

Expedited System Impact Assessment Report

Final Report- Addendum Assessment Summary

Bruce Power Inc.



Bruce B Standby Generator Control Upgrades

CAA ID Number: 2006-EX295

1.0 General Description

This addendum updates the System Impact Assessment originally issued on February 19, 2009 for the Bruce B Standby Generator SG5 to SG8 AVR replacements (2006-EX295).

On March 23, 2009, Bruce Power completed commissioning results for Bruce SG7. Bruce SG7 is the first of four standby generator units to have undergone upgrades. The remaining standby generators will be replaced within the time frame of 2010 and 2012. Bruce Power has since informed the IESO of additional modifications to the Bruce B standby units. They include:

- **Governor:** New Avon fuel pump microprocessor based governor.
- **Generator Protections:** Installation of three new multifunctional relays: (1) Areva P143 Feeder Management relay, (2) Areva P343 Generator Protection Relay and (3) GE Multilin G60 Generator Protection Relay. The former two serve as the group “A” protective device, while the latter serves as group “B” protective device.

These additional modifications have been implemented on Bruce B SG7 along with its AVR replacement.

In addition to the modifications listed above, this addendum accounts for the updated models for the exciter and generator as per Bruce SG7 commissioning test results.

2.0 Models and Parameters

2.1 AVR and Exciter Model and Parameters

The following are the Bruce B standby generator AVR and exciter model parameters validated from the SG7 commissioning tests. Parameters that are different from what was previously assessed are highlighted.

Bruce Standby Generator Exciter Model: ESAC8B									
T_R	K_P	K_I	K_D	T_D	K_A	T_A	V_{RMAX}	V_{RMIN}	T_E
0.01	155	138	28	0.04	0.6	0.005	7.47	0	0.48
K_E	E_1	$S_E(E_1)$	E_2	$S_E(E_2)$					
1.0	7.89	0.077	8.47	0.214					

2.2 Generator Model

The following are the Bruce B standby generator parameters measured and validated from the SG7 commissioning tests. Parameters that are different from what were previously assessed are highlighted.

Bruce Standby Generator Model: GENSAL								
T'_{do}	T''_{do}	T'_{qo}	T''_{qo}	H	D	X_d	X_q	X'_d
6.0	0.006	0	0.045	2.14	1.5	1.60	0.86	0.25
X''_d	XI	S(1.0)	S(1.2)					
0.18	0.15	0.05	0.298					

2.3 Compensator Model

The following are the Bruce B standby generator compensator model parameters. This model was not previously included in the original SIA.

Compensator Model: IEEEVC	
Parameter	Value
R_C	0
X_C	0.01

2.4 Governor Model

The following are the governor model parameters for the Bruce B Standby generator.

Bruce Standby Generator SG7 Governor Model: GGOV1								
R	T_{PELEC}	M_{axerr}	M_{inerr}	K_{pgov}	K_{igov}	K_{dgv}	T_{dgv}	V_{max}
0	1	0.1	-0.1	6.0	0	0	100	0.6
V_{min}	T_{act}	K_{turb}	W_{fnl}	T_b	T_c	T_{eng}	T_{fload}	K_{pload}
0	0.4	3.3	0.22	3.5	0	0	3	1.0
K_{iload}	L_{dref}	D_m	R_{open}	R_{close}	K_{imw}	A_{set}	K_a	T_a
1.0	99.0	3.3	0.6	-0.6	0	10	10	1.0
T_{rate}	db	T_{sa}	T_{sb}	R_{up}	R_{down}	R_{select}	Flag	
12.1	0.0	4.0	5.0	99	-99	0	0	

3.0 Assessment and Conclusions

In performing this assessment, it was assumed that all modifications applicable to Bruce SG7 will be applicable to Bruce SG5, SG6, and SG8. Should this not be the case, Bruce Power will be required to notify the IESO in advance.

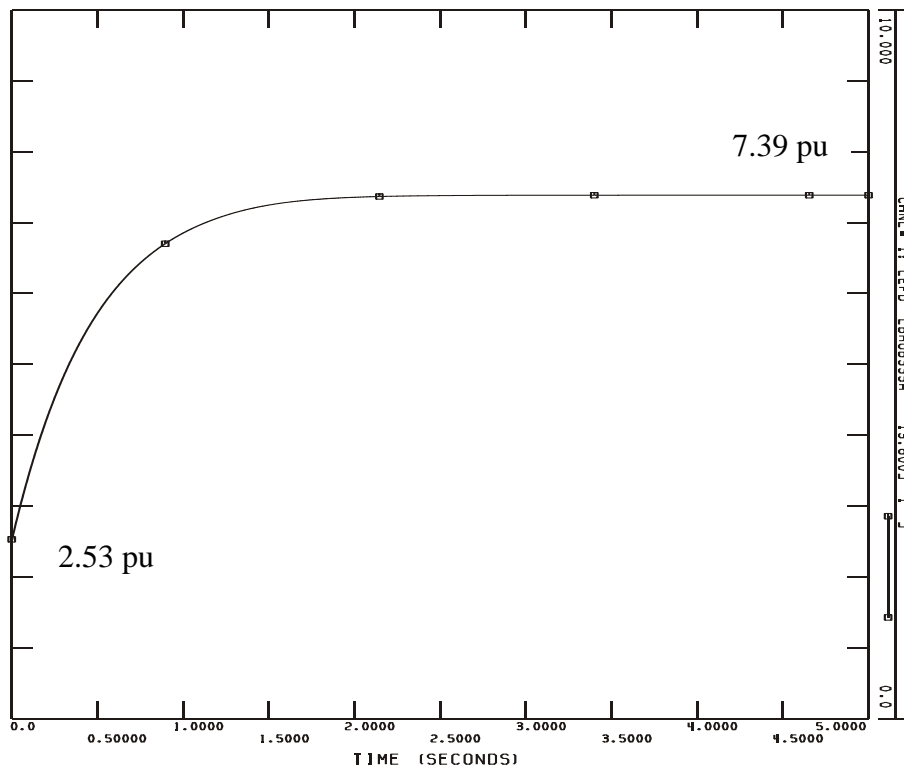
3.1 Excitation System Performance

In situations where the AVR is replaced, the IESO requires that the new AVR must meet or exceed the performance of the old AVR. Although Bruce Power was unable to provide the old excitation model to the IESO, Bruce Power did indicate through technical data sheets that the response ratio of the old exciter was 1.0.

In the original SIA assessment (2006-EX295), it was determined that the Bruce B standby generator would meet the following IESO's lesser excitation performance requirements:

- An excitation system nominal response of at least 0.50 and
- A positive ceiling voltage at least 150% of rated field voltage

Studies with the Bruce B SG7 post-commissioning test model values indicate that the nominal response is 3.0 . As shown in the figure below, the positive ceiling voltage is 292% of the rated field voltage. These values are slightly lower than the nominal response and positive ceiling values obtained in the original SIA, however, the IESO lesser requirements are still satisfied.



SUM07 - EXTERN TEMP - PD=27464 - 6.6856HD8NOLK168K4L84LX165010S
1400BLP.3829F8C.1563FETI.-1178FN.-79CLAN.1458F10.
FILE: rr_6927_actual.out

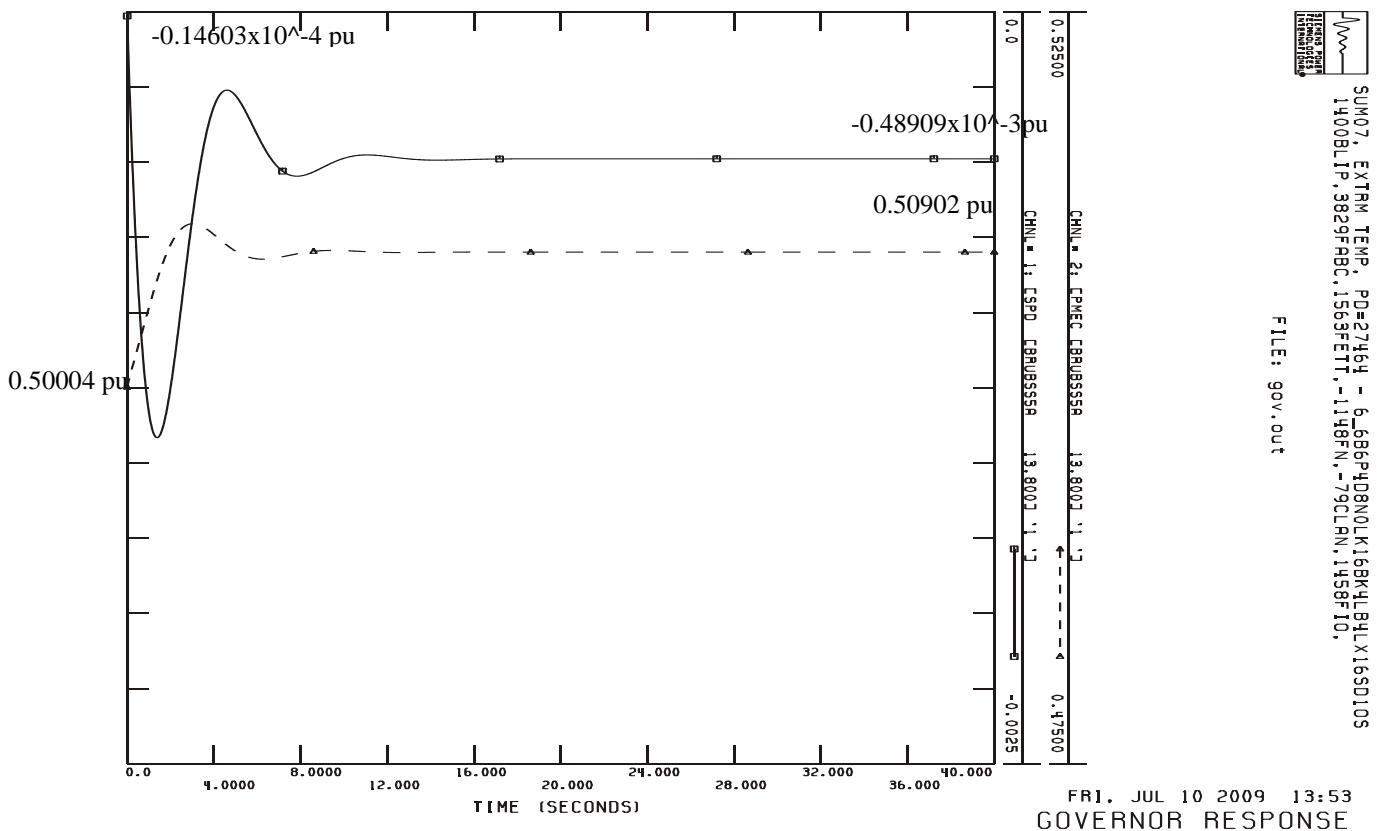
FRI, JUL 10 2009 13:56
RESPONSE RATIO

A comparison of the post-commissioning nominal response (3.0) to that of the old exciter (1.0) indicates that the new AVR will result in better performance than the old AVR.

Therefore, this assessment concludes that the new AVR at Bruce SG units will have a performance that meets or exceeds the old AVR.

3.2 Governor Performance

In the governor test, the change in the rotor speed is observed for a load step change of a certain magnitude. The IESO requires governors to have a permanent speed droop that can be set in the range between 3% and 7%. The response obtained for a 1% load increase from an initial machine loading of 50% of the generator's MVA rating is shown below along with a summary of the change in speed,



Δ Speed	-0.474487×10^{-3}
ΔP_{mec}	8.98×10^{-3}
Droop	5.3%

The droop is 5.4%, and thus meets the IESO criteria.

3.3 Generator Protections

Prior to the Bruce B SG7 upgrade, each of the generator’s protection function was achieved by an individual relay. In the new implementation, all protection functions reside within group “A” and redundant group “B” multifunctional relays.

The following table shows which generator protections functions have been incorporated in the new group “A” and group “B” protection devices. In all cases, unless noted, Bruce Power confirmed that it has either identically or approximately replicated previous protection settings in both the Group “A” and Group “B” protection devices:

Protection Functions	Protective Device		
	Group “A”		Group “B”
	P143	P343	G60
1. Phase Back-Up via Distance Relay (21B)		X	X
2. Field Failure (40G)		X	X ¹
3. Synchronization Check (25)	X		X
4. Reverse Power (32G)		X	X
5. Overvoltage (59G)		X	X
6. Generator Ground Fault via Core Balance (64G)	X		X
7. Unit Auxiliary Transformer Ground Fault (64T)	X		X
8. Generator Ground Back-up (64B)		X	X
9. Negative Phase Sequence (46G)		X	X ²
10. Generator Differential (87G)	Functionality not deployed. Stator differential protection redundancy provided by the Generator Ground Fault via Core Balance (64G) function in the GE Multilin G60 and Areva P143.		X ³

- (1) Previous protections replicated are within the new relay with the assumption that the previous protections had a setting of K1=0.75 and not the documented value of K1=0.875. The other three SG units have a documented K1 value of 0.75.
- (2) Previous $I_2t^2 = K$ curve replicated with K=10 and stage 1 pick up = 10%. Minimum operate time are similar to previous characteristic. Maximum operate time arbitrarily set at 1000 s and cool down time set at the maximum of 1000 s, which are different from existing settings.
- (3) GE Multilin G60 relay utilizes a low impedance, dual slope, percentage restraining algorithm that is different from previous high impedance scheme. Settings calculated based on manufacturer and industry best practices and current transformer saturation calculations.

Bruce Power has confirmed that these modified protection settings will not affect the standby generators’ capability curves. The IESO has concluded that the new protection settings will not result in an adverse material impact on the IESO-controlled grid.

4.0 Conclusions

- Based on the post-commissioning test model parameters provided for SG7, the proposed AVR for the Bruce standby generators will have an excitation performance that meets the old AVR.
- Based on the post-commissioning test model parameters provided for SG7, the proposed new governors for the Bruce standby generators will have a governor response that meets IESO requirements.
- The IESO has concluded that the new protection settings will not result in an adverse material impact on the IESO-controlled grid.

5.0 Requirements

The applicant must notify the IESO as soon as it becomes aware of any changes to the model parameters or assumptions made in the connection assessment. The IESO will determine whether these changes require a reassessment.

6.0 Notification of Approval

From the information provided, our review concludes that the proposed changes will not result in a material adverse impact on the reliability of the IESO-controlled grid. It is recommended that a Notification of Conditional Approval be re-issued for Bruce B Standby Generator SG5 to SG8 control upgrades to account for (1) the AVR replacements, (2) Governor replacements and (3) Protection Upgrades subject to the requirements identified above.

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