MRO Generator Testing Guidelines

Approved by the MRO Board of Directors

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MIDWEST RELIABILITY ORGANIZATION
Roseville, MN

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1.0 Introduction

The Midwest Reliability Organization (MRO) is a voluntary association committed to safeguarding reliability of the bulk electric power system in the north central region of North America.

The essential purposes of the MRO are: (1) the development and implementation of regional and NERC reliability standards, and (2) determining compliance with those standards, including enforcement mechanisms. The MRO also provides other services consistent with its reliability charter.

The MRO Generator Testing Review Task Force (GTRTF) is an ad-hoc group formed by the MRO Reliability Assessment Committee (RAC) to prepare the MRO Generator Testing Guidelines Document to address NERC generator testing standards.

The purpose of this document is to establish MRO member guidelines to comply with the following NERC generator performance verification standards:

1) NERC Standard MOD-024-1 Verification of Generator Gross and Net Real Power Capability. This standard has been approved and Generator Owners must comply with the associated requirements in this document.

2) NERC Standard MOD-025-1 Verification of Generator Gross and Net Reactive Power Capability. This standard has been approved and Generator Owners must comply with the associated requirements in this document.

3) NERC Standard MOD-026-1 Verification of Models and Data for Generator Excitation System Functions. This standard is in draft form at NERC. The associated requirements in this document are meant to serve as a guideline for field testing the standard and to make Generator Owners aware of the general form of future requirements. Compliance is not required at this time.

4) NERC Standard MOD-027-1 Verification of Generator Unit Frequency Response. This standard is in draft form at NERC. The associated requirements in this document are meant to serve as a guideline for field testing the standard and to make Generator Owners aware of the general form of future requirements. Compliance is not required at this time.

5) NERC Standard PRC-019-1 Coordination of Generator Voltage Regulator Controls with Unit Capabilities and Protection. The associated requirements in this document are meant to serve as a guideline for field testing the standard and to make Generator Owners aware of the general form of future requirements. Compliance is not required at this time.

6) NERC Standard PRC-024-1 Generator Performance During Frequency and Voltage Excursions. The associated requirements in this document are meant to

serve as a guideline for field testing the standard and to make Generator Owners aware of the general form of future requirements. Compliance is not required at this time.

The above standards are geared towards establishing a set of common objectives for the development and submission of necessary data for electric system reliability assessment and apply to all generator owners within the MRO footprint. Accurate generator dynamics data is essential to provide reliable system analyses. Data needed to analyze and model the electric system and its component facilities must be developed, maintained, and made available for use in interconnected operating and planning studies.

Neither the MRO nor members of the working group mentioned above, nor any person acting on behalf of any of them makes any warranty, expressed or implied with respect to the use of any information, method or process, or instrument/device disclosed in this document, or assumes any liabilities with respect to the use of, or for damages resulting from the use of any information, method or process, or instrument/device disclosed in this document.

2.0 Verification of Real Power Capability

2.1 Controlling Document

NERC Standard MOD-024-1 Verification of Generator Gross and Net Real Power Capability

This is an active standard. Generator Owners must comply with the requirements in this section upon approval of this document by the MRO Board of Directors.

2.2 Applicability

Generator Owners of units 10 MVA and larger or aggregate to 10 MVA or more of nameplate capacity at the point of interconnection with the transmission system must, at minimum, follow the testing and reporting requirements set forth in this section.

2.3 Responsibilities

2.3.1 General Testing Requirements

2.3.1.1 Real power capability will be verified, at minimum, annually.

2.3.1.2 If the total capability of a plant or group of units is materially affected by the interaction of its parts, a test of the entire plant or group of units will be performed to

verify the capability and the results apportioned among the appropriate units.

2.3.1.3 The reported test results will be no greater than the net integrated MWh/hr output for the test period.

2.3.2 Requirements for Coal-fired and Nuclear Steam Turbines

2.3.2.1 The test period shall not be less than four continuous hours.

2.3.2.2 Generating unit net capability as affected by turbine exhaust pressure will be corrected for the past five years' average daily maximum circulating water temperature for the month of the test.

2.3.2.3 Steam conditions will correspond to the operating standard established by the Generator Owner.

2.3.2.4 The steam generator shall be operated with the regularly available type and quality of fuel.

2.3.3 Requirements for Simple-Cycle and Combined-Cycle Combustion Turbines, Gas or Oil-Fired Steam Turbines, and Diesel Units

2.3.3.1 The test period shall not be less than one hour.

2.3.3.2 Generating steam unit net capability as affected by turbine exhaust pressure will be corrected for the past five years' average daily maximum circulating water temperature for the month of the test.

2.3.3.3 Generating unit net capability as affected by ambient temperature will be corrected for the past five years' average monthly maximum temperature for the month of the test. Where evaporative coolers are used to reduce turbine inlet air temperature, the temperature at the cooler discharge shall be the basis for ambient temperature corrections.

2.3.3.4 Steam conditions will correspond to the operating standard established by the Generator Owner.

2.3.3.5 The unit shall be operated with the regularly available type and quality of fuel.

2.3.4 Requirements for Pumped Storage and Reservoir Hydro Units

2.3.4.1 The test period shall not be less than one hour.

2.3.4.2 Generating unit net capability as affected by water conditions shall be corrected to the five-year median conditions for the month of the test.

2.3.5 Requirements for Wind, Solar, and Run-of-River Hydro Units

The net real power capability of these units shall be calculated on the following basis:

2.3.5.1 For wind and solar units, the five-year median of the net integrated hourly capability for the month of the test.

2.3.5.2 For run-of-river hydro units, the average of the net integrated hourly capability for all hours of historical operation pertaining to the month of the test.

2.4 Reporting Requirements

2.4.1 The results shall be recorded on the Real Power Capability Test Data Form appropriate for the type of unit (see Appendix A).

2.4.2 The Generator Owner shall retain the information for the most current and one prior real power capability test for each applicable unit.

2.4.3 The information on maximum gross and net real power capability shall be forwarded to the Transmission Planner responsible for building the local power flow study model.

3.0 Verification of Reactive Power Capability

3.1 Controlling Document

NERC Standard MOD-025-1 Verification of Generator Gross and Net Reactive Power Capability

This is an active standard. Generator Owners must comply with the requirements in this section upon approval of this document by the MRO Board of Directors.

3.2 Applicability

3.2.1 Single Unit

The requirements set forth in this section apply to individual synchronous generators and synchronous condensers within the MRO footprint rated at or over 10 MVA.

3.2.2 Multiple Units

Sites where individual generators or synchronous condensers are smaller than 10 MVA but have a combined total greater than 10 MVA must be tested if the site is modeled for load flow or stability purposes. If there are a number of units of similar design (i.e. same model and rating), a representative number of units may be tested. No fewer than two units and at least ten percent of the units must be tested.

3.2.3 Dual Mode Operation

Synchronous machines that operate as generators at some times and as synchronous condensers at other times must perform a reactive capability test in each operating mode.

3.2.4 Waivers

The MRO recognizes that under some conditions, such as a relatively small generator located within a large load center, testing may not be necessary. The owner may submit a request, with adequate justification, to the MRO Reliability Assessment Committee to waive these testing requirements.

3.3 Responsibilities

3.3.1 Periodicity

Each generator owner shall test a minimum of twenty percent (20%) of the number of applicable generators and synchronous condensers each year. One hundred percent (100%) of all applicable units shall be tested within a five-year interval. The test shall be repeated on each applicable unit at least once every five years.

Testing of a unit shall be performed sooner than the normal five-year interval if it becomes apparent as a result of a change in equipment, operation or test that those reactive capabilities have permanently changed.

3.3.2 Test Requirements

3.3.2.1 The maximum gross and net reactive power capability, both lagging and leading, shall be verified with the unit operating at its seasonal real power generating capability. If safety or system conditions do not allow testing to full capability, computations and engineering reports of estimated capability shall be provided.

3.3.2.2 The limiting factor shall be determined and documented. Factors which may limit reactive capability include, but are not limited to capability curve, terminal voltage, temperature, humidity, and excitation limiter action.

3.3.2.3 The reactive power requirements of the unit auxiliary loads shall be determined for calculation of the unit net reactive capability. The reactive power requirements of auxiliary loads that are not unit specific, but are common to multiple units at a site, are to be apportioned to the applicable units.

3.3.2.4 The date and conditions during the tests shall be recorded.

3.3.3 Test Guidelines

3.3.3.1 The operating limits (capability curve, voltages, currents, temperatures, etc.) for the unit to be tested should be reviewed prior to performing the test.

3.3.3.2 All protective relaying should be in service and the voltage regulator operating in automatic voltage regulation (AVR) mode.

3.3.3.3 The testing should be conducted while maintaining the scheduled voltage on the system bus. Coordination with other units may be necessary to maintain the scheduled voltage.

3.3.3.4 Lagging (overexcited) reactive power tests should be conducted for a minimum of two hours, or longer until temperatures have stabilized. Leading (underexcited) tests should be conducted for a minimum of one hour, or longer until temperatures have stabilized.

3.4 Reporting Requirements

3.4.1 The results shall be recorded on the Reactive Power Capability Test Data Form (see Appendix B).

3.4.2 The Generator Owner shall retain the information for the most current and one prior reactive power capability test for each applicable unit.

3.4.3 The information on maximum gross and net lagging and leading reactive power capability shall be forwarded to the Transmission Planner responsible for building the local power flow study model.

3.4.4 The information reported must indicate whether the net reactive capability is determined at the generator terminals or at the system side of the Generator Step-Up (GSU) transformer.

4.0 Verification & Modeling of Generator Excitation Systems & Voltage Controls

4.1 Controlling Document

NERC Standard MOD-026-1 Verification of Models and Data for Generator Excitation System Functions

This is a draft standard in Field Testing status. The information in this section is for the purpose of conducting field tests. Generator Owners and Operators are not required to comply at this time.

4.2 Applicability

4.2.1 Single Units

The requirements set forth in this section apply to individual synchronous generators and synchronous condensers within the MRO footprint rated at or over 10 MVA.

4.2.2 Multiple Unit Sites

Sites where individual generators or synchronous condensers are smaller than 10 MVA but have a combined total greater than 10 MVA must be tested if the site is modeled for stability purposes. If there are a number of units of similar design (i.e. same model and rating), a representative number of units may be tested. No fewer than two units and at least ten percent of the units must be tested.

4.2.3 Waivers

The MRO recognizes that under some conditions, such as a relatively small generator located within a large load center, testing may not be necessary. The owner may submit a request to the MRO Reliability Assessment Committee to waive these testing requirements.

4.3 Responsibilities

4.3.1 Periodicity

Each generator owner shall perform the Baseline Test on applicable units on the following schedule during the first five years following implementation of this standard:

A minimum of 20% complete by the end of Year 1
A minimum of 40% complete by the end of Year 2
A minimum of 60% complete by the end of Year 3
A minimum of 80% complete by the end of Year 4
100 % complete by the end of Year 5.

A Validation Test shall be performed on each applicable unit at least once every five years following its previous Baseline or Validation Test.

A Baseline Test of a unit shall be performed within 30-days of return to service following a change in equipment that makes it likely that the excitation response has changed.

4.3.2 Baseline Test Requirements

4.3.2.1 Identification of the manufacturer and type of excitation system, voltage regulator, and power system stabilizer (if installed).

4.3.2.2 The model of the excitation system, voltage regulator, and power system stabilizer with associated gains, time constants, and limits.

4.3.2.3 Verification of the model for the excitation system and voltage regulator. This is to be accomplished by performing an open circuit step response test with the voltage regulator in automatic voltage control mode.

- The step in terminal voltage reference must be at least 2.0% of rated generator voltage.
- Recorded parameters must include at minimum generator terminal voltage and generator field voltage (exciter field voltage and current for brushless units).
- The data must be recorded at a sampling rate of 20 samples per second or faster for a minimum of ten seconds.
- The recorded data is to be compared to the modeled step response test. There should be close agreement in initial value, rise time, overshoot, and final value.

4.3.2.4 Verification of the set points for under excitation and over excitation limiters. This verification may be accomplished by either of the following methods:

4.3.2.4.1 Operating the generator in a manner that activates the limiter. Note that for digital voltage regulators, the limiter set point may be changed to a value closer to the normal operating range of the generator for the purpose of performing the verification test, and then reset to its normal value after the test is complete. This is not allowable for analog voltage regulators because it is not possible to verify that the set point has been restored accurately

4.3.2.4.2 Applying appropriate currents and voltages to the voltage regulator during shutdown testing to simulate generator operation at the limiting regions.

4.3.2.5 Verification of the reactive droop or line drop compensation settings in the voltage regulator.

4.3.2.6 Verification of the power system stabilizer (PSS) model. This verification may be accomplished by performing an on-line swept frequency response test with the voltage regulator in automatic voltage control mode and the PSS in service. Owners of units with PSS should also review MRO Standard MPRC-018-0 “Power System Stabilizer and Small Signal Assessment Requirement.” The test must meet the following requirements:

- The frequency must, at minimum, range from 0.2 to 2.0 Hz. A range of 0.1 to 10.0 Hz is normally recommended, subject to shaft resonant frequency concerns (see Test Guidelines).
- Recorded parameters must include the input signal and generator terminal voltage.
- The recorded data is to be compared to the modeled swept frequency response test. There should be close agreement in terminal voltage magnitude and phase lead/lag.

4.3.2.7 Confirmation that any testing was conducted with the voltage regulator in automatic voltage control mode.

4.3.2.8 The method of verification used.

4.3.2.9 The date each verification was performed.

4.3.3 Validation Test Requirements

4.3.3.1 Verification of the model for the excitation system, voltage regulator, and power system stabilizer. This may be accomplished by either of the following methods:

4.3.3.1.1 Recording the response of the unit to a system disturbance that meets the following criteria:

- The disturbance must cause a sudden change in system voltage of at least 2% of nominal bus voltage or a sudden change in reactive power of at least 10% of the rated generator MVA.
- The data must be recorded at a rate of 20 samples per second or faster.
- The recorded data and simulation should cover a minimum ten (10) seconds.
- Recorded parameters include generator real and reactive power, generator terminal voltage, and system voltage.
- The voltage regulator must be in automatic voltage control mode and the power system stabilizer (if installed) in service.
- The recorded data is to be compared to a modeled disturbance of the system voltage. There should be close agreement in generator real and reactive power, and generator terminal voltage.

4.3.3.1.2 Performing an open circuit step response test with the voltage regulator in automatic voltage control mode and an on-line swept frequency response test.

- For the open circuit step response test:
  - The step in terminal voltage reference must be at least 2.0% of rated generator terminal voltage.
  - Recorded parameters must include at minimum generator terminal voltage and generator field voltage (exciter field voltage and current for brushless units).
  - The data must be recorded at a sampling rate of 20 samples per second or faster for a minimum of ten seconds.

- The recorded data is to be compared to the modeled step response test. There should be close agreement in initial value, rise time, overshoot, and final value.

- For the swept frequency response test:
  - The frequency must, at minimum, range from 0.2 to 2.0 Hz. A range of 0.1 to 10.0 Hz is recommended.
  - Recorded parameters must include the input signal and generator terminal voltage.
  - The recorded data is to be compared to the modeled swept frequency response test. There should be close agreement in terminal voltage magnitude and phase lead/lag.

4.3.4 Test Guidelines

4.3.4.1 The operating limits (capability curve, voltages, currents, temperatures, etc.) for the unit to be tested should be reviewed prior to performing the test.

4.3.4.2 All protective relaying should be in service during any on-line testing or off-line testing with the unit at speed.

4.3.4.3 Any on-line testing should be conducted while maintaining the scheduled voltage on the system bus. Coordination with other units may be necessary to maintain the scheduled voltage.

4.3.4.4 The time sampling and data format for open circuit step response testing should be coordinated with the Transmission Planner that maintains the system stability model to facilitate comparison.

4.3.4.5 A review of unit shaft resonant torsional frequencies should be performed before performing the swept frequency test. Care should be taken to avoid approaching the first resonant frequency to avoid exciting the turbine-generator shaft.

4.4 Reporting Requirements

4.4.1 The results shall be recorded on the Excitation System and Voltage Control Baseline Test Data Form (see Appendix C1) or Excitation

System Voltage Control Validation Test Data Form (see Appendix C2).

4.4.2 The Generator Owner shall retain the information for the most current and one prior excitation test for each applicable unit.

4.4.3 The Excitation System and Voltage Control Test Baseline Data Form, or Validation Data Form and all required attachments shall be forwarded to the Transmission Planner responsible for maintaining the system stability model incorporating that generator.

5.0 Verification of Generator Unit Frequency Response

5.1 Controlling Document

NERC Standard MOD-027-1 Verification of Generator Unit Frequency Response

This is a draft standard in Field Testing status. The information in this section is for the purpose of conducting field tests. Generator Owners and Operators are not required to comply at this time.

5.2 Applicability

5.2.1 Single Units

The requirements set forth in this section apply to individual synchronous generators and synchronous condensers within the MRO footprint rated at or over 10 MVA.

5.2.2 Multiple Unit Sites

Sites where individual generators or synchronous condensers are smaller than 10 MVA but have a combined total greater than 10 MVA must be tested if the site is modeled for load flow or stability purposes. If there are a number of units of similar design (i.e. same model and rating), a representative number of units may be tested. No fewer than two units and at least ten percent of the units must be tested.

5.2.3 Waivers

The MRO recognizes that under some conditions, such as a relatively small generator located within a large load center, testing may not be necessary. The owner may submit a request, with adequate justification, to the MRO Reliability Assessment Committee to waive these testing requirements.

5.3 Responsibilities

5.3.1 Periodicity

Each generator owner shall perform a test on applicable units on the following schedule during the first five years following implementation of this standard:

A minimum of 20% complete by the end of Year 1
A minimum of 40% complete by the end of Year 2
A minimum of 60% complete by the end of Year 3
A minimum of 80% complete by the end of Year 4
100 % complete by the end of Year 5.

The test shall be repeated within five years of the previous test of a unit and shall be performed and reported within 30-days of return to service following a change in equipment that makes it likely that the frequency response has changed.

5.3.2 Test Requirements

5.3.2.1 The manufacturer and type of the speed governor controls.

5.3.2.2 The correct model of the speed governor including associated gains, time constants, limits, and deadband.

5.3.2.3 Verification of the frequency response of the model for the governor. This verification may be accomplished by one of the following methods:

5.3.2.3.1 Performing an On-line Speed Reference Step Response Test and comparing the results to a modeled test.

- The recorded data must be recorded at a rate of 20 samples per second or faster.
- The recorded data and simulation should cover a minimum of thirty (30) seconds.
- Recorded parameters include speed reference signal, frequency, and generator real power.

5.3.2.3.2 Performing a Partial Load Rejection Test and comparing the results to a modeled test.

- The recorded data must be recorded at a rate of 20 samples per second or faster.

- The recorded data and simulation should cover a minimum of thirty (30) seconds.
- Recorded parameters include generator real power and unit speed.

5.3.2.3.3 Recording the response of a unit to a sudden system frequency change that meets the following criteria:

- The disturbance must encompass a change of frequency of at least 0.05 Hz within a one second period.
- The recorded data must be recorded at a rate of 20 samples per second or faster.
- The recorded data and simulation should cover a minimum of thirty (30) seconds.
- Recorded parameters include system frequency and generator real power.

5.3.3 Test Guidelines

5.3.3.1 Partial load rejection tests should be conducted from no more than 20% of rated load.

5.4 Reporting Requirements

5.4.1 The results shall be recorded on the Generator Unit Frequency Response Test Data Form (see Appendix D).

5.4.2 The Generator Owner shall retain the information for the most current Baseline Test and Validation Test (if performed) for each applicable unit.

5.4.3 The Generator Unit Frequency Response Test Baseline Data Form or Validation Data Form and all required attachments shall be forwarded to the Transmission Planner responsible for maintaining the system stability model incorporating that generator.

6.0 Coordination of Generator Voltage Regulator Controls with Unit Capabilities and Protection

6.1 Controlling Document

NERC Standard PRC-019-1 Coordination of Generator Voltage Regulator Controls with Unit Capabilities and Protection

This is a draft standard in Field Testing status. The information in this section is for the purpose of conducting field tests. Generator Owners and Operators are not required to comply at this time.

6.2 Applicability

6.2.1 Single Units

The requirements set forth in this section apply to individual synchronous and non-synchronous generators, and synchronous condensers with voltage control within the MRO footprint rated at or over 10 MVA.

6.2.2 Multiple Unit Sites

Sites where individual generators or synchronous condensers are smaller than 10 MVA but have a combined total greater than 10 MVA must be analyzed and documented if the site is modeled for load flow or stability purposes.

6.2.3 Waivers

If the owner feels there is a valid reason to waive the requirements for verifying the coordination of generator voltage regulator controls with unit capabilities and protection for an otherwise-applicable unit, the owner may submit a request to the MRO Reliability Assessment Committee to waive these verification requirements.

6.3 Responsibilities

6.3.1 Periodicity

Each generator owner shall perform the coordination analysis on applicable units on the following schedule during the first five years following implementation of this standard:

A minimum of 20% complete by the end of Year 1
A minimum of 40% complete by the end of Year 2
A minimum of 60% complete by the end of Year 3
A minimum of 80% complete by the end of Year 4
100 % complete by the end of Year 5.

The coordination must be re-verified when upgrades, refurbishments, or setting changes are made that affect unit real and reactive power capability or protective relay operation.

6.3.2 Verification Requirements

6.3.2.1 Verification of the coordination of generator voltage regulator controls with unit capabilities and protection shall be performed by supplying the following information (see Appendix E for a sample of the following plots):

6.3.2.1.1 The generator reactive capability curve, including specification of nominal voltage, and ambient air or cooling temperature, or hydrogen pressure.

6.3.2.1.2 The under-excitation limiter control characteristics plotted on the reactive capability curve.

6.3.2.1.3 The characteristics of any overexcitation limiter that is based on field current level (converted to a reactive power level for a set of real power levels using the generator “V-curve” assuming the unit is at 1.0 p.u. voltage) and plotted on the reactive capability curve.

For any other type of overexcitation limiter, provide a description of its operation.

6.3.2.1.4 The nameplate real power limit of the prime mover plotted as a vertical line on the reactive capability curve.

6.3.2.1.5 The loss-of-field relay characteristics plotted on the reactive capability curve.

6.3.2.1.6 The characteristics of any overexcitation protection relay that is based on field current level (converted to a reactive power level for a set of real power levels using the generator “V-curve” assuming the unit is at 1.0 p.u. voltage) and plotted on the reactive capability curve.

For any other type of overexcitation protection relay, provide a description of its operation.

6.3.2.1.7 A description of any other limiter that could restrict the real power or reactive power capability.

6.4 Reporting Requirements

6.4.1 The Generator Owner shall retain the most current information for each applicable generator.

6.4.2 A copy of the analyses that demonstrate coordination of generator voltage regulator controls with unit capabilities and protection shall be forwarded to the Transmission Planner responsible for maintaining the system stability model incorporating that generator.

6.4.3 The Generator Owner shall show the most current information to the MRO upon request (within 30 calendar days).

7.0 Generator Performance During Frequency and Voltage Excursions

7.1 Controlling Document

NERC Standard PRC-024-1 Generator Performance During Frequency and Voltage Excursions

This is a draft standard in Field Testing status. The information in this section is for the purpose of conducting field tests. Generator Owners and Operators are not required to comply with the verification requirements at this time. However, there are requirements associated with other NERC standards that limit generator frequency excursion tripping. Refer to the MRO Underfrequency Load Shedding Report.

7.2 Applicability

7.2.1 Single Units

The requirements set forth in this section apply to all synchronous and non-synchronous generators, and synchronous condensers within the MRO footprint.

7.2.2 Waivers

If the generator owner feels there is a valid reason to waive the requirements for a particular unit to remain connected to the electrical grid during the types of frequency or voltage excursions described in this section, the owner may submit a request to the MRO Reliability Assessment Committee.

7.3 Responsibilities

7.3.1 Periodicity

Each generator owner shall ensure that all generators comply with the requirements within two years following adoption of the Controlling standard by the NERC Board of Trustees.

7.3.2 Underfrequency Ride-through

The requirements for remaining connected during a system underfrequency excursion are being determined by the MRO Underfrequency Load Shedding Task Force. These requirements will be published in this document following completion of the UFLS TF report.

7.3.3 Overfrequency Ride-through

The requirements for remaining connected during a system overfrequency excursion are being determined by the MRO Underfrequency Load Shedding Task Force. These requirements will be published in this document following completion of the UFLS TF report.

7.3.4 Low Voltage Ride-through

All generators must remain connected to the grid for the following grid voltage (i.e. the voltage at the high side of the Generator Step-Up transformer) characteristic:

A decrease to 0.00 p.u. voltage for 5 cycles (0.083 seconds) followed by a recovery to 0.90 p.u. voltage at 25 cycles (0.417 seconds). Maintain continuous operation thereafter at a minimum of 0.90 p.u. voltage.

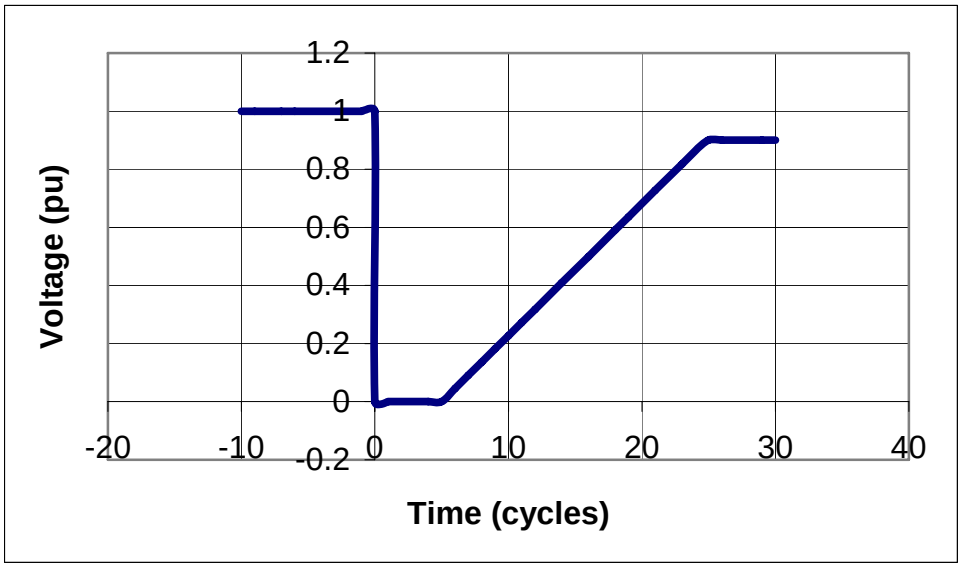

Diagram 1 – Low Voltage Ride Through

7.3.5 Over voltage Ride-through

Generators must remain connected to the grid for the following grid voltage (i.e. at the high side of the Generator Step-Up transformer) characteristic:

An increase to 1.3 p.u. for 12 cycles (0.2 seconds) followed by a decrease to 1.1 p.u. at 2.0 seconds. Maintain continuous operation thereafter at a maximum of 1.1 p.u.

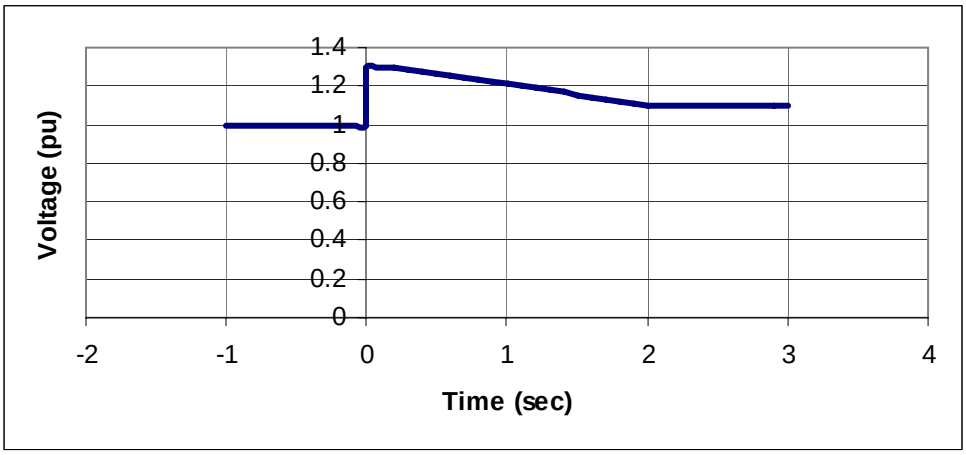

Diagram 2 – Over voltage ride through requirement

7.3.6 Coordination of Generator Protection with Transmission Protection

The MRO Protective Relay Task Force will determine specifications for the coordination of Generator Protection with Transmission Protection. This should include any documentation required to demonstrate coordination.

7.4 Reporting Requirements

Generator Owners shall provide to the Transmission Planner responsible for maintaining the stability model incorporating that generator and to the MRO on request (within 30 days), documentation that shows:

7.4.1 Under and over-frequency relay settings

7.4.2 Ability to ride through an under voltage and over voltage excursion. For example, a modeled grid voltage excursion showing generator terminal voltage response, real and reactive power fluctuations and auxiliary bus voltage.

7.4.3 A description of the methodology used to determine the coordination between generator and transmission protection. (This may be refined by the MRO Protective Relay Task Force).

8.0 Bibliography

NERC Standards MOD-024-1, MOD-025-1, MOD-026-1, MOD-027-1, PRC-019-1, and PRC-024-1

MRO Model Building Procedural Manual, Draft Revision December 14, 2005

MRO Underfrequency Load Shedding Recommendation Report

MAPP Generator Testing Requirements, Revision 2000-08-29

MAPP Generation Reserve Sharing Pool Handbook, Revision October 12, 2004

MAIN Guide No. 3A, Revision No. 4

MAIN Guide No. 3B, Revision August 17, 1995

MAIN Guide No. 3C, Revision March 23, 2005

FERC Docket No. RM05-4-001; Order No. 661-A “Interconnection for Wind Energy” Appendix G

WECC Generating Unit Model Validation Policy

WECC Generating Unit Data Requirements

WECC Generating Unit Baseline Test Requirements

WECC Generating Facility Model Validation Requirements

WECC Low Voltage Ride Through Standard

Appendix A – Real Power Verification Test Data Forms

STEAM TURBO-GENERATOR UNIT TEST REPORT

Company _____ Reported By _____

Station Name and Unit Number _____

Month and Date of Test	
. Gross MWh/hr Generated	
MWh/hr Station Service	
Net MWh/hr Generated	
Test Average Cooling Water Temperature During Test	
Five Year Average for Month of Test, Maximum Cooling Water Temperature	
Average MWh/hr Net Adustment for Step 8	
Rated Net Capability for Month of Test	
Fuel: (Coal/ Gas/ Oil/ Residue (Approx. %) or Nuclear)	

Notes: _____

_____

COMBUSTION TURBINE AND DIESEL UNIT TEST REPORT

Company _____ Reported By _____

Station Name and Unit Number _____

Month and Date of Test	
. Gross MWh/hr Generated	
MWh/hr Station Service	
Net MWh/hr Generated	
Test Average Ambient Temperature	
Inlet Cooling Discharge Temp (if evap. Coolers used)	
Five Year Average for Month of Test, Maximum Ambient Temperature	
Average MWh/hr Net Adustment	
Rated Net Capability for Month of Test	
Fuel: (Oil or Gas)	

Notes: _____

_____

PUMPED STORAGE AND RESERVOIR HYDRO UNIT TEST REPORT

Company _____ Reported By _____

Station Name and Unit Number _____

Month and Date of Test	
. Gross MWh/hr Generated	
MWh/hr Station Service	
Net MWh/hr Generated	
Test Average Head Condition in Meters (m) or Feet (ft)	
Five Year Median Head Conditions for the Month of the Test in Meters (m) or Feet (ft)	
Average MWh/hr Net Adustment	
Rated Net Capability for Month of Test	

Notes: _____

_____

VARIABLE CAPACITY NET GENERATION RECORD REPORT

Company _____ Reported By _____

Station (Farm) Name and Type of Capacity _____

Number of Units and Total Nameplate Capacity _____

	Net Generation Output
5. Monthly Net Generation Data (Month, Year)	**Actual Net (MWH)**
January, ____	
February, ____	
March, ____	
April, ____	
May, ____	
June, ____	
July, ____	
August, ____	
September, ____	
October, ____	
November, ____	
December, ____	

Notes: _____

_____

Appendix B – Reactive Power Capability Test Data Form

Company _____ Plant Name _____

Unit Number(s) _____ Date _____

Reported By _____ Tested By _____

Measured Parameters	Overexcited	Underexcited
Date of Test		
Duration of Test		
Generator voltage		
GSU High Side (system) voltage		
Generator current		
Ambient air temperature		
Rotor current*		
Generator stator temperature*		
Generator rotor temperature*		
GSU oil temperature*		
Generator coolant temperature*		
Generator coolant pressure*		

*If available

	Gross Sustained Generation	Unit Auxiliary Load*	Net Sustained Generation
Overexcited	_____ MW _____ MVAr	_____ MW _____ MVAr	_____ MW _____ MVAr
Underexcited	_____ MW _____ MVAr	_____ MW _____ MVAr	_____ MW _____ MVAr

*Explain any common auxiliary load apportionment in the Remarks section

Overexcited Limiting Factor _____

Underexcited Limiting Factor _____

Net Reactive Capability reported at ☐ Generator terminals ☐ GSU high-side

Remarks _____

_____

Appendix C1 – Excitation System and Voltage Control Modeling Baseline Test Data Form

Company _____ Plant Name _____

Unit Number(s) _____ Submittal Date _____

Reported By _____ Tested By _____

Exciter Data:

Manufacturer _____ Model _____

Exciter Type (e.g. brush rotating / brushless / static, etc.) _____

Base Voltage (volts) _____

Rated Voltage (volts) _____

Ceiling Voltage (volts) _____

Voltage Regulator:

Manufacturer _____ Model _____

Normal Operating Mode (Auto voltage, VAR control, Power factor, Manual, Other-specify) _____

Method of verification: _____ Date_____

- **Attach a block diagram with all required parameters**
- **Attach open circuit step response test data verifying the model.**

Auxiliary Control Status:

Device	Status*:
Power System Stabilizer (PSS)	
Reactive Current Compensation (RCC)	
Line Drop Compensation or Droop	
Other (_____)	

*Place "IS" for In-Service, "OOS" for Out-of-Service, or "N/A" for Not Applicable

Over excitation (OEL) and Under excitation (UEL) Limiters:

Method of OEL verification: _____ Date:_____

Method of UEL verification: _____ Date:_____

- **Attach information describing the settings and characteristics of the OEL and UEL.**

Line Drop Compensator Settings:

Method of verification: _____ Date:_____

- **Attach information describing the Line Drop Compensator (or Reactive Droop) setting**

Power System Stabilizer:

Manufacturer _____ Model _____

Method of verification: _____ Date:_____

- **Attach a block diagram with all required parameters**
- **Attach swept frequency response test data verifying the model.**

Remarks:

Appendix C2 – Excitation System and Voltage Control Modeling Validation Test Data Form

Company _____ Plant Name _____

Unit Number(s) _____ Submittal Date _____

Reported By _____ Tested By _____

Voltage Regulator:

Method of verification: _____ Date:_____

- **Attach a block diagram with all required parameters**
- **Attach a disturbance recording or open circuit step response test data verifying the model.**

Power System Stabilizer:

Method of verification: _____ Date:_____

- **Attach a block diagram with all required parameters**
- **Attach a disturbance recording or swept frequency response test data verifying the model.**

Note: the same system disturbance may be used to verify both models.

Appendix D – Generator Unit Frequency Response Test Data Form

Company _____ Plant Name _____

Unit Number(s) _____ Submittal Date _____

Reported By _____ Tested By _____

Governor Data:

Manufacturer _____ Model _____

Governor Type (e.g. hydraulic, electro-hydraulic, etc.) _____

Method of verification: _____ Date:_____

- **Attach a block diagram with all required parameters**
- **Attach frequency response test data verifying the model.**

Appendix E – Coordination of Generator Voltage Regulator Controls with Unit Capabilities and Protection

Example of coordination information plotted on a reactive capability curve showing generator reactive capability, overexcitation limiters, underexcitation limiter, and loss-of-field relay characteristics, and a separate chart showing volts per hertz limiter and protection information.