

Standard Development Roadmap

This section is maintained by the drafting team during the development of the standard and will be removed when the standard becomes effective.

Development Steps Completed:

1. Standards Committee approves SAR for posting on June 5, 2007.
2. The SAR was posted for comment from June 11, 2007–July 10, 2007.
3. The SC approves development of the standard on August 13, 2007.
4. First posting of revised standard on July 24, 2009.
5. Second posting of revised standard on June 11, 2010

Description of Current Draft:

This is the second draft of the Standard. This standard merges previous standards PRC-005-1, PRC-008-0, PRC-011-0, and PRC-017-0. It also addresses FERC comments from Order 693, and addresses observations from the NERC System Protection and Control Task Force, as presented in *NERC SPCTF Assessment of Standards: PRC-005-1 — Transmission and Generation Protection System Maintenance and Testing, PRC-008-0 — Underfrequency Load Shedding Equipment Maintenance Programs, PRC-011-0 — UVLS System Maintenance and Testing, PRC-017-0 — Special Protection System Maintenance and Testing.*

Future Development Plan:

Anticipated Actions	Anticipated Date
1. Post for combined pre-ballot review and comment.	June 11–July 16, 2010
2. Conduct initial ballot.	July 8–July 17, 2010
3. Drafting Team Responds to Comments.	July 19–July 22, 2010
4. Post response to comments and modified standard.	July 23, 2010
5. Conduct 10-day recirculation ballot.	July 23–August 2, 2010
6. Present to BOT for action.	August 5, 2010

Definitions of Terms Used in Standard

This section includes all newly defined or revised terms used in the proposed standard. Terms already defined in the Reliability Standards Glossary of Terms are not repeated here. New or revised definitions listed below become approved when the proposed standard is approved. When the standard becomes effective, these defined terms will be removed from the individual standard and added to the Glossary.

Protection System Maintenance Program (PSMP) — An ongoing program by which Protection System components are kept in working order and proper operation of malfunctioning components is restored. A maintenance program for a specific component includes one or more of the following activities:

- Verification — A means of determining that the component is functioning correctly.
- Monitoring — Observation of the routine in-service operation of the component.
- Testing — Application of signals to a component to observe functional performance or output behavior, or to diagnose problems.
- Inspection — To detect visible signs of component failure, reduced performance and degradation.
- Calibration — Adjustment of the operating threshold or measurement accuracy of a measuring element to meet the intended performance requirement.
- Upkeep — Routine activities necessary to assure that the component remains in good working order and implementation of any manufacturer's hardware and software service advisories which are relevant to the application of the device.
- Restoration — The actions to restore proper operation of malfunctioning components.

Protection System (modification) — Protective relays, communication systems necessary for correct operation of protective functions, voltage and current sensing inputs to protective relays and associated circuitry from the voltage and current sensing devices, station dc supply, and control circuitry associated with protective functions from the station dc supply through the trip coil(s) of the circuit breakers or other interrupting devices.

A. Introduction

1. **Title:** Protection System Maintenance
2. **Number:** PRC-005-2
3. **Purpose:** To ensure all transmission and generation Protection Systems affecting the reliability of the Bulk Electric System (BES) are maintained.
4. **Applicability:**
 - 4.1. **Functional Entities:**
 - 4.1.1 Transmission Owners
 - 4.1.2 Generator Owners
 - 4.1.3 Distribution Providers
 - 4.2. **Facilities:**
 - 4.2.1 Protection Systems applied on, or designed to provide protection for the BES.
 - 4.2.2 Protection System components used for underfrequency load-shedding systems installed per ERO underfrequency load-shedding requirements.
 - 4.2.3 Protection System components used for undervoltage load-shedding systems installed to prevent system voltage collapse or voltage instability for BES reliability.
 - 4.2.4 Protection System components installed as a Special Protection System for BES reliability.
 - 4.2.5 Protection Systems for generator Facilities that are part of the BES, including:
 - 4.2.5.1 Protection System components that act to trip the generator either directly or via generator lockout or auxiliary tripping relays.
 - 4.2.5.2 Protection Systems for generator step-up transformers for generators that are part of the BES.
 - 4.2.5.3 Protection Systems for transformers connecting aggregated generation, where the aggregated generation is part of the BES (e.g., transformers connecting facilities such as wind-farms to the BES).
 - 4.2.5.4 Protection Systems for generator-connected station service transformers for generators that are part of the BES.
 - 4.2.5.5 Protection Systems for system-connected station service transformers for generators that are part of the BES.
5. **(Proposed) Effective Date:** See Implementation Plan

B. Requirements

- R1. Each Transmission Owner, Generator Owner, and Distribution Provider shall establish a Protection System Maintenance Program (PSMP) for its Protection Systems that use measurements of voltage, current, frequency and/or phase angle to determine anomalies and to

trip a portion of the BES¹ and that are applied on, or are designed to provide protection for the BES. The PSMP shall meet the following criteria: *[Violation Risk Factor: High] [Time Horizon: Long Term Planning]*

- 1.1.** Identify all Protection System components.
 - 1.2.** Identify whether each Protection System component is addressed through time-based (per Table 1a), condition-based (per Table 1b or 1c), performance-based (per Attachment A), or a combination of these maintenance methods and identify the associated maintenance interval.
 - 1.3.** For each Protection System component, include all maintenance activities specified in Tables 1a, 1b, or 1c associated with the maintenance method used per Requirement 1, Part 1.2.
 - 1.4.** Include all batteries associated with the station dc supply component of a Protection System in a time-based program.
- R2.** Each Transmission Owner, Generator Owner, and Distribution Provider that uses condition-based maintenance intervals in its PSMP for partially or fully monitored Protection Systems shall ensure the components to which the condition-based criteria are applied, possess the monitoring attributes identified in Tables 1b or 1c. *[Violation Risk Factor: Medium] [Time Horizon: Long Term Planning]*
- R3.** Each Transmission Owner, Generator Owner, and Distribution Provider that uses performance-based maintenance intervals in its PSMP shall follow the procedure established in PRC-005 Attachment A to establish and maintain its performance-based intervals. *[Violation Risk Factor: Medium] [Time Horizon: Long Term Planning]*
- R4.** Each Transmission Owner, Generator Owner, and Distribution Provider shall implement its PSMP, including identification of the resolution of all maintenance correctable issues² as follows: *[Violation Risk Factor: Medium] [Time Horizon: Long Term Planning]*
- 4.1.** For time-based or condition-based maintenance programs, perform, the maintenance activities detailed in Table 1 (for the appropriate monitoring level(s)) for all Protection System components according to the PSMP established per Requirement R1 within maximum allowable intervals not to exceed those established in Tables 1a, 1b, and 1c.
 - 4.2.** For performance-based maintenance programs, perform, the maintenance activities detailed in Table 1 (for the appropriate monitoring level(s)) for all Protection System components in accordance within the maximum allowable intervals established per Requirement R3.
 - 4.3.** Ensure either that the components are within acceptable parameters at the conclusion of the maintenance activities or initiate any necessary activities to correct unresolved maintenance correctable issues³.

¹ Devices that sense non-electrical conditions, such as thermal or transformer sudden pressure relays are not included within the scope of this standard.

² A maintenance correctable issue is a failure of a device to operate within design parameters that cannot be restored to functional order by repair or calibration while performing the initial on-site maintenance activity, and that requires follow-up corrective action

³ A maintenance correctable issue is a failure of a device to operate within design parameters that cannot be restored to functional order by repair or calibration while performing the initial on-site maintenance activity and that requires follow-up corrective action.

C. Measures

- M1.** Each Transmission Owner, Generator Owner and Distribution Provider will have a documented Protection System Maintenance program that addresses protective relays, communication systems necessary for correct operation of protective functions, voltage and current sensing inputs to protective relays and associated circuitry from the voltage and current sensing devices, station dc supply, and control circuitry associated with protective functions from the station dc supply through the trip coil(s) of the circuit breakers or other interrupting devices, as required by Requirement R1. For each protection system component, the documentation shall include the type of maintenance program applied, maintenance activities, and maintenance intervals as specified in Requirement R1, Parts 1.1 through 1.4.
- M2.** Each Transmission Owner and Generator Owner that uses a condition-based maintenance program should have evidence such as engineering drawings or manufacturer’s information showing that the components possess the monitoring attributes identified in Tables 1b or 1c, as required by Requirement R2.
- M3.** Each Transmission Owner, Generator Owner, or Distribution Provider that uses a performance-based maintenance program should have evidence such as equipment lists, maintenance records, and analysis records and results that its performance-based maintenance program is in accordance with Requirement R3.
- M4.** Each Transmission Owner, Generator Owner, or Distribution Provider shall have evidence such as maintenance records or maintenance summaries (including dates that the components were maintained) that it has implemented the Protection System Maintenance Program in accordance with Requirement R4.

D. Compliance

1. Compliance Monitoring Process

1.1. Compliance Monitoring Responsibility

Regional Entity

1.2. Compliance Monitoring and Enforcement Processes:

Compliance Audits

Self-Certifications

Spot Checking

Compliance Violation Investigations

Self-Reporting

Complaints

1.3. Data Retention

The Transmission Owner, Generator Owner, and Distribution Provider shall each retain documentation of the two most recent performances of each distinct maintenance activity for the Protection System components, or to the previous on-site audit date, whichever is longer.

The Compliance Enforcement Authority shall keep the last periodic audit report and all requested and submitted subsequent compliance records.

1.4. Additional Compliance Information

None.

2. Violation Severity Levels

Requirement Number	Lower VSL	Moderate VSL	High VSL	Severe VSL
R1	<p>The entity’s PSMP included all of the ‘types’ of components included in the definition of ‘Protection System’, but, for no more than 5% of the components, failed to either</p> <ul style="list-style-type: none"> • Identify the component, • Specify whether the component is being addressed by time-based, condition-based, or performance-based maintenance, or • Include all maintenance activities specified in Table 1a, Table 1b, or Table 1c, as applicable. 	<p>The entity’s PSMP included all of the ‘types’ of components included in the definition of ‘Protection System’, but, for greater than 5%, but no more than 10% of the components, failed to either</p> <ul style="list-style-type: none"> • Identify the component, • Specify whether the component is being addressed by time-based, condition-based, or performance-based maintenance, or • Include all maintenance activities specified in Table 1a, Table 1b, or Table 1c, as applicable. 	<p>The entity’s PSMP included all of the ‘types’ of components included in the definition of ‘Protection System’, but, for greater than 10%, but no more than 15%, of the components, failed to either</p> <ul style="list-style-type: none"> • Identify the component, • Specify whether the component is being addressed by time-based, condition-based, or performance-based maintenance, or • Include all maintenance activities specified in Table 1a, Table 1b, or Table 1c, as applicable. 	<p>The entity’s PSMP failed to address one or more of the types of components included in the definition of ‘Protection System’</p> <p>OR</p> <p>Entity has not established a PSMP.</p> <p>OR</p> <p>The entity’s PSMP included all of the ‘types’ of components included in the definition of ‘Protection System’, but, for more than 15% of the components, failed to either</p> <ul style="list-style-type: none"> • Identify the component, • Specify whether the component is being addressed by time-based, condition-based, or performance-based maintenance, or • Include all maintenance activities specified in Table 1a, Table 1b, or Table 1c, as applicable.
R2	<p>Entity has Protection System components in a condition-based PSMP, but documentation to support Partially-Monitored Protection System classification or Fully-Monitored Protection System classification is incomplete on no more than 5% of the Protection System components maintained according to Tables 1b and 1c.</p>	<p>Entity has Protection System elements in a condition-based PSMP, but documentation to support Partially-Monitored Protection System classification or Fully-Monitored Protection System classification is incomplete on more than 5%, but 10% or less, of the Protection System components maintained according to Tables 1b</p>	<p>Entity has Protection System elements in a condition-based PSMP, but documentation to support Partially-Monitored Protection System classification or Fully-Monitored Protection System classification is incomplete on more than 10%, but 15% or less, of the Protection System components maintained according to Tables 1b</p>	<p>Entity has Protection System elements in a condition-based PSMP, but documentation to support Partially-Monitored Protection System classification or Fully-Monitored Protection System classification is incomplete on more than 15% of the Protection System components maintained according to Tables 1b and 1c.</p>

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Requirement Number	Lower VSL	Moderate VSL	High VSL	Severe VSL
		and 1c.	and 1c.	
R3	Entity has Protection System elements in a performance-based PSMP but has: <ol style="list-style-type: none"> 1) Failed to reduce countable events to less than 4% within three years. OR <ol style="list-style-type: none"> 2) Failed to annually document program activities, results, maintenance dates, or countable events for 5% or less of components in any individual segment OR <ol style="list-style-type: none"> 3) Maintained a segment with 54-59 components or containing different manufacturers. 	NA	Entity has Protection System elements in a performance-based PSMP but has failed to reduce countable events to less than 4% within four years.	Entity has Protection System components in a performance-based PSMP but has: <ol style="list-style-type: none"> 1) Failed to reduce countable events to less than 4% within five years. OR <ol style="list-style-type: none"> 2) Failed to annually document program activities, results, maintenance dates, or countable events for over 5% of components in any individual segment. OR <ol style="list-style-type: none"> 3) Maintained a segment with less than 54 components. OR <ol style="list-style-type: none"> 4) Failed to annually update the list of components, <ul style="list-style-type: none"> • Perform maintenance on the greater of 5% of the segment population or 3 components, or • Annually analyze the program activities and results for each segment.
R4	Entity has failed to complete scheduled program on 5% or less of total Protection System components.	Entity has failed to complete scheduled program on greater than 5%, but no more than 10% of total Protection System components.	Entity has failed to complete scheduled program on greater than 10%, but no more than 15% of total Protection System components.	Entity has failed to complete scheduled program on greater than 15% of total Protection System components. OR Entity has failed to initiate resolution of maintenance-correctable issues

E. Regional Variances

None

F. Supplemental Reference Documents

The following documents present a detailed discussion about determination of maintenance intervals and other useful information regarding establishment of a maintenance program.

1. PRC-005-2 Protection System Maintenance Supplementary Reference — July 2009.
2. NERC Protection System Maintenance Standard PRC-005-2 FREQUENTLY ASKED QUESTIONS — Practical Compliance and Implementation DRAFT 1.0 — June 2009

Version History

Version	Date	Action	Change Tracking
2	TBD	Complete revision, absorbing maintenance requirements from PRC-005-1, PRC-008-0, PRC-011-0, PRC-017	Complete revision

Table 1a — Time-Based Maintenance — Level 1 Monitoring

Maximum Allowable Testing Intervals and Maintenance Activities for Unmonitored Protection System Components

General Description: Protection System components which do not have self-monitoring alarms, or if self-monitoring alarms are available, the alarms are not transmitted to a location where action can be taken for alarmed failures.

General Maintenance Requirements: Perform maintenance activities listed and initiate necessary corrective actions in accordance with Requirement R4.

Type of Protection System Component	Maximum Maintenance Interval	Maintenance Activities
Protective Relays	6 Calendar Years	Test and calibrate the relays (other than microprocessor relays) with simulated electrical inputs. (Note 1) Verify that settings are as specified. For microprocessor relays, check the relay inputs and outputs that are essential to proper functioning of the Protection System. For microprocessor relays, verify acceptable measurement of power system input values.
Voltage and Current Sensing Inputs to Protective Relays and associated circuitry	12 Calendar Years	Verify proper functioning of the current and voltage signals necessary for Protection System operation from the voltage and current sensing devices to the protective relays.
Control and trip circuits with electromechanical trip or auxiliary contacts (except for microprocessor relays, UFLS or UVLS)	6 Calendar Years	Perform a complete functional trip test that includes all sections of the Protection System control and trip circuits, including all electromechanical trip and auxiliary contacts essential to proper functioning of the Protection System.
Control and trip circuits with unmonitored solid-state trip or auxiliary contacts (except for UFLS or UVLS)	12 Calendar Years	Perform a complete functional trip test that includes all sections of the Protection System control and trip circuits, including all solid-state trip and auxiliary contacts (e.g. paths with no moving parts), devices, and connections essential to proper functioning of the Protection System.
Control and trip circuits with electromechanical trip or auxiliary (UFLS/UVLS Systems Only)	6 Calendar Years	Perform a complete functional trip test that includes all sections of the Protection System control and trip circuits, including all electromechanical trip and auxiliary contacts essential to proper functioning of the Protection System, except that verification does not require actual tripping of circuit breakers or interrupting devices.
Control and trip circuits with unmonitored solid-state trip or auxiliary contacts (UFLS/UVLS Systems Only)	12 Calendar Years	Perform a complete functional trip test that includes all sections of the Protection System control and trip circuit, including all solid-state trip and auxiliary contacts (e.g. paths with no moving parts), devices, and connections essential to proper functioning of the Protection System, except that verification does not require actual tripping of circuit breakers or interrupting devices.

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Table 1a — Time-Based Maintenance — Level 1 Monitoring

Maximum Allowable Testing Intervals and Maintenance Activities for Unmonitored Protection System Components

General Description: Protection System components which do not have self-monitoring alarms, or if self-monitoring alarms are available, the alarms are not transmitted to a location where action can be taken for alarmed failures.

General Maintenance Requirements: Perform maintenance activities listed and initiate necessary corrective actions in accordance with Requirement R4.

Type of Protection System Component	Maximum Maintenance Interval	Maintenance Activities
Station dc Supply (used only for UVLS or UFLS)	(when the associated UVLS or UFLS system is maintained)	Verify proper voltage of the dc supply.
Station dc supply	18 Calendar Months	Verify: <ul style="list-style-type: none"> • State of charge of the individual battery cell/units • Float voltage of battery charger • Battery continuity • Battery terminal connection resistance • Battery cell-to-cell connection resistance Inspect: <ul style="list-style-type: none"> • Cell condition of all individual battery cells where cells are visible – or measure battery cell/unit internal ohmic values where the cells are not visible • Physical condition of battery rack • The condition of non-battery-based dc supply
Station dc supply (that has as a component any type of battery)	3 Calendar Months	Check: <ul style="list-style-type: none"> • Electrolyte level (excluding valve-regulated lead acid batteries) • Station dc supply voltage • For unintentional grounds
Station dc supply (that has as a component Valve Regulated Lead-Acid batteries)	3 Calendar Years - or - 3 Calendar Months	Verify that the station battery can perform as designed by conducting a performance or service capacity test of the entire battery bank. (3 calendar years) - or - Verify that the station battery can perform as designed by evaluating the measured cell/unit internal ohmic values to station battery baseline. (3 months)

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Table 1a — Time-Based Maintenance — Level 1 Monitoring

Maximum Allowable Testing Intervals and Maintenance Activities for Unmonitored Protection System Components

General Description: Protection System components which do not have self-monitoring alarms, or if self-monitoring alarms are available, the alarms are not transmitted to a location where action can be taken for alarmed failures.

General Maintenance Requirements: Perform maintenance activities listed and initiate necessary corrective actions in accordance with Requirement R4.

Type of Protection System Component	Maximum Maintenance Interval	Maintenance Activities
Station dc supply (that has as a component Vented Lead-Acid Batteries)	6 Calendar Years - or - 18 Calendar Months	Verify that the station battery can perform as designed by conducting a performance, service, or modified performance capacity test of the entire battery bank. (6 calendar years) - or - Verify that the station battery can perform as designed by evaluating the measured cell/unit internal ohmic values to station battery baseline. (18 Months)
Station dc supply (that has as a component Nickel-Cadmium batteries)	6 Calendar Years	Verify that the substation battery can perform as designed by conducting a performance service, or modified performance capacity test of the entire battery bank.
Station dc supply (battery is not used)	6 Calendar Years	Verify that the dc supply can perform as designed when the ac power from the grid is not present.
Station dc Supply (battery is not used)	18 Calendar Months	Verify proper voltage of the station dc supply. Verify that no unintentional dc supply grounds are present. Perform a visual inspection, of all components of the station dc supply to verify that the physical condition of the station dc supply is as desired and any visual inspection if required by the manufacturer on the condition of the dc supply that is the source of dc power when ac power is unavailable. Verify where applicable the proper voltage level of each component of the station dc supply. Verify the correct operation of ac powered dc power supplies. Verify the continuity of all circuit connections that can be affected by wear or corrosion. Inspect all circuit connections that can be affected by wear and corrosion.
Associated communications systems	3 Calendar Months	Verify that the Protection System communications system is functional.
Associated communications systems	6 Calendar Years	Verify that the performance of the channel and the quality of the channel meets performance criteria, such as via measurement of signal level, reflected power, or data error rate. Verify proper functioning of communications equipment inputs and outputs that are essential to proper functioning of the Protection System. Verify the signals to/from the associated protective relay(s).

Standard PRC-005-2 – Protection System Maintenance

Table 1a — Time-Based Maintenance — Level 1 Monitoring

Maximum Allowable Testing Intervals and Maintenance Activities for Unmonitored Protection System Components

General Description: Protection System components which do not have self-monitoring alarms, or if self-monitoring alarms are available, the alarms are not transmitted to a location where action can be taken for alarmed failures.

General Maintenance Requirements: Perform maintenance activities listed and initiate necessary corrective actions in accordance with Requirement R4.

Type of Protection System Component	Maximum Maintenance Interval	Maintenance Activities
UVLS and UFLS relays that comprise a protection scheme distributed over the power system	6 Calendar Years	Test and calibrate the relays (other than microprocessor relays) with simulated electrical inputs. (Note 1) Verify proper functioning of the relay trip outputs. For microprocessor relays verify the proper functioning of the A/D converters. Verify that settings are as specified.
Relay sensing for Centralized UFLS or UVLS systems UVLS and UFLS relays that comprise a protection scheme distributed over the power system	See Maintenance Activities	Perform all of the Maintenance activities listed above as established for components of the UFLS or UVLS systems at the intervals established for those individual components. The output action may be breaker tripping, or other control action that must be verified, but may be verified in overlapping segments. A grouped output control action need be verified only once within the specified time interval, but all of the UFLS or UVLS components whose operation leads to that control action must each be verified.
SPS	See Maintenance Activities	Perform all of the Maintenance activities listed above as established for components of the SPS at the intervals established for those individual components. The output action may be breaker tripping, or other control action that must be verified, but may be verified in overlapping segments. A grouped output control action need be verified only once within the specified time interval, but all of the SPS components whose operation leads to that control action must each be verified.

Table 1b — Condition-Based Maintenance - Level 2 Monitoring

Maximum Allowable Testing Intervals and Maintenance Activities for Partially Monitored Protection System Components

General Description: Protection System components whose conditions or alarms are automatically provided daily (or more frequently) to a location where action can be taken for alarmed failures. Detected maintenance-correctable issues for Level 2 Monitored Protection Systems must be reported within 1 day or less of the maintenance-correctable issue occurring, to a location where action can be taken to initiate resolution of the maintenance-correctable issue. Level 2 monitoring includes all monitoring attributes as listed below for the individual type of component.

General Maintenance Requirements: Perform maintenance activities listed and initiate necessary corrective actions in accordance with Requirement R4.

Type of Protection System Component	Level 2 Monitoring Attributes for Component	Maximum Maintenance Interval	Maintenance Activities
Protective Relays	Includes <ul style="list-style-type: none"> • Internal self diagnosis and alarm capability • Alarm must assert for power supply failures • Input voltage or current waveform sampling three or more times per power cycle • Conversion of samples to numeric values for measurement calculations by microprocessor electronics that are also performing self diagnosis and alarming 	12 Calendar Years	Verify the status of relays is normal with no alarms indicated. Verify acceptable measurement of power system input values. For microprocessor relays, check the relay inputs and outputs that are essential to proper functioning of the Protection System. Verify that settings are as specified. Verify that the relay alarms will be received at the location where action can be taken. Verify correct operation of output actions that are used for tripping.
Voltage and Current Sensing Inputs to Protective Relays and associated circuitry	No Level 2 monitoring attributes are defined – use Level 1 Maintenance Activities	12 Calendar Years	Verify the proper functioning of current and voltage circuit signals necessary for Protection System operation from the voltage and current sensing devices to the protective relays.
Control Circuitry (Trip Coils and Auxiliary Relays)	Monitoring and alarming of continuity of trip circuits(s)	6 Calendar Years	Verify that each breaker trip coil, each auxiliary relay, and each lockout relay is electrically operated within this time interval.

Table 1b — Condition-Based Maintenance - Level 2 Monitoring

Maximum Allowable Testing Intervals and Maintenance Activities for Partially Monitored Protection System Components

General Description: Protection System components whose conditions or alarms are automatically provided daily (or more frequently) to a location where action can be taken for alarmed failures. Detected maintenance-correctable issues for Level 2 Monitored Protection Systems must be reported within 1 day or less of the maintenance-correctable issue occurring, to a location where action can be taken to initiate resolution of the maintenance-correctable issue. Level 2 monitoring includes all monitoring attributes as listed below for the individual type of component.

General Maintenance Requirements: Perform maintenance activities listed and initiate necessary corrective actions in accordance with Requirement R4.

Type of Protection System Component	Level 2 Monitoring Attributes for Component	Maximum Maintenance Interval	Maintenance Activities
Control Circuitry (Trip Circuits) (except for UFLS/UVLS)	Monitoring of Protection System component inputs, outputs, and connections with reporting of monitoring alarms to a location where action can be taken Connection paths using electronic signals or data messages are monitored by periodic signal changes or messages that verify ability to convey Protection System operating values	12 Calendar Years	Verify that the alarms will be received at the location where action can be taken.
Control and trip circuitry	Monitoring of the continuity of breaker trip circuits along with the presence of tripping voltage supply all the way from relay terminals (or from inside the relay) through to the trip coil(s), including any auxiliary contacts essential to proper Protection System operation. If a trip circuit comprises multiple paths, each of the paths must be monitored, including monitoring of the operating coil circuit(s) and the tripping circuits of auxiliary tripping relays and lockout relays. Alarming for loss of continuity or dc supply for trip circuits is reported to a location where action can be taken.	12 Calendar Years	Verify that the alarms will be received at the location where action can be taken.

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Table 1b — Condition-Based Maintenance - Level 2 Monitoring

Maximum Allowable Testing Intervals and Maintenance Activities for Partially Monitored Protection System Components

General Description: Protection System components whose conditions or alarms are automatically provided daily (or more frequently) to a location where action can be taken for alarmed failures. Detected maintenance-correctable issues for Level 2 Monitored Protection Systems must be reported within 1 day or less of the maintenance-correctable issue occurring, to a location where action can be taken to initiate resolution of the maintenance-correctable issue. Level 2 monitoring includes all monitoring attributes as listed below for the individual type of component.

General Maintenance Requirements: Perform maintenance activities listed and initiate necessary corrective actions in accordance with Requirement R4.

Type of Protection System Component	Level 2 Monitoring Attributes for Component	Maximum Maintenance Interval	Maintenance Activities
Station dc supply	Monitor and alarm for: <ul style="list-style-type: none"> • Station dc supply voltage • Unintentional dc grounds • Electrolyte level of all cells in a station battery • Individual battery cell/unit state of charge • Battery continuity of station battery • Cell-to-cell and battery terminal resistance 	6 Calendar Years	Verify that the monitoring devices are calibrated (where necessary) and alarms will be received at the location where action can be taken.
Station dc supply	No Level 2 monitoring attributes are defined – use Level 1 Maintenance Activities	18 Calendar Months	Inspect: <ul style="list-style-type: none"> • Cell condition of individual battery cells where cells are visible, or measure battery cell/unit internal ohmic values where cells are not visible • Physical condition of battery rack • The condition of non-battery based dc supply
Station dc supply (that has as a component Valve Regulated Lead-Acid batteries)	No Level 2 monitoring attributes are defined – use Level 1 Maintenance Activities	3 Calendar Years - or - 3 Calendar Months	Verify that the station battery can perform as designed by conducting a performance or service capacity test of the entire battery bank. (3 calendar years) - or - Verify that the station battery can perform as designed by evaluating the measured cell/unit internal ohmic values to station battery baseline. (3 months)

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Table 1b — Condition-Based Maintenance - Level 2 Monitoring

Maximum Allowable Testing Intervals and Maintenance Activities for Partially Monitored Protection System Components

General Description: Protection System components whose conditions or alarms are automatically provided daily (or more frequently) to a location where action can be taken for alarmed failures. Detected maintenance-correctable issues for Level 2 Monitored Protection Systems must be reported within 1 day or less of the maintenance-correctable issue occurring, to a location where action can be taken to initiate resolution of the maintenance-correctable issue. Level 2 monitoring includes all monitoring attributes as listed below for the individual type of component.

General Maintenance Requirements: Perform maintenance activities listed and initiate necessary corrective actions in accordance with Requirement R4.

Type of Protection System Component	Level 2 Monitoring Attributes for Component	Maximum Maintenance Interval	Maintenance Activities
Station dc supply (that has as a component Vented Lead-Acid batteries)	No Level 2 monitoring attributes are defined – use Level 1 Maintenance Activities	6 Calendar Years - or - 18 Calendar Months	Verify that the substation battery can perform as designed by conducting a performance service, or modified performance capacity test of the entire battery bank. (6 calendar years) - or - Verify that the station battery can perform as designed by evaluating the measured cell/unit internal ohmic values to station battery baseline. (18 Months)
Station dc supply (that has as a component Nickel-Cadmium batteries)	No Level 2 monitoring attributes are defined – use Level 1 Maintenance Activities	6 Calendar Years	Verify that the substation battery can perform as designed by conducting a performance service, or modified performance capacity test of the entire battery bank.
Station dc Supply (battery is not used)	No Level 2 monitoring attributes are defined – use Level 1 Maintenance Activities	6 Calendar Years	Verify that the dc supply can perform as designed when ac power from the grid is not present.
Associated communications system	Monitoring and alarming of protection communications system by mechanisms that check for presence of the communications channel.	12 Calendar Years	Verify that the performance of the channel and the quality of the channel meets performance criteria, such as via measurement of signal level, reflected power, or data error rate. Verify proper functioning of communications equipment inputs and outputs that are essential to proper functioning of the Protection System. Verify the signals to/from the associated protective relay(s). Verify proper functioning of alarm notification.

Table 1b — Condition-Based Maintenance - Level 2 Monitoring

Maximum Allowable Testing Intervals and Maintenance Activities for Partially Monitored Protection System Components

General Description: Protection System components whose conditions or alarms are automatically provided daily (or more frequently) to a location where action can be taken for alarmed failures. Detected maintenance-correctable issues for Level 2 Monitored Protection Systems must be reported within 1 day or less of the maintenance-correctable issue occurring, to a location where action can be taken to initiate resolution of the maintenance-correctable issue. Level 2 monitoring includes all monitoring attributes as listed below for the individual type of component.

General Maintenance Requirements: Perform maintenance activities listed and initiate necessary corrective actions in accordance with Requirement R4.

Type of Protection System Component	Level 2 Monitoring Attributes for Component	Maximum Maintenance Interval	Maintenance Activities
UVLS and UFLS relays that comprise a protection scheme distributed over the power system	Includes internal self diagnosis and alarm capability, which must assert for power supply failures. Includes input voltage or current waveform sampling three or more times per power cycle, and conversion of samples to numeric values for measurement calculations by microprocessor electronics that are also performing self diagnosis and alarming.	12 Calendar Years	<p>Verify the status of relays as in service with no alarms.</p> <p>Verify acceptable measurement of power system input values the proper function of the A/D converters (if included in relay).</p> <p>Verify proper functioning of the relay trip outputs.</p> <p>Verify that settings are as specified.</p> <p>Verify that the relay alarms will be received at the location where action can be taken.</p>
Relay sensing for centralized UFLS or UVLS systems	See the attributes of Level 2 Monitoring for the individual components of the SPS	See Maintenance Intervals for the individual components of the UFLS/UVLS	Perform all of the Maintenance activities listed above as established for components of the UFLS or UVLS systems at the intervals established for those individual components. The output action may be breaker tripping, or other control action that must be verified, but may be verified in overlapping segments. A grouped output control action need be verified only once within the specified time interval, but all of the UFLS or UVLS components whose operation leads to that control action must each be verified.
SPS	See the attributes of Level 2 Monitoring for the individual components of the SPS	See Maintenance Intervals for the individual components of the SPS	Perform all of the Maintenance activities listed above as established for components of the SPS, at the intervals established for those individual components. The output action may be breaker tripping, or other control action that must be verified, but may be verified in overlapping segments. A grouped output control action need be verified only once within the specified time interval, but all of the SPS components whose operation leads to that control action must each be verified.

Table 1c — Condition-based Maintenance — Level 3 Monitoring

Maximum Allowable Testing Intervals and Maintenance Activities for Fully Monitored Protection System Components

General Description: Protection System components in which every function required for correct operation of that component is continuously monitored and verified, and detected maintenance-correctable issues reported. Level 3 Monitored Protection Systems also includes verification of the means by which alarms and monitored values are transmitted to a location where action can be taken. Detected maintenance-correctable issues for Level 3 Monitored Protection Systems must be reported within 1 hour or less of the maintenance-correctable issue occurring, to a location where action can be taken to initiate resolution of the maintenance-correctable issue. Level 3 Monitoring includes all attributes of Level 2 Monitoring, with additional monitoring attributes as listed below for the individual type of component.

General Maintenance Requirements: Perform maintenance activities listed and initiate necessary corrective actions in accordance with Requirement R4.

Type of Protection System Component	Level 3 Monitoring Attributes for Component	Maximum Maintenance Interval	Maintenance Activities
Protective Relays	Relay A/D converters are continuously monitored and alarmed	Continuous	Continuous verification of the status of the relays Alarm on change of settings
Protective Relays with trip contacts	All Level attributes, except relay possesses mechanical output contacts	12 Calendar Years	Verify proper functioning of the relay trip contacts.
Voltage and Current Sensing Inputs to Protective Relays and associated circuitry	Verification of the analog values (magnitude and phase angle) measured by the microprocessor relay or comparable device, by comparing against other measurements using other voltage and current sensing devices	Continuous	Continuous verification and comparison of the current and voltage signals from the voltage and current sensing devices of the Protection System
Protection System control and trip circuitry	Monitoring and alarming of the alarm path itself	Continuous	Continuous verification of the status of the monitored control circuits
Station dc supply	No Level 3 monitoring attributes are defined – use Level 1 Maintenance Activities and intervals	18 Calendar Months	Inspect: <ul style="list-style-type: none"> • Cell condition of all individual battery cells where cells are visible – or measure battery cell/unit internal ohmic values where the cells are not visible • Physical condition of battery rack • The condition of non-battery-based dc supply

Table 1c — Condition-based Maintenance — Level 3 Monitoring

Maximum Allowable Testing Intervals and Maintenance Activities for Fully Monitored Protection System Components

General Description: Protection System components in which every function required for correct operation of that component is continuously monitored and verified, and detected maintenance-correctable issues reported. Level 3 Monitored Protection Systems also includes verification of the means by which alarms and monitored values are transmitted to a location where action can be taken. Detected maintenance-correctable issues for Level 3 Monitored Protection Systems must be reported within 1 hour or less of the maintenance-correctable issue occurring, to a location where action can be taken to initiate resolution of the maintenance-correctable issue. Level 3 Monitoring includes all attributes of Level 2 Monitoring, with additional monitoring attributes as listed below for the individual type of component.

General Maintenance Requirements: Perform maintenance activities listed and initiate necessary corrective actions in accordance with Requirement R4.

Type of Protection System Component	Level 3 Monitoring Attributes for Component	Maximum Maintenance Interval	Maintenance Activities
Station dc supply (that has as a component Valve Regulated Lead-Acid batteries)	No Level 3 monitoring attributes are defined – use Level 1 Maintenance Activities and intervals	3 Calendar Years - or - 3 Calendar Months	Verify that the station battery can perform as designed by conducting a performance or service capacity test of the entire battery bank. (3 calendar years) - or - Verify that the station battery can perform as designed by evaluating the measured cell/unit internal ohmic values to station battery baseline. (3 months)
Station dc supply (that has as a component Vented Lead-Acid Batteries)	No Level 3 monitoring attributes are defined – use Level 1 Maintenance Activities and intervals	6 Calendar Years - or - 18 Calendar Months	Verify that the station battery can perform as designed by conducting a performance service, or modified performance capacity test of the entire battery bank. (6 calendar years) - or - Verify that the station battery can perform as designed by evaluating the measured cell/unit internal ohmic values to station battery baseline. (18 Months)
Station dc supply (that has as a component Nickel-Cadmium batteries)	No Level 3 monitoring attributes are defined – use Level 1 Maintenance Activities and intervals	6 Calendar Years	Verify that the substation battery can perform as designed by conducting a performance service, or modified performance capacity test of the entire battery bank.
Station dc Supply (any battery technology)	Monitoring and alarming for station dc supply voltage, unintentional dc grounds, electrolyte level of all cells of a station battery, individual battery cell/unit state of charge, battery continuity of station battery and cell-to-cell and battery terminal resistance	Continuous	Continuous monitoring of station dc supply voltage, unintentional dc grounds, electrolyte level of all cells of a station battery, individual battery cell/unit state of charge, battery continuity of station battery and cell-to-cell and battery terminal resistance are provided with alarming to remote location upon any failure of the monitoring device or when sensors for the devices are out of calibration.

Table 1c — Condition-based Maintenance — Level 3 Monitoring

Maximum Allowable Testing Intervals and Maintenance Activities for Fully Monitored Protection System Components

General Description: Protection System components in which every function required for correct operation of that component is continuously monitored and verified, and detected maintenance-correctable issues reported. Level 3 Monitored Protection Systems also includes verification of the means by which alarms and monitored values are transmitted to a location where action can be taken. Detected maintenance-correctable issues for Level 3 Monitored Protection Systems must be reported within 1 hour or less of the maintenance-correctable issue occurring, to a location where action can be taken to initiate resolution of the maintenance-correctable issue. Level 3 Monitoring includes all attributes of Level 2 Monitoring, with additional monitoring attributes as listed below for the individual type of component.

General Maintenance Requirements: Perform maintenance activities listed and initiate necessary corrective actions in accordance with Requirement R4.

Type of Protection System Component	Level 3 Monitoring Attributes for Component	Maximum Maintenance Interval	Maintenance Activities
Station dc Supply which do not use a station battery	No Level 3 monitoring attributes are defined – use Level 1 Maintenance Activities and intervals	6 Calendar Years	Verify that the dc supply can perform as designed when the ac power from the grid is not present.
Associated communications systems	Evaluating the performance of the channel and its interface to protective relays to determine the quality of the channel and alarming if the channel does not meet performance criteria	Continuous	Continuous verification that the performance and quality of the channel meets performance criteria is provided. Continuous verification of the communications equipment alarm system is provided.
UVLS and UFLS relays that comprise a protection scheme distributed over the power system.	The relay A/D converters are continuously monitored and alarmed.	Continuous	Continuous verification of the status of the relays Alarm on change of settings Verification does not require actual tripping of circuit breakers or interrupting devices
Relay sensing for centralized UFLS or UVLS systems.	See the attributes of Level 3 Monitoring for the individual components of the UFLS/UVLS	See Maintenance Activities	Perform all of the Maintenance activities listed above as established for components of the UFLS or UVLS systems at the intervals established for those individual components. The output action may be breaker tripping, or other control action that must be verified, but may be verified in overlapping segments. A grouped output control action need be verified only once within the specified time interval, but all of the UFLS or UVLS components whose operation leads to that control action must each be verified.

Table 1c — Condition-based Maintenance — Level 3 Monitoring

Maximum Allowable Testing Intervals and Maintenance Activities for Fully Monitored Protection System Components

General Description: Protection System components in which every function required for correct operation of that component is continuously monitored and verified, and detected maintenance-correctable issues reported. Level 3 Monitored Protection Systems also includes verification of the means by which alarms and monitored values are transmitted to a location where action can be taken. Detected maintenance-correctable issues for Level 3 Monitored Protection Systems must be reported within 1 hour or less of the maintenance-correctable issue occurring, to a location where action can be taken to initiate resolution of the maintenance-correctable issue. Level 3 Monitoring includes all attributes of Level 2 Monitoring, with additional monitoring attributes as listed below for the individual type of component.

General Maintenance Requirements: Perform maintenance activities listed and initiate necessary corrective actions in accordance with Requirement R4.

Type of Protection System Component	Level 3 Monitoring Attributes for Component	Maximum Maintenance Interval	Maintenance Activities
SPS	See the attributes of Level 3 Monitoring for the individual components of the SPS	See Maintenance Activities	Perform all of the Maintenance activities listed above as established for components of the SPS at the intervals established for those individual components. The output action may be breaker tripping, or other control action that must be verified, but may be verified in overlapping segments. A grouped output control action need be verified only once within the specified time interval, but all of the SPS components whose operation leads to that control action must each be verified.

Notes for Table 1a, Table 1b, and Table 1c

1. For some Protection System components, adjustment is required to bring measurement accuracy within parameters established by the asset owner based on the specific application of the component. A calibration failure is the result if testing finds the specified parameters to be out of tolerance.

PRC-005 — Attachment A

Criteria for a Performance-Based Protection System Maintenance Program

Purpose: To establish a technical basis for initial and continued use of a performance-based Protection System Maintenance Program (PSMP).

Segment: In this procedure, the term, “segment” is a grouping of Protection Systems or components from a single manufacturer, with common factors such that consistent performance is expected across the entire population of the segment, and shall only be defined for a population of 60 or more individual components.⁴

To establish the technical justification for the initial use of a performance-based PSMP:

1. Develop a list with a description of components included in each designated segment of the Protection System component population.
2. Maintain the components in each segment according to the time-based maximum allowable intervals established in Table 1 until results of maintenance activities for the segment are available for a minimum of 30 individual components of the segment.
3. Document the maintenance program activities and results for each segment, including maintenance dates and countable events⁵ for each included component.
4. Analyze the maintenance program activities and results for each segment to determine the overall performance of the segment and develop maintenance intervals.
5. Determine the maximum allowable maintenance interval for each segment such that the segment experiences countable events on no more than 4% of the components within the segment, for the greater of either the last 30 components maintained or all components maintained in the previous year.

To maintain the technical justification for the ongoing use of a performance-based PSMP:

1. At least annually, update the list of Protection System components and segments and/or description if any changes occur within the segment.
2. Perform maintenance on the greater of 5% of the components (addressed in the performance based PSMP) in each segment or 3 individual components within the segment in each year.
3. For the prior year, analyze the maintenance program activities and results for each segment to determine the overall performance of the segment.
4. If the components in a Protection System segment maintained through a performance-based PSMP experience 4% or more countable events, develop, document, and

⁴ Entities with smaller populations of component devices may aggregate their populations to define a segment and shall share all attributes of a single performance-based program for that segment.

⁵ Countable events include any failure of a component requiring repair or replacement, any condition discovered during the verification activities in Table 1a through Table 1c which requires corrective action, or a Misoperation attributed to hardware failure or calibration failure.

implement an action plan to reduce the countable events to less than 4% of the segment population within 3 years.

5. Using the prior year's data, determine the maximum allowable maintenance interval for each segment such that the segment experiences countable events on no more than 4% of the components within the segment, for the greater of either the last 30 components maintained or all components maintained in the previous year.