

NERC

NORTH AMERICAN ELECTRIC
RELIABILITY CORPORATION

NERC Reliability Standard PRC-024-1 Generator Frequency and Voltage Protective Relay Settings

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to ensure
the reliability of the
bulk power system

Reliability Standard PRC-024-1

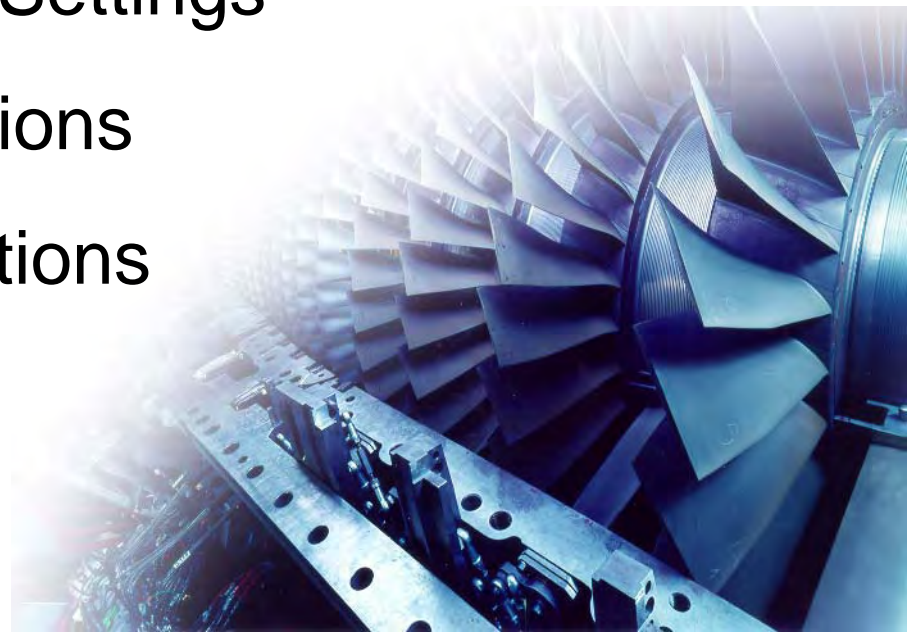
Title: Generator Frequency and Voltage Protective Relay Settings

Purpose: Ensure that generator frequency and voltage protective relays¹ are set to support transmission system stability during voltage and frequency excursions.

¹ Includes voltage and frequency protective functions for discrete relays, multi-function protective devices, voltage regulators, etc.

PRC-024-1 Technical Requirements

- R1: Frequency Relay Setting
- R2: Voltage Relay Setting
- R3: Relay Setting Changes
- R4: Written Request for Settings
- R5: Existing Unit Exceptions
- R6: Questions on Limitations



GENERATOR OWNERS WITH
INSTALLED VOLTAGE or
FREQUENCY PROTECTIVE RELAYS

and

UNITS > 20 MVA

or

EACH UNIT WHERE PLANT TOTAL
MVA > 75 MVA

Effective Dates

1ST Day of 1ST Calendar
Quarter After Applicable
Regulatory Approval



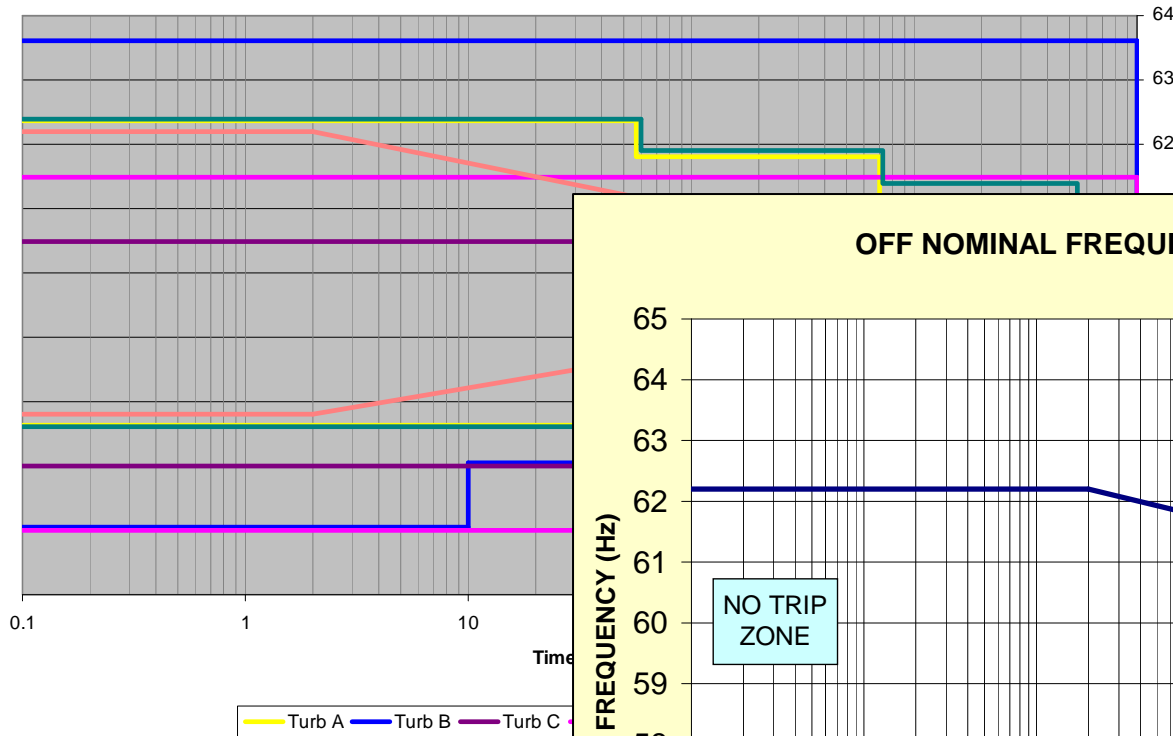
33%
of GO units
compliant

66%
of GO units
compliant

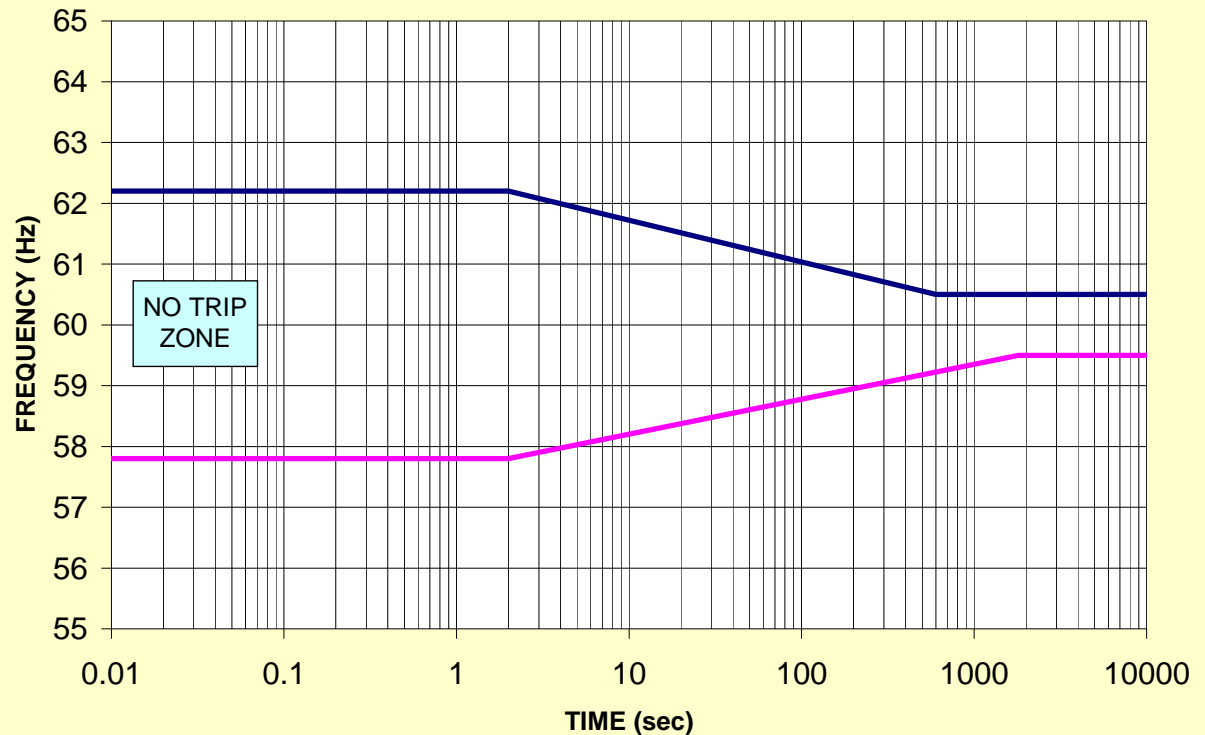
100%
of GO units
compliant

R1: Frequency Relay Setting

Comparison of Turbine Capability to PRC-024 Criteria



OFF NOMINAL FREQUENCY CAPABILITY CURVE



NOTE: Times shown are relay setting times, not elapsed times.

Requirement R1 and Measure M1

R1. Each Generator Owner shall set installed generator frequency protective relaying not to trip during the following frequency-related operating conditions unless the Generator Owner's unit has an exception in accordance with Requirement R5:

(Violation Risk Factors:

High - Units ≥ 500 MVA;

Medium - Units > 100 MVA and < 500 MVA;

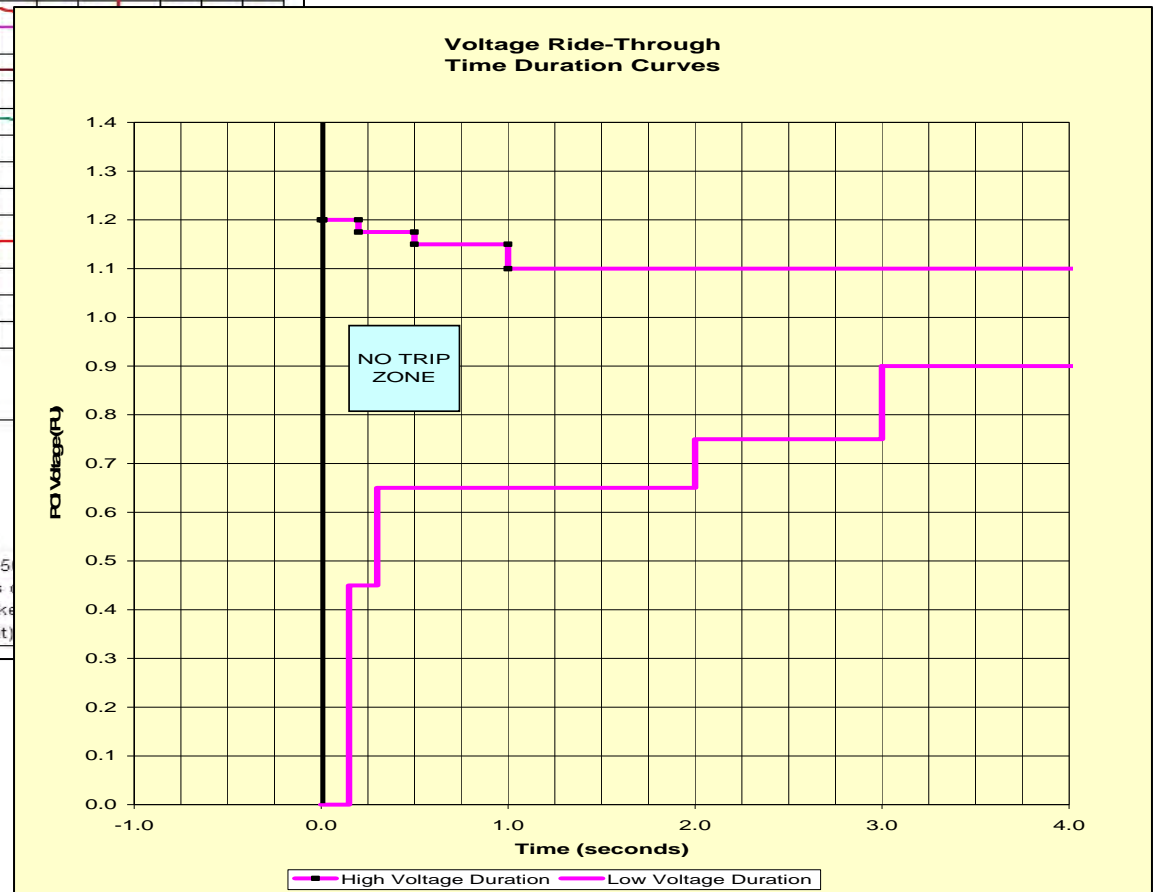
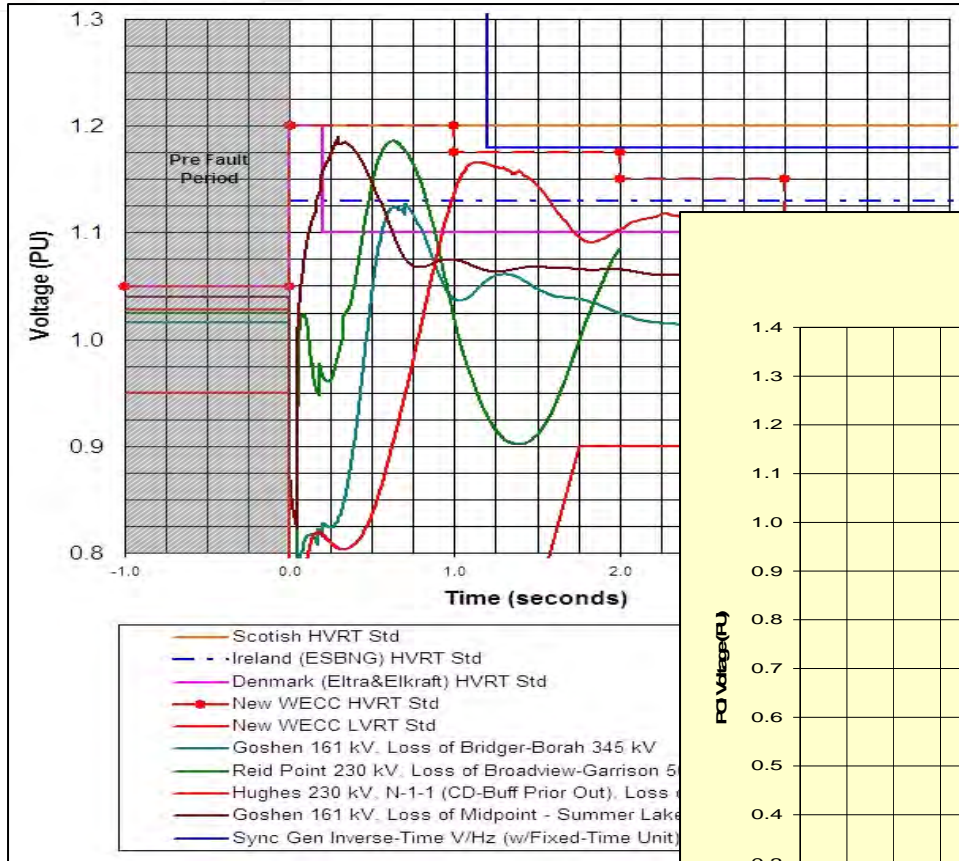
Lower - Units ≤ 100 MVA)

(Time Horizon – Operations Planning)

- R1.1 When operating within a frequency range of 59.5 Hz to 60.5 Hz, inclusive.
- R1.2 During the off-normal frequency excursions specified in PRC-024-1 Attachment 1.
- R1.3 Instantaneous underfrequency relay trip setting shall be set no higher than 57.8 Hz.
- R1.4 Instantaneous overfrequency relay trip settings shall be set no lower than 62.2 Hz.

M1. Each Generator Owner shall have evidence such as setting sheets, calibration sheets, or other documentation, that generator frequency protective relays have been set in accordance with Requirement R1.

R2: Voltage Relay Setting



NOTE: Times shown are relay setting times, not elapsed times.

Requirement R2 and Measure M2

R2. Each Generator Owner shall set installed generator over and under voltage (including volts per hertz relays evaluated at nominal frequency) protective relays not to trip during the steady-state and voltage-related operating conditions as follows unless the Generator Owner's unit has an exception in accordance with Requirement R5 of this standard:

(Violation Risk Factors: High - Units ≥ 500 MVA; Medium - Units > 100 MVA and < 500 MVA; Lower - Units ≤ 100 MVA) (Time Horizon – Operations Planning)

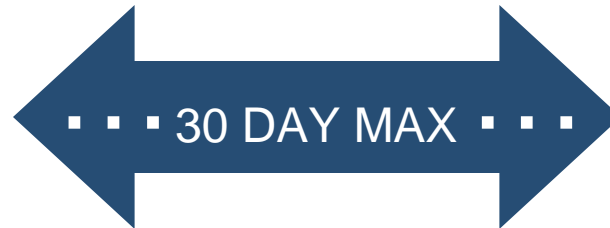
- R2.1** When operating within 95% to 105% of rated generator terminal voltage.
- R2.2** During the transient voltage excursions measured at the point of interconnection to the Bulk Electric System as specified in PRC-024-1 Attachment 2. The following generator protective relaying settings are acceptable:
 - R2.2.1** For three-phase transmission system Zone 1 faults with Normal Clearing, relaying may be set based on actual fault clearing times, but not greater than 9 cycles.
 - R2.2.2** Relaying may be set to meet a shorter voltage ride through duration curve as specified by the Transmission Planner based on the location specific voltage recovery characteristics.
 - R2.2.3** Relaying may be set to trip a generator after fault initiation if this action is intended as part of a special protection scheme (SPS) or remedial action scheme (RAS).
 - R2.2.4** Relaying may be set to trip a generator if clearing a system fault necessitates disconnecting the generator.

M2. Each Generator Owner shall have 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.

R3: Relay Setting Changes

**GO
changes
settings**

of Frequency
or Voltage
Relays in R1
or R2



**GO
provides
settings**

to RC, PC,
TP, & TOP

Requirement R3 and Measure M3

R3. 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 Requirement R1 and Requirement R2 within 30 calendar days of any change to those trip settings.

(Violation Risk Factor – Lower)

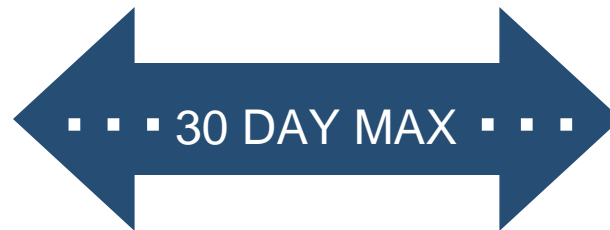
(Time Horizon – Operations Planning)

M3. Each Generator Owner shall have evidence such as dated e-mails, mail receipts or other documentation that generator protective relay settings changes have been communicated to the entities listed in Requirement R3.

R4: Written Request for Settings

RC, PC, TP,
or TOP
request
settings

of Frequency or
Voltage Relays in
R1 or R2



GO
provides
settings

to RC, PC,
TP, & TOP

Requirement R4 and Measure M4

R4. Each Generator Owner shall provide its affected Reliability Coordinator, Planning Coordinator, Transmission Operator and Transmission Planner (that monitor or model the associated unit), its generator protection trip settings as specified by Requirement R1 and Requirement R2 within 30 calendar days of a written request for the data.

(Violation Risk Factor – Lower)

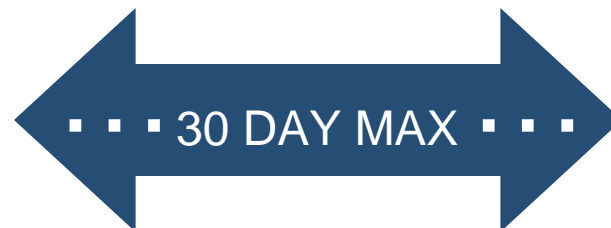
(Time Horizon – Operations Planning)

M4. Each Generator Owner shall have evidence such as dated e-mails, mail receipts, request received or other documentation that generator protective relay settings have been communicated to the entities listed in Requirement R4.

R5: Existing Unit Exceptions

- Manufacturer Limits
- Warranty Related
- Insurance Agreements
- Engineering Analysis
- Other?

GO
discovers
equipment
limitation



GO provides
documentation
to RC, PC, TP, & TOP

Requirement R5 and Measure M5

R5. If an existing generator unit² cannot meet either Requirement R1 or Requirement R2 due to equipment limitations, such as manufacturer warranty requirements or limitations that endangers the equipment according to published manufacturer instructions, (Protection System excluded), the Generator Owner of that unit shall provide documentation of the equipment limitation(s) to the Reliability Coordinators, Planning Coordinators, Transmission Operators and Transmission Planners that monitor or model the associated unit, within 30 days of identifying the equipment limitation.

The exception for the equipment limitation shall expire coincident with either of the following conditions:

- **The equipment causing the limitation is replaced with equipment that removes the technical limitation.**
- **The equipment causing the limitation is modified or upgraded resulting in an increase of generator nameplate capacity rating greater than 10%.**

*(Violation Risk Factor – Medium – Units >100MVA
 Lower – Units ≤100 MVA)*

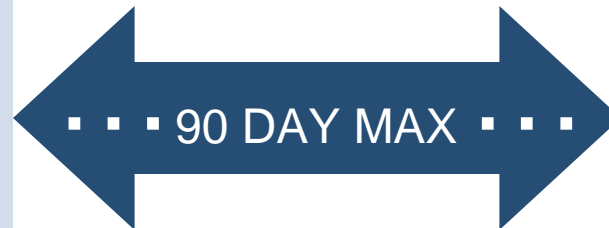
(Time Horizon – Operations Planning)

M5. Each Generator Owner of existing generators that are unable to comply with Requirements R1 or R2 due to equipment limitations (Protection System excluded) shall have evidence such as warranty agreements, insurance agreements, manufacturers documented limitations, engineering analysis or other documentation that explains the equipment limitation of the unit(s).

²Including generators under construction, generators with an executed interconnection agreement or Power Purchase Agreement, or generators with an executed equipment purchase contract and scheduled delivery within 2 years of the effective date of the standard.

R6: Questions on Limitations

GO receives
written
communication
from RC, PC, TP, or
TOP



GO provides
written response
to RC, PC, TP, & TOP

Requirement R6 and Measure M6

R6. The Generator Owner shall provide a written response within 90 calendar days of receipt of written comments from the Reliability Coordinators, Planning Coordinators, Transmission Operators or Transmission Planners (that monitor or model the associated unit) regarding the equipment limitation. The response shall indicate whether a change will be made to the equipment limitation or if no change will be made to the equipment limitation, the reason why.

(Violation Risk Factor – Lower)

(Time Horizon – Operations Planning)

M6. Each Generator Owner shall have evidence such as dated copy, e-mail receipts or other evidence that it provided a written response to a commenting entity within 90 calendar days of receipt of comments.

Documentation Examples

- Relay Setting:
 - Setting Sheets,
 - Calculation Sheets,
 - Voltage vs. Time curves,
 - Frequency vs. Time curves,
 - Coordination Plot,
 - Dynamic Simulation Studies
 - Other?

Documentation Examples

- Other Communication
 - Dated emails
 - Mail receipts
 - Other?



Coordination with UFLS

- GV SDT Chair is member of UFLS SDT
- Generator Frequency Relay Setting precedes UFLS Setting

- “The Technical Justification for the New WECC Voltage Ride-Through (VRT) Standard, A White Paper Developed by the Wind Generation Task Force (WGTF)” – June 13, 2007



- Relay setting vs. Unit Performance
- 9 cycles
- Duration curve vs. No Trip Envelope
- Technology neutral and forward looking
- Synchronous and non-synchronous generators



Question & Answer