

Standard Development Timeline

This section is maintained by the drafting team during the development of the standard and will be removed when the standard is adopted by the NERC Board of Trustees (Board).

Description of Current Draft

This is the second draft of the proposed standard being posted for a formal 45-day comment period and additional ballot.

Completed Actions	Date
Standards Committee approved Standard Authorization Request (SAR) for posting	January 20, 2021
SAR posted for comment	March 4 – April 2, 2021
45-day formal or informal comment period with ballot	September – November 2022

Anticipated Actions	Date
45-day formal or informal comment period with additional ballot	April – June 2023
10-day final ballot	July 2023
Board adoption	August 2023

New or Modified Term(s) Used in NERC Reliability Standards

This section includes all new or modified terms used in the proposed standard that will be included in the *Glossary of Terms Used in NERC Reliability Standards* upon applicable regulatory approval. Terms used in the proposed standard that are already defined and are not being modified can be found in the *Glossary of Terms Used in NERC Reliability Standards*. The new or revised terms listed below will be presented for approval with the proposed standard. Upon Board adoption, this section will be removed.

Term(s):

None.

A. Introduction

1. **Title:** Verification of Real and Reactive Power Capability for BES Facilities
2. **Number:** MOD-025-3
3. **Purpose:** To ensure that accurate information on Bulk Electric System (BES) Facility Real and Reactive Power capability is available for planning models used to assess BES reliability.
4. **Applicability:**
 - 4.1. **Functional Entities:**
 - 4.1.1 Generator Owner
 - 4.1.2 Transmission Owner
 - 4.1.3 Transmission Planner
 - 4.2. **Facilities:** For the purpose of this standard, the term “applicable Facility” or “Facility” shall mean any one of the following:
 - 4.2.1 Individual generating resource identified through Inclusion I2 of the BES definition.
 - 4.2.2 Generating plant/Facility identified through Inclusion I2 of the BES definition.
 - 4.2.3 Generating plant/Facility of dispersed power producing resources identified through Inclusion I4 of the BES definition.
 - 4.2.4 Dynamic reactive devices identified through Inclusion I5 of the BES definition with a gross (individual or aggregate) nameplate rating greater than 20 MVA including, but not limited to:
 - 4.2.4.1 Synchronous condenser; and
 - 4.2.4.2 Flexible alternating current transmission system (FACTS) devices.
 - 4.2.5 High-voltage direct current (HVDC) terminal equipment including:
 - 4.2.5.1 Voltage source converter (VSC).
 - 4.2.6 Facilities meeting an exclusion of the BES definition are exempt as an applicable Facility.
5. **Effective Date:** see Implementation Plan.

B. Requirements and Measures

- R1.** Each Generator Owner shall verify the Real Power and Reactive Power capability of its applicable Facilities and inform its Transmission Planner as follows: *[Violation Risk Factor: Medium] [Time Horizon: Long-term Planning]*
- 1.1.** Verify the Real Power capability, if applicable, of its applicable Facilities in accordance with Attachment 1.
 - 1.2.** Verify the Reactive Power capability of its applicable Facilities in accordance with Attachment 1.
 - 1.3.** Submit the following information, in accordance with Attachment 2, to the Transmission Planner within 30 calendar days after the verification date. The verification date, as specified in Attachment 2, should represent the date that the engineering review or engineering analysis is complete. The verification date is the basis of the recurring periodicity.
 - 1.3.1.** Simplified one-line diagram representing the applicable Facility;
 - 1.3.2.** Composite capability curve and associated PQ data table; and
 - 1.3.3.** Documentation of the underlying assumptions, design criteria, and methods for the chosen verification methodology from Attachment 1.
- M1.** Each Generator Owner shall have evidence that it verified Real Power and Reactive Power capability of each applicable Facility, such as completed attachments or summary report(s); and have evidence that it submitted the information within 30 calendar days after the verification date to its Transmission Planner in accordance with Requirement R1.
- R2.** Each Transmission Owner shall verify the Real Power and Reactive Power capability of its applicable Facilities and inform its Transmission Planner as follows: *[Violation Risk Factor: Medium] [Time Horizon: Long-term Planning]*
- 2.1.** Verify the Real Power capability, if applicable, of its applicable Facilities in accordance with Attachment 1.
 - 2.2.** Verify the Reactive Power capability of its applicable Facilities, in accordance with Attachment 1.
 - 2.3.** Submit the following information, in accordance with Attachment 2, to the Transmission Planner within 30 calendar days after the verification date. The verification date, as specified in Attachment 2, should represent the date that the engineering review or engineering analysis is complete. The verification date is the basis of the recurring periodicity.
 - 2.3.1.** Simplified one-line diagram representing the applicable Facility;
 - 2.3.2.** Composite capability curve and associated PQ data table; and

2.3.3. Documentation of the underlying assumptions, design criteria, and methods for the chosen verification methodology from Attachment 1.

- M2.** Each Transmission Owner shall have evidence that it verified Real Power and Reactive Power capability of each applicable Facility, such as completed attachments or summary report(s); and have evidence that it submitted the information within 30 calendar days after the verification date to its Transmission Planner in accordance with Requirement R2.
- R3.** Each Transmission Planner shall review the information submitted by each Generator Owner or Transmission Owner in accordance with Requirement R1, R2, or R4 and provide a written response to the submitter within 90 calendar days from receiving each submission. The written response shall contain one of the following: *[Violation Risk Factor: Lower] [Time Horizon: Operations Planning]*
- Notification that the Transmission Planner has reviewed the information and has not identified any technical concerns with the Real and Reactive Power capability information submitted by the Generator Owner or Transmission Owner; or
 - Notification that the Transmission Planner has reviewed the information and has identified a technical concern, including the basis for the technical concern.
- M3.** Each Transmission Planner shall have evidence, such as a summary of items reviewed and dated correspondence of the notification, that it reviewed the information submitted and provided notification to the Generator Owner or Transmission Owner within 90 calendar days in accordance with Requirement R3.
- R4.** Each Generator Owner or Transmission Owner receiving a notification of a technical concern under Requirement R3 shall provide a written response to its Transmission Planner within 90 calendar days from receiving a notification. The written response shall contain one of the following: *[Violation Risk Factor: Lower] [Time Horizon: Operations Planning]*
- Updated capability information in accordance with Requirement R1 or R2;
 - A plan to update the capability information in accordance with Requirement R1 or R2; or
 - Technical justification and supporting evidence for maintaining the existing capability information in accordance with Requirement R1 or R2.
- M4.** Each Generator Owner or Transmission Owner shall have evidence that it responded to the Transmission Planner within 90 calendar days in accordance with Requirement R4.

C. Compliance

1. Compliance Monitoring Process

1.1. Compliance Enforcement Authority: “Compliance Enforcement Authority” means NERC or the Regional Entity, or any entity as otherwise designated by an Applicable Governmental Authority, in their respective roles of monitoring and/or enforcing compliance with mandatory and enforceable Reliability Standards in their respective jurisdictions.

1.2. Evidence Retention: The following evidence retention period(s) identify the period of time an entity is required to retain specific evidence to demonstrate compliance. For instances where the evidence retention period specified below is shorter than the time since the last audit, the Compliance Enforcement Authority may ask an entity to provide other evidence to show that it was compliant for the full-time period since the last audit.

The applicable entity shall keep data or evidence to show compliance as identified below unless directed by its Compliance Enforcement Authority to retain specific evidence for a longer period of time as part of an investigation.

- Each Generator Owner shall keep data or evidence of Requirement R1 since the most current verification for each applicable BES Facility.
- Each Transmission Owner shall keep data or evidence of Requirement R2 since the most current verification for each applicable BES Facility.
- Each Transmission Planner shall keep data or evidence of Requirement R3 for a rolling 12 month period.
- Each Generator Owner and Transmission Owner shall keep data or evidence of Requirement R4 for a rolling 12 month period.

1.3. Compliance Monitoring and Enforcement Program: As defined in the NERC Rules of Procedure, “Compliance Monitoring and Enforcement Program” refers to the identification of the processes that will be used to evaluate data or information for the purpose of assessing performance or outcomes with the associated Reliability Standard.

Violation Severity Levels

R #	Violation Severity Levels			
	Lower VSL	Moderate VSL	High VSL	Severe VSL
R1.	<p>The applicable entity provided all items in Requirement R1 Part 1.3, but did so between 31 and 90 calendar days after the verification date.</p> <p>OR</p> <p>The applicable entity verified the Real and Reactive Power capability in Part 1.1 and 1.2, per Attachment 1 Section 1 Item 3, but did so between 120 calendar months and 126 calendar months.</p> <p>OR</p> <p>The applicable entity verified the Real and Reactive Power capability in Part 1.1 and 1.2, per Attachment 1 Section 1 Item 2, 4, or 5, but did so between 181 and 270 calendar days.</p>	<p>The applicable entity provided all items in Requirement R1 Part 1.3, but did so between 91 and 180 calendar days after the verification date.</p> <p>OR</p> <p>The applicable entity verified the Real and Reactive Power capability in Part 1.1 and 1.2, but failed to include the information required in Requirement R1, Part 1.3.1.</p> <p>OR</p> <p>The applicable entity verified the Real and Reactive Power capability in Part 1.1 and 1.2, per Attachment 1 Section 1 Item 3, but did so between 127 and 132 calendar months.</p> <p>OR</p> <p>The applicable entity verified the Real and Reactive Power capability in Part 1.1 and 1.2, per Attachment 1 Section 1 Item 2, 4, or 5, but did so</p>	<p>The applicable entity provided all items in Requirement R1 Part 1.3, but did so between 181 and 270 calendar days after the verification date.</p> <p>OR</p> <p>The applicable entity verified the Real and Reactive Power capability in Part 1.1 and 1.2, but failed to include the information required in Requirement R1, Part 1.3.3.</p> <p>OR</p> <p>The applicable entity verified the Real and Reactive Power capability in Part 1.1 and 1.2, per Attachment 1 Section 1 Item 3, but did so between 133 and 138 calendar months.</p> <p>OR</p> <p>The applicable entity verified the Real and Reactive Power capability in Part 1.1 and 1.2, per Attachment 1 Section 1 Item 2, 4, or 5, but did so</p>	<p>The applicable entity provided all items in Requirement R1 Part 1.3, but did so greater than 270 calendar days after the verification date.</p> <p>OR</p> <p>The applicable entity verified the Real and Reactive Power capability in Part 1.1 and 1.2, but failed to include the information required in Requirement R1, Part 1.3.2.</p> <p>OR</p> <p>The applicable entity verified the Real and Reactive Power capability in Part 1.1 and 1.2, per Attachment 1 Section 1 Item 3, but did so in more than 138 calendar months.</p> <p>OR</p> <p>The applicable entity verified the Real and Reactive Power capability in Part 1.1 and 1.2, per Attachment 1 Section 1</p>

R #	Violation Severity Levels			
	Lower VSL	Moderate VSL	High VSL	Severe VSL
		between 271 and 360 calendar days.	between 361 and 450 calendar days.	Item 2, 4, or 5, but did so in more than 450 calendar days. OR The applicable entity failed to verify the Real and/or Reactive Power capability in Part 1.1 and 1.2.
R2.	<p>The applicable entity provided all items in Requirement R2 Part 2.3, but did so between 31 and 90 calendar days after the verification date.</p> <p>OR</p> <p>The applicable entity verified the Real and Reactive Power capability in Part 2.1 and 2.2, per Attachment 1 Section 1 Item 3, but did between 120 and 126 calendar months.</p> <p>OR</p> <p>The applicable entity verified the Real and Reactive Power capability in Part 2.1 and 2.2, per Attachment 1 Section 1 Item 2, 4, or 5, but did so between 181 and 270 calendar days.</p>	<p>The applicable entity provided all items in Requirement R2 Part 2.3, but did so between 91 and 180 calendar days after the verification date.</p> <p>OR</p> <p>The applicable entity verified the Real and Reactive Power capability in Part 2.1 and 2.2, but failed to include the information required in Requirement R2, Part 2.3.1.</p> <p>OR</p> <p>The applicable entity verified the Real and Reactive Power capability in Part 2.1 and 2.2, per Attachment 1 Section 1 Item 3, but did so between 127 and 132 calendar months.</p> <p>OR</p>	<p>The applicable entity provided all items in Requirement R2 Part 2.3, but did so between 181 and 270 calendar days after the verification date.</p> <p>OR</p> <p>The applicable entity verified the Real and Reactive Power capability in Part 2.1 and 2.2, but failed to include the information required in Requirement R2, Part 2.3.3.</p> <p>OR</p> <p>The applicable entity verified the Real and Reactive Power capability in Part 2.1 and 2.2, per Attachment 1 Section 1 Item 3, but did so between 133 and 138 calendar months.</p> <p>OR</p>	<p>The applicable entity provided all items in Requirement R2 Part 2.3, but did so greater than 270 calendar days after the verification date.</p> <p>OR</p> <p>The applicable entity verified the Real and Reactive Power capability in Part 2.1 and 2.2, but failed to include the information required in Requirement R2, Part 2.3.2.</p> <p>OR</p> <p>The applicable entity verified the Real and Reactive Power capability in Part 2.1 and 2.2, per Attachment 1 Section 1 Item 3, but did so in more than 138 calendar months.</p> <p>OR</p>

R #	Violation Severity Levels			
	Lower VSL	Moderate VSL	High VSL	Severe VSL
		The applicable entity verified the Real and Reactive Power capability in Part 2.1 and 2.2, per Attachment 1 Section 1 Item 2, 4, or 5, but did so between 271 and 360 calendar days.	The applicable entity verified the Real and Reactive Power capability in Part 2.1 and 2.2, per Attachment 1 Section 1 Item 2, 4, or 5, but did so between 361 and 450 calendar days.	The applicable entity verified the Real and Reactive Power capability in Part 2.1 and 2.2, per Attachment 1 Section 1 Item 2, 4, or 5, but did so in more than 450 calendar days. OR The applicable entity failed to verify the Real and/or Reactive Power capability in Part 2.1 and 2.2.
R3.	The Transmission Planner provided a written response to the submitter, but it was provided between 91 to 120 calendar days after receiving the verified model information.	The Transmission Planner provided a written response to the submitter, but it was provided between 121 to 150 calendar days after receiving the verified model information.	The Transmission Planner provided a written response to the submitter, but it was provided between 151 to 180 calendar days after receiving the verified model information.	The Transmission Planner failed to provide a written response to the submitter. OR The Transmission Planner provided a written response to the submitter but it was provided more than 180 calendar days after receiving the verified model information.
R4.	The applicable entity provided a written response to its Transmission Planner, but it was provided between 91 to 120 calendar days after	The applicable entity provided a written response to its Transmission Planner, but it was provided between 121 to 150 calendar days after	The applicable entity provided a written response to its Transmission Planner, but it was provided between 151 to 180 calendar days after	The applicable entity failed to provide a written response to its Transmission Planner. OR The applicable entity provided a written response to its

R #	Violation Severity Levels			
	Lower VSL	Moderate VSL	High VSL	Severe VSL
	receiving a notification of technical concern.	receiving a notification of technical concern.	receiving a notification of technical concern.	Transmission Planner, but it was provided greater than 180 calendar days after receiving a notification of technical concern.

D. Regional Variances

None.

E. Associated Documents

Reliability Guideline Power Plant Model Verification and Testing for Synchronous Machines, July 2018.

NATF Reporting and Verification of Generating Unit Reactive Power Capability for Synchronous Machines Reference, September 2020.

Version History

Version	Date	Action	Change Tracking
1	12/1/2005	<ol style="list-style-type: none"> 1. Changed tabs in footer. 2. Removed comma after 2004 in “Development Steps Completed,” #1. 3. Changed incorrect use of certain hyphens (-) to “en dash” (–) and “em dash (—).” 4. Added “periods” to items where appropriate. 5. Changed apostrophes to “smart” symbols. 6. Changed “Timeframe” to “Time Frame” in item D, 1.2. 7. Lower cased all instances of “regional” in section D.3. 8. Removed the word “less” after 94% in section 3.4. Level 4. 	01/20/06
2	February 7, 2013	Adopted by NERC Board of Trustees	Revised per SAR for Project 2007-09 and combined with MOD-024-1
2	March 20, 2014	FERC Order issued approving MOD-025-2. (Order becomes effective on 7/1/16.)	
3	TBD	Adopted by NERC Board of Trustees	Revised per SAR for Project 2021-01

MOD-025-3 Attachment 1

Section I. Periodicity of verification:

The periodicity to verify the Real and Reactive Power capability for each applicable BES Facility is as follows:

1. The applicable entity designates the verification date and notates the verification date in a summary report (refer to Attachment 2). The verification date should represent the date that the engineering review or engineering analysis is complete. The verification date is the basis of the recurring periodicity.
2. Verify each new applicable Facility within 180 calendar days of its commercial operation date.
3. Verify each existing applicable Facility at a periodicity not to exceed 120 calendar months from the last verification date, unless it meets the following condition:
 - The Facility has been on a planned or unplanned outage of 180 days or greater, which overlaps its scheduled verification date. Verify the applicable Facility within 180 calendar days of its return to service date.
4. Verify an existing applicable Facility within 180 calendar days of the discovery of a change that affects its Real Power or Reactive Power capability by more than a 10 percent increase or decrease of the nameplate rating and is expected to last more than 180 calendar days.

Section II. Verification specifications for applicable Facilities:

1. For individual devices or generators greater than 20 MVA (gross nameplate rating) perform verification on an individual basis.
2. For individual devices or generators 20 MVA (gross nameplate rating) or less that are part of an applicable Facility greater than 75 MVA (gross nameplate rating) in aggregate, perform verification on an individual unit basis or in the aggregate, considering applicable modeling expectations of the respective Transmission Planner.
3. Create a simplified one-line diagram representing the Facility (refer to Attachment 2). Identify on the one-line diagram where the composite capability curve created in Section II, Items 6-8 is represented.
 - 3.1. The simplified one-line diagram representing the Facility shall represent all auxiliary equipment expected to be in-service for normal operation, including dynamic and static reactive devices and auxiliary load, the generator step-up (GSU), and/or system interconnection transformer(s), unit auxiliary transformer(s), and station services auxiliary transformer(s).
4. If an applicable Facility has no leading or lagging capability, then it should be reported with no leading or lagging capability.

5. The Generator Owner or Transmission Owner shall utilize and document one or more of the following methodologies to verify the Facility Real and Reactive Power capability for all equipment expected to be in-service for normal operation. The engineering analysis or engineering review documentation shall include the underlying assumptions, design criteria, and methods used to create the Facility's composite capability curve under Section II, Items 6-8.
 - Utilize staged testing data, in accordance with Section III, obtained from a date within 365 calendar days prior to verification date, and perform engineering analysis as needed per Note 1, that validates the Facility capability;
 - Utilize operational data, in accordance with Section III, obtained from a date within 365 calendar days prior to verification date, and perform engineering analysis as needed per Note 1, that validates the Facility capability; or
 - Perform an engineering review of all Real and Reactive Power Facility capability information including, but not limited to, in-service equipment design limitations, excitation limiter settings, and operational limitations.
6. For an applicable Facility as identified in Section 4.2.1, 4.2.2, or 4.2.4.1, when performing verification on an individual unit basis, create a graphical representation of the steady-state composite capability curve (CCC) for the Real Power and Reactive Power. The steady-state CCC shall include at a minimum the following:
 - 6.1. The generator nameplate steady-state Real Power and Reactive Power capability curve, or the synchronous condenser nameplate steady-state Reactive Power capability curve, provided by the equipment manufacturer. If the equipment manufacturer curve is not available, the curve shall be derived using the best available data.
 - 6.1.1 The curve shall represent generator/synchronous condenser capability at a nominal voltage of 1.0 per unit at the generator/synchronous condenser terminal; and
 - 6.1.2 The curve shall notate the operating conditions that dictate the power capability, for example H2 pressure, ambient temperature, or other conditions.
 - 6.2. Excitation limiters, if more restrictive than the equipment nameplate capability curve, at nominal voltage 1.0 per unit;
 - 6.3. Identification of any Real Power or Reactive Power operational limitations,¹ if applicable;

¹ Such as generator cooling, vibration, de-rated rotor, de-rated GSU transformer, generator bus de-rating, software limitations, or distributed control system (DCS) setpoints (outer-loop control system paths). This excludes fuel availability, such as water levels for hydro, cloud cover for PV, wind speed, or river level for run of river.

- 6.4. Identification of the steady-state minimum (P_{\min}) and maximum (P_{\max}) Real Power output at the generator terminal(s), based on the least restrictive seasonal or operating conditions; and
- 6.5. Identification of final PQ curve, which defines the normal operating region.
7. For an applicable Facility as identified in Section 4.2.2 or Section 4.2.3, when performing verification in aggregate, create a graphical representation of the steady-state composite capability curve (CCC) for the Real Power and Reactive Power. The steady-state CCC shall include at a minimum the following:
 - 7.1. The steady-state Real and Reactive Power capability curve represented as an aggregate.
 - 7.1.1 The curve shall represent Facility capability at a steady-state nominal voltage of 1.0 per unit at the common point of connection; and
 - 7.1.2 The curve shall notate the operating conditions that dictate the power capability, for example H2 pressure, ambient temperature, or other conditions.
 - 7.2. Aggregate Facility capability includes all auxiliary equipment expected to be in-service for normal operation, including dynamic and static reactive resources and auxiliary loads;
 - 7.3. Identification of any Real Power or Reactive Power operational limitations, if applicable;
 - 7.4. For inverter based resources, a description of all power plant controller and inverter control functions during normal operating conditions that dictate the aggregate Facility capability;
 - 7.5. Identification of the steady-state minimum (P_{\min}) and maximum (P_{\max}) Real Power output at the common point of connection, based on the least restrictive seasonal or operating conditions; and
 - 7.6. Identification of final PQ curve, which defines the normal operating region.
8. For an applicable Facility as identified in Section 4.2.4.2 and Section 4.2.5.1, create a graphical representation of the steady-state composite capability curve (CCC) for the Real Power and Reactive Power. The steady-state CCC shall include at a minimum the following:
 - 8.1. The HVDC nameplate steady-state Real Power and Reactive Power capability curve, or the FACTS device steady-state Reactive Power capability, provided by the equipment manufacturer. If the equipment manufacturer curve is not available, the curve shall be derived using the best available data.
 - 8.1.1 The curve shall represent Facility capability at a steady-state nominal voltage of 1.0 per unit at the common point of connection; and

- 8.1.2 The curve shall notate the operating conditions that dictate the power capability, for example ambient temperature or other conditions.
- 8.2. Any limiters, if more restrictive than the equipment nameplate capability curve(s), at nominal voltage 1.0 per unit;
- 8.3. Identification of any Real Power or Reactive Power operational limitations, if applicable;
- 8.4. A description of all control functions during normal operating conditions and a description of any Facility overload capabilities that dictate the aggregate Facility capability;
- 8.5. Identification of the steady-state minimum (P_{\min}) and maximum (P_{\max}) Real Power output at the common point of connection, based on the least restrictive seasonal or operating conditions; and
- 8.6. Identification of final PQ curve, which defines the normal operating region.

Section III. Staged test and operational data specifications:

1. Section III applies when a staged test and/or operational data verification methodology is utilized. If utilizing multiple methodologies to verify the Facility capability, not all data points outlined in Section III, Item 6, 7, 8, or 9 need to be recorded.
2. Record any staged test or operational data in Attachment 3 (or a form containing the same information). If metering does not exist to measure specific values listed in Attachment 3, provide an engineering estimate and associated calculations. Refer to the associated labels depicted in the one-line diagram created in Section II, Item 3. Record any additional data deemed necessary to perform engineering analysis per Note 1.
3. Staged testing or operating conditions should be maintained constant for a sufficient time in order to ensure that the applicable Facility can perform at that level of Real and Reactive Power during steady-state conditions.
4. All auxiliary equipment is expected to be in service for normal operation.
5. The Facility voltage/Reactive power control equipment is in the normal mode of operation.
6. For an applicable Facility with Real Power capability, not meeting the criteria of Section III, Part 7, 8 or 9, record measurements at the following four points:
 - 6.1. Maximum lagging Reactive Power at maximum Real Power until a limit is reached;²

² In addition, consider steady state thermal or mechanical limitations of Facility equipment to determine whether it limits the Reactive Power capability during a staged test.

- 6.2. Maximum leading Reactive Power at maximum Real Power until a limit is reached;
- 6.3. Maximum lagging Reactive Power at minimum Real Power until a limit is reached;
- 6.4. Maximum leading Reactive Power at minimum Real Power until a limit is reached.
7. For an applicable Facility with no Real Power capability, record measurements at the following two points (one over-excited point and one under-excited point):
 - 7.1. Maximum lagging Reactive Power until a limit is reached;
 - 7.2. Maximum leading Reactive Power until a limit is reached.
8. For an applicable Facility with equal minimum and maximum Real Power output during normal operation, such as a nuclear unit, record measurements at the two points in Items 8.1 and 8.2 below. The Facility need only perform staged testing or provide operational data for Reactive Power at maximum Real Power output. If applicable, provide the theoretical Reactive Power capability at minimum Real Power output in accordance with Attachment 2.
 - 8.1. Maximum lagging Reactive Power at normal operating Real Power until a limit is reached;
 - 8.2. Maximum leading Reactive Power at normal operating Real Power until a limit is reached.
9. For variable generating resources, such as wind, solar, or run-of-river hydro, and non-variable generating resources, such as battery energy storage systems, staged testing or operational data should be recorded with at least 90 percent of the inverters/generators at a Facility on-line. If staged testing or operational data capture of a Facility cannot be accomplished while meeting the 90 percent inverter/generator threshold, document the reason(s) the threshold was not met and test to the full available capability at the time of the test. Maintain, as steady as practical, the maximum Real Power output that the resource can provide at the time of the verification. Record measurements at the two points in Items 9.1 and 9.2 below at the maximum Real Power output the variable resource can provide at the time of the staged test or operational data.
 - 9.1. Maximum lagging Reactive Power at normal operating Real Power until a limit is reached;
 - 9.2. Maximum leading Reactive Power at normal operating Real Power until a limit is reached.

Note 1: Under restrictive transmission system conditions, the data points obtained from a staged test or operational data might not duplicate the manufacturer supplied thermal capability curve (D-curve). When the applicable Facility's reactive capability is not fully demonstrated, perform a simulation or engineering analysis to determine

expected capability under less restrictive system voltages. Even though this analysis will not verify the complete thermal capability curve (D-curve), it provides a reasonable estimate of applicable Facility capability that the Transmission Planner can use for modeling.

MOD-025-3 Attachment 2 – BES Facility Capability Report

A completed report shall contain the following information at a minimum per Requirement R1 and R2:

- Section I: One-line diagram of the applicable Facility
- Section II: Composite capability curve and associated PQ data table
- Section III: Documentation showing the engineering basis and verification methodology

An example report is provided below. The report may vary based on the Facility being represented.

Company:

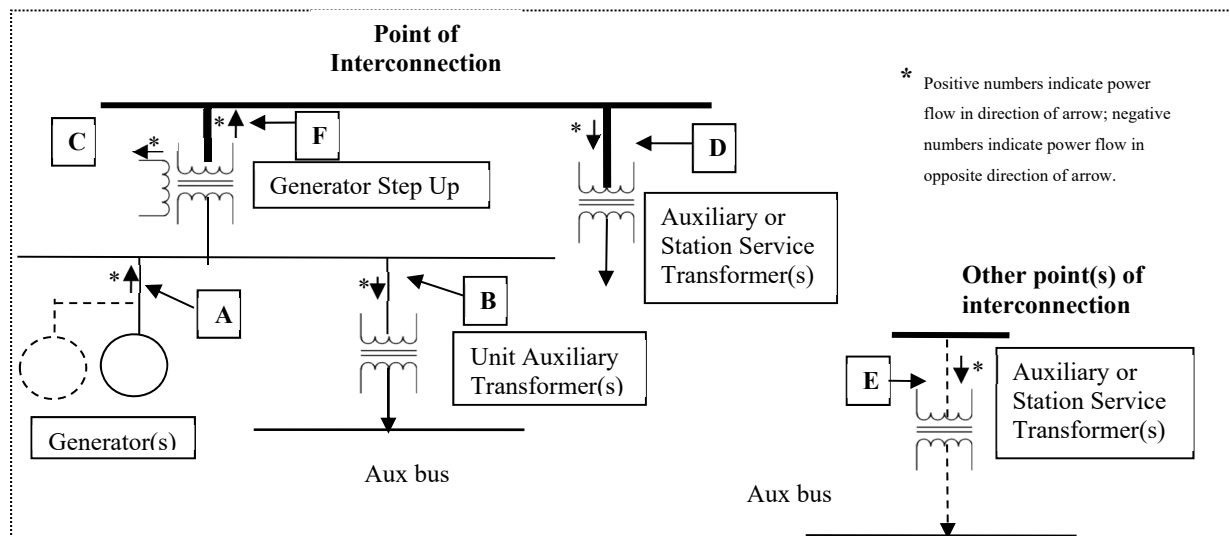
Reported By (name):

Plant:

Unit No.:

Verification Date:

Section I. Provide simplified one-line diagram representing the applicable Facility showing plant auxiliary Load connections. Identify on the one-line diagram where the composite capability curve is represented.



Section II. Provide composite capability curve as defined in Attachment 1, Section II, with associated PQ curve data table.

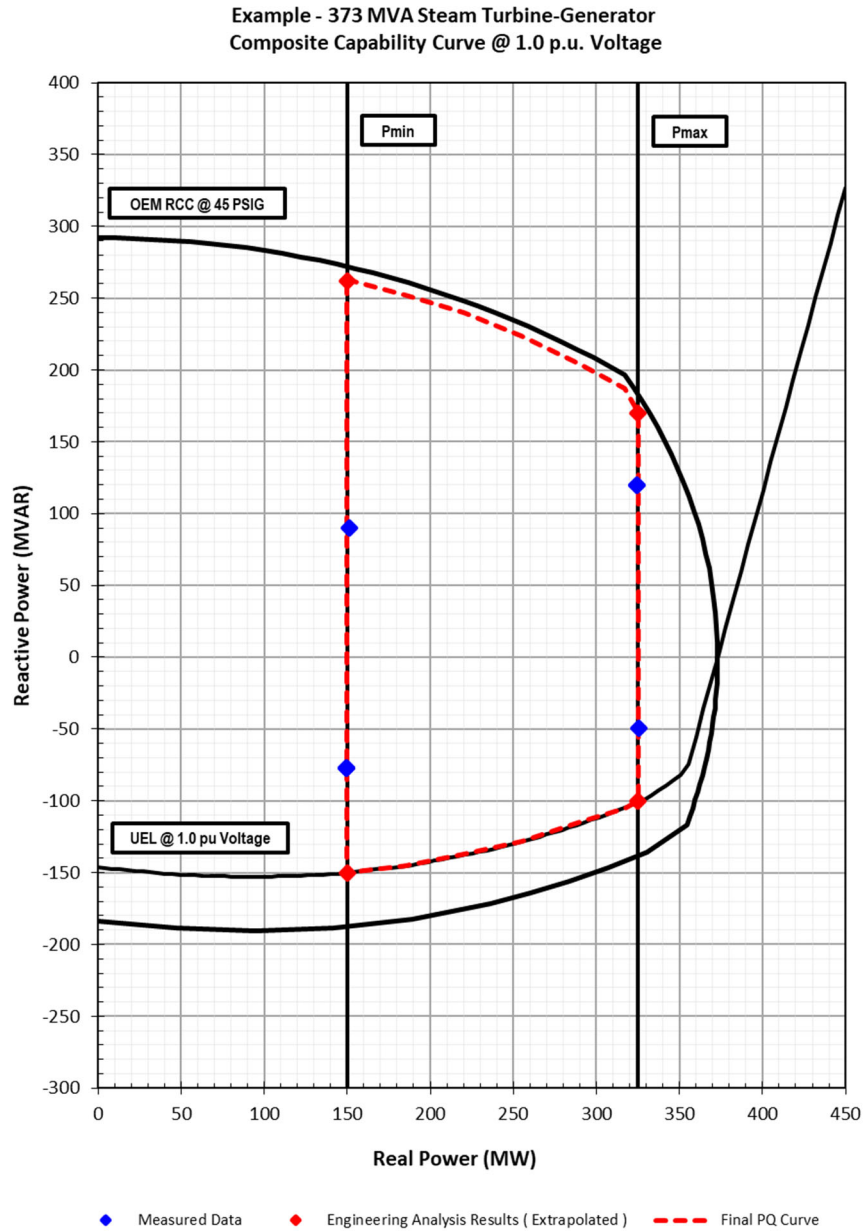


Figure 1: Example Composite Capability Curve for Synchronous Generator

	P (MW)	Qmin (MVA _r)	Qmax (MVA _r)	Qmin Limit	Qmax Limit
Pmin	150.0	-150.0	263.0	UEL @ 1.0 Vterm	lfd Rated
Pmin + 20% of range	185.0	-145.0	252.0	UEL @ 1.0 Vterm	lfd Rated
Pmin + 40% of range	220.0	-137.0	240.0	UEL @ 1.0 Vterm	lfd Rated
Pmin + 60% of range	255.0	-128.0	224.0	UEL @ 1.0 Vterm	lfd Rated
Pmin + 80% of range	290.0	-115.0	204.0	UEL @ 1.0 Vterm	lfd Rated
Breakpoint	317.1	-105.0	187.0	UEL @ 1.0 Vterm	lfd Rated
Pmax	325.0	-100.0	170.0	UEL @ 1.0 Vterm	lfd Rated

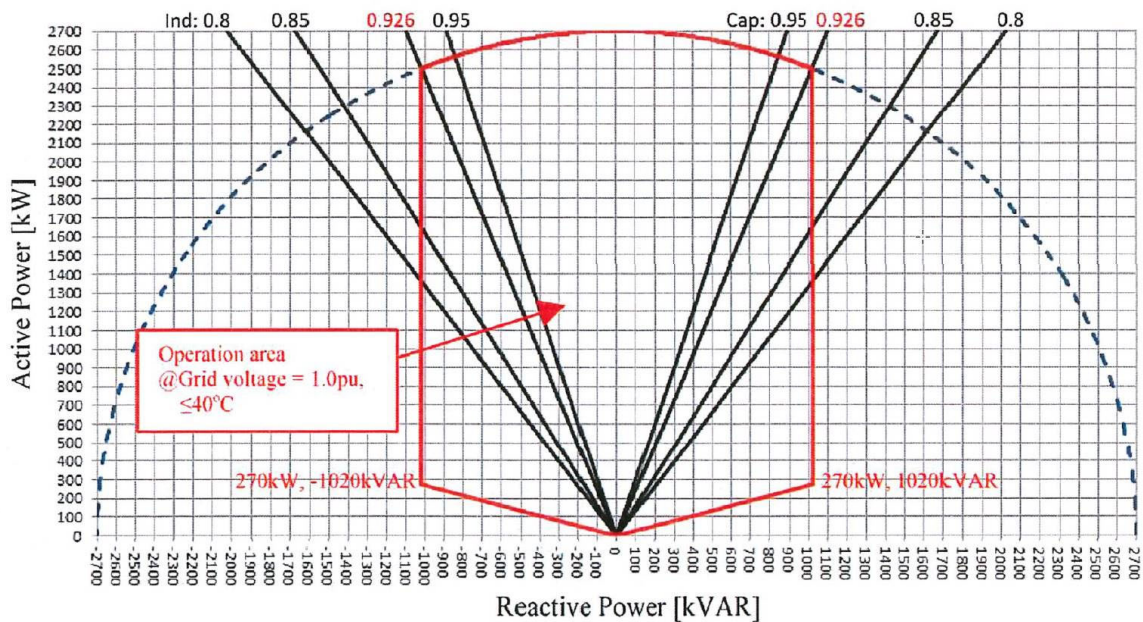


Figure 2: Example Composite Capability Curve for IBR Unit

PQ Curve Data Table (template)

Description	Pmax (MW)	Qmax (MVAR)	Qmin (MVAR)	Qmax Limiting Factor	Qmin Limiting Factor
Pmin					
Pmin + (0.20*Range) Range = (Pman - Pmin)					
Pmin + (0.40*Range)					
Pmin + (0.60*Range)					
Pmin + (0.80*Range)					
Pmax					
Additional data points such as breakpoints are optional.					

1. Limiting factor: UEL/OEL, field current rating, distributed control system (DCS) limit, etc.

Section III. Supplemental documentation of verification methodology.

MOD-025-3 Attachment 3

Data Table and Summary of Staged Test or Operational Data

Reference Attachment 2 one-line diagram measurement points and direction of flow arrows when recording Real and Reactive Power in data table. If the configuration of the applicable Facility does not lend itself to the use of the diagram, tables, or summaries for reporting the required information, changes may be made to this form, provided that all required information is reported.

Company: _____ **Reported By (name):** _____

Plant: _____ **Unit No.:** _____

Check all that apply:

- Over-excited Maximum Load Reactive Power Verification
- Under-excited Maximum Load Reactive Power Verification
- Over-excited Minimum Load Reactive Power Verification
- Under-excited Minimum Load Reactive Power Verification
- Real Power Verification
- Staged Test Data
- Operational Data

Data Table for Recording Measurements

Point	Voltage	Real Power	Reactive Power	Comment
A	kV	MW	Mvar	Sum multiple generators that are verified together or are part of the same unit. Report individual unit values separately whenever the verification measurements were taken at the individual unit. Individual values are required for units or synchronous condensers > 20 MVA.
Identify calculated values, if any:				
B	kV	MW	Mvar	Sum multiple unit auxiliary transformers.
Identify calculated values, if any:				
C	kV	MW	Mvar	Sum multiple tertiary Loads, if any.
Identify calculated values, if any:				

D	kV	MW	Mvar	Sum multiple auxiliary and station service transformers.
Identify calculated values, if any:				
E	kV	MW	Mvar	If multiple points of Interconnection, describe these for accurate modeling; report points individually (sum multiple auxiliary transformers).
F	kV	MW	Mvar	Net unit capability
Identify calculated values, if any:				

Summary of Test / Operational Data

- Date of Staged Test (or oldest Date of Operational Data): _____
- Start Time _____, End Time _____, Staged Test or Operational Data _____
- Transformer Voltage Ratio: GSU _____, Unit Aux _____, Station Aux _____, Other Aux _____
- Transformer Tap Setting: GSU _____, Unit Aux _____, Station Aux _____, Other Aux _____
- Transformer Impedance: GSU _____; Transformer X/R ratio: GSU _____
- Generator or Exciter Field Current (synchronous only): Start _____, End _____
- Ambient conditions at the end of the verification period:
 Air or inlet temperature: _____ Humidity: _____
 Cooling water temperature: _____ Stator temperature: _____
 Other data as applicable: _____
- Generator cooling gas pressure at time of test (if applicable) _____
- If the staged test/operational data did not reach capability curve (D-curve), describe the limiting factor.

Testing Remarks: