ISO New England Operating Procedure No. 12

Voltage and Reactive Control

Effective Date: September 12, 2024

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References:

1. ISO New England Inc. Transmission, Markets, and Services Tariff - Attachment D - ISO New England Information Policy
2. NERC Reliability Standard IRO-008 - Reliability Coordinator Operational Analyses and Real-time Assessments
3. NERC Reliability Standard VAR-001 - Voltage and Reactive Control
4. NERC Reliability Standard VAR-002 - Generator Operation for Maintaining Network Voltage Schedules
5. NPCC MOD-25-2 Implementation Plan
6. ISO New England Ancillary Service Schedule No. 2 Business Procedure
7. ISO New England Operating Procedure No. 4 - Action During a Capacity Deficiency (OP-4)
8. ISO New England Operating Procedure No. 7 - Action in an Emergency (OP-7)
9. ISO New England Operating Procedure No. 14 - Technical Requirements for Generators, Demand Response Resources, Asset Related Demands and Alternative Technology Regulation Resources (OP-14)
10. ISO New England Operating Procedure No. 16 - Transmission System Data (OP-16)
11. ISO New England Operating Procedure No. 18 – Metering and Telemetering Criteria (OP-18)
12. ISO New England Operating Procedure No. 19 - Transmission Operations (OP-19)
13. ISO New England Operating Procedure No. 23 - Resource Auditing (OP-23)
14. ISO New England Transmission Operating Guides - All Voltage/Reactive Guides

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APPENDICES

I. INTRODUCTION

This Operating Procedure (OP) establishes criteria, operating practices, and responsibilities to maintain desired/reliable voltage and reactive conditions on the power system. It includes general actions to control voltage/reactive conditions when deviations from normal conditions occur, or are needed, to minimize adverse effects during abnormal conditions.

Specific criteria and actions are contained in detailed voltage/reactive documents issued as part of the ISO New England (ISO) Transmission Operating Guides (TOGs). Temporary transmission operating guides (TGs) may contain additional criteria and actions required to correct abnormal voltage/reactive conditions. Permanent TOGs and TGs are published in the Operations Documents Management System (ODMS); all are classified under Attachment D - ISO New England Information Policy to the ISO New England Inc. Transmission, Markets, and Services Tariff, as Confidential and Critical Energy Infrastructure Information (CEII) documents and are not publically available.

II. CRITERIA

A. Voltage Schedules and Limits for Transmission Equipment and Generators

Voltage schedules and limits for transmission equipment and NERC registered and/or transmission connected (69 kV or higher) Generators that can control transmission voltage are specified by ISO in Appendix B - Voltage & Reactive Schedules (OP-12B) of this OP. The majority of the information in OP-12B is sourced from the NX database.

As described in ISO New England Operating Procedure No. 14 - Technical Requirements for Generators, Demand Response Resources, Asset Related Demands and Alternative Technology Regulation Resources (OP-14), Generators are required to submit Form NX-12D. As described in ISO New England Operating Procedure No. 16 – Transmission System Data (OP-16), Transmission Owners (TOs) are required to submit Form NX-9 for transmission equipment. Non-Generator Dynamic Reactive Resources are also required to submit Form NX-12D.

OP-12B includes schedules and device information for:

- Transmission-connected Generators, which includes but is not limited to:
  - Multi-machine Synchronous Generator Plants
  - Solar Photovoltaic Generation Plants
  - Wind Turbine Generation Plants
  - Fuel Cell Plants
- Transmission-connected Non-Generator Dynamic Reactive Resources, which includes but is not limited to:
  - Transmission Static Synchronous Compensators (STATCOMs)
  - Transmission Static VAR Compensators
  - Synchronous Condensers

  For the above devices, OP-12B reports voltage schedules and device parameters as approved in Form NX-12D. Reactive capabilities shall represent test data. If test data is not available, theoretical values may be used.

OP-12B also includes information for:

- Autotransformers with Load Tap Changers (LTCs) – OP-12B reports voltage schedules and device parameters as approved in Form NX-9B.
- Transmission Capacitors – OP-12B reports device parameters as approved in Form NX-9D.
- Transmission Reactors – OP-12B reports device parameters as approved in Form NX-9D and Form NX-9G.

OP-12B classifies the Generator and Non-Generator Dynamic Reactive Resources based on voltage control:

- Part of the Form NX-12D describes the Generator and Non-Generator Dynamic Reactive Resources capability to control voltage. A Generator or Non-Generator Dynamic Reactive Resources voltage control capability is described by one of these three categories:

- Option A – These Generators and Non-Generator Dynamic Reactive Resources directly regulate transmission system voltage (69kV and above) to a schedule. These Generators and Non-Generator Dynamic Reactive Resources are listed in OP-12B

    - Newly-interconnecting transmission-connected Generators (and Gen installed reactive devices) and Non-Generator Dynamic Reactive Resources must have a voltage control system that directly regulates a transmission bus to a voltage schedule. Transmission voltage schedules will be provided in OP-12B and are adjustable in real-time by the LCC / ISO. Plant terminal voltage(s) and/or reactive power output(s) must adjust automatically, without a human in the loop, to adhere to the plants transmission voltage schedule.

        Transmission-connected Generators and Non-Generator Dynamic Reactive Resources are those whose Point Of Interconnection (POI) is 69 kV and above, as described in their S/LGIA.

        By exception, if a documented technical rationale demonstrates that an alternate voltage control strategy not involving direct regulation of a transmission bus is warranted on an engineering basis (for example, as an outcome of the System Impact Study), such a transmission-connected Generator or Non-Generator Dynamic Reactive Resource would not be considered Option A.

    - Existing Option A Generators and Non-Generator Dynamic Reactive Resources may utilize human operator intervention to regulate a transmission bus to a voltage schedule. For example, an existing unit (without an automatic outer loop control system) where the plant operator provides the outer loop control function by manually adjusting a terminal voltage control set point to achieve transmission system voltage regulation to its OP-12B schedule will remain an Option A unit.

        If such an existing Generator or Non-Generator Dynamic Reactive Resource undergoes a reactive power control system replacement (e.g. excitation system upgrade), the Generator or Non-Generator Dynamic Reactive Resource shall meet the requirement described in i. for automatic outer loop direct transmission bus voltage regulation.

    - Generators and Non-Generator Dynamic Reactive Resources are considered to be interconnecting at transmission voltage levels if they are directly stepping up (or down), via transformation, from their local voltage into a transmission station.

Transmission voltage schedules are **not** specified for Generator and Non-Generator Dynamic Reactive devices **not** modeled in the ISO Energy Management System (EMS) Network Database.

- Option B – These Generator and Non-Generator Dynamic Reactive Resources regulate voltage at a bus below that of a transmission voltage level (less than 69 kV). They may follow local voltage schedules specified by the low voltage facility owner in accordance with LCC requirements or as required in their Interconnection Agreements.
    - At the discretion of ISO in coordination with the LCC, a transmission-connected Option B unit may warrant inclusion in OP-12B, listing the non-transmission voltage schedule.
- Option C – These Generators are exempt from the requirement to have an automatic voltage regulator (AVR). These Generators are listed in M/LCC 8A. As noted in M/LCC 8A, these Generators commonly follow a reactive power schedule by operating with a constant power factor as specified in their Interconnection Agreements.

OP-12B contains voltage schedules for all Generators and Non-Generator Dynamic Reactive Resources that are Option A, which are Generators and Non-Generator Dynamic Reactive Resources that regulate transmission voltage. OP-12B also may include certain transmission-connected Option B Generators and Non-Generator Dynamic Reactive Resources at the discretion of ISO in coordination with the LCC.

The voltage schedule specified for a Generator in OP-12B is the prescribed normal voltage that a Generator shall maintain. This normal voltage schedule is represented by a kV schedule value with accompanying operational kV high and kV low values that establish the “voltage schedule tolerance band.”

Currently, the normal voltage schedule is indicated in the “On Peak Period” fields, and if applicable, an alternate schedule is indicated in the “Off Peak Period” fields. A Generator shall maintain voltage output within its normal voltage schedule tolerance band values in system operations at all times while one or more units at the generating station are online, unless otherwise directed by ISO or the LCC. These voltage schedules shall also be used by operators and planners in off-line studies of the power system.

During certain infrequent, atypical conditions at a generating station or on the power system, ISO or an LCC may issue an Operating Instruction to a Generator or Non-Generator Reactive Resource to deviate from its normal voltage schedule and to temporarily operate at a voltage output level outside of the normal voltage schedule tolerance band, but within the wider minimum and maximum “acceptable” voltage schedule range, which is also listed in OP-12B. Note this operation may need to be examined by engineering to determine if operation at this temporary voltage schedule impacts stability limits for the unit or system.

During these conditions, if ISO or the LCC issue an Operating Instruction to a generating station to operate to a temporary voltage schedule, ISO or the LCC shall provide each applicable generating station operator with the following:

- The temporary voltage schedule to be maintained with the AVR in-service and controlling to a voltage setpoint
- The temporary voltage schedule tolerance band to be maintained
- The expected duration of this temporary voltage schedule change (if known, or "until further notice")

During normal operations on the power system, the ISO or an LCC may issue an Operating Instruction to a Generator or Non-Generator Dynamic Reactive Resource to adjust their voltage setpoint while remaining within the normal voltage schedule tolerance band. Adjustments such as these are not considered a change to the OP-12B listed voltage schedule provided the setpoint remains within the original tolerance band.

If the generating station operator has been directed to deviate from the normal voltage schedule and tolerance band, the LCC shall contact the generating station operator at least once per shift to confirm the temporary voltage schedule and tolerance band. Once the temporary voltage schedule is **no** longer applicable, the ISO or LCC shall issue an Operating Instruction to the generating station operator to return to the normal voltage schedule and tolerance band.

B. Generator and Non-Generator Dynamic Reactive Resources Reactive Capabilities, Commitments and Required Reactive Reserves

Generators' and Non-Generator Dynamic Reactive Resources' reactive capabilities entered in the NX-12D Forms shall be used in system operations and analyses. Each Generator's and Non-Generator Dynamic Reactive Resources' reactive capability shall be fully available when the Generator and Non-Generator Dynamic Reactive Resource is on-line and any change to the Generator or Non-Generator Dynamic Reactive Resource reactive capability shall be reported to the ISO and LCC in Real-Time in accordance with Appendix B to OP-14 (OP-14B).

To reflect Generators' and Non-Generator Dynamic Reactive Resources' updated reactive capabilities, and to capture any voltage schedule or equipment parameter changes, OP-12B will be updated as needed, using the NX database as its source.

To promote security of the transmission system during adverse voltage/reactive conditions, required Generator and Non-Generator Dynamic Reactive Resource commitments and levels of required reactive reserve from Generators and Non-Generator Dynamic Reactive Resources within certain areas of the New England Reliability Coordinator Area (RCA) have been established. System conditions that warrant the prescribed Generator and Non-Generator Dynamic Reactive Resource commitments or reactive reserves have also been identified. As applicable, details are contained in the TOGs and TGs.

III. VOLTAGE/REACTIVE OPERATING PRACTICES

A. Traditional Voltage/Reactive Control

Dispatch of shunt capacitors/reactors combined with effective transformer voltage schedules or fixed tap settings are the most traditional means of achieving desired voltages and reactive conditions while maintaining dynamic reactive reserve on Generators. Switchable shunt devices installed to support the New England Transmission System (115 kV and above) and guides for switching them can be found in OP-12B and in the TOGs.

B. Transmission Interface Transfer Limits to Avoid Low Voltage

In some cases, custom software tools have been developed to calculate voltage-based transfer limits for transmission interfaces. These limits provide acceptable voltage response to contingencies. As applicable, details are contained in the TOGs and TGs.

C. Circuit Switching to Control High Voltage

In some areas, transmission circuit switching is a viable option for controlling high voltage/excessive charging conditions. As applicable, details are contained in the TOGs and TGs

D. Load Management for Voltage/Reactive Reliability

In severe cases of low voltage and/or inadequate reactive reserves, load management actions may be taken. Details on conditions when these actions may/shall be used and how they shall be implemented are described in the TOGs and ISO New England Operating Procedure No. 4 - Action During a Capacity Deficiency (OP-4) and ISO New England Operating Procedure No. 7 - Action in an Emergency (OP-7).

IV. RESPONSIBILITIES

This OP is based on the principle that voltage control is best achieved when action is taken as close as possible to the affected area. Voltage schedules and other reactive conditions shall be supervised by the generating station operators, transmission station operators, LCC System Operators and ISO System Operators, each having a specific area of responsibility. Regardless of who issues an Operating Instruction for a corrective measure (ISO or LCC, respectively), action shall ultimately be taken by a generating/transmission station operator or LCC System Operator depending on who has "hands on" control of the reactive resource.

A. Generating and Transmission Stations

1. Generating Station and Transmission Station Operation to Maintain Voltage Schedule

Generating station operators and transmission station operators are responsible for maintaining station service and other local voltage requirements and scheduled voltages at levels designated by ISO in OP-12B, or as otherwise specified through an Operating Instruction issued by ISO or an LCC.

Transmission station operators with control over dynamic reactive resources maintaining a voltage schedule within a voltage schedule tolerance band outlined in OP-12B shall comply with the requirements for generating station operators outlined in this Section IV.A.1.

Automatic voltage regulation normally works off the low-side of the step-up transformer (generator terminals). In order to maintain a high-side voltage schedule, manual intervention may be required to offset varying power flows through and voltage drops across the step-up transformer.

The generating station operator shall maintain the high-side bus voltage within the normal voltage schedule tolerance band, as specified in the “kV High” and “kV Low” levels for the appropriate load period and indicated in the “Operational Voltage Schedules” columns of OP-12B. If a Generator does **not** have high-side bus voltage visibility (visibility of the bus voltage that is of the same voltage class as its schedule), a description of the method used to derive its GSU low-side schedule to achieve the assigned voltage schedule shall be included in the unit’s NX-12D Form in accordance with OP-14B.

Operation outside of the prescribed normal voltage schedule tolerance band shall be kept to a minimum. The generating station operator shall regularly check Generator high-side bus voltage against scheduled voltage and if the high-side voltage is outside the voltage schedule tolerance band, act to reestablish voltage within the tolerance band within 15 minutes. When a generating station operator or transmission station operator is unable to maintain the scheduled voltage within the voltage schedule tolerance band and local voltages with the means under its control, the generating station operator or transmission station operator shall notify its respective LCC System Operator (and local dispatch authority if appropriate). If a Generator’s high-side bus voltage drifts outside of its normal voltage schedule tolerance band, the generating station operator shall immediately notify the LCC

when one of the following conditions is met:

(1) The Generator has been operating outside of its prescribed voltage schedule tolerance band for a continuous period of 15 minutes; or

(2) The generating station operator determines that the Generator will be unable to return to operating within its prescribed voltage schedule tolerance band within 15 minutes

A unit is **not** allowed to operate outside its normal voltage schedule tolerance band unless ISO or the LCC issues an Operating Instruction to do so. If a unit is **not** maintaining its voltage within the prescribed normal voltage schedule tolerance band for a period exceeding 15 minutes and has **not** notified the LCC (as described above), or is **not** closely following an alternative voltage schedule issued by ISO or the LCC, then the unit shall be considered to be in violation of this OP.

When a Generator is issued an Operating Instruction to deviate from its normal voltage schedule and tolerance band, the Generator shall operate within this temporary voltage schedule tolerance band until further notice.

2. Generator Operation in Automatic Voltage Control Mode

NERC Reliability Standard VAR-002 - Generator Operation for Maintaining Network Voltage Schedules requires each Generator equipped with an AVR to operate in the automatic voltage control mode. Whenever the AVR operation is available, the Generator AVR shall:

- Be in-service and controlling voltage, and
- Remain in this configuration unless otherwise directed by the ISO or LCC System Operator.

In ISO New England Operating Procedure No. 18 – Metering and Telemetering Criteria (OP-18), ISO-NE requires each Generator modeled in the ISO EMS Network Database to provide telemetry indicating its AVR's status. Generators exempted from operating with their AVR in the voltage control mode will be documented in M/LCC 8A and will not be required to provide AVR status telemetry. The ISO may require AVR status for a Generator that has an operational impact but is not modeled in the ISO EMS Network Database.

When a Generator AVR is out-of-service, the generating station operator shall use an alternative method to control the Generator reactive output to meet the voltage or Reactive Power schedule. Actual or expected changes in AVR operating status shall be reported in accordance with this OP and with M/LCC 8 as follows:

- The generating station operator shall report changes to AVR status in Real-Time except for conditions that the Lead Market Participant (Lead MP) has reported in advance on Form NX-12D, as described in the following paragraph. The Generator shall make those reports whenever the AVR is removed from or placed in-service unless taking those actions is warranted by emergency plant conditions. The generating station operator shall also report any problems that could interfere with proper operation of an AVR. These reports shall be made to the following entities as soon as the AVR status

change condition arises, as follows:

- The generating station operator shall report to the applicable LCC; and
- The Lead MP shall report to ISO through its assigned Designated Entity (DE)

- When the Lead MP describes expected changes to AVR status that occur during Real-Time conditions on Form NX-12D for the Generator in accordance with ISO OP-14 (*i.e.* periods of time when the Lead MP routinely expects that its Generator will **not** operate with the AVR in-service and controlling voltage, such as during start-up or shut-down) these changes shall **not** to be reported in Real-Time. When conditions that match the conditions described on Form NX-12D occur, the information on Form NX-12D shall serve as advance standing notification and Real-Time reporting shall **not** be required.

3. Generator Verification of Reactive Capability

Each generating station operator is responsible to comply with the reactive capability verification process detailed in ISO New England Operating Procedure No.23 - Resource Auditing (OP-23).

B. LCCs

Each LCC is responsible for monitoring the following:

(1) Generator, STATCOM, synchronous condenser, and static VAR compensator voltage schedules, limits and AVR status.

(2) Generator, STATCOM, synchronous condenser, and static VAR compensator MVAr loadings, capabilities and reserves.

(3) Transformer voltage schedules.

(4) MVAr flows between the AC system and HVDC facilities.

(5) Other predefined indicators of voltage/reactive security (*e.g.*, a particular circuit flow, the status of specific Generators, area load level, etc.).

The LCCs are responsible for:

(1) Dispatching shunt capacitors and reactors.

(2) Implementing transformer fixed and seasonal tap settings.

(3) Line switching for voltage/reactive control (which shall be coordinated with ISO and, if warranted, with other LCCs).

(4) Detecting and correcting deviations from the voltage schedule tolerance band on a Generator, STATCOM, synchronous condenser, and/or static VAR compensator.

Providing Real-time voltage setpoint changes to the operator of a Generator, STATCOM, synchronous condenser or static VAR compensator to include the

temporary voltage setpoint to maintain, with AVR in-service and controlling voltage.

(5) Providing Real-Time voltage schedule changes to the operator of a Generator, STATCOM, synchronous condenser, or static VAR compensator, including the following information:

- The temporary voltage schedule to maintain with AVR in-service and controlling voltage.
- The temporary voltage schedule tolerance band to maintain.
- The expected duration of this temporary voltage schedule change.

(6) Contacting the operator of a Generator, STATCOM, synchronous condenser, or static VAR compensator that has been directed to deviate from the normal voltage schedule and tolerance band at least once per shift, to confirm the temporary voltage schedule and tolerance band.

(7) Directing the operator of a Generator, STATCOM, synchronous condenser, or static VAR compensator to return to the normal voltage schedule and tolerance band once the temporary voltage schedule is **no** longer applicable.

(8) Responding to notifications from the operator of a Generator, STATCOM, synchronous condenser, or static VAR compensator of their difficulty in maintaining station or other local voltage or reactive schedules.

(9) Responding to ISO requests to assist with inter-LCC or inter-area problems.

(10) Notifying/coordinating with ISO when there is a need to adjust the real power (MW) output of a Generator in order to adjust its MVAr output. ISO shall provide the direction to the DE to adjust its Generator real power (MW) output. Unless an emergency condition warrants such action, the LCCs shall **not** directly issue an Operating Instruction to the generating station operator to adjust the real power output (MW) of its Generator in order to adjust its MVAr output.

(11) Notifying/coordinating with ISO, any of the following voltage/reactive control actions prior to implementation:

- Line switching.
- Load management in response to voltage SOL exceedance/violation.
- Generator, STATCOM, synchronous condenser, or static VAR compensator voltage schedule tolerance band (kV high and/or kV low) changes.

If ISO and an LCC differ on what the voltage schedule should be for a given unit, then ISO and that LCC shall discuss and agree upon the appropriate voltage schedule to be communicated to the unit.

When an LCC is unable to correct a voltage/reactive problem using all available actions or the LCC believes that the problem should be handled on a multi-LCC or inter-RCA basis, the LCC shall notify ISO and request assistance.

To verify a Generator's voltage control capability, each LCC shall use the template provided in OP-12, Appendix D - Voltage Schedule Annual Transmittal Form (OP-12D). During the first quarter of each year, each LCC shall email the OP-12D transmittal form to each Option A or Option B Generator within its operational footprint that is represented in the ISO EMS. The OP-12D transmittal form shall be sent to the Lead MP for that Generator.

As the source of email addresses for the Lead MPs, each LCC shall use the DE Contact Information posted on the confidential satellite information website at:

https://smd.iso-ne.com/satellite/nx12_initialdisplay/

On each such transmittal, the LCC shall copy the Chair of the Voltage Task Force at email address:

vtfcontact@iso-ne.com

C. ISO

ISO is responsible for;

(1) General monitoring and supervision of voltage/reactive conditions in the New England RCA (115 kV and above). When system monitoring detects a problem within an LCC, ISO shall contact the LCC and request action.

(2) Notifying the applicable LCC as soon as it becomes aware of an emergency or forced outage of a Generator AVR.

- When an LCC reports to ISO that it is **not** possible to correct an abnormal voltage/reactive-related operating condition at a station or an LCC level, ISO shall assume direct responsibility for alleviating the problem. ISO shall direct, through the appropriate LCC(s), all actions listed in the above LCC Section IV. B of this OP as well as any MW re-dispatching.

- If ISO and an LCC differ on what the voltage schedule should be for a given unit, then ISO and that LCC shall discuss and agree upon the appropriate voltage schedule to be communicated to the unit.

(3) Monitoring and supervising voltage/reactive operations of inter-RCA ties. Abnormal voltage/reactive-related operating conditions may be noticed by ISO or appear in the form of requests from a neighboring Reliability Coordinator or entities for assistance. ISO shall inform the appropriate LCC(s) of the nature of the problem specifying; the pool or entity involved, the location of the undesirable voltage/reactive condition and general conditions aggravating the difficulty. ISO may work with/through the LCCs and use all actions under Section IV. B of this OP as well as MW re-dispatching to eliminate the problem.

- When abnormal voltage/reactive operating conditions materialize, ISO may initiate a survey of key system parameters to better assess the nature and expanse of the conditions. Online tools are used to conduct the surveys.

OP-12 REVISION HISTORY

Document History (This Document History documents action taken on the equivalent NEPOOL Procedure prior to the RTO Operations Date as well revisions made to the ISO New England Procedure subsequent to the RTO Operations Date.)

Rev. No.	Date	Reason
--	06/04/20	For previous revision history, refer to Rev 10 available through Ask ISO;
Rev 11	06/04/20	Biennial review performed by document owner Provide attribution for source of resource reactive limit values and define when updates will occur to document Truncated the Revision History per SOP-RTMKTS.0210.0010 Section 5.6;
Rev 12	01/07/21	Retire Appendix A; globally delete App A references in document
Rev 12.1	03/24/22	Biennial review performed by document owner with minor editorial changes; Added language to line up with OP-12D for Option A and Option B Generators; Removed OP-12B exception for generators for BSF; Removed reference in Option B for OP-12B and M/LCC-8A; Replaced “near unity” with “with a constant” in Option C; Removed reference to measuring at the high side of the GSU under voltage schedule.
Rev 12.2	02/07/24	Biennial review performed by document owner with no changes; Made Administrative changes to publish a Minor Revision.
Rev 13	09/12/24	Biennial review performed by document owner; Revised language in Section II.A for applicability of this OP; Revised language and added clarity for Options A, B, and C; Added explicit voltage control requirements for Options A and B; Provided a clarification for voltage schedule changes: as long as within the voltage control bandwidth, a request to alter the voltage schedule is not technically a voltage schedule change.