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NPCC
Regional Reliability Reference Directory # 3
Maintenance Criteria for Bulk Power System Protection

Task Force on System Protection Revision Review Record:
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Adopted by the Members of the Northeast Power Coordinating Council, Inc. this July 11, 2008 based on recommendation by the Reliability Coordinating Committee, in accordance with Section VIII of the NPCC Amended and Restated Bylaws dated July 24, 2007 as amended to date.

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Revision History

Version	Date	Action	Change Tracking (New, Errata or Revisions)

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**NPCC Directory D3
Maintenance Criteria for Bulk Power System Protection**

1.0 Introduction

1.1 Title Maintenance Criteria for BPS Protection

1.2 Directory Number 3

1.3 Objective

The purpose of this Directory is to present the basic maintenance requirements for **bulk power system protection systems**. It is recognized that responsible entities may choose to apply more rigid requirements because of local considerations.

1.4 Effective Date July 11, 2008

1.5 Background

This Directory was developed from the NPCC A-04 Maintenance Criteria for Bulk Power System Protection and B-23 Guideline document. Guidelines and procedures for consideration in the implementation of this Directory are provided in Appendix B.

1.6 Applicability

1.6.1 Functional Entities¹

Transmission Owners
Generator Owners
Distribution Providers

1.6.2 Facilities

These criteria shall apply to all **protection** of the NPCC **bulk power system**, including Type I **special protection systems** and **protection** required for the NPCC Automatic Underfrequency **Load Shedding** Program.

Automatic underfrequency **load shedding protection systems** and generator underfrequency tripping **relays** are not generally

¹ Any of these entities that own a transmission protection system and/or a Underfrequency Load Shedding (UFLS) facility/program

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located at **bulk power system** stations; however, they have a direct effect on the operation of the **bulk power system** during major **emergencies**, and as such, they are subject to this Criteria.

2.0 Terms Defined in this Directory

The definitions of terms found in this Directory appearing in bold typeface can be found in Document A-07, NPCC Glossary of Terms.

3.0 NERC Reliability Standard Requirements

The NERC Reliability Standards containing Requirements that are associated with this Directory include:

- 3.1 [PRC-005-1 – Transmission and Generation Protection System Maintenance and Testing](#)
- 3.2 [PRC-008-0 - Implementation and Documentation of UFLS Equipment Maintenance Program](#)
- 3.3 [PRC-011-0 – UVLS System Maintenance and Testing](#)
- 3.4 [PRC-012-0 – Special Protection System Review Procedure](#)
- 3.5 [PRC-017-0 – Special Protection System Maintenance and Testing](#)

4.0 NPCC Regional Reliability Standard Requirements

None developed at this time.

5.0 NPCC Full Member, More Stringent Criteria

5.1 General Criteria

Minimum periodic testing of each **protection group** shall be conducted to verify that the **protection group** is capable of performing its intended **protection** function. Such testing shall include **protection** assembly testing (as illustrated in attached Figure 1) and **protection group** system testing. To assure satisfactory operation of the protective equipment as a system, test procedures and test facilities must ensure that related tests properly overlap.

5.2 **Protection** Assembly Testing Requirements

Refer to Figure 1, equipment marked as [1]

The following **Protection** Assembly testing shall be performed on an interval not exceeding that specified in Table 1 for **bulk power system**

protection groups:

- 5.2.1 Make visual inspections,
- 5.2.2 Verify inputs and outputs,
- 5.2.3 Confirm that the intended version of software is installed (microprocessor-based **relays**),
- 5.2.4 Verify correct **protection** operation,
- 5.2.5 Verify the integrity of current and voltage transformers and associated circuitry. This verifies that the correct secondary quantities are input to the **relay**. For microprocessor **relays**, verify the internal analog inputs with an independent source.

**TABLE 1
INTERVALS FOR PROTECTION ASSEMBLY TESTING**

	Non-Self Monitored Protection Assembly Note (1)	Microprocessor-Based Protection Assembly Note (2)	Microprocessor-Based Protection Assembly Note -(3)
All Protection Groups	4 years	6 years	8 years

Notes:

- (1) Non-Self Monitored **protection** assemblies include electromechanical **relays** and solid state **relays**.
- (2) Microprocessor-based **protection** assemblies where the principal fault-sensing and logic components include self monitoring or self checking, and the failure alarm is monitored to an Operator.
- (3) Microprocessor-based **protection** assemblies as per Note (2), plus additional self monitoring or self checking of ac voltage and current input integrity, and the failure alarm is monitored to an Operator.

5.3 Protection Group DC Circuits Testing Requirements

Refer to Figure 1, equipment marked as [2]

Tests performed in Section 5.2 above verify the operation of the ac signaling, measuring **relays**, and verify a **protection** assemblies' ability to

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initiate a trip output(s). However, to verify operation of the **protection group** as a system, DC circuit testing is required. These tests verify the **protection** equipment operation from the trip outputs of the protection assembly up to breaker trip coils. DC circuit testing can be achieved by verifying overlapping **protection group** equipment zones, normally bound by test switches, or by test tripping the **protection group**.

DC circuit test tripping shall be performed on an interval not exceeding that specified in Table 2 for **bulk power system protection groups**:

TABLE 2
INTERVALS FOR DC CIRCUIT TEST TRIPPING

	Non-Monitored	Monitored Note (1)
DC Circuit Tripping	4 years	6 years

Note (1): Trip coil and DC circuit continuity is continuously monitored to an Operator.

5.4 Battery Banks and Chargers Testing Requirements

Refer to Figure 1, equipment marked as [5]

Voltage verification of the station battery(s) shall be performed on an interval not exceeding that specified in Table 3 for **bulk power system protection groups**:

TABLE 3
INTERVALS FOR BATTERY BANKS AND CHARGER TESTING

	Non-Monitored	Monitored Note (1)
Battery Voltage	Every month	Continuous None

Note (1): Battery Voltage alarms are continuously monitored to an Operator

5.5 Breaker Test Tripping Requirements

Refer to Figure 1, equipment marked as [4]

The ability of the breaker(s) to trip via each trip coil shall be verified every two years. Nuclear plants **bulk power system unit breaker trip tests** ~~can may be completed~~ ~~these tests~~ at an interval not to exceed three years.

5.6 Telecommunication Testing Requirements

Refer to Figure 1, equipment marked as [3a] and [3b]

5.6.1 Terminal Equipment

Telecommunications terminal equipment shall be tested on the same time interval as the protection assemblies as per Table 1 above.

5.6.2 Channel Health

For trip equipment which uses frequency shift keying (FSK) mode of communication and the channel (for example, Guard Signal) is continuously monitored, such as Power Line Carrier systems, the ability to perform its intended trip function shall be verified every twelve months.

For telecommunication system channels that are continuously monitored and continuously provide verification of trip capability to an Operator, no additional testing is necessary. This testing is not required for telecommunication systems that continuously verify this functionality to an Operator—alarmed and monitored.

For telecommunication system channels that are not continuously monitored, The signal adequacy shall be tested every month and the ability of a channel to perform its intended function shall be verified every twelve months ~~on telecommunication systems that are not continuously monitored.~~ An example of such a system is on/off Power Line Carrier.

5.7 Underfrequency Load Shedding Testing and Generator ~~Trip~~ Underfrequency Relay Testing Requirements

5.7.1 **Protection group** DC circuit tests, battery bank and charger tests and breaker test tripping for **protection** required by the NPCC Automatic Underfrequency **Load Shedding** Program need not be performed more frequently than the **protection group** DC circuit tests, battery bank and charger tests and breaker test tripping for other **protection** on the same breaker. Because of the distributed nature of this **load shedding protection**, random failures to trip do not compromise the objectives of the NPCC Automatic Underfrequency **Load Shedding** Program.

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5.7.2 The successful operation of the NPCC Automatic Underfrequency **Load Shedding** Program requires the proper coordination of generator underfrequency tripping, as described in Directory 2. For generators rated 20 MW and above, the correct calibration of generator underfrequency tripping **relays** shall be verified at an interval not exceeding that specified in Table 1.

6.0 Measures and Assessments

None developed at this time.

7.0 Compliance Monitoring

Adherence to requirements in this Directory must be reported in a manner and form designated by the Compliance Committee. Exceptions to the requirements stipulated herein are acceptable if the exceptions are completely removed within five (5) months of the end of the calendar year in which the testing is due. The intervals specified in this document refer to calendar year in which testing is due regardless of the date.

Prepared by: Task Force on System Protection

Review and Approval: Revision to any portion of this Directory will be posted by the lead Task Force in the NPCC Open Process for a 45 day review and comment period. Upon satisfactorily addressing all the comments in this forum, the Directory document will be sent to the remaining Task Forces for their recommendation to seek RCC approval.

Upon approval of the RCC, this Directory will be sent to the Full Member Representatives for their final approval if sections pertaining to the Requirements and Criteria portion have been revised. All voting and approvals will be conducted according to the most current "NPCC. Bylaws" in effect at the time the ballots are cast.

Revisions pertaining to the Appendices or any other portion of the document such as Links glossary terms, etc., only RCC Members will need to conduct the final approval ballot of the document.

This Directory will be updated at least once every 3 years and as often as necessary to keep it current and consistent with NERC, Regional Reliability Standards and other NPCC documents.

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NPCC Directory D3
Maintenance Criteria for Bulk Power System Protection

References: NPCC Glossary of Terms (Document A-7)

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Appendix A Definition of Terms

Bulk power system - The interconnected electrical systems within northeastern North America comprising **generation** and transmission facilities on which faults or disturbances can have a significant adverse impact outside of the local area. In this context, local areas are determined by the Council members.

Element — any electric device with terminals that may be connected to other electric devices, such as a generator, transformer, circuit, circuit breaker, or bus section.
Limiting Element — the element that is either operating at its appropriate **rating** or would be following a limiting **contingency** and, as a result, establishes a system limit.

Load — the electric **power** used by devices connected to an electrical generating system. (IEEE Power Engineering). Also see **Demand**.

NPCC Specific Definitions:

Firm Load — Loads that are not **Interruptible Loads**.

Interruptible Load — Loads that are interruptible under the terms specified in a contract.

Load Shedding — the process of deliberately removing (either manually or automatically) preselected customers' **load** from a power system in response to an abnormal condition to maintain the integrity of the system and minimize overall customer outages.

Protection - The provisions for detecting power system **faults** or abnormal conditions and taking appropriate automatic corrective action.

Protection group — a fully integrated assembly of **protective relays** and associated equipment that is designed to perform the specified protective functions for a power system **element**, independent of other groups.

Notes:

(a) Variously identified as Main **Protection**, Primary **Protection**, Breaker Failure **Protection**, Back-Up **Protection**, Alternate **Protection**, Secondary **Protection**, A **Protection**, B **Protection**, Group A, Group B, System 1 or System 2.

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(b) Pilot **protection** is considered to be one **protection group**.

Protection system

Element Basis

One or more **protection** groups; including all equipment such as instrument transformers, station wiring, circuit breakers and associated trip/close modules, and communication facilities; installed at all terminals of a power system **element** to provide the complete **protection** of that **element**.

Terminal Basis

One or more **protection** groups, as above, installed at one terminal of a power system **element**, typically a transmission line.

Pilot **Protection** — a form of line **protection** that uses a communication channel as a means to compare electrical conditions at the terminals of a line.

Relay — an electrical device designed to respond to input conditions in a prescribed manner and after specified conditions are met to cause contact operation or similar abrupt change in associated electric control circuits. (Also: see **protective relay**).

Special protection system (SPS) – A **protection system** designed to detect abnormal system conditions, and take corrective action other than the isolation of faulted **elements**. Such action may include changes in **load, generation,** or system configuration to maintain system **stability**, acceptable voltages or power flows. Automatic underfrequency **load shedding** as defined in the *Emergency Operation Criteria A-3*, is not considered a **Special Protection System**. Conventionally switched, locally controlled shunt devices are not **Special Protection Systems**

Appendix B

Guideline and Procedure for Maintenance of Bulk Power System Protection

1.0 Introduction

This Appendix provides the guidelines and procedures for consideration in the implementation of this Directory.

2.0 General

2.1 Generator Under-frequency Tripping

For generators rated less than 20 MW, consideration may be given to verifying the calibration of generator underfrequency **relays** at an interval not exceeding that specified in Table 1.

3.0 Microprocessor-based Protective Relays

The use of computer based technology for **protective relays** has influenced what is considered sufficient for periodic maintenance of microprocessor-based **relays**. The purpose of this document is to provide guidance for the maintenance of microprocessor-based **protective relays** as required in Section 5.2 and in notes (2) and (3) of Table 1 of this Directory.

This Section applies only to the maintenance of microprocessor-based **protective relays** (**Protection** Assembly Testing Requirements, verify correct **protection** operation). It does not include other **protection** maintenance that is still required, as outlined in the remaining Sections of this Directory.

This Section is not intended to be a maintenance procedure, but rather a guide for member systems to develop their maintenance procedures.

3.1 Testing of Microprocessor-Based Relays

For the purposes of maintenance testing, microprocessor-based **relays** or Intelligent Electronic Devices (IEDs), can be viewed as being composed of four sections:

- 3.1.1 Analog Input Section;
- 3.1.2 Digital Input/Output Section;
- 3.1.3 Processor Section; and;
- 3.1.4 Power supply Section

3.2 Analog Input Section

Measurements of magnitude and angle (calculate where not available directly) of metered values should be compared with known quantities. This supposes that the device uses the same hardware for both protection and metering. If this is not the case, then a calibration test should be conducted to verify the analog inputs.

It is not sufficient to compare the magnitudes as measured by the IED. The input section has filtering with active and passive components, which are vulnerable to change over time and cause changes in the phase characteristics of the channel. Measuring and recording of the phase angle readings is, therefore, required.

3.3 Digital Input and Output Sections

Each digital input and output that is utilized should be verified for proper functions.

3.3.1 Inputs

Operation of all used physical inputs should be verified by applying the DC control voltage, and observing associated display, or the computer interface.

3.3.2 Outputs

Outputs of the IED should be verified either by:

3.3.2.1 Asserting the output element using appropriate relay commands and observe the status of the output relay, or;

3.3.2.2 Where such features are not available, the appropriate output contact can be verified by asserting the associated logic settings that permit contact operation.

3.4 Processor Section

The processor section samples the analog and digital inputs, executes the algorithm and logic, and provides the outputs. It includes program memory, non-volatile memory for settings and volatile memory for

sequence of events and oscillography. The processor section also performs self-checking.

All of the downloaded settings and the firmware version should be compared with the official copy of the protection settings to verify that the **relay** contains the intended settings, and it is working with the intended version of firmware.

3.5 Power Supply Section

Most microprocessor-based IEDs provide measurement of the power supply voltages and/or continuously monitor the power supply voltages, and provide a **relay** failure alarm if they go out of limits. Where these values are accessible, they should be checked against specified ranges. Alternatively, the alarm should be checked on loss of dc voltage to the power supply.

3.6 Integrity Testing

This test is intended to verify the integrity of operation of the **relay** program execution and the processing of the phase voltages and current signals. Verify the correct operation of one of the three-phase protection elements, or a single phase, for a single-phase **relay**. As an example, for a distance **relay**, test one of a zone's A-G, B-G, and C-G elements.

3.7 Multi-Processor Based IEDs

Most **relays** are designed using a single processor; however, some **relay** designs use multiple processors. If the processing is divided among several processors, then tests should be conducted to include testing of functions that are executed in the respective processors. The manufacturer and/or manual should be consulted to verify hardware configuration. As an example, if a **relay** uses two processors, one each for phase and ground elements, then integrity testing should be repeated for phase and ground elements respectively.
