Standard Development Roadmap

This section is maintained by the drafting team during the development of the standard and will be removed when the standard becomes effective.

Development Steps Completed:

Proposed Action Plan and Description of Current Draft:
This is the second draft of the proposed standard and includes requirements with violation risk factors, time horizons and measures; and Violation Severity Levels. This second posting of the standard is for a 30-day comment period from October 1 through October 30, 2009.

Future Development Plan:

<table>
<thead>
<tr>
<th>Anticipated Actions</th>
<th>Anticipated Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Post response to comments and second version of standard.</td>
<td>December 2009</td>
</tr>
<tr>
<td>2. Post response to comments and third version of standard.</td>
<td>June 2010</td>
</tr>
<tr>
<td>3. Post response to comments and request authorization to ballot the revised standard.</td>
<td>September 2010</td>
</tr>
<tr>
<td>4. Conduct initial ballot.</td>
<td>October 2010</td>
</tr>
<tr>
<td>5. Post response to comments.</td>
<td>November 2010</td>
</tr>
<tr>
<td>6. Conduct recirculation ballot.</td>
<td>December 2010</td>
</tr>
<tr>
<td>7. BOT adoption.</td>
<td>February 2011</td>
</tr>
<tr>
<td>8. File with regulatory authorities.</td>
<td>March 2011</td>
</tr>
</tbody>
</table>
Definitions of Terms Used in Standard

*This section includes all newly defined or revised terms used in the proposed standard. Terms already defined in the Reliability Standards Glossary of Terms are not repeated here. New or revised definitions listed below become approved when the proposed standard is approved. When the standard becomes effective, these defined terms will be removed from the individual standard and added to the Glossary.*

**Frequency/Voltage Excursion** – an exceedance of system frequency or system voltage beyond a continuous operating band; 60±0.5 Hertz for frequency and ±5% of scheduled for voltage.
Introduction

1. Title: Generator Performance During Frequency and Voltage Excursions
2. Number: PRC-024-1
3. Purpose: Ensure generating units remain connected during frequency and voltage excursions and ensure expected generating unit performance during frequency and voltage excursions is communicated to system planners for accurate system modeling.

4. Applicability

4.1. Functional entities:

4.1.1 Generator Owner

4.2. Facilities:

4.2.1 Each generating unit greater than 20 MVA (gross nameplate rating) connected at 60 kV and higher

4.2.2 Each generating plant/facility consisting of multiple units with total generation > 75 MVA (gross aggregate nameplate rating) connected at 60 kV and higher.

5. Effective Dates: The standard is effective the first day of the first calendar quarter after applicable regulatory approvals (or the standard otherwise becomes effective the first day of the first calendar quarter after NERC Board of Trustees adoption in those jurisdictions where regulatory approval is not required).

Each Generator Owner’s applicable unit(s) shall be compliant with the standard based on the following phased implementation schedule:

5.1. No less than 33% of a Generator Owner’s units shall be fully compliant with the standard within 1 year of the effective date of the standard.

5.2. No less than 66% of a Generator Owner’s units shall be fully compliant with the standard within 2 years of the effective date of the standard

5.3. No less than 100% of a Generator Owner’s units shall be fully compliant with the standard within 3 years of the effective date of the standard

A. Requirements

R1. Each Generator Owner that has frequency protective relaying\(^1\) activated to trip its new or existing generating unit shall set such protective relaying not to trip per the following operating conditions and relay settings unless the Generator Owner has documented and communicated a non-protection system equipment limitation in accordance with R3 for an existing generating unit\(^2\):

\[ (\text{Violation Risk Factors: High - unit or generating plant/facility } \geq 200 \text{ MVA; Medium - unit or generating plant/facility } < 200 \text{ MVA}) \text{(Time Horizon – Operations Planning)} \]

\(^1\) Each Generator Owner is not required to have frequency or voltage protective relaying (Includes frequency and voltage protective functions for discrete relays, volts per hertz relays evaluated at nominal frequency, multi-function protective devices or protective functions within excitation controls that directly trip or provide tripping signals to the generator based on frequency or voltage inputs.) installed or activated on its unit.

\(^2\) Including generators under construction, generators with an executed interconnection agreement or Power Purchase Agreement by the effective date of version 1 of this standard, or generators with an executed equipment purchase contract and scheduled delivery of major components within 2 years of the effective date of version 1 of this standard.
1.1. When operating within a frequency range of 59.5 Hz to 60.5 Hz, inclusive.

1.2. During the off-nominal frequency excursions specified in PRC-024-1 Attachment 1.

1.3. Instantaneous underfrequency relay trip setting shall be set no higher than 57.8 Hz.

1.4. Instantaneous overfrequency relay trip settings shall be set no lower than 62.2 Hz.

1.5. 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

R2. Each Generator Owner that has voltage protective relaying activated to trip its new or existing unit or generating plant/facility shall set its protective relaying not to trip as a result of a voltage excursion at the point of interconnection, caused by an event external to the plant per the following operating conditions and relay settings unless the Generator Owner has documented and communicated a non-protection system equipment limitation in accordance with R3 for an existing unit or generating plant/facility:

(Violation Risk Factors: High - unit or generating plant/facility \( \geq \) 200 MVA; Medium - unit or generating plant/facility < 200 MVA) (Time Horizon – Operations Planning)

2.1. When operating within 95% to 105% of rated generator terminal voltage and during the transmission system operating conditions as defined in PRC-024-1 Attachment 2, with the following clarifications:

2.1.1. For three-phase transmission system zone 1 faults with Normal Clearing, voltage relay setting requirements shall be set based on actual fault clearing times, not to exceed 9 cycles.

2.1.2. The Transmission Planner may specify a less stringent voltage relay setting parameters than the duration curve based on the location specific voltage recovery characteristics.

2.1.3. Relaying may be set to trip a generator after fault initiation if this action is designed as part of a Special Protection System (SPS) or Remedial Action Scheme (RAS).

2.1.4. Relaying may be set to trip a generator if clearing a system fault necessitates disconnecting the generator.

R3. Each Generator Owner of an existing generating unit or generating plant/facility shall document any non-protection system equipment limitation that prevents compliance with R1 or R2 and communicate the documented limitation to its Reliability Coordinator, Planning Coordinator, Transmission Operator and Transmission Planner within 30 days of identifying the limitation to ensure the accuracy of planning studies and system modeling studies. (Violation Risk Factor – Lower) (Time Horizon – Operations Planning)

3.1. Each Generator Owner shall provide a written response to the commenting entity within 90 calendar days of receipt of written comments from a Reliability Coordinator, Planning Coordinator, Transmission Operator or Transmission Planner regarding an equipment limitation.

3.1.1. The response shall indicate whether a change will be made to the equipment limitation or the reason why no change will be made to the equipment limitation.
3.2. The equipment limitation shall expire coincident with either of the following conditions:

3.2.1. The equipment causing the limitation is repaired or replaced with equipment that removes the limitation

3.2.2. The existing generating unit increases the nameplate capacity rating greater than 15%.

R4. Each Generator Owner of an existing unit or generating plant/facility shall provide an estimate of unit performance during Frequency/Voltage Excursions to the requesting entity (Reliability Coordinators, Planning Coordinators, Transmission Operators and Transmission Planners that monitor or model the associated unit) within 30 days of a written request to ensure the accuracy of planning studies and system modeling studies. The documentation shall include: (Violation Risk Factors: Medium) (Time Horizon – Operations Planning)

4.1. An estimate of the time range when the existing unit or generating plant/facility may trip due to a Frequency/Voltage Excursions similar to the curves as set forth in Attachments 1 and 2

4.2. An estimated/approximate probability in 25% increments that the existing unit or generating plant/facility will remain connected during Frequency/Voltage Excursions as set forth in Attachments 1 and 2.

4.3. The existing unit or generating plant/facility tripping estimates will be based on experience, actual event histories, sound engineering judgment, or other applicable information.

R5. Each Generator Owner shall keep its new unit or generating plant/facility connected during a Frequency/Voltage Excursion at the Point of Interconnection, caused by an event external to the plant, within the parameters set forth in Attachment 1 and Attachment 2 and in accordance with the following conditions and exceptions:

(Violation Risk Factors: High - unit or generating plant/facility ≥200 MVA; Medium - unit or generating plant/facility <200 MVA) (Time Horizon – Real-Time)

5.1. When the unit or generating plant/facility is operating at or above the minimum sustainable generation.

5.1.1. For a generating plant/facility consisting of multiple units with total generation > 75 MVA (gross aggregate nameplate rating) connected at 60 kV and higher, when the facility is producing at least 20% of the facility’s rated capacity and the voltage support equipment is in service.

5.2. For a new generating plant/facility consisting of multiple units less than 20 MVA each with total facility generation > 75 MVA (gross aggregate nameplate rating) connected at 60 kV and higher, at least 90% of the individual generating units shall remain connected.

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3 Excluding generators in service prior to the effective date of version 1 of this standard and excluding generators referenced in Footnote 1.
5.3. A unit or generating plant/facility may operate to a less stringent voltage ride-through performance criterion than the duration curve based on the location specific voltage recovery characteristics as specified by the Transmission Planner.

5.4. A unit or generating plant/facility may trip if this action is designed as part of a Special Protection System (SPS) or Remedial Action Scheme (RAS).

5.5. A unit or generating plant/facility may trip if clearing a system fault necessitates disconnecting the unit or generating plant/facility.

5.6. A unit or generating plant/facility may trip if the Generator Owner has a temporary exemption granted by its Reliability Coordinator based on a documented equipment limitation.

R6. Each Generator Owner shall provide to the Reliability Coordinators, Planning Coordinators, Transmission Operators and Transmission Planners (that monitor or model the associated unit) its generator protection trip settings as specified by R1 and R2, and documented equipment limitations as specified by R3 within 30 calendar days of any change to those trip settings or limitations, and shall provide the requesting entity (listed in this requirement) the trip settings or limitations within 30 calendar days of a written request for the data to ensure the accuracy of planning studies and system modeling studies. *(Violation Risk Factor – Lower) (Time Horizon – Operations Planning)*

B. Measures

M1. Each Generator Owner has evidence such as setting sheets, calibration sheets, or other documentation, that generator frequency protective relays have been set in accordance with Requirement R1. Each Generator Owner of an existing generating unit that is unable to comply with Requirement R1 due to equipment limitations (Protection System excluded) has evidence or other documentation that explains the equipment limitation of the unit(s).

M2. Each Generator Owner has evidence such as setting sheets, voltage-time curves, calibration sheets, coordination plots or dynamic simulation studies, that generator voltage protective relays have been set in accordance with Requirement R2. Each Generator Owner of an existing generating unit that is unable to comply with Requirements R2 due to equipment limitations (Protection System excluded) has evidence or other documentation that explains the equipment limitation of the unit(s).

M3. Each Generator Owner has evidence that it has documented and communicated any technical limitation(s) that resulted in an exception to Requirements R1 or R2 in accordance with Requirement R3.

M4. Each Generator Owner has evidence such as dated e-mails, mail receipts or other documentation that an estimate(s) of the performance of its existing generating unit(s) during Frequency/Voltage Excursions has been communicated to the entities listed in Requirement R4.

M5. Each Generator Owner has evidence such as unit output records, trip investigation reports or disturbance monitoring records that its new generating units/facilities did not trip during a Frequency/Voltage Excursion in accordance with Requirement R5.

M6. Each Generator Owner has evidence such as dated e-mails, mail receipts or other evidence that it communicated generator protective relay settings or equipment limitations to a
requesting entity within 30 calendar days of a request or change in setting(s) in accordance with Requirement R6.

C. Compliance

1. Compliance Monitoring Process

   i. Compliance Enforcement Authority
      Regional Entity

   ii. Regional Entity Compliance Monitoring Period and Reset
      Not Applicable

   iii. Compliance Monitoring and Enforcement Processes:
      Compliance Audits
      Self-Certifications
      Spot Checking
      Compliance Violation Investigations
      Self-Reporting
      Complaints

   iv. Data Retention
      The Generator Owner shall 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 Generator Owner shall retain its current, in force document and any documents in force since the last compliance audit.
      - If a Generator Owner is found non-compliant, it shall keep information related to the non-compliance until found compliant.
      - The Compliance Enforcement Authority shall keep the last audit records and all requested and submitted subsequent audit records.

2. Additional Compliance Information
   None

3. Violation Severity Levels

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Violation Risk Factor</th>
<th>Violation Severity Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>R1</td>
<td>High - unit or generating plant/facility</td>
<td>Lower</td>
</tr>
<tr>
<td></td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>R2</td>
<td>High - unit or generating plant/facility $\geq 200,\text{MVA}$; Medium - unit or generating plant/facility $&lt;200,\text{MVA}$</td>
<td>N/A</td>
</tr>
<tr>
<td>---</td>
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</tr>
<tr>
<td>R3</td>
<td>Lower</td>
<td>The Generator Owner provided a written response to written comments provided by the Reliability Coordinator, Planning Coordinator, Transmission Operator, or Transmission Planner</td>
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<tr>
<td>R4</td>
<td>Medium</td>
<td>The Generator Owner supplied the information on estimated generator performance during excursions to the appropriate entities more than 30 days from the date it was requested.</td>
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<tr>
<td>---</td>
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</tr>
<tr>
<td>R5</td>
<td>High - unit or generating plant/facility ≥200 MVA; Medium - unit or generating plant/facility &lt;200 MVA)</td>
<td>A Generator Owner’s generating unit or generating plant/facility tripped off line after 20 seconds of the start of a Voltage Excursion but within the No Trip Zone of Attachment 2 in accordance with R5.</td>
</tr>
</tbody>
</table>
D. **Regional Variances**

None

E. **References**

## OFF NOMINAL FREQUENCY CAPABILITY CURVE

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<thead>
<tr>
<th>Frequency (hertz)</th>
<th>57.8</th>
<th>59.5</th>
<th>62.2</th>
<th>60.5</th>
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<tr>
<td>Time (seconds)</td>
<td>0 to 2</td>
<td>Over 1800</td>
<td>0 to 2</td>
<td>Over 600</td>
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</table>
Voltage Ride-Through Time Duration Curves

Point of Interconnection - Voltage (PU)

High Voltage Duration

Low Voltage Duration

No Trip Zone

Return to between .95 PU and 1.05 PU dependant on automatic or manual changes to the system.
The following data points would apply to this curve:

<table>
<thead>
<tr>
<th>HVRT DURATION</th>
<th>Time (Sec)</th>
<th>Voltage (p.u.)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.20</td>
<td>1.200</td>
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<tr>
<td></td>
<td>0.50</td>
<td>1.175</td>
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<tr>
<td></td>
<td>1.00</td>
<td>1.150</td>
</tr>
<tr>
<td></td>
<td>600</td>
<td>1.100</td>
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</tbody>
</table>

<table>
<thead>
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<th>Time (Sec)</th>
<th>Voltage (p.u.)</th>
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<tr>
<td></td>
<td>0.15</td>
<td>0.000</td>
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<tr>
<td></td>
<td>0.30</td>
<td>0.450</td>
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<td>2.00</td>
<td>0.650</td>
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<tr>
<td></td>
<td>3.00</td>
<td>0.750</td>
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<tr>
<td></td>
<td>600</td>
<td>0.900</td>
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Voltage Ride-Through Curve Clarifications

1. The per unit voltage base for this curve is the scheduled operating voltage as measured at the point of interconnection to the Bulk Electric System.

2. The curves depicted in this Attachment 2 are applicable for a three-phase transmission system zone 1 faults with Normal Clearing.

3. As long as the cumulative voltage duration at the point of interconnection with the Bulk Electric System is within the voltage boundaries of the curve, the generator voltage protective relaying will not trip the generator.

4. The curves depicted in this Attachment 2 assume system frequency of 60 Hertz.

5. Voltage protection relay setting calculations may be based on the static case, for steady state initial conditions using the following assumptions:
   a. All of the units connected to the same transformer are on line and operating,
   b. All of the units are at full nameplate real-power output.
   c. Power factor of 0.95 lagging.
   d. Scheduled voltage as measured at point of interconnection.

6. Voltage protection relay settings will be calculated to comply with Attachment 2 assuming that any additional installed generating plant reactive support equipment (such as static VAr compensators, synchronous condensers, or capacitors) is available and operating normally.

7. Voltage protection relay settings will be calculated to comply with Attachment 2 accounting for the actual tap settings of transformers between the generator terminals and the POI.