

Appendix B - Generator Reactive Data Explanation of Terms and Instructions for Data Preparation for ISO Form NX-12D

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References:

1. North American Electric Reliability Corporation (NERC) Reliability Standard VAR-002 - Generator Operation for Maintaining Network Voltage Schedules
2. ISO New England Operating Procedure No. 12 - Voltage and Reactive Control (OP-12), Appendix B - Voltage and Reactive Schedules (OP-12B)
3. ISO New England Operating Procedure No. 12 - Voltage and Reactive Control (OP-12), Appendix D - Voltage Schedule Annual Transmittal Form (OP-12D)
4. ISO New England Operating Procedure No. 14 - Technical Requirements for Generators, Demand Response Resources, Asset Related Demands and Alternative Technology Regulation Resources (OP-14)
5. ISO New England Operating Procedure No. 16 - Transmission System Data (OP-16)

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INTRODUCTION

Data, which defines and represents the physical characteristics and ratings of generators (as defined in Section II.A of ISO New England Operating Procedure No. 14 - Technical Requirements for Generators, Demand Response Resources, Asset Related Demands and Alternative Technology Regulation Resources (OP-14) is required by ISO New England (ISO) and the Local Control Centers (LCCs). Reactive capability (NX-12D) data is used to develop accurate system models and to support the day-to-day reliable operation of the New England bulk power transmission system. The Lead Market Participant (Lead MP) is required to provide such data through the ISO NX submittal software in accordance with this Appendix B to OP-14.

NX-12D data is required for each generating unit (generator/inverter/etc.) comprising a generator that is located in the New England Reliability Coordinator Area. The Lead MP may submit one set of representative reactive capability data, including the number of units installed, for wind turbines and other generating units that: (1) use an inverter (e.g., photovoltaic), (2) are associated with the same Generator Asset and, (3) have the same point of interconnection.

The generating unit manufacturer nameplate lagging and leading reactive power (MVar) output capability is based on the design parameters of the generating unit. This capability represents the theoretical maximum reactive capability of a specific generating unit.

The generating unit manufacturer nameplate operating lagging and leading MVar output capability can be limited during normal operation by any one of several devices or considerations other than the manufacturer nameplate capability curve. Limiting devices can be equipment such as excitation limiters, electrical and/or thermal protection relaying, etc. Limiting considerations can be station voltage requirements, auxiliary equipment constraints, generator step up transformers (GSUs), and/or transmission restrictions, contractual arrangements, etc. In all of these cases, the generating unit cannot operate at the manufacturer nameplate reactive capability. This restricted capability represents the normal reactive operating capability and shall also be represented in the NX-12D data.

The Designated Entity shall report any change to a generating unit reactive capability in Real-Time to ISO and the appropriate LCC. If it is determined that the change will last longer than six months, the Lead MP shall update NX-12D data in the NX submittal software.

The Lead MP shall verify all NX-12D data as correct upon submittal and at least annually. ISO shall initiate the annual verification, which shall be performed through the NX submittal software.

DATA SUBMITTAL INSTRUCTIONS

The Lead MP shall submit NX-12D data through ISO NX submittal software. The following sections describe how to calculate and provide the required data. Data shall be submitted at least five Business Days prior to the requested effective date for the data, unless otherwise agreed upon between by ISO and the Lead MP.

Theoretical and Tested Values:

These capability values represent gross real power MW and MVAR output levels as measured at the generating unit terminal prior to station service load. The Lead MP shall provide generating unit capability curves (both nameplate and normal operating). Additional reactive capability curves shall be submitted for generating units capable of operating as a synchronous condenser or for reversible hydroelectric generating units.

The following definitions shall be utilized to determine the appropriate data to submit.

Minimum Manual Load Point

The lowest MW capability that the generating unit is required to sustain for unit stability. For the Minimum Manual Load Point, use the lower of the winter or summer generating unit minimum manual MW output capability.

Unity Generating Unit Power Factor Load Point

The maximum MW capability of the generator at unity machine power factor (i.e., no lagging or leading capability).

Intermediate Load Point

The MW output that is 50% between the Unity Generating Unit Power Factor Load Point and the Minimum Manual Load Point. Therefore: $\text{Intermediate Load Point} = \text{Minimum Manual Load Point} + 0.50 \times (\text{Unity Generating Unit Power Factor Load Point} - \text{Minimum Manual Load Point})$.

Three Quarter Load Point

The MW output that is 75% between the Unity Generating Unit Power Factor Load Point and the Minimum Manual Load Point. Therefore: $\text{Three Quarter Load Point} = \text{Minimum Manual Load Point} + 0.75 \times (\text{Unity Generating Unit Power Factor Load Point} - \text{Minimum Manual Load Point})$.

Break Point Load Point

The MW output at the point of transition between the two curve sections based on field winding versus stator design limits on the manufacturer nameplate reactive capability curve.

Transitional Load Point

The MW output at which the most limiting lagging or leading normal operating curve intersects the manufacturer's nameplate capability curve

Motoring

Motoring is the term given to a generating unit that can operate as a synchronous condenser.

Full Pumping Capability (Reversible Hydroelectric Generating Units Only)

Pumping is the term given to a hydroelectric generating unit that can operate as a motor used to pump water into the reservoir.

Nameplate Operating Reactive Capability Data

The nameplate reactive capability is provided by the manufacturer based upon design specifications of the generating unit. Figure 1 illustrates typical nameplate capability curves for a sample generating unit at various hydrogen pressures when not encumbered by any protective or limiting concerns. The sample generating unit is designed to operate at 30 psia hydrogen pressure level. For generating unit nameplate capability the requested data consists of MW and MVAR pairs for nine points along the capability curve (see Figure 1).

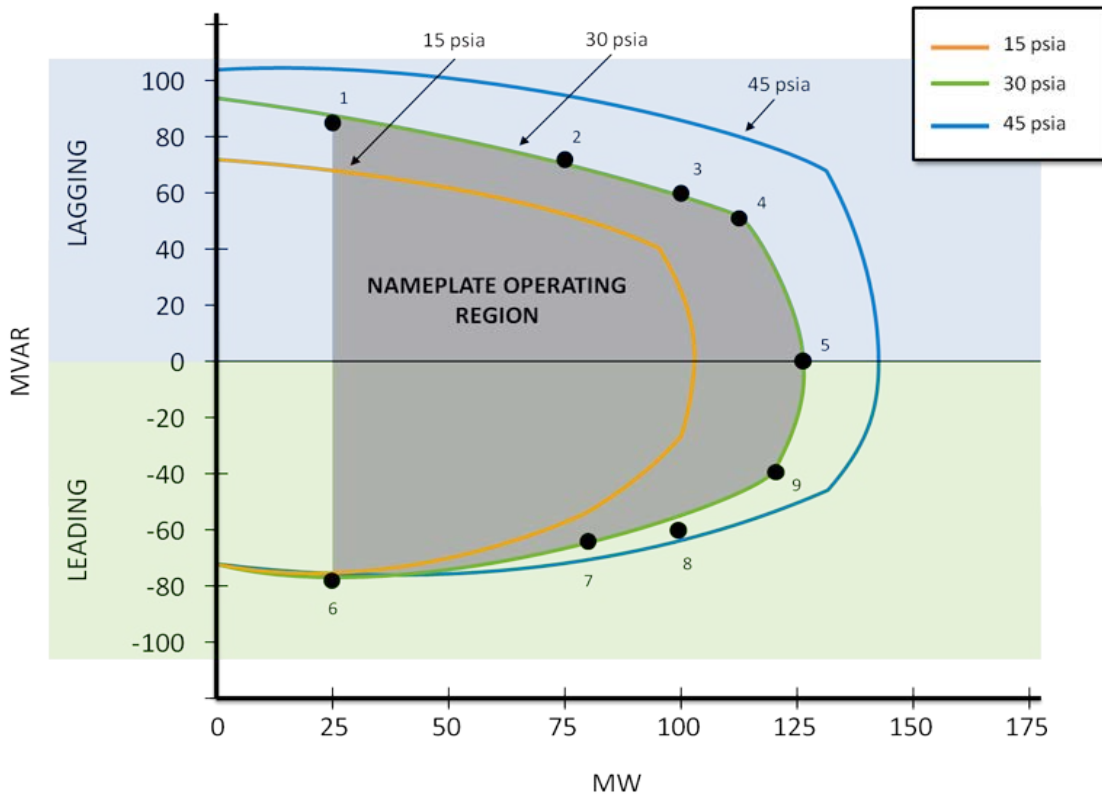


Figure 1

The Lead MP shall provide the MW and MVAR data for each point along the nameplate reactive capability curve. For units with multiple temperature curves, the Lead MP shall provide the data based upon the most restrictive temperature curve. For units with curves for multiple voltage levels, the Lead MP shall provide data at 1.0 per unit.

- The maximum MVAR lagging capability at the Minimum Manual Load Point (Point 1).
- The maximum MVAR lagging capability at the Intermediate Load Point (Point 2).
- The maximum MVAR lagging capability at the Three Quarter Load Point (Point 3).
- The maximum MVAR lagging capability at the Break Point Load Point (Point 4). Nameplate Points 4 and 9, the two break points, do not necessarily correspond to the same MW output value of the generating unit.
- The maximum MW capability at the Unity Generating Unit Power Factor Load Point. (Point 5)

- The maximum MVAR leading capability at the Minimum Manual Load Point (Point 6).
- The maximum MVAR leading capability at the Intermediate Load Point (Point 7).
- The maximum MVAR leading capability at the Three Quarter Load Point (Point 8).
- The maximum MVAR leading capability at the Break Point Load Point (Point 9). Nameplate Points 9 and 4, the two break points, do not necessarily correspond to the same MW output value of the generating unit.
- The maximum leading and lagging MVAR capability of the generating unit while motoring [Not Applicable (NA) if not able to motor].
- The maximum leading and lagging MVAR capability of the generating unit while pumping (NA if not a reversible hydroelectric generating unit).

Normal Operating Reactive Capability Data

For the generating unit normal operating capability, the case where the generating unit reactive capability is limited by devices or considerations other than design parameters, the generating unit output can be derived from the detailed capability curve similar to the sample shown in Figure 2. Figure 2 shows the effect on the generating unit manufacturer nameplate capability curve when it is restricted by example limitations A through D. If the generating unit is not limited at any of the corresponding MW output values by these limitations, then by default, the normal operating capability is the same as the manufacturer nameplate capability. This data form assumes a generating unit can operate between its listed maximum lagging MVAR capability and zero MVAR. The Lead MP shall provide comments if a generating unit must maintain a minimum lagging MVAR output and cannot operate at zero MVAR output.

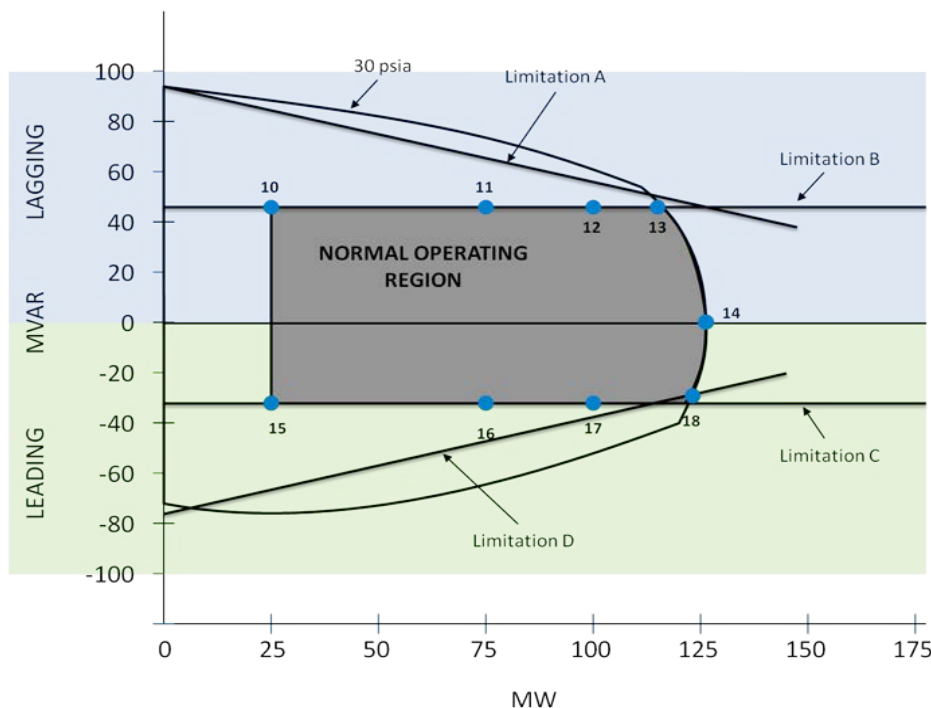


Figure 2

The Lead MP shall provide the MW and MVAR data for each point along the normal operating reactive capability curve. For units with multiple temperature curves, the Lead MP shall provide the data

based upon the most restrictive temperature curve. For units with curves for multiple voltage levels, the Lead MP shall provide data at 1.0 per unit.

- The most restrictive maximum MVAR lagging capability attainable at the Minimum Manual Load Point (Point 10).
- The most restrictive maximum MVAR lagging capability attainable at the Intermediate Load Point (Point 11).
- The most restrictive maximum MVAR lagging capability attainable at the Three Quarter Load Point (Point 12).
- The most restrictive maximum MVAR lagging capability at the Transitional Load Point (Point 13).

For example: in Figure 2, the limitation is the point where the limiting concern of the B constraint line intersects the generating unit manufacturer nameplate capability curve. Point 13 and point 4 (Figure 1) do not necessarily correspond to the same MW output of the generating unit. Normal operating points 13 and 18 do not necessarily correspond to the same value of MW output of the generating unit.

- The maximum MW capability at Unity Generating Unit Power Factor Load Point (Point 14). It is possible to have two valid MW entries for the unity point: points 5 (Figure 1) and 14 (Figure 2). Example: manufacturer nameplate operation of the generating unit is at 30 psia hydrogen and the normal operation of the generating unit is at 15 psia hydrogen. In this case, there are two x axis cross over points. If nameplate and normal capabilities are the same, then normal shall be entered as NA.
- The most restrictive maximum MVAR leading capability at the Minimum Manual Load Point (Point 15).
- The most restrictive maximum MVAR leading capability at the Intermediate Load Point (Point 16)
- The most restrictive maximum MVAR leading capability at the Three Quarter Load Point (Point 17).
- The most restrictive maximum MVAR leading capability at the Transitional Load Point (Point 18).

For example: in Figure 2, the limitation is the point where the limiting concern of the D constraint line intersects the generating unit manufacturer nameplate capability curve. Point 18 and point 9 (Figure 1) do not necessarily correspond to the same MW output of the generating unit. Normal operating points 13 and 18 do not necessarily correspond to the same value of MW output of the generating unit.

- The most restrictive maximum MVAR lagging capability attainable at summer Seasonal Claimed Capability. For new generators, this will be an estimated value until the first summer Seasonal Claimed Capability Audit is complete.
- The most restrictive maximum MVAR leading capability attainable at summer Seasonal Claimed Capability. For new generators, this will be an estimated value until the first summer Seasonal Claimed Capability Audit is complete.
- The most restrictive maximum MVAR lagging capability attainable at the Economic Min Load Point.
- The most restrictive maximum MVAR leading capability attainable at the Economic Min Load Point.

- The most restrictive leading and lagging MVAR capability of the generating unit while motoring (NA if unable to motor).
- The most restrictive leading and lagging MVAR capability of the generating unit while pumping (NA if not a reversible hydroelectric generating unit).

Station Service Load Data

The Lead MP shall provide the expected gross MW and MVAR station service loads for normal operation at the various load points. In the event that summer and winter station service loads are different, the Lead MP shall provide the maximum station service load expected at that real power load point. The data provided shall reflect tested data if available.

Tested Data

The Lead MP shall provide the real and reactive power values at the generating unit terminals and the station service real and reactive power values from the most recently performed reactive capability test (if the generator has performed a reactive capability test).

Values at Rated MVA and Rated Power Factor from Interconnection Agreement

The Lead MP shall provide the values from the most recent approved and implemented Interconnection Agreement with ISO. (e.g., a generator rated at 100 MVA and required by the Interconnection Agreement to have a 0.95 lagging power factor and a 0.95 leading power factor would have lagging 95 MW (-31 MVAR); leading 95 MW (-31 MVAR). In the event that the generator does not have an Interconnection Agreement with ISO, the Lead MP shall provide values at the most restrictive generator capability or 0.95 lagging or leading whichever is less.

Generating Units Not Directly Connected at 115 kV or Above

The Lead MP shall provide data for the equivalent impedance from generating unit terminals to the closest (electrically) substation operating at 115 kV or above. In certain instances, ISO may require impedance data to a substation that is not the closest (electrically). ISO shall make this determination and inform the Lead MP. If the generating unit has a GSU, the GSU impedance shall be provided separately in accordance with ISO New England Operating Procedure No. 16 - Transmission System Data (OP-16). Data collection may require coordination between the Lead MP and the entities that own lines between the GSU and the required substation.

For wind plants, the equivalent impedance is from the transformer between the collector bus and the Point of Interconnection (or an equivalent value from the GSU if no such transformer is installed) to the required substation.

Bus Loading Not Explicitly Modeled on Equivalent Network

When a generator is connected via equivalent transmission impedance, there is the potential to eliminate modeling of intermediate busses which may contain load and/or shunt. A composite of these values shall be modeled on the generator bus to accurately capture the net generator contribution to the network.

High Side Visibility

NOTE

If the generator operator does not have Real-Time high side voltage reading, then the "High Side Visibility" box would not be checked.

Check this box when the generating unit operator has, available in the control room, a real-time voltage reading indicating the voltage on the high side of the generator GSU that can be used as a reference to make voltage control set-point corrections. This voltage reading would be comparable to the generator voltage schedule provided by the LCC.

Generator Voltage Schedule

NOTE

On-Peak refers to the hours between 0700 and 2300 on weekdays that are not NERC holidays.

Off-Peak refers to the hours between 2300 and 0700 on weekdays, all weekends and NERC holidays.

For generators with multiple generating units aggregated behind a single Point of Interconnection, the transformer at the Point of Interconnection for these resources is the equivalent of a GSU for conventional generators.

The voltage schedule limits shall accurately reflect restrictions on generating unit operation, including but not limited to: terminal voltage constraints, auxiliary equipment limitations, station service requirements, GSU, and transmission restrictions and/or contractual arrangements.

The maximum and minimum acceptable voltage schedule limits will typically differ from the more narrow voltage schedule tolerance bands as stated in ISO New England Operating Procedure No. 12 - Voltage and Reactive Control (OP-12), Appendix B - Voltage and Reactive Schedules (OP-12B).

In addition to generator maximum and minimum acceptable voltage limits, there are transmission voltage limits that shall also be respected. The maximum and minimum acceptable voltage schedule limits provided by the Lead MP when submitting the reactive capability data may be narrowed further by ISO or the LCC due to more restrictive transmission voltage limits.

NOTE

For wind plants, the terminal voltage is between the individual turbine and its GSU.

The Lead MP shall provide maximum and minimum acceptable voltage schedule limits in addition to the voltage schedule which the generating unit is expected to maintain with its automatic voltage regulator (AVR) in-service and controlling constant voltage (if **not** exempted from AVR requirements). These voltages shall be provided as follows:

1. For generators that have been identified as "Option A" on the most recent ISO New England Operating Procedure No. 12 (OP-12) Appendix D-Voltage Schedule Annual Transmittal Form:
 - a. Select voltage control "Option A".
 - b. Enter the "GSU High Side" maximum and minimum acceptable voltage limits.
 - c. Enter the tolerance band high, voltage schedule, and tolerance band low values as provided on OP-12 Appendix D.
 - d. If the generator has Real-Time High Side Visibility: enter the rated terminal bus voltage for the terminal bus maximum, terminal bus scheduled, and terminal bus minimum.
 - e. If the generator does not have High Side Visibility:
 - i. Enter the terminal bus maximum, scheduled, and minimum voltage schedules.
 - ii. Enter a detailed description of the method used to monitor GSU high side voltage in the voltage control option comments or as a separate document. If the description is provided as a separate file, enter a reference to the file in the

voltage control option comments.

2. For generators that have been identified as “Option B” on the most recent OP-12 Appendix D transmittal form:
 - a. Select Voltage Control “Option B”.
 - b. If the generator has a voltage schedule provided for the high side of the GSU and has High Side Visibility:
 - i. Enter the voltage schedule maximum, voltage schedule, and voltage schedule minimum values as provided on the most recent OP-12 Appendix D transmittal form.
 - ii. Enter the rated terminal bus voltage for the terminal bus maximum, terminal bus scheduled, and terminal bus minimum
 - c. If the generator has a voltage schedule provided for the high side of the GSU and does not have High Side Visibility:
 - i. Enter the voltage schedule maximum, voltage schedule, and voltage schedule minimum values as provided on the most recent OP-12 Appendix D transmittal form.
 - ii. Enter the terminal bus maximum, scheduled, and minimum voltage schedules.
 - iii. Enter a detailed description of the method used to monitor GSU high side voltage in the voltage control option comments or as a separate document. If the description is provided as a separate file, enter a reference to the file in the voltage control option comments.
 - d. If the generator has a voltage schedule provided for the low side of the GSU:
 - i. Enter the rated voltage of the GSU high side terminal as the voltage schedule maximum, scheduled, and voltage schedule minimum.
 - ii. Enter the terminal bus maximum, scheduled, and minimum voltage schedules as provided on the most recent OP-12 Appendix D transmittal form.
3. For generators that have been identified as “Option C” on the most recent OP-12 Appendix D transmittal form (i.e., generators that have been exempted from having an AVR in automatic and controlling to a voltage set-point):
 - a. Select voltage control “Option C”.
 - b. Enter a description of the generator reactive controls and operation in lieu of maintaining a voltage schedule through use of AVR or its equivalent. This description can be entered in the voltage control option comments field or uploaded as a separate file. If the description is provided as a separate file, enter a reference to the file in the voltage control option comments.

Operation of Automatic Voltage Regulator (AVR)

OP-12 and NERC Reliability Standard VAR-002 - Generator Operation for Maintaining Network Voltage Schedules require each generator equipped with an AVR to operate with the AVR in service in the automatic voltage control mode and controlling voltage and to notify ISO and the applicable LCC of any AVR status changes. The Lead MP shall indicate when the AVR will be automatically controlling voltage during Start-Up, normal operation, and shut-down. When such conditions occur

that match the conditions indicated on Form NX-12D, this serves as advance standing notification and Real-Time reporting is not required

Plant Voltage Control Document

All generators that employ an overall plant voltage control scheme (including but not limited to wind plant controllers and combined cycle distributed control systems) shall upload a file containing a detailed explanation of the voltage control scheme into the NX software.

OP-14 Appendix B 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
Rev 1	10/23/98	
Rev 2	05/28/04	
Rev 3	02/01/05	Updated to conform to RTO Terminology
Rev 4	04/05/07	Revised for Schedule 2 VAR process changes and annual review
Rev 5	09/09/11	Minor format, grammar changes, added Table of Contents, added uncontrolled disclaimers; Updated with enhanced NX-12D form, additional information regarding the data required in the form and requirement to submit an updated form annually. Add requirement that every unique generator must submit an NX-12D. Clean up language describing the information that is required to be submitted on the form
Rev 6	10/07/13	Minor changes consistent with current practices and management expectations i.e., editorial, format, grammar, punctuation, etc); Update for VAR-002-2b Requirement R1 changes
Rev 7	12/09/13	Updated to reflect change from excel spreadsheet to software submittal. Major format, content changes.
Rev 8	12/12/14	Added References Section for all documents referred to in this document contents; Globally defined acronym "MP" for Market Participant in 1 st use and made consistent use of Lead "MP" in remaining instances and made consistent use of the term "generating unit" where applicable; Changes made for all units required to provide NX-12D information; Changes made from "December 1 deadline" for certification to "as requested"; Clarified voltage schedule requirements
Rev 9	02/18/16	Corrected OP-14 title in headers; Modified Generator Voltage Schedule section to reflect changes in NX software capabilities;
Rev 9.1	09/19/16	Periodic review performed requiring no content changes; Added required corporate document identity to all Footers;
Rev 10	06/01/18	Periodic review by procedure owner; Globally, made editorial modifications to be consistent with current conditions, practices, and management expectations; Globally, replaced "Demand Resources" with "Demand Response Resources"; Nameplate Operating ReactiveCapability Data section (for Figure 1) and Normal Operating Reactive Capability Data section (for Figure 2), the 2 nd paragraph data for both sections have been updated to reference using most restrictive temperature curve and 1.0 p.u. voltage curve;