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Equipment Technical Specification

12kV, 24kV and 36kV reclosers

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Substation Design Instruction

ASSET STANDARDS & DESIGN

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ETS 0074 12KV, 24KV AND 36KV RECLOSER

CONTENTS

1.0	PURPOSE.....	4
2.0	SCOPE	4
3.0	REFERENCES.....	4
4.0	DEFINITIONS AND ABBREVIATIONS.....	5
5.0	ACTIONS.....	5
5.1	Service conditions.....	5
5.1.1	General.....	5
5.1.2	Service conditions.....	6
5.2	Health, safety and environment (HSE) requirements.....	7
5.2.1	Special environmental requirements - toxicology safety.....	7
5.2.2	Noise levels and radio interference voltage (RIV)	7
5.2.3	Fire and blast hazards	7
5.3	Technical requirements.....	7
5.4	Construction requirements.....	9
5.4.1	Primary switch	9
5.4.2	Mounting.....	9
5.4.3	Bushings.....	10
5.4.4	Control and protection cubicle.....	10
5.5	Protection, control and metering.....	11
5.5.1	Protection	11
5.5.2	Metering	14
5.5.3	Control.....	15
5.5.4	Local control and indication	15
5.5.5	Remote control and indication.....	16
5.6	Firmware and hardware change controls	20
5.6.1	Design changes.....	20
5.6.2	Firmware upgrades.....	21

5.7	Rating plate	21
5.8	Additional information.....	21
5.9	Tests	22
5.9.1	<i>Type tests</i>	22
5.9.2	<i>Routine tests.....</i>	23
5.9.3	<i>Accreditation and acceptability of testing authorities</i>	24
5.10	Product approval	24
5.10.1	<i>Product approval and audit forms</i>	24
5.10.2	<i>Product approval process</i>	25
6.0	AUTHORITIES AND RESPONSIBILITIES.....	25
7.0	DOCUMENT CONTROL	25

1.0 PURPOSE

To set out in detail the minimum technical requirements for the selection of 12kV, 24kV and 36kV reclosers for use in the company's 12kV, 24kV and 36kV distribution network.

2.0 SCOPE

This Specification covers the design, engineering, manufacture, testing, supply and delivery of 12kV, 24kV and 36kV reclosers. It is not the intention to specify all design, manufacturing and constructional details of the reclosers. However, the equipment supplied must meet the highest standards of design, engineering and manufacturing practices.

All supplied reclosers and associated equipment must be manufactured and tested to the standards with the year of publication listed in section 3.0 below. In some circumstances based on local network conditions and experience, this specification is more stringent or is inclusive of requirement not covered in Australian and International Standards; in this circumstance the requirements of this specification must take precedence.

The tenderer must state any non-compliance with the specification in the tender submission and any alternative offers must be submitted in full and separately from the main offer. Any proposed variations from this specification must be referred to Network Substations Manager for approval prior to acceptance.

3.0 REFERENCES

Internal

Company Policy (Network) 9.2.2 – Network Protection
Company Policy (Network) 9.2.5 – Network Asset Design
Company Policy (Network) 9.7.1 – Network Asset Construction
Company Policy (Network) 9.8.3 – Network Operations
Company Policy (Network) 9.9.1 – Network Asset Maintenance
Mains Construction Instruction MCI 0005 – Overhead distribution: Construction standards manual
Mains Design Instruction MDI 0031 – Overhead distribution network design
Substation Design Instruction SDI 101 – Distribution substation general details and minimum requirements
Substation Maintenance Instruction SMI 101 – Minimum requirements for maintenance of distribution equipment
Company Network Management Plan December - 2013 Review
Branch Form FAE 3080 - 12kV, 24kV and 36kV reclosers product approval form
Branch Procedure (System Operations) NCB 4377 - Pole mounted reclosing circuit breakers

External

Work Health and Safety Act 2011 (NSW)
Work Health and Safety Regulation 2011
ENA National Electricity Network Safety Code (Doc. 01-2008)
Australian Standards AS ISO 1000:1998 - The international system of units (SI) and its application
AS1824.1:1995 - Insulation coordination - Definitions, principles and rules
AS 1931.1:1996 - High voltage testing techniques - General definitions and test requirements
AS 2067:2008 - Substations and high voltage installations exceeding 1kV ac
AS 2344:1997 - Limits of electromagnetic interference from overhead a.c. powerlines and high voltage equipment installations in the frequency range 0.15 to 1000 MHz
AS 4398.2:2005 Insulators – Ceramic or glass – Station post for indoor or outdoor use – Voltages greater than 1000V a.c. Part 2: Tests

AS 4435.4:2005 Insulators - Composite for overhead power lines - Voltages greater than 1000V a.c. - Definitions, test methods, acceptance criteria for post insulator units
 AS 60044.1:2007 - Instrument transformers Part 1: Current transformers
 AS 60137:2008 - Insulated bushings for alternating voltages above 1000V
 AS 60270:2001 - High voltage test techniques - Partial discharge measurements
 AS 62217:2007 - Polymeric insulators for indoor and outdoor use with a nominal voltage > 1000V - General definitions, test methods and acceptance criteria
 AS 62271.1-2012 - High voltage switchgear and control gear – common requirements
 AS 62271.100-2008 - High voltage switchgear and control gear - High voltage alternating current circuit breakers
 AS 62271.301-2005 - High voltage switchgear and control gear Part 301: Dimensional standardization of terminals
 AS/NZS 2344:1997 - Limits of electromagnetic interference from overhead a.c. powerlines and high voltage equipment installations in the frequency range 0.15 to 1000MHz
 AS/NZS 4680:2006 - Hot dip galvanised (zinc) coatings on fabricated ferrous articles
 IEC 62271-111:2012/IEEE Std C37.60-2012 - High-voltage switchgear and controlgear – Part 111: Automatic circuit reclosers and fault interrupters for alternating current systems up to 38 kV
 IEC 60255-1:2009 - Measuring relays and protection equipment Part 1: Common requirements
 IEC 60255-151:2009 - Measuring relays and protection equipment - Part 151: Functional requirements for over/under current protection

4.0 DEFINITIONS AND ABBREVIATIONS

ABC	aerial bundle cable
AC	alternating current
ARC	automatic recloser
CCT	covered conductor thick
company	Endeavour Energy
CT	current transformer
DC	direct current
HV	high voltage
LV	low voltage
NATA	National Association of Testing Authorities
RMS	root mean square
SCADA	Supervisory control and data acquisition
SF6	sulphur hexafluoride gas
VT	voltage transformer
XLPE	cross linked polyethylene

5.0 ACTIONS

5.1 Service conditions

5.1.1 General

Reclosers are used throughout the company's network as part of a strategy to cost effectively improve the restoration of supply after a power loss due to a network failure and provide reliability and grading performance.

The reclosers supplied must conform to all the current requirements of the relevant Australian and IEC Standards and this specification.

The equipment supplied must meet the highest standards of engineering, design and manufacturing practices.

The supplier must provide everything necessary, including any special tools, usually supplied for the safe operation of the equipment, whether directly specified or not.

The insulation level must be in accordance with the technical requirements stated. The design and construction must be in accordance with the technical requirements stated. All materials must be of a type and quality that must give a normal life expectancy of 45 years without deterioration (unless detailed otherwise). All equipment must be enclosed to the extent that there is no safety hazard to operating employee. The equipment must be fully shrouded to prevent accidental shorts by human error, flying objects or by rodents.

The manufacturer must provide details of the recommended maintenance procedures for the equipment.

Note: All values submitted to tender and in Product Approval Forms must be guaranteed values and must be treated as such in the evaluation, and when assessing whether the delivered equipment meets the specification.

5.1.2 Service conditions

The reclosers must be suitable for use on the company's 11kV, 22kV and 33kV, 3 phase 50Hz system. The neutral point of 11kV, 22kV and 33kV systems are effectively earthed.

The highest system voltages are 12kV, 24kV and 36kV RMS respectively.

However, in some 11kV, 22kV and 33kV areas in the company's system, the neutral point is non-effectively earthed. The insulation system must be suitable for non-effectively earthed systems.

The equipment must be designed for operation in the ambient temperature range of –10 deg. C to 45 deg. C. The air temperature inside the recloser may be higher due to the effects of solar radiation. The recloser must be mounted outdoors in potentially dusty, moist and coastal environments. All ratings and equipment must be suitable for this environment.

Table 1 - Service conditions

Description	Criteria
Normal service condition	Outdoor to AS62271.1
Altitude	<1000m*
Maximum ambient temperature	45 deg. C
Minimum ambient temperature	-10 deg. C
Average annual lighting 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
Wind speed	34m/s

Note * - Max altitude is 1200m in a small portion of the network which must be evaluated in accordance with the conditions in AS62271.1

5.2 Health, safety and environment (HSE) requirements

5.2.1 Special environmental requirements - toxicology safety

The supplier must 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 must be provided for the safe handling, safe operation and maintenance of products supplied. The means of disposal of the materials must be clearly stated. Material safety data sheets (MSDS) must be provided for materials that are supplied and subject to safety considerations in handling and use.

All equipment, packaging and all other accessories provided must be asbestos free. Oil provided must be PCB free.

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

5.2.2 Noise levels and radio interference voltage (RIV)

The recloser may be installed in a residential area in close proximity to residences. Therefore, it is necessary to determine if the noise level complies with this specification and the radio interference is 17 μ V/m for 11kV, 22 μ V/m for 22kV, and 26 μ V/m for 36kV, as specified in AS/NZS 2344.

5.2.3 Fire and blast hazards

The recloser and its components must be designed in a manner to reduce the risk of rupture and explosive failure and subsequent fire risk.

5.3 Technical requirements

Table 2 - Technical requirements

Description	12kV	24kV	36kV
General product details			
Applicable standards	IEC 62271-111		
Nominal voltage rating (Ur)	11 kV	22 kV	33kV
Expected life:			
• Recloser	45 yrs		
• Voltage transformer	45 yrs		
• Protection relay/system	10 yrs		
Current interrupting medium	Vacuum preferred (see clause 5.4.1)		
Insulation medium * special insulating oil, for example: Envirotemp FR3	Solid dielectric/special insulating oil * / others must be considered		
Leakage rate (where applicable)	< 0.1%/yr sealed system (< 0.5% closed system)		
Minimum creepage distance	31 mm/kV		
Pollution level	Very Heavy		

Description	12kV	24kV	36kV
Tank material/grade	304/316 stainless steel		
Insulation level (all equipment)			
Highest system voltage	12 kV	24 kV	36kV
System earthing (Refer also to Cl. 5.1.2)	Effective earth	Effective or non effective earth	Effective or non effective earth
Frequency	50 Hz	50 Hz	50 Hz
Power freq. withstand:			
• ph-E (rms for 1 sec)	28 kV	50 kV	70kV
• Across the open contacts	28 kV	50 kV	70kV
Lightning impulse withstand:			
• ph-ph-E	95 kVp	125 kVp	170kVp
• Across the open contacts	95 kVp	125 kVp	170kVp
Max partial discharge at 1.1Ur and 1.1Ur/1.73 (pC)	10	10	10
Ratings			
Rated continuous current	630 A	630 A	800 A
Short time withstand current *	16 kA	16 kA	16 kA
Short circuit making current *	16 kA	16 kA	16 kA
Short circuit breaking current *	16 kA	16 kA	16 kA
Peak withstand current *	40kA	40kA	40kA
Duration of short circuit	1 sec	1 sec	1 sec
Line charging breaking current	2A	5A	5A
Cable charging breaking current	10A	25A	40A
Single capacitor breaking current	Manuf. to specify	Manuf. to specify	Manuf. to specify
Back-back cap breaking current	Manuf. to specify	Manuf. to specify	Manuf. to specify
Small inductive breaking current	Manuf. to specify	Manuf. to specify	Manuf. to specify
Short line fault breaking current	Manuf. to specify	Manuf. to specify	Manuf. to specify
Out of phase breaking current	Manuf. to specify	Manuf. to specify	Manuf. to specify
Total short circuit breaking time	Manuf. to specify	Manuf. to specify	Manuf. to specify
Rated TRV for terminal faults	Manuf. to specify	Manuf. to specify	Manuf. to specify
First pole to clear factor	1.5	1.5	1.5
Duty cycle/operating sequence	O-0.5s-CO-2s-CO-2s-CO followed by 300s recovery		
Min. no. of operations:			
• Mechanical on/off	10,000	10,000	10,000
• Electrical on/off at rated A	10,000	10,000	10,000
• Fault break at rated kA	100	100	100
• Fault make at rated kA	100	100	100

Description	12kV	24kV	36kV
Operational details			
Operating mechanism	Electrical (solenoid, spring or magnetic actuators)		
• Closing			
• Opening			
Insulators	Porcelain/Silicone/ cycloaliphatic epoxy resin		
Degree of protection-Protection	IP55		
Protection/CT/VT requirements	As specified in section 5.5.1		
Communication	As specified in section 5.5.5.3		
Auxiliary supply	As specified in section 5.5.5.4		
External connections	Bare, ABC or CCT connection		
Fittings	See details below		

* Options for lower short current fault level must be considered as an option where cost effective.

5.4 Construction requirements

5.4.1 Primary switch

The recloser must be of dead tank stainless steel construction with the primary connections made by way of six (6) bushings.

The company's preference is for the use of equipment that does not contain SF6 gas where alternative technologies are available. Designs using cost efficient equipment containing SF6 must be considered, however, designs with the lowest quantity by weight of SF6 must be given favourable consideration. SF6 management, environmental and disposal costs must be considered in the evaluation process.

Where tanks contain SF6 gas as an insulation medium, it is preferable that the unit operates with low gas quantities and pressure. Leakage rates must not exceed 0.1% by weight each year. The tank must be provided with a reliable pressure relief system.

The recloser tank must be manufactured from 304/316 marine grade stainless steel or equivalent material. All support structures and associated bolts and nuts with these parts must be hot-dip galvanised. Precautions must be taken to prevent corrosion due to the use of dissimilar materials. Two (2) M12 studs, complete with a nut, a locknut and a washer, must be provided on the recloser tank for earthing. The M12 studs must be on diagonally opposite sides.

A manual operating lever must be located in a position that allows operation from the ground using an appropriate operating stick. A position indicator must clearly identify, from ground level, the status (open or closed) of the recloser. Failure of the recloser must not create a safety hazard to the operator due to recoil of such items as the operating stick, cranks or levers.

5.4.2 Mounting

The recloser must be suitable for a single pole mounting, however, in certain situations, it may be necessary to mount the recloser in a substation on the ground. Lifting eyes of adequate strength must be provided, and labelled, to enable the recloser to be lifted using a crane for erection on poles or on the ground.

A safe working load (SWL) sticker **must** be placed on each recloser. The supply **must** include all necessary hardware needed to mount the switch on a wood, concrete, steel or composite pole.

Brackets **must** be provided on both sides of the auto-recloser for the mounting of surge diverters fitted with disconnect devices. M12 studs complete with nuts, locknuts and washers **must** be provided on the mounting bracket for the termination of an earth.

5.4.3 Bushings

The bushings **must** be suitable for outdoor operations, using materials such as porcelain/cycloaliphatic resin/ silicone rubber. Complete bushing details, such as a general arrangement drawing, electrical and mechanical characteristics, sealing arrangement with the tank, pollution performance and test certificates, **must** be submitted for approval.

All bushing terminals **must** be fitted with the company's standard two (2) hole palm.

Each recloser **must** be supplied with the following to provide a fully insulated bushing arrangement:

- Three (3) metres 180 mm² XLPE insulated aluminum water blocked cable tails (for 22kV - 120 mm²).
- The connection **must** be suitable to fit two (2) cables per phase to achieve the full rating of the switch.
- Six (6) silicone rubber bushing boots to match with the cable and to accommodate 2 cables per phase if required.

5.4.4 Control and protection cubicle

A cubicle **must** be provided to house the protection, control and communications equipment, including batteries and chargers. The cubicle **must** be constructed of 316 marine grade stainless steel or equivalent material unless approval to use a lower grade material is approved. The degree of protection **must** be IP 55 or better.

The equipment housed in the cubicle **must** withstand the heating effect due to internal heat generation and external solar heating. All connections into the cubicle **must** be waterproof and the cubicle designed to avoid condensation. An M12 stud, complete with nut, locking nut and washer, **must** be provided on the cubicle for the termination of an earth. There **must** be provision for padlocking all doors. The cubicle **must** be designed for mounting on a pole 4000mm from the ground.

Provision **must** be made in the cubicle for bottom entry of three (3) cables. This **must** be achieved with two (2) 21mm and one (1) 32mm diameter pre-punched holes. The holes **must** be suitably blanked off.

The door of the cabinet **must** be fitted with a robust fastening arrangement that is capable of being secured by a padlock that has a shackle of 8mm diameter. The cabinet **must** be easily removable for workshop repair purposes.

The cubicle **must** be connected to the recloser by way of a screened, flexible cable connection. The scope includes the supply of a seven (7) metre long ultraviolet radiation resistant flexible cable to connect the recloser tank to the control cabinet.

It **must** be possible to disconnect the cable both at the auto-recloser and at the control cubicle end whilst the recloser is connected in the system without damage or any mal-operation. It is therefore necessary that the cord be provided with secured detachable connectors on both the ends. The CTs **must** not be open circuited.

The control must not suffer any damage if one or more poles of the recloser fail to respond to either a trip or a close command. The electronic control module must perform a continuous diagnostic monitoring, and must contain hardware and software watchdog checking.

5.5 Protection, control and metering

5.5.1 Protection

Over-current (O/C), earth fault (E/F) and sensitive earth fault (SEF) functions must be equipped with harmonic filtering.

All protection functions (including O/C, E/F and SEF) must have elements with characteristics that comply with IEC 60255.151.

It must be possible to program the sequence of trip and auto-recloser characteristics for O/C, E/F and SEF to enable the selection of any combination of the available elements for each trip in the trip-reclose sequence.

A single shot trip function must be available and must be settable by selecting one of the shots in the sequence or must have independent settings

The recloser must have a zone sequence coordination (ZSC) feature to provide trip-close sequence co-ordination for combinations of rapid and delayed protection operations.

Loss of phase (LOP) protection must be provided to trip the recloser in case there is a loss of voltage on one or two phases on the upstream part of the line. Loss of supply on all three phases must also be available as a separate protection function.

Directional control of over current and earth fault elements must be provided. Two modes of operation must be possible, tripping in one direction only, and tripping in both directions with separate settings for forward and reverse directions. The preferred method of directional decision is by the "I_a vs V_{bc}" method.

Live line (work tag), high set elements with selectable time delay (and instantaneous) must all be available. Cold load pickup functionality is preferred.

The controller must support at least four (4) independent protection setting groups.

Access to the protection device must be by use of a password or other approved method.

It is preferable if the pick-up of any protection element is able to initiate a voltage free contact for protection control functions, such as blocking or inter-tripping.

Protection elements must meet the requirements of the following two tables.

Table 3 - Protection requirements for the 12kV, 24kV, and 36kV Reclosers

Item	Requirement
Standard IDMT curves available	IEC Standard inverse IEC Very inverse IEC Extremely inverse
Fast Curves	Various fast curves available. Characteristic must be suitable for fuse saving.
Phase overcurrent element (OC)	Yes
• OC elements (for each trip) – number of:	≥ 1 IDMT + ≥1 DT element + (optional and preferred) ≥ 1 instantaneous/DT element First two trips in any sequence must be able to include at least: one fast fuse saving IDMT trip, then one slower IEC IDMT trip, with optional DT element available for both. Preferred if each trip in the sequence can be set with different curves, pickups, delays etc..
Earth fault element (EF)	Yes
• OC elements (for each trip) – number of:	≥ 1 IDMT + ≥1 DT element + (optional and preferred) ≥ 1 instantaneous/DT element First two trips in any sequence must be able to include at least: one fast fuse saving IDMT trip, then one slower IEC IDMT trip, with optional DT element available for both. Preferred if each trip in the sequence can be set with different curves, pickups, delays etc..
• OC/EF setting range	≤ 10A primary ≥ 400A primary
• OC/EF definite time delay range	≤50 ms to ≥10 s (steps size of ≤10 ms)
• OC/EF instantaneous delay range	=0ms
• OC/EF reset characteristic	Required: Time delayed Preferred: Time delayed and simulated disc Reset delay range: 0 ms to ≥10 s (steps size of ≤10 ms)
Sensitive earth fault (SEF) element	Yes
• SEF elements – number of:	≥ 1 DT element (2 preferred) (See Note 1)
• SEF definite time delay range	≤ 100 ms (prefer 0ms) to ≥10 seconds (steps of ≤ 0.1s)
• SEF element setting range	≤ 4A (≤ 1A preferred) ≥ 10A

Item	Requirement
- SEF reset characteristic - SEF reset delay range:	Time delayed 0 ms to ≥ 10 s (steps size of ≤ 100 ms)
Directional control	Yes - for all OC, EF, and SEF elements
Directionality decision method	Preferred option is for directionality decision by "Ia vs Vbc" method Both directions to be operable at the same time Must be possible to have separate settings for forward and reverse directions
Loss of phase (LOP) protection (single or two phase under/no-voltage)	Yes
Loss of supply (3 phase under/no-voltage)	Yes
Cold load pickup	Preferred
Check-sync protection element	Preferred
Live line (Work Tag) function	Yes Required for OC and EF elements. Desirable for SEF elements (*1) Time delayed. Minimum setting: 0ms for OC/EF; ≤ 100 ms for SEF Reset delay range: 0 ms to ≥ 1000 ms (steps size of ≤ 10 ms)
Event record	Yes
Disturbance file recording	Yes
COMTRADE format	Yes
Customisable durations	Yes Duration: ≥ 0.5 s (prefer ≥ 5 s)
Customisable triggers	Yes Required triggers: pickup OR trip Preferred triggers: pickup AND trip

Note 1 - SEF protection must include: one time delayed element (operating full time), and; a second element that is enabled/disabled over comms that provides fast tripping (required ≤ 100 ms, prefer 0ms). The second element may be combined with the live line / work tag, and may be integrated into the EF element provided the pickup can be set at ≤ 4 A.

This following table of requirements is for the inclusion of distance protection functions in the 36kV recloser. The distance protection functions must comply with IEC60255-121. The items in this table are all preferred requirements and are in addition to the requirements above for overcurrent and earth fault elements.

Table 4 - Additional preferred protection requirements for the 36kV recloser

Item	Requirement
Number of zones of distance protection	≥ 3 for forward direction (variation to this requirement may be acceptable)
	+ ≥ 3 for reverse direction (variation to this requirement may be acceptable)
Distance protection characteristic	Mho (required)
	Mho and quadrilateral (preferred)
Distance Reach setting	0.5Ω to ≥ 100Ω (step size ≤ 0.01Ω)
Distance zone timers	0ms to ≥ 5.0s (step size ≤ 10ms)
Timers for phase and earth elements	Selectable: shared timer between OC and EF, or; independent OC and EF timers.
Maximum fault measurement time inside characteristic	1.5 cycles
Switch on to fault logic	Yes
Fault type decision making (or starter) does not delay tripping	No delay
Distance to fault	Yes
Allowable error in distance to fault	≤ 5% (of line length)

5.5.2 Metering

Quantities to be measured/calculated with specified accuracy are:

Table 5 – Metering accuracy of measurement

Parameter	Accuracy of measurement
Voltage rms ph-ph and ph-n all the three phases, kV	±2.5%
Current rms on each phase, A	±2.5%
Active power three phase, kW	±5%
Peak fault current on each phase	±2.5%
Reactive power three phase, kVar	±5%

The voltage factor of the voltage transformers **must** be a minimum of 1.9.

The control element **must** have the facilities to record the number and duration of outages. The information **must** be accessible locally or remotely using the SCADA system. The following parameters **must** be recorded:

- Cumulative total number of outages.
- Cumulative total outage duration.
- Time and duration of each outage.
- Peak fault current, or distance to fault.

5.5.3 Control

5.5.3.1 Recloser operation parameters

Protection operation **must** be possible by selecting fast and slow trip operations with up to **four (4)** operations in a sequence before lockout.

- Selection of the number of sequential trips to reach lockout **must** be 1, 2, 3 or 4.
- Independent selection of the dead time between each successive reclose from instantaneous to 30s for the first reclose, and from a minimum of 2s up to a maximum of 120s for subsequent recloses.
- A close instruction initiated locally or remotely during a dead time **must be blocked, allowing the recloser to continue its reclose sequence.**
- The ability to program the reclaim time up to a maximum of at least five (5) minutes.

5.5.4 Local control and indication

The minimum specification of local controls and indications are as follows:

Table 6 – Local control and indication

Item	Features	Remarks
Local control	Local/remote	2 position key switch-able
	Circuit-breaker open	Secure control
	Circuit-breaker close	Secure control
	ARC ON/OFF	Secure control
	SEF ON/OFF	Secure or toggle control
	Live line	
Local indication	Local/remote	
	Circuit-breaker open	
	Circuit-breaker closed	
	Circuit-breaker lock-out	
	ARC ON/OFF	
	SEF ON/OFF	
	Live line	
	Protection operation	
	Controller not healthy	
	SF6 Alarm	
	AC fail	
	DC abnormal	
	DC fail	
	Charger fail	

Item	Features	Remarks
Local analogue indication	rms phase-to-phase and phase to neutral voltage of all three phases	
	rms current on each phase	
	three-phase active power in kW three-phase reactive power in kvars	
	Peak fault current for each protection trip event	

- Access to local controls and indications in adverse weather conditions.
- The recloser **must** be provided with external levers to permit manual operation, using an insulated operating stick, to open, close, lock-out and reset the recloser from ground level. Where these operations can be performed at the control cabinet, it **must** only be necessary to provide a mechanical means to open and lockout the recloser using an insulated operating stick.
- The recloser status **must** be clearly visible from ground level. **Opened** **must** be indicated with a green **O**. A red **I** **must** indicate **Closed**. Alternative indications **must** be subject to approval.
- Pressure relief facilities **must** be provided to enable the recloser to withstand safely the effects of excessive pressure rise due to an internal fault.
- Malfunction of the recloser **must** not pose a safety hazard to the operator due to the recoil or backlash of items such as external operating rods, cranks and levers.
- Easily available (that is, by a single keystroke) local indication of protection operation **must** be provided for at least the last operation of the recloser. The function, phase involved and the current magnitude **must** be indicated.
- Switches used for local control **must** offer the type of control described above, that is, secure or toggled control.
- Electronic keypad controls **must** offer quick key (single keystroke) access to the controls if not implemented with switches.
- Reclosers using SF6 as an arc extinguishing medium **must** be provided with a two-stage low gas pressure switch. Stage 1 to alarm/indicate low gas pressure and stage 2 to inhibit recloser operation.
- The ability to reset the event recorder and maintain a minimum of one hundred (100) events in a last in last out stack.

5.5.5 Remote control and indication

The minimum requirements of remote controls and indication are as follows:

Table 7 – Remote control and indication

Item	Features	Remarks
Remote control	Circuit-breaker open	Secure control
	Circuit-breaker close	Secure control
	ARC ON	Secure control
	ARC OFF	Secure control
	SEF ON	Secure control
	SEF OFF	Secure control
	Live line ON	

Item	Features	Remarks
	Live line OFF	
Remote indication (See notes)	Local/remote	
	Circuit-breaker open	
	Circuit-breaker closed	
	ARC lock-out	
	ARC ON	
	ARC OFF	
	SEF ON	
	SEF OFF	
	Live line ON	
	Live line OFF	
	IDMTL O/C Trip	
	Low Set DTL O/C Trip	
	Rapid O/C Trip	
	High Set O/C Trip	
	IDMTL E/F Trip	
	Rapid E/F Trip	
	High Set E/F Trip	
	SEF Trip	
	ARC	
	Controller not healthy	
	SF6 Alarm	
	AC fail	
	DC abnormal	
	DC fail	
	Charger fail	
Analogue indication (See notes)	rms phase-to-phase voltage of all three phases	
	rms current on each phase	
	three-phase active power in kW	
	three-phase reactive power in kVARs total	
	Peak fault current in each phase for each protection trip event	

Notes

- The *controller not healthy* indication must indicate that the control equipment not healthy (watchdog) function has operated. It must not operate during the normal pole-mounted switch

operating cycle. This indication **must** remain active until the unhealthy state that initiated it returns to normal.

- The two-(2) position switch (labelled as below) **must** allow the recloser controller to be set in the following modes:

Remote

In this mode, a local operator can trip the recloser and change the mode. A remote operator can trip or close the recloser and change configuration parameters. All reporting functions are active.

Local

In this mode, a local operator can trip and close the recloser and change configuration parameters. Only monitoring functions are available to remote operators. The local and remote positions **must** be indicated separately.

- The ARC indication **must** give an alarm with any ARC attempt.

5.5.5.1 *Local engineering*

The controller **must** have a real time clock that can be set both locally and remotely. The accuracy of the clock **must** be subject to approval.

A facility for selecting all the protection, operating and communications characteristics **must** be locally available in the control cabinet. Optional password protection against unauthorised changes **must** be available.

Non-volatile memory storage **must** be sized to store the following minimum data:

- All operating, protection and communications parameters.
- An event record containing at least 3,000 events.

Maximum demand **must** have the facilities to be configured for weekly or monthly demand.

The facility to clear the event record **must** be provided.

An event recorder **must** monitor the protection operations and provide as a minimum:

- The time of pickup and dropout of any protection element, and the associated currents and voltages.
- The time of the trip operation of any protection element and the associated currents and voltages.
- The type and time of any local control operations by remote or operator interface, excluding any automatic time synchronisation events.

Event recorder and oscillography records **must** be readable/downloadable without taking the recloser out of service, and all protection functions **must** remain fully operable. It is preferred that event records and oscillography are stored on internal memory.

All events **must** be time and date stamped with a resolution of at least 1ms relative to the onboard real time clock.

The software necessary for setting the protection and downloading event data **must** be supplied free of charge on a site basis. It must be capable of operating on Microsoft Windows 7 and 10.

It must be possible to alter individual settings using a personal computer (PC) without having to transfer all settings to or from the controller.

It must be possible to send SCADA configuration settings to the recloser without re-writing protection settings.

A protection settings file compare facility must be included with the software.

The software must be capable of creating a settings file without it being necessary to connect to a controller. The settings file that is created must be a stand-alone file that is not part of a settings database.

5.5.5.2 Tele-control requirements

The recloser controller must detect and report disconnection of the control cable between the controller and recloser. It must be possible to operate the recloser, change the active protection group, and turn recloser capabilities ON/OFF and turn E/F, Live Line (or work tag) mode and SEF ON/OFF remotely using the specified protocol.

5.5.5.3 Communications

The recloser controller must have local data logging, communication functions, and mounting space for a radio.

As a minimum, the following communication ports must be provided:

Table 8 - Communication ports

Communication interface	Physical port	Function	Protocol
RS232	DB9	Remote communications	DNP3 compliant to Level 2
Ethernet	RJ45	Remote communications	DNP3 compliant to Level 2
RS232	DB9	Local engineering	n/a

The local computer port must provide communication between the controller and a PC using either a standard USB or RS232 cable. The local computer port must:

- Provide the ability to program and configure the controller; and,
- Provide the ability to download data logs.

5.5.5.4 Power supplies

All equipment required to supply the auxiliary power needed for open/close operations of the recloser, protection, control and communication equipment, must be provided. This must include auxiliary transformer, rectifier, batteries, and associated equipment.

For pole mounted reclosers, a step down transformer must be provided to supply the auxiliary power needs of the recloser. This transformer must be mounted externally on the recloser tank in a location that is suitable for pole mounting with disconnect type surge arresters fitted.

All necessary HV connection cable, lugs/PG clamps and silicone rubber bushing covers must be provided. A single phase to ground transformer must not be used, however a phase to phase

voltage transformer with adequate output can be used for this purpose. Alternative proposals may be submitted for consideration.

Reclosers installed within substations must generally have access to 240V, single phase 50Hz AC or 110 V DC supply.

The auxiliary power supply must use a storage battery of adequate capacity with a suitable constant voltage battery charger, to provide a standby power for at least 10 open/close operations in the event of AC power loss.

The storage batteries must be sealed, requiring no maintenance over their life. All batteries must have a maintenance free life of at least five (5) years.

A label showing the year of manufacture and recommended replacement year must be affixed to each battery. Full details of the battery included must be submitted for approval. Power supply to the radio must be 12V, 8A peak, 4A continuous with battery backup suitable for 4 amp-hours capacity.

Low battery indication is to be provided locally and remotely. Remote low battery indication is to be initiated prior to the failure of the radio due to low voltage. The recloser must not close when insufficient energy is available to open the recloser for protection function.

5.5.5.5 Maintenance and commissioning

All the communications equipment must be easily accessible in the control cabinet. Wiring of communication links in the control cabinet must permit the connection of a temporary protocol-monitor.

- The recloser must be able to be secondary injection tested; using AC current up to 90A and voltage up to 300V a.c. Secondary injection test must be able to be performed without encroaching on minimum safe work clearance distances (for example, at ground level).
- It must be possible to disconnect the recloser and connect a simulated recloser to the control cabinet for testing purposes.
- The recloser must not malfunction while the radio is transmitting through an antenna in close proximity and the control cabinet door is open.
- Provision must be made in the control cabinet for individually isolating the power supply to/from the battery, battery charger, radio, and primary supply to the control cabinet electronics.

5.6 Firmware and hardware change controls

5.6.1 Design changes

It is required that the reclosers delivered within the duration of the Contract be identical (same hardware, model, software and firmware version number) to the Production Model supplied for the technical evaluation.

Where it becomes essential for a manufacturer to initiate a design change, the company must be advised of the details of the proposed change prior to any change being implemented in reclosers due for delivery on subsequent orders.

In such cases, the company reserves the right to request that a change is not implemented or to ask that a modified production model is submitted for an additional technical evaluation.

5.6.2 Firmware upgrades

Firmware upgrades must be treated in the same way as any other design change as described in clause 5.6.1. It is required that the manufacturer agrees to provide the same version of firmware for the duration of the Contract. This includes any minor revision numbers.

Where a firmware upgrade is considered essential in order to remove design errors or operating limitations detected during service, the company must be advised of the necessity of any changes prior to their implementation in reclosers on subsequent orders.

Where it can be shown that a firmware upgrade is absolutely essential, the manufacturer agrees to provide, at no charge, modified firmware for installation into reclosers already delivered on earlier orders. The upgrade must be carried out by a change of erasable programmable read only memory (EPROM) or by downloading the new firmware version from a personal computer (PC) running Windows software.

5.7 Rating plate

Each recloser must bear a rating plate manufactured from 316 stainless steel (other material must be considered on application), indelibly marked with the sea-level rating for which the equipment has been type tested. The rating plate must be indelibly marked with:

- manufacturer's name;
- equipment type designation and serial number of the recloser;
- mass, in kilograms;
- date of manufacture;
- rated load current
- rated fault current
- rated voltage
- voltage transformer ratio, classes and burden; and,
- auxiliary supply voltage (if applicable)

5.8 Additional information

The following must be submitted:

- A schematic wiring diagram of the recloser offered.
- A general arrangement drawing of the recloser offered.
- Details of the maintenance and operating equipment and procedures needed, and a detailed parts list of the various components.
- A description of the recloser operation, with instruction and maintenance manuals, including maintenance schedules, protection characteristics, communications facilities, the method of applying settings to relays and controls, together with any software required and its cost. The software requirements must be stated in the tender documentation.
- Details and the cost of any available portable calibration and diagnostic test set that may be used to perform the functionality described. Details of the test set must be given in the tender document.
- A list of recommended spares and tools, quoting the prices of each item and its availability.
- If protection-setting changes are accomplished by resistors, electronic cards or modules, or computer programs, the price and range of such items. The method of changing protection settings must be stated in the tender documentation.
- Details of technical back-up facilities available.
- Details of the class, ratio(s) and burden of the protection current transformer and voltage transformer must be stated, if mounted externally to the recloser tank.

- Details of the low gas pressure alarm/lock-out operation, if applicable.
- Details of recloser operating history, including how many in service, where and for what period with contact names and numbers.
- Details of LV trip/close coil if available as an option.
- Power requirements for a close operation.
- The maximum achievable separation between the control unit and the recloser.
- Full details of the protocol implementation and the complete point database.

5.9 Tests

5.9.1 Type tests

The recloser must be of a type-tested design in accordance with the requirements of IEC 62271-111/IEEE Std C37.60, grouping of tests may be carried out in accordance with AS62271.111 clause 6.1.1 for the following:

Table 9 - Type tests

No	Type test	Test method	Acceptable value
1	Dielectric tests include power frequency voltage tests and main and auxiliary circuits and lightning impulse voltage tests	IEC62271.111 Cl 6.2	Conforms to conditions in IEC62271.111 Clause 6.2.4. No disruptive discharge
2	Partial discharge test	IEC62271.111 Cl 6.106	Conforms to conditions in IEC62271.111 Cl 6.106 - < 10pC at 1.1Ur
3	Control electronic elements surge withstand capability tests	IEC62271.111 Cl 6.111	Conforms to conditions in IEC62271.111 Cl 6.111.3.4 - No operation and no change of state during tests
4	Ice loading test	IEC62271.111 Cl 6.110	Conforms to conditions in IEC62271.111 Cl 6.110.5 - No deterioration and can perform normal operation
5	Radio interference voltage tests	AS62271.1 Cl. 6.3	<2500µV
6	X-radiation test	IEC62271.111 Cl 6.11	Conforms to conditions in AS62271.1 Cl 6.11.1.1 X-radiation emitted does not exceed stated values
7	Measurement of the resistance of the main circuit	IEC62271.111 Cl. 6.4	Specified by the manufacturer
8	Temperature-rise tests	IEC62271.111 Cl 6.5	Conforms to conditions in AS62271.1 Cl. 6.5.6 and AS62271.1 Table 3 Resistance of main circuit after the temperature rise test must not be increased by more than 20%.
9	Mechanical duty test	IEC62271.111 Cl 6.109	Conforms to conditions in IEC62271.111 Cl 6.109

No	Type test	Test method	Acceptable value
			- Travel characteristics before test same as after test
10	Short-time withstand current and peak withstand current tests	IEC62271.111 Cl 6.6	Conforms to conditions in AS62271.1 Cl. 6.6.4 No deterioration and can perform normal operation
11	Critical current test	IEC62271.111 Cl 6.104	Conforms to conditions in IEC62271.111 Cl 6.112
12	Line charging current and cable charging current interruption tests - Capacitive current switching tests	IEC62271.111 Cl 6.101	Conforms to conditions in IEC62271.111 Cl 6.101.10
13	Making current capability	IEC62271.111 Cl.6.102	Conforms to conditions in IEC62271.111 Cl 6.102.2
14	Rated symmetrical interrupting current tests - Breaking current capability	IEC62271.111 Cl.6.103	Conforms to conditions in IEC62271.111 Cl 6.103.6
15	Verification of the Protection	IEC62271.111 Cl 6.7	Meets requirements of IP55
16	Tightness tests	IEC62271.111 Cl 6.8	$\leq 0.1\%$ per annum for sealed and $\leq 0.5\%$ per annum for closed pressure systems
17	Minimum tripping current	IEC62271.111 Cl 6.105	Conforms to conditions in IEC62271.111 Cl 6.105 - Within $\pm 10\%$ or 3A
18	Time current tests	IEC62271.111 Cl 6.108	Conforms to conditions in IEC62271.111 Cl 6.108 - Meets manufacturers declared value

Test reports **must** not be more than five (5) years old from the closing date of the tender.

Test records (on identical equipment) in the form of validated copies of test certificates **must** be submitted for approval/information.

Copies of the test reports **must** be provided to the company. Reports written in any language other than English **will** not be accepted by the company unless such reports are translated into the English language by a sworn translator.

The company reserves the right to witness type tests for which a minimum of four (4) weeks' notice **must** be given.

5.9.2 Routine tests

The routine test **must** be conducted on each unit in accordance with the requirements of IEC 62271-111/IEEE Std C37.60.

Table 10- Routine tests

No	Routine test	Test method	Acceptable value
1	Dielectric tests on main circuit	IEC62271.111 CI 7.1	Conforms to conditions in IEC62271.111 Clause 6.2.4. No disruptive discharge
2	Tests on auxiliary and control circuits	IEC62271.111 CI 7.2	Wiring connections and continuity checked. Devices and relays checked by actual operation
3	Measurement of the resistance of the main circuit	IEC62271.111 CI. 7.3	Specified by the manufacturer
4	Tightness tests	IEC62271.111 CI 7.4	Conforms to conditions in IEC62271.111 CI 7.4. $\leq 0.1\%$ per annum for sealed and $\leq 0.5\%$ per annum for closed pressure systems. No dielectric breakdown for vacuum
5	Reclosing and over current trip calibration	IEC62271.111 CI 7.101	Conforms to manufacturers stated values and curves
6	Partial discharge test	IEC62271.111 CI 7.102	Conforms to conditions in IEC62271.111 CI 6.106 - < 10pC at 1.1U
7	Mechanical operation test	IEC62271.111 CI 7.103	Conforms to conditions in IEC62271.111 CI 7.103 - No trouble or malfunction

Duplicate copies of routine test certificates must be supplied with each piece of equipment. The company reserves the right to witness routine testing, for which at least two (2) weeks' notice must be given.

5.9.3 Accreditation and acceptability of testing authorities

All tests must 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 Network Substations Manager.

However, routine tests carried out at the manufacturer's testing facilities may be accepted provided the facilities are pre-qualified by the Manager Asset Standards & Design to perform the tests.

5.10 Product approval

5.10.1 Product approval and audit forms

Complete information of the recloser must be provided on Branch Form FAE 3080.

5.10.2 Product approval process

The company must approve the equipment/components for use on the network. The recloser must be evaluated under the product approval process set out in PAE 1004.

6.0 AUTHORITIES AND RESPONSIBILITIES

General Manager Asset Management has the authority and responsibility for:

- approving this specification, including any variations;
- making all decisions concerning compliance in respect to this specification;
- nominating the company's representative(s) for either the manufacturing facility inspection and/or witness testing; and
- delegating any of these authorities and responsibilities to the Manager Asset Standards & Design.

Manager Asset Standards & Design has the authority and responsibility for:

- reviewing this specification and making recommendations to the General Manager Asset Management; and
- making recommendations concerning compliance in respect of this specification; and
- making nominations of the company's representatives.

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 Asset Standards & Design;
- clarifying all the technical aspects of this specification to the stakeholders; and
- approving the relevant actions required and outlined in this specification.

Protection Manager will be responsible for updating the relevant sections related to protection and control.

SCADA and Program Manager will be responsible for updating the relevant sections related to SCADA and communications.

Contractor Operations Manager has the authority and responsibility for confirming all equipment installed by Level 1 Accredited Service Providers comply with the requirements of this specification.

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

Manufacturers/suppliers have the authority and responsibility for:

- establishing awareness of their responsibilities under this specification;
- determining the contractor/s under their control have provided suitable training for their employee;
- implementing an effective safety, environmental and quality auditing system is in place; and
- Implementing this specification and keeping the company 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	:	Branch Process Coordinator