ISO new england

Operating Procedures

ISO New England Operating Procedure No. 14

Technical Requirements for Generators,Demand Resources and Asset Related Demands – Appendix B – Generator Reactive Data Explanation of Terms and Instructions for Data Preparation for ISO Form NX-12D

Effective Date: September 9, 2011
Revision No. 5

APPENDIX B -GENERATOR REACTIVE DATA EXPLANATION OF TERMS AND INSTRUCTIONS FOR DATA PREPARATION FOR ISO FORM NX-12D

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GENERAL INFORMATION

The NX-12D Generator Reactive Data form requests entry of ***gross*** Generator reactive output (MVAR) based on both the manufacturers' nameplate capability and on the Generator normal operating capability. The Generator nameplate lagging and leading MVAR output capability is based on the design parameters of the Generator field winding, end turn winding and stator. This capability represents the theoretical maximum reactive capability of a specific Generator.

The Generator nameplate operating lagging and leading MVAR output capability ***can be*** limited by any one of several devices or considerations other than Generator field winding, end turn winding or stator design. 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, GSU and/or transmission restrictions, contractual arrangements, etc. In all of these cases, the Generator ***can not operate*** at the manufactures' nameplate reactive capability. This restricted capability represents the normal reactive operating capability. Having both sets of reactive data, nameplate and normal, will allow identification of Generators where potential upgrades may be justified to enhance system reliability.

The reactive data is required for:

- All Generators, or collection of Generators having the same interconnection point, having a real power output in excess of 10 MW (Excluding Generators registered as Settlement Only Generators)
- All nuclear Generators

Data is required for each Generator comprising a defined Generator that meets these data submittal guidelines. Every individual generating unit must submit an NX-12D even if multiple generating units comprise a single market asset.

  - However, noting that wind turbines can be identical in manufacture, wind turbines may submit one representative NX12D for identical turbines at a single interconnection point. The number of common turbines at that interconnection point must also be provided.

Data is required where a Generator’s normal reactive operating capability is substantially affected by infrequent abnormal system conditions, (i.e., line-out conditions, a Generator outage at a defined Generator, seasonal fuel type conversion, etc.) that are not specifically covered by existing guides, procedures or criteria, a second complete set of data highlighting the limitations should be provided.

Any change in a defined Generator’s MVAR capability or voltage schedule shall be reported through normal Generator - Local Control Center - ISO New England channels to insure reliable system operation. If it is determined that the change will last longer than one month, a revised NX-12D Attachment highlighting the change shall be submitted.

Annually, an updated NX-12D attachment shall be submitted before December 1 of each calendar year.

DATA SUBMITTAL INSTRUCTIONS

All data on the NX-12D Generator Reactive Data Form shall be verified as correct upon submittal and at least annually

Reactive Capability - The ability of a Generator to supply gross lagging and/or leading MVAR capability to the transmission network.

MVAR Output Level - The gross reactive power output of a Generator over a range of different gross real power (MW) output levels.

MW Output Level - The gross real power output levels corresponding to reported MVAR data. This relationship is demonstrated in the sample figures provided below.

Maximum MVAR Lagging - The maximum amount of lagging reactive power that can be delivered to the system (overexcited state), as measured at the Generator leads for various levels of real power output. Generator lagging capability is expressed in terms of field design limitations at the lower Generator MW outputs and stator design limitations at the higher MW outputs. In Figure 1 below, point #4 represents the transition between the two lagging curve sections based on field verses stator limits respectively.

Maximum MVAR Leading - The maximum amount of leading reactive power that can be delivered to the system (underexcited state), as measured at the Generator leads for particular levels of real power output. Generator leading capability is expressed in terms of end turn winding design limitations at the lower Generator MW outputs and stator design limitations at the higher MW outputs.

Table 1: NX-12D Generator Reactive Data Form

NX-12D GENERATOR REACTIVE DATA FORM

1. Data Preparation Documentation

Generator Name	Asset ID	Unit No.***	# wind units ^	Lead Participant	LCC

Prepared By	Date Prepared	Effective Date	Contact Phone #	Contact E-mail

AVR installed and normal operating mode is in automatic controlling voltage?

2. Reactive Capability Information

Theoretical Values:**	Nameplate Reactive Capability				Normal Operating Reactive Capability**				Station Service Load	
	Lagging (MVAR value positive)		*Leading (MVAR value negative)*		*Lagging (MVAR value positive)*		*Leading (MVAR value negative)*			
MW Output Reference	MW	MVAR	MW	MVAR	MW	MVAR	MW	MVAR	MW	MVAR
Minimum Manual Load Point										
Intermediate Load Point										
Three Quarter Load Point										
Break Point Load										
Transitional Load Point										
Unity Generating Unit Power Factor Load Point (N/A for Normal Operating if same as Nameplate)		0		0						
Summer Seasonal Claimed Capability Load Point										
EcoMin Load Point										
Motoring Capability										
Full Pumping Capability										

Tested Values:	Tested Reactive Capability (MVAR Lag is positive, Lead is negative)		Station Service		Date Tested
MW Output Reference	MW	MVAR	MW	MVAR	mm/dd/yyyy
At S-SCC Load Point - Lag Test					
At EcoMin Load Point - Lead Test					

	Values at Rated MVA and Rated Power Factor from Interconnection Agreement	
	MW	MVAR
Lagging		
Leading		

KEY
- Positive Number
- Negative Number
- Positive or N/A
- Negative or N/A
- Zero
- Zero or N/A
- Freeform Text
- Text
- Dropdown
- Add/Delete fields

For specific note explanation please see notes within OP-14 Appendix B.

*** *A separate form is required for each unique unit that is part of a particular asset*

^ *Number of wind turbines with the same characteristics at the same interconnection point*

** *For Normal Operating values all data must be adjusted to reflect the facility's MEL settings or other limitations.*

Notes:

3. Generator Interconnection Impedance

Impedance values reflect those between the generating unit GSU highside terminal through the network to the interconnecting bulk transmission bus *All Values Supplied should be in Percent on a 100 MVA Base*		
Resistance R	Reactance X	Susceptance B
GSU Parameters in Percent on a 100 MVA Base		
Resistance R	Reactance X	Tap Position in Per Unit
Bus Loading Not Explicitly Modeled on Equivalent Network		
MW	MVAR	Shunt Admittance

4. Generator Voltage Schedules

Heavy Load Season Regulated Bus Voltages in kV		Light Load Season Regulated Bus Voltages in kV	
0700-2200 Monday-Saturday except Holidays		All other hours	
Highside Scheduled Voltage	Min/Max Acceptable Voltage Range	Highside Scheduled Voltage	Min/Max Acceptable Voltage Range
Terminal Bus Voltages in kV		Terminal Bus Voltages in kV	

5. Generating unit capability curve.

Please Attach a .jpg image from the generating unit capability D curve with V and Q as axis (curve should include nameplate and normal operating restrictions)

Cells have been shaded to assist in the completion of the form. There are also validations embedded in the form to minimize user entry errors. This will assist in the completion and processing of the form by requiring the submitter to enter the proper type of data in each of the data fields.

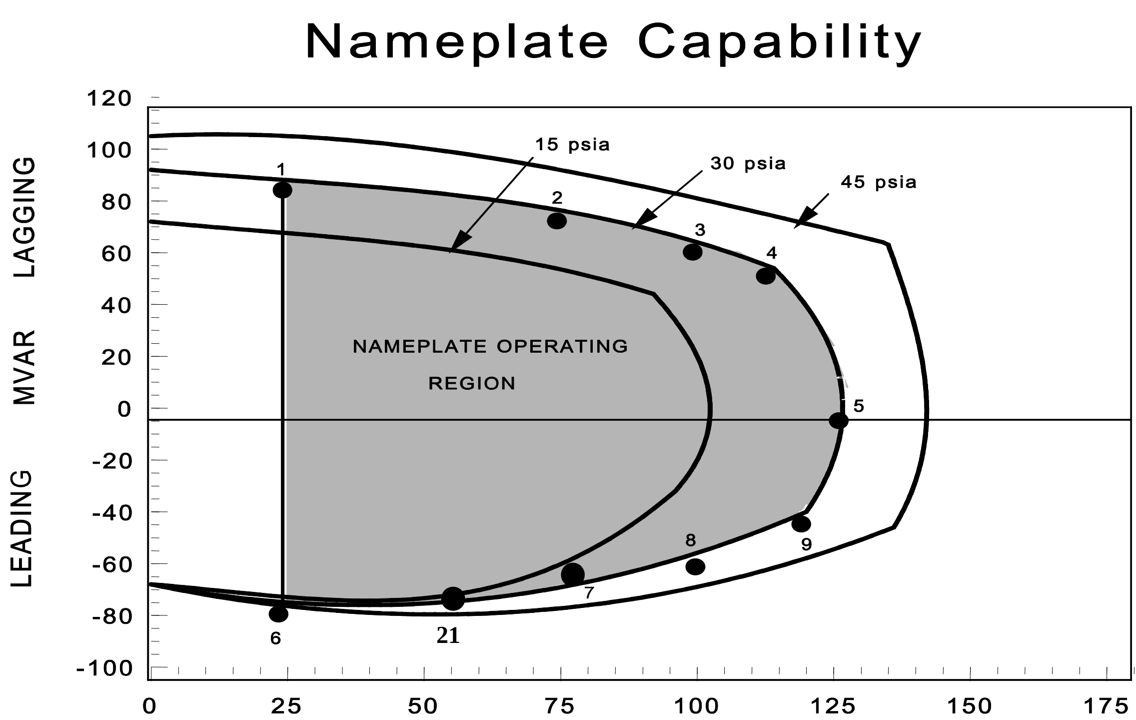
Section 1:

Generator Name: Generator Name as registered with ISO New England
Unit No.: Designation of specific physical machine if part of a multiple unit station (May be multiple designations for wind)
Wind Units: The number of common wind turbines at a single interconnection point
Asset ID: Asset ID as provided by ISO New England
Lead Participant: Lead Market Participant (LMP) as defined in ISO New England OATT
LCC: Local Control Center to which Asset is assigned
Prepared By: Author of form
Date Prepared: Date form was prepared by Author
Effective Date: Date that the LMP wishes the form to be effective. This must be at least five (5) business days after the form will be received at the ISO
Contact Phone #: Phone number to contact at Asset regarding questions about NX-12D form
Contact Email: Email address to contact at Asset regarding questions about NX-12D form
Automatic Voltage Regulation equipment installed?
State whether the unit has Automatic Voltage Regulation equipment installed, on automatic and controlling voltage

Section 2:

Figure #1 demonstrates typical nameplate capability curves for a sample Generator at various hydrogen pressures when not encumbered by any protective or limiting concerns. The sample Generator is designed to operate at 30 psia Hydrogen pressure level.

Figure 1 - Typical Capability Curve for a Turbine Generator at Various Hydrogen Pressures



Hard Copy Is Uncontrolled

For Generator nameplate capability, the case where the Generator reactive capability is design limited, the requested data consists of nine points (#1 through #9) along the capability curve (see figure #1).

- Point #1 is the maximum MVAR lagging capability at minimum manual Generator MW output (use the lower of the winter or summer minimum manual MW output capability).
- Point #2 is the maximum MVAR lagging capability at the intermediate MW output. Intermediate MW output is defined as the mid-point between the maximum MW output of the Generator at unity MPF point #5, (no lagging or leading capability), and the minimum manual MW output value used for Point #1.
- Point #3 is the maximum MVAR lagging capability at the three quarter MW output. Three quarter MW output is defined as 75% between the maximum MW output of the Generator at unity MPF point #5, (no lagging or leading capability), and the minimum manual MW output value used for Point #1.
- Point #4 is the maximum MVAR lagging capability at the reactive curve break point (point of transition between the two lagging curve sections based on field winding verses stator design limits).
- Point #5 is the maximum MW capability of the Generator at unity MPF, (no lagging or leading capability).
- Point #6 is the maximum MVAR leading capability at minimum manual Generator MW output (this is the same MW output used for Point #1).
- Point #7 is the maximum MVAR leading capability at the intermediate MW output. Intermediate MW output is defined as the mid-point between the maximum MW output of the Generator at unity MPF point #5, (no lagging or leading capability). This is the same MW output used for Point #2.
- Point #8 is the maximum MVAR leading capability at the three quarter MW output. Three quarter MW output is defined as 75% between the maximum MW output of the Generator at unity MPF point #5, (no lagging or leading capability). This is the same MW output used for Point #3.
- Point #9 is the maximum MVAR leading capability at the reactive curve break point (point of transition between the two lagging curve sections based on end turn winding verses stator design limits). Points #9 and #4, the two break points, do not necessarily correspond to the same MW output of the Generator.
- Point #21 is the most restrictive maximum MVAR leading capability attainable at the EcoMin MW output. Figure #1 shows a relative point where this capability may occur, but is dependent on Generator EcoMin offers.

Figure 2 - Typical Capability Curve for a Turbine Generator at Rated Hydrogen Pressure

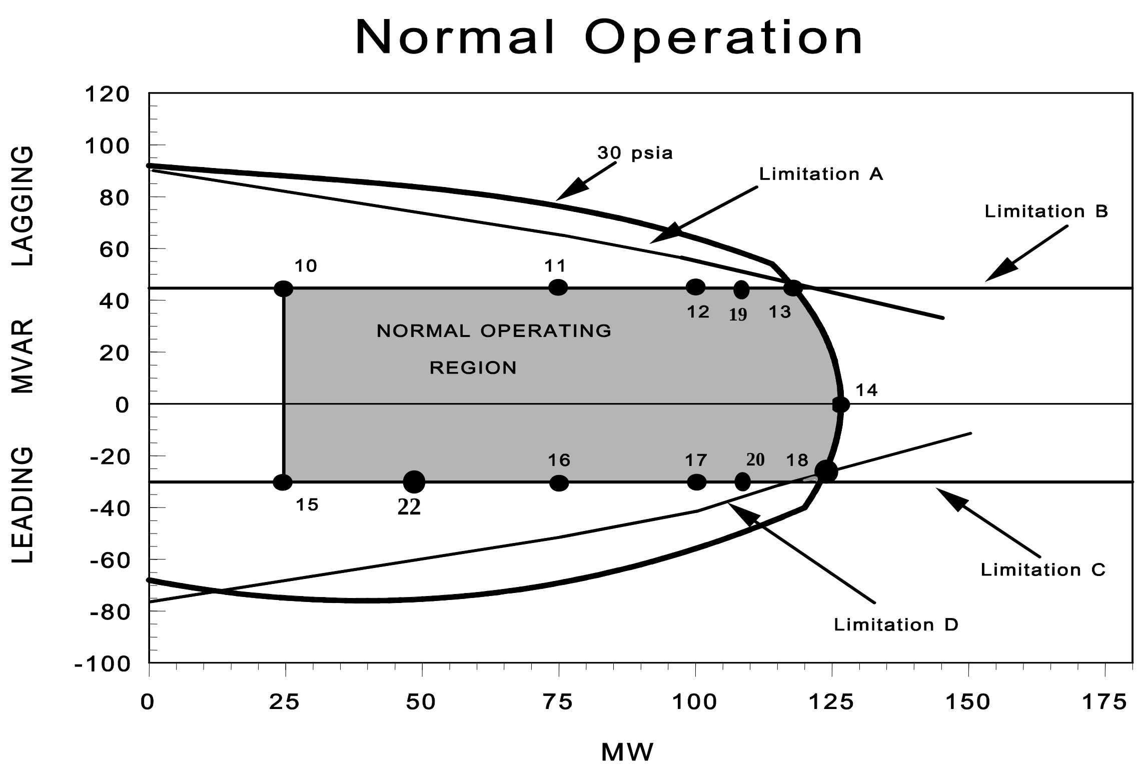


Figure #2 shows the same Generator nameplate capability curve when the nameplate lagging and/or leading capability is limited by any one of several devices or considerations other than Generator field or stator design limits. In this case, Generator can not operate at some or all of the design nameplate capability indicated in Figure #1. The sample Generator is designed to operate at 30 psia Hydrogen pressure.

These capability curves represent MW and MVAR output levels as measured at the Generator leads (prior to station service). For the purposes of data reporting, gross MW and MVAR output levels should be reported. To facilitate data submittal, Generator capability curves should be attached to the NX-12D form.

For the Generator normal operating capability, the case where the Generator reactive capability is limited by devices or considerations other than design parameters, the Generator's output can be derived from the detailed capability curve similar to the sample shown in Figure 2. The requested data consists of nine points (points #10 through #18) along the capability curve. For each of these points, the actual lagging and leading capability is less than that indicated by the corresponding points 1 through 9 on the sample Generator capability curve shown in figure #1. Figure #2 shows the effect on the actual Generator curve when it is restricted by example limitations A through D. If the Generator was not limited at any of the corresponding MW output values by these limitations, then by default, the normal operating capability would be the same as the manufactures nameplate capability and no additional reactive data would be required.

- Point #10 is the most restrictive maximum MVAR lagging capability attainable at minimum manual Generator MW output (the same corresponding MW output as in point #1, Figure #1).

- Point #11 is the most restrictive maximum MVAR lagging capability attainable at intermediate MW output (the same corresponding MW output as in point #2, Figure #1).

- Point #12 is the most restrictive maximum MVAR lagging capability attainable at three quarter MW output (the same corresponding MW output as in point #3, Figure #1).

- Point #13 is the most restrictive maximum MVAR lagging capability attainable where the limitation is the point where the limiting concern of the B constraint line intersects the Generator capability curve. This is not technically a break point in the true sense of the definition but merely the intersection of two limitations. Point #13 and point #4, Figure #1; do not necessarily correspond to the same MW output of the Generator.

- Point #14 is the maximum MW capability of the Generator at unity MPF, (no lagging or leading capability). Generally this point would be the same as point #5, Figure #1. An example of where point #14 and point #5 would differ is the case where a generating unit is operated at a lower hydrogen pressure that it was designed for.

- Point #15 is the most restrictive maximum MVAR leading capability attainable at minimum manual generating unit MW output (the same corresponding MW output as in point #6, Figure #1).

- Point #16 is the most restrictive maximum MVAR leading capability attainable at intermediate MW output (the same corresponding MW output as in point #7, Figure #1).

- Point #17 is the most restrictive maximum MVAR leading capability attainable at three quarter MW output (the same corresponding MW output as in point #8, Figure #1).

- Point #18 is the most restrictive maximum MVAR leading capability attainable where the limitation is the point the constraint line of limiting concern B intersects the Generator capability curve. This is not technically a break point in the true sense of the definition but merely the intersection of two limitations. Point #18 and point #9, Figure #1, do not necessarily correspond to the same MW output of the Generator.

- Point #19 is the most restrictive maximum MVAR lagging capability attainable at Summer Seasonal Claimed Capability MW output.

- Point #20 is the most restrictive maximum MVAR leading capability attainable at Summer Seasonal Claimed Capability MW output.

- Point #22 is the most restrictive maximum MVAR leading capability attainable at the EcoMin MW output. Figure #2 shows a relative point where this capability may occur, but is dependent on Generator EcoMin offers.

Nameplate Operating Reactive Capability:

Data provided by the manufacturer

Normal Operating Reactive Capability

Provide only if reactive capability is limited by any one of several limiting devices or considerations to levels less than the manufactures nameplate. This data form assumes a Generator can operate between its listed maximum lagging capability and zero MVAR. If for some reason, a Generator must maintain a minimum lagging MVAR output and cannot operate down to zero output, please indicate in the Notes section.

Station Service Load

Provide the larger of the two gross MW and MVAR station service loads for operation at either the summer or winter full load capability (maximum MW output).

Minimum Manual Load Point

For the Minimum Manual Load Point, use the lower of the winter or summer generating unit minimum manual MW output capability.

Intermediate Load Point

For the Intermediate Load Point, use the mid-point between the maximum MW output of the Generator at unity

MPF, (no lagging or leading capability), and the minimum manual MW output value defined in note #3.

Three Quarter Load Point

For the Three Quarter Load Point, use the three quarter point between the maximum MW output of the Generator at unity MPF, (no lagging or leading capability), and the minimum manual MW output value defined in note #3.

Break Point Load

Nameplate points #4 and #9 do not necessarily correspond to the same value of real power output of the Generator. Specification of the lagging MW and leading MW level of operation may be required.

Transitional Load Point

Normal Operating points #13 and #18 do not necessarily correspond to the same value of real power output of the Generator. Specification of the lagging MW and leading MW level of operation may be required.

Unity Generating Unit Power Factor Load Point

It is possible to have two valid MW entries for the unity MPF point (points #5 and #14). Example: Nameplate operation of the Generator 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. Please provide both the Nameplate and Normal MW values in the space provided for in the table. If Nameplate and Normal Capabilities are the same, then Normal shall be N/A on the form.

Summer Seasonal Claim Capability Load Point

Reactive Capability at Summer Seasonal Claim Capability. For new generators, this will be an estimated value until first Summer Seasonal Claim Capability Audit is complete

EcoMin Load Point

Reactive Capability at most restrictive anticipated normally bid EcoMin Load Point

Lagging Test at S-SCC Point

Values obtained during testing

Leading Test at EcoMin Load Point

Values obtained during testing

Normal Operating Reactive Capability

Normal Operating Points # 21 and # 22 represent the most restricted Normal Operating Reactive Capability of the generating unit corresponding to the EcoMin value.

Maximum MVAR leading and lagging while motoring (HYDRO GENERATOR S ONLY) –

Motoring is the term given to a Hydro Generator that can operate as a synchronous condenser and therefore are operating at a zero MW output. In this case, please provide the maximum leading and lagging MVAR capability of the Generator while motoring.

Maximum MVAR leading and lagging while pumping (Dispatchable Asset Related Demands (DARDs)ONLY) –

Pumping is the term given to a DARD that can operate as a motor used to pump water back in to the reservoir. In this case please provide the maximum leading and lagging MVAR capability of the DARD in the full pump mode.

Notes –

Provide any extra data not captured in the form including: information regarding the difference between the nameplate and normal operating reactive capabilities, i.e. identification of limiting equipment, contractual arrangements, operational requirements, etc..

Values at Rated MVA and Rated Power Factor from Interconnection Agreement

Values submitted on the most recent approved and implemented Interconnection Agreement with ISO New England. (e.g. a generator rated at 100MVA and required by I.A. to have a 0.95 lagging power factor and a 0.95 leading power factor would have lagging 95MW 31MVAR, leading 95MW -31 MVAR)

Section 3:

Generator Interconnection Impedance -

For Generators Not Directly Connected to The Bulk Transmission - Data for the equivalent impedance from Generator terminals to the nearest bulk transmission substation must be provided. If the Generator has a GSU, the GSU impedance should be modeled separately from the equivalent transmission impedance.

When a Generator is connected to the system via equivalent impedance, it is possible there may be intermediate busses between the Generator and the bulk transmission system that are not explicitly modeled. These busses may have load and/or shunt that could reduce the contribution of the Generator as seen by the bulk transmission system. To accurately capture this effect, a composite of the loads and shunts that are not modeled in detail should be represented on the Generator bus.

Impedance values reflect those between the generating unit GSU high side terminal through the network to the interconnecting bulk transmission bus

If there is a generating unit step-up transformer, include its impedance separate from the equivalent transmission impedance. Also include the GSU tap position. If a GSU is not present the middle row of this table need not be completed.

Bus Loading Not Explicitly Modeled on Equivalent Network

When a generating unit is connected via an 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 should be modeled on the generating unit bus to accurately capture the net generating unit contribution to the network.

Section 4:

Generator Voltage Schedule - Generator voltage schedule information must be provided for all Generators. If a Generator is directly connected to the bulk transmission system, (69 kV and above) or is connected to the bulk transmission system via an equivalent impedance that includes a series GSU, then a high side regulated bus voltage schedule and a minimum to maximum acceptable high side voltage range is required. When the Generator is controlling high side voltage across a transformer, there may also be a voltage constraint on the low voltage Generator terminals; therefore, a minimum to maximum acceptable voltage operating range at the Generator terminals is also required.

If a Generator is connected to the bulk transmission system via an equivalent impedance that does not have an imbedded GSU, then only provide a terminal bus voltage schedule and a minimum to maximum acceptable terminal voltage range.

In the case of a Dispatchable Asset Related Demand that can operate in the pumping mode, similar voltage scheduling information as that provided for generation mode should be provided for pumping mode.

Any minimum to maximum acceptable voltage range should accurately reflect restrictions on Generator operation, i.e., terminal voltage constraints, auxiliary equipment limitations, station service requirements, GSU and transmission restrictions and/or contractual arrangements, etc.

Heavy Load (Light Load) Season Regulated Bus Voltages in kV

Generating unit voltage schedule information must be provided for all generating units. If a generating unit is directly connected to the bulk transmission system, (69 kV and above) or is connected to the bulk transmission system via an equivalent impedance that includes a series GSU, (see section 2), then a high side regulated bus voltage schedule and a minimum to maximum acceptable high side voltage range is required. When the generating unit is controlling voltage across a transformer, there may also be a voltage constraint on the low voltage generating unit terminals; therefore, a minimum to maximum acceptable generating unit terminal voltage range is also required.

If a generating unit is connected to the bulk transmission system via an equivalent impedance and does not have a series GSU, then only provide a generating unit terminal bus voltage schedule and a minimum to maximum acceptable terminal voltage range.

Min/Max Acceptable Voltage Range

The minimum to maximum acceptable voltage ranges should accurately reflect restrictions on generating unit operation, i.e., terminal voltage constraints, auxiliary equipment limitations, station service requirements, GSU and transmission restrictions and/or contractual arrangements, etc.

Section 5

Attach the generating unit reactive capability curve provided by the manufacturer indicating any additional limitations restricting the unit. Curve shall be in .jpg format.

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