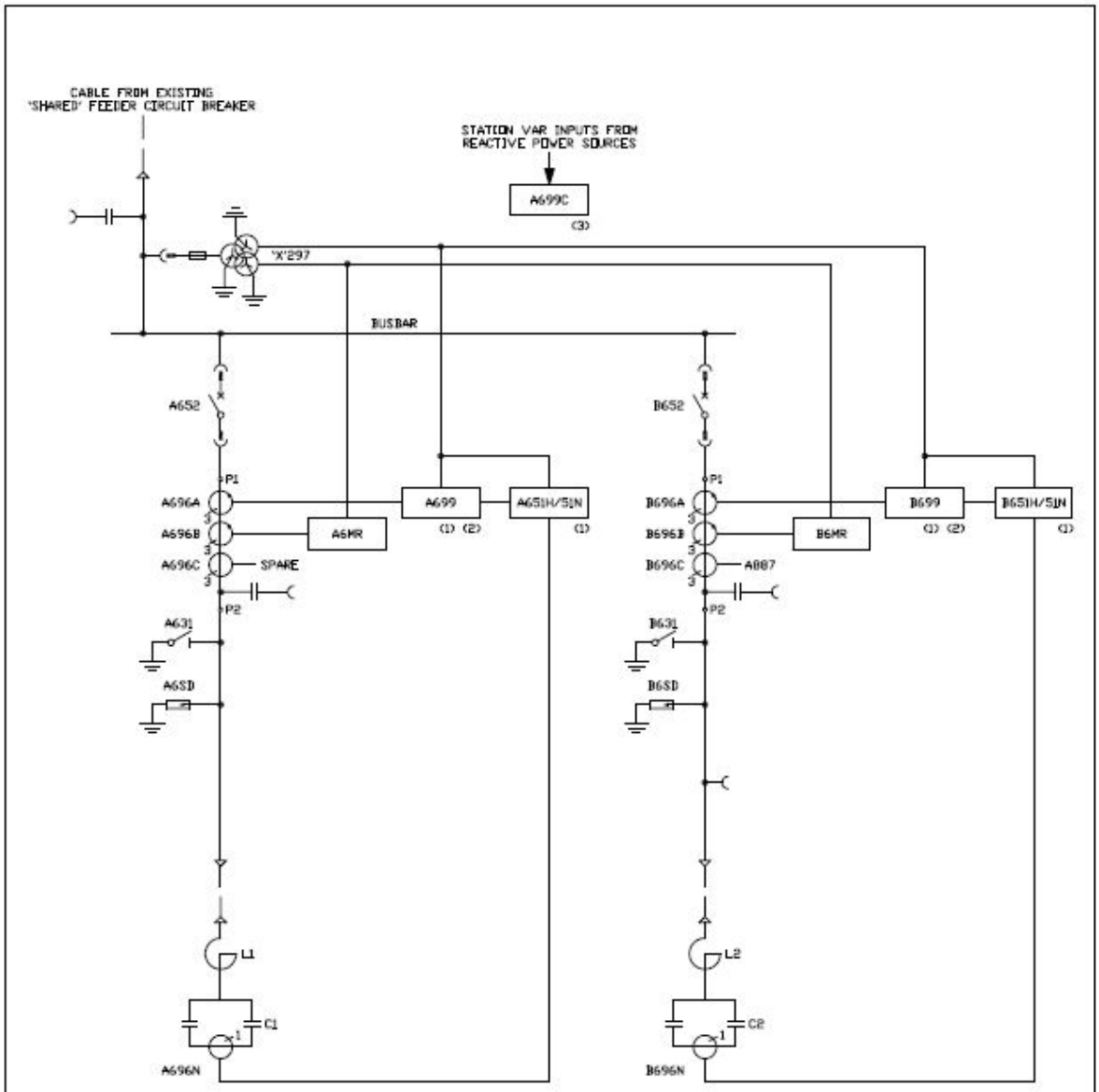

EXISTING BUSBAR
A652
P1
A696A
A696B
A696C
P2
A631
A65D
A697
L1
C1
A696N
BUSBAR
B652
P1
B696A
B696B
B696C
P2
B631
B65D
L2
C2
B696N
NOTE:
1. VT SUPPLY MAY BE OBTAINED FROM EXISTING BUS VT WHERE AVAILABLE.
STANDARD
'DEDICATED' FEEDER
2 STAGE HV CAPACITOR BANK
ONE LINE DIAGRAM
FIGURE 2
24-05-2006


CABLE FROM EXISTING
'SHARED' FEEDER CIRCUIT BREAKER
'X'297
BUSBAR
A652
P1
A696A
3
A696B
3
A696C
3
P2
A631
A6SD
L1
C1
1
A696N
NOTE:
1. VT 'X'297 DEVICE NUMBER TO MATCH THE ASSOCIATED FEEDER 'ALPHA-NUMERIC'.
STANDARD
'SHARED' FEEDER
1 STAGE HV CAPACITOR BANK
ONE LINE DIAGRAM
FIGURE 3
24-05-2006


CABLE FROM EXISTING
'SHARED' FEEDER CIRCUIT BREAKER
'X'297
BUSBAR
A652
B652
P1
A696A
A696B
A696C
3
P2
A631
B631
A6SD
B6SD
L1
L2
C1
C2
1
A696N
B696N
NOTE:
1. VT 'X'297 DEVICE NUMBER TO MATCH THE ASSOCIATED FEEDER 'ALPHA-NUMERIC'.
STANDARD
'SHARED' FEEDER
2 STAGE HV CAPACITOR BANK
ONE LINE DIAGRAM
FIGURE 4
24-05-2006


EXISTING BUSBAR
STATION VAR INPUTS FROM
REACTIVE POWER SOURCES
A652
A699C
(3)
P1
A696A
3
A696B
3
3
A887
A699
A651H/51N
(1)(2)
(1)
A6MR
P2
A631
A6SD
A697
L1
C1
1
A696N
LEGEND
C1 CAPACITOR
L1 REACTOR
SD SURGE DIVERTER
MR METER REVENUE
27 UNDER VOLTAGE RELAY
31 EARTH SWITCH
51 OVERCURRENT RELAY
51H HARMONIC OVERLOAD RELAY
51N NEUTRAL UNBALANCE/
UNDER CURRENT RELAY
52 CIRCUIT BREAKER
59 OVER VOLTAGE RELAY
64 EARTH LEAKAGE RELAY
87 BUS ZONE
96 CURRENT TRANSFORMER
97 VOLTAGE TRANSFORMER
99 MULTI-FUNCTION FEEDER
MANAGEMENT DEVICE
PROTECTION OPERATION
(1) TRIPS A652 AND WHERE APPLICABLE,
INITIATES CB FAIL PROTECTION.
(2) a) OPERATIONAL METERING
b) CB OPEN/CLOSE
c) TRIP CIRCUIT SUPERVISION
d) BLOCKS CLOSURE OF ES A631
FOR A TIME DELAY
AFTER OPENING OF CB A652
(3) PROVIDE CAPACITOR BANK
AUTOMATIC CONTROL VIA
A699 DEVICE.
NOTES:
1. VT SUPPLY MAY BE OBTAINED FROM
EXISTING BUS VT WHERE AVAILABLE.
2. PROTECTION FUNCTIONS MAY BE COMBINED
INTO A SINGLE DEVICE.
3. WHERE POSSIBLE, A699 DEVICE TO BE IDENTICAL MAKE
AND TYPE AS ON OTHER EXISTING FEEDERS.
4. SEPARATE AUTOMATIC CONTROL DEVICE REQUIRED
WHERE MORE THAN ONE HV CAPACITOR BANK INSTALLED
AT A SUBSTATION.
STANDARD
'DEDICATED' FEEDER
1 STAGE HV CAPACITOR BANK
METERING AND PROTECTION ONE LINE DIAGRAM
FIGURE 5
11-11-2005


CABLE FROM EXISTING
'SHARED' FEEDER CIRCUIT BREAKER
'X'297
BUSBAR
STATION VAR INPUTS FROM
REACTIVE POWER SOURCES
A699C
(3)
A652
P1
A696A
A696B
A696C
SPARE
A699
(1X2)
A651H/51N
(1)
A6MR
P2
A631
A6SD
L1
C1
A696N
LEGEND
C1 CAPACITOR
L1 REACTOR
SD SURGE DIVERTER
MR METER REVENUE
27 UNDER VOLTAGE RELAY
31 EARTH SWITCH
51 OVERCURRENT RELAY
51H HARMONIC OVERLOAD RELAY
51N NEUTRAL UNBALANCE/
UNDER CURRENT RELAY
52 CIRCUIT BREAKER
59 OVER VOLTAGE RELAY
64 EARTH LEAKAGE RELAY
87 BUS ZONE
96 CURRENT TRANSFORMER
97 VOLTAGE TRANSFORMER
99 MULTI-FUNCTION FEEDER
MANAGEMENT DEVICE
PROTECTION OPERATION
(1) TRIPS A652.
(2) a) OPERATIONAL METERING
b) CB OPEN/CLOSE
c) TRIP CIRCUIT SUPERVISION
d) BLOCKS CLOSURE OF ES A631
FOR A TIME DELAY
AFTER OPENING OF CB A652
e) RECEIVES INTERTRIP FROM
ASSOCIATED FEEDER AND
BUSBAR PROTECTION
f) INTERLOCKING WITH ASSOCIATED
FEEDER CIRCUIT BREAKER
(3) PROVIDE CAPACITOR BANK
AUTOMATIC CONTROL VIA
A699 DEVICE.
NOTES:
1. VT SUPPLY MAY BE OBTAINED FROM
EXISTING BUS VT WHERE AVAILABLE.
2. PROTECTION FUNCTIONS MAY BE COMBINED
INTO A SINGLE DEVICE.
3. SEPARATE AUTOMATIC CONTROL DEVICE REQUIRED
WHERE MORE THAN ONE HV CAPACITOR BANK
INSTALLED AT A SUBSTATION.
STANDARD
'SHARED' FEEDER
1 STAGE HV CAPACITOR BANK
METERING AND PROTECTION ONE LINE DIAGRAM
FIGURE 7
24-05-2006



LEGEND
C1 CAPACITOR
L1 REACTOR
SD SURGE DIVERTER
MR METER REVENUE
27 UNDER VOLTAGE RELAY
31 EARTH SWITCH
51 OVERCURRENT RELAY
51H HARMONIC OVERLOAD RELAY
51N NEUTRAL UNBALANCE/
UNDER CURRENT RELAY
52 CIRCUIT BREAKER
59 OVER VOLTAGE RELAY
64 EARTH LEAKAGE RELAY
87 BUS ZONE
96 CURRENT TRANSFORMER
97 VOLTAGE TRANSFORMER
99 MULTI-FUNCTION FEEDER
MANAGEMENT DEVICE

PROTECTION OPERATION
(1) TRIPS ASSOCIATED CB
(2) a) OPERATIONAL METERING
b) CB OPEN/CLOSE
c) TRIP CIRCUIT SUPERVISION
d) BLOCKS CLOSURE OF ASSOCIATED ES
FOR A TIME DELAY AFTER
OPENING OF ASSOCIATED CB
(3) PROVIDE CAPACITOR BANK
AUTOMATIC CONTROL VIA
A699 OR B699 DEVICE, RESPECTIVELY.

NOTES:
1. VT SUPPLY MAY BE OBTAINED FROM
EXISTING BUS VT WHERE AVAILABLE.
2. PROTECTION FUNCTIONS MAY BE COMBINED
INTO A SINGLE DEVICE FOR EACH CAPACITOR BANK.
3. SEPARATE AUTOMATIC CONTROL DEVICE REQUIRED
WHERE MORE THAN ONE HV CAPACITOR BANK INSTALLED
AT A SUBSTATION.

STANDARD
'DEDICATED' FEEDER
2 STAGE HV CAPACITOR BANK
METERING AND PROTECTION ONE LINE DIAGRAM

FIGURE 8 24-05-2006

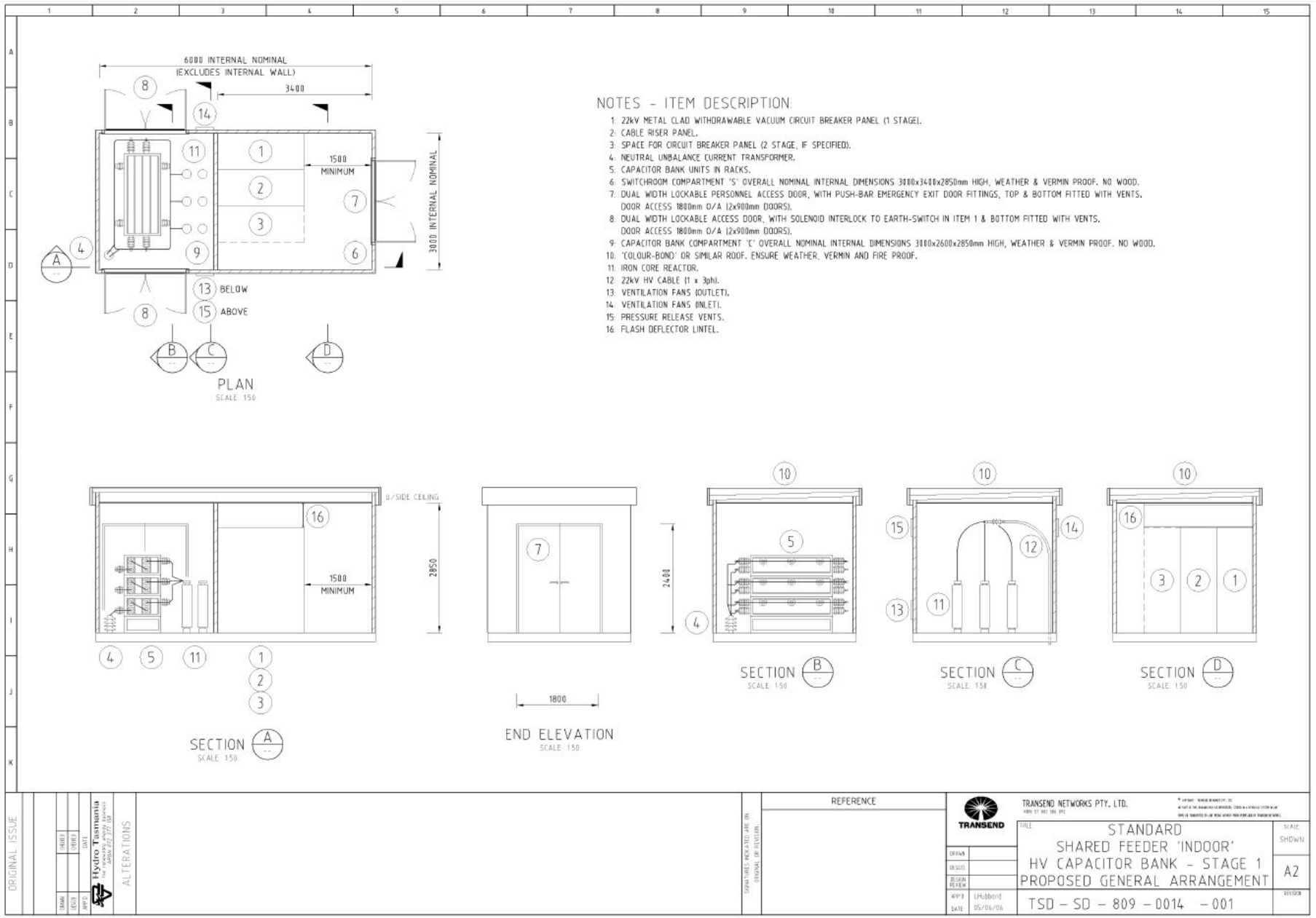


FIGURE 9: Transend HV Capacitor Bank Standard, Document TNM-DS-806-0259

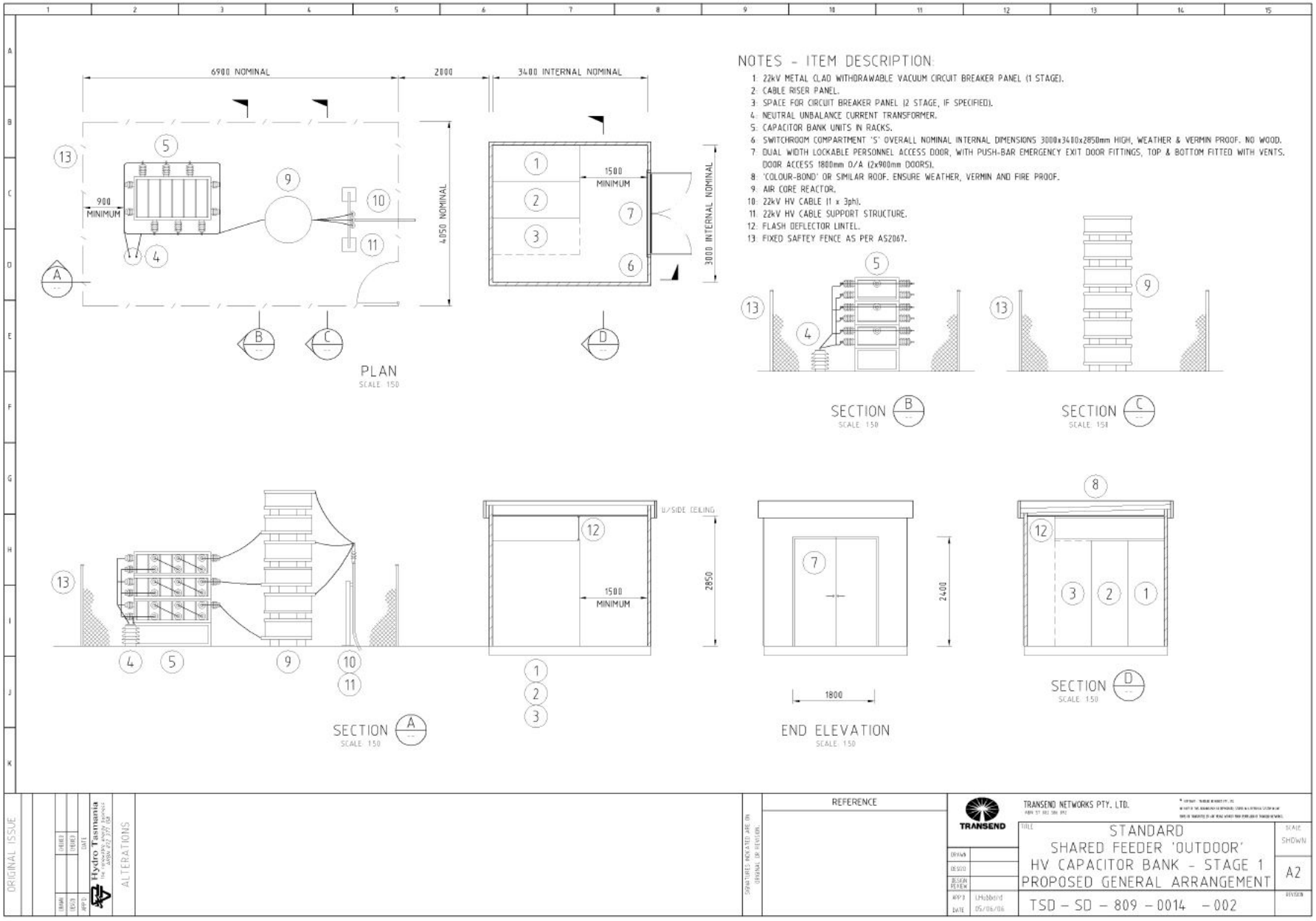


FIGURE 10: Transend HV Capacitor Bank Standard, Document TNM-DS-806-0259