BEFORE THE
NATIONAL ENERGY BOARD

NORTH AMERICAN ELECTRIC	**)**
RELIABILITY CORPORATION	**)**

NOTICE OF FILING OF FIVE PROPOSED RELIABILITY STANDARDS MOD-025-2, MOD-026-1, MOD-027-1, PRC-019-1 AND PRC-024-1

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June 10, 2013

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The North American Electric Reliability Corporation ("NERC") hereby provides notice of five proposed Reliability Standards which were approved by the NERC Board of Trustees on February 7, 2013 and May 9, 2013:[1]

- MOD-025-2—Verification and Data Reporting of Generator Real and Reactive Power Capability and Synchronous Condenser Reactive Power Capability;
- MOD-026-1—Verification of Models and Data for Generator Excitation Control System or Plant Volt/Var Control Functions;
- MOD-027-1—Verification of Models and Data for Turbine/Governor and Load Control or Active Power/Frequency Control Functions;
- PRC-019-1—Coordination of Generating Unit or Plant Capabilities, Voltage Regulating Controls, and Protection; and
- PRC-024-1—Generator Frequency and Voltage Protective Relay Settings.

NERC is hereby providing notice of the proposed Reliability Standards, the associated implementation plans, Violation Risk Factors ("VRFs") and Violation Severity Levels ("VSLs"), and retirement of MOD-024-1 – Verification of Generator Gross and Net Real Power Capability

[1] MOD-025-2, MOD-026-1, MOD-027-1 and PRC-019-1 were approved by the NERC Board of Trustees on February 7, 2013 and PRC-024-1 was approved on May 9, 2013. Unless otherwise designated, all capitalized terms shall have the meaning set forth in the Glossary of Terms Used in NERC Reliability Standards, available here: http://www.nerc.com/files/Glossary_of_Terms.pdf.

and MOD-025-1 – Verification of Generator Gross and Net Reactive Power Capability prior to the effective date of MOD-025-2.

I. EXECUTIVE SUMMARY

The purpose of Project 2007-09, Generator Verification and the proposed Reliability Standards included herein is to ensure (i) that generators will not trip off-line during specified voltage and frequency excursions[2] or as a result of improper coordination between generator protective relays and generator voltage regulator controls and limit functions (such coordination will include the generating unit's capabilities), and (ii) that generator models accurately reflect the generator's capabilities and operating characteristics. Four of the five proposed Reliability Standards are new. Existing Reliability Standards MOD-024-1 and MOD-025-1 were combined into a single proposed Reliability Standard, MOD-025-2. Together, these five proposed Reliability Standards address generator verifications needed to support Bulk-Power System reliability and will ensure that accurate data is verified and made available for planning simulations.

Good quality simulation models of power system equipment are beneficial to the reliability of the Bulk-Power System. Model validation ensures the proper performance of the control systems and validates the computer models used for stability analysis. In addition to obtaining model data, the tests performed to gather this information may uncover latent defects that could lead to inappropriate unit response during system disturbances, thereby improving the reliability of the unit and the power system.

[2] System frequency reflects the instantaneous balance between generation and load. Reliable operation of a power system depends on maintaining frequency within predetermined boundaries above and below a scheduled value, which is 60 Hertz ("Hz") in North America.

Power system planning and operational studies require the simulation of the response of synchronous machines and their respective control systems. For these studies, it is essential that the control systems of the synchronous machines be modeled in sufficient detail.[3] The desired models must be suitable for representing the actual equipment performance for large, severe disturbances as well as for small perturbations. To obtain accurate simulation, not only must the models contain an adequate level of detail, but the values of the parameters in the models must also correspond to actual field values. The equipment to be tested and modeled includes the generator and its control systems,[4] excitation systems,[5] power system stabilizers and turbine governors.[6] Protective relay coordination with equipment capabilities and control system limiters is equally important.[7] Collectively, these five proposed Reliability Standards address generator verifications needed to support Bulk-Power System reliability.

A. Modeling, Data and Analysis Standards: MOD-025-2, MOD-026-1 and MOD-027-1

The Modeling, Data and Analysis ("MOD") body of Reliability Standards ensure that power system models accurately reflect the generator's capabilities and operating characteristics of the power system elements. The models are used in operating and planning studies. The MOD Standards are intended to standardize methodologies and system data needed for traditional transmission system operation and expansion planning, reliability assessment and the calculation of available transfer capability in an open access environment.

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[3] *See* IEEE Task Force on Generator Model Validation Testing of the Power System Stability Subcommittee, "Guidelines for Generator Stability Model Validation Testing," IEEE PES General Meeting 2007, paper 07GM1307.

[4] This equipment is addressed in proposed Reliability Standard MOD-25-2.

[5] The primary function of the excitation system is to regulate voltage and thereby control var flow in the system.

[6] This equipment is addressed in proposed Reliability Standards MOD-026-1 and MOD-027-1.

[7] This equipment is addressed in proposed Reliability Standards PRC-019-1 and PRC-024-1.

Proposed Reliability Standard MOD-025-2 requires verification of Real and Reactive Power of applicable generator and synchronous condenser facilities. The standard drafting team removed the fill-in-the-blank components of the version 1 standards (MOD-024-1 and MOD-025-1) and provided for explicit verification requirements in the proposed MOD-025-2 Standard. This proposed Reliability Standard ensures that accurate information on generator gross and net Real and Reactive Power capability and synchronous condenser Reactive Power capability is available for planning models used to assess Bulk Electric System ("BES") reliability.

Proposed Reliability Standard MOD-026-1 relates to the generator excitation control system or the plant volt/var control functions. The Generator Owner is required to provide a verified model to the Transmission Planner according to the periodicity specified in the standard. The purpose is to verify that the generator excitation control system or plant volt/var control function model and the model parameters used in dynamic simulations[8] performed by the Transmission Planner accurately represent the generator excitation control system or plant volt/var control function behavior when assessing BES reliability.

Proposed Reliability Standard MOD-027-1 relates to the generating unit turbine/governor and load control[9] or active power/frequency control functions.[10] The Generator Owner is required to provide a verified model to the Transmission Planner according to the periodicity specified in the standard. The purpose is to verify that the turbine/governor and load control or active power/frequency control model and the model parameters, used in dynamic simulations

[8] Dynamic simulations simulate real-life reactions whereas static simulations only take a snapshot in time. Dynamic simulations are intended to show how the power system will react over time to certain events. The models for dynamic simulations are more complicated and involve voltage and frequency response characteristics over a fixed time period. Each event on the grid causes voltages and/or frequency to change. Dynamic simulations are designed to predict these changes.

[9] Turbine/governor and load control applies to conventional synchronous generation.

[10] Active power/frequency control applies to inverter connected generators (often found at variable energy plants).

performed by the Transmission Planner that assess BES reliability, accurately represent generator unit real power response to system frequency variations.[11]

B. Protection and Control Standards: PRC-019-1 and PRC-024-1

The Protection and Control ("PRC") body of Reliability Standards apply to Transmission Operators, Transmission Owners, Generator Operators, Generator Owners, Distribution Providers and Regional Reliability Organizations and cover a wide range of topics related to the protection and control of power systems. Protection and control systems on Bulk-Power System elements are an integral part of reliable grid operation. Protection systems are designed to detect and isolate faulty elements on a system, thereby limiting the severity and spread of system disturbances, and preventing possible damage to protected elements. The function, settings, and limitations of a protection system are critical in establishing System Operating Limits and Interconnection Reliability Operating Limits.

Proposed Reliability Standard PRC-019-1 is a protection Standard that requires the Generator Owner and Transmission Owner[12] to coordinate the voltage regulating system controls with the equipment capabilities and settings of Protection System devices and functions.

Proposed Reliability Standard PRC-024-1 contains requirements for generator protection system performance during frequency and voltage excursions. The proposed Reliability Standard ensures that generating units are not tripped by their protective relays and remain connected during specified frequency and voltage excursions and ensures expected generating unit performance during frequency and voltage excursions is communicated to Planning Coordinators and Transmission Planners for accurate system modeling.

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[11] The proposed implementation plans for MOD-026-1 and MOD-027-1 are of a longer duration due to the complexity of the tasks involved as explained in **Exhibit C**.

[12] Only applicable to Transmission Owners that own synchronous condenser(s). *See* PRC-019-1, Section 4.1.2.

II. NOTICES AND COMMUNICATIONS

Notices and communications with respect to this filing may be addressed to the following:

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III. BACKGROUND

A. NERC Reliability Standards Development Procedure

The proposed Reliability Standards were developed in an open and fair manner and in accordance with the Reliability Standard development process. NERC develops Reliability Standards in accordance with Section 300 (Reliability Standards Development) of its Rules of Procedure and the NERC Standard Processes Manual.[13] NERC's proposed rules provide for reasonable notice and opportunity for public comment, due process, openness, and a balance of interests in developing Reliability Standards and thus satisfies certain of the criteria for approving Reliability Standards. The development process is open to any person or entity with a legitimate interest in the reliability of the Bulk-Power System. NERC considers the

[13] The NERC Rules of Procedure are available here: http://www.nerc.com/AboutNERC/Pages/Rules-of-Procedure.aspx. The current NERC Standard Processes Manual is available here: http://www.nerc.com/files/Appendix_3A_StandardsProcessesManual_20120131.pdf.

comments of all stakeholders, and a vote of stakeholders and the NERC Board of Trustees is required to approve a Reliability Standard before the Reliability Standard is submitted to the applicable governmental authorities.

IV. JUSTIFICATION OF PROPOSED RELIABILITY STANDARDS

Provided below is the following: (A) a description of each proposed Reliability Standard and discussion of how applicable Federal Energy Regulatory Commission ("FERC") directives are satisfied; and (B) justification for the proposed Reliability Standards on a Requirement by Requirement basis.

A. MOD-025-2 -- Verification and Data Reporting of Generator Real and Reactive Power Capability and Synchronous Condenser Reactive Power Capability

Proposed Reliability Standard MOD-025-2 consists of three Requirements and two Attachments. The proposed Reliability Standard is a result of merging two existing Reliability Standards, MOD-024-1 and MOD-025-1, into a single standard and is applicable to Generator Owners and Transmission Owners that own synchronous condenser(s). Attachment 1 is incorporated into all three Requirements (R1.1, R2.1 and R3.1) and specifies: (1) the frequency with which a new verification must be conducted of generator Real and Reactive Power capability and synchronous condenser Reactive Power capability; and (2) the specifications for applicable Facilities, including a requirement to record data for the verifications. Attachment 2 is incorporated into all three Requirements (R1.2, R2.2, and R3.2) and is to be used to report the information identified in Attachment 1.[14]

[14] Note, if the configuration of the applicable Facility does not lend itself to the use of the diagram, tables or summaries for reporting the required information, changes may be made to the form, provided that all required information is reported.

1. Merger of MOD-024-1 and MOD-025-1

Existing Reliability Standard MOD-024-1, Verification of Generator Gross and Net Real Power Capability, is a fill-in-the-blank standard and requires the regional reliability organization to establish and maintain procedures to address verification of generator gross and net real power capability. It also requires a generator owner to follow its regional reliability organization's procedure for verifying and reporting gross and net real power generating capability.[15] Existing Reliability Standard MOD-025-1 is also a fill-in-the-blank standard and requires the regional reliability organization to establish and maintain procedures to address verification of generator gross and net reactive power capability.[16]

Existing Reliability Standards MOD-024-1 and MOD-025-1 have been combined into a single proposed Reliability Standard, MOD-025-2, that requires verification of Real and Reactive Power of applicable generator and synchronous condenser facilities. The fill-in-the-blank components of the version 1 standards have been removed from proposed Reliability Standard, MOD-025-2, and the Standard contains explicit verification requirements. This proposed Standard ensures that accurate information on generator gross and net Real and Reactive Power capability and synchronous condenser Reactive Power capability is available for planning models used to assess BES reliability.

[15] FERC neither approved nor remanded MOD-024-1 in Order No. 693 and instead directed NERC to submit additional information.

[16] Existing Reliability Standard MOD-025-1 requires the regional reliability organization to provide its generator gross and net reactive power capability verification and reporting procedures, and any changes to those procedures, to the generator owners, generator operators, transmission operators, planning authorities and transmission planners affected by the procedure within 30 calendar days of approval of the Reliability Standard. Like MOD-024-1, FERC neither approved nor remanded MOD-025-1 in Order No. 693 and instead directed NERC to submit additional information. *See* Order No. 693 at P 1320. ("The Commission will not approve or remand MOD-025-1 until the ERO submits additional information.").

2. FERC Directives

FERC issued three directives with respect to MOD-024-1 and MOD-025-1 that are resolved by proposed Reliability Standard MOD-025-2: (1) FERC expressed a concern in Order No. 693 (at P 1311) that Requirement R2 of MOD-024-1, which specifies that the "regional reliability organization shall provide generator gross and net real power capability verification within 30 calendar days of approval," is not clear;[17] (2) FERC directed NERC to "develop appropriate requirements to document test conditions and the relationships between test conditions and generator output so that the amount of power that can be expected to be delivered from a generator at different conditions, such as peak summer conditions, can be determined"[18]; and (3) FERC directed NERC to require verification of Reactive Power capability at multiple points over a unit's operating range.[19]

The first directive to clarify Requirement R2 of MOD-024-1 is satisfied by Requirement R1, Part 1.2 of proposed Reliability Standard MOD-025-2 , which specifies that a completed Attachment 2 (or a form containing the same information as identified in Attachment 2) must be submitted by a Generator Owner to its Transmission Planner within 90 calendar days of either (i) the date the data is recorded for a staged test; or (ii) the date the data is selected for verification using historical operational data.

FERC's second directive to "develop appropriate requirements to document test conditions and the relationships between test conditions and generator output so that the amount

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[17] FERC directed NERC to modify the Reliability Standard by adding clarifying information, specifically regarding what approval is required and when the 30-day period starts. Order No. 693 at P 1311 ("We repeat our concern that Requirement R2, which specifies that the 'regional reliability organization shall provide generator gross and net real power capability verification within 30 calendar days of approval,' is not clear. The requirement lacks a definition of what approval is required and when the 30-day period starts. Therefore, we direct the ERO to modify this Reliability Standard by adding information that will clarify this requirement.").

[18] Order No. 693 at P 1310.

[19] Order No. 693 at P 1321. ("The Commission "direct[ed] the ERO to modify MOD-025-1 to require verification of reactive power capability at multiple points over a unit's operating range.").

of power that can be expected to be delivered from a generator at different conditions, such as peak summer conditions, can be determined"[20] is satisfied by Part 1.1 of Requirement R1 of proposed Reliability Standard MOD-025-2, which requires entities to verify the Real Power capability of its generating units in accordance with Attachment 1. Section 3.4 of Attachment 1 includes the ambient conditions during a verification period such as:

- Ambient air temperature
- Relative humidity
- Cooling water temperature
- Other data as determined to be applicable by the Generator Owner to perform corrections for ambient conditions.

Therefore, Proposed Reliability Standard MOD-025-2 provides for the determination of the amount of power that can be expected to be delivered from a generator under different conditions, including peak summer conditions, as directed by FERC in Order No. 693.

Attachment 1 of proposed Reliability Standard MOD-025-2 satisfies FERC's third directive in Order No. 693 (at P 1321) to require verification of Reactive Power capability at multiple points over a unit's operating range.[21] Sections 2.1 through 2.4 of Attachment 1 require the verification of Reactive Power capability at multiple points over a unit's operating range. For example, Section 2.1 requires the verification of synchronous generating unit's maximum Real Power and lagging Reactive Power for a minimum of one hour.

Section 2.2 requires verification of the Reactive Power capability of all applicable Facilities, other than wind and photovoltaic, for maximum overexcited (lagging) and under-excited (leading) reactive capability under several conditions.[22] Collectively, Sections 2.1

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[20] Order No. 693 at P 1310.

[21] *See* MOD-025-2, Attachment 1, Sections 2.1 through 2.2.

[22] Attachment 1, Section 2.2 provides:

2.2. Verify Reactive Power capability of all applicable Facilities, other than wind and photovoltaic, for maximum overexcited (lagging) and under-excited (leading) reactive capability for the following conditions:

through 2.4 of Attachment 1 satisfy FERC's directive to require verification of reactive power capability at multiple points over a unit's operating range.

Provided below is a justification of proposed Reliability Standard MOD-025-2 on a Requirement by Requirement basis.

Proposed Requirements – MOD-025-2

R1. Each Generator Owner shall provide its Transmission Planner with verification of the Real Power capability of its applicable Facilities as follows: *[Violation Risk Factor: Medium] [Time Horizon: Long-term Planning]*

1.1. Verify the Real Power capability of its generating units in accordance with Attachment 1.

1.2. Submit a completed Attachment 2 (or a form containing the same information as identified in Attachment 2) to its Transmission Planner within 90 calendar days of either (i) the date the data is recorded for a staged test; or (ii) the date the data is selected for verification using historical operational data.

Requirement R1 addresses Real Power and requires Generator Owners to verify the Real Power capability of its generating units and provide that verification to its Transmission Planner.

R2. Each Generator Owner shall provide its Transmission Planner with verification of the Reactive Power capability of its applicable Facilities as follows: *[Violation Risk Factor: Medium] [Time Horizon: Long-term Planning]*

2.1. Verify, in accordance with Attachment 1, (i) the Reactive Power capability of its generating units and (ii) the Reactive Power capability of its synchronous condenser units.

2.2. Submit a completed Attachment 2 (or a form containing the same information as identified in Attachment 2) to its Transmission Planner within 90 calendar days of either (i) the date the data is recorded for a staged test; or (ii) the date the data is selected for verification using historical operational data.

2.2.1 At the minimum Real Power output at which they are normally expected to operate collect maximum leading and lagging reactive values as soon as a limit is reached.

2.2.2 At maximum Real Power output collect maximum leading reactive values as soon as a limit is reached.

2.2.3 Nuclear Units are not required to perform Reactive Power verification at minimum Real Power output.

Requirement R2 addresses Reactive Power and requires Generator Owners to verify the Reactive Power capability of its generating units and provide that verification to its Transmission Planner.

R3. Each Transmission Owner shall provide its Transmission Planner with verification of the Reactive Power capability of its applicable Facilities as follows: *[Violation Risk Factor: Medium] [Time Horizon: Long-term Planning]*

> **3.1.** Verify, in accordance with Attachment 1, the Reactive Power capability of its synchronous condenser units.
>
> **3.2.** Submit a completed Attachment 2 (or a form containing the same information as identified in Attachment 2) to its Transmission Planner within 90 calendar days of either (i) the date the data is recorded for a staged test; or (ii) the date the data is selected for verification using historical operational data.

Like Requirement R2, Requirement R3 addresses Reactive Power, although Requirement R2 applies to Transmission Owners and requires Transmission Owners to verify the Reactive Power capability of applicable Facilities and provide that verification to its Transmission Planner.

B. MOD-026-1 -- Verification of Models and Data for Generator Excitation Control System or Plant Volt/Var Control Functions

Proposed Reliability Standard MOD-026-1 is a new Reliability Standard and consists of six Requirements and an Attachment (Attachment 1, Excitation Control System or Plant Volt/Var Function Model Verification Periodicity). The primary function of the excitation system is to regulate voltage and thereby control var flow in the system. When the behavior of generators is to be simulated accurately in power system stability studies, it is essential that the excitation systems of the generators be modeled in sufficient detail. Proposed Reliability Standard MOD-026-1 ensures that the generator excitation control system or plant volt/var control function model and the model parameters used in dynamic simulations performed by the

Transmission Planner accurately represent the generator excitation control system or plant volt/var control function behavior when assessing BES reliability. Proposed Reliability Standard MOD-026-1 is applicable to Generator Owners and Transmission Planners.

Proposed Requirements – MOD-026-1

R1. Each Transmission Planner shall provide the following requested information to the Generator Owner within 90 calendar days of receiving a written request : *[Violation Risk Factor: Lower] [Time Horizon: Operations Planning]*

- Instructions on how to obtain the list of excitation control system or plant volt/var control function models that are acceptable to the Transmission Planner for use in dynamic simulation,
- Instructions on how to obtain the dynamic excitation control system or plant volt/var control function model library block diagrams and/or data sheets for models that are acceptable to the Transmission Planner, or
- Model data for any of the Generator Owner's existing applicable unit specific excitation control system or plant volt/var control function contained in the Transmission Planner's dynamic database from the current (in-use) models, including generator MVA base.

Requirement R1 of proposed Reliability Standard MOD-026-1 is intended to ensure that the Transmission Planner provides information to the Generator Owner necessary to ensure that they provide a useable model in an acceptable format. This ensures that Generator Owners can comply with Requirement R2 and in turn, provide information to Transmission Planners.

R2. Each Generator Owner shall provide for each applicable unit, a verified generator excitation control system or plant volt/var control function model, including documentation and data (as specified in Part 2.1) to its Transmission Planner in accordance with the periodicity specified in MOD-026 Attachment 1. *[Violation Risk Factor: Medium] [Time Horizon: Long-term Planning]*

2.1. Each applicable unit's model shall be verified by the Generator Owner using one or more models acceptable to the Transmission Planner. Verification for individual units less than 20 MVA (gross nameplate rating) in a generating plant (per Section 4.2.1.2, 4.2.2.2, or 4.2.3.2) may be performed using either individual unit or aggregate unit model(s), or both. Each verification shall include the following:

2.1.1. Documentation demonstrating the applicable unit's model response matches the recorded response for a voltage excursion from either a staged test or a measured system disturbance,

2.1.2. Manufacturer, model number (if available), and type of the excitation control system including, but not limited to static, AC brushless, DC rotating, and/or the plant volt/var control function (if installed),

2.1.3. Model structure and data including, but not limited to reactance, time constants, saturation factors, total rotational inertia, or equivalent data for the generator,

2.1.4. Model structure and data for the excitation control system, including the closed loop voltage regulator if a closed loop voltage regulator is installed or the model structure and data for the plant volt/var control function system,

2.1.5. Compensation settings (such as droop, line drop, differential compensation), if used, and

2.1.6. Model structure and data for power system stabilizer, if so equipped.

Requirement R2 of proposed Reliability Standard MOD-026-1 ensures that Generator Owners provide Transmission Planners a verified generator excitation control system or plant volt/var control function model. The testing of excitation systems to validate their performance specifications and to construct models can be a time consuming task[23] and Attachment 1, *Excitation Control System or Plant Volt/Var Function Model Verification Periodicity*, which is incorporated into Requirement R2, reflects these realities. Initial validation testing should be part of equipment commissioning. Initial verification for a new applicable unit or for an existing applicable unit with new excitation control system or plant volt/var control function equipment installed is required by row number 3 of Attachment 1 within 365 calendar days after the commissioning date. Testing of excitation limiters is complicated since it involves verifying that once engaged, the limiter is capable of controlling the excitation level in a stable manner.

[23] *See* IEEE Task Force on Generator Model Validation Testing of the Power System Stability Subcommittee, "Guidelines for Generator Stability Model Validation Testing," at 7, IEEE PES General Meeting 2007, paper 07GM1307.

The purpose of Requirement R2 is to verify that the generator excitation control system or plant volt/var control function model and the model parameters used in dynamic simulations performed by the Transmission Planner accurately represent the generator excitation control system or plant volt/var control function behavior when assessing BES reliability.

R3. Each Generator Owner shall provide a written response to its Transmission Planner within 90 calendar days of receiving one of the following items for an applicable unit:

- Written notification from its Transmission Planner (in accordance with Requirement R6) that the excitation control system or plant volt/var control function model is not usable,
- Written comments from its Transmission Planner identifying technical concerns with the verification documentation related to the excitation control system or plant volt/var control function model, or
- Written comments and supporting evidence from its Transmission Planner indicating that the simulated excitation control system or plant volt/var control function model response did not match the recorded response to a transmission system event.

The written response shall contain either the technical basis for maintaining the current model, the model changes, or a plan to perform model verification[FN3] (in accordance with Requirement R2). *[Violation Risk Factor: Lower] [Time Horizon: Operations Planning]*
[FN 3: If verification is performed, the 10-year period as outlined in MOD-026 Attachment 1 is reset.]

Requirement R3 of proposed Reliability Standard MOD-026-1 provides response requirements for a Generator Owner when it receives certain requests from the Transmission Planner. This communication ensures that Generator Owners have an obligation to respond in a timely fashion when there are demonstrated problems with a model that was provided by the Generator Owner in accordance with Requirement R2.

R4. Each Generator Owner shall provide revised model data or plans to perform model verification[FN4] (in accordance with Requirement R2) for an applicable unit to its Transmission Planner within 180 calendar days of making changes to the excitation control system or plant volt/var control function that alter the equipment response characteristic.[FN5] *[Violation Risk Factor: Lower] [Time Horizon: Operations Planning]*

[FN 4: Ibid]

[FN 5: Exciter, voltage regulator, plant volt/var or power system stabilizer control replacement including software alterations that alter excitation control system equipment response, plant digital control system addition or replacement, plant digital control system software alterations that alter excitation control system equipment response, plant volt/var function equipment addition or replacement (such as static var systems, capacitor banks, individual unit excitation systems, etc), a change in the voltage control mode (such as going from power factor control to automatic voltage control, etc), exciter, voltage regulator, impedance compensator, or power system stabilizer settings change. Automatic changes in settings that occur due to changes in operating mode do not apply to Requirement R4.]

Requirement R4 of proposed Reliability Standard MOD-026-1 ensures that when a Generator Owner makes a change to an applicable unit that would affect the model provided in accordance with Requirement R2, the Generator Owner then has an obligation to determine whether there is an impact on the model and to provide the Transmission Planner with revised model data or plans to perform model verification.

R5. Each Generator Owner shall provide a written response to its Transmission Planner, within 90 calendar days following receipt of a technically justified[FN6] unit request from the Transmission Planner to perform a model review of a unit or plant that includes one of the following: *[Violation Risk Factor: Lower] [Time Horizon: Operations Planning]*

- Details of plans to verify the model (in accordance with Requirement R2), or
- Corrected model data including the source of revised model data such as discovery of manufacturer test values to replace generic model data or updating of data parameters based on an on-site review of the equipment.

[FN 6: Technical justification is achieved by the Transmission Planner demonstrating that the simulated unit or plant response does not match the measured unit or plant response.

Requirement R5 of proposed Reliability Standard MOD-026-1 ensures that there is a process for Transmission Planners to request a model review for technically justified units not specified in the standard Applicability section but that meet or exceed the Registry Criteria unit MVA thresholds. Footnote 2 clarifies that technical justification is achieved by the Transmission Planner demonstrating that the simulated unit or plant response does not match the measured unit

or plant response. Requirement R5 allows Generator Owners 90 days to provide Transmission Planners with: (1) its plans to verify the model or (2) corrected model data.

R6. Each Transmission Planner shall provide a written response to the Generator Owner within 90 calendar days of receiving the verified excitation control system or plant volt/var control function model information in accordance with Requirement R2 that the model is usable (meets the criteria specified in Parts 6.1 through 6.3) or is not usable.

6.1. The excitation control system or plant volt/var control function model initializes to compute modeling data without error,

6.2. A no-disturbance simulation results in negligible transients, and

6.3. For an otherwise stable simulation, a disturbance simulation results in the excitation control and plant volt/var control function model exhibiting positive damping.

If the model is not usable, the Transmission Planner shall provide a technical description of why the model is not usable. *[Violation Risk Factor: Medium] [Time Horizon: Operations Planning]*

Requirement R6 of proposed Reliability Standard MOD-026-1 requires the Transmission Planner to inform the Generator Owner within 90 calendar days whether a model is useable or not. The response from the Transmission Planner verifies that the Transmission Planner has sufficient information and ensures that the verification process is complete.

C. MOD-027-1 – Verification of Models and Data for Turbine/Governor and Load Control or Active Power/Frequency Control Functions

Proposed Reliability Standard MOD-027-1 is a new Reliability Standard and consists of five Requirements. The purpose of proposed Reliability Standard MOD-027-1 is to verify that the turbine/governor and load control or active power/frequency control model and the model parameters, used in dynamic simulations that assess BES reliability, accurately represent generator unit Real Power response to system frequency variations.

Proposed Requirements MOD-027-1

R1. Each Transmission Planner shall provide the following requested information to the Generator Owner within 90 calendar days of receiving a written request: *[Violation Risk Factor: Lower] [Time Horizon: Operations Planning]*

- Instructions on how to obtain the list of turbine/governor and load control or active power/frequency control system models that are acceptable to the Transmission Planner for use in dynamic simulation,
- Instructions on how to obtain the dynamic turbine/governor and load control or active power/frequency control function model library block diagrams and/or data sheets for models that are acceptable to the Transmission Planner, or
- Model data for any of the Generator Owner's existing applicable unit specific turbine/governor and load control or active power/frequency control system contained in the Transmission Planner's dynamic database from the current (in-use) models.

Requirement R1 of proposed Reliability Standard MOD-027-1 requires Transmission Planners to provide information to Generator Owners upon written request within 90 calendar days. This information ensures that Generator Owners can provide Transmission Planners the information required in Requirements R2 and R4 of proposed Reliability Standard MOD-027-1.

R2. Each Generator Owner shall provide, for each applicable unit, a verified turbine/governor and load control or active power/frequency control model, including documentation and data (as specified in Part 2.1) to its Transmission Planner in accordance with the periodicity specified in MOD-027 Attachment 1. *[Violation Risk Factor: Medium] [Time Horizon: Long-term Planning]*

2.1. Each applicable unit's model shall be verified by the Generator Owner using one or more models acceptable to the Transmission Planner. Verification for individual units rated less than 20 MVA (gross nameplate rating) in a generating plant (per Section 4.2.1.2, 4.2.2.2, or 4.2.3.2) may be performed using either individual unit or aggregate unit model(s) or both. Each verification shall include the following:

2.1.1. Documentation comparing the applicable unit's MW model response to the recorded MW response for either:

- A frequency excursion from a system disturbance that meets MOD-027 Attachment 1 Note 1 with the applicable unit on-line,
- A speed governor reference change with the applicable unit online, or
- A partial load rejection test,[FN 2]

2.1.2. Type of governor and load control or active power control/frequency control1 equipment,

[FN2: Differences between the control mode tested and the final simulation model must be identified, particularly when analyzing load rejection data. Most controls change gains or have a set point runback which takes effect when the breaker opens. Load or set point controls will also not be in effect once the breaker opens. Some method of accounting for

these differences must be presented if the final model is not validated from on-line data under the normal operating conditions under which the model is expected to apply.]

Requirement R2 of proposed Reliability Standard MOD-027-1 requires Generator Owners to provide Transmission Planners information and documentation as specified in Attachment 1. Attachment 1, *Turbine/Governor and Load Control or Active Power/Frequency Control Model Periodicity*, is a table that lists verification conditions and the accompanying required actions. In addition to obtaining model data, the tests performed to gather this information may uncover latent defects that could lead to inappropriate unit response during system disturbances and thereby improve reliability.[24]

R3. Each Generator Owner shall provide a written response to its Transmission Planner within 90 calendar days of receiving one of the following items for an applicable unit.

- Written notification, from its Transmission Planner (in accordance with Requirement R5) that the turbine/governor and load control or active power/frequency control model is not "usable,"
- Written comments from its Transmission Planner identifying technical concerns with the verification documentation related to the turbine/governor and load control or active power/frequency control model, or
- Written comments and supporting evidence from its Transmission Planner indicating that the simulated turbine/governor and load control or active power/frequency control response did not approximate the recorded response for three or more transmission system events.

The written response shall contain either the technical basis for maintaining the current model, the model changes, or a plan to perform model verification[FN 3] (in accordance with Requirement R2). *[Violation Risk Factor: Lower] [Time Horizon: Operations Planning]*

[FN3: If verification is performed, the 10 year period as outlined in MOD-027 Attachment 1 is reset.]

Requirement R3 of proposed Reliability Standard MOD-027-1 ensures that there is appropriate communication between Generator Owners and Transmission Planners when an issue is identified with a model or where there is a difference between the model and actual

[24] *See* IEEE Task Force on Generator Model Validation Testing of the Power System Stability Subcommittee, "Guidelines for Generator Stability Model Validation Testing," at 1, IEEE PES General Meeting 2007, paper 07GM1307.

recorded events for three or more transmission system events. The evidence of compliance with Requirement R3, included in Measure M3,[25] would consist of the Generator Owner's dated written response containing the information identified in Requirement R3 and dated evidence of the transmittal of the response.

R4. Each Generator Owner shall provide revised model data or plans to perform model Verification[FN 4] (in accordance with Requirement R2) for an applicable unit to its Transmission Planner within 180 calendar days of making changes to the turbine/governor and load control or active power/frequency control system that alter the equipment response characteristic[FN 5]. *[Violation Risk Factor: Lower] [Time Horizon: Operations Planning]*

[FN4: Ibid.
[FN5: Control replacement or alteration including software alterations or plant digital control system addition or replacement, plant digital control system software alterations that alter droop, and/or dead band, and/or frequency response and/or a change in the frequency control mode (such as going from droop control to constant MW control, etc).]

Requirement R4 of proposed Reliability Standard MOD-027-1 ensures that Generator Owners provide Transmission Planners with updated information when changes occur; this ensures that the information in Requirement R2 is updated when necessary (*i.e.*, when changes are made to the turbine/governor and load control or active power/frequency control system that alter the equipment response characteristic). The evidence of compliance for Requirement R4, included in Measure M4, would consist of dated revised model data or dated plans to perform a model verification and dated evidence of transmittal.

R5. Each Transmission Planner shall provide a written response to the Generator Owner within 90 calendar days of receiving the turbine/governor and load control or active power/frequency control system verified model information in accordance with Requirement R2 that the model is usable (meets the criteria specified in Parts 5.1 through 5.3) or is not usable.

[25] Measures identify the evidence or types of evidence needed to demonstrate compliance with the associated Requirement. *See* NERC Standard Processes Manual, *available here*: http://www.nerc.com/pa/Stand/Resources/Documents/Appendix3AStandardsProcessesManual.pdf.

5.1. The turbine/governor and load control or active power/frequency control function model initializes to compute modeling data without error,
5.2. A no-disturbance simulation results in negligible transients, and
5.3. For an otherwise stable simulation, a disturbance simulation results in the turbine/governor and load control or active power/frequency control model exhibiting positive damping.

If the model is not usable, the Transmission Planner shall provide a technical description of why the model is not usable. *[Violation Risk Factor: Medium] [Time Horizon: Operations Planning]*

Requirement R5 of proposed Reliability Standard MOD-027-1 requires Transmission Planners to provide verification to Generator Owners that the model provided (pursuant to Requirement R2 or R4) is useable. This is necessary to ensure that there is appropriate communication between Generator Owners and Transmission Planners and ensures that if the model provided by the Generator Owner is not useable, the Generator Owner has an appropriate technical explanation of the issue. Generator Owners are also then obligated to provide a written response, pursuant to Requirement R3, within 90 calendar days.

D. PRC-019-1 – Coordination of Generating Unit or Plant Capabilities, Voltage Regulating Controls, and Protection

Proposed Reliability Standard PRC-019-1 is a new Reliability Standard and consists of two Requirements. The purpose of the proposed Reliability Standard is to verify coordination of generating unit Facility or synchronous condenser voltage regulating controls, limit functions, equipment capabilities and Protection System settings. Proposed Reliability Standard PRC-019-1 is applicable to Generator Owners and Transmission Owners that own synchronous condenser(s).

Proposed Requirements – PRC-019-1

R1. At a maximum of every five calendar years, each Generator Owner and Transmission Owner with applicable Facilities shall coordinate the voltage regulating system controls, (including in-service[FN 1] limiters and protection functions) with the applicable

equipment capabilities and settings of the applicable Protection System devices and functions. *[Violation Risk Factor: Medium] [Time Horizon: Long-term Planning]*

1.1. Assuming the normal automatic voltage regulator control loop and steady-state system operating conditions, verify the following coordination items for each applicable Facility:

1.1.1. The in-service limiters are set to operate before the Protection System of the applicable Facility in order to avoid disconnecting the generator unnecessarily.

1.1.2. The applicable in-service Protection System devices are set to operate to isolate or de-energize equipment in order to limit the extent of damage when operating conditions exceed equipment capabilities or stability limits.

[FN 1: Limiters or protection functions that are installed and activated on the generator or synchronous condenser.]

Requirement R1 of proposed Reliability Standard PRC-019-1 requires Generator Owners and Transmission Owners to coordinate voltage regulating system controls with the equipment of the applicable Protection System devices and functions. Measure M1 states that each Generator Owner and Transmission Owner should have evidence that it coordinated the voltage regulating system controls and examples of coordination are provided in the Reference section of the standard. The Reference Section of proposed Reliability Standard PRC-019-1 states that evidence of coordination associated with Requirement R1 may be in the form of:

- P-Q Diagram (Example in Attachment 1), or
- R-X Diagram (Example in Attachment 2), or
- Inverse Time Diagram (Example in Attachment 3) or,
- Equivalent tables or other evidence

This evidence should include the equipment capabilities and the operating region for the limiters and protection functions. Equipment limits, types of limiters and protection functions which could be coordinated include (but are not limited to):

- Field over-excitation limiter and associated protection functions.
- Inverter over current limit and associated protection functions.
- Field under-excitation limiter and associated protection functions.
- Generator or synchronous condenser reactive capabilities.
- Volts per hertz limiter and associated protection functions.

- Stator over-voltage protection system settings.
- Generator and transformer volts per hertz capability.
- Time vs. field current or time vs. stator current.

(NOTE: This listing is for reference only. This standard does not require the installation or activation of any of the above limiter or protection functions.)

R2. Within 90 calendar days following the identification or implementation of systems, equipment or setting changes that will affect the coordination described in Requirement R1, each Generator Owner and Transmission Owner with applicable Facilities shall perform the coordination as described in Requirement R1. These possible systems, equipment or settings changes include, but are not limited to the following *[Violation Risk Factor: Medium] [Time Horizon: Long-term Planning]*:

- Voltage regulating settings or equipment changes;
- Protection System settings or component changes;
- Generating or synchronous condenser equipment capability changes; or
- Generator or synchronous condenser step-up transformer changes.

Requirement R2 of proposed Reliability Standard PRC-019-1applies when there are equipment or setting changes. Collectively, Requirements R1 and R2 ensure an appropriate level of coordination between Generator Owners and Transmission Owners. The evidence of compliance with Requirement R2 (included in Measure M2) would consist of dated documentation that demonstrates that the specified intervals in Requirement R2 have been met.

E. PRC-024-1 – Generator Frequency and Voltage Protective Relay Settings

Proposed Reliability Standard PRC-024-1 is a new Reliability Standard and consists of four Requirements and two Attachments. The purpose of proposed Reliability Standard PRC-024-1 is to ensure that Generator Owners set their generator protective relays such that generating units remain connected during defined frequency and voltage excursions.

Attachment 1 is the Off Nominal Frequency Capability Curve and establishes a "no trip zone;" it is incorporated into the language of Requirement R1 of proposed Reliability Standard PRC-024-1. The X-axis of the Attachment 1 curve represents time and the scale is logarithmic. The Y-axis of the Attachment 1 curve represents the frequency of the specific Interconnection.

The "no trip zone" does not include the colored lines delineating the zones illustrated in Attachment 1. The curve data points provided in the tables of Attachment 1 detail the exact points on the curve for each Interconnection and represent the amount of time a generator needs to stay connected at specific defined frequency excursions. For the Eastern Interconnection, the relays for each generator are expected to be set to remain online between frequencies of greater than (and not including) 60.5 hz and less than (and not including) 59.5 hz. For all other Interconnections, the relays for each generator are expected to be set to remain online between frequencies of greater than (and not including) 60.6 hz and less than (and not including) 59.4 hz. For example, in the Western Interconnection if the frequency drops to 58.0 hz the relays are required to be set such that they do not trip the generating units for up to (and not including) 12 seconds. For time periods of 12 seconds and beyond, the proposed Standard allows for the relays to be set to trip the generating units.

Attachment 2 is the Voltage Ride-Through Time Duration Curve and is incorporated into the language of Requirement R2 of proposed Reliability Standard PRC-024-1.

1. FERC Directives

Proposed Reliability Standard PRC-024-1 satisfies two FERC directives from Paragraph 1787 of Order No. 693.

> 1787. In the NOPR, the Commission identified an implicit assumption in the TPL Reliability Standards that all generators are required to ride through the same types of voltage disturbances and remain in service after the fault is cleared. This implicit assumption should be made explicit. Commenters agree with the proposed requirement for all generators to ride through the same set of Category B and C events as required for wind generators. The Commission understands that [United States Nuclear Regulatory Commission ("NRC")] has both degraded voltage and loss of voltage requirements. The degraded voltage requirement allows the voltage at the auxiliary power system busses to go below the minimum value for a time frame that is usually much longer than normal fault clearing time. If a specific nuclear power plant has an NRC requirement that would force it to

> trip off-line if its auxiliary power system voltage was depressed below some minimum voltage, the simulation should include the tripping of the plant in addition to the faulted facilities. In this regard, the Commission agrees that NRC requirements should be used when implementing the Reliability Standards. Using NRC requirements as input will assure that there is consistency between the Reliability Standards and the NRC requirement that the system is accurately modeled. Accordingly, the Commission directs the ERO to modify the Reliability Standard to explicitly require either that all generators are capable of riding through the same set of Category B and C contingencies, as required by wind generators in Order No. 661, or that those generators that cannot ride through be simulated as tripping. If a generator trips due to low voltage from a single contingency, the initial trip of the faulted element and the resulting trip of the generator would be governed by Category B contingencies and performance criteria.[26]

Requirement R2 and Attachment 2 (which is incorporated), of proposed Reliability Standard PRC-024-1 satisfy FERC's directive in Order No. 693 to "explicitly require either that all generators are capable of riding through the same set of Category B and C contingencies, as required by wind generators in Order No. 661, or that those generators that cannot ride through be simulated as tripping."[27]

The technical basis for the curves in Attachment 2 of NERC Standard PRC-024-1 comes principally from *The Technical Basis for the New WECC Voltage Ride-Though (VRT) Standard*, a whitepaper developed by the WECC Wind Generation Task Force ("WGTF").[28]

During the process of drafting the proposed Reliability Standard PRC-024-1, a comparison was done by a utility company between the results of fault recordings and studies from their region with the curves in Attachment 2 and this demonstrated that the curves properly bounded the voltage profiles actually experienced. It should be noted that, unlike a number of

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[26] Order No. 693 at P 1787(internal citation omitted)(emphasis added).

[27] Order No. 693 at P 1787.

[28] Available here: http://www.wecc.biz/Standards/Development/WECC-60/Shared Documents/The Technical Basis for the New WECC Voltage Ride-Through (VRT).doc. In developing the whitepaper, the WGTF examined the voltage profiles of various line faults in the Western Electricity Coordinating Council ("WECC") region and drew a voltage vs. time envelope around that encompassed all of the normally cleared faults. The WGTF also reviewed various international voltage ride-through standards and found the proposed WECC curves.

other regulatory requirements for voltage ride-through, the proposed WECC curves (and subsequently the curves in PRC-024-1 Attachment 2) contain requirements for the high voltage excursions that occur following clearing of a fault on the transmission system. The standard drafting team reviewed these curves to ensure they did not compromise equipment safety due to overexcitation of magnetic circuits as described in IEEE[29] and ANSI[30] standards. The standard drafting team also had the benefit of input from a manufacturer of power conversion electronic equipment to ensure the curves were realistic from their perspective.

Requirement R3 allows NRC requirements to supersede portions of the voltage and frequency ride through criteria in proposed Reliability Standard PRC-024-1. Requirement R3 allows generators an exemption from portions of the ride through curves for documented regulatory limitations. The standard drafting team asserts that NRC requirements qualify as regulatory limitations for the purposes of proposed Reliability Standard PRC-024-1 and therefore, Requirement R3 satisfies FERC's guidance that "NRC requirements should be used when implementing the Reliability Standards."[31]

Proposed Requirements – PRC-024-1

R1. Each Generator Owner that has generator frequency protective relaying[FN1] activated to trip its applicable generating unit(s) shall set its protective relaying such that the generator frequency protective relaying does not trip the applicable generating unit(s) within the "no trip zone" of PRC-024 Attachment 1, subject to the following exceptions: *[Violation Risk Factor: Medium] [Time Horizon: Long-term Planning]*

- Generating unit(s) may trip if the protective functions (such as out-of-step functions or loss-of-field functions) operate due to an impending or actual loss of synchronism or, for asynchronous generating units, due to instability in power conversion control equipment.
- Generating unit(s) may trip if clearing a system fault necessitates disconnecting (a) generating unit(s).

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29 Institute of Electrical and Electronics Engineers ("IEEE").

30 American National Standards Institute ("ANSI").

31 *Id.*

- Generating unit(s) may trip within a portion of the "no trip zone" of PRC-024 Attachment 1 for documented and communicated regulatory or equipment limitations in accordance with Requirement R3.

  [FN1: Each Generator Owner is not required to have frequency or voltage protective relaying (including but not limited to frequency and voltage protective functions for discrete relays, volts per hertz relays evaluated at nominal frequency, multi-function protective devices or protective functions within control systems that directly trip or provide tripping signals to the generator based on frequency or voltage inputs) installed or activated on its unit.]

Requirement R1 of proposed Reliability Standard PRC-024-1 ensures that generating units remain connected during frequency excursions.

R2. Each Generator Owner that has generator voltage protective relaying[FN 1] activated to trip its applicable generating unit(s) shall set its protective relaying such that the generator voltage protective relaying does not trip the applicable generating unit(s) as a result of a voltage excursion (at the point of interconnection[FN 2]) caused by an event on the transmission system external to the generating plant that remains within the "no trip zone" of PRC-024 Attachment 2. If the Transmission Planner allows less stringent voltage relay settings than those required to meet PRC-024 Attachment 2, then the Generator Owner shall set its protective relaying within the voltage recovery characteristics of a location-specific Transmission Planner's study. Requirement R2 is subject to the following exceptions: *[Violation Risk Factor: Medium] [Time Horizon: Long-term Planning]*

- Generating unit(s) may trip in accordance with a Special Protection System (SPS) or Remedial Action Scheme (RAS).
- Generating unit(s) may trip if clearing a system fault necessitates disconnecting (a) generating unit(s).
- Generating unit(s) may trip by action of protective functions (such as out-of-step functions or loss-of-field functions) that operate due to an impending or actual loss of synchronism or, for asynchronous generating units, due to instability in power conversion control equipment.
- Generating unit(s) may trip within a portion of the "no trip zone" of PRC-024 Attachment 2 for documented and communicated regulatory or equipment limitations in accordance with Requirement R3.

[FN1 Each Generator Owner is not required to have frequency or voltage protective relaying (including but not limited to frequency and voltage protective functions for discrete relays, volts per hertz relays evaluated at nominal frequency, multi-function protective devices or protective functions within control systems that directly trip or provide tripping signals to the generator based on frequency or voltage inputs) installed or activated on its unit.

[FN2 For the purposes of this standard, point of interconnection means the transmission (high voltage) side of the generator step-up or collector transformer.]

Requirement R2 and Attachment 2 (which is incorporated), of proposed Reliability Standard PRC-024-1 satisfy FERC's directive in Order No. 693 to "explicitly require either that all generators are capable of riding through the same set of Category B and C contingencies, as required by wind generators in Order No. 661, or that those generators that cannot ride through be simulated as tripping."[32] Requirement R2 ensures that generating unit protection systems do not disconnect the generator from the grid during the voltage excursions defined in Attachment 2. The standard drafting team believes the voltage profile described in Attachment 2 covers excursions that would be expected under Category B and C contingencies.

R3. Each Generator Owner shall document each known regulatory or equipment limitation[FN3] that prevents an applicable generating unit with generator frequency or voltage protective relays from meeting the relay setting criteria in Requirements R1 or R2 including (but not limited to) study results, experience from an actual event, or manufacturer's advice. *[Violation Risk Factor: Lower] [Time Horizon: Long-term Planning]*

3.1. The Generator Owner shall communicate the documented regulatory or equipment limitation, or the removal of a previously documented regulatory or equipment limitation, to its Planning Coordinator and Transmission Planner within 30 calendar days of any of the following:

- Identification of a regulatory or equipment limitation.
- Repair of the equipment causing the limitation that removes the limitation.
- Replacement of the equipment causing the limitation with equipment that removes the limitation.
- Creation or adjustment of an equipment limitation caused by consumption of the cumulative turbine life-time frequency excursion allowance.

[FN 3: Excludes limitations that are caused by the setting capability of the generator frequency and voltage protective relays themselves but does not exclude limitations originating in the equipment that they protect.]

[32] Order No. 693 at P 1787.

Requirement R3 of proposed Reliability Standard PRC-024-1 requires Generator Owners to document known regulatory or equipment limitations and to communicate these limitations to Planning Coordinators and Transmissions within 30 days of identifying a limitation or repair or replacement of the equipment causing the limitation. This allows the Transmission Planners to properly simulate the performance of the protection systems of those generators that must have their protection systems set to operate within the No Trip Zones described in Requirements R1 and R2.

R4. Each Generator Owner shall provide its applicable generator protection trip settings associated with Requirements R1 and R2 to the Planning Coordinator or Transmission Planner that models the associated unit within 60 calendar days of receipt of a written request for the data and within 60 calendar days of any change to those previously requested trip settings unless directed by the requesting Planning Coordinator or Transmission Planner that the reporting of relay setting changes is not required. *[Violation Risk Factor: Lower] [Time Horizon: Operations Planning]*

Requirement R4 of proposed Reliability Standard PRC-024-1 requires Generator Owners to provide its protection trip settings associated with Requirements R1 and R2 to the Planning Coordinator or Transmission Planner within 60 days of (1) a written request for that information or (2) a change to any previously requested trip settings.

F. Enforceability of the Proposed Reliability Standards

The proposed Reliability Standards include Violation Risk Factors ("VRFs") and Violation Severity Levels ("VSLs"). The VSLs provide guidance on the way that NERC will enforce the Requirements of the proposed Reliability Standard. The VRFs and VSLs for the proposed Reliability Standards comport with NERC and FERC guidelines related to their assignment. For a detailed review of the VRFs, the VSLs, and the analysis of how the VRFs and VSLs were determined using these guidelines, please see **Exhibit E**.

The proposed Reliability Standards also include Measures that support each Requirement by clearly identifying what is required and how the Requirement will be enforced. These Measures help ensure that the Requirements will be enforced in a clear, consistent, and non-preferential manner and without prejudice to any party.

Respectfully submitted,

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June 10, 2013

EXHIBITS A, B D and F

(Available on the NERC Website at
http://www.nerc.com/fileUploads/File/Filings/Attachments_generator_verification_filing)

Exhibit C — Order No. 672 Criteria

Reliability Standards Criteria

1. Proposed Reliability Standards must be designed to achieve a specified reliability goal and must contain a technically sound means to achieve that goal.

The proposed Standards achieve the specific reliability goal of ensuring that (i) generators will not trip off-line during specified voltage and frequency excursions or as a result of improper coordination between generator protective relays and generator voltage regulator controls and limit functions (such coordination will include the generating unit's capabilities), and (ii) generator models accurately reflect the generator's capabilities and operating characteristics. Together, these five proposed Reliability Standards address generator verifications needed to support Bulk-Power System reliability and will ensure that accurate data is collected, verified, and made available for planning simulations.

2. Proposed Reliability Standards must be applicable only to users, owners and operators of the bulk power system, and must be clear and unambiguous as to what is required and who is required to comply.

The proposed Reliability Standards are clear and unambiguous as to what is required and who is required to comply. All of the proposed Reliability Standards apply to Generator Owners. MOD-025-2 and PRC-019-1 also apply to Transmission Owners that own synchronous condenser(s). MOD-026-1 and MOD-027-1 also apply to Transmission Planners.

3. A proposed Reliability Standard must include clear and understandable consequences and a range of penalties (monetary and/or non-monetary) for a violation.

The VRFs and VSLs for the proposed Reliability Standards comport with NERC and FERC guidelines related to their assignment. The assignment of the severity level for each VSL is consistent with the corresponding Requirement and the VSLs should ensure uniformity and

consistency in the determination of penalties. The VSLs do not use any ambiguous terminology, thereby supporting uniformity and consistency in the determination of similar penalties for similar violations. For these reasons, the proposed Reliability Standards include clear and understandable consequences.

4. A proposed Reliability Standard must identify clear and objective criterion or measure for compliance, so that it can be enforced in a consistent and non-preferential manner.

The proposed Reliability Standards contain Measures that support each Requirement by clearly identifying what is required and how the Requirement will be enforced. These Measures help provide clarity regarding how the Requirements will be enforced, and ensure that the Requirements will be enforced in a clear, consistent, and non-preferential manner and without prejudice to any party.

5. Proposed Reliability Standards should achieve a reliability goal effectively and efficiently — but do not necessarily have to reflect "best practices" without regard to implementation cost or historical regional infrastructure design.

The proposed Reliability Standards achieve the reliability goal effectively and efficiently.

6. Proposed Reliability Standards cannot be "lowest common denominator," *i.e.*, cannot reflect a compromise that does not adequately protect Bulk-Power System reliability. Proposed Reliability Standards can consider costs to implement for smaller entities, but not at consequences of less than excellence in operating system reliability.

The proposed Reliability Standards do not reflect a "lowest common denominator" approach. To the contrary, the proposed Reliability Standards represent a significant improvement over the previous version as described herein.

7. Proposed Reliability Standards must be designed to apply throughout North America to the maximum extent achievable with a single Reliability Standard while not favoring one geographic area or regional model. It should take into account regional variations in the organization and corporate structures of transmission owners and operators, variations in generation fuel type and ownership patterns, and regional variations in market design if these affect the proposed Reliability Standard.

The proposed Reliability Standards apply throughout North America and do not favor one geographic area or regional model.

8. Proposed Reliability Standards should cause no undue negative effect on competition or restriction of the grid beyond any restriction necessary for reliability.

The proposed Reliability Standards do not restrict the available transmission capability or limit use of the bulk-power system in a preferential manner.

9. The implementation time for the proposed Reliability Standard is reasonable.

The proposed effective dates for the Reliability Standards are just and reasonable and appropriately balance the urgency in the need to implement the standards against the reasonableness of the time allowed for those who must comply to develop necessary procedures, software, facilities, staffing or other relevant capability. This will allow applicable entities adequate time to ensure compliance with the requirements.

Specifically, the proposed implementation plans for MOD-026-1 and MOD-027-1 are of a longer duration due to the complexity of the tasks involved. Model verification testing on generating units is a relatively specialized and complex task that involves some risk to the operating unit. The reasons for this are as follows:

- The unit must have temporary monitoring equipment connected to record the necessary parameters;
- To install the equipment necessary to obtain shaft position information, a unit shutdown may be required;
- A specialized skill set is required both to perform the test and to process the data obtained during testing. There are not large numbers of these personnel available;
- Each unit takes 2-3 days to instrument, collect data, and then process the data to verify that the model is correct, unlike MOD-025 testing which can typically be accomplished with already installed instruments and within 1 day.

Given that there are many units to test, a long period of time was deemed to be necessary to get all the units complete. Obviously, entities with few units will probably have more time than needed, but entities with large numbers of units may be challenged even by the 10 year period. If the planning entity has a need for a particular unit, they can require that unit to be verified under Requirement R3 of the proposed Standards. The proposed effective dates are explained in the proposed Implementation Plan, attached as **Exhibit C**.

10. The Reliability Standard was developed in an open and fair manner and in accordance with the Reliability Standard development process.

The proposed Reliability Standards were developed in accordance with NERC's ANSI-accredited processes for developing and approving Reliability Standards. **Exhibit E** includes a summary of the Reliability Standard development proceedings, and details the processes followed to develop the Reliability Standards.

These processes included, among other things, multiple comment periods, pre-ballot review periods, and balloting periods. Additionally, all meetings of the drafting team were properly noticed and open to the public. The initial and recirculation ballots both achieved a quorum and exceeded the required ballot pool approval levels.

11. NERC must explain any balancing of vital public interests in the development of proposed Reliability Standards.

NERC has identified no competing public interests regarding the request for approval of the proposed Reliability Standards. No comments were received that indicated the proposed Reliability Standards conflict with other vital public interests.

12. Proposed Reliability Standards must consider any other appropriate factors.

No other negative factors relevant to whether the proposed Reliability Standards are just and reasonable were identified.

Exhibit E — Summary of the Reliability Standard Development Proceeding and Complete Record of Development of Proposed Reliability Standard

The development record for the proposed Reliability Standards is summarized below.

I. Overview of the Standard Drafting Team

The technical expertise of the ERO is derived from the standard drafting team. For this project, the standard drafting team consisted of four industry experts with a diversity of experience. A detailed set of biographical information for each of the team members is included along with the drafting team roster in **Exhibit F**.

II. Standard Development History

A. SAR Development

A Standard Authorization Request ("SAR") was submitted on April 3, 2007 and was posted for a 30-day public comment period from April 20, 2007 to May 21, 2007. There were 16 sets of comments, including comments from 63 different individuals from more than 35 organizations representing 7 of the 10 Industry Segments. In response to the comments received, the SAR drafting team revised the SAR for Project 2007-09 Generator Verification as follows:

- Added the Generator Operator and Reliability Coordinator as reliability functions that may have responsibilities in the proposed standards.
- Added language to clarify that the standard drafting team will consider the Phase III & IV field test results when developing the standards associated with this project.

The SAR was modified on June 14, 2007.

B. First Posting

MOD-026-1 and PRC-024-1 were posted for a 45-day formal comment period from February 17, 2009 to April 2, 2009. MOD-026-1 received 45 sets of comments, including

comments from more than 100 different people from over 50 companies representing 8 of the 10 industry segments. The standard drafting team considered stakeholder comments and made the following changes based on those comments:

- The standard drafting team consulted the Functional Model Working Group (FMWG), who rendered the opinion that the Generator Owner should be responsible for model verification, not the Generator Operator. Based on consultation with the FMWG, and supported by the majority of industry comments, the standard drafting team changed the applicability from the Generator Operator to the Generator Owner.
- The layout and the formatting of the standard were significantly updated. Periodicity has been moved to a separate attachment, as the standard drafting team determined that it is not a stand-alone reliability requirement.

For PRC-024-1, there were 43 sets of comments, including comments from more than 100 different people from over 60 companies representing 9 of the 10 industry segments. The standard drafting team considered stakeholder comments and made the following changes to PRC-024-1 based on those comments:

- The drafting team revised the purpose to clarify that new generators must be capable of riding through voltage and frequency excursions and expected unit performance during frequency and voltage excursions must be communicated to entities that monitor or model the associated generator.
- With respect to applicability, the standard drafting team determined that only the Generator Owner has responsibilities required by this NERC Standard. The "facility applicability" language that duplicated the language from the Compliance Registry Criteria is not necessary to include in the applicability section of the standard, and was removed. The team added a footnote to both Requirements R1 and R2 to clarify that the requirements in the standard do not require any entity to have frequency or voltage protective relaying installed or activated on its units.
- With respect to Requirement R1, the standard drafting team modified the sequence of the wording in the requirement; replaced the range of VRFs based on MVA to a single VRF for consistency with other standards; added the following as an additional criterion under which the generating unit may not trip: when the transmission system frequency rate of change is less than 2.5 Hz/second with a total change of up to 1.0 Hz.
- With respect to Requirement R2, the standard drafting team modified the language to clarify that the intent is to address trippings associated with events external to the generator; added more specificity to each of the criterion under which the generator

unit may not trip; and replaced the range of VRFs based on MVA to a single VRF for consistency with other standards.

- Requirements R3 and R4 were merged and moved so that it is the last requirement, R7, so that the sequence of requirements is in chronological order.
- The language of Requirement R5 was modified and simplified for clarify regarding the required documentation of equipment limitations.
- A new Requirement was drafted to require Generator Owners to provide requesting entities with specific documentation to support an estimate of a unit's performance during Frequency/Voltage Excursions for modeling and study accuracy.
- The standard drafting team developed the off nominal frequency curve (Attachment 1) in coordination with the NERC UFLS Standard Drafting Team. The 57.8 Hz setting for generator underfrequency and 58 Hz for UFLS is to ensure that the UFLS will have a chance to arrest the system frequency decline before reaching the minimum permissible frequency for generators. The intent of the curves is to ensure that the generators do not trip when the frequency is within the area bounded by the high and low frequency curves. When the frequency excursion reaches outside the high or low curve, the generator is allowed to trip.
- The standard drafting team updated Attachment 2 to add more clarity on the calculations for the voltage ride through curve.

MOD-024-2 was posted for a 30-day public comment period from January 18, 2010 to February 18, 2010. There were 47 sets of comments, including comments from more than 130 different people from over 60 companies representing 8 of the 10 industry segments. The standard drafting team considered stakeholder comments and made the following changes to MOD-024-2 based on those comments:

- The requirement for the Resource Planner and Planning Coordinator to provide the Generator Owner with schedules and temperature adjustments was deleted, and the applicability section of the standard was revised to omit the Planning Coordinator and Resource Planner.
- The standard drafting team combined the requirements of MOD-024 and MOD-025 into MOD-025. Under the combined standard, all applicable units will be verified for both real and reactive power capability just once every five years. To avoid having many units requiring verification in any one year, the initial implementation period proposed requires verification of 20% of an entity's units each year.

MOD-025-2, MOD-027-1 and PRC-019-1 were posted for a formal 30-day comment period from June 15, 2011 to July 15, 2011. There were 65 sets of comments, including

comments from approximately 182 different people from approximately 95 companies representing 9 of the 10 industry segments.

The standard drafting team considered stakeholder comments and made the following changes to MOD-025-2 based on those comments:

- Language was added to recommend that the AVR be in automatic control while conducting reactive capability testing, but that reactive capability testing must be done even if the AVR is not available.

The standard drafting team considered stakeholder comments and made the following changes to MOD-027-1 based on those comments:

- The standard drafting team expanded the applicability of MOD-027-1 to include plants/facilities comprised of multiple small units such as variable energy resource plants/facilities;
- Corrections of various typos in the body of the standard, the VSLs, and in Attachment 1;
- Extended the time to comply with Requirement 1 from 30 to 90 days;
- Modified Attachment 1 (Periodicity Table) to address units which are always base loaded (by definition a base loaded unit is considered verified);
- Modified Attachment 1 (Periodicity Table) to clarify establishing the Initial Ten Year Unit Verification Period Start Date;
- Reduced the maximum time allowed between capture of an event and completing model verification from two years to one year;
- Referenced the NERC GADS document for references to capacity factor in the draft standard; and
- Included partial load rejection as a potential test to obtain a recording of the equipment response to be used in model verification.

The standard drafting team considered stakeholder comments and made the following changes to PRC-019-1 based on those comments:

- The example diagrams added that they are drawn at nominal voltage and frequency;
- The formula for calculating the radius of the SSSL was corrected;
- The items “under-excited limiters or minimum excitation limiters” and “over-excited limiters or maximum excitation limiters” have been placed in the bulleted list of the standard;
- The SDT changed “protective” to “protection” within the standard to be consistent with Section G; and
- The SDT added a reference document for use in calculation of SSSL.

C. Second Posting

MOD-026-1 and PRC-024-1 were posted for a 45-day formal public comment period from June 15, 2011 to August 1, 2011, with an initial ballot and non-binding poll from July 22, 2011 to August 1, 2011. For both standards, there were 66 sets of comments, including comments from approximately 185 different people from approximately 120 companies representing all 10 of the 10 industry segments. MOD-026-1 received a quorum of 90.25% and an approval rating of 46.53%. PRC-024-1 received a quorum of 90.82% and an approval of 18.23%.

The standard drafting team considered stakeholder comments and made the following changes to MOD-026-1 based on those comments:

- Correcting several VSL grammatical errors and ensuring consistency between the VSL "increment for tardiness" time period specified and the Requirement language.
- An additional condition, row 12, was added to Attachment 1 (the Periodicity Table) specifying that validation is not required for an excitation control system or plant volt/var control that does not include an active closed loop voltage regulation function. This condition exempts wind and solar plants that do not have the capability to regulate plant voltage or respond to grid voltage fluctuations other than switching capacitor and reactor banks in and out of service.
- The format and column information of Attachment 1 was revised for clarity.
- The typographical errors in R2.1.1 language was corrected to clearly state expectation that "the unit or plant's model response matches the recorded response for a voltage excursion at the generator or plant point of interconnection from either a staged test or a measured system disturbance."
- The language of R2.1.4 was revised to align with the style of R2.1.6.
- To clarify concerns regarding calculating unit capacity factor, the SDT has incorporated into the standard the capacity factor calculation specified in Appendix F of the GADS Data Reporting Instructions (which can be obtained from the NERC website).
- There was some confusion regarding the treatment of small units at plants. The SDT modified the language in the Applicability / Facilities section for clarity and for consistency to the extent possible with the other draft standards in the Generation Verification effort.

The standard drafting team considered stakeholder comments and made the following changes to PRC-024-1 based on those comments:

- The two new terms proposed in the standard were removed. The voltage and frequency excursion values are now located in the requirements where they apply.
- Attachment 1 (Off Nominal Frequency Capability Curve) was revised to clarify the "no trip" zone.
- Attachment 2 (Voltage Ride-Through Time Duration Curves) has been clarified. The per unit voltage base for these curves is the base voltage specified in the system models used by the Transmission Planner in the analysis of the reliability of the Interconnected Transmission Systems at the point of interconnection to the Bulk Electric System (BES). In addition, the definition was modified to include the phrase, "voltages in the curve assume minimum phase-to-ground or phase-to-phase voltage for the low voltage duration curve and maximum phase-to-ground or phase-to-phase voltage for the high voltage duration curve."
- The Requirement Parts were revised in Requirement R1. Part 1.5 was moved into the body of R1.
- Requirement Part 2.1.1 was removed from Requirement R2. The body of the requirement and the remaining Parts were modified to clarify intent.
- Requirement R3 was changed to clarify the intent of non-protection system limitations and when such limitations must be addressed.

MOD-025-2, MOD-027-1 and PRC-019-1 were posted for a 45-day formal comment period from February 29, 2012 to April 16, 2012 with an initial ballot and non-binding poll from April 6, 2012 to April 16, 2012. There were 57 sets of comments, including comments from approximately 159 different people from approximately 51 companies representing 9 of the 10 industry segments. MOD-025-2 received a quorum of 88.28% with an approval rating of 41.09%. MOD-027-1 received a quorum of 88.04% with an approval rating of 36.84%.

For PRC-019-1, there were 65 sets of comments, including comments from approximately 182 different people from approximately 95 companies representing 9 of the 10 industry segments. PRC-019-1 received a quorum of 88.04% with an approval rating of 48.70%.

D. Third Posting

MOD-026-1 and PRC-024-1 were posted for a formal 30-day public comment period from February 29, 2012 to March 29, 2012 with a successive ballot from March 19, 2012 to March 29, 2012. There were 53 sets of comments, including comments from approximately 127

different people from approximately 88 companies representing 9 of the 10 industry segments. MOD-026-1 received a quorum of 81.45% and an approval rating of 61.21%. PRC-024-1 received a quorum of 80.38% and an approval of 41.09%.

The standard drafting team considered stakeholder comments and made the following changes to MOD-026-1 based on those comments:

- Included the term "impedance compensation" to Footnote 1 in the description of what constitutes an excitation control system for synchronous machines.
- Clarified that the response by the Transmission Planner to the Generator Owner concerning the results of testing the model useability is required to be a written response (R6). Also, for ease of reading, moved the last sentence in the requirement to after the Requirement Parts 1-3.
- Revised the first sentence in R1 to read: "Each Transmission Planner shall provide the following requested information to the Generator Owner within 90 calendar days of receiving a written request:" Stakeholders believed the previous language was not as clear as it could be, so the standard drafting team made this revision.
- Refined sub part 2.1.2 to read: "Manufacturer, model number (if available), and type of the excitation control system including, but not limited to static, AC brushless, DC rotating, and/or the plant volt/var control function (if installed)."

The standard drafting team considered stakeholder comments and made the following changes to PRC-024-1 based on those comments:

- The standard drafting team noted that some stakeholders were still unclear if the activities described in Requirement R4 were to be performed by request only, so the standard drafting team rearranged the sentences to make that more clear. Some stakeholders pointed out the RCs and TOPs can request such information via requirements in other standards (IRO-010-1a and TOP-003-2), so these two functional entities were removed from this requirement.
- Based on comments from a majority of stakeholders, Requirement R5 (along with its associated Measure M5 and VSL's) was removed from the Standard. The standard drafting team believes that Requirement R4 achieves the reliability objective of Paragraph 1787 of FERC Order No. 693 that Requirement R5 was written to address.

MOD-025-2, MOD-027-1 and PRC-019-1 were posted for a 30-day formal public comment period from September 28, 2012 to October 31, 2012 with a successive ballot and non-binding poll from October 19, 2012 to October 31, 2012.

For MOD-025-2, there were 48 sets of comments, including comments from approximately 155 different people from approximately 100 companies representing 8 of the 10 industry segments. MOD-025-2 received a quorum of 83.61% and an approval rating of 68.31%.

For-MOD-027-1, there were 46 sets of comments, including comments from approximately 152 different people from approximately 98 companies representing 9 of the 10 industry segments. MOD-027-1 received a quorum of 82.34% and an approval rating of 71.53%.

For PRC-019-1 there were 47 sets of comments, including comments from approximately 153 different people from approximately 99 companies representing 9 of the 10 industry segments. PRC-019-1 received a quorum of 82.07% and an approval rating of 70.64%.

E. Fourth Posting

MOD-026-1 and PRC-024-1 were posted for a formal comment period from September 28, 2012 to October 31, 2012 with a successive ballot and non-binding poll from October 19, 2012 to October 31, 2012.

MOD-026-1 received a quorum of 75.55% and an approval of 76.50%. PRC-024-1 received a quorum of 75% and an approval rating of 57.24%.

MOD-025-2, MOD-027-1 and PRC-019-1 were posted for a recirculation ballot from December 12, 2012 to December 21, 2012. MOD-025-2 received a quorum of 86.89% and an approval rating of 73.06%. MOD-027-1 received a quorum of 86.68% and an approval rating of 74.27%. PRC-019-1 received a quorum of 85.87% and an approval rating of 73.63%.

F. Fifth Posting

PRC-024-1 was posted for a formal comment period from December 12, 2012 to January 11, 2013 with a successive ballot and non-binding poll from January 2, 2013 to January 11, 2013. PRC-024-1 received a quorum of 78.16% and an approval rating of 60.31%.

The standard drafting team considered stakeholder comments and made the following changes to PRC-024-1 based on those comments:

- Revised the title of the standard to "Generator Frequency and Voltage Protective Relay Settings" and the Purpose Statement to "Ensure Generator Owners set their generator protective relays such that generating units remain connected during defined frequency and voltage excursions."
- Revised "generating unit(s)" to "applicable generating unit(s)" to reflect that the standard only applies to units that meet the registry criteria.
- Removed Requirement R4 from the standards because of ambiguous language and dubious limited reliability benefit.
- Revised Requirement R5 (now R4) to indicate that the trip settings to be provided are only those "associated with Requirements R1 and R2" and not all relays.
- Revised Requirement R2 so that the sentences were shorter and easier to read, and made conforming language changes in Requirement R1.

MOD-026-1 was posted for a recirculation ballot from December 12, 2012 to December 21, 2012. MOD-026-1 received a quorum of 79% and an approval rating of 79.36%.

G. Sixth Posting

PRC-024-1 was posted for a 30-day public comment period from January 25, 2013 to February 25, 2013, with a successive ballot and non-binding poll from February 15, 2013 to February 28, 2013. PRC-02401 received a quorum of 78.80% and an approval rating of 89.01%.

There were 29 sets of comments, including comments from approximately 90 different people from approximately 63 companies representing 7 of the 10 industry segments

The standard drafting team considered stakeholder comments and made the following changes to PRC-024-1 based on those comments:

- Added page numbers to first section of the standard.

- Added the word “generator” before “frequency protective relaying” (second line) in Requirement R1 and before “voltage protective relaying” (second line) in Requirement R2 so that the language mirrored the first line of each requirement.
- Added the phrase “for asynchronous generating units” to the first bullet of Requirement R1 to match the language in the analogous bullet 3 in Requirement R2.
- Added the phrase “the applicable generating unit(s)” to the third line of Requirement R2 to match the language in Requirement R1.
- Added the phrase “with generator frequency or voltage protective relays” to the second line of Requirement R3 to clarify the language.

H. Board of Trustees Approval

MOD-025-2, MOD-026-1, MOD-027-1 and PRC-019-1 were approved by the NERC Board of Trustees on February 7, 2013. PRC-024-1 was approved by the NERC Board of Trustees on May 9, 2013.