

Equipment Technical Specification

33kV, 66kV and 132kV outdoor dead tank circuit breakers

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EQUIPMENT TECHNICAL SPECIFICATION

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ETS 0022 33kV, 66kV and 132kV outdoor dead tank circuit breakers

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1.0 PURPOSE

To set out in detail the minimum technical requirements for 33kV, 66kV and 132kV outdoor dead tank circuit breakers used in transmission and zone substations in the Endeavour Energy network.

2.0 SCOPE

This Specification covers the design, manufacture, factory testing, delivery and testing at site of 33kV, 66kV and 132kV dead tank circuit breakers which are complete with bushing current transformers. It is not the intention to specify all the design and constructional details of the circuit breakers, however the equipment supplied shall meet all the requirements specified in the standards and in this document.

The scope includes all accessories and equipment necessary and normally supplied for the safe operation of the equipment, whether specified or not. The requirement is for self-contained outdoor circuit breaker, complete with mechanism box and support structure.

Circuit breakers offered in response to this Specification shall be manufactured and tested to the standards with the year of publication listed in section 3 of this document. Endeavour Energy will consider equipment manufactured to other recognised international standards provided the standards are at least equivalent to Australian and/or IEC standards. In some circumstances based on local network experience, this specification is more stringent than the Australian and International standards it references, in this circumstance the requirements of this specification shall prevail. Any proposed variations from this specification shall be referred to Network Substations Manager for approval in writing prior to acceptance.

3.0 REFERENCES

- Company Policy 9.1.8 - Network Configuration
- Company Policy 9.6.1 - Network Connections
- Company Policy 9.2.5 - Network Asset Design
- Company Policy 9.2.10 - Network Asset Management
- Company Policy 9.7.1 - Network Asset Construction
- Company Policy 9.9.1 - Network Asset Maintenance
- Company Procedure GRM 0003 – Risk Management
- Company Procedure GSY 0026 – Work Health and Safety Risk Assessment
- Company Form FSY 0138 – Risk Register
- Company Network Management Plan – 2013 Review
- *Electricity Supply Act 1995* (as amended)
- ENA National Electricity Network Safety Code (Doc 01-2008)
- *Work Health and Safety Act 2011*(NSW)
- Earthing Design Instruction EDI 516 – Major substation earthing design, construct and commissioning
- Engineering Technical Specification ETS 0014 –Protection and control panels
- Substation Design Instruction SDI 526 - Control cabling, panels and termination
- SDI 545 – Acceptable purity limits for SF6 gas
- AS/NZS 3000:2007 - Wiring Rules
- Service and Installation Rules of NSW (Amendment 2: January 2009)
- AS1000:1998 - The international system of units (SI)
- AS 60270:2001 - Recommendations for partial discharge measurements
- AS/NZS CISPR16.2:2002 - Electromagnetic interference measuring equipment
- AS 4398.2:2005 - Insulators, station post insulators
- AS1627.4:2005 - Code of practice - abrasive blast cleaning of steel surfaces
- AS/NZS 4680:2006 - Galvanised coatings
- AS 60044.1:2007 - Current transformers for measurement and protection

- AS 1734:1997 - Aluminium and aluminium alloy sheet and plate
- AS 1824.2:1985 - Insulation Co-ordination (above 1kV)
- AS 1874:2000 - Aluminium ingots and castings
- AS 1852:1988 - International electrotechnical vocabulary
- AS1931.1:1996 - High voltage testing techniques
- AS 2067:2008 - Specification for switchgear assemblies and ancillary equipment¹
- AS 2532:1982 - CTs and VTs for measurement and protection. Measurement of PD
- AS 2700:2011 - Colour standards for general purposes
- AS 2981:2008 - High voltage a.c. switchgear and controlgear-vacuum interrupters-High voltage testing- Protection of personnel from X-ray emissions
- AS/NZS 2344:1997 - Limits of electromagnetic interference from overhead a.c. power lines and high voltage equipment installations
- AS 60137:2008 - High voltage bushings
- AS 62271.1:2012 - High voltage switchgear and control gear Part 1: Common specifications
- AS 62271.100:2008 – High voltage switchgear and controlgear – High voltage alternating current circuit breakers
- AS 62271.203:2012 – High voltage switchgear and controlgear – Gas insulated metal enclosed switchgear for rated voltages above 52kV
- AS 62271.301:2005 - High voltage switchgear and controlgear – Dimensional standardisation of terminals
- IEC 60376:2005 - Specification of technical grade sulfur hexafluoride (SF₆) for use in electrical equipment
- IEC60529:2013 - Degrees of protection provided by enclosures (IP Code)
- Drawing no. 355758 – Interface terminal block connection diagram
- Drawing no. 355759 – Typical HV Outdoor Dead Tank CB CT Circuit Diagram
- Drawing no. 356531 – Tender base design typical HV outdoor dead tank circuit breaker current transformer circuit design
- Drawing no. 364495 – Equipment Technical Specification HV Outdoor CB Circuit Diagram
- Branch Procedure PAE 1004 - Product approval process
- Branch form FAE 3142 – 33kV, 66kV and 132kV dead tank circuit breaker evaluation form

4.0 DEFINITIONS AND ABBREVIATIONS

CT	current transformer
DTCB	dead tank circuit breaker
r.m.s	root mean square
AC/a.c.	alternating current
DC/d.c.	direct current
SCADA	Supervisory Control And Data Acquisition
SF₆	sulphur hexafluoride

5.0 ACTIONS

5.1 General requirements

Dead tank circuit breakers (DTCB) supplied shall be designed and manufactured in conformance with the series AS 62271, except where specifically varied in this Specification.

The equipment supplied shall meet the highest standards of engineering, design and manufacturing practices. Any deviations from this Specification shall be approved by the Manager Primary Systems.

The arc quenching or interrupting medium of the dead tank circuit breaker may be vacuum or SF₆, as appropriate for the voltage level. Alternative suitable offers will be considered provided they are sufficiently detailed in writing for consideration for the Manager, Primary Systems.

Similar components of similar circuit breakers shall be capable of being interchanged.

Circuit breakers shall be designed, manufactured and tested for outdoor service conditions. The supplier shall provide all accessories necessary for the safe operation of the equipment.

All connections shall be terminated using crimp lugs and stainless steel or hot dip galvanised bolts, as appropriate. Clamps or u-bolt connections are not acceptable.

All equipment except the outdoor bushing terminations shall be effectively earthed and enclosed in earthed enclosures to the extent that there is no safety hazard to operating personnel, to prevent accidental shorts by human error, flying objects or rodents, and to prevent mechanical damage to the circuit breakers.

The design and construction shall be in accordance with the technical requirements stated. All materials and the design shall be of the type and quality that will give a normal life expectancy of 45 years.

All values submitted shall be guaranteed values and shall be treated as such in the evaluation when assessing whether the delivered equipment meets the Specification.

5.1.1 Service conditions

Circuit breakers shall be suitable for use on the Endeavour Energy's 33kV, 66kV and 132kV 3-phase 50Hz system having the neutral point of the source effectively earthed. The highest system voltage is 36kV, 72.5 and 145kV RMS respectively.

Service conditions shall be in accordance with the outdoor standard requirements of clause 2.1 of AS 62271.1. The circuit breakers shall be designed to operate in service conditions summarised in the table below

Service condition	Criteria
Altitude	<1000m
Maximum ambient temperature	45 deg. C
Minimum ambient temperature	-10 deg. C
Average annual lightning ground flash density	3 strikes per km ²
Solar radiation- maximum	1.1 kW/m ²
Average index of mean relative humidity: 9:00am	95%
Seismic acceleration coefficient (maximum)	0.09
Pollution level	Level IV in accordance with AS4436:1996
Ice coating	1mm
Wind speed	34m/s
Consideration to condensation/precipitation	Yes

5.2 Health, safety and environment (HSE) requirements

5.2.1 Insulating gas global warming potential (GWP)

Endeavour Energy's preference is for the use of switchgear that does not contain SF₆ gas given its management and global warming potential (GWP) where alternative cost-effective technologies are available. Cost-efficient offers of equipment containing SF₆ will be considered however weighting will be applied in the evaluation process to preference equipment with no or minimal SF₆. SF₆ management, environmental impact and disposal costs will be considered in the evaluation process. A similar evaluation weighting will be applied to all gas insulated switchgear, regardless of gas used weighted by its GWP.

5.2.2 Special environmental requirements - toxicology safety

The supplier shall provide with the offer, full details, including composition and toxicological information, regarding the health and safety aspects of all the materials offered in their offer or supplied equipment regardless of content.

Recommended procedures shall be provided for the safe handling, safe operation and maintenance of products supplied. The means of disposal of the materials shall be clearly stated.

Material safety data sheets (MSDS) shall be provided, with copies available on site, for materials that are supplied and subject to safety considerations in handling and use.

All equipment, packaging and all other accessories provided shall be asbestos free.

The above information is required as part of the offer and will be reviewed as part of the tender process.

5.2.3 Noise levels and radio interference voltage (RIV)

The equipment may be installed in a residential area in close proximity to family residences. Noise and radio interference voltage shall be kept to the minimum levels to comply with all the requirements of AS/NZS 2344:1997.

5.2.4 Fire and blast hazards

The DTCB shall be designed in a manner to eliminate the risk of rupture and explosive failure and subsequent personnel and fire risk. Where pressurised gas is used or a rapid pressure increase could cause safety hazards to personnel or other equipment, the use of appropriately placed pressure release diaphragms and venting positioning shall be provided.

Where SF₆ or other gas which release potentially corrosive and toxic by-products as a result of arcing are used, the supplier shall detail appropriate measures to manage the risk to personnel and provide measures to eliminate the likelihood of uncontrolled rupture.

5.3 Performance characteristics

5.3.1 Circuit breaker ratings

The outdoor dead tank circuit breaker shall have the following general ratings:

Voltage level	33kV	66kV	132kV
Compliance with current Australian Standard	AS 62271.100-2008 and AS 62271.1-2012		
Class	Outdoor		
Interrupting medium	Vacuum (preferred)		SF ₆ /Vacuum
Rated voltage (U _r) (kV)	36	72.5	145
Rated insulation level – lightning impulse (U _p) (kV peak)	170	325	650

Voltage level	33kV	66kV	132kV
Rated insulation level – one (1) min power freq (Ud) (kV rms)	70	140	275
Rated frequency (fr) (Hz)	50		
Rated current (Ir) (A)	2000/2500	2000	2500/3150
Rated short time withstand current (I _k) (kA))	31.5	31.5	40
Rated peak withstand current (Ip) (kA rms)	78.75	78.75	100
Rated duration of short circuit current (t _k)(sec)	1		
First pole to clear factor	1.5		
Rated operating sequence (t=0.3sec,t'=3min)	O-t-CO-t'-CO		
Total short circuit breaking time	0.05 sec		
Rated supply voltage of close, trip/open device and aux. CTs (Ua) (V DC)	120 Nominal		
Number of shunt trip coils	Two (2) independently operated coils		
Number of close coils	1		
Mode of closing	Motor charged spring		
Minimum bushing creepage distance (mm)	1116	2248	4495
Feeder conditions	Long lines, moderate to severe lightning		
Maximum partial discharge level at 1.2Um/ $\sqrt{3}$	5pC		
Number of available normally open auxiliary contacts	8 minimum		
Number of available normally closed auxiliary contacts	8 minimum		
Minimum operations with spring fully charged and circuit breaker fully de-energised	Trip – close – trip		
Bushing: - Colour - Material	Light grey Porcelain / silicone		

5.3.2 Details of construction and fittings

The outdoor dead tank circuit breaker assembly covered by this specification shall include the following circuit breaker construction features:

- A 33kV, 66kV or 132kV outdoor dead tank circuit breaker complete with external tank and bushings and adequate lifting handles to maintain safety of equipment and employees.

- Vacuum or SF₆ interrupters inside the circuit breaker tank.
- Secondary gas insulation surrounding the vacuum interrupters as applicable. The insulation medium around the vacuum bottles shall be any gas that is ozone friendly, provided the insulation levels required for the circuit breaker to meet the lightning impulse withstand and power frequency withstand design levels are not compromised.
- Bushing current transformers incorporated on the circuit breaker.
- A fully functional operating mechanism enclosure.
- A fully integrated steel structure of adequate mechanical strength suitable to mount the circuit breaker and mechanism box.

Bolts, screws and nuts shall be ISO metric. All bolts shall be no longer than necessary. All bolts, nuts and washers used shall be hot dip galvanised or stainless steel. All nuts used shall be fitted with approved positive locking device.

Sharp edges and corners shall be rounded off to avoid risk of injury.

The general arrangement and configuration of individual components shall allow for easy dismantling and removal without the need to dismantle other components. Welded surfaces shall be free of scale, dirt, grease, paint or heavy rust. The welding sequence adopted should be to reduce distortion as much as possible.

All similar parts shall be accurately machined so that they can be interchangeable. All surfaces that will be connected together, or that have to be accurate for the purposes of sealing, levelling or setting up during erection, shall be accurately machined.

5.4 Technical requirements

5.4.1 General

The technical requirements for the 33kV, 66kV or 132kV outdoor dead tank circuit breakers shall be as indicated in the technical descriptions below. All technical requirements shall be met. Any deviations from the requirements shall be stated in the offer.

All technical parameters shall have a guaranteed value that the supplier shall enter, as appropriate, in Branch form FAE 3142 - 33kV, 66kV and 132kV dead tank circuit breaker evaluation form .

5.4.2 Circuit breaker type

The arc quenching or interrupting medium for the circuit breaker shall be either vacuum or SF₆.

Each circuit breaker shall consist of three (3) separate pole units mounted on a one-piece dead tank frame and shall be mechanically connected.

The circuit breaker nameplate details and the current transformer details shall be stamped on a stainless steel plate and attached to the mechanism enclosure. The nameplate shall be easily readable, from ground level, in low lighting conditions.

The name plate for the circuit breaker shall contain the following information as a minimum:

- Rated voltage of closing and opening devices.
- Rated short circuit withstand rating of the circuit breaker
- Rated voltage of spring charging motor.
- Rated voltage of auxiliary circuits.
- Type of gas insulation.
- Gas density of circuit breaker, if applicable.

- Weight, volume and quality of gas used in the circuit breaker, if applicable.
- Two (2) name-plates shall be provided for the current transformers, with one (1) on the current transformer and the other name-plate on the mechanism box.
- For class PX current transformers, the CT nameplate shall always have the actual knee point voltage and secondary resistance, for example, 0.05PX1500R4.5 @ 2000:1.

5.4.3 Vacuum circuit breakers

The design of the interrupting mechanism and contacts shall ensure that the energy dissipated in the vacuum is low and does not cause appreciable degradation of the contacts.

Means shall be provided to test the units for the existence of a vacuum without needing to remove the vacuum bottle(s). Any special test equipment required for this purpose shall be included as an option as part of the offer. Means for checking the contact wear shall also be provided. The manufacturer shall submit a graph displaying the maximum permissible electrical contact wear as a function of operations.

The vacuum bottles shall be approved for use by the Manager Primary Systems through the product approval process.

The contacts of the interrupter shall be held open by a positive fail-safe device that is independent of the interrupter vacuum. The closing arrangement shall be designed so as to give a positive closing action whilst overcoming the contact hold open device.

The secondary insulation gas parameters and insulators supporting the vacuum interrupter shall be categorically stated in Branch form FAE 3142 - 33kV, 66kV and 132kV dead tank circuit breaker evaluation form.

The supplier shall provide full details of charging/discharging and storing of the gas, including equipment needed and any safety measures necessary.

The gas leakage rate shall be guaranteed to be less than 0.1% a year for sealed and 0.5% a year for closed pressure system, for the whole life of the equipment.

A temperature compensated gas density gauge shall be provided to indicate safe gas operating density within the tank. There shall be provision to fill or top up gas with the unit in service without loss of gas. The types of valves to be used shall be agreed at contract negotiations.

Each circuit breaker (or each pole of a circuit breaker where not in a common housing) shall be fitted with a gas density sensing device arranged to prevent the operation of the circuit breaker where the gas density is less than that specified by the manufacturer for correct and safe operation of the circuit breaker.

A density switch shall be provided with three (3) sets of contacts, the first on stage one low gas for alarm, and the second on stage of two (2) contacts low gas that open when the gas density falls below the manufacturer's recommended minimum. A link shall be provided for Endeavour Energy to choose whether the breaker should trip or stay closed on low pressure. A typical concept of the tripping and closing scheme is outlined on drawing numbers: 364493, 364494 and 364495.

The circuit breaker tank shall be capable of withstanding absolute vacuum.

The gas tightness shall be obtained by elimination of any part likely to wear or age.

All exposed gas pipe work shall be mechanically protected against any accidental damage.

A WorkCover Pressure Vessel Certificate shall be provided with the tender. Failure to provide the certificate will result in disqualification of the tender

The supplier shall outline the relevant precautions to be taken by Endeavour Energy when testing the vacuum circuit breaker in line with the requirements of AS 2981:2008.

5.4.4 *SF₆ circuit breakers*

Where SF₆ circuit breakers are offered, the following shall apply:

- The tank shall be filled with SF₆ gas for arc quenching and/or electrical insulation.
- Tanks with SF₆ shall be sealed for life.
- The supplier of the SF₆ switchgear shall have a return policy whereby they will accept responsibility for disposal of the SF₆ switchgear and any remaining SF₆ gas or by-products for the whole life of the CB. The supplier shall also accept SF₆ gas that is evacuated during maintenance for the whole life of the circuit breaker.
- The acceptable level of purity of new SF₆ gas shall be specified by the supplier and be in accordance with Substation Design Instruction SDI 545 – Acceptable purity limits for SF₆ gas.
- All the requirements for the treatment of gas as outlined in clause 5.4.3 shall apply to the treatment of SF₆.
- The supplier shall provide as a part of the tender submission the mass, volume and pressure of the SF₆ contained in each circuit breaker any gas compartment.

5.4.5 *Circuit breaker operating mechanism and enclosure*

The circuit breaker operating mechanism shall be an integral part of the circuit breaker.

The parts of the mechanism that require preventive inspection and maintenance shall not be enclosed in any gas tight compartment.

The mechanism shall contain stored energy motor spring charging equipment to operate the circuit breaker. It shall be possible to perform all operations of the circuit breaker manually and electrically.

The circuit breaker in the closed position shall be able to have a TRIP-CLOSE-TRIP operation before the spring needs to be charged.

The mechanism enclosure shall be manufactured from grade 316 stainless steel of adequate strength and thickness. The enclosure shall achieve a rating of IP55 in accordance with IEC 60529:2013.

The enclosure shall be arranged to accept bottom entry cabling and shall be provided with a 4mm thick aluminium or brass gland plate, suitably sized to accommodate the required cabling whilst leaving at least 50% additional spare capacity.

The enclosure shall be supplied complete with a weather-proof hood and shall be vermin proof.

A vertically hinged door shall be provided to allow access to all equipment in the cubicle.

Each door shall be of full height and shall not exceed 1000mm in width. The door shall open through 120°, be provided with a device to secure the door in the open position, and be secured closed by not more than two (2) hand operated lockable handles suitable for Lockwood 234/45 (8mm shank) locks.

The outdoor enclosure shall be provided with a low surface temperature thermostatically controlled anti-condensation heater, interior cubicle light and associated control switches.

The terminals of these devices shall be segregated from all other terminals, shrouded against direct contact and provided with a red-white *Traffolyte* live connections warning label.

All enclosures shall be mounted so that there is clear unimpeded access to the enclosure and all equipment mounted in the enclosure.

The circuit breaker enclosure must be provided to house terminal strips and control and monitoring equipment.

Isolating switches shall be provided in the enclosure to enable all control circuits in the cabinet to be isolated during maintenance.

These switches should be Kraus and Naimer C26 or similar.

All 230/400V terminals shall be shrouded and fitted with a warning label.

The degree of protection of the mechanism box enclosure shall be not less than IP55 and it shall be mounted so that the gland plate is no lower than 800mm above ground level, and its top no higher than 2000mm (1800mm preferred) above ground level.

The mechanism enclosure shall be provided suitable for two (2) M12 earthing studs on opposite sides of the box for connection of cable lugs for 95mm² or 120mm² earthing cables.

5.4.6 *Circuit breaker operation and control*

The circuit breaker closing mechanism shall be electrically operated trip-free.

The circuit breaker shall close when the close command is applied. The circuit breaker shall not attempt to make a second attempt to close if it fails to close on the first attempt.

The circuit breaker shall open on an open command when a trip signal is applied to one (1) or both trip coils, as appropriate.

The circuit breaker shall be capable of being operated locally at the mechanism box, or remotely through a SCADA system. The SCADA system will provide an OPEN or CLOSE command signal of 1.0 Amp DC maximum for a duration of one (1) second.

A LOCAL- REMOTE changeover switch shall also be provided in the mechanism enclosure to facilitate the changeover of control.

Local CLOSE and OPEN switches or push buttons, coloured red and green respectively, shall be provided in the breaker enclosure to operate the breaker locally.

A mechanical push button or similar device shall be provided for tripping the circuit breaker manually.

Necessary provision shall be made to prevent the spring charging motor from running continuously in the event that the springs have failed to charge.

The circuit breaker shall trip only once, even if the trip button is continuously depressed, and shall also close only once in the event that the close button is continuously depressed.

This shall be achieved by using an anti-pumping relay.

The coils of the control contactors associated with the solenoid operated closing device shall be rated for continuous operation.

5.4.7 *Circuit breaker indication*

The following indications shall be provided on the control panel:

- An indicator to show whether the stored energy device is charged or discharged shall be provided.
- A mechanically operated indicator that shows whether the breaker is open or closed.
The word OPEN or CLOSED shall clearly indicate and be clearly visible in indicating the status of the circuit breaker. The colour red shall indicate the closed position and the colour green shall indicate the open position
- Each circuit breaker shall be equipped with a non-resettable mechanically operated counter for indicating the number of tripping operations. The counter shall be readable from the front of the switchgear, from ground level, without the removal of equipment.

5.4.8 *Circuit breaker auxiliary and ancillary equipment*

Ancillary equipment shall be supplied and mounted in the mechanism box on the switchgear in accordance with the following:

5.4.8.1 *Auxiliary supplies*

120V dc station battery supplies will be available for closing, tripping and spring charging motors. Battery voltage: maximum 130V dc, minimum 80V dc.

A three phase, four (4) wire 230/400V, 50Hz station supply is available for power outlets and heater supplies.

5.4.8.2 *Access to control equipment*

All control equipment within the cubicle shall be easily accessible with the labelling visible from ground level to an operator of average height (175cm).

5.4.8.3 *Control fuses*

All secondary fuse holders, including those used as links, shall be GEC *Safeclip* C32/20 or similar.

Fuse holders containing a fuse link shall be coloured black and those containing a solid link shall be coloured white.

All fuses, links and terminals shall be accessible from the front of the control panel.

5.4.8.4 *Auxiliary contacts and relays*

All ancillary contactors and relays shall be of a type proven to be capable of handling the current and voltages involved in the normal operation of the switchgear. All operating coils, except the trip coils, shall be continuously rated for the supply voltage used.

The supervisory open and close relays to be used in the circuit breaker control scheme shall be as stated above.

5.4.8.5 *Circuit breaker auxiliary switches*

Each unit shall be fitted with sufficient auxiliary switches to perform all the functions required by the CB, as shown on Drawing no. 364495.

Each contact shall be suitable for making, carrying and breaking five (5) Amps at 120Vdc and three (3) Amps at 250Vac in a typically inductive (magnet coil) circuit.

5.4.8.6 *Control cable wiring*

Control cable terminating facilities shall be provided on each unit. All external cabling shall be supplied and terminated by Endeavour Energy.

The supplier shall provide all internal wiring including the external interface wiring to be terminated at the terminal blocks ready for external wiring termination. A typical terminal block is as set out in Drawing no. 356531.

All wiring shall be carried out in accordance with Equipment Technical Specification (ETS) 0014 section 5.3. All the wiring requirements outlined in Equipment Technical Specification ETS 0014 - Protection and control panels shall be followed.

The supplier shall make themselves aware of these requirements before submitting the tender.

A blank removable gland plate shall be provided so that Endeavour Energy may drill to suit the cables used. The gland plate shall be large enough to accommodate four (4) glands, each with an overall diameter of 60mm.

5.4.8.7 Wire termination

All control cables (internal panel wiring and external control cables) shall be terminated in accordance with section 5.1 of Substation Design Instruction SDI 526 - Control cabling, panels and termination.

5.4.8.8 Secondary terminal blocks

The acceptable terminal blocks to be used are as indicated in Table 1 of Equipment Technical Specification ETS 0014 – Protection and control panels.

Current transformer terminal blocks shall be of the bolt type (min. 5mm) or tunnel connectors. Where tunnel connectors are used, they shall be spring pressure, for example, WDU SL

Protection circuit terminal blocks shall be tunnel connectors of the spring pressure type, for example, WDU SL

Control wiring terminal blocks shall be suitable for the size of conductor being used and the type of terminal strip employed.

Suitable plastic shrouds shall be provided for all control wiring terminal blocks. Where the terminal blocks are used for 230V AC termination, the warning labels with white letters of **Warning 230V AC** on a red background, with minimum letter size of 5mm are required.

5.4.8.9 Control switch

Each unit shall be fitted with a Kraus and Naimer (or equivalent) C26 (operating handle G1,02) or push button control switch with spring return to the neutral position following the electrical operation of the circuit breaker by an operator standing at the switchgear.

The escutcheon of the switch shall include a function designation of the circuit breaker operation. The rating of the switch contacts shall ensure that they are capable of clearing the coil currents in the event of the breaker not functioning correctly.

5.4.8.10 Conduits

Threads shall join all conduits used in the secondary circuits with approved fittings

5.4.8.11 Labels

All equipment within the cubicle(s) shall be clearly labelled to show its function. Labels shall be of laminated plastic having black upper case letters on a white background. Lettering and numbering on labels shall be as large as practical and not less than 5mm high.

All labels shall be of the same size or at least the number of different sizes is kept to a minimum. Labels within the control cubicle shall be affixed using mechanical means or a very high bond foam tape.

External labels shall be affixed using mechanical means. Labels shall not be directly affixed to items that are readily removable or interchangeable. Gluing of labels to surfaces is not acceptable. Labels shall contain the device number and description of its function.

Drawings of the labels shall be submitted for approval prior to manufacture.

5.4.9 Terminal palms

The material of the palm shall be aluminium alloy 6061 to AS 1734:1997 or equivalent.

The terminal palms shall be free of sharp edges to reduce radio interference voltages/corona.

Termination palms shall suit the rating of the equipment, that is, Type 8 in accordance with AS 62271.301:2005.

The supplier shall supply a typical general arrangement drawing showing terminal detail and location with their tender submission.

5.4.10 Bushings

The circuit breaker bushings shall comply with AS 60137:2008.

The bushings shall be porcelain or silicone based and grey in colour.

The internal surfaces of the porcelain bushings shall be glazed.

5.4.11 Current transformers

Current transformers shall comply with AS 60044.1:2007 and data provided in Annexure 1. The exact CT details applicable shall be confirmed in the tender inquiry.

The secondary windings of the current transformers shall be capable of carrying continuously a current not less than two (2) times the rated secondary current.

The order of the current transformers and the position of the primary terminals relative to the circuit breaker are as shown on Drawing no. 356531.

Each set of current transformers shall have all secondary leads brought out to an accessible terminal block inside the mechanism/control box.

The terminals and leads shall be clearly marked with current transformer secondary terminal markings complying to AS 60044.1:2007 and show the current transformer group number in which the current transformer is mounted (for example, 3S2 - terminal number S2 of the third group).

Wiring and terminal/links shall be arranged to enable the easy changing of CT ratios.

The induced high voltage test on secondary insulation, as specified in AS 60044.1-2007, shall be applied equally to all current transformer secondary wiring and terminals between the current transformer secondary terminals and terminals provided for ratio change.

5.4.12 Drawings

The following drawings are included as part of this specification.

Drawing number	Issue	Description
355759	A	Typical HV Outdoor Dead Tank CB CT Circuit Diagram
355758	A	Interface terminal block connection diagram
364495	A	Equipment Technical Specification HV outdoor circuit breaker control circuit diagram

5.5 Surface finish

Circuit breaker support structures shall have a hot dipped galvanised finish to AS4680:2006. The galvanised finish thickness shall be at least 85 microns.

Control cabinets shall be grade 316 stainless steel and in accordance with AS4680-2006.

Details of the protection system for the enclosure are to be provided with the tender.

The contractor shall touch up paintwork damaged in transit or during installation.

5.6 Testing

5.6.1 General

The supplier shall provide one (1) copy of certified test reports for all type tests required by AS 62271.100, AS 62271.1, and AS 60044.1 with the tender.

Reports written in any language other than English shall not be accepted by Endeavour Energy unless such reports are translated into English by a sworn translator.

All tests shall be carried out by a testing authority holding appropriate accreditation:

- by NATA Australia; or,
- by an accreditation authority recognised by NATA Australia.

Tests from other testing authorities, such as KEMA, may be accepted at the discretion of the Network Substations Manager.

All routine tests and acceptance tests required by the above standards shall be performed and one (1) copy of test reports supplied.

Where special tests are required in addition to the above, the cost of these is to be included in the contract. The supplier shall submit details of type, routine and special tests that are performed, as standard, to the various 33kV, 66kV or 132kV insulation components during and on completion of manufacture.

5.6.2 Type test

The supplier shall carry out the following pertinent tests, as a minimum. These tests together with the routine tests shall be carried out as part of factory acceptance tests. The test results shall be submitted for approval by the Network Substations Manager before the CB is shipped.

5.6.2.1 Circuit breaker

The following type tests shall be performed on a representative circuit breaker according to the relevant standards.

Type tests	Acceptable value	Test method reference
1. Dielectric tests	No disruptive discharge	AS62271.1:2012 Cl 6.2
2. Radio interference voltage tests	<2500 μ V.	AS62271.1:2012 Cl. 6.3
3. Measurement of the resistance of the main circuit	Specified by the manufacturer.	AS62271.1:2012 Cl. 6.4
4. Temperature-rise tests	In accordance with Table 3 of AS62271.1-2012 Resistance of main circuit after the temperature rise test shall not be increased by more than 20%.	AS62271.1:2012 Cl 6.5 and 6.4
5. Short-time withstand current and peak withstand current tests	Conforms to conditions in AS62271.1:2012 Cl. 6.6.4	AS62271.1:2012 Cl 6.6
6. Tightness tests :leakage rate at 45 deg C	$\leq 0.1\%$ per annum for sealed and $\leq 0.5\%$ per annum for closed pressure systems.	AS62271.1:2012 Cl 6.8
7. Mechanical operation test at ambient temperature	Travel characteristics before test same as after test	AS62271.100:2008 Cl.6.101.2.1 to 6.101.2.3
8. Short-circuit current making and breaking tests	No failure to break from 10% to 100% of rated breaking current.	AS62271.100:2008 Cl.6.102 to 6.106

Type tests	Acceptable value	Test method reference
9. Capacitive current switching tests: line charging and cable charging current switching tests	Conforms to conditions in AS62271.100:2008 Cl. 6.111.11.2 (a) & (b).	AS62271.100:2008 Cl. 6.111.5.1 to 6.111.5.2
10. Verification of the degree of protection	Meets requirements of IP55	IEC60529:2013 Cl.11 to 15
11. Low and high temperature tests	CB settings, operating characteristics and tightness are the same as before the test.	AS62271.100:2008 Cl. 6.101.3
12. Electrical endurance tests	Conforms to conditions in AS62271.100:2008 Cl. 6.102.9.2 and 6.102.9.3.	AS62271.100:2008 Cl.6.112
13. Single-phase and double earth fault tests	No undue failure of breaker	AS62271.100:2008 Cl.6.108

5.6.2.2 Current transformers

The following type tests shall be conducted on the current transformers according to the relevant standards:

Type test	Acceptable value	Test method reference
1. Short time current test	Conforms to conditions in AS60044.1:2007 Cl. 7.1 (a) – (d)	AS 60044.1:2007 Cl.7.1
2. Temperature rise test	Complies with the requirements of section 4.6 of AS60044.1:2007	AS 60044.1:2007 Cl.7.2
3. Lightning impulse test	No disruptive discharge.	AS 60044.1:2007 Cl.7.3.2
4. Wet test	No flashover	AS 60044.1:2007 Cl.7.4
5. Determination of errors	Table 11 of AS60044.1:2007	AS 60044.1:2007 Cl.11.4
6. Radio interference voltage measurement	<2500µV	AS 60044.1:2007 Cl.7.5
7. Proof of low reactance type (for class PX current transformers)	Conforms to conditions in AS60044.1:2007 Cl. 14.3.1	AS 60044.1:2007 Cl.14.3

5.6.3 Routine test

The following routine tests shall be carried out on each piece of equipment supplied to Endeavour Energy. Routine test reports shall be submitted and approved by Endeavour Energy with each piece of equipment prior to dispatch from factory.

5.6.3.1 *Circuit breaker*

The following routine tests shall be carried out on each circuit breaker by the supplier prior to delivery to the nominated site.

Routine test	Acceptable value	Test method reference
1. Dielectric test on main circuit	No disruptive discharge	AS62271.1:2012 Cl.7.1
2. Dielectric test on auxiliary and control circuits	>5 MΩ using 1000 Volt megger	AS62271.1:2012 Cl.7.2
3. Measurement of resistance of main circuit	Shall not exceed 1.2 times of the type test values.	AS62271.1:2012 Cl.7.3
4. Mechanical operation test	Complies with standard after five (5) close/open operations	AS62271.100:2008 Cl.7.101
5. Design and visual test	Meets specification	AS62271.1:2012 Cl.7.5
6. Tightness test	No gas leaks.	AS62271.1:2012 Cl.7.4
7. Dielectric dissipation factor (bushings)	<5mR	AS62271.100:2008 Cl.7.200
8. Partial discharge test at $1.2U_m/\sqrt{3}$	<5pC	AS62271.100:2008 Cl.7.201

5.6.3.2 Current transformer

The following routine tests shall be carried out on current transformer supplied to Endeavour Energy. All routine test reports, as set out in AS 60044.1:2007, resistance measurements, accuracy checks and CT saturation curve shall be provided.

Routine test	Acceptable value	Test method reference clause
1. Verification of terminal markings	As verified	AS 60044.1: 2007 Cl. 8.1
2. Power frequency withstand test on primary winding	No disruptive discharge.	AS 60044.1: 2007 Cl. 8.2.1
3. Partial discharge measurement	In accordance with table 6 of AS60044.1:2007	AS 60044.1: 2007 Cl. 8.2.2
4. Power frequency withstand tests, between sections and on secondary windings	No disruptive discharge at 3kV	AS 60044.1: 2007 Cl. 8.3
5. Inter turn over voltage test (including leads)	No inter-turn short circuit.	AS 60044.1: 2007 Cl. 8.4
6. Determination of errors	As set out in table 11 of standard.	AS 60044.1: 2007 Cl. 11.5
7. Additional test for Class PX protective current transformers: (i) Rated knee point emf and maximum exciting current (ii) Secondary winding resistance (iii) Turns ratio error (iv) Insulation tests (v) Inter-turn insulation test (including leads)	Conforms to conditions in AS60044.1:2007 Cl. 14.4	AS 60044.1: 2007 Cl. 14.4

For metering CTs, where required, accuracy reports shall meet the requirements of the National Electricity Market Code (Chapter 7, Metering), Schedule 7.3, Clause S7.3.1 (b) (or as amended) in respect of measurement of class accuracy within stated uncertainty of measurement limits. All tests shall be carried out by a testing authority holding appropriate accreditation:

- By NATA Australia; or,
- By an accreditation authority recognised by NATA Australia.

5.6.4 Site tests

The circuit breakers shall be tested at site, by the supplier as follows:

The test schedule shall include, but not be limited to, the following:

- Physical inspection
- Insulation resistance testing (primary circuit) - acceptable limit is >250 Giga Ohm using 2.5kV megger.
- Insulation resistance (secondary circuit) - acceptable limit is >5 Mega Ohm using 1000V megger.
- Contact resistance testing – The measured value shall not exceed 1.2 times of the type test values.
- Gas quality tests (if applicable).

- DDF acceptable limit is <5mRad;
- Circuit breaker partial discharge level at $1.2U_m/\sqrt{3}$ <5pC.
- Opening and closing coil resistances.
- Timing tests.
 - 5 off close operations
 - 5 off trip 1 operations
 - 5 off trip 2 operations
 - 2 off C-O operations (trip 1)
 - 2 off C-O operations (trip 2)
 - 2 off close operation minimum operating Volts
 - 2 off trip1 operation minimum operating Volts
 - 2 off trip 2 operation minimum operating Volts

5.7 Maintenance requirements

5.7.1 Maintenance instructions

The supplier shall provide detailed instructions for the maintenance of the circuit breaker..

5.7.2 Spare parts

The supplier shall supply a list of recommended spare parts, special tools and appliances required for the whole of life operation and maintenance of the switchboard installation. The list, together with prices, shall be indicated in the appropriate schedule. The supplier must also provide details of the recommended maintenance and the frequency at which it must be carried out. Special tools are to be part of the main contract.

The items nominated must allow most common defects to be repaired and recommended maintenance to be carried out expeditiously over the whole life of the switchboard.

Predicted availability and compatibility of ex-stock parts over the life of the switchboard will be considered. Lists shall be complete with part numbers and current prices for each item. Where identical items have been supplied to Endeavour Energy as spares on previous contracts, details of the quantity and type supplied shall be provided. The final quantities of spares to be supplied will be decided as part of contract negotiation.

5.7.3 Failure mode analysis and preventative maintenance

The supplier shall indicate and provide updates to Endeavour Energy the mean time between failures (MTBF) of the switchboard and its components including the recommended maintenance regime and maintenance tasks and intervals. This regime shall be based on the mean time between failure (MTFB) and the critical failure modes identified by the failure mode, effects and criticality analysis (FMECA) of the equipment. Details substantiating the FMECA analysis shall be included in the offer.

Recommended tests to be carried out throughout the life of the switchboard and its components, including the pass/caution/fail criteria for each test shall be included in the offer.

5.8 Quality assurance

Quality assurance certification is required to ensure the manufacturers ability to design and consistently manufacture switchgear to this specification. The supplier and all its contractors shall have a quality system which complies with the requirements of AS/NZS ISO 9001 or other comparable Australian or International equivalent.

All nominated drawings and documents that have to be reviewed by Endeavour Energy are to be submitted as complete packages using document controls systems such that all the relevant information to enable the design to be reviewed are available. Design suitability approval will not relieve the supplier of its responsibilities for the correctness and appropriateness of the design or their responsibility to conform to this specification.

5.8.1 *Quality assurance plan*

A quality assurance plan is to be provided as part of the tender; it shall be a document subject to approval of Endeavour Energy and shall contain as a minimum the following information:

- a) The supplier's organisational structure for the works.
- b) A planned outline meeting the requirements and all stages of the scope and specification.
- c) An index showing all existing procedures, inspection and test plans and drawings.
- d) AS/NZS ISO 9001 certification for itself and subcontractors.
- e) A plan detailing the design, ordering of materials, manufacturing and test plans.

5.8.2 *Operations and maintenance manual*

The manufacturer/supplier shall submit the following documentation prior to delivery of the equipment to Endeavour Energy as follows:

Two (2) hard copies and two (2) electronic copies of the complete installation, operation and maintenance manual shall be provided for the complete switchgear supplied for each contract. Each manual shall relate specifically to the equipment supplied and must not contain any material that is not applicable. The manual shall be A4 size and all drawings shall be suitably folded or reduced for filing within the manual. Each manual shall include:

- a) A hard cover to withstand normal handling.
- b) A comprehensive index.
- c) Installation instructions.
- d) Operating instructions.
- e) Instructions for the routine maintenance of the equipment and associated auxiliary equipment.
- f) Recommended maintenance schedules.
- g) Tests after maintenance work
- h) Type test reports.
- i) Details of the attachment point for a transducer to perform a travel curve test; the transfer function (formulae) for the relationship between the transducer attachment point and the movement of the arc and main contacts; and the measurement table as in Branch form FAE 3142 - 33kV, 66kV and 132kV dead tank circuit breaker evaluation form.
- j) A complete list of parts with serial numbers.
- k) Copies of detailed drawings.
- l) Drawings of auxiliary equipment.
- m) Routine factory tests.
- n) Data sheets for each piece of equipment used clearly marking the components used.
- o) Design risk assessment.

Following this, for each order, one (1) hard copy and one (1) electronic copy of the following shall be provided.

- a) A complete list of parts with serial numbers.
- b) Copies of detailed drawings.
- c) Drawings of auxiliary equipment.
- d) Routine factory tests.
- e) Data sheets for each piece of equipment used in the circuit breaker clearly marking the components used.

5.8.3 Additional information

The following information shall also be submitted:

- a) A list of recommended spares and tools, with prices and availability of each item.
- b) Details of technical back-up facilities available.
- c) Details of equipment operating history, including how many in service, where, and for what period, plus reference contact names and numbers.

5.9 Transportation

The supplier to this specification is responsible for the transportation between a manufacturer's works and the site nominated by Endeavour Energy within Endeavour Energy's franchise area.

The costs, risks and responsibilities for transportation are the responsibility of the supplier and shall be agreed prior to contract acceptance. This include the responsibility for the load profile for each transport mode, transport route, the means of transport, any necessary route alteration, statutory approval or licenses, shipping reservations and documentation or any other requirement concerning the delivery of the switchgear to the nominated site.

5.9.1 Design for transport

The DTCB shall be of a robust design and safeguarded for transportation, capable of withstanding any shock to which it may be subjected to during transport taking all planned transport modes into consideration. Necessary mechanical withstand capability shall be built into the design. Endeavour Energy requires the installation on the packaging of suitable shock indicators based on the equipment design to ensure no equipment damage has occurred during transport. All equipment damage shall be the responsibility of the supplier.

5.9.2 Packing

The supplier shall suitably pack each switchgear unit in a wooden crate complete with all other accessories, such as bolts, nuts, operating shafts, links, and enclosure parts.

All measures shall be taken to ensure that damage will be avoided during packing, transporting and dismantling.

The following shall be written in BLACK lettering (75mm high) on each wooden crate:

- Endeavour Energy.
- Contract number.
- Supplier's name.
- Mass.
- Voltage rating

5.10 Product approval

5.10.1 Product approval and audit form

Complete information of the equipment shall be provided on branch form FAE 3142 - 33kV, 66kV and 132kV dead tank circuit breaker evaluation form .

5.10.2 Product approval process

The equipment shall be evaluated under the product approval process set out in Branch Procedure PAE 1004 – Product Approval Process. The Network Substations Manager will approve the equipment/components for use on the network.

6.0 AUTHORITIES AND RESPONSIBILITIES

The **Chief Engineer** has the authority and responsibility for:

- approving this Specification, including any variations;
- making all decisions concerning compliance in respect to this Specification;
- nominating Endeavour Energy's representative(s) for either the manufacturing facility inspection and/or witness testing; and,
- delegating any of these authorities and responsibilities to the Manager Primary Systems.

The **Manager Primary Systems** has the authority and responsibility for:

- reviewing this specification and making recommendations to the Chief Engineer; and,
- making recommendations concerning compliance in respect of this Specification; and
- making nominations of Endeavour Energy's representatives.

The **Manager Project Development** has the authority and responsibility for:

- determining the equipment procured complies with the requirements of this specification.
- checking FAT and site test reports and seek dispensation from Primary Systems as necessary for marginal non-compliances.

The **Network Substations Manager** has authority and responsibility for:

- reviewing all type and routine test reports and alternative proposals submitted for evaluation, and making recommendations to the Manager Primary Systems.
- clarifying all the technical aspects of this specification to the stakeholders; and
- approving the relevant actions required and outlined in this specification.

The **Project Managers** have the authority and responsibility for certifying that the CBs procured comply with the requirements of this specification.

The **Commercial Manager** has the authority and responsibility to certify that the circuit breaker purchased through the tender process complies with the requirements of this specification.

Manufacturers/suppliers have the authority and responsibility for:

- adherence and awareness of their responsibilities under this specification;
- providing suitable training for the contractor/s under their control to safely perform works to this specification;
- implementing an effective safety, environmental and quality auditing system is in place; and,
- implementing this specification and keeping Endeavour Energy or other responsible equivalent officers informed of any factors that may prevent them from accepting responsibility for its full implementation.

7.0 DOCUMENT CONTROL

Documentation content coordinator: Network Substations Manager

Documentation process coordinator: Standards Process Coordinator

Annexure 1: Current transformers**132kV current transformers**

	Option - 1	Option - 2
Total protection cores/phase	4	4
Protection cores	All four cores	All four cores
Rated transformation ratio	2000/1500/1000/1	3000/2000/500/1
Class/designation	0.05PX150(R _{ct} +2) on 2000:1	0.05PX200(R _{ct} +3) on 2000:1
Secondary winding resistance at 75°C (R _{ct})	the supplier shall specify this value in the tender offer	the supplier shall specify this value in the tender offer
Rated secondary thermal current	2A	2A
Rated primary current	2500A	3150A/2500A
Nominal system voltage	132kV	132kV
Highest voltage for equipment	145kV	145kV
Rated frequency	50Hz	50Hz
Rated short time power frequency voltage	275kV	275kV
Rated lightning impulse withstand voltage	650kV	650kV
Rated short time withstand current	40kA/1Sec	40kA/1Sec
Note-1: Option-1 is suitable for green-field transmission substation. Option-2 is suitable for the large transmission substations with the existing protection schemes. Note-2: A metering core of class 0.5S, 5VA is to be provided. Available ratio of the metering core shall be identical to the ratio of the protection cores. Note-3: -The CT class/designation format provided in the table to give the manufacturer some flexibility in how they build the CT. But actual values for knee point voltage (V_k) and secondary winding resistance at 75°C (R_{ct}) shall be specified in the tender offer and these need to be maintained consistently throughout the contract term. Actual knee point voltage (V_k) and secondary winding resistance at 75°C (R_{ct}) shall be provided on the nameplate of the CT. All current transformers shall be tested for compliance to class as set out in AS 60044.1-2003.		

66kV current transformers

	Option - 1		Option - 2
Total protection cores/phase	4		4
Protection cores	1 st & 2 nd core	3 rd & 4 th core	All four cores
Rated transformation ratio	2000/1500/1000/1	2000/1000/500/2501	1000/500/250/1
Class/designation	0.05PX200(R _{ct} +2) on 2000:1	0.05PX150(R _{ct} +2) on 2000:1	0.05PX100(R _{ct} +2) on 1000:1
Secondary winding resistance at 75°C (R _{ct})	the supplier shall specify in the tender	the supplier shall specify in the tender	the supplier shall specify in the tender
Rated secondary thermal current	2A	2A	2A
Rated primary current	2000A	2000A	2000A
Nominal system voltage	66kV	66kV	66kV
Highest voltage for equipment	72.5kV	72.5kV	72.5kV
Rated frequency	50Hz	50Hz	50Hz
Rated short time power frequency voltage	140kV	140kV	140kV
Rated lightning impulse withstand voltage	325kV	325kV	325kV
Rated short time withstand current	31.5kA/1Sec	31.5kA/1Sec	31.5kA/1Sec
Note-1: Option-1 is suitable for transmission substations and large zone substations (1st and 2nd core will be used for feeder protection and 3rd and 4th core will be used for BBP). Option-2 is suitable for small zone substations. Note-2: A metering core of class 0.5S, 5VA is to be provided. Available ratio of the metering core shall be identical to the ratio of the protection cores. Note-3: -The CT class/designation format provided in the table to give the manufacturer some flexibility in how they build the CT. But actual values for knee point voltage (V_k) and secondary winding resistance at 75°C (R_{ct}) shall be specified in the tender offer and these need to be maintained consistently throughout the contract term. Actual knee point voltage (V_k) and secondary winding resistance at 75°C (R_{ct}) shall be provided on the nameplate of the CT. All current transformers shall be tested for compliance to class as set out in AS 60044.1-2003.			

33kV current transformer

	Option - 1	Option - 2
Total protection cores/phase	4	3
Protection Cores	All four cores	All three cores
Rated Transformation Ratio	2000/1500/1000/1	1000/800/300/1
Class/Designation	0.05PX150(Rct+3) on 2000:1	0.05PX100(Rct+3) on 1000:1
Secondary Winding Resistance at 75°C (R _{ct})	the supplier shall specify in the tender	the supplier shall specify in the tender
Rated Secondary thermal Current	2A	2A
Rated Primary Current	2000A	2000A
Nominal System Voltage	33kV	33kV
Highest Voltage for Equipment	36kV	36kV
Rated Frequency	50Hz	50Hz
Rated Short time Power Frequency Voltage	70kV	70kV
Rated Lightning Impulse withstand Voltage	170kV	170kV
Rated Short Time Withstand Current	31.5kA/1Sec	31.5kA/1Sec

Note-1: Option-1 is suitable for transmission substations and option-2 is suitable for zone substations

Note-2: A metering core of class 0.5S, 5VA is to be provided. Available ratio of the metering core shall be identical to the ratio of the protection cores.

Note-3: -The CT class/designation format provided in the table to give the manufacturer some flexibility in how they build the CT. But actual values for knee point voltage (V_k) and secondary winding resistance at 75°C (R_{ct}) shall be specified in the tender offer and these need to be maintained consistently throughout the contract term. Actual knee point voltage (V_k) and secondary winding resistance at 75°C (R_{ct}) shall be provided on the nameplate of the CT. All Current Transformers shall be tested for compliance to class as per AS60044.1-2007.