Reclosers

Functional Specification Guide

SPEAR Single-Phase Recloser System

PS280003EN

1. Scope

This specification describes the features of the SPEAR single-phase recloser and control. The SPEAR recloser system shall consist of one single-phase recloser suitable for pole or substation mounting, and utilize a shatter-resistant outdoor cycloaliphatic epoxy encapsulated axial-field vacuum interrupter.

The SPEAR single-phase recloser control shall be a microprocessor-based recloser control, which is part of a line of fully integrated controls. These controls feature a standard look and feel, and universal platform that can be programmed for almost any protective application.

In addition to the flexible and user-friendly platform, the SPEAR single-phase recloser control shall utilize modern communications technology. For remote communication, the SPEAR single-phase recloser shall support cellular and radio communications utilizing Serial DNP3. The side panel RS-232 communications port shall be available as an accessory and can be used for connection to SCADA or other devices. The communications port shall be accessed by swinging the control panel forward.

The SPEAR single-phase recloser control shall provide phase current sensing, and one voltage and current input. The SPEAR single-phase recloser control can compute power, energy, power factor, and power flow direction from the voltage and current inputs.

The standardized front panel of the SPEAR single-phase recloser control shall be used to program and interrogate the control, as well as to display metering and alarm information. Control parameters can also be programmed via personal computer using ProView NXG interface software. The ProView NXG interface software shall include the functionality to select and modify time-current curves (TCCs), and provides diagnostic information. The SPEAR single-phase recloser control analysis tools include event recording, data profiling, and various metering capabilities.

2. Applicable Standards

2.1. The Quality Management System shall be ISO 9001 Certified.

The SPEAR single-phase recloser system shall be designed in accordance with the following standards as applicable:

IEEE Std C37.60™-2012 standard - Requirements for Overhead Pad-mounted, Dry Vault and Submersible Automatic Circuit –Reclosers and Fault Interrupters for Alternating Current Systems

ANSI/IEEE Std C37.90™-1989 standard - IEEE Standard for Relays and Relay Systems Associated with Electric Power Apparatus

IEEE Std C37.90.1™-2002 standard - Standard for Surge Withstand Capability (SWC) Tests for Relays and Relay Systems Associated with Electric Power Apparatus

IEEE Std C37.90.2™-2004 standard - Standard for Withstand Capability of Relay Systems to Radiated Electromagnetic Interference from Transceivers

IEC 255-21-1: 1988 - IEC Standard for Vibration, Shock, Bump and Seismic Tests on Measuring Relays and Protection Equipment, Section One - Vibration Tests (Sinusoidal), Class 1

IEC 255-21-2: 1988 - IEC Standard for Vibration, Shock, Bump and Seismic Tests on Measuring Relays and Protection Equipment, Section Two - Shock and Bump Tests, Class 1

IEC 255-21-3: 1993 - IEC Standard for Vibration, Shock, Bump and Seismic Tests on Measuring Relays and Protection Equipment, Section Three - Seismic Tests, Class 1 minimum, class 2 preferred

IEC 60255-5: 2000 - Electrical Relays-Part 5: Insulation Coordination for Measuring Relays and Protection Equipment - Requirements and Tests

- **a.** Test 6.1.3 – Impulse Voltage Withstand Test
- **b.** Test 6.1.4 – Dielectric Test

IEC 60255-22-1: 2005 - Measuring Relays and Protection Equipment - Part 22-1: Electrical Disturbance Tests - 1 MHz Burst Immunity Tests

- **a.** 2.5 kV Common Mode
- **b.** 1.0 kV Differential Mode

IEC 60068-2-1: 2007 – IEC Standard for Environmental Testing - Part 2-2; Test A: Cold, Section 4

IEC 60068-2-2: 2007 – IEC Standard for Environmental Testing - Part 2-2; Test B: Dry Heat, Section 3

IEC 60068-2-30: 2005 – IEC Standard for Basic Environmental Testing- Part 2-30: Procedures - Damp Heat, Cyclic

EN 55022:2006 (Class A, Industrial) – Informational Technology Equipment – Radio Disturbance Characteristics – Limits & Methods of Measurement; Conducted & Radiated Emissions

IEC 61000-4-2: 2008 – Electromagnetic Compatibility, Part 4: Test and Measurement Techniques; Section 2: Electrostatic Discharge Test

IEC 61000-4-3: 2006 (Edition 1.1) – Electromagnetic Compatibility, Part 4: Testing and Measurement Techniques; Section 3: Radiated Radio Frequency Immunity Test

IEC 61000-4-4: 2004 – Electromagnetic Compatibility (EMC) – Part 4-4: Testing and Measurement Techniques – Electrical Fast Transient/Burst Immunity Test

IEC 61000-4-6: 2003 - Electromagnetic Compatibility, Part 4-6: Testing and Measurement Techniques, Immunity to Conducted Disturbances, Induced by Radio-Frequency Fields; Level 3

IEC 61000-4-11: 2004 - Electromagnetic Compatibility (EMC) - Part 4-11: Testing and Measurement Techniques – Voltage Dips, Short Interruptions and Voltage Variations Immunity Tests

- **a.** 0% of voltage for 25 cycles
- **b.** 40% and 70% of voltage for 50 cycles

IEC 61000-4-5: 2005 - Electromagnetic Compatibility, Part 4: Testing and Measurement Techniques; Section 5: Surge Immunity Test, Class 3 minimum, electrical interconnections running as outdoor cables along with power cables

IEC 61000-4-12: 2006 - Electromagnetic Compatibility (EMC) - Part 4-12: Testing and Measurement Techniques – Ring Wave Immunity Test

- **a.** 100 kHz ring wave (contact inputs at level 2), all other circuits at level 4
- **b.** 100 kHz and 1.0 MHz damped oscillatory at level 3 for all circuits

MIL-STD-810F – Wind Blow Rain Test, Method 506.4 Procedure 1-40 mph Wind with a 4 Inch/Hour Rainfall Rate

IEC 61000-4-11: 2004 - Electromagnetic Compatibility, Part 4-11: Testing and Measurement Techniques, Voltage Dips, Short Interruptions and Voltage Variations Immunity Tests

TIA/EIA 232-F - Interface between Data Terminal Equipment and Data Circuit-Terminating Equipment Employing Serial Binary Data Interchange

Distributed Network Protocol Basic Four Document Set

3. Ratings

3.1. The SPEAR single-phase recloser shall be designed in accordance with this specification and shall be rated as follows:

3.1.1. Weight

Recloser	kg (lbs)
SPEAR15	52 (114)
SPEAR27	54 (118)
SPEAR38	56 (122)

Control	kg (lbs)
SPEAR control	27 (60)

3.1.2. Voltage

Rating	SPEAR15	SPEAR27	SPEAR38
Maximum Design Voltage (kV)	15.5	27	38.0
Nominal Operating Voltage (kV)	14.4	24.9	34.5
Basic Insulation Level (kV)	110	125	170
60 Hertz Withstand Voltage (kV)			
Dry, one minute	50	60	70
Wet, ten seconds	45	50	60
Radio Influence Voltage (RIV)			
100 µV Maximum (kV)	9.4	16.4	23.0

3.1.3. Current

Rating	SPEAR15	SPEAR27	SPEAR38
Continuous Current (A)	400/630/800	400/630/800	400/630/800
Symmetric Interrupting Current (A)			
400 A	8,000	8,000	8,000
630 A	12,500	12,500	12,500
800 A	12,500	12,500	12,500
Overload Capability			
400 A (125% - 8 Hrs.) (A)	500	500	500
400 A (150% - 4 Hrs.) (A)	600	600	600
630 A (125% - 8 Hrs) (A)	788	788	788
630 A (150% - 4 Hrs) (A)	945	945	945
800 A (125% - 8 Hrs.) (A)	None	None	None
800 A (150% - 4 Hrs.) (A)	None	None	None
Cable Charging Current (A)	10	25	40
Line Charging Current (A)	2	5	5
Three-Second Current Symmetric (A)			
400 A	8,000	8,000	8,000
630/800 A	12,500	12,500	12,500

3.1.4. Mechanical Life

Rating	SPEAR15	SPEAR27	SPEAR38
Minimum Operations	10,000	10,000	10,000

3.1.5. Frequency

Rating	SPEAR15	SPEAR27	SPEAR38
Rated Frequency (Hz)	50/60	50/60	50/60

3.1.6. Duty Cycle

Percent of Maximum Circuit Interrupting Rating	Minimum X/R Ratio	Number of Unit Operations at 12.5 kA
15-20	4	88
45-55	8	112
90-100	17	32
		Total 232

3.1.7. Creepage

Rating	SPEAR15	SPEAR27	SPEAR38
Creepage Distances	mm (in)	mm (in)	mm (in)
Terminal to Terminal	1052 (41.5)	1052 (41.5)	1052 (41.5)
Lower Terminal to Ground	673 (26.5)	760 (30.0)	950 (37.5)

4. Construction

4.1. The recloser manufacturer shall have no less than 10 years of experience in the design and fabrication of reclosers.

4.2. The SPEAR single-phase recloser system shall consist of one SPEAR single-phase recloser with one SPEAR single-phase recloser control, connected via 14-pin cable at customer specified length.

4.3. The recloser shall be electrically trip free. Any electrically applied close signal shall not inhibit the recloser from tripping on the programmed time-current curve.

4.4. The reclosers shall utilize environmentally friendly cycloaliphatic epoxy as the dielectric insulating medium. The use of SF_6 gas or oil for insulation or interruption is prohibited. Foam or Polyurethane insulation systems are not allowed.

4.5. A sensing bushing current transformer, 1000:1 ratio, for use with the recloser control, shall be an integral part of the recloser.

4.6. A 4-digit mechanical counter shall be provided under the sleet hood.

4.7. A yellow manual open operating handle shall be provided under the sleet hood.

4.8. Pulling the yellow handle down when in the closed position shall result in a manual opening operation. With the handle in the OPEN position, the recloser is in a “lock-out” position and shall not accept an electrical close signal from the control.

4.9. Returning the yellow operating handle to the CLOSED (UP) position shall not close the recloser. The yellow operating handle must be returned to the CLOSED (UP) position for the recloser to respond to a close signal from the SPEAR control. All close operations shall be initiated by the control.

4.10. A red/green (closed/open) position indicator flag shall be visible on the side of the sleet hood to provide contact position indication.

4.11. The recloser shall include provisions for mounting arresters to the recloser tank (one source and one load side arrester).

4.12. The recloser shall have an operating temperature range of -40 ºC to +55 ºC.

4.13. The recloser tank shall be heated and vented to mitigate condensation.

4.14. The recloser tank construction shall be mild steel, with stainless steel as an option.

5. Mechanism

5.1. The preferred recloser mechanism shall consist of a dual-coil (bi-stable) magnetic actuator capable of fast opening and closing operations with no recharging delay. Bi-stable means that no operating power is required to hold the unit open or closed.

5.1.1. The use of a single-coil magnetic actuator shall be prohibited.

5.2. A capacitor shall be used to store the necessary electrical energy for operating the magnetic actuator.

5.3. The design of the recloser shall permit for at least 1 open and close operation after loss of primary control voltage for dead line operation.

5.4. The reclosers shall contain no high voltage closing coils. The recloser shall be capable of operating fully from either 120 Vac or 240 Vac and 24 Vdc internal control battery.

6. Solid Dielectric Insulation

6.1. Cycloaliphatic epoxy shall be utilized as the dielectric insulating medium and be highly resistant to ozone, oxygen, moisture, contamination and ultraviolet light. No coatings or UV protective covers are acceptable.

6.1.1. The cycloaliphatic epoxy shall provide a non-brittle, non-flexible and a high resistance to damage dielectric insulating medium.

6.1.2. The cycloaliphatic epoxy shall provide complete encapsulation of the internal vacuum interrupter. The encapsulation shall also be completely bonded to the source and load side bushing terminals.

6.2. The recloser bushings shall be designed utilizing alternating minor and major skirts to increase creepage distance.

7. Vacuum Interrupters

7.1. The recloser shall make use of Axial-Magnetic vacuum interrupters from Eaton to ensure high fault-interrupting capability, provide fast low energy arc interruption and minimize heat generation.

7.1.1. Current interruption shall occur in vacuum interrupters, providing minimum and even contact wear, long life and maximum reliability and quality.

8. Current Transformers (CTs)

8.1. The current transformers shall be an integral part of the cycloaliphatic epoxy bushings. The CTs shall be a 1000:1 sensing CT used for all overcurrent protection, general metering and event history.

8.2. The current transformers shall be protected by a CT clamping circuit internal to the recloser to minimize the possibility of hazardous voltage entering the control compartment or exposed due to the control cable

being disconnected.

9. Mounting Frame

9.1. The SPEAR single-phase recloser shall have a tank mounting bracket so it can be directly mounted to a wooden pole or crossarm substation steel.

9.2. The SPEAR single-phase recloser shall have a pole mounting or crossarm mounting frame as an available accessory.

SPEAR Single-Phase Recloser Control Specifications

10. Control Housing

10.1. The standard recloser control shall be housed in a mild steel, weather-proof outdoor cabinet with accessible entry through one door. A stainless steel control cabinet is available as an option.

10.2. The recloser control cabinet shall be of the following dimension:

10.2.1. 12.01 in (305.05 mm) wide

10.2.2. 22.60 in (574.04 mm) high

10.2.3. 11.75 in (298.5 mm) deep

10.3. The recloser control cabinet door shall include gasketing to assure a weather-tight seal and include two locking provision.

10.4. A minimum of two latch points shall be required for the cabinet door.

10.5. A nameplate shall be attached to the front door.

10.6. Front door entry shall allow access to the operating panel without exposure to battery, or primary power voltage.

10.7. The swing panel of the recloser control module shall allow direct access to all control wiring, including incoming voltage, communication port, hardwired inputs and outputs, and the battery.

10.8. As part of the housing, a factory-mounted and pre-wired control cable receptacle shall allow the user a quick-disconnect from the recloser.

10.9. The recloser control housing shall have a provision for cable entry – up to three cable openings including the control cable receptacle to be connected to the high-voltage apparatus.

10.10. The recloser control housing shall have vent holes in the bottom of the control cabinet to prevent moisture buildup. The control shall have a standard thermostatically-controlled heater for humidity control. The heater shall draw power from the power input.

11. Temperature Range

11.1.1. The operating temperature range of the control shall be -40 °C to +65 °C ambient.

11.1.2. The recloser control shall operate within specification and not be damaged by temperature rates-of-change up to 0.2°C per minute.

11.1.3. The recloser control (minus the battery) shall not be damaged by short-term storage at ambient temperatures from -40 °C to +85 °C. Battery shall be stored at temperatures less than 47 °C.

11.1.4. The recloser control shall operate from 120 or 240 Vac for control power.

11.1.5. The recloser control shall include a battery that shall provide sufficient power to run the control without ac power for 48 hours at 20°C.

11.1.6. The recloser control shall operate on 50 and 60 Hz systems.

12. Front Panel

12.1.1. The front panel shall be designed to minimize training costs and avoid potential mis-operation.

12.1.2. The front panel shall be separated into two sections clearly identified by color-coding.

12.1.2.1. The top portion of the control shall be used for programming the control.

12.1.2.2. The lower portion of the control shall be used for operation.

12.1.3. The recloser control shall be integrated as a system to include proper status of the recloser on the front panel.

13. Programming/Status

13.1.1. The control programming section shall provide the user LED status indication. Each LED shall be rated for visibility in bright sunlight.

13.1.2. The control shall have a total of eleven LEDs available for direct control and recloser status information. As a minimum, dedicated LEDs shall include status indication as follows:

- Phase Fault
- Above Min Trip
- Lockout
- Open
- Closed
- Alarm
- Control OK
- AC Power
- Battery

13.2. A sharp, backlit 4-line x 16-character display shall be included in the programming section.

13.3. The LCD shall provide extensive status information regarding the distribution system, recloser, and control using a minimum of seven navigational keypads in an organized menu structure.

13.4. The navigational keypads shall include direct scroll up, down, left, and right keys, along with immediate enter, escape, and edit keys for direct operation.

13.5. The programming section shall also include a USB connector for direct connection to a personal computer (PC). The interface shall be designed DCE to directly connect to the USB port of the PC without any special cables or connectors. (Refer to Section 26.3)

14. Operating Section

14.1. The operating section shall allow the user direct open and close operation of the recloser along with pre-defined operating functions.

14.2. The TRIP and CLOSE buttons shall use a membrane push button and shall be sufficiently spaced apart to prevent incidental trip or close.

14.2.1. The TRIP button shall be green and the CLOSE button shall be red. No exceptions to the color of the TRIP and CLOSE button standards shall be accepted.

14.3. The front operating panel shall include the following pushbutton with LED Indicators:

- Supervisory OFF
- Non-Reclose
- Battery Test
- Alt Profile

14.3.1. The front operating panel shall include the following:

- Hot Line Tag ON/OFF Membrane Pushbutton
- Hot Line Tag LED Indicator Ring
- USB Data Port

15. Software

15.1. The recloser control shall use Microsoft® Windows® operating system-based interface software. The software shall be separate from the recloser control.

15.2. The executable configuration interface software shall allow the user the ability to save and edit files based upon user requirements independent of connectivity to the control.

15.3. All settings, metering, and diagnostic tools shall use standard dialog boxes, including available minimum and maximum values, for each setting.

15.4. Firmware upgrades shall be available through direct connection to the dedicated USB port on the control front panel using a (PC) computer only.

15.5. The executable configuration interface software shall allow for the following save and create options:

15.5.1. Save only communication settings to files based upon user requirements, independent of connectivity to control.

15.5.2. Save only protection profile settings to files based upon user requirements, independent of connectivity to control.

15.5.3. Save only system configuration settings to files based upon user requirements, independent of connectivity to control.

16. Protection

16.1. **Protection Profiles:** Two protection profiles shall be provided, each capable of fully specifying the operation of the control.

16.1.1. The protection profile shall be selectable from the front-panel pushbutton overlays, through the interface software, via the human-machine interface (HMI), through SCADA communications, or front panel USB port using (PC) computer.

16.1.2. Each protection profile shall include the following as a minimum:

- Overcurrent Protection
- Operation Settings

16.2. Overcurrent Protection/Time-Current Curves (TCC): The overcurrent protection feature shall allow the user to program the control with the settings associated with the phase overcurrent elements that are common to all TCC elements (TCC1, TCC2).

16.2.1. Time-current curves shall be available for fast and delayed operations.

16.2.2. Each time-current curve shall be selected from a defined 54 standard curves.

16.2.3. The time-current curves shall include the following modifications for phase protection:

16.2.3.1. Time Multiplier with a range of .1 to 25.

16.2.3.2. Time Adder with a range of 0 to 30 seconds.

16.2.3.3. Minimum Response Time with a range of 0.01 to 1.0 seconds.

16.2.3.4. High Current Trip with a range of 1 to 32 multiples of minimum trip.

16.2.3.5. HCT Time Delay with a range of 0.01 to 0.150 seconds.

17. High Current Lockout

17.1. The control shall include a High Current Lockout (HCL) feature that will automatically lockout the control when current exceeds a programmable level.

17.1.1. The active shot numbers for the lockout shall be selectable for phase.

17.1.2. Direct Current values, not multiples of minimum trip, shall be provided.

17.1.3. The HCL feature shall be independently selectable for each protection profile.

18. Cold Load Pickup: The control shall include a Cold Load Pickup (CLPU) feature to prevent the control from tripping due to short-term increases in current caused by a loss of normal load diversity or feeder inrush.

18.1. The CLPU settings shall be active for a specific time as determined by the Activation Time setting, after both of the following have occurred:

18.1.1. The recloser was open and locked out longer than a user-defined period of time (CLPU minimum recloser open time).

18.1.2. One of the following Close conditions:

- Manual Close initiated via the front panel Close membrane push-button
- Assertion of a Close contact input
- Supervisory Close command (SCADA or Remote)

18.1.3. The CLPU feature shall inhibit ‘normal’ overcurrent protection during the CLPU active time.

18.1.4. The CLPU feature shall have a separate, group-independent Phase minimum trip, reclose interval, and number of operations to lockout elements.

18.1.5. The CLPU TCC curve collection shall be the same as the Overcurrent TCC curves.

19. Hot Line Tag: The control shall include a Hot Line Tag (HLT) feature to block all electronic Close operations (local or remote) for live-line work.

19.1. When activated, the HLT feature shall only be capable of being deactivated from the source that activated HLT. Multiple sources may activate HLT. Each source that activates HLT must individually disable HLT.

19.2. The control shall trip on one operation-to-lockout on the composite curve of the HLT definite time and the TCC1 curve (whichever is faster) when HLT is active.

19.3. The HLT time delay shall be independently selectable for each protection profile.

20. Fast Trips Disabled: The control shall include a Fast Trips Disabled (FTD) feature to ignore the normal TCCs and number of trips, and instead use the FTD settings when FTD is active.

20.1. FTD shall have its own set of TCCs and number of trips.

20.2. The FTD feature shall be independently selectable for each protection profile.

21. Sequence Coordination: The control shall include a Sequence Coordination feature which will allow the control to step through selected operations in the operating sequence without tripping.

21.1. The number of Sequence Coordination advances shall be programmable from one to three operations to provide trip coordination with a downline recloser.

21.2. The Sequence Coordination feature shall be independently selectable for each protection profile.

22. Metering

22.1. The control shall provide instantaneous, demand, and energy metering.

22.2. The control shall provide the following metering values:

- Real and reactive power, including directional
- Demand currents
- Instantaneous currents
- Instantaneous voltage
- Instantaneous frequency
- Instantaneous power factor
- Metering settings to include power factor alarm, alarm time delay, demand interval, and alarm thresholds for current, single-phase kW and kVAR measurements.

22.3. An on-board Data Profiler shall be provided to record user-configured values (See Section 25).

22.4. The control shall have Diagnostic information stored in non-volatile memory and shall be available from the front panel or remotely.

23. Apparatus Wear Monitor: The control shall be equipped with an Apparatus Wear Monitor system to monitor the lifetime of the recloser mechanism.

23.1. The Apparatus Wear Monitor will record how many times the recloser has been opened as well as keep track of the current interrupted in percentage compared to preset total Duty Cycle Factor.

23.2. The Apparatus Wear Monitor shall permit programmable entries to preset the duty of an existing recloser.

24. Event Recorder: The control shall be equipped with a Sequence of Events (SOE) recorder that will capture discrete events such as recloser Open/Close status changes, faults, mechanism failures, and system-oriented events, such as setting the control time.

24.1. The SOE recorder shall place an accurate time stamp and analog information on events and store them in non-volatile memory.

24.2. The SOE recorder shall maintain a minimum of 1,000 events.

24.3. The SOE recorder shall be capable of recording up to 48 event types, some of which include:

- Overcurrent Protection Trip
- External Trip
- Non-Reclose Trip
- External Close
- Lockout
- Reset

24.4. The SOE recorder shall allow for exporting to a CSV file by ProView NXG software.

25. Data Profiler: The control shall include a Data Profiler that shall record configurable analog data for a specific period of time and store them in volatile memory.

25.1. The Data Profiler shall be configured to allow periodic recording with ranges from 1 minute to 24 hours for all selected parameters.

25.2. The number of data samples that can be retained shall be dependent upon the number of profile data selected, the sample rate, and duration.

25.3. At least 21 days of data shall be saved if 10 analog data points are selected and being continuously recorded with an interval of 15 minutes.

25.4. The Data Profiler shall present the data in table form and allow exporting to a CSV file.

26. Communications

26.1. The control shall support the following digital communication protocol options in the control to interface with locally connected and remote systems:

- Serial DNP3

26.2. The control shall support two auxiliary inputs and outputs.

26.3. The front panel shall include one (1) USB 2.0-compatible port for local connection to the control.

26.3.1. The USB 2.0-compatible device port shall be used for communications to a laptop or a PC.

26.3.2. All settings, real-time data, and archived data may be saved to a laptop or a PC.

26.4. The communication interface card shall be accessible through the module side cover when the swing panel is open and have provisions to support communication features and future released communication card interfaces.

27. Control Security

27.1. The control shall have a customer-programmable security code to limit access of control programming and viewing functions to authorized personnel.

27.2. There shall be a connection password when communicating between the control and a computer.