



NU-LEC
INDUSTRIES

A SCHNEIDER ELECTRIC COMPANY

ELECTRICAL SWITCHGEAR ENGINEERS AND
AUTOMATION SPECIALISTS

N-Series automatic circuit recloser

Introduction and Features

The Nu-Lec Industries N-Series gas insulated automatic circuit recloser (also known as a circuit breaker) provides the features of traditional reclosers, plus the benefits of up to date design optimised for automation, remote control and monitoring, now or in the future.

The development of this product was driven by customer demand for improved return on capital investment in the distribution network. After carefully evaluating customers' needs, the N-Series gas insulated reclosers were developed to achieve optimum performance and reliability, making use of the latest in available technology in vacuum arc interruption and microelectronics. The result is a competitive world-class product of which we are justly proud.

In the past, distribution equipment such as reclosers have been purchased only to support load growth. Today, your customers, the electricity consumers, are demanding reduced outages and lower tariffs. We at Nu-Lec Industries are continually working to provide advanced equipment needed for tomorrow's competitive electricity distribution system.

By using this technologically advanced equipment, operating costs will be reduced, revenue will be increased through reduced outages and capital works can be deferred through better management of existing plant.

In addition to automatic circuit reclosers, the Nu-Lec Industries family of switchgear includes a range of remotely controlled and monitored pole mounted load break switches and sectionalisers as well as remote control and monitoring software. This product family is a complete solution for distribution system automation.

Reduced Purchase Cost

- Remote Terminal Unit (RTU) and modem are included in the standard equipment. No additional RTU, modem, power supplies, batteries, wiring, connectors or enclosures are required.
- A 400A insulated cable connection kit is provided as part of the standard package. Optional 250A, 630A and 800A cable kits are also available.

Reduced Installation Costs

- Lightning arrester mounting, up to 630A insulated cable tail kit and pole mounting brackets are provided in the standard package. An optional Voltage Transformer (VT) for auxiliary supply is available.
- Configuration of the unit is from the Operator Control Panel, making commissioning simple.
- These automatic circuit reclosers are ideally suited as low cost feeder circuit breakers in outdoor zone substations. In this application, connection into the substation control or automation system is simple and low cost.

Reduced Operating Costs

- The integral protection relay provides fast isolation of faults, reducing damage.
- The recloser constantly monitors line current and voltage without the need for additional statistical measurement devices. This data can then be used for forward planning and optimisation of existing plant. This will reduce distribution system losses.
- Long lifetime, low maintenance equipment reduces lifetime cost.

DSA/SCADA Compatibility

When used with a compatible Distribution System Automation (DSA) or SCADA system, Nu-Lec Industries automatic circuit reclosers support remote control and monitoring to provide the following advantages:

- Information on recloser status and fault current values transmitted to system control allows fast location of the faulted line section, reducing the travelling time of line crews.
- This same information allows informed remote switching which reduces the affected area and quickly restores supply.
- Reclosers can be configured and settings managed from system control, without technicians having to visit each individual recloser in the field, with a consequent reduction in staffing and improved system integrity.

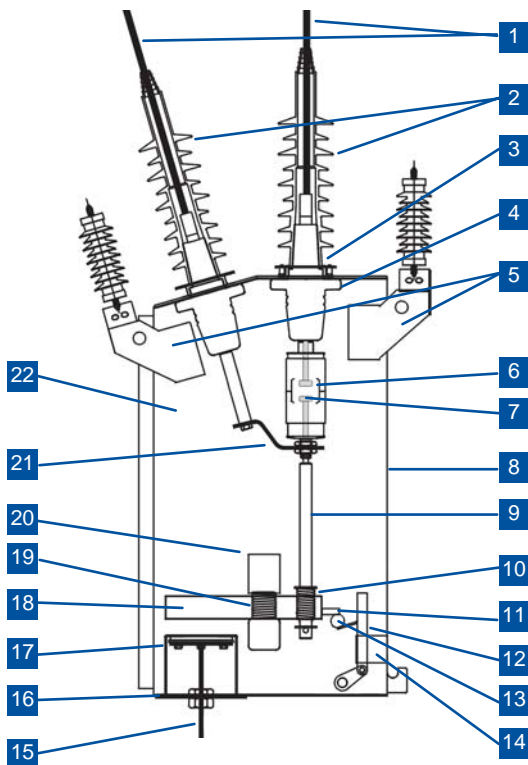
Increased Revenue

- Supply can be quickly restored to unaffected areas, resulting in less outage time and therefore increased revenue.

Deferred Capital Works

- Remotely controlled and monitored automatic circuit reclosers give an improved knowledge of a system and provide better system control. Feeder and substation load can then be remotely managed improving utilisation of existing plant. Purchase of new plant can then most likely be deferred for a considerable period of time.

Circuit Breaker Overview and Operation



Cross Section of Circuit Breaker

Legend

- | | |
|---|--------------------------------------|
| 1. Insulated cable tails | 12. Trip bar armature |
| 2. Polymeric bushing boot | 13. Trip bar |
| 3. DIN 47 636 bushings | 14. Trip Coil |
| 4. Current transformer | 15. Cable to control cubicle |
| 5. Lightning arresters (optional) and mountings | 16. Cable entry cover |
| 6. Vacuum interrupter | 17. Switch Cable Entry Module (SCEM) |
| 7. Contacts | 18. Mechanism plate |
| 8. Stainless steel tank | 19. Opening spring |
| 9. Contact pushrod | 20. Closing solenoid |
| 10. Contact pressure spring | 21. Flexible connection |
| 11. Latch | 22. Gas filled tank |

The N-Series gas insulated automatic circuit recloser is designed around vacuum interrupters contained in a fully welded and sealed 316 grade stainless steel enclosure. The enclosure is filled with sulphur hexafluoride (SF₆) gas, which has excellent electrical insulating properties, resulting in a compact and low maintenance device.

A pole mounted control and communications cubicle houses the Operator Control Panel and microelectronics. This cubicle houses an electronic controller that monitors the circuit breaker and provides protection functions. A detachable control cable is used to connect the cubicle to the circuit breaker. Combined together, the circuit breaker and communications cubicle form a remotely controlled and monitored automatic circuit recloser.

The circuit breaker is operated by sending a controlled pulse of current from a storage capacitor in the communications cubicle through a solenoid. This attracts the mechanism plate which in turn closes the contacts in the vacuum interrupter. The contacts are held in the closed position by latch tongues resting on the trip bar.

Opening of the contacts is achieved by releasing a controlled pulse of current from a capacitor through the trip coil. This attracts the trip bar armature, turning the trip bar and releasing the latch. The opening spring and the contact pressure springs accelerate the contacts open. A flexible connection is provided to allow movement of the contacts to occur.

Epoxy bushings insulate the main circuit conductors from the outer case and provide a double "O" ring seal. They also provide the necessary insulation and support for the embedded voltage sensing screens and for the current transformers. The bushings are DIN 47 636 (threaded option) and allow the connection of alternative cable connection elbows if desired. Lightning arrester mounting is provided for installation convenience.

A standard kit for field fitting is supplied with the circuit breaker. It contains polymeric bushing boots and 3 metre lengths of 185 mm² aluminium insulated water tight cable tails rated at 400A. This arrangement results in an automatic circuit recloser suitable for connection into an insulated conductor system, or a bare conductor system, as appropriate. The fully insulated system provides freedom from faults caused by birds and other wildlife.

An auxiliary voltage supply of 110, 220, 240, or 415 volts AC is required to power the unit. Where this is inconvenient, a voltage transformer can be provided as a purchase option. The control cubicle is connected by a control cable to the bottom of the circuit breaker through a rubber covered plug/socket arrangement.

A clearly visible external pointer shows the contact position. The automatic circuit recloser can be tripped from the ground by a hookstick. It can then be locked out by opening the isolating switches located on the Operator Control Panel. These switches are physically connected in series with both the Trip and Close solenoids.

The Pole Top Control Cubicle (PTCC) interfaces to the recloser via the control cable and connects to the Switch Control Entry Module (SCEM) in the base of the tank. The SCEM uses EEPROM memory to store all relevant calibration data, ratings and number of operations conducted. The SCEM also provides the first stage of electrical isolation and shorting electronics to short the CTs and CVTs in the event the control cable is disconnected while current is flowing through the automatic circuit recloser.



N-Series gas insulated circuit breaker

Communications Cubicle Overview

The advanced protection, data logging and communications abilities of the N-Series recloser are made possible by the technology housed in the control and communications cubicle. It has been designed especially for outdoor, pole mounted operation and is normally mounted low on the pole for ease of access by maintenance personnel.

The cubicle is insulated and designed to minimise any temperature rise resulting from solar heating. An internal equipment panel is used to mount all the equipment, including the batteries, storage capacitors, mains transformer, low voltage circuit breakers, Control And Protection Module (CAPM), Operator Control Panel and radio or modem. These components are carefully located so that the heat generating parts are at the top, while the battery is at the bottom to keep it cool. In this way battery life in excess of 5 years can be achieved.

All weather access is provided to the Operator Control Panel through a lockable door on the front of the control cubicle. Vents are screened against vermin entry and the door is sealed against the outer with a rubber extrusion. All electronic parts are well protected from entry of moisture and condensation ensuring a long lifetime.

Three models of control and communications cubicle are available, Tropical, Moderate and Temperate. The Tropical version is well ventilated and is suitable for climates where the ambient temperature can reach 50°C and only occasionally goes below 0°C, with a lower limit of -10°C.

The Moderate version has reduced ventilation and is used where temperatures rarely go above 40°C and occasionally go below -5°C, with a lower limit of -15°C.

The Temperate model has a heater installed, making it suitable for climates where the temperature rarely goes above 40°C but can fall as low as -30°C.

All three cubicles are fitted with the same electronics and incorporate the functions of an overcurrent protection relay, a sensitive earth fault relay, a reclose relay, and a remote terminal unit. Additionally, the electronics measure line current, voltage, real and reactive power, fault currents, and stores these for transmission or off-line analysis.

A unique feature of the Nu-Lec Industries automatic circuit recloser is the built in microprocessor controlled power supply. This provides uninterrupted operation of not only the recloser and protection relay, but also the communications radio or modem. No other power supplies are required for connection into your SCADA or Distribution Automation System.

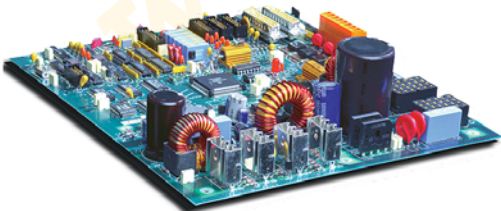
Due to careful design the efficiency of all parts is extremely high, allowing a battery hold up time of five days after auxiliary supply failure (from fully charged battery, excluding telemetry radio or modem usage). The architecture used has the advantage that the circuit breaker operation is independent of the high voltage supply, relying on a set of batteries charged by the auxiliary supply.

Due to sophisticated power supply management techniques, a circuit breaker operation is always guaranteed when attempted and alarms are raised over the telemetry when auxiliary power is lost.

A communications radio or special modem can be mounted within the control and communications cubicle. A V23 FSK modem is included as standard equipment.



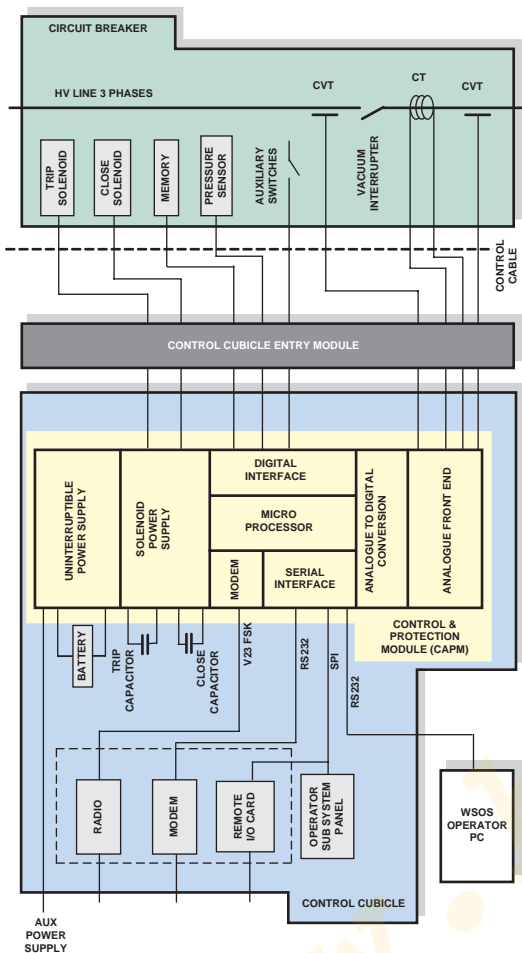
Pole Top Control & Communications Cubicle



Control and Protection Module (CAPM) Circuit Board

Block Diagram & Features

Nu-Lec Industries' automatic circuit reclosers provide many outstanding advantages to the user. New and innovative features have been made possible by the intimate way the pole mounted circuit breaker and communications cubicle work together. The block diagram below shows how the two items are interfaced. The heart of the unit is the Control and Protection Module (CAPM) and the intelligent Operator Control Panel.



Block diagram of a typical automatic circuit recloser

HV Line signals are connected into the electronics module by direct connection to the analogue front end. Special extended range current transformers provide a range from 1A to 16,000A for measurement and protection. Embedded voltage screens accurately image the primary voltage value and phase relationship, allowing measurement of voltage, current, power factor and frequency in the electronic module.

Each recloser is provided with an Operator Control Panel which has a four line liquid crystal display with back lighting for night operation. From here a user can access and program the many measurement and protection features available.

Three levels of user interface with the Operator Control Panel are provided as follows:

1. Operator Level

This allows basic operation like Trip, Close and display of settings, such as:

- Protection settings and fault history
- Line measurements and historical data
- Recloser functions such as:

Remote control	ON
Local control	ON
Sensitive Earth Fault	ON/OFF
Earth Fault	ON/OFF
Auto reclose mode	ON/OFF
Close/Trip	ISOLATE
- Alarms/Status such as:
 - Auxiliary supply fail
 - Battery supply fail
 - Lockout
 - Gas loss

2. Technician Level

This level is password protected at the user's discretion in the "Engineer Level" and allows the setting of all protection related parameters.

3. Engineer Level

This is accessible through a laptop or desktop computer and allows advanced customisation of the operator panel, setting of passwords, and all the Operator and Technician Level functions.

Telemetry Interface

The Nu-Lec Industries automatic circuit recloser can be interfaced to your SCADA system either through its built-in V23 modem and a radio, or its RS232 port and a modem of your choice. A variable voltage uninterruptible power supply is included for the radio or modem, which can be mounted inside the communications cubicle. Almost all telemetry protocols can be supported. DNP3, IEC870, Conitel and Modbus are some of the available protocols.

Computer Interface

The Windows Switchgear Operating System (WSOS) is an advanced personal computer based software package to allow off-line and on-line programming, monitoring and control of a recloser via the RS232 port. This is available as an option to the basic Nu-Lec Industries recloser.

Remote Control

As an additional option, Nu-Lec Industries offers the WSOS multiple connect PC based software package to individually remote control and monitor a population of field mounted reclosers and/or load break switches. The system communicates with the control cubicle by either cable, fibre optic, telephone line or radio. WSOS provides additional features such as alarm and event handling, dial in and dial out facilities and report generation.



Operator Control Panel

Operating Sequence

Reclose times are individually selectable. The operating sequence is defined by:
 O - 1st rt - CO - 2nd rt - CO - 3rd rt - CO where rt = reclose time.

Reclose Times

1st Reclose Time range:	0.5 - 180 sec
2nd Reclose Time range:	2.0 - 180 sec
3rd Reclose Time range:	2.0 - 180 sec
Timing resolution:	0.1 sec

Fast Trip Input Module

This module is available as an accessory. It provides an optically isolated input to unconditionally trip the recloser within 60ms of activation (including debounce and breaker operating time). This module is purchased as an additional hardware item. For further details or application suitability, refer to Nu-Lec Industries.

Sequence Reset Time

Sequence Reset Time:	5 - 180 sec
Timing resolution:	1 sec

Trips to Lockout

Overcurrent and fault trips to lockout are selectable between 1 and 4. A separate setting is available for Sensitive Earth Fault (SEF).

Inverse Time Curves

The CAPM offers a total of 48 user selectable inverse time protection curves. These are:

Three IEC255 curves:	Standard Inverse, Very Inverse and Extremely Inverse.
Three IEEE C37.112 Inverse Time curves:	Moderately Inverse, Very Inverse and Extremely Inverse.
42 Non Standard Inverse Time Curves:	Refer to the Technical Manual for a full listing.

User Defined Curves

Up to five User Defined Curves (UDCs) may be selected at the control panel in the same manner as the above curves. The UDC module in WSOS is used to configure the UDCs.

Instantaneous Protection

Instantaneous Protection works by tripping the recloser if the line current exceeds the Instantaneous Multiplier x Setting Current.

Multiplier range:	1 - 30
Resolution of setting:	0.1
Max effective setting:	16kA

Definite Time Protection

Definite Time is available on phase and earth protection as an alternative to Inverse Time protection. It works by tripping the recloser at a fixed time after pickup.

Setting current range:	10 - 1260A
Definite time resolution:	0.1 sec
Definite time range:	0.5 - 100 sec
Setting current resolution:	1A

Sensitive Earth Fault (SEF)

SEF causes the recloser to trip when the earth current rises above a set level for longer than the set time.

SEF trip current range:	4 - 20A
1A SEF option available on request	1 - 20A
SEF operating time range:	0.1 - 100 sec
SEF trip current setting resolution:	1 A
SEF operating time resolution:	0.1 sec

Sequence Coordination

Sequence Coordination allows a recloser to keep its trip sequence in step with another recloser downstream.

Directional Blocking

Directional blocking is an additional protection feature that restricts tripping on faults to a designated side of the recloser. It prevents nuisance tripping if particular network conditions are causing “false” earth faults. In radial systems Directional Blocking prevents nuisance tripping by blocking faults in the source direction and only responding to faults in the load direction.

Live Load Blocking

Live Load Blocking prevents a recloser from closing if any of the load side terminals are live.

Live Load Threshold Voltage range: 2 - 15kV

Loss of Phase

Loss of Phase Protection trips the recloser if phase-earth voltage on one or two phases falls below a set voltage threshold for a set length of time.

Threshold voltage range: 2 - 15kV
 Voltage resolution: 1V
 Time range: 0.1 - 100 sec
 Time resolution: 0.1 sec

Negative Phase Sequence

Negative Phase Sequence (NPS) current protection enables detection of low level phase-to-phase faults in the presence of high level three phase loads. Inverse Time, Definite Time and Instantaneous operation are available.

Setting current range: 10 - 1260 A

Inrush Restraint

Inrush Restraint raises the phase and earth threshold currents for a short period of time to allow for short duration inrush currents when closing onto a load.

Multiplier range: 1 - 30
 Multiplier resolution: 0.1
 Time range: 0.05 - 30 sec
 Time resolution: 0.05 sec

Cold Load Pickup

Cold Load Pickup allows for a loss of diversity when a load has been without supply for a period of time.

Multiplier range: 1 - 5
 Multiplier resolution: 0.1
 Time Constant range: 1 - 480 min
 Time constant resolution: 1 min

Under / Over Frequency Protection

This is an additional protection feature.

Frequency tripping range: 45 - 65 Hz
 Frequency calculation: Once per cycle over a two cycle period
 Number of under/over frequency cycles before tripping: 2 - 1000
 Accuracy: $\pm 0.05\text{Hz}$

Multiple Protection Groups

The CAPM supports up to 10 Protection Groups, each of which can be configured with completely separate protection characteristics with different inverse time curves and setting currents. The number of protection groups available to the operator can be configured using the Windows Switchgear Operating System thereby restricting or enabling access to protection settings as required.

Range of protection groups: A - J

Automatic Protection Group Selection

Automatic Protection Group Selection is used to change the protection characteristics depending on the direction of power flow. This allows the recloser to be correctly graded with devices downstream regardless of the power flow direction.

Range of protection group pairs: A&B, C&D, E&F, G&H, I&J

Automation Software

Optional software for Loop Automation and Auto-Changeover can be purchased at time of order or for field upgrade.

Voltage

True RMS voltage is measured on all six terminals. A user configured threshold indicates live terminal (accuracy $\pm 2.5\%$).

Current

RMS current is measured on three phases (accuracy $\pm 2.5\%$, reading 2-800A), Earth and Negative Phase Sequence.

Real Power (signed or unsigned)

Determined by multiplying $V \times I$ in real time and averaging over 2 seconds (accuracy $\pm 5\%$ of reading, within limits of V and I above).

Power Factor

Determined from line voltage and line current phase relationship and the previously calculated real power (accuracy $\pm 5\%$ of reading, within limits of V and I above).

Default Historical Measurements

Power flow is integrated over 5, 15, 30, or 60 minute intervals (kWh) and recorded for 2 months at the default setting. This can be viewed on the Operator Control Panel, computer, or compatible SCADA system. Additionally, data can be uploaded into a portable computer or a compatible SCADA system.

Configurable Historical Measurements

Average Demand Profiles may be configured using WSOS. Customised configuration enables the user to specify only the parameters that are required negating unnecessary information capture.

Event History

Minimum number of typical events stored in the event history:	3,000 events
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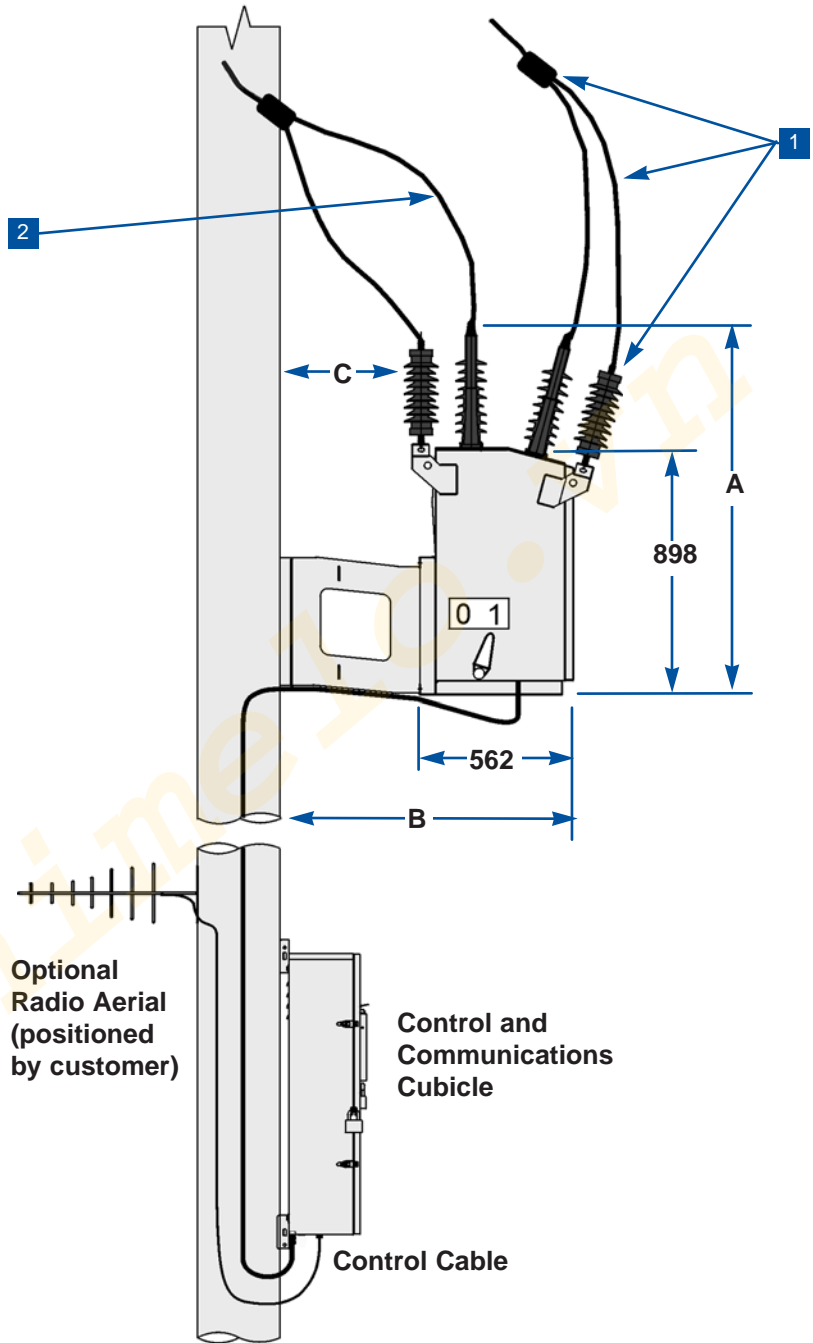
Gas Pressure Measurement

Gas Pressure Display Resolution	1kPa
Gas Pressure Display Accuracy	$\pm 5\text{kPa}$
Gas Low Alarm Setting	15kPa Gauge @ 20°C
Gas Low Alarm Accuracy	$\pm 5\text{kPa}$

Pole Mounting Details

- 1** Customer supplied
 - Insulated connectors
 - Connecting cables
 - Lightning arresters

- 2** 3 meter 400A cable tails are supplied with the models. (250, 630 or 800A tails on request)



Note:

1. Details given in this illustration are subject to change without notice. For full details see the separate Technical Manual.
2. Earthing connections are not shown and are to be in accordance with the Technical Manual.
3. Recloser can be mounted closer to pole if lightning arresters are pole mounted.
4. Optional substation mounting frame available on request.

Model	Rated Voltage	A[mm]	B[mm]	C[mm]
N15	15.5kV	1370	880	315
N27	27kV	1370	880	315
N38	38kV	1410	955	480

N-Series ACR specifications

Ratings	15kV 12.5kA	27kV 12.5kA	38kV 12.5kA	38kV 16kA
Maximum System Voltage	15.5kV	27kV	38kV	38kV
Rated Continuous Current	630A	630A	630A	800A
Fault Make Capacity (RMS).....	12.5kA	12.5kA	12.5kA	16kA
Fault Make Capacity (Peak).....	31.5kA	31.5kA	31.5kA	40kA
Power Operating Time (Close/Open).....	0.1 / 0.05s	0.1 / 0.05s	0.1 / 0.05s	0.1 / 0.05s
Mechanical Operations	10000	10000	10000	10000
Rated Full Load Operations	10000	10000	10000	10000
Short Time Current (1 & 3s RMS)	12.5kA	12.5kA	12.5kA	16kA

Breaking Capacity	15kV 12.5kA	27kV 12.5kA	38kV 12.5kA	38kV 16kA
Mainly Active (0.7pf)	630A	630A	630A	800A
Fault Break Capacity.....	12.5kA	12.5kA	12.5kA	16kA
Cable Charging	25A	40A	40A	40A
Transformer Magnetising	22A	22A	22A	22A
Capacitor Current.....	250A			

Impulse Insulation Level	15kV 12.5kA	27kV 12.5kA	38kV 12.5kA	38kV 16kA
Phase to Earth	110kV	150kV	170kV	170kV
Across Interrupter.....	110kV	150kV	170kV	170kV
On Loss of SF6.....	60kV	70kV	70kV	70kV

Power Frequency Insulation Level	15kV 12.5kA	27kV 12.5kA	38kV 12.5kA	38kV 16kA
Phase to Earth	50kV	70kV	70kV	70kV
Across Interrupter.....	50kV	70kV	70kV	70kV

Environmental	15kV 12.5kA	27kV 12.5kA	38kV 12.5kA	38kV 16kA
Ambient Temperature ⁽¹⁾	-30 to 50°C	-30 to 50°C	-30 to 50°C	-30 to 50°C
Radiation (Max).....	1.1kW/m ²	1.1kW/m ²	1.1kW/m ²	1.1kW/m ²
Humidity	0 to 100%	0 to 100%	0 to 100%	0 to 100%
Altitude (Max) ⁽²⁾	3000m	3000m	3000m	3000m

Net Weights ⁽³⁾	15kV 12.5kA	27kV 12.5kA	38kV 12.5kA	38kV 16kA
Standard Model.....	327kg	327kg	327kg	327kg
with External VT.....	380kg	387kg	387kg	387kg

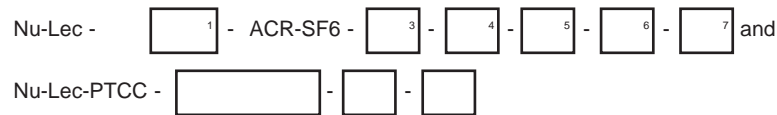
Crate Dimensions	15kV 12.5kA	27kV 12.5kA	38kV 12.5kA	38kV 16kA
Standard.....	W=1160mm	D=730mm	H=1640mm	
with External VT	W=1160mm	D=730mm	H=1960mm	

- 1 -30 to +50°C available as option when heater fitted to control cubicle.
- 2 For altitudes above 1000m, derate in accordance with ANSI C37.60.
- 3 For Gross Weights add 75kg.

Ordering Information

The N-Series ACR ordering information comprises two part numbers. The circuit breaker part number includes a Model Identifier and fields describing the Insulation Type, System Voltage, Interrupt Capacity, Insulation Level, Cable Rating and Mounting Bracket. The Pole Top Control Cubicle (PTCC) comprises temperature range, cable length and auxiliary supply. The part numbers do not include measurement units and is constructed using only one option per field in the selection chart below. A part number example is shown below:

Nu-Lec-N36S-ACR-SF6-38-16-170-800-C and **Nu-Lec-PTCC-Moderate-240-11**



Field descriptions

1. Model:
 4-20A SEF in N15,27 & 38.
 1-20A SEF in 'S' models.

2. Insulation medium:
 SF₆ gas insulated automatic circuit recloser.

3. System Voltage:
 15 = 15.5kV,
 27 = 27kV,
 38 = 38kV

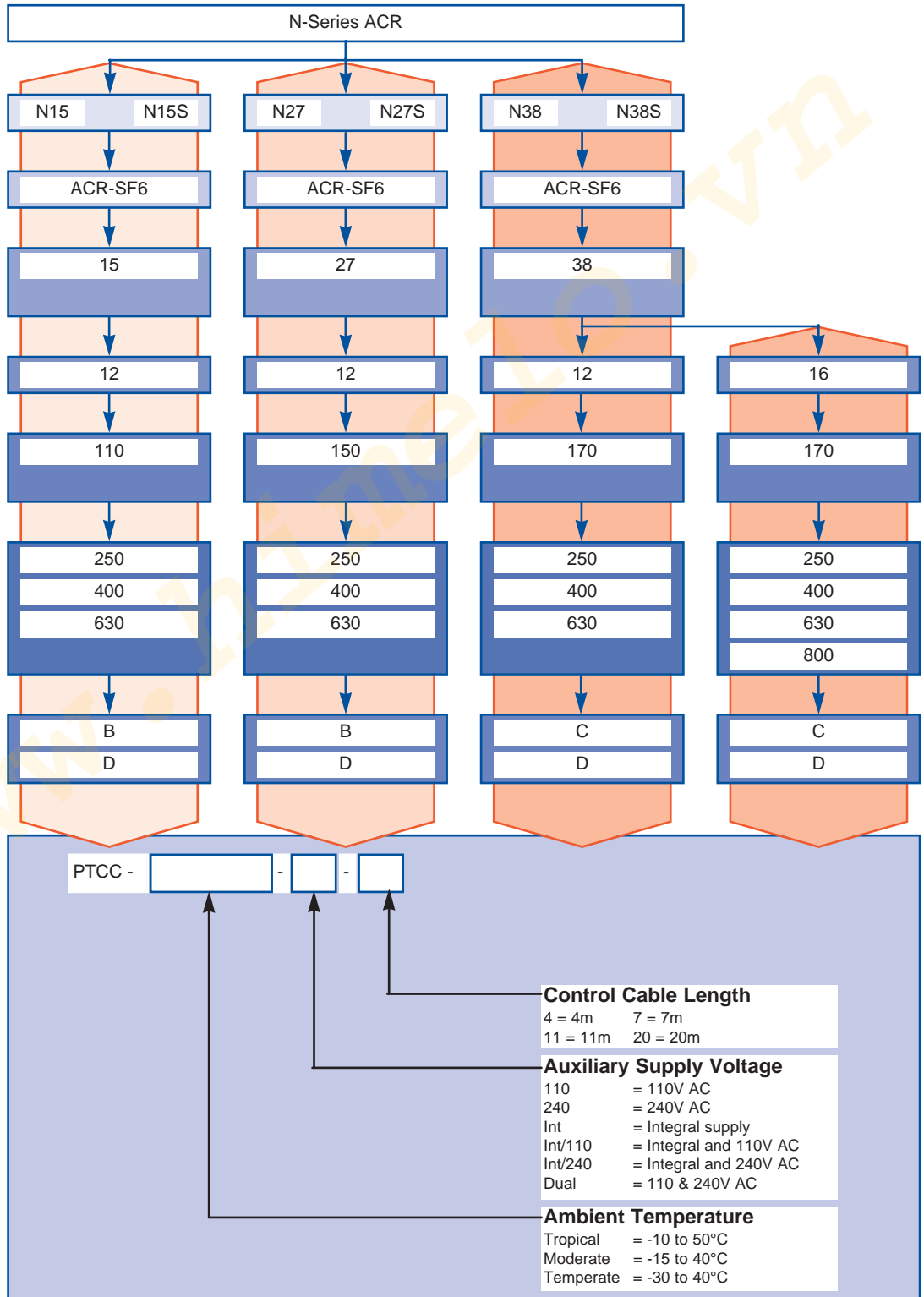
4. Interrupt Capacity
 12 = 12.5kA
 16 = 16kA.

5. Insulation Level:
 110 = 110kV
 150 = 150kV
 170 = 170kV (38kV N36/S)

6. Cable Rating:
 250 = 250A
 400 = 400A
 630 = 630A
 800 = 800A

7. Mounting Bracket:
 B = Type B
 C = Type C
 D = Substation mounting frame

Common control cubicle:
 Specify the temperature range, auxiliary supply voltage and control cable length for the Pole Top Control Cubicle (PTCC). Communication Protocol and radio/modem cable type must be separately specified at time of order.





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Distributor:

Brochure Part Number: N00-575

CORPORATE OFFICE & FACTORY

35-37 South Street, Lytton, 4178
Queensland, Australia
PO Box 761, Edith Street
Wynnum, Queensland, 4178
Telephone (07) 3249 5444
Intl +61 7 3249 5444
Facsimile (07) 3249 5888
Intl +61 7 3249 5888
E-mail: sales@nulec.com.au
<http://www.nulec.com.au>

USA OFFICE

1252 Old Alpharetta Road
Alpharetta, Georgia
30005-3986
United States of America
Telephone (770) 521 2000
Intl +1770 521 2000
Facsimile (770) 521 2100
Intl +1770 521 2100
E-mail: sales@nulec.com
<http://www.nulec.com>