PJM RTEP – Artificial Island Area Proposal Window Problem Statement & Requirements Document

PJM Interconnection

Original Document: April 29, 2013

Version 14.0

Revised: May 16, 2013

Email: RTEP@pjm.com with any questions or clarifications and include a reference to Artificial Island Window

REQUEST FOR PROPOSAL - Improve Artificial Island Area System Performance

I. Purpose of Proposal

PJM seeks technical solution alternatives (hereinafter referred to as "Proposals") to improve PJM Operational Performance in the Artificial Island area under a range of anticipated system conditions and to eliminate potential planning criteria (PJM, NERC, RFC, and Local Transmission Owner criteria) violations in the Artificial Island area.

II. Terminology

Artificial Island Area = "AI"
The system consisting of the transmission and generation facilities as depicted in Figure 1-Artificial Island 500 kV network. The Artificial Island includes the Salem #1, Salem #2, and Hope Creek #1 nuclear generation facilities

System Operating Limit = "SOL"
A System Operating Limit (SOL) is defined as:
The value (such as MW, MVAr, Amperes, Frequency or Volts) that satisfies the most limiting of the prescribed operating criteria for a specified system configuration to ensure operation within applicable reliability criteria. System Operating Limits are based upon certain operating criteria. These include, but are not limited to:

- Facility Thermal Ratings (Applicable pre- and post-Contingency equipment or facility ratings)
- Transient Stability Ratings or Limits (Applicable pre- and post-Contingency Stability Limits)
- Voltage Stability Ratings or Limits (Applicable pre- and post-Contingency Voltage Stability)
- System Voltage Ratings or Limits (Applicable pre- and post-Contingency Voltage Limits)

Critical Contingency:
The most limiting (i.e. the "worst") contingency.

III. Scope of Work

Objectives

1. Generate maximum power (3818 MW total) from all AI Units (Salem1: 1253MW, Salem-2: 1245MW, Hope Creek: 1320MW) without a minimum MVAr requirement from the AI. Full maximum power must be maintained under both the baseline and all N-1 outage conditions of 500kV transmission lines in the AI area. For both the baseline and N-1 outage conditions, AI voltage must be maintained within operating limits and stable for all NERC Category B and C contingencies. NERC Category C3 contingencies "N-1-1 contingencies" do not need to be run on top of the N-1 outage condition.
2. Maximum MW output from AI should not be affected by the simultaneous outage of Power System Stabilizers (PSS) of Artificial Island units Hope Creek and Salem-2. The Salem-1 PSS is assumed to be on for all scenarios.
3. Reduce operational complexity.
4. Improve Artificial Island stability.
5. Maintain PJM System Operating Limits (SOLs)

What PJM Provides:

The following data and related information is required for this project and is expected to be available from PJM:

Modeling Data:

The following data is provided:

1. **Base power flow case.** This case has all lines in service with AI units at maximum real power output. This case has been developed based on the NERC MMWG 2011 Series 2017 Summer Light Load case in PSS/E version 32 (separate file).
2. **Dynamic Case.** This case has been developed based on the NERC SSDWG 2011 Series 2017 Summer Light Load case in PSS/E version 32 (separate files)
3. **Short Circuit Case.** This case has a 2017 short circuit model in PSS/E version 32 and ASPEN *.olr format. (separate file)
4. **Contingency list** to ensure stability in Table 2 – Fault List.
5. **Fault clearing times** for buses at/near the Artificial Island are provided in Tables 3 and 4. Examples of fault clearing time calculation using Tables 3 and 4 are also provided for contingency creation.
6. **Machine Capability Curves** ("D Curves") of the AI Units in Figures 2~4 for reactive power capability at the target MW output.
7. **Description of Salem unit 1 user-defined exciter model (USAC6AU).**

Other Supporting Data:

1. One-line diagram of Artificial Island Area in Fig. 1.
2. Applicable stability criteria (system performance criteria).

3. AI case description (separate file: "Artificial Island Dynamics Case.docx")

Response back to PJM (Deliverables)

1. Description of the proposed solution.
2. Detailed analysis report on proposed solutions, including:
    a) Response plots (e.g. Machine angles over time)
    b) Breaker one-line diagrams to illustrate system topology
    c) Spreadsheets (e.g. Table of system voltages)
    d) High level estimate of:
        i. Time to construct the proposed solutions
        ii. Cost estimates with a description of assumptions (e.g. base cost, risk and contingency (R&C) costs, and total cost)
        iii. Availability of right of ways
3. Equipment parameters and assumptions
    a) All parameters (Ratings, impedances, mileage, etc.)
    b) For reactive devices, settings and outputs
    c) For synchronous machines, MW and MVAR output assumptions
4. Complete set of power flow and dynamic cases containing proposed solutions. If possible, also provide a PSS/E IDEV file so that the modeling of the proposal may be easily applied to other models. This may be difficult for non PSS/E users, please contact PJM with any questions. Provide any other necessary data including critical contingency files to reproduce the proposed solutions. All cases and data files for dynamic simulations should be in PSS/E ver. 32 format.
5. Any other supporting documentation required for the proposal performance validation by PJM.
6. Submission of Deliverables
    a) Preferred - VIA electronic mail to RTEP@pjm.com
    b) Alternate - VIA FedEx to Nancy Muhl, PJM Interconnection, 955 Jefferson Avenue, Norristown, PA 19403

Timeline

Monday, 4/29/2013, Opening of Artificial Island RTEP Proposal window
Friday, 6/28/2013, Close of Artificial Island RTEP Proposal window

- All proposals and pre-qualification documentation due by 6/28

Action	Target Date
PJM distributes RFP to Artificial Island RTEP proposal window participants	4/29/2013
RFP recipients submit questions to PJM	4/29/2013 – 6/28/2013

PJM distributes answers to questions to all recipients*	4/29/2013 – 6/28/2013
Recipients submit proposals to PJM**	On or before 6/28/2013
Recipients submit pre-qualification packages to PJM**	On or before 6/28/2013

*PJM will maintain confidentiality of individual proposals for the duration of the window, but will distribute general information to the Artificial Island RTEP proposal window participants

**Any proposals received after close of the proposal will not be accepted.

Stability Performance Criteria

PJM Manual 14B, Attachment G.
http://www.pjm.com/~/media/documents/manuals/m14b.ashx

(a) *Steady state voltage*: pre-fault voltages at selected 500 kV buses should be within operating range in Table 1. This pre-fault voltage must be noted for the following buses:

Table 1 – Steady State Voltage Limits

Bus Name	Bus Voltage	Bus # Identifier	Steady state pre-fault Voltage
Branchburg	500 kV	200002	1.0 – 1.1 p.u.
Deans	500 kV	200006	1.0 – 1.1 p.u.
Keeney	500 kV	200010	1.0 – 1.1 p.u.
New Freedom	500 kV	200012	1.0 – 1.1 p.u.
Peach Bottom	500 kV	200013	1.0 – 1.1 p.u.
Salem	500 kV	200014	1.0 – 1.1 p.u.
Red Lion	500 kV	200027	1.0 – 1.1 p.u.
East Windsor	500 kV	200028	1.0 – 1.1 p.u.
Hope Creek	500 kV	200029	1.0 – 1.1 p.u.
Orchard	500 kV	200063	1.0 – 1.1 p.u.

1. Post-fault steady state voltage shall not be below 0.986 pu at the Salem and Hope Creek 500kV buses.
2. The voltage drop magnitude from pre-trip to post-trip conditions for any of the Artificial Island Units shall not exceed:
   a) 2% - Salem Unit 1 and Unit 2
   b) 2.5% - Hope Creek
3. The operating voltage range of AI generator terminal (25kV bus) is from 0.95 pu to 1.05 pu.

(b) *Transient stability*: PJM's transient stability criteria are applied:

1. Monitored Facilities:
   a) All machines in Artificial Island and neighboring areas. Area numbers in the power flow case to monitor include areas 225, 227, 228, 229, 230, 231, 232, 234, 235, 201 (please refer to the area information embedded in the power flow case to map the area numbers to area names).
   b) PJM 500kV bus voltages (500kV bus voltages in area 225) and Deans, New Freedom, Red Lion and Keeney 230kV bus voltages.
2. Monitored Data Channels
   a) Rotor angles of all machines in the monitored areas. Real and reactive power output, EFD (generator field voltage), speed and terminal voltage of machines in area 225 (PJM) must be monitored in the simulation.
   b) PJM 500kV bus voltages (500kV bus voltages in area 225) and Deans, New Freedom, Red Lion and Keeney 230kV bus voltages are also monitored.
   c) Monitored facilities and data channel information for the given cases are stored in the snap shot file (.snp) in dynamics case. If proposed solutions include new dynamic devices and/or topology, proper data channels need to be included in the snap shot file to monitor stability.
3. Fault List
   a) See “Fault List” section below.
4. Overall test procedure:
   a) A minimum of fifteen (15) seconds time domain simulation shall be conducted for each contingency.
   b) The system must be stable for all faults considered.
   c) Rotor angles should be represented in relative quantities with respect to a reference machine’s rotor angle. In the dynamics case, a reference machine shall be set to Sea Brook unit 1 (bus 105568)
   d) If the system performance simulation is stable but the maximum angle swing of any unit (relative to the reference generator) exceeds 120 degrees, a safety margin test is performed.
   e) Safety margin test procedure: Delay fault clearance by a half cycle and re-run the simulation. The case is not considered secure if the system is unstable for the delayed fault clearance.
   f) Post-fault transient voltages at AI 500 kV buses shall not be below 0.7 pu after fault clearing.

(c) *Damping*:

1. Monitored Facilities:
   a) Same facilities to those in transient stability.
2. Monitored Data Channels:
   a) Rotor angles.
3. Fault List
   a) See “Fault List” section below.
4. Overall test procedure

a) Fifteen (15) seconds time domain simulation shall be conducted for each contingency.
b) Damping ratio of rotor angle is calculated for the period of 10~15 seconds using a modal analysis tool (e.g. PSSPLT modal analysis tool).
c) Damping ratio shall be above 3% and remains above 3% until the end of the simulation.
d) If nonlinearity is significant for the period of 10 to 15 seconds, it is necessary to extend the time domain simulation to longer time to capture system linear characteristics.

Fault List

All of the following faults, at a minimum, must be simulated whenever "Fault List" is referenced in the procedure above. If proposed solutions require modification of existing contingencies and/or creation of new contingencies due to topology changes, the modified and/or new contingencies should be added in the fault list with proper fault IDs.

Table 2 - Fault List

Fault ID	Fault Description
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]

[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]

*SLG: Single-Line-to-Ground
**SB: Stuck Breaker

Artificial Island One-line Diagram

[redacted]

Figure 1 - Artificial Island Area 500 kV Network

Fault Clearing Times

All fault clearing times are in cycles.

Table 3 - Fault Clearing Times

Station	Faulted Line /Transformer	Fault Clearing Times (cycles)			
		Three phase or SLG fault on Line/Transformer with Normal Clearing	Delayed Clearing Due to Stuck Breaker		Three phase or SLG fault on Bus with Normal Clearing
			Local Station Clearing	Remote Station Clearing	
Hope Creek	5037	[redacted]			
	5015, 5023				
Salem*	5024, 5021				
Orchard	5039, 230kV Transformer				
Red Lion	5015, 230kV Transformer				
East Windsor	5022				
	5038				
New Freedom	5038				

*Note: for a fault on 5037 near Salem (e.g., contingency IDs 5a and 5b), please use the information for Hope Creek station related to 5037.

Table 4 – Transfer Trip Delay

Line	From	To	Transfer Trip Delay (cycles)*
5037	Hope Creek	Salem	[redacted]
5015	Hope Creek	Red Lion	
5023	Hope Creek	New Freedom	
5024	Salem	New Freedom	
5021	Salem	Orchard	
5039	Orchard	New Freedom	
5015	Red Lion	Hope Creek	
5038	New Freedom	East Windsor	

5022	East Windsor	Deans	[redacted]

*Note: it is assumed that the transfer trip delay is the same at both ends of the line unless both cases are specified in the table.

Examples of fault clearing time calculation using Tables 3 and 4 for contingency creation

Three Phase Bus Fault

Suppose a bus fault occurs at Salem bus [redacted] with no outages. The fault will clear in [redacted] cycles by opening breakers [redacted]

Line Fault and Transfer Trip

Suppose a line fault occurs on 5024 near Salem. The fault will clear at Salem by opening breakers [redacted] and [redacted] in [redacted] cycles. The transfer trip delay for 5024 is [redacted] cycles. Therefore, the fault at New Freedom will clear in [redacted] cycles [redacted]).

Line Fault with Breaker Failure

Suppose a line fault occurs on 5024 near Salem. Breaker [redacted] opens in [redacted] cycles but [redacted] fails to open. To clear the fault, breakers [redacted] and [redacted] will open after [redacted] cycles. At New Freedom, the fault clears in [redacted] cycles.

Line Fault with Breaker Failure involving remote station clearing

Suppose a line fault occurs on 5038 near New Freedom. Breaker [redacted] and [redacted] at New Freedom open in [redacted] cycles and breaker [redacted] at East Windsor opens in [redacted] cycles but breaker [redacted] at East Windsor fails to open. To clear the fault, breakers [redacted] will open after [redacted] cycles. At Deans, the fault clears in [redacted] cycles.

Generator Capability Curves

SALEM 1:

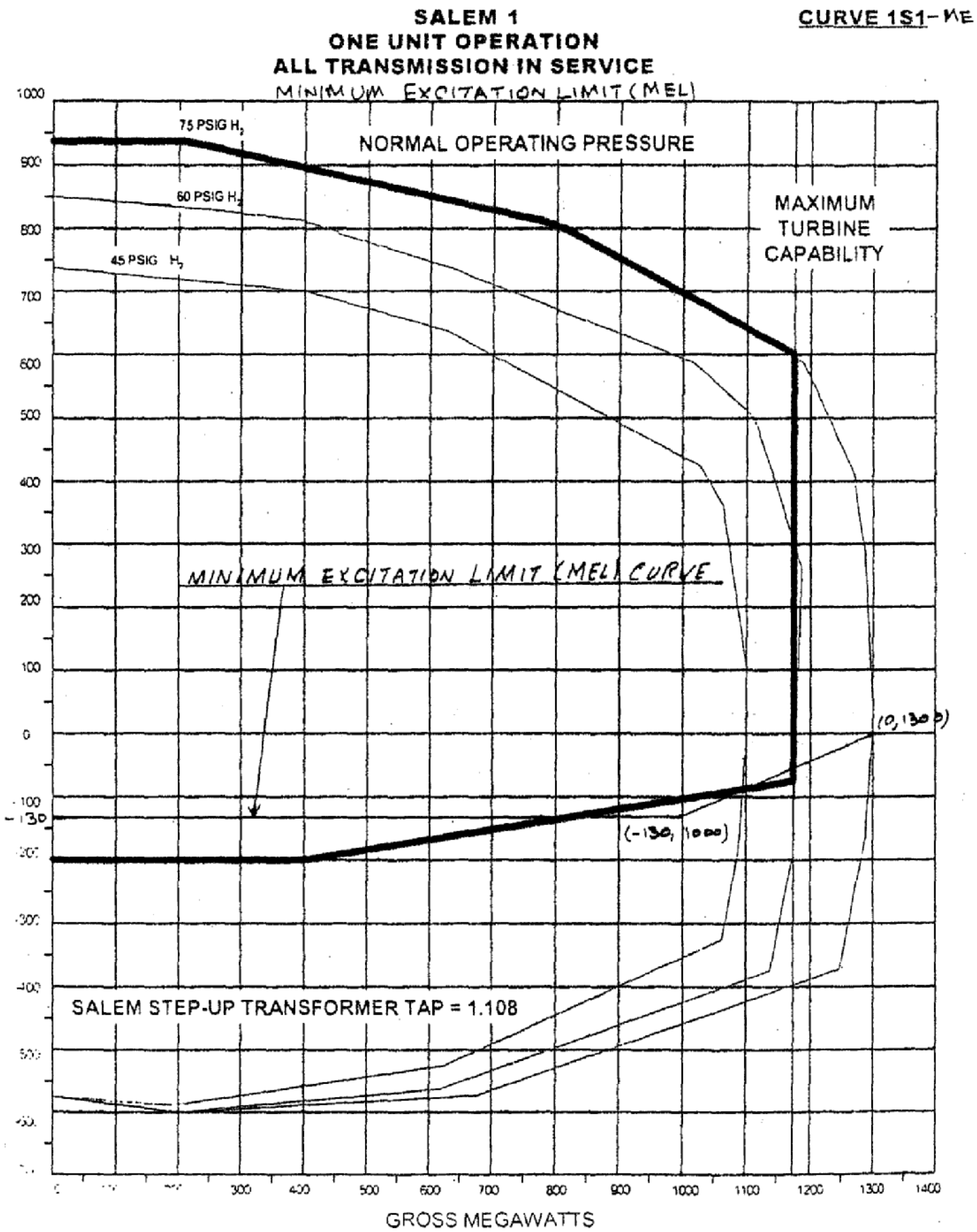

Figure 2 – Salem unit 1 capability curve

SALEM 2:

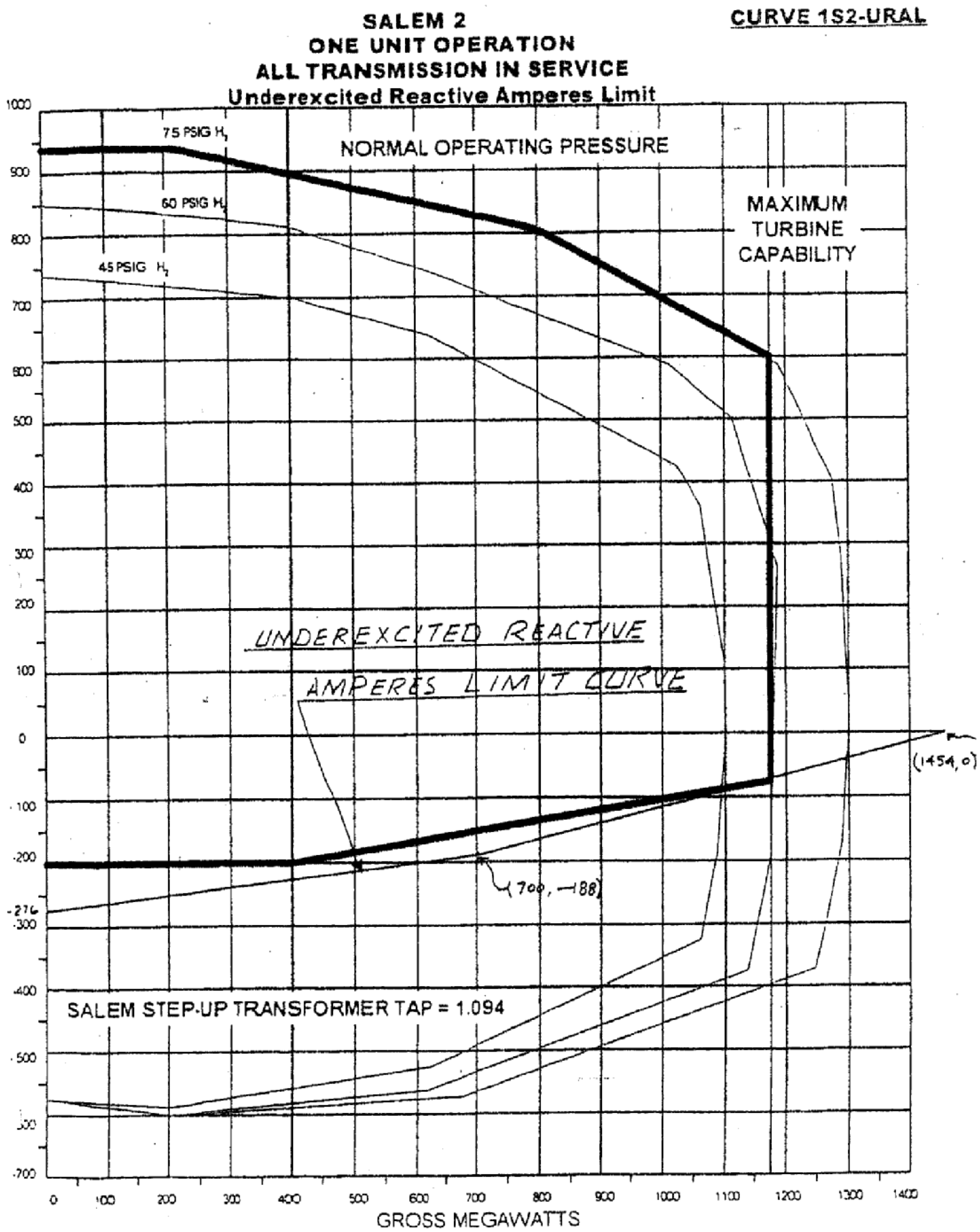

Figure 3 – Salem unit 2 capability curve

HOPE CREEK:

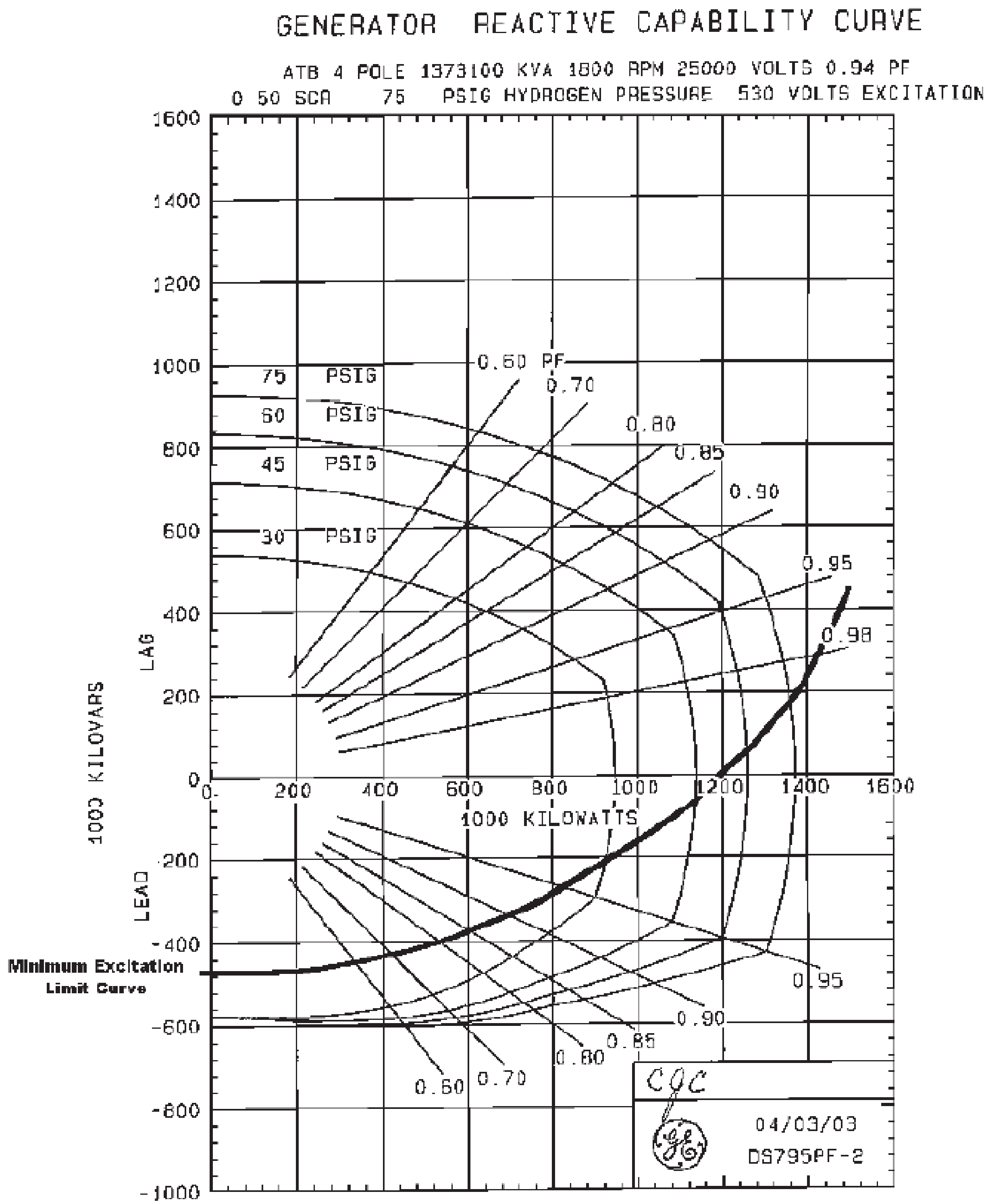

Figure 4 – Hope Creek unit capability curve

Salem unit 1 User-defined Exciter Model (USAC6AU – Modified ESAC6A)

The user-written model USAC6A is a modified version of the PSSE standard model ESAC6A. The difference between the USAC6A and ESAC6A is in the way the non-windup limit is applied on the lead-lag block (STATE(K+2)). In the USAC6A model, the implementation of the non-wind up limit on STATE(K+2) is consistent with the recommendation as given in the IEEE 421.5 2005 standard.

Table 5 – USAC6AU model parameter description

CONs	#	Value	Description
[redacted]			

Data format in the dyr file:
IBUS, 'USRMDL', ID, 'USAC6AU', 4, 0, 0, 23, 5, 0, CON(J) to CON(J+22) /

Table 6 – USAC6AU model dynamic states description

STATEs	#	Value	Description
[redacted]			

[redacted]

Figure 5 – Block Diagram of USAC6AU exciter model

Document Revision History

April 29, 2013
Original File Posted

April 30, 2013
Table 2 – Fault List updated
Table 3 – Fault Clearing Times updated
Table 4 – Transfer Trip Delay updated
Figure 1- Updated Deans bus number in the Figure from 20006 to 200006

May 3, 2013
Added a short circuit model in Aspen *.olr format
Added a Description of Salem unit 1 user-defined exciter model (USAC6AU), which includes a new Table 5 and Table 6
Described the operating voltage range of AI generator terminal (25kV bus) - from 0.95 pu to 1.05 pu