Document Title	Synchronous Machine Reactive Limits Verification
File Name	WECCSynchronousMachineReactiveLimitsVerification.pdf
Category	( ) Regional reliability standard ( ) Regional criteria ( ) Policy (X) Guideline ( ) Report or other ( ) Charter
Document date	May 14, 2010
Adopted/approved by	CWG (Controls Work Group)
Date adopted/approved	November 25, 1996
Custodian (entity responsible for maintenance and upkeep)	Controls Work Group
Stored/filed	Physical location: Web URL:
Previous name/number	1996ReactiveLimitsTest.pdf
Status	(X) in effect ( ) usable, minor formatting/editing required ( ) modification needed ( ) superceded by _____ ( ) other _____ ( ) obsolete/archived)

WECC Guideline:

Synchronous Machine Reactive Limits Verification

Date: 11/25/1996

Introduction

This guideline provides instructions and a form to complete to provide information regarding reactive limits of generators. It was written to provide guidance on how to verify reactive limits to comply with a recommendation resulting from the 1996 WECC disturbance.

Approved By:

Approving Committee, Entity or Person	Date
WECC Control Work Group	November 1996

Western Systems Coordinating Council

REPLY TO:
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November 25, 1996

OPERATIONS COMMITTEE
POWER PLANT CONTACTS

The August 10, 1996 System Disturbance Report contained recommendations calling for all generation owning and operating entities in the WSCC region to test their generating units with a rating of 10 MVA or greater. These tests are intended to ensure proper operation of exciter controls and protection and to determine steady state and dynamic reactive capabilities. The Control Work Group has developed the attached guidelines for testing exciter controls, protection and steady state reactive capabilities. Appendix A to the guidelines lists the pertinent conclusions and recommendations stemming from the August 10 report. Guidelines for determining dynamic reactive capabilities are under development.

In the meantime, you should begin scheduling and conducting tests on your generating units in accordance with the attached guidelines. Please use the form provided (last page of the attached) to provide the data to WSCC by June 1997. Make as many copies of the form as you will need to report all your units of the appropriate size. Return the completed form(s) to WSCC, either by mail or by fax. Operations Committee representatives should coordinate with their Power Plant Contact Persons to determine who will submit their reports to WSCC.

I encourage you not to delay conducting these tests. If everyone waits until near the June deadline, we'll be faced with an excessive number of units being tested simultaneously and the resulting risk to system reliability.

Sincerely,

Joseph W. Comish

attachments

cc: Control Work Group Members
Technical Studies Subcommittee
w/attachment

SYNCHRONOUS MACHINE REACTIVE LIMITS VERIFICATION

BACKGROUND:

The WSCC Control Work Group has been tasked with developing procedures for testing synchronous machines (generators and condensers) and exciters due to problems noted during the Aug. 10, 1996, disturbance. The procedures outlined in this document should determine the true MVAR capability of the tested machines and reveal problems in exciter control and protection schemes (see Conclusion 4 and Recommendation 4.c. in Appendix A). Appendix A contains the text of the August 10 disturbance report pertinent to this assignment.

The procedures outlined are for steady state conditions. More comprehensive procedures for testing units outside normal operating range will be developed and distributed by the WSCC Control Work Group at a later date.

REQUIREMENTS:

All synchronous machines (Generators and synchronous condensers must be tested and the same results reported) rated at 10 MVA or greater should be tested. Machines that tripped during system disturbances (July 2 and/or August 10) due to relaying or excitation control problems should be tested first; the remainder should be tested starting with the largest machines. If machines have been tested within the last two years and the requested data are available, no additional testing is required, just data transmittal.

NOTE: To minimize the risk of tripping several large units nearly simultaneously during testing, the tests should be scheduled with your control area's dispatcher/system operator. The dispatcher/system operator should, in turn, provide the scheduled test notification for units larger than 100 MW to all systems, using the WSCC Communication System.

PROCEDURES:

In order to obtain the steady state MVAR capability of a generating unit or synchronous condenser, perform the following tests. Operating conditions should be as close to normal as practicable, including loading, unit temperatures (field, etc.) and pressures (hydrogen, boiler, etc.). Tests should be performed during periods of operation which maximize the MVAR in/output of the machine. Therefore, testing should be performed during a period when system voltage is most advantageous to yield these results . When possible other synchronous machines or power system components should be used, to obtain the most advantageous terminal voltage during these tests.. Ensure that controls such as volts/hertz limiters and UELs (see ¶ B) are coordinated and at proper settings prior to testing to prevent unnecessary relaying by volts/hertz relays or loss of excitation relays..

A. While operating in a steady state mode at net dependable MW capability (near rated output), raise excitation in automatic voltage control until one of the following conditions occurs:

   1) The 100% MVA rating of the machine is reached (reach capability curve);
   2) Rated field current or field voltage is reached;
   3) Terminal voltage limit is reached (105-110%, depending on unit);
   4) Generator temperature limits are reached;

5) The maximum/over excitation limiter is reached/alarms;
6) Maximum reference adjuster travel or limit is reached;
7) Maximum auxiliary bus voltage is reached.

Hold unit at this level for a minimum of 15 minutes (30 minutes is a preferable duration) then take the measurements outlined in C.

B. While operating in a steady state mode at net dependable MW capability, lower excitation in automatic voltage control until one of the following conditions occurs: Note: The acronym UELs (underexcitation limiters) used in this paragraph is synonymous with MELs (minimum excitation limiters) and URALs (underexcited reactive ampere limiters). CAUTION - determine first the expected MVAR limiting point, and do not proceed past that point. If this point is reached without activating the underexcitation limiters/minimum excitation limiters return to normal excitation and determine why the limiter is not functioning. Also, ensure that all transformer taps throughout the power plant are coordinated so the terminal voltage can reach the minimum (90-95%, depending on unit) without causing problems to the auxiliary power further in the plant.

1) UELs are activated;
2) 100% MVA rating is reached;
3) Generator temperature limits are reached;
4) Minimum reference adjuster travel or limit is reached;
5) Minimum auxiliary bus voltage is reached;
6) Minimum terminal voltage is reached.

Take measurements outlined in C (no need to hold as in A).

C. Measurements: The following values should be reported to the WSCC Staff at 540 Arapeen Drive, Suite 203, Salt Lake City, UT 84108:

1) Gross MW output at both test points;
2) Gross MVAR output of generator reached in tests A and B;
3) Generator terminal voltage at maximum positive and negative MVARs;
4) Actual field current at both test points;
5) Machine MVA rating, both original nameplate rating and tested rating, if different;
6) Generator rated terminal voltage and rated field current;
7) Auxiliary bus voltage at minimum and maximum points;
8) Rated power factor.

D. The following machine parameters may be recorded for use during future testing (in addition to values being reported):

1) Generator field voltage;
2) Rotating exciter field current and voltage (if appropriate);
3) Generator stator currents;
4) Field temperature.

E. PRECAUTIONS: If the generator does not normally operate in these regions, strip chart recording of exciter quantities may be helpful for problem resolution. All relay targets on the generator protection and excitation system should be reset before testing. Some excitation systems transfer to manual or backup controllers if overexcitation is detected. If this happens, record the level at which it occurs and

reset the control to automatic before placing the unit back in normal service. If the machine trips for any reason during these tests, specify what tripped and why it tripped. Correct the problem and retest the unit.

F. These tests should be repeated every five years or anytime there is a major change in an excitation system including, but not limited to, stator or rotor rewinds.

G. Subject to operating economics, etc., testing the units at reduced MW loading is encouraged (do not include these values in the test results). This is especially important for units that are not usually base loaded at dependable MW capability.

Appendix A - Excerpts from August 10, 1996 Disturbance Report

4. **Conclusion:** Immediately following the loss of the Ross-Lexington 230-kV line and the Merwin-St. Johns 115-kV line, the McNary units began tripping due to excitation system protection problems, withdrawing substantial real, reactive, and inertial support from the system. Three McNary units also tripped prior to COI separation during the July 2 disturbance and were identified in the disturbance review.

Recommendation

c. The WSCC Control Work Group (CWG) shall determine what tests need to be applied to generating unit exciters to ensure proper operation of exciter controls and protection. They shall also determine what unit MVA level must be tested and develop a procedure to ensure uniform testing, including the frequency of testing and a recommended priority list of units to be tested first. (The CWG work must be completed by November 1, 1996.) All generation owning and operating entities in the WSCC region shall perform the prescribed testing and report to CMOPS. (June 1997) The results should be used to properly model generating units in system studies, and actions taken reported to CMOPS. (June 1997)

10. **Conclusion:** The system oscillations increased until voltage finally collapsed on the COI, leading to the COI opening and the subsequent formation of four islands in the WSCC. Generating units in the Northwest (such as Hermiston, and Coyote Springs) did not respond dynamically or in the steady state with reactive support as predicted in studies. The level of dynamic reactive support from generation at the northern terminus of the COI and PDCI has been greatly reduced by fish operation constraints, particularly at The Dalles.

Recommendation:

a. By November 1997, the WSCC CWG shall determine what tests should be applied to generating units to determine their steady state and dynamic reactive capabilities and provide appropriate guidelines. They shall also determine what unit MVA level must be tested and develop a procedure to ensure uniform testing, including the frequency of testing, and a recommended priority list of units to be tested first. (The CWG work must be completed by November 1, 1996.) Generation-owning and operating entities in WSCC shall test, or provide proof of tests on, their generating units with capacity of ten MW or greater to determine their steady state and dynamic reactive capabilities, adjust study assumptions to match the test results, and report to CMOPS. (June 1997)

DATA REPORTING FORM FOR REACTIVE LIMITS TESTS

Reporting Entity :_____Page ____ of ____ Pages
(Organization Name) Make as many copies of this form as you need

Plant Name: _____Person Reporting (Name):_____

Phone/Fax No.: _____/_____

Unit Name (Number) _____

Machine Ratings

Terminal Voltage: _____, Stator Current: _____, Power Factor: _____, MVA: _____,

Field Current: _____, Field Voltage: _____, Exciter Field Voltage: _____,
Exciter Field Current: _____

Test Results at Maximum Output (Procedure A)

Gross	Gross	Terminal	Field	Auxiliary Bus	Rated Power	Tested MVA

Test Results at Minimum Output (Procedure B)

Gross MW	Gross MVAR	Terminal Voltage	Field Current	Auxiliary Bus Voltage	Rated Power Factor

Unit Name (Number) _____

Machine Ratings

Terminal Voltage: _____, Stator Current: _____, Power Factor: _____,
MVA: _____,

Field Current: _____, Field Voltage: _____, Exciter Field Voltage: _____, Exciter Field
Current: _____

Test Results at Maximum Output (Procedure A)

Gross	Gross	Terminal	Field	Auxiliary Bus	Rated Power	Tested MVA

Test Results at Minimum Output (Procedure B)

Gross	Gross	Terminal	Field Current	Auxiliary Bus	Rated Power