Technical Justification

PRC-027-1 Protection System Coordination for Performance During Faults

The purpose of the proposed PRC-027-1 reliability standard is to coordinate Protection Systems for Interconnected Facilities, such that those Protection Systems remove from service only those Elements required to isolate Faults, while meeting the system performance specified within requirements established in other approved NERC reliability standards. This purpose is consistent with NERC's goal to create and implement reliability standards that enable or support at least one of the eight defined Reliability Principles. The requirements of the proposed PRC-027-1 reliability standard directly support the following Reliability Principles:

> Reliability Principle 1 – Interconnected bulk power systems shall be planned and operated in a coordinated manner to perform reliably under normal and abnormal conditions, as defined in the NERC Standards.
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> Reliability Principle 3 – Information necessary for the planning and operation of interconnected bulk power systems shall be made available to those entities responsible for planning and operating the systems reliably.
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> Reliability Principle 7 – The reliability of the interconnected bulk power systems shall be assessed, monitored, and maintained on a wide-area basis.

Reliability Standard PRC-001-1, as assessed by the NERC System Protection and Control Task Force (SPCTF) in its report of December 7, 2006, does not assign responsibility to the appropriate functional entities, contains several fundamental flaws within the requirements, and mixes training, operational, and planning related requirements in one standard. Primarily, as stated in the conclusion of this assessment, the SPCTF asserts:

> *"The applicable entities in the existing Standard are incorrect for many of the requirements, and the requirements themselves are vague and not measurable. In addressing the "operating horizon," "operations planning horizon," and "planning horizon" protection coordination issues, the deficiencies in the current standard are magnified."*

And further:

> *"The SPCTF… recommends that the requirements for the operating horizon and planning horizon be clearly delineated and warrants consideration of dividing this standard into two standards."*

With the development of the proposed PRC-027-1 reliability standard, the Standard Drafting Team (SDT) for Project 2007-06 – System Protection Coordination has followed the observations and recommendation of the NERC SPCTF assessment of PRC-001-1. In the proposed standard, the SDT properly assigns the applicable functional entities and builds upon the planning horizon requirements

of PRC-001-1 that are applicable to Protection System coordination related to system Faults (Requirements R3 and R4). The SDT accomplishes this by:

1. Incorporating and building upon the elements of the two planning horizon Requirements R3 and R4 of PRC-001-1 into a new standard (as recommended by the SPCTF assessment), focusing on the performance of Protection Systems during Faults. Requirements R3 and R4 of PRC-001-1 (now R2 and R3 of PRC-001-2) will be retired upon appropriate regulatory approval of the proposed standards PRC-001-3 and PRC-027-1.)
2. Assigning responsibility to the appropriate functional entities – the Protection System equipment owners, specifically: Transmission Owners, Generator Owners, and Distribution Providers.
3. Transferring the responsibility of addressing the three operating horizon Requirements R2, R5, and R6 of PRC-001-1 to Project 2007-03 Real-time Operations for inclusion in the revisions of the appropriate operating standard(s) within that project.

   Note: The proposed disposition of Requirements R2, R5, and R6 of PRC-001-1 is posted on the Project 2007-03 page. The Project 2007-03 SDT is recommending retirement of Requirements R2, R5, and R6 of PRC-001-1 because they address data and data requirements which are covered in TOP-003-2. For Project 2007-03, the SDT included a redlined version of PRC-001-1 and a clean version of PRC-001-2 with the conforming changes, along with a mapping document and implementation plan describing the translation of the legacy requirements into TOP-003-2.
4. Leaving the legacy Requirement R1 of PRC-001-1 in PRC-001-2 (thereby not creating a reliability gap) until it is incorporated into a new or revised reliability standard.

The proposed PRC-027-1 reliability standard includes four requirements that build upon the reliability objectives of Requirements R3 and R4 of PRC-001-1 (now R2 and R3 of PRC-001-2), and further provide a defense-in-depth strategy for ensuring Bulk Power System (BPS) reliability associated with Protection System coordination for Interconnected Facilities between owners by:

- Requiring a documented Protection System Study of the Protection Systems applied on the Interconnected Facilities between owners, within 36 months of the effective date of the proposed standard.
- Establishing criteria for a periodic review of the previously-documented Protection System Study of the Protection Systems applied on the Interconnected Facilities between owners.
- Continuing the requirement that installing new Protection Systems and making changes to existing Protection Systems will require interaction between owners to ensure no coordination issues exist prior to implementation of these changes.
- Establishing, where applicable, time frames for one entity to respond to requests by other entities for information and/or concurrence related to Protection System Studies associated with Interconnected Facilities.

Individually, the requirements of the proposed PRC-027-1 reliability standard construct a defense-in-depth strategy and improve upon the existing PRC-001-1 Reliability Standard Requirements R3 and R4, (now R2 and R3 of PRC-001-2) as detailed by the following:

Requirement R1:

This requirement directs that Protection System Studies are performed for every Interconnected Facility defined as: "Facilities that are electrically joined by one or more Element(s) and are owned by different functional entities;" to verify coordination of existing Protection Systems where no recent study exists or when Facility configuration or Fault current deviations of 10% or more have occurred. In developing the language to define a Protection System Study, the SDT considered various reference books discussing protective relaying theory and application, along with the following description of "coordination of protection" from the pending revision of IEEE C37.113 Guide for Protective Relay Applications to Transmission Lines:

> *"The process of choosing current or voltage settings, or time delay characteristics of protective relays such that their operation occurs in a specified sequence so that interruption to customers is minimized and least number of power system elements are isolated following a system fault."*

Using the reference material cited above as guidance, the SDT defines the term Protection System Study as:

"A study that demonstrates existing or proposed Protection Systems operate in the desired sequence for clearing Faults."

Protection System Studies comprise a variety of assessments and underlying database activities that cumulatively serve to provide verification that Protection Systems will function as designed. Typical database activities performed during these studies include assembling impedance data for Fault studies and modeling Protection Systems. Ultimately, the particular studies performed depend on the protective relays installed, their application, and the Protection System philosophies of each Transmission Owner, Generator Owner, and Distribution Provider. These studies may include graphical coordination of protection characteristics on time-current or impedance graphs; relay scheme simulation studies using sequence of operations during pre-defined Faults; and sensitivity studies to confirm effective reaches, sufficient operating parameters (energy or operating torque), and adequate directional polarizing quantities.

The SDT believes applicable entities should have a documented Protection System Study for each Interconnected Facility to validate the Protection Systems perform in a manner consistent with the purpose of this standard. Additionally, the SDT believes that 36 months is an appropriate amount of time for entities to perform the initial studies expected under this requirement. This period considers the time some entities may require to create project scopes, acquire proposals, and secure contracts to hire external resources that may be needed to perform the studies. The SDT also has no evidence there is widespread miscoordination between Interconnected Facilities that might warrant a shorter time frame for the studies to be performed. Protection Systems are continually challenged by Faults

on the BES, but records collected for Reliability Standard PRC-004 do not indicate that lack of coordination was the predominate root cause of reported Misoperations.

It should be noted that Protection System Studies performed after June 18, 2007 (the effective date of PRC-001-1) are sufficient to meet Requirement R1.

Requirement R1, Parts 1.1.2 and 1.1.3 further direct that Protection System Studies must be completed under the following two circumstances:

1. After notification of an identified 10% or greater deviation in Fault current, the notified entities must perform a new Protection System Study of the Interconnected Facility, or document why a study is not required. The SDT recognizes that, based on the Protection Systems installed (e.g., current differential), a 10% or greater deviation in Fault current may not necessitate a new Protection System Study be performed; therefore this part of the requirement includes the statement, "… unless the entity can demonstrate that such a study is not required," The SDT believes the six months time frame associated with this requirement represents a reasonable amount of time to perform the studies required after identification by the 24-month Fault current review.

2. After proposing or being notified of a change at an Interconnected Facility, entities must perform a new Protection System Study, or document why a study is not required. The SDT recognizes that, based on the scope of the proposed change and/or the Protection Systems installed (e.g., current differential), the change may not necessitate a new Protection System Study be performed; therefore, this part of the requirement includes the statement, "… unless the entity can demonstrate that such a study is not required." The SDT believes that specifying a single time frame for evaluation of the wide variety of conditions that may be associated with a particular change is not appropriate. This is because the SDT sees the entity initiating any change as having the incentive to move this along in a timely fashion to keep the associated project on schedule and to confirm the changes are acceptable "prior to the in-service date," as stipulated by Requirement R4, Part 4.2.

Requirement R1, Part 1.2 requires that the entity performing the Protection System Study provide a summary of the study results to the affected owners of Protection Systems applied at Interconnected Facilities. As guidance, the SDT lists the following inputs and results of a Protection System Study that may be included in the summary provided pursuant to this requirement:

1. Data used to determine Fault currents in performing the study along with a listing of the single-line-to-ground and 3-phase Fault currents for the bus or Element at the Interconnected Facility under study.
2. A listing of the Protection System(s) owned by the entity performing the study that are adjacent to the bus or Element at the Interconnected Facility and were reviewed for coordination of protective relays as part of the study.
3. A listing of any issues associated with the relay settings of the other owner(s) at the Interconnected Facility that were identified by the study.

4. Any proposed revisions to a Protection System or its protective relay settings that were identified by the study.

Requirement R2:

The SDT investigated various inputs that would trigger a review of the existing Protection System Studies, and determined through the experience of the SDT members, along with informal surveys of several regional protection and control committees, that variations in Fault currents of 10% or more are an appropriate indicator that an updated Protection System Study may be necessary. These variations could result from the accumulation of incremental changes over time. This requirement mandates a periodic review of Fault currents and includes the calculation of the percent deviation between the Fault current values used in the most recent Protection System Study and the present Fault current values indicated by the short circuit study performed pursuant to this requirement. This calculation is necessary to identify Fault current changes that must be communicated in accordance with Requirement R2, Part 2.3.

Polling of SDT membership and various protection engineering committees indicates that short circuit databases are customarily updated annually. Based on this information, the SDT believes that requiring a 24-month periodic review of Fault currents provides entities additional flexibility to schedule and perform these studies and calculate the percent deviation as described in Requirement R2, Part 2.2. The SDT believes studies associated with changes that would affect the coordination in less than 24 months would be triggered by conditions addressed by other requirements in this standard.

Requirement R2, Part 2.3 further directs the Transmission Owner to, within 30 calendar days; inform Interconnected Facility owners when short circuit studies indicate that 10% deviations in Fault current have occurred at the Interconnected Facility. The SDT believes the 30-day time frame associated with this requirement is reasonable for sending notification to the interconnected entity(s), and is consistent with other NERC Reliability Standards.

In Requirement R2, the Transmission Owner is identified as the functional entity responsible for performing the Fault current studies because they maintain the data required to perform the studies. Generator data (including data provided by Distribution Providers) is incorporated into the Transmission Owners' short circuit models.

Requirement R3:

This requires the Interconnected Facility owners to evaluate the impact to their Protection Systems due to proposed changes by requiring the registered functional entity initiating the changes to provide the details to the other affected entities of the Interconnected Facility. Documentation provided to these other owners may include, but is not limited to, power system configurations; protection schemes; schematics; instrument transformer ratios; type of relay(s); communication equipment applied for protection; and Protection System settings. The recipient will incorporate the applicable information into its Protection System Studies to evaluate whether changes are required.

The list of applicable changes provided in Requirement R3, Part 3.1 is inclusive, as it comprises either the protective equipment itself or the power system Elements that affect the coordination of Protection Systems. The SDT recognizes that other Facility changes not directly associated with the interconnection can impact the Protection System Study of the Interconnected Facilities; e.g., the addition of a large autotransformer bank or generator not directly associated with the Interconnected Facilities. The SDT believes that it is not appropriate to specify a single time frame for providing the details of the wide variety of conditions listed in Requirement R3, Part 3.1 that may be associated with a particular change. This is because the SDT sees the entity initiating any change as having the incentive to move the process along in a timely fashion in order to both keep the associated project on schedule and confirm the changes are acceptable "prior to the in-service date," as stipulated by Requirement R4, Part P.2.

Requirement R3, Part 3.2 allows for entities to agree upon a schedule, appropriate to the circumstances, for providing the details needed to conduct a Protection System Study; or absent such agreement, within 30 days of a request for this information. This requirement provides a means for entities to receive requested information in a timely manner. In consideration of circumstances where the information may not be readily available or may be incomplete due the retirement of personnel, the purging of records, change of ownership, etc., it also provides the flexibility of mutually agreeing to a schedule for exchanging information. The SDT believes 30 calendar days after receipt of the request is a sufficient amount of time to provide the requested information where no other agreement exists.

Additionally, this requirement includes a provision for providing details associated with changes to the previously-agreed upon coordination when: (1) Protection System errors are found during Misoperation investigations, commissioning, or maintenance activities; (2) Emergency replacements are made due to failures of Protection System components. Based upon the limited number of instances that would occur under such circumstances, the SDT believes 30 calendar days after determining that changes are required is an appropriate time frame for providing the associated details to affected entities.

Requirement R4:

The reliability objective of this requirement is to bring the process of Protection System coordination full circle by gaining the confirmation of interconnected entities that their Protection Systems are coordinated consistent with the purpose of this standard. Cooperative participation of Interconnected Facility owners in communicating Protection System(s) design and study results will achieve coordination of Protection Systems for reliable operation of the BES during Faults.

Requirement R4, Part 4.1 directs applicable entities to confirm, within 90 days of receipt, agreement with the summary results of a Protection System Study, as described in Requirement R1, Part 1.2; or absent such agreement, propose revisions to achieve acceptable results. The SDT believes 90 calendar days after receipt of the results of a Protection System Study provides a reasonable time for the owners of Interconnected Facilities to resolve differences and reach agreement that their Protection Systems are coordinated.

Requirement R4, Part 4.2 directs entities to confirm that planned changes described in Requirement 3.1 are acceptable prior to the in-service date of those changes. The purpose of this requirement is to assure the effects that planned changes have on Protection Systems at Interconnected Facilities have been considered by all affected entities.

Requirement R4, Parts 4.3.1 and 4.3.2 direct confirmation within 30 calendar days that changes are acceptable when corrections are made due to Protection System errors found during Misoperation investigations, commissioning, or maintenance activities, or when Emergency replacements are made due to failures of Protection System components. Based upon the limited number of instances that would occur under such circumstances, the SDT believes 30 calendar days provides adequate time for achieving such agreement.

Conclusion

The proposed PRC-027-1 reliability standard builds upon the effectiveness of Requirements R3 and R4 of PRC-001-1 (now R2 and R3 of PRC-001-2). It also corrects the assignment of applicability of these requirements to the owners of the applicable Protection Systems. It establishes a structured roadmap of entity-to-entity communication and a process to ensure proper coordination of Protection Systems applied on Interconnected Facilities. Within this roadmap, as each requirement is combined with the other requirements, the standard achieves a defense-in-depth strategy for assuring proper coordination of Protection Systems applied on Interconnected Facilities. As such, the proposed PRC-027-1 reliability standard satisfies the overall objective of a true, reliability-based standard appropriate for approval of the NERC Board of Trustees and other applicable regulatory authorities.