

## **A. Introduction**

- 1. Title:** Verification of Models and Data for Turbine/Governor and Load Control or Active Power/Frequency Control Functions
- 2. Number:** MOD-027-2
- 3. Purpose:** To verify that the turbine/governor and load control or active power/frequency control<sup>1</sup> model and the model parameters, used in dynamic simulations that assess Bulk Electric System (BES) reliability, accurately represent generator unit real power response to system frequency variations.
- 4. Applicability:**
  - 4.1. Functional entities**
    - 4.1.1** Generator Owner
    - 4.1.2** Transmission Planner
  - 4.2. Facilities**

For the purpose of the requirements contained herein, Facilities that are directly connected to the Bulk Electric System (BES) will be collectively referred to as an “applicable unit” that meet the following:

- 4.2.1** Generation in the Eastern or Quebec Interconnections with the following characteristics:
  - 4.2.1.1** Individual generating unit greater than 100 MVA (gross nameplate rating).
  - 4.2.1.2** Individual generating plant consisting of multiple generating units that are directly connected at a common BES bus with total generation greater than 100 MVA (gross aggregate nameplate rating).
- 4.2.2** Generation in the Western Interconnection with the following characteristics:
  - 4.2.2.1** Individual generating unit greater than 75 MVA (gross nameplate rating).
  - 4.2.2.2** Individual generating plant consisting of multiple generating units that are directly connected at a common BES bus with total generation greater than 75 MVA (gross aggregate nameplate rating).
- 4.2.3** Generation in the ERCOT Interconnection with the following characteristics:

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<sup>1</sup> Turbine/governor and load control or active power/frequency control:

- a. Turbine/governor and load control applies to conventional synchronous generation.
- b. Active power/frequency control applies to inverter connected generators (often found at variable energy plants).

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**4.2.3.1** Individual generating unit greater than 50 MVA (gross nameplate rating).

**4.2.3.2** Individual generating plant consisting of multiple generating units that are directly connected at a common BES bus with total generation greater than 75 MVA (gross aggregate nameplate rating).

### **5. Effective Date:**

- 5.1.** For Requirements R1, and R3 through R5, the first day of the first calendar quarter beyond the date that this standard is approved by applicable regulatory authorities or as otherwise made effective pursuant to the laws applicable to such ERO governmental authorities. In those jurisdictions where regulatory approval is not required, the standard shall become effective on the first day of the first calendar quarter beyond the date this standard is approved by the NERC Board of Trustees, or as otherwise made effective pursuant to the laws applicable to such ERO governmental authorities.
- 5.2.** For Requirement R2, 30 percent of the entity's applicable unit gross MVA for each Interconnection on the first day of the first calendar quarter that is four years following applicable regulatory approval or as otherwise made effective pursuant to the laws applicable to such ERO governmental authorities, or in those jurisdictions where no regulatory approval is required, on the first day of the first calendar quarter that is four years following NERC Board of Trustees adoption or as otherwise made effective pursuant to the laws applicable to such ERO governmental authorities.
- 5.3.** For Requirement R2, 50 percent of the entity's applicable unit gross MVA for each Interconnection on first day of the first calendar quarter that is six years following applicable regulatory approval or as otherwise made effective pursuant to the laws applicable to such ERO governmental authorities, or in those jurisdictions where no regulatory approval is required, on the first day of the first calendar quarter that is six years following NERC Board of Trustees adoption or as otherwise made effective pursuant to the laws applicable to such ERO governmental authorities.
- 5.4.** For Requirement R2, 100 percent of the entity's applicable unit gross MVA for each Interconnection on the first day of the first calendar quarter that is 10 years following applicable regulatory approval or as otherwise made effective pursuant to the laws applicable to such ERO governmental authorities, or in those jurisdictions where no regulatory approval is required, on the first day of the first calendar quarter that is 10 years following NERC Board of Trustees adoption or as otherwise made effective pursuant to the laws applicable to such ERO governmental authorities.

## **B. Requirements**

- 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.
- 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 on-line, or
  - A partial load rejection test,<sup>2</sup>
- 2.1.2.** Type of governor and load control or active power control/frequency control<sup>3</sup> equipment,

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<sup>2</sup> 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.

<sup>3</sup> Turbine/governor and load control or active power/frequency control:

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- 2.1.3. A description of the turbine (e.g. for hydro turbine - Kaplan, Francis, or Pelton; for steam turbine - boiler type, normal fuel type, and turbine type; for gas turbine - the type and manufacturer; for variable energy plant - type and manufacturer),
  - 2.1.4. Model structure and data for turbine/governor and load control or active power/frequency control, and
  - 2.1.5. Representation of the real power response effects of outer loop controls (such as operator set point controls, and load control but excluding AGC control) that would override the governor response (including blocked or nonfunctioning governors or modes of operation that limit Frequency Response), if applicable.
- 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<sup>4</sup> (in accordance with Requirement R2). [*Violation Risk Factor: Lower*] [*Time Horizon: Operations Planning*]

- R4.** Each Generator Owner shall provide revised model data or plans to perform model verification<sup>5</sup> (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<sup>6</sup>. [*Violation Risk Factor: Lower*] [*Time Horizon: Operations Planning*]

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- a. Turbine/governor and load control applies to conventional synchronous generation.
  - b. Active power/frequency control applies to inverter connected generators (often found at variable energy plants).

<sup>4</sup> If verification is performed, the 10 year period as outlined in MOD-027 Attachment 1 is reset.

<sup>5</sup> Ibid.

<sup>6</sup> 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).

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- 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.
- 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*]

### C. Measures

- M1.** The Transmission Planner must have and provide the dated request for instructions or data, the transmitted instruction or data, and dated evidence of a written transmittal (e.g., electronic mail message, postal receipt, or confirmation of facsimile) as evidence that it provided the request within 90 calendar days in accordance with Requirement R1.
- M2.** The Generator Owner must have and provide dated evidence it verified each generator turbine/governor and load control or active power/frequency control model according to Part 2.1 for each applicable unit and a dated transmittal (e.g., electronic mail message, postal receipt, or confirmation of facsimile) as evidence it provided the model, documentation, and data to its Transmission Planner, in accordance with Requirement R2.
- M3.** Evidence for Requirement R3 must include the Generator Owner's dated written response containing the information identified in Requirement R3 and dated evidence of transmittal (e.g., electronic mail message, postal receipt, or confirmation of facsimile) of the response.
- M4.** Evidence for Requirement R4 must include, for each of the Generator Owner's applicable units for which system changes specified in Requirement R4 were made, dated revised model data or dated plans to perform a model verification and dated evidence of transmittal (e.g., electronic mail message, postal receipt, or confirmation of facsimile) within 180 calendar days of making changes.
- M5.** Evidence of Requirement R5 must include, for each model received, the dated response indicating the model was usable or not usable according to the criteria specified in Parts 5.1 through 5.3 and for a model that is not useable, a technical description is the model is not usable, and dated evidence of transmittal (e.g., electronic mail messages, postal receipts, or confirmation of facsimile) that the Generator Owner was notified within 90 calendar days of receipt of model information in accordance with Requirement R5.

## **D. Compliance**

### **1. Compliance Monitoring Process**

#### **1.1. Compliance Enforcement Authority**

The Regional Entity shall serve as the Compliance Enforcement Authority unless the applicable entity is owned, operated, or controlled by the Regional Entity. In such cases the ERO or a Regional entity approved by FERC or other applicable governmental authority shall serve as the CEA.

#### **1.2. Data Retention**

The following evidence retention periods identify the period of time an entity is required to retain specific evidence to demonstrate compliance. For instances where the evidence retention period specified below is shorter than the time since the last audit, the Compliance Enforcement Authority may ask an entity to provide other evidence to show that it was compliant for the full time period since the last audit.

The Generator Owner and Transmission Planner shall each keep data or evidence to show compliance as identified below unless directed by its Compliance Enforcement Authority to retain specific evidence for a longer period of time as part of an investigation:

- The Transmission Planner shall retain the information/data request and provided response evidence of Requirements R1 and R5, Measures M1 and M5 for 3 calendar years from the date the document was provided.
- The Generator Owner shall retain the latest turbine/governor and load control or active power/frequency control system model verification evidence of Requirement R2, Measure M2.
- The Generator Owner shall retain the information/data request and provided response evidence of Requirements R3, and R4 Measures M3 and M4 for 3 calendar years from the date the document was provided.

If a Generator Owner or Transmission Planner is found non-compliant, it shall keep information related to the non-compliance until mitigation is complete and approved or for the time specified above, whichever is longer.

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

#### **1.3. Compliance Monitoring and Assessment Processes**

Compliance Audit

Self-Certification

Spot Checking

Compliance Investigation

Self-Reporting

Complaint

**1.4. Additional Compliance Information**

None

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**2. Violation Severity Levels**

| R #       | Lower VSL  | Moderate VSL   | High VSL   | Severe VSL  |
|-----------|--|--|--|---|
| <b>R1</b> | The Transmission Planner provided the instructions and data to the Generator Owner more than 90 calendar days but less than or equal to 120 calendar days of receiving a written request.  | The Transmission Planner provided the instructions and data to the Generator Owner more than 120 calendar days but less than or equal to 150 calendar days of receiving a written request.   | The Transmission Planner provided the instructions and data to the Generator Owner more than 150 calendar days but less than or equal to 180 calendar days of receiving a written request.   | The Transmission Planner failed to provide the instructions and data to the Generator Owner within 180 calendar days of receiving a written request.  |
| <b>R2</b> | <p>The Generator Owner provided its verified model(s) to its Transmission Planner after the periodicity timeframe specified in MOD-027 Attachment 1 but less than or equal to 90 calendar days late;</p> <p>OR</p> <p>The Generator Owner provided the Transmission Planner a verified model that omitted one of the five Parts identified in Requirement R2, Subparts 2.1.1, through 2.1.5.</p> | <p>The Generator Owner provided its verified model(s) to its Transmission Planner more than 90 calendar days but less than or equal to 180 calendar days late as specified by the periodicity timeframe in MOD-027 Attachment 1;</p> <p>OR</p> <p>The Generator Owner provided the Transmission Planner a verified model that omitted two of the five Parts identified in Requirement R2, Subparts 2.1.1, through 2.1.5.</p> | <p>The Generator Owner provided its verified model(s) to its Transmission Planner more than 180 calendar days but less than or equal to 270 calendar days late as specified by the periodicity timeframe in MOD-027 Attachment 1;</p> <p>OR</p> <p>The Generator Owner provided the Transmission Planner verified models that omitted three of the five Parts identified in Requirement R2, Subparts 2.1.1, through 2.1.5.</p> | <p>The Generator Owner provided its verified model(s) more than 270 calendar days late to its Transmission Planner in accordance with the periodicity specified in MOD-027 Attachment 1;</p> <p>OR</p> <p>The Generator Owner failed to use model(s) acceptable to the Transmission Planner as specified in Requirement R2, Part 2.1;</p> <p>OR</p> <p>The Generator Owner provided the Transmission Planner verified model(s) that omitted four or more of the five Parts identified in Requirement R2, Subparts 2.1.1, through 2.1.5.</p> |



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| R #       | Lower VSL  | Moderate VSL   | High VSL   | Severe VSL   |
|-----------|--|--|--|--|
| <b>R3</b> | The Generator Owner provided a written response more than 90 calendar days but less than or equal to 120 calendar days of receiving written notice.  | The Generator Owner provided a written response more than 120 calendar days but less than or equal to 150 calendar days of receiving written notice.   | The Generator Owner provided a written response more than 150 calendar days but less than or equal to 180 calendar days of receiving written notice.   | The Generator Owner failed to provide a written response within 180 calendar days of receiving written notice;<br><br>OR<br><br>The Generator Owner's written response failed to contain either the technical basis for maintaining the current model, or a list of future model changes, or a plan to perform another model verification. |
| <b>R4</b> | The Generator Owner provided revised model data or plans to perform model verification more than 180 calendar days but less than or equal to 210 calendar days of making changes to the turbine/governor and load control or active power/frequency control system that alter the equipment response characteristic. | The Generator Owner provided revised model data or plans to perform model verification more than 210 calendar days but less than or equal to 240 calendar days of making changes to the turbine/governor and load control or active power/frequency control system that alter the equipment response characteristic. | The Generator Owner provided revised model data or plans to perform model verification more than 240 calendar days but less than or equal to 270 calendar days of making changes to the turbine/governor and load control or active power/frequency control system that alter the equipment response characteristic. | The Generator Owner failed to provide revised model data or failed to provide plans to perform model verification within 270 calendar days of making changes to the turbine/governor and load control or active power/frequency control system that altered the equipment response characteristic.   |

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| R #       | Lower VSL  | Moderate VSL   | High VSL  | Severe VSL  |
|-----------|--|--|---|---|
| <b>R5</b> | <p>The Transmission Planner provided a written response to the Generator Owner indicating whether the model is usable or not usable, including a technical description if the model is not usable, more than 90 calendar days but less than or equal to 120 calendar days of receiving verified model information;</p> <p>OR</p> <p>The Transmission Planner provided a written response to the Generator Owner within 90 calendar days indicating that the model is not usable; but did not include a technical description</p> | <p>The Transmission Planner provided a written response to the Generator Owner indicating whether the model is usable or not usable, including a technical description if the model is not usable, more than 120 calendar days but less than or equal to 150 calendar days of receiving the verified model information;</p> <p>OR</p> <p>The Transmission Planner’s written response omitted confirmation for one of the specified model criteria listed in Requirement R5, Parts 5.1 through 5.3;</p> <p>OR</p> <p>The Transmission Planner provided a written response to the Generator Owner indicating that the model is not usable, but did not include a technical description and provided the response more than 90 calendar days but less than or equal to 120 calendar days of receiving verified model information.</p> | <p>The Transmission Planner provided a written response to the Generator Owner indicating whether the model is usable or not usable, including a technical description if the model is not usable, more than 150 calendar days but less than or equal to 180 calendar days of receiving the verified model information;</p> <p>OR</p> <p>The Transmission Planner’s written response omitted confirmation for two of the specified model criteria listed in Requirement R5, Parts 5.1 through 5.3;</p> <p>OR</p> <p>The Transmission Planner provided a written response to the Generator Owner indicating that the model is not usable, but did not include a technical description and provided the response more than 120 calendar days but less than or equal to 150 calendar days of receiving verified model information.</p> | <p>The Transmission Planner failed to provide a written response to the Generator Owner within 180 calendar days of receiving the verified model information;</p> <p>OR</p> <p>The Transmission Planner provided a written response without including confirmation of all specified model criteria listed in Requirement R5, Parts 5.1 through 5.3;</p> <p>OR</p> <p>The Transmission Planner provided a written response to the Generator Owner indicating that the model is not usable, but did not include a technical description and provided the response more than 150 calendar days after receiving verified model information.</p> |

## **E. Regional Variances**

### **E.A. Regional Variance for the Western Electricity Coordinating Council**

**The Applicability Section 4.2.2 would be replaced in its entirety with the following:**

#### **4. Applicability**

##### **4.2 Facilities**

**4.2.2** Generation in the Western Interconnection meeting the Bulk Electric System definition.

**The Effective Date Section 5 would be replaced in its entirety with the following and apply only to the Regional Variance section of this document:**

#### **5. Effective Date**

**5.1** In those jurisdictions where regulatory approval is not required, all Requirements of this variance shall become effective on the first day of the first calendar quarter beyond the date this standard and its variance are approved by the NERC Board of Trustees, or as otherwise made effective pursuant to the laws applicable to such ERO governmental authorities.

##### **For all other jurisdictions:**

**5.2** The Effective Date for Requirements R1, R3, R4, and R5 is the first day of the first calendar quarter after the date that this standard and its variance are approved, by applicable regulatory authorities, or as otherwise made effective pursuant to the laws applicable to such ERO governmental authorities (Applicable Regulatory Approval).

##### **For Requirement R2 only:**

The Effective Date for Requirement R2 (Sections 5.2, 5.3 and 5.4 of the underlying standard) are replaced in their entirety as follows:

**5.3** For 30% of an entity's applicable-unit gross MVA, the Effective Date is the latter of either July 1, 2019, or Applicable Regulatory Approval.

**5.4** For 50% of an entity's applicable-unit gross MVA, the Effective Date is the latter of either July 1, 2020 or Applicable Regulatory Approval.

**5.5** For 75% of an entity's applicable-unit gross MVA, the Effective Date is the latter of either July 1, 2021 or Applicable Regulatory Approval.

**5.6** For 100% of an entity's applicable-unit gross MVA, the Effective Date is the latter of either July 1, 2022 or Applicable Regulatory Approval.

**E.B. Requirements**

**The following two Regional Variance requirements are added to Requirement R2. They are to be read as if inserted immediately after Requirement R2, Part 2.1.5, creating two new Parts to Requirement R2.**

**E.B.1.** Verification using measured system disturbance shall meet each of the following: *[Violation Risk Factor: Medium] [Time Horizon: Long-term Planning]*

- 1) Input measured frequency into the model and then compare measured real power output to the modeled power output;
- 2) Measured power output and measured frequency shall both be recorded at either the point of interconnection or the generator's terminals; and
- 3) Recorded signals shall have a minimum sampling rate of 10 times per second.

**E.B.2.** Verification using staged tests shall include each of the following: *[Violation Risk Factor: Medium] [Time Horizon: Long-term Planning]*

- 1) Recorded signals shall have a minimum sampling rate of 10 times per second.

**E.B.3.** Not Used

**The following Regional Variance replaces Requirement R3, Footnote 4 in its entirety.**

Footnote 4: If verification is performed, the five-year period as outlined in MOD-027 Attachment 1 is reset.

**The following Regional Variance requirement replaces Requirement R4 in its entirety.**

**E.B.4.** Each Generator Owner shall provide revised model and validation data, or its plans to perform verification<sup>7</sup> for an applicable unit (in accordance with Requirement R2) to its Transmission Planner, to include each of the following numbered items describing modifications to its turbines, governors, power and frequency control systems, if any, each time such a modification changes the equipment response characteristics, within 180 days of making a change, except when the change is 180 days or less in duration.<sup>8</sup> *[Violation Risk Factor: Lower] [Time Horizon: Operations Planning]*

- 1) Response characteristics from DC to 1 Hz that includes effects of load and plant control loops, if any;

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<sup>7</sup> If verification is performed, the five-year period as outlined in MOD-027 Attachment 1 is reset.

<sup>8</sup> 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.).

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- 2) Steady state droop;
- 3) For hydro units, report the steady state power vs. gate position (and blade angle, if applicable) characteristics.

### E.C. Measures

The Measure for Regional Variance E.B.1 and E.B.2 is the same as Measure M2 for MOD-027, Requirement R2.

E.B.3 was not used.

The Measure for Regional Variance E.B.4 is the same as Measure M4 for MOD-027, Requirement R4, with the following addition:

For auditing purposes, the intent of the exception noted in the Measure for E.B.4 is to exclude short-term changes less than 180 days, such as occur in testing and tuning. The automatic changes in settings that occur due to changes in operating mode do not apply to Regional Variance E.B.4. The 180-day count starts when the generator is returned to commercial service.

### F. Associated Documents

None.

### Version History

| Version | Date              | Action  | Change Tracking |
|---------|-------------------|---|-----------------|
| 1       | February 7, 2013  | Adopted by NERC Board of Trustees   | New             |
| 1       | March 20, 2014    | FERC Order issued approving MOD-027-1. (Order becomes effective for R1, R3, R4, and R5 on 7/1/14. R2 becomes effective 7/1/18.) |                 |
| 1       | May 7, 2014       | NERC Board of Trustees adopted revisions to VSLs in Requirement R5.   | Revisions       |
| 1       | November 26, 2014 | FERC issued a letter order approved revisions to VSLs in Requirement R5.  |                 |

### G. References

The following documents contain technical information beyond the scope of this Standard on turbine/governor and load control or active power/frequency control system functionality, modeling, and testing.

- 1) 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

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- 2) L. Pereira "New Thermal Governor Model Development: Its Impact on Operation and Planning Studies on the Western Interconnection" IEEE POWER AND ENERGY MAGAZINE, MAY/JUNE 2005
- 3) D.M. Cabbell, S. Rueckert, B.A. Tuck, and M.C. Willis, "The New Thermal Governor Model Used in Operating and Planning Studies in WECC," in Proc. IEEE PES General Meeting, Denver, CO, 2004
- 4) S. Patterson, "Importance of Hydro Generation Response Resulting from the New Thermal Modeling-and Required Hydro Modeling Improvements," in Proc. IEEE PES General Meeting, Denver, CO, 2004
- 5) L. Pereira, D. Kosterev, D. Davies, and S. Patterson, "New Thermal Governor Model Selection and Validation in the WECC," IEEE Trans. Power Syst., vol. 19, no. 1, pp. 517-523, February 2004
- 6) L. Pereira, J. Undrill, D. Kosterev, D. Davies, and S. Patterson, "A New Thermal Governor Modeling Approach in the WECC," IEEE Trans. Power Syst., vol. 18, no. 2, pp. 819-829, May 2003
- 7) P. Pourbeik, C. Pink and R. Bisbee, "Power Plant Model Validation for Achieving Reliability Standard Requirements Based on Recorded On-Line Disturbance Data", Proceedings of the IEEE PSCE, March, 2011

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| <b>MOD-027 Attachment 1</b>  |   |  |
|--|---|--|
| <b>Turbine/Governor and Load Control or Active Power/Frequency Control Model Periodicity</b> |   |  |
| <b>Row Number</b>  | <b>Verification Condition</b>   | <b>Required Action</b>   |
| 1  | Establishing the initial verification date for an applicable unit.<br>(Requirement R2)  | Transmit the verified model, documentation and data to the Transmission Planner on or before the Effective Date.<br><br>Row 5 applies when calculating generation fleet compliance during the 10year implementation period.<br><br>See Section A5 for Effective Dates.   |
| 2  | Subsequent verification for an applicable unit.<br>(Requirement R2)   | Transmit the verified model, documentation and data to the Transmission Planner on or before the 10-year anniversary of the last transmittal (per Note 2).   |
| 3  | Applicable unit is not subjected to a frequency excursion per Note 1 by the date otherwise required to meet the dates per Rows 1, 2, 4, or 6.<br><br>(This row is only applicable if a frequency excursion from a system disturbance that meets Note 1 is selected for the verification method and the ability to record the applicable unit’s real power response to a frequency excursion is installed and expected to be available).<br><br>(Requirement R2) | Requirement 2 is met with a written statement to that effect transmitted to the Transmission Planner. Transmit the verified model, documentation and data to the Transmission Planner on or before 365 calendar days after a frequency excursion per Note 1 occurs and the recording equipment captures the applicable unit’s real power response as expected. |
| 4  | Initial verification for a new applicable unit or for an existing applicable unit with new turbine/governor and load control or active power/frequency control equipment installed.<br><br>(Requirement R2)   | Transmit the verified model, documentation and data to the Transmission Planner within 365 calendar days after the commissioning date.   |

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| <b>MOD-027 Attachment 1</b>  |   |  |
|--|---|--|
| <b>Turbine/Governor and Load Control or Active Power/Frequency Control Model Periodicity</b> |   |  |
| <b>Row Number</b>  | <b>Verification Condition</b>   | <b>Required Action</b>   |
| 5  | <p>Existing applicable unit that is equivalent to another applicable unit(s) at the same physical location;</p> <p>AND</p> <p>Each applicable unit has the same MVA nameplate rating;</p> <p>AND</p> <p>The nameplate rating is <math>\leq 350</math> MVA;</p> <p>AND</p> <p>Each applicable unit has the same components and settings;</p> <p>AND</p> <p>The model for one of these equivalent applicable units has been verified.</p> <p>(Requirement R2)</p> | <p>Document circumstance with a written statement and include with the verified model, documentation and data provided to the Transmission Planner for the verified equivalent unit.</p> <p>Verify a different equivalent unit during each 10-year verification period.</p> <p>Applies to Row 1 when calculating generation fleet compliance during the 10-year implementation period.</p> |
| 6  | <p>The Generator Owner has submitted a verification plan.</p> <p>(Requirement R3 or R4)</p>   | <p>Transmit the verified model, documentation and data to the Transmission Planner within 365 calendar days after the submittal of the verification plan.</p>  |



**Standard MOD-027-2 — Verification of Models and Data for Turbine/Governor and Load Control or Active Power/Frequency Control Functions**

| <b>MOD-027 Attachment 1</b>  |  |  |
|--|--|--|
| <b>Turbine/Governor and Load Control or Active Power/Frequency Control Model Periodicity</b> |  |  |
| <b>Row Number</b>  | <b>Verification Condition</b>  | <b>Required Action</b>   |
| 7  | <p>Applicable unit is not responsive to both over and under frequency excursion events (The applicable unit does not operate in a frequency control mode, except during normal start up and shut down, that would result in a turbine/governor and load control or active power/frequency control mode response.);</p> <p>OR</p> <p>Applicable unit either does not have an installed frequency control system or has a disabled frequency control system.</p> <p>(Requirement R2)</p> | <p>Requirement 2 is met with a written statement to that effect transmitted to the Transmission Planner.</p> <p>Perform verification per the periodicity specified in Row 4 for a “New Generating Unit” (or new equipment) only if responsive control mode operation for connected operations is established.</p>  |
| 8  | <p>Existing applicable unit has a current average net capacity factor over the most recent three calendar years, beginning on January 1 and ending on December 31 of 5% or less.</p> <p>(Requirement R2)</p>   | <p>Requirement 2 is met with a written statement to that effect transmitted to the Transmission Planner.</p> <p>At the end of this 10 calendar year timeframe, the current average three year net capacity factor (for years 8, 9, and 10) can be examined to determine if the capacity factor exemption can be declared for the next 10 calendar year period. If not eligible for the capacity factor exemption, then model verification must be completed within 365 calendar days of the date the capacity factor exemption expired.</p> <p>For the definition of net capacity factor, refer to Appendix F of the GADS Data Reporting Instructions on the NERC website.</p> |

| <b>MOD-027 Attachment 1</b>  |                               |                        |
|--|-------------------------------|------------------------|
| <b>Turbine/Governor and Load Control or Active Power/Frequency Control Model Periodicity</b>   |                               |                        |
| <b>Row Number</b>  | <b>Verification Condition</b> | <b>Required Action</b> |
| <p><b>NOTES:</b></p> <p><b>NOTE 1:</b> Unit model verification frequency excursion criteria:</p> <ul style="list-style-type: none"> <li>• <math>\geq 0.05</math> hertz deviation (nadir point) from scheduled frequency for the Eastern Interconnection with the applicable unit operating in a frequency responsive mode</li> <li>• <math>\geq 0.10</math> hertz deviation (nadir point) from scheduled frequency for the ERCOT and Western Interconnections with the applicable unit operating in a frequency responsive mode</li> <li>• <math>\geq 0.15</math> hertz deviation (nadir point) from scheduled frequency for the Quebec Interconnection with the applicable unit operating in a frequency responsive mode</li> </ul> <p><b>NOTE 2:</b> Establishing the recurring ten year unit verification period start date:</p> <ul style="list-style-type: none"> <li>• The start date is the actual date of submittal of a verified model to the Transmission Planner for the most recently performed unit verification.</li> </ul> <p><b>NOTE 3:</b> Consideration for early compliance:</p> <p>Existing turbine/governor and load control or active power/frequency control model verification is sufficient for demonstrating compliance for a 10 year period from the actual transmittal date if either of the following applies:</p> <ul style="list-style-type: none"> <li>• The Generator Owner has a verified model that is compliant with the applicable regional policies, guidelines or criteria existing at the time of model verification</li> <li>• The Generator Owner has an existing verified model that is compliant with the requirements of this standard</li> </ul> |                               |                        |

**Standard MOD-027-2 — Verification of Models and Data for Turbine/Governor and Load Control or Active Power/Frequency Control Functions**

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**Violation Severity Levels for WECC Regional Variance**

| E #           | Violation Severity Levels   |  |  |   |
|---------------|---|--|--|---|
|               | Lower VSL   | Moderate VSL   | High VSL   | Severe VSL  |
| <b>E.B.1.</b> | Same as MOD-027 R2.1.1.   | Same as MOD-027 R2.1.1.  | Same as MOD-027 R2.1.1.  | Same as MOD-027 R2.1.1.   |
| <b>E.B.2.</b> | Same as MOD-027 R2.1.1.   | Same as MOD-027 R2.1.1.  | Same as MOD-027 R2.1.1.  | Same as MOD-027 R2.1.1.   |
| <b>E.B.3.</b> | Not Used  | Not Used   | Not Used   | Not Used  |
| <b>E.B.4</b>  | The Generator Owner did not provide to the Transmission Planner all of the data required in E.B.4, on any one occasion. | The Generator Owner did not provide to the Transmission Planner all of the data required in E.B.4, on any two occasions. | The Generator Owner did not provide to the Transmission Planner all of the data required in E.B.4, on any three occasions. | The Generator Owner did not provide to the Transmission Planner all of the data required in E.B.4, on four or more occasions. |

**Standard MOD-027-2 — Verification of Models and Data for Turbine/Governor and Load Control or Active Power/Frequency Control Functions**

The following table replaces the MOD-027 Attachment 1, Turbine/Governor and Load Control or Active Power/Frequency Control Model Periodicity table in its entirety, and is only applicable to the Western Interconnection.

| Row Number | MOD-027 Attachment 1<br>This Table is Applicable Only to the Western Interconnection.<br>Turbine/Governor and Load Control or Active Power/Frequency Control Model Periodicity  |   |
|------------|---|---|
|            | Verification Condition  | Required Action   |
| 1          | Establishing the initial verification date for an applicable unit.<br><br>(Requirement R2)  | Transmit the verified model, documentation and data to the Transmission Planner on or before the Effective Date.<br><br>Row 5 applies when calculating generation fleet compliance during the five-year implementation period.<br><br>See Section E.A.5 of this variance for Effective Dates.   |
| 2          | Subsequent verification for an applicable unit.<br><br>(Requirement R2)   | Transmit the verified model, documentation and data to the Transmission Planner on or before the five-year anniversary of the last transmittal, per Note 2 at the end of this table.  |
| 3          | Applicable unit is not subjected to a frequency excursion per Note 1 at the end of this table, by the date otherwise required to meet the dates per Rows 1, 2, 4, or 6.<br><br>(This row is only applicable if a frequency excursion from a system disturbance that meets Note 1 at the end of this table is selected for the verification method and the ability to record the applicable unit's real power response to a frequency excursion is installed and expected to be available).<br><br>Requirement R2) | Requirement 2 is met with a written statement to that effect transmitted to the Transmission Planner. Transmit the verified model, documentation and data to the Transmission Planner on or before 365 calendar days after a frequency excursion per Note 1 at the end of this table occurs and the recording equipment captures the applicable unit's real power response as expected. |
| 4          | Initial verification for a new applicable unit or for an existing applicable unit with new turbine/governor and load control or active power/frequency control equipment installed.<br><br>(Requirement R2)   | Transmit the verified model, documentation and data to the Transmission Planner within 365 calendar days after the commissioning date.  |

**Standard MOD-027-2 — Verification of Models and Data for Turbine/Governor and Load Control or Active Power/Frequency Control Functions**

| Row Number | MOD-027 Attachment 1<br>This Table is Applicable Only to the Western Interconnection.<br>Turbine/Governor and Load Control or Active Power/Frequency Control Model Periodicity   |  |
|------------|--|--|
|            | Verification Condition   | Required Action  |
| 5          | <p>Existing applicable unit that is equivalent to another unit(s) at the same physical location;</p> <p>AND</p> <p>Each applicable unit has the same MVA nameplate rating;</p> <p>AND</p> <p>The nameplate rating is <math>\leq 350</math> MVA;</p> <p>AND</p> <p>Each applicable unit has the same components and settings;</p> <p>AND</p> <p>The model for one of these equivalent applicable units has been verified.</p> <p>(Requirement R2)</p>                                   | <p>Document circumstance with a written statement and include with the verified model, documentation and data provided to the Transmission Planner for the verified equivalent unit.</p> <p>Verify a different equivalent unit during each five-year verification period.</p> <p>Applies to Row 1 when calculating generation fleet compliance during the five-year implementation period.</p> |
| 6          | <p>The Generator Owner has submitted a verification plan.</p> <p>(Requirement R3 or R4)</p>  | <p>Transmit the verified model, documentation and data to the Transmission Planner within 365 calendar days after the submittal of the verification plan.</p>  |
| 7          | <p>Applicable unit is not responsive to both over and under frequency excursion events (The applicable unit does not operate in a frequency control mode, except during normal start up and shut down, that would result in a turbine/governor and load control or active power/frequency control mode response.);</p> <p>OR</p> <p>Applicable unit either does not have an installed frequency control system or has a disabled frequency control system.</p> <p>(Requirement R2)</p> | <p>Requirement 2 is met with a written statement to that effect transmitted to the Transmission Planner.</p> <p>Perform verification per the periodicity specified in Row 4 for a “New Generating Unit” (or new equipment) only if responsive control mode operation for connected operations is established.</p>  |

**Standard MOD-027-2 — Verification of Models and Data for Turbine/Governor and Load Control or Active Power/Frequency Control Functions**

| Row Number   | MOD-027 Attachment 1<br>This Table is Applicable Only to the Western Interconnection.<br>Turbine/Governor and Load Control or Active Power/Frequency Control Model Periodicity                               |   |
|--|--|---|
|  | Verification Condition   | Required Action   |
| 8  | <p>Existing applicable unit has a current average net capacity factor over the most recent three calendar years, beginning on January 1 and ending on December 31 of 5% or less.</p> <p>(Requirement R2)</p> | <p>Requirement 2 is met with a written statement to that effect transmitted to the Transmission Planner.</p> <p>At the end of this five-year timeframe, the current average three-year net capacity factor (for years 3, 4, and 5) can be examined to determine if the capacity factor exemption can be declared for the next five-year period. If not eligible for the capacity factor exemption, then model verification must be completed within 365 calendar days of the date the capacity factor exemption expired.</p> <p>For the definition of net capacity factor, refer to Appendix F of the GADS Data Reporting Instructions on the NERC website.</p> |
| <p><b>NOTES:</b></p> <p><b>NOTE 1:</b> Unit model verification frequency excursion criteria:</p> <ul style="list-style-type: none"> <li>• <math>\geq 0.10</math> hertz deviation (nadir point) from scheduled frequency for the Western Interconnection with the applicable unit operating in a frequency responsive mode.</li> </ul> <p><b>NOTE 2:</b> Establishing the recurring five-year unit verification period start date:</p> <ul style="list-style-type: none"> <li>• The start date is the actual date of submittal of a verified model to the Transmission Planner for the most recently performed unit verification.</li> </ul> <p><b>NOTE 3:</b> Consideration for early compliance:</p> <p>Existing turbine/governor and load control or active power/frequency control verification is sufficient for demonstrating compliance for a five-year period from the actual transmittal date if either of the following applies:</p> <ul style="list-style-type: none"> <li>• The Generator Owner has a verified model that is compliant with the applicable regional policies, guidelines or criteria existing at the time of model verification.</li> <li>• The Generator Owner has an existing verified model that is compliant with the requirements of this standard.</li> </ul> |  |   |