NERC
NORTH AMERICAN ELECTRIC
RELIABILITY CORPORATION

Project 2015-10

Single Points of Failure TPL-001 Technical Rationale

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RELIABILITY | ACCOUNTABILITY




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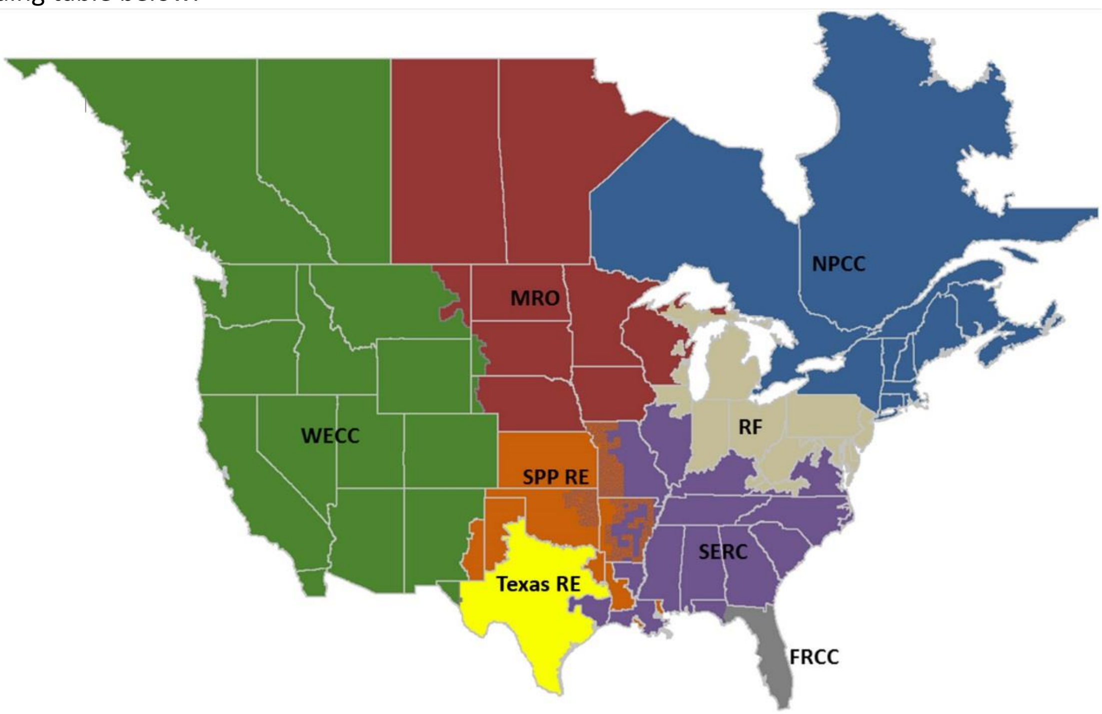
Preface

The North American Electric Reliability Corporation (NERC) is a not-for-profit international regulatory authority whose mission is to assure the reliability and security of the bulk power system (BPS) in North America. NERC develops and enforces Reliability Standards; annually assesses seasonal and long-term reliability; monitors the BPS through system awareness; and educates, trains, and certifies industry personnel. NERC's area of responsibility spans the continental United States, Canada, and the northern portion of Baja California, Mexico. NERC is the Electric Reliability Organization (ERO) for North America, subject to oversight by the Federal Energy Regulatory Commission (FERC) and governmental authorities in Canada. NERC's jurisdiction includes users, owners, and operators of the BPS, which serves more than 334 million people.

The North American BPS is divided into eight Regional Entity (RE) boundaries as shown in the map and corresponding table below.



The North American BPS is divided into eight RE boundaries. The highlighted areas denote overlap as some load-serving entities participate in one Region while associated transmission owners/operators participate in another.

FRCC	Florida Reliability Coordinating Council
MRO	Midwest Reliability Organization
NPCC	Northeast Power Coordinating Council
RF	ReliabilityFirst
SERC	SERC Reliability Corporation
SPP RE	Southwest Power Pool Regional Entity
Texas RE	Texas Reliability Entity
WECC	Western Electricity Coordinating Council

Executive Summary

Project 2015-10 Technical Rationale provides the background and rationale for proposed revisions to Reliability Standard TPL-001-4. The proposed revisions address reliability issues concerning the study of single points of failure (SPF) on Protection Systems from FERC Order No. 754, directives from FERC Order No. 786 regarding planned maintenance outages and stability analysis for spare equipment strategy , and replaces references to the MOD-010 and MOD-012 standards with the MOD-032 Reliability Standard.

Key Concepts of FERC Order No. 754

The Standards Development Team (SDT) took into account the recommendations for modifying NERC Reliability Standard TPL-001-4 identified in both the SPCS and SAMS report titled *Order No. 754 Assessment of Protection System Single Points of Failure Based on the Section 1600 Data Request* and the *Informational filing of the North American Electric Reliability Corporation in Response to Order No. 754* to the FERC. In "Table 1 – Steady State and Stability Performance Planning Events," breaker failure and failure of a non-redundant component of a Protection System are differentiated. The SDT recognizes that sequence and timing of Protection System action leading to Delayed Clearing may be quite different between the two causalities, and also that fault severity and acceptable consequence of failure of a non-redundant component of a Protection System should be differentiated. Proposed revisions to "Table 1 – Steady State and Stability Performance Planning Events", adds a new P8 Planning Event to include a 3-phase fault and failure of a non-redundant component of a Protection System. Footnote 13 of the "Table 1 – Steady State & Stability Performance Footnotes" describes the non-redundant Protection System components to be considered for Category P5 and the proposed new Category P8 Planning Events.

Key Concepts of FERC Order No. 786

The SDT considered the Commission's concern that the outages of significant facilities less than six months could be overlooked for planning purposes, Category P3 and P6 do not sufficiently cover planned maintenance outages, and Near-Term Transmission Planning Horizon requires annual assessments using Year One or year two, and year five, and known planned facility outages of less than six months should be addressed so long as their planned start times and durations may be anticipated as occurring for some period of time during the planning time horizon. Proposed revisions remove the six month outage duration and replace it with the requirement to document an established procedure or the technical rationale, to determine which known outages to study.. Proposed revisions includes stability study for long lead equipment that does not have a spare.

Summary of proposed revisions:

- Requirement R1 – Updated for MOD-032-1 standard.
- Requirement R1, Part 1.1.2 – Modified how known outages are selected for study.
- Requirement R2, Part 2.1.3 – Added model conditions for steady state analysis of P1 events for known outages.
- Requirement R2, Part 2.4.3 – Added model conditions for stability analysis of P1 events for known outages.
- Requirement R2, Part 2.4.5 – Added stability analysis requirement for long lead time equipment unavailability.
- Requirement R4, Part 4.2 – Document internal conforming clean-up to incorporate the last sentence of Part 4.5.
- Table 1 – Modified Category P5 event to include SPF.
- Table 1 – Note the Steady State and Stability performance thresholds that are applicable to Category P1 through P7 events only and not to P8 events

- Table 1 – Added Category P8 event to include SPF following a 3-phase fault, with applicable performance thresholds
- Table 1 – Modified Footnote 13 to specify SPF.

Introduction

NERC Reliability Standard TPL-001-4 (Transmission System Planning Performance Requirements) is being modified to address reliability issues and standard modification directives contained in FERC Order No. 754[1] and FERC Order No. 786.[2] Proposed Reliability Standard TPL-001-5 revises the TPL-001 standard to address the reliability risks posed by SPF on Protection Systems.

Background

FERC Order No. 754

FERC Order No. 754 directed NERC to study the reliability risk associated with single points of failure (SPF) in Protection Systems. As a follow-up to a NERC Technical Conference where the risks and concerns associated with SPF were discussed, the NERC System Protection and Control Subcommittee (SPCS) and the System Analysis and Modelling Subcommittee (SAMS) conducted an assessment of Protection System SPF in response to FERC Order 754, including analysis of data collected pursuant to a request for data or information under Section 1600 of the NERC Rules of Procedure. The SPCS and SAMS report titled *Order No. 754 Assessment of Protection System Single Points of Failure Based on the Section 1600 Data Request* and the *Informational filing of the North American Electric Reliability Corporation in Response to Order No. 754* to the FERC provide extensive general discussion about the reliability risks associated with a SPF. Available

FERC Order No. 786

In Order No. 786, FERC directed NERC to address two issues. The first issue is the concern that the six month outage duration threshold could exclude planned maintenance outages of significant facilities from future planning assessments. FERC directed NERC to modify TPL-001-4 to address this concern. The second issue involves adding clarity regarding dynamic assessment of outages of critical long lead time equipment, consistent with the entity's spare equipment strategy. FERC directed NERC to consider this issue upon its next review of TPL-001-4. The NERC SAMS developed a white paper documenting the technical analysis conducted by SAMS to address the two directives contained in the FERC Order 786. The white paper provides extensive general discussion regarding the directives.

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[1] Order No. 754, *Interpretation of Transmission Planning Reliability Standard*, 136 FERC ¶ 61,186 (2011) ("Order No. 754").

[2] Order No. 786, *Transmission Planning Reliability Standards*, 145 FERC ¶ 61,051 (2013) ("Order No. 786").

Section 1: Single Points of Failure on Protection Systems (FERC Order No. 754)

NERC Advisory

On March 30, 2009, NERC issued an advisory[3] report notifying the industry that a SPF issue had caused three significant system disturbances in 5 years.

Transmission Owners, Generation Owners, and Distribution Providers owning Protection Systems installed on the Bulk Electric System were advised to address SPF on their Protection Systems when identified in routine system evaluations to prevent N-1 transmission system contingencies from evolving into more severe or even extreme events.

These entities were additionally advised to begin preparing an estimate of the resource commitment required to review, re-engineer, and develop a workable outage and construction schedule to address SPF on their Protection Systems.

FERC Order No. 754

In Order No. 754 Paragraph 20, FERC directed NERC to "to make an informational filing within six months of the date of the issuance of this Final Rule explaining whether there is a further system protection issue that needs to be addressed and, if so, what forum and process should be used to address that issue and what priority it should be accorded relative to other reliability initiatives planned by NERC."

FERC Technical Conference

A FERC technical conference concerning the Commission's Order 754 titled Staff Meeting on Single Points of Failure on Protection Systems was held on October 24-25, 2011 at FERC in Washington, DC.

At the Technical Conference, the attendees discussed the SPF issue and narrowed their concerns into four consensus points:

- The concern with assessment of SPF is a performance-based issue, not a full redundancy issue.
- The existing approved standards address assessments of SPF.
- Assessments of SPF of non-redundant primary protection (including backup) systems need to be sufficiently comprehensive.
- Lack of sufficiently comprehensive assessments of non-redundant primary Protection Systems is a reliability concern.

Joint SPCS-SAMS Report

One outcome of the FERC Technical Conference was that NERC would conduct a data collection effort to provide a broad factual foundation that could aid in assessing the reliability risks posed by SPF. The NERC Board of Trustees approved the request for data or information under Section 1600 of the NERC Rules of Procedure ("Order No. 754 Data Request") on August 16, 2012.

In September 2015, SPCS and SAMS issued a report to the NERC PC/OC, summarizing the information collected under the Order No. 754 Data Request. The assessment confirmed the existence of a reliability risk associated with SPF in Protection Systems that warrants further action. To address this risk, the SPCS and the SAMS

[3] *See [Industry Advisory: Single Point of Failure](http://www.nerc.com/files/Final_Order_754_Informational_Filing_3-15-12_complete.pdf)*
http://www.nerc.com/files/Final_Order_754_Informational_Filing_3-15-12_complete.pdf

considered a variety of alternatives and concluded that the most appropriate recommendation that aligns with FERC Order 754 directives and maximizes reliability of Protection System performance is to modify NERC Reliability Standard TPL-001-4 (Transmission System Planning Performance Requirements) through the NERC standards development process.

The report recommendations, as well as how they have been addressed in proposed TPL-001-5 by the Project 2015-10 standard drafting team are summarized in the following section.

Revisions to TPL-001-4

Table 1-Footnote 13

The SPCS/SAMS report recommended replacing "relay" with "component of a Protection System" in the Table 1 P5 event and replace Footnote 13 in TPL-001-4 with the following alternate wording:

> The components from the definition of 'Protection System' for the purposes of this standard include (1) protective relays that respond to electrical quantities, (2) single station DC supply that is not monitored for both low voltage and open circuit, with alarms centrally monitored (i.e., reported within 24 hours of detecting an abnormal condition to a location where corrective action can be initiated), and (3) DC control circuitry associated with protective functions through the trip coil(s) of the circuit breakers or other interrupting devices.

Based on discussion and industry comment, the SDT proposes similar revisions to Footnote 13 to clarify the components of the Protection System that must be considered when simulating Delayed Fault Clearing due to the failure of a non-redundant component of a Protection System. This consideration is intended to account for:

- failed non-redundant components of a Protection System that may impact one or more Protection Systems;
- the duration that faults remain energized until Delayed Fault Clearing, and;
- additional system equipment removed from service following fault clearing depending upon the specific failed non-redundant component of a Protection System.

The SPCS/SAMS report described voltage or current sensing devices as having a lower level of risk of failure to trip due to robustness and likelihood to actually cause tripping upon failure. Therefore, these components of a Protection System are omitted from Footnote 13.

Noting that Requirement R3, Part 3.3.1 and Requirement R4, Part 4.3.1 require simulation of Protection System action, the drafting team sought to limit the scope of Footnote 13, item 1 with respect to protective relays that may be non-redundant components of a Protection System. Specifically, Footnote 13 limits single protective relays that may be a SPF to those which respond to electrical quantities and are used for primary protection resulting in Normal Clearing. An SPF in a single protective relay that is a non-redundant component of a Protection System may result in the primary Protection System failing to properly operate, leading to Delayed Fault Clearing performed by backup protective relays and/or overlapping zonal protection. Conversely, the drafting team did not include backup protective relays in the scope of Footnote 13, item 1 given that an SPF in a single protective relay used for backup protection will not affect primary protection resulting in Normal Clearing.

The drafting team recognizes that Bulk Electric System (BES) Elements are predominantly protected by relays which respond to electrical quantities. However, in some Protection System designs, non-redundant single protective relays which respond to electrical quantities may be redundant to protective relays that do not respond to electrical quantities. For example, an independent differential relay and independent sudden pressure relay may protect the same transformer from faults inside the transformer tank. In this example, the differential relay responds to electrical quantities, while the sudden pressure relay does not. While the transformer differential relay may be an SPF, an internal transformer tank fault may not lead to Delayed Clearing given the sudden pressure protection, provided, in this example, that the resulting clearing time is similar to that achieved with the differential relay. Subsequently, the P5 event, for a single phase-to-ground (line-to-ground) fault, and P8 event, for a 3-phase fault, in the transformer tank need not be simulated for Delayed Fault Clearing due to the SPF of the transformer differential relay if the resulting clearing time is similar to that achieved with the differential relay. However, care must be taken when evaluating protective relays which respond to electrical quantities in combination with protective relays which do not respond to electrical quantities; in this same example, faults that occurred outside of the transformer tank given the SPF of the non-redundant transformer differential relay would be unaffected by the presence of the sudden pressure relay and would lead to delayed clearing, necessitating its assessment as P5 and P8 events.

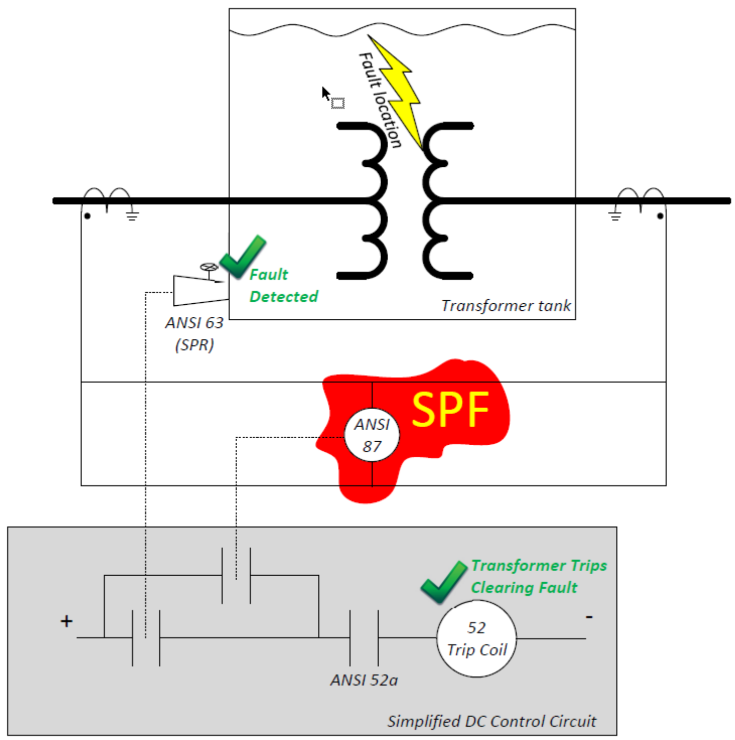

Figure 2.1: Internal Transformer Tank Fault with Sudden Pressure Protection and failed Transformer Differential Relay

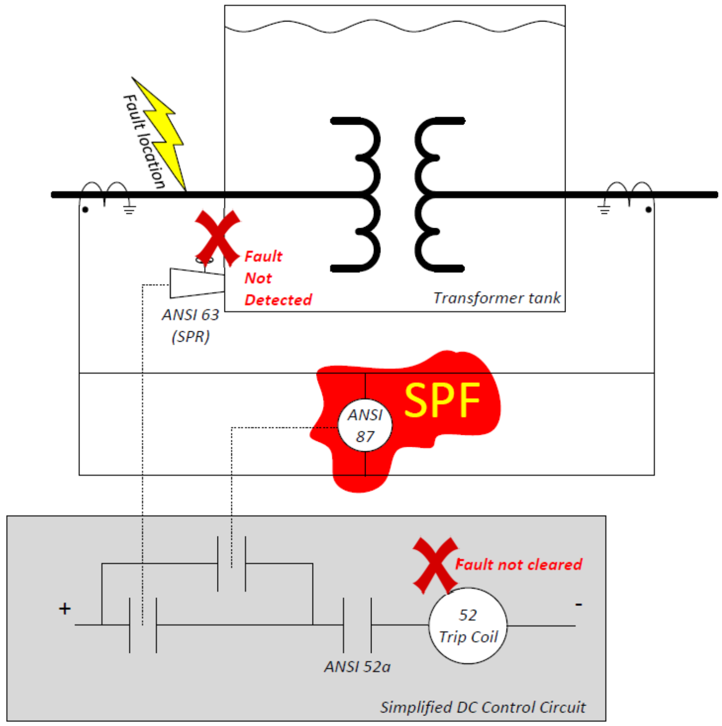

Figure 2.2: External Transformer Tank Fault with Sudden Pressure Protection and failed Transformer Differential Relay

Given the increasing importance of communication-aided Protection Systems (e.g., pilot protection schemes, direct transfer tripping schemes, permissive transfer tripping schemes, line differential relaying schemes, etc.), the proper operation of the communication system must be considered when considering potential SPF components of Protection Systems. The drafting team augmented the SAMS/SPCS recommendations to include reference to the subset of communication systems that are part of a communication-aided Protection System, necessary where the performance of that Protection System is required to achieve Transmission System Planning (TPL) Performance Requirements, enumerated in Table 1 of TPL-001-4. In other words, a communication-aided Protection System that may experience an SPF, causing it to operate improperly or not at all, must be considered as part of non-redundancy. The drafting team concluded that, although the failure of communication-aided Protection Systems may take many forms, by monitoring and reporting the status of these systems, the overall risk of impact to the Bulk Electric System can potentially be reduced to an acceptable level. However, monitoring and reporting the status of these systems can only really be considered as a sufficient alternative to physical redundancy if the result is prompt notification and remediation which minimizes the exposure to and consequence of this failed component. Most new Protection Systems deployed in the industry include communication-aided protection with component and communication failure alarms monitored at centralized Control Centers. Therefore, this requirement is more applicable to legacy systems that need communication-aided Protection Systems to meet performance requirements of the TPL standards.

The drafting team adopted the fundamental principles of the SAMS/SPCS recommendations regarding station protection system DC supply. Failure of a single station protection system DC supply is a significant point of failure as it will prevent the operation of all local protection, including back-up protection. The drafting team partly modified the SAMS/SPCS recommendation regarding single station DC supply, including removal of the specific requirement that reporting the detection of an abnormal condition to a location where corrective action can be initiated must occur within 24 hrs. This modification recognizes the wide variety of reporting and monitoring that exists. However, it remains the intention of Footnote 13, item c, that monitoring and reporting the status of the DC supply can only really be considered as a sufficient alternative to physical redundancy if the result is prompt notification and remediation which minimizes the exposure to and consequence of DC supply failure. Similar to as noted with communication-aided Protection Systems, most new Protection Systems include DC supply status alarms which are monitored at centralized Control Centers; however, they may not necessarily be monitored for both low voltage and open circuit Therefore, this requirement may be more applicable to legacy systems.

The Distinction Between Category P4 and Category P5/P8 Planning Events

"Table 1 – Steady State and Stability Performance Planning Events," makes a clear distinction between breaker failure, Category P4 Planning Events, and failure of a non-redundant component of a Protection System, Category P5 and P8 Planning Events. The sequence and timing of Protection System action leading to Delayed Clearing may be quite different between the two fundamentally different causalities. Category P4 events involving the failure specifically of a circuit breaker assume that only the circuit breaker has failed, and that all other protection functions, including proper initiation of local breaker failure operation, has occurred correctly. For Category P5 and P8 Planning Events, failure of the various non-redundant components of a Protection System, as enumerated in Table 1, Footnote 13, can result in a relatively broader range of final system states, resulting from the Delayed Clearing associated with the specific SPF, and which may or may not resemble the system states resulting from Delayed Clearing associated with circuit breaker failure.

Single Points of Failure – Category P5 and P8 Planning Events

Analysis of the data collected under the Order No. 754 Data Request demonstrates the existence of a reliability risk associated with SPF in Protection Systems. Further, while the analysis shows that the risk from SPF is not an endemic problem and instances of SPF exposure are lower on higher voltage systems, the risk is sufficient to warrant action. Risk-based assessment should be used to identify Protection Systems of concern (i.e., locations on the BES where there is a susceptibility to unacceptable system performance if a Protection System component SPF exists).

The drafting team has modified Table 1, Footnote 13 to capture the SAMS/SPCS recommendations for Category P5 events, which expands beyond the previously limited set of relays identified in TPL-001-4, to capture the identified single points of failure of concern.

Proposed revisions to "Table 1 – Steady State and Stability Performance Planning Events", adds a new P8 Planning Event to include a 3-phase fault and failure of a non-redundant component of a Protection System. Footnote 13 of the "Table 1 – Steady State & Stability Performance Footnotes" describes the non-redundant Protection System components to be considered for Category P5 and the proposed new Category P8 Planning Events

Given the risk to BES reliability raised at the FERC Technical Conference in conjunction with the SAMS/SPCS recommendations, the drafting team considered the manner in which additional emphasis in planning studies should be placed on assessment of three-phase faults involving Protection System SPF. While events initiated by a three-phase fault are less probable than events initiated by a single-phase-to-ground faults, single-phase-to-ground faults with Delayed Clearing, particularly associated with the non-redundant components of a Protection System enumerated in Table 1, Footnote 13, can often evolve into three-phase faults, leading to system performance which is more severe than for the Table 1, P5 event. To address this concern (the study of Protection System SPF with a three-phase fault), the drafting team has developed a new P8 Planning Event; however, unlike the Category P1-P7 Planning Events, a Corrective Action Plan is only required if the P8 event results in Cascading. Accepting more severe system performance is seen as a reasonable balance with the lower likelihood, but reasonable risk, of the SPF with a three-phase fault. Table 1, Footnote 13 also provides the attributes of the specific non-redundant Protection System components that the entity shall consider for evaluation for the P5 and P8 events.

It is anticipated that the most cost-effective Corrective Action Plans to address unacceptable system performance for the P5 and P8 Planning Events will likely be to add Protection System component redundancy, consistent with the components enumerated in Footnote 13. Protection System redundancy changes to address P5 concerns should also reduce or even negate non-redundant components that need to be considered in P8 events; hence, potentially mitigating many P8 concerns.

The P5 event steady-state analysis should also be valid and representative of P8 events. It should be noted that the addition of the P8 event will only add the need for additional stability analysis.

Requirement R4 Parts 4.2 and 4.5

The drafting team proposes non-substantive editorial changes to combine part of Requirement R4, Part 4.5 with Requirement R4, Part 4.2. The rearrangement of Requirement 4, Parts 4.2 and 4.5 were done to improve consistency within the Standard and do not create any new requirements. However, it should be noted that the evaluation of possible actions designed to reduce the likelihood or mitigate the consequences of the (extreme) event is intended to support and encourage the implementation of reasonable low-cost, cost-effective measures to lessen the risk or severity of these events.

Section 2: FERC Order No. 786 Directives

Background

In addition to addressing reliability issues involving SPF on Protection Systems, proposed Reliability Standard TPL-001-5 revises the TPL-001 standard to address two directives from FERC Order No. 786.

Order No. 786 P. 40: Maintenance outages in the Planning Horizon

FERC Order No. 786, Paragraph 40 directs NERC to modify Reliability Standard TPL-001-4 to address the concern that the six month threshold could exclude planned maintenance outages of significant facilities from future planning assessments. Order No. 786 provides the following considerations:

- Planned maintenance outages less than six months may result in impacts during peak and off-peak periods;
- Planned outages during those times should be considered to allow for a single element to be taken out of service without compromising the ability to meet demand;
- Criticality of elements taken out for maintenance could result in N-1 outage and loss of non-consequential load or impact to reliability;
- Planned outages are not “hypothetical outages” and should not be treated as multiple contingencies in the planning standard (should be addressed in N-0 base case);
- Relying on Category P3 and P6 is not sufficient and does not cover maintenance outages;
- The Near-Term Transmission Planning Horizon requires annual assessments using Year One or year two and year five. Known planned facility outages of less than six months should be addressed so long as their planned start times and durations may be anticipated as occurring for some period of time during the planning time horizon.

NERC SAMS Whitepaper Recommendations

To address this directive, the NERC SAMS recommended modifications to NERC Reliability Standards IRO-017-1 and TPL-001-4. The SAMS recommended that IRO-017-1 be used as the vehicle to assure that all types of known scheduled outages are being reviewed and coordinated to mitigate reliability impact as the most cost-effective means to address the intent of the NERC directive. The NERC SAMS also recommended modifying TPL-001-4, Requirement R1, Part 1.1.2 by removing “with duration of at least six months” and adding language referencing the outage coordination process developed in IRO-017-1, Requirement R1 as described above.

To understand the relationship between outage coordination and Transmission Planning Assessments, and how those relate to the FERC Order 786 directive and the current state of NERC Reliability Standards, SAMS considered the following:

- The duration of planned maintenance and construction outages can range from hours to many months or years. The impact that these outages can have on reliable operation of the BPS are irrespective of the duration of these outages, depending on many factors.
- Longer-term assessment of short-term outages or even longer-term outages is often considered an “academic exercise” due to concurrent outages, outage coordination practices and procedures, outage rescheduling and redesign, and alternative outage methods.
- The directives in FERC Order 786 pre-date the development of IRO-017-1, which was developed specifically to recognize the importance of outage coordination.
- Regional differences result in different outage coordination methods and procedures.

Revisions to TPL-001-4

Requirement R1 Part 1.1.2

The drafting team gave due consideration to the NERC SAMS recommendations and to a range of opinions and options regarding how to determine which known outages to include in the Near-Term Planning Assessment, which included varying perspectives, such as that:

- the RC should not be consulted or involved at all in Planning Assessments,
- it is reasonable, appropriate, and efficient to consult with the RC,
- IRO-017 is adequate and applicable as it exists or with some modification, or
- maintenance outage selection for planning purposes should be at the sole discretion of the TP or PC.

The range of these options reflects, in part, the substantial regional differences in outage coordination methods and procedures to address these types of outages. Those differences contribute to a legitimate difficulty in designing a reasonable and cost-effective "one size fits all" means of addressing the FERC directive. However, FERC's Order 786 requires that the issue be addressed. The rationale for selecting the known outages to be studied must be well thought out and available.

The drafting team modified Requirement R1, Part 1.1.2 consistent with FERC's directive, eliminating the specified six month outage duration and recognizing the various means that TPs and PCs currently employ to consider the maintenance outages of concern, while meeting the requirements of Order No. 786. The proposed modifications place limitations on the known outages that need to be studied.

It is only necessary to consider known outages expected to result in Non-Consequential Load Loss for P1 event in Table 1. This allows the PC and TP to use applicable means to assess which known outages are significant and prevents the need for conducting unnecessary modeling of outages which the PC and TP do not expect to be a problem.

Consistent with the intention of Order No. 786, the drafting team included the specification that the limitation of known outages to be modeled cannot be based solely on the outage duration. However, the presence of other accompanying factors, which in conjunction with outage duration, may form a reasonable basis for supporting that the known outage need not be modeled.

The PC and TP must have documented either an established procedure or technical rationale for the determination of which known outages may be excluded from modeling. The established procedure is intended to include consultation with the affected Reliability Coordinator, consultation with outage Transmission and/or Generator Owner(s), or application of established outage coordination processes. The technical rationale is intended to include well-reasoned technical bases for making the determination.

This proposed modification is for consideration of known outages beyond the Operations Planning time horizon.

Requirements R2 Part 2.1.3 and Part 2.4.3

Consistent with FERC's directive, the drafting team modified Requirements **R2 Parts** 2.1.3 and 2.4.3 to further recognize the intent to limit required study to only those known outages that are expected to produce severe System impacts on the PC/TP's respective portion of the BES.

Order No. 786 P 89: Dynamic assessment of outages of critical long lead time equipment

In paragraph 89 of Order No. 786, FERC stated:

> The spare equipment strategy for steady state analysis under Reliability Standard TPL-001-4, Requirement R2, Part 2.1.5 requires that steady state studies be

> performed for the P0, P1 and P2 categories identified in Table 1 with the conditions that the system is expected to experience during the possible unavailability of the long lead time equipment. The Commission believes that a similar spare equipment strategy for stability analysis should exist that requires studies to be performed for P0, P1 and P2 categories with the conditions that the system is expected to experience during the possible unavailability of the long lead time equipment.

FERC did not direct a change but did direct NERC to consider this issue upon the next review cycle of TPL-001-4. The Project 2015-10 Standard Authorization Request included this issue within the scope of this project.

NERC SAMS Whitepaper Recommendations

The NERC SAMS considered the following key points related to FERC's Paragraph 89 guidance:

- Removal of Elements in the Planning Assessment for spare equipment strategy is only applicable for those Elements that have "a lead time of one year or more."
- Each long-lead time Element that is removed from service creates a new operating condition considered the "normal" (P0) condition for Table 1. The applicable contingencies will be studied with that Element removed from service in the pre-contingency state for stability analysis. For example, if a long-lead time transformer does not have a spare, it would be studied as a P1.3 event. Since P0 does not include an Event, P0 does not and should not be included in the stability analysis section for long-lead time Elements not included as part of a spare equipment strategy.
- System adjustments may need to be made to the power flow base case to accurately reflect reasonable and expected operating conditions with that Element removed from service in the pre-contingency (P0) operating state.
- TPL-001-4, Requirement R4, Part4.1.1, related to P1 Events, requires that no generating unit pull out of synchronism. The outage of a long-lead time Element followed by a P1 contingency should not result in a generating unit losing synchronism.
- TPL-001-4, Requirement R4, Part 4.1.2, related to P2 Events, allows for generating units to pull out of synchronism. The outage of a long-lead time Element followed by a P2 contingency should not result in tripping of any Transmission System Elements other than the generating unit and its directly connected Facilities.

The NERC SAMS white paper contains the flowing recommendations for stability analysis for long lead time Elements not included as part of a spare equipment strategy:

- The outage of long lead time Elements has an equally important impact from a stability standpoint as it does from a steady-state standpoint.
- The Planning Coordinator and Transmission Planner must demonstrate that they have met the TPL-001-4 performance criteria for specified contingency events and contingency combinations thereof as per Table 1. This should include long lead time outages that can occur for equipment that does not have a spare equipment strategy.
- TPL-001-4, Requirement R4, Part4.1.1 requires that no generating unit pull out of synchronism, while R4.1.2 allows for generating units to pull out of synchronism so long as the resulting instability does not result in tripping of any Transmission System Elements other than the generating unit and its directly connected Facilities. The outage of a long lead time Element followed by a P1 contingency should not result in a generating unit losing synchronism.

- While the P2 contingency allows for individual generating unit instability, the Transmission Planner and Planning Coordinator must ensure that this instability does not result in tripping of any Transmission System Elements other than the generating unit and its directly connected Facilities and therefore should include P2 contingencies event.

Revisions to TPL-001-4

Requirement R2 Part 2.4.5

Consistent with FERC's Order No. 786 guidance and the SAMS recommendations, the Project 2015-10 standard drafting team revised TPL-001-4 Requirement R2, Part 2.4.5 to add a similar requirement for stability analysis. The change to Requirement R2, Part 2.4.5, which includes similar language to that used for the steady-state analysis under Requirement R2, Part 2.1.5, adds clarity that the outage of long lead time Elements has an equally important impact from a stability standpoint as it does from a steady-state standpoint and should be assessed commensurate with an entity's spare equipment strategy.

Section 3: Applicability

The requirements remain applicable to the Planning Coordinator and Transmission Planner. Coordination and cooperation between operating and planning entities in concert with asset owners will be required to implement the standard requirements. The planning and protection engineers that will need to conduct the studies and submit the data may be working for different companies or business units, and time will be required to accommodate the development of processes and data flow that cross company or business unit lines.

Generator Owners, Transmission Owners, and Distribution Providers are required to evaluate the Protection System(s) for locations on the system where a failure of a non-redundant Protection System component could result in a potential reliability risk. These entities must provide this information, as well as resulting fault clearing times, to Transmission Planners for proper study.