FENOC
FirstEnergy Nuclear Operating Company

Davis-Besse Nuclear Power Station
5501 N. State Route 2
Oak Harbor, Ohio 43449

October 14, 2015
L-15-268

10 CFR 50.90

ATTN: Document Control Desk
U. S. Nuclear Regulatory Commission
Washington, DC 20555-0001

SUBJECT:
Davis-Besse Nuclear Power Station, Unit No. 1
Docket No. 50-346, License No. NPF-3
Response to Request for Additional Information Regarding License Amendment Request to Revise Emergency Diesel Generator Minimum Voltage and Frequency Surveillance Requirements (TAC No. MF6060)

By correspondence dated April 1, 2015 (Accession No. ML15091A143), FirstEnergy Nuclear Operating Company (FENOC) submitted a license amendment request to amend the operating license for the Davis-Besse Nuclear Power Station, Unit No. 1. The proposed amendment would revise certain Technical Specification minimum voltage and frequency acceptance criteria for emergency diesel generator testing. The changes are necessary to address non-conservatism in the testing acceptance criteria.

By letter dated September 21, 2015 (ML15222A179), the NRC requested additional information to complete its review of the license amendment. By electronic correspondence, the NRC staff and FENOC agreed on a due date of October 16, 2015. FENOC's response to this request is attached.

There are no regulatory commitments contained in this letter. If there are any questions or if additional information is required, please contact Mr. Thomas A. Lentz, Manager – Fleet Licensing, at 330-315-6810.

I declare under penalty of perjury that the foregoing is true and correct. Executed on October 14, 2015.

Sincerely,

David M. Imlay

David M. Imlay
Director, Site Performance Improvement

Attachment: Response to September 21, 2015 Request for Additional Information

cc: NRC Region III Administrator
NRC Project Manager
NRC Resident Inspector
Executive Director, Ohio Emergency Management Agency,
State of Ohio (NRC Liaison)
Utility Radiological Safety Board

By letter dated September 21, 2015 the Nuclear Regulatory Commission (NRC) staff requested additional information to complete its review of FirstEnergy Nuclear Operating Company's (FENOC's) April 1, 2015 license amendment request (Accession No. ML15091A143) to amend the operating license for the Davis-Besse Nuclear Power Station, Unit No. 1. The proposed amendment would revise certain Technical Specification minimum voltage and frequency acceptance criteria for emergency diesel generator testing. Each request for additional information (RAI) is presented below in bold type, and is followed by the FENOC response.

RAI-1

According to the Updated Final Safety Analysis Report (UFSAR) (ADAMS Accession No. ML14339A821), Table 8.3-1 for EDG loading, Step 1 loading includes loads that do not trip on a loss of power and a 400 horse-power (hp) component cooling water pump that starts as soon as the EDG output breaker closes with the proposed allowable voltage of 4070 V. A large motor (e.g., make up pump) starts within 2.5 seconds of breaker closure.

Explain how the evaluation performed demonstrates that the voltage drop (Attachment H of the LAR) during this stage of EDG loading satisfies Safety Guide 9 criterion and the minimum voltage required for running equipment.

Response:

Attachment H of the license amendment request (LAR) documents an emergency diesel generator (EDG) transient loading analysis that is based on equipment operability limits. This document does not demonstrate that the Safety Guide 9 criterion is met. Rather, "Evaluation of Davis Besse EDG Transient Response During Design Basis LOOP/LOCA, LOOP Only and Appendix R Loading," (hereafter referred to as the EDG Transient Response Analysis) demonstrates that the Safety Guide 9 acceptance criterion is satisfied with the EDG breaker closing at its permissive setpoint of 3990 volts (V) with a voltage set point of 4088 V. The proposed allowable voltage of 4070 V considers a setpoint of 3990 V with a maximum relay setting tolerance of 2 percent. Excerpts from the EDG Transient Response Analysis applicable to the voltage setpoint are provided in Appendix 1.

RAI-2

Provide the acceleration time for the large motors started in load sequencer Step 1 and 1a. Provide a list of the motor-operated valves that are required to operate during this period. Provide a summary of the assumptions, methods, and results of the evaluation performed for this additional loading.

Response:

As shown in the DBNPS UFSAR, Table 8.3-1, the large motors that start in load sequencer Steps 1 and 1a are the component cooling water pumps 1 and 2 and the make-up pumps 1 and 2. The acceleration times of these motors are shown in the table below.

Load	Description	Acceleration Time (sec) at % rated Voltage		
		70	80	100
MP0431	Component Cooling Water Pump 1	4.8	-	1.9
MP0432	Component Cooling Water Pump 2	4.8	-	1.9
MP371A	Make-up Pump 1	-	4.18	0.94
MP372A	Make-up Pump 2	1.27	0.79	0.45

Drawing E-17B sheets 1 through 7, which are incorporated by reference in the DBNPS UFSAR and are included in Appendix 2, contains the listing of motor-operated valves that are required to operate during load sequencer steps 1 and 1a. These valves are identified as SEQ. STEP 1.

The EDG Transient Response Analysis and Attachment H of the LAR submittal accommodate for the additional loading of the large motors during starting when they are drawing locked rotor current prior to reaching full speed. Although the starting time of these motors in the analysis is not specified, the dynamic motor model parameters that determine the starting time of these motors have been adjusted to match measured performance. Tables 5-17 and 5-18 of the EDG Transient Response Analysis show these parameters for the cooling water pump and make-up pump motors and are provided in Appendix 2. A summary of the results for the evaluation performed for additional loading is in Appendix 1, the methods are in Appendix 2, and the assumptions are in Appendix 5.

RAI-3

The NRC staff notes that an 800 hp motor-driven feedwater pump can be manually loaded on the EDG.

Provide a summary of the assumptions, methods, and results of the evaluation performed to demonstrate that the voltage drop in the auxiliary system will not adversely impact safety-related equipment if the EDG was operating at the steady state voltage of 4088 V prior to pump start.

Response:

The operating procedure requires a voltage between 4200 V and 4250 V on the bus prior to manually starting the motor driven feedwater pump (MDFP). The EDG Transient Response Analysis does not evaluate the MDFP starting at a voltage of 4088 V. Rather, the analysis evaluates starting of the MDFP motor on the EDG with a nominal voltage of 4200 V. The analysis (Appendix 3) concludes that the EDGs are capable of starting the MDFP and that the minimum requirements for voltage (75 percent nominal, based on 4160 root mean square voltage) and frequency (95 percent nominal, based on 60 Hertz [Hz]) are met at this voltage level. The methods used to perform the analysis are described in Appendix 2 whereas the assumptions are provided in Appendix 5.

RAI-4.a

For surveillance requirements associated with steady state operation of the EDG, the LAR proposes the following limits: Steady state voltage ≥ 4088 V and ≤ 4400 V, and frequency ≥ 59.5 Hz and ≤ 60.5 Hz.

a. **Explain how the maximum postulated loading evaluated in Attachment H considered the worst-case combination of allowable voltage and frequency coupled with large pumps operating at run out conditions.**

Response:

Attachment H of the LAR documents an EDG transient loading analysis that is based on equipment operability limits. This attachment evaluates three cases: 1) Minimum Voltage, 2) Minimum Frequency, and 3) Maximum Voltage and Frequency.

For case 1, the minimum voltage case, the voltage setpoint of 3744 V was used and then raised until acceptance criterion 3.1 of Attachment H was met. During this case a frequency of 61.2 Hz is used to conservatively increase the motor loading.

For case 2, the minimum frequency case, the voltage determined from case 1 above (3850 V) was used with an initial frequency setpoint of 58.8 Hz. This frequency was then increased until the requirement of acceptance criterion 3.3 of Attachment H was met.

For case 3, maximum voltage and frequency case, the maximum voltage and frequency of 4400 V and 61.2 Hz were used, respectively.

For these three cases, the analysis considers the large pumps operating at the operating load percentage documented in the "Operating Load Inputs for AC Power System Analysis." The large motors that operate at an elevated level during a loss of coolant accident (LOCA) with a loss of offsite power (LOOP) are as follows:

- Low pressure injection/decay heat pump 2 motor (MP42-2) operates at 105 percent based on the brake horsepower (Bhp) at a maximum calculated flow of 4300 gallons per minute (gpm) during a LOCA.

- Containment spray pump 2 motor (MP56-2) operates at 110 percent based on the Bhp at a maximum calculated flow of 1800 gpm.
- High pressure injection pump 2 motor (MP58-2) operates at 117 percent based on the highest recorded motor load from baseline tests at 950 gpm. This flow rate bounds the maximum required flow for the LOCA analysis.
- Make-up pump 2 motor (MP37-2A) operates at 124 percent based on the Bhp at the calculated flow rate during a LOCA with one make-up pump running.

Excerpts from the Operating Load Inputs for AC Power System Analysis that determine the percent operating load for the large motors that start during loading category 6, LOCA with LOOP, are provided in Appendix 4. Of note, only the large motors fed from EDG 2 are included, as the EDG Transient Response Analysis and Attachment H of the LAR only evaluate EDG 2. This is acceptable because the loading difference between the EDGs is relatively small and the Safety Guide 9 criteria would be met for both EDGs.

RAI-4.b

For surveillance requirements associated with steady state operation of the EDG, the LAR proposes the following limits: Steady state voltage ≥ 4088 V and ≤ 4400 V, and frequency ≥ 59.5 Hz and ≤ 60.5 Hz.

b. Explain how fuel oil consumption for EDG operation was evaluated after establishing the maximum EDG loading. Compare the revised EDG fuel oil consumption results with the design-bases and TS requirements for the EDG day tank and bulk storage (week) tank.

Response:

FENOC evaluated the EDG steady state loading condition with a maximum voltage of 4400 V and a frequency of 61.2 Hz and determined the loading to be 2413 kW or 3236 HP (2413 kW x 1.341 HP/kW = 3236 HP.) This loading condition is less than the EDG 100 percent full rated loading condition of 3600 HP. Useable fuel inventory was evaluated based on a 100 percent full load consumption rate. The evaluation shows that TS Surveillance requirement SR 3.8.3.1 for minimum fuel oil storage tank volume and SR 3.8.1.4 for minimum EDG day tank volume are met for EDG operation for 7 days at full load.

RAI-5

In the LAR, the licensee stated that a transient analysis computer model was used to analyze the voltage and frequency response of the DBNPS EDGs during

load sequencing associated with the design-basis loss of coolant accident and loss of offsite power. The licensee states this analysis showed that DBNPS EDGs are capable of starting their dedicated engineered safety features loads in the required sequence while meeting the minimum voltage and frequency recommendations of Safety Guide 9 for the loading sequence and each load sequence time interval.

Provide a summary of the EDG frequency and voltage response in a tabulated form with assumptions made for starting voltage and frequency.

Response:

The EDG Transient Response Analysis provides a summary of the EDG frequency and voltage response in Table 7-15, "Summary of Results for Design Basis LOOP/LOCA Analyses – Case 7," and Table 7-18, "Summary of Results for Design Basis LOOP /LOCA Analyses – Case 8." These tables are provided in Appendix 1. EDG Transient Response Analysis, Section 4.1, "Assumptions," describing starting voltage and frequency assumptions, is provided in Appendix 5.

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Appendix 1

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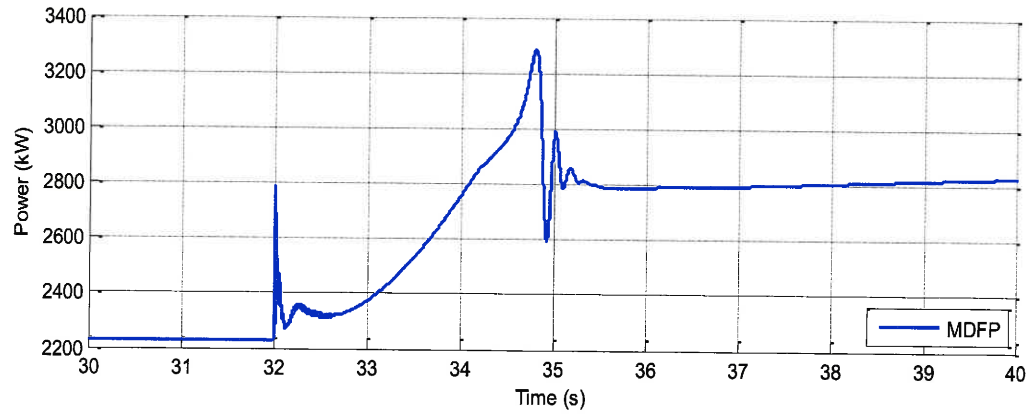

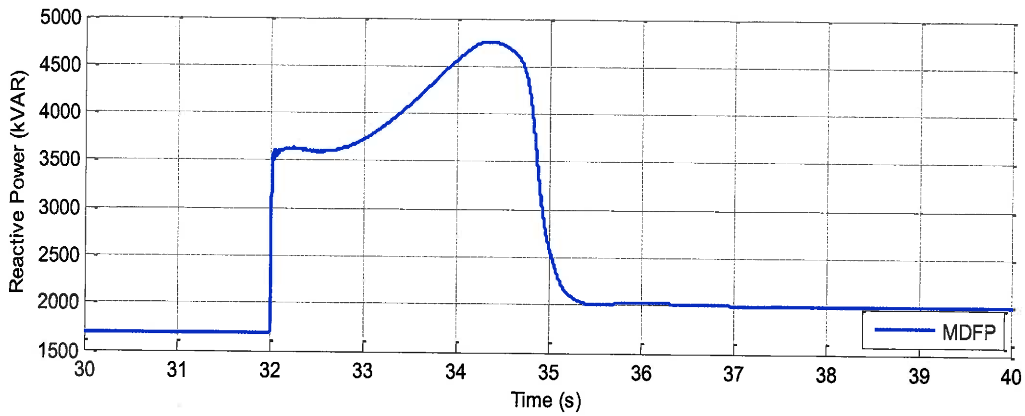

Figure 3-6. Power and Reactive Power Response for EDG Appendix R- MDFP Start

3.4 Design Basis LOOP/LOCA with 4088 V Set Point and Minimum/Maximum Frequency Set Point

The voltage and frequency responses of the Davis-Besse EDGs to design basis LOOP/LOCA load sequencing with 4088 V set point and 59.5/60.5 Hz set points were analyzed using a transient analysis computer model. A hot generator field was used for the bounding case (see further discussion in Section 7.4). The bounding analysis results, including minimum voltage and frequency for each load step and the time to recover to the required values (i.e., USAR design basis criteria), are presented in Table 3-4 and Table 3-5. The simulation results were not

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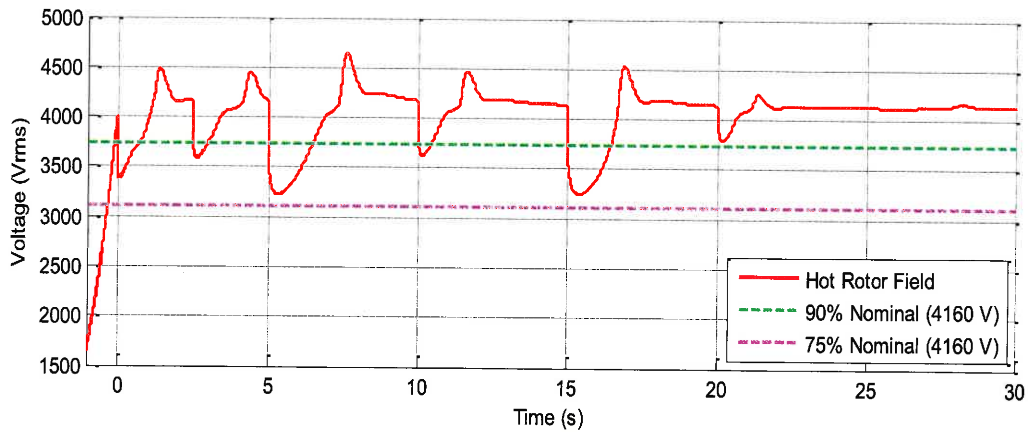
compared to ETAP load flow data in cases 7 and 8 due to the difference in steady state conditions, i.e. the voltage and frequency set points between the two studies are not the same.

The analysis shows that Davis-Besse EDGs are capable of starting their dedicated engineered safety features loads in the required sequence. Figure 3-7 shows the voltage and frequency response for the design basis LOOP/LOCA loading sequence with 4088 V set point and 59.5 Hz set point. Figure 3-8 shows the voltage and frequency response for the design basis LOOP/LOCA loading sequence with 4088 V set point and 60.5 Hz set point.

Table 3-4. Summary of Results for Design Basis LOOP/LOCA Analyses – Case 7

	Step 1	Step 1a	Step 2	Step 3	Step 4	Step 5
Generator Voltage						
Minimum Required Voltage, V (75% Nominal)[(1)]	3120	3120	3120	3120	3120	3120
Calculated Minimum Voltage, V (% Nominal)	3379 (81.2%)	3592 (86.3%)	3229 (77.6%)	3625 (87.1%)	3250 (78.1%)	3790 (91.1%)
Voltage Margin, V	259	472	109	505	130	670
Allowable Time[(2)] to recover to 90% Nominal Voltage (3744 V), sec	1	1	2	2	2	N/A
Calculated Time to Recover to 90% Nominal Voltage, sec	0.75	0.5	1.5	0.46	1.48	N/A
Recovery Time Margin, sec	0.25	0.5	0.5	1.54	0.52	N/A
Generator Frequency						
Minimum Required Frequency, Hz (95% Nominal)[(1)]	57	57	57	57	57	57
Calculated Minimum Frequency, Hz (% Nominal)	58.2 (96.9%)	59.1 (98.5%)	59 (98.3%)	59.2 (98.7%)	58.8 (98.0%)	59.1 (98.6%)
Frequency Margin, Hz	1.2	2.1	2	2.2	1.8	2.1
Allowable Time[(2)] to recover to 98% Nominal Frequency (58.8 Hz), sec	1	1	2	2	2	N/A
Calculated Time to Recover to 98% Nominal Frequency, sec	0.37	N/A	N/A	N/A	N/A	N/A
Recovery Time Margin, sec	0.63	N/A	N/A	N/A	N/A	N/A

Note 1: 4160V is taken as nominal voltage and 60Hz is taken as nominal frequency
Note 2: Voltage should be restored to within 10 percent of nominal and frequency should be restored to within 2 percent of nominal in less than 40 percent of each load sequence time interval.



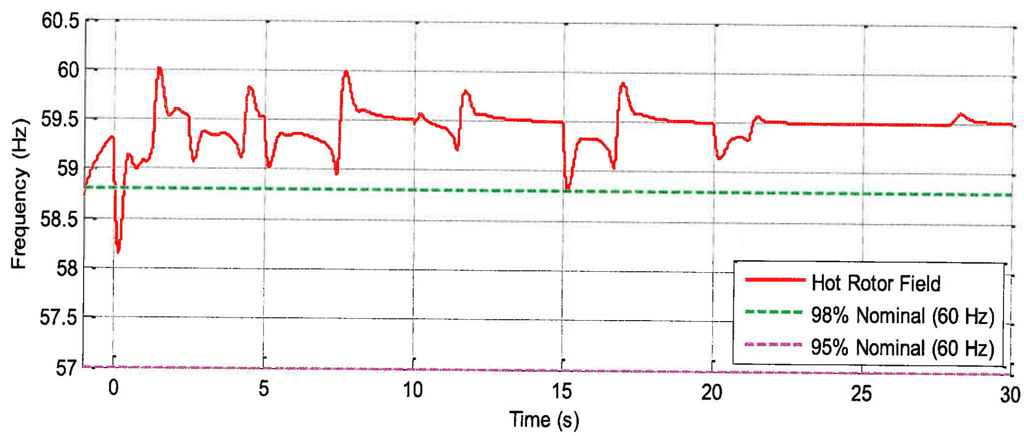


Figure 3-7. Voltage and Frequency Response for EDG Design Basis LOOP/LOCA with Hot Field – Case 7

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Table 3-5. Summary of Results for Design Basis LOOP/LOCA Analyses – Case 8

	Step 1	Step 1a	Step 2	Step 3	Step 4	Step 5
Generator Voltage						
Minimum Required Voltage, V (75% Nominal)[(1)]	3120	3120	3120	3120	3120	3120
Calculated Minimum Voltage, V (% Nominal)	3386 (81.4 %)	3589 (86.3%)	3204 (77.0%)	3626 (87.2%)	3225 (77.5%)	3785 (91.0%)
Voltage Margin, V	266	469	84	506	105	665
Allowable Time[(2)] to recover to 90% Nominal Voltage (3744 V), sec	1	1	2	2	2	N/A
Calculated Time to Recover to 90% Nominal Voltage, sec	0.65	0.50	1.50	0.44	1.53	N/A
Recovery Time Margin, sec	0.35	0.50	0.50	1.56	0.47	N/A
Generator Frequency						
Minimum Required Frequency, Hz (95% Nominal)[(1)]	57	57	57	57	57	57
Calculated Minimum Frequency, Hz (% Nominal)	59.2 (98.3%)	60.1 (100.2%)	60.0 (100.0%)	60.2 (100.3%)	59.8 (99.8%)	60.2 (100.3%)
Frequency Margin, Hz	2.2	3.1	3.0	3.2	2.8	3.2
Allowable Time[(2)] to recover to 98% Nominal Frequency (58.8 Hz), sec	1	1	2	2	2	N/A
Calculated Time to Recover to 98% Nominal Frequency, sec	N/A	N/A	N/A	N/A	N/A	N/A
Recovery Time Margin, sec	N/A	N/A	N/A	N/A	N/A	N/A

Note 1: 4160V is taken as nominal voltage and 60Hz is taken as nominal frequency
Note 2: Voltage should be restored to within 10 percent of nominal and frequency should be restored to within 2 percent of nominal in less than 40 percent of each load sequence time interval.

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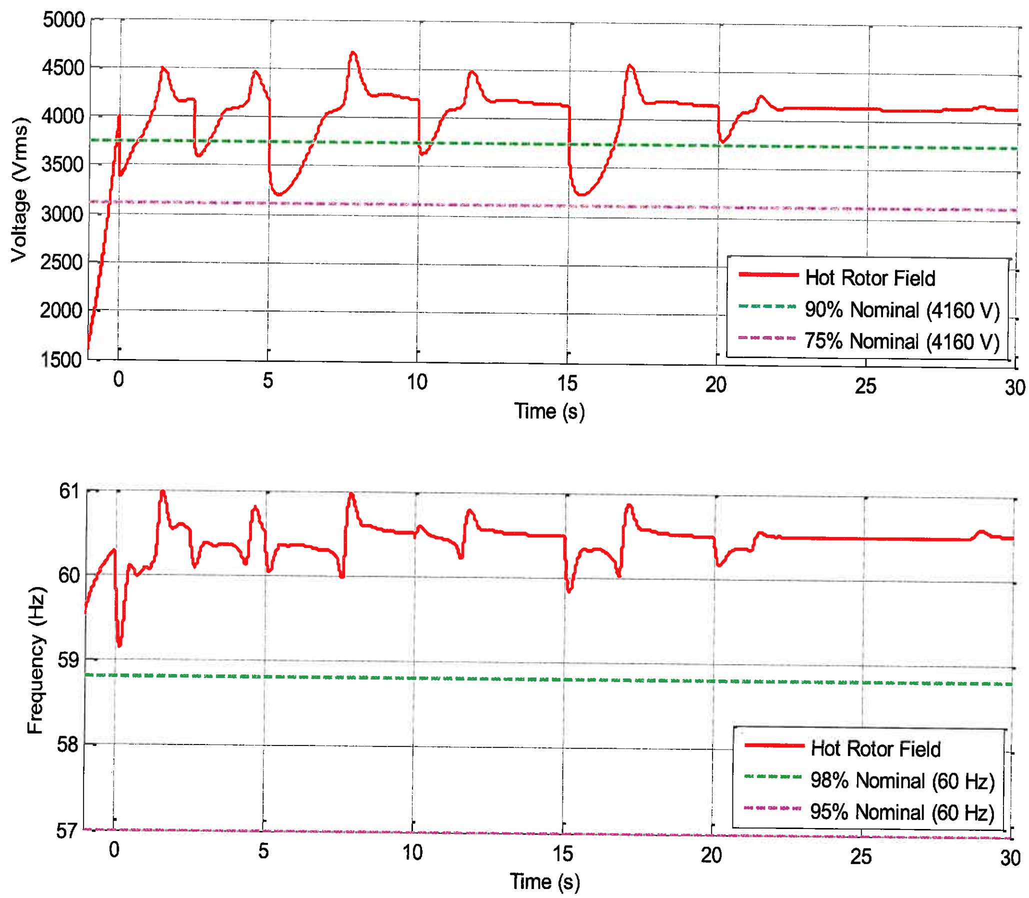

Figure 3-8. Voltage and Frequency Response for EDG Design Basis LOOP/LOCA with Hot Field – Case 8

7.4 Design Basis LOOP/LOCA with 4088 V Set Point and Minimum/Maximum Frequency Set Point

Condition report CR09-67370 (Reference 61) describes a potentially non-conservative technical specification value for minimum EDG voltage. The Davis-Besse Technical Specifications Surveillance Requirements stipulate that the EDG steady state voltage must be greater than or equal to 3744 V. A preliminary evaluation discovered that a minimum voltage set point of 4088 V (Reference 61) would satisfy the acceptance criteria of Safety Guide 9, i.e. that voltage does not dip below 75% and that recovery to 90% is within 40% of the specified load time step.

Cases 7 and 8 were created to verify that a voltage set point of 4088 V would continue to satisfy the acceptance criteria. The condition report was also concerned with minimum and maximum frequency set points; these conditions do have an effect on the voltage dips due to motor/pump speed variations affecting load on the generator. The minimum and maximum frequency set points also affect the frequency recovery during load steps, and must be accounted for in order to satisfy the acceptance criteria.

Case 7 is the design basis LOOP/LOCA loading scenario with a voltage set point of 4088 V and a frequency set point of 59.5 Hz. Case 8 is the design basis LOOP/LOCA loading scenario with a voltage set point of 4088 V and a frequency set point of 60.5 Hz.

7.4.1 Case 7 – 4088 V Set Point and 59.5 Hz Set Point

The initial conditions at breaker closure for this analyzed case are shown in Table 7-14. The only differences between Case 3 and Case 7 are the frequency and voltage set points. The case specific input file is `case_7.m`. The model results are shown in Table 7-15. Figure 7-17 through Figure 7-20 show the calculated EDG transient response. The acceptance criteria indicated in Section 2.1 are satisfied. Figure 7-20 shows the voltage response of the 480V MCC bus. Table 7-16 shows the calculated minimum voltage values at 480V MCC bus.

Table 7-14. Variables Used in System Model Voltage and Speed Setpoint Blocks – Case 7

Parameter Name	Units	Value
Voltage Setpoint Parameters:		
Final Setpoint (Volt_Setpoint)	Volts	4088
Initial Setpoint (V_SP_initial)	Volts	4088
Time of Setpoint Step Change (time_V_SP_step)	Seconds	0
Electronic Governor Setpoint Parameters:		
Final Setpoint (Freq_SetPoint)	RPM	892.5
Initial Setpoint (Fr_SP_initial)	RPM	825
Time of Setpoint Step Change (time_Fr_SP_step)	Seconds	3
K2 Relay Energizing Speed (RPM_K2)	RPM	830
Engine Initial Parameters		
Engine Initial Speed(EngRating_eng(3))	RPM	775

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Table 7-15. Summary of Results for Design Basis LOOP/LOCA Analyses – Case 7

	Step 1	Step 1a	Step 2	Step 3	Step 4	Step 5
Generator Voltage						
Minimum Required Voltage, V (75% Nominal)(1)	3120	3120	3120	3120	3120	3120
Calculated Minimum Voltage, V (% Nominal)	3379 (81.2%)	3592 (86.3%)	3229 (77.6%)	3625 (87.1%)	3250 (78.1%)	3790 (91.1%)
Voltage Margin, V	259	472	109	505	130	670
Allowable Time(2) to recover to 90% Nominal Voltage (3744 V), sec	1	1	2	2	2	N/A
Calculated Time to Recover to 90% Nominal Voltage, sec	0.75	0.5	1.5	0.46	1.48	N/A
Recovery Time Margin, sec	0.25	0.5	0.5	1.54	0.52	N/A
Generator Frequency						
Minimum Required Frequency, Hz (95% Nominal)(1)	57	57	57	57	57	57
Calculated Minimum Frequency, Hz (% Nominal)	58.2 (96.9%)	59.1 (98.5%)	59 (98.3%)	59.2 (98.7%)	58.8 (98.0%)	59.1 (98.6%)
Frequency Margin, Hz	1.2	2.1	2	2.2	1.8	2.1
Allowable Time(2) to recover to 98% Nominal Frequency (58.8 Hz), sec	1	1	2	2	2	N/A
Calculated Time to Recover to 98% Nominal Frequency, sec	0.37	N/A	N/A	N/A	N/A	N/A
Recovery Time Margin, sec	0.63	N/A	N/A	N/A	N/A	N/A

Note 1: 4160V is taken as nominal voltage and 60Hz is taken as nominal frequency
Note 2: Voltage should be restored to within 10 percent of nominal and frequency should be restored to within 2 percent of nominal in less than 40 percent of each load sequence time interval.

Table 7-16. 480V MCC Voltage Response Results for Design Basis LOOP/LOCA Analyses – Case 7

	Step 1	Step 1a	Step 2	Step 3	Step 4	Step 5
480V MCC Voltage						
Calculated Minimum Voltage, V (% Nominal)	363(1) (75.6%)	410 (85.4%)	366 (76.2%)	414 (86.3%)	368 (76.7%)	396 (82.5%)

Note 1. The high frequency transient value which occurs for first few cycles of first load step has been ignored.

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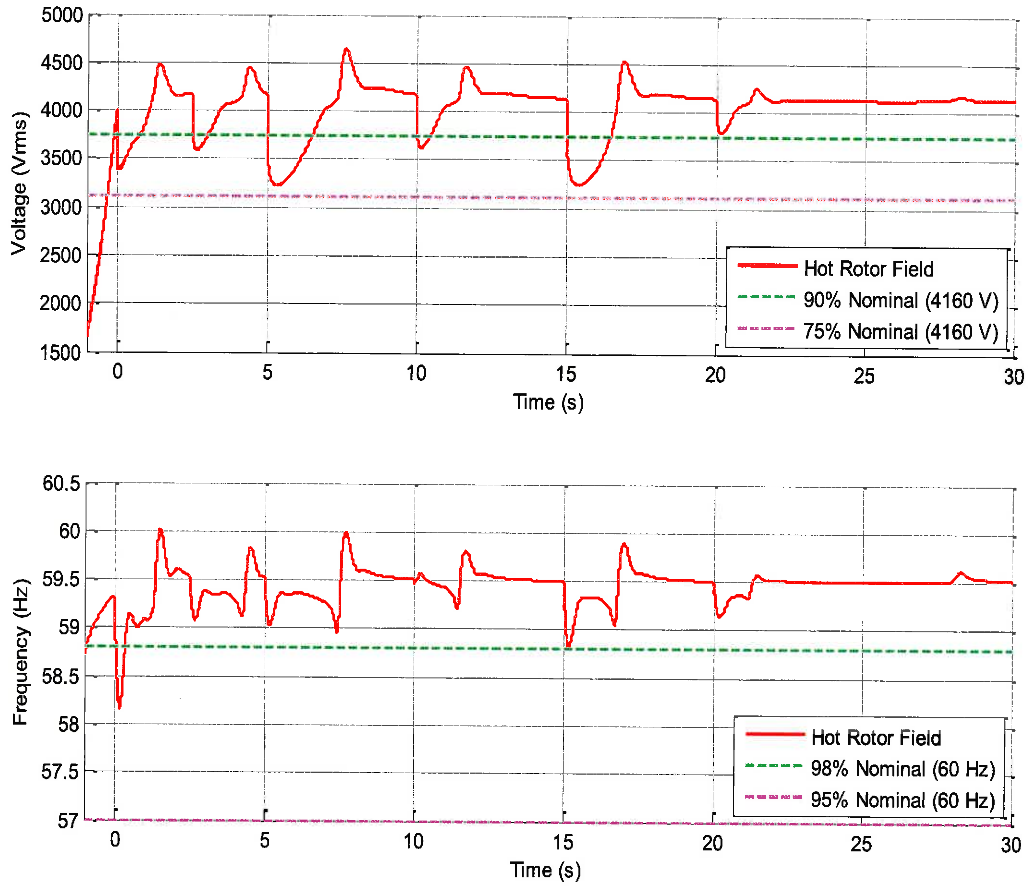
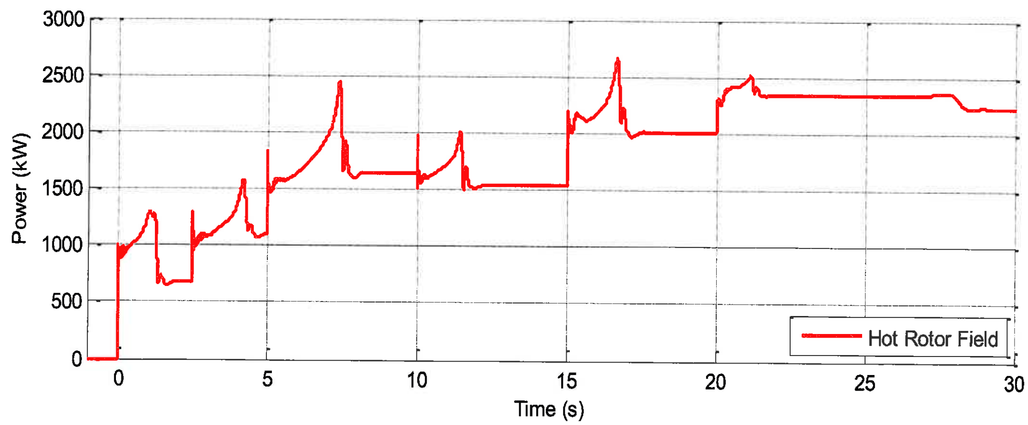


Figure 7-17. Voltage and Frequency Response for EDG Design Basis LOOP/LOCA with Hot Field – Case 7



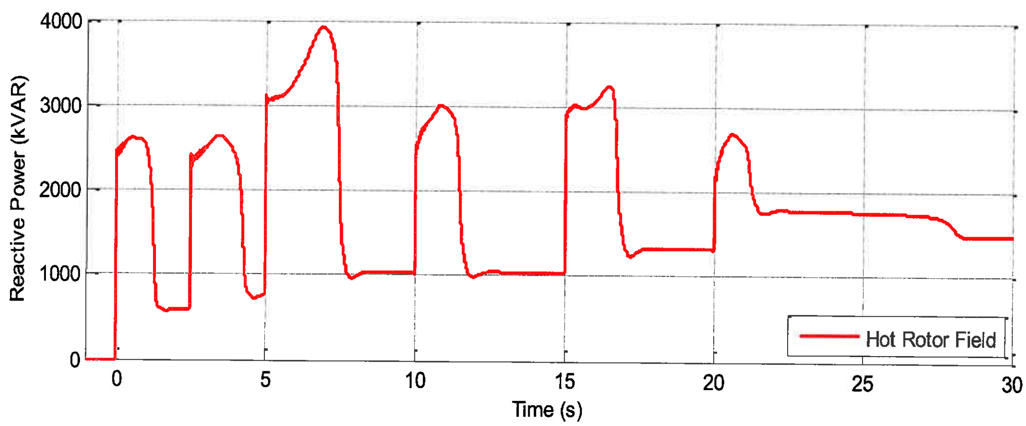


Figure 7-18. Real Power and Reactive Power Response for EDG Design Basis LOOP/LOCA with Hot Field – Case 7

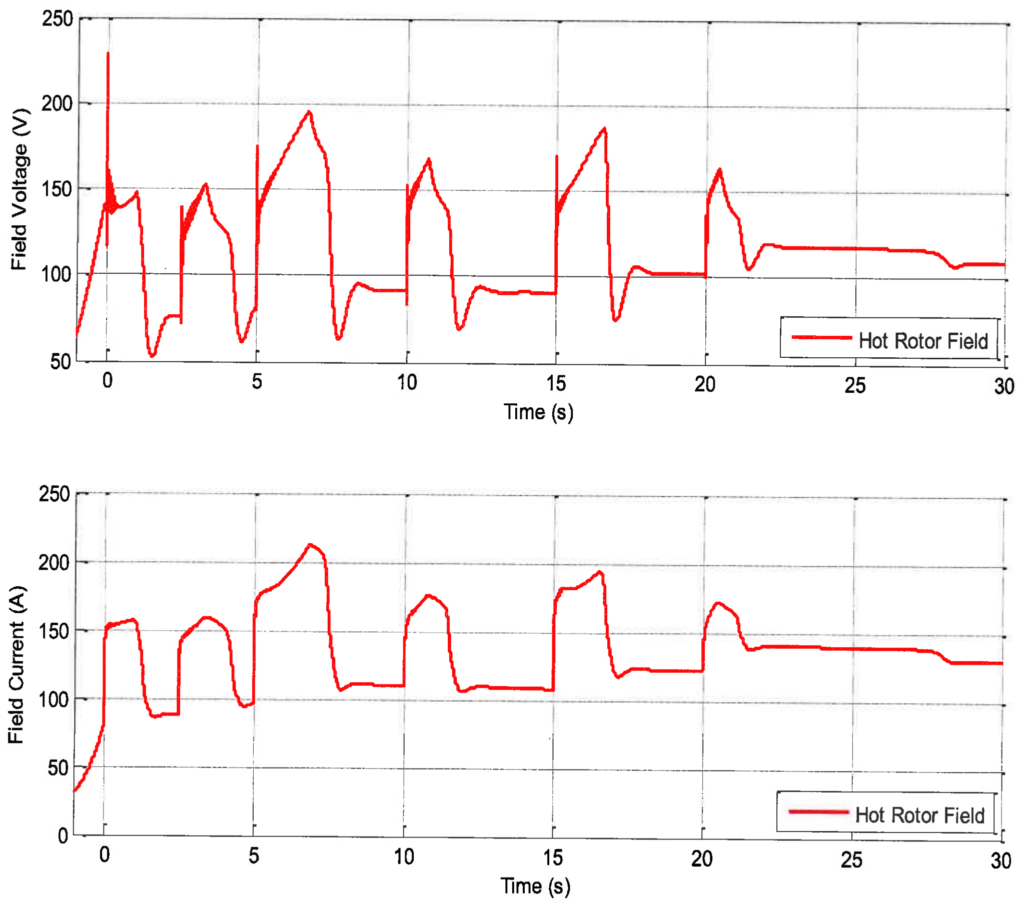


Figure 7-19. Field Voltage and Field Current Response for EDG Design Basis LOOP/LOCA with Hot Field – Case 7

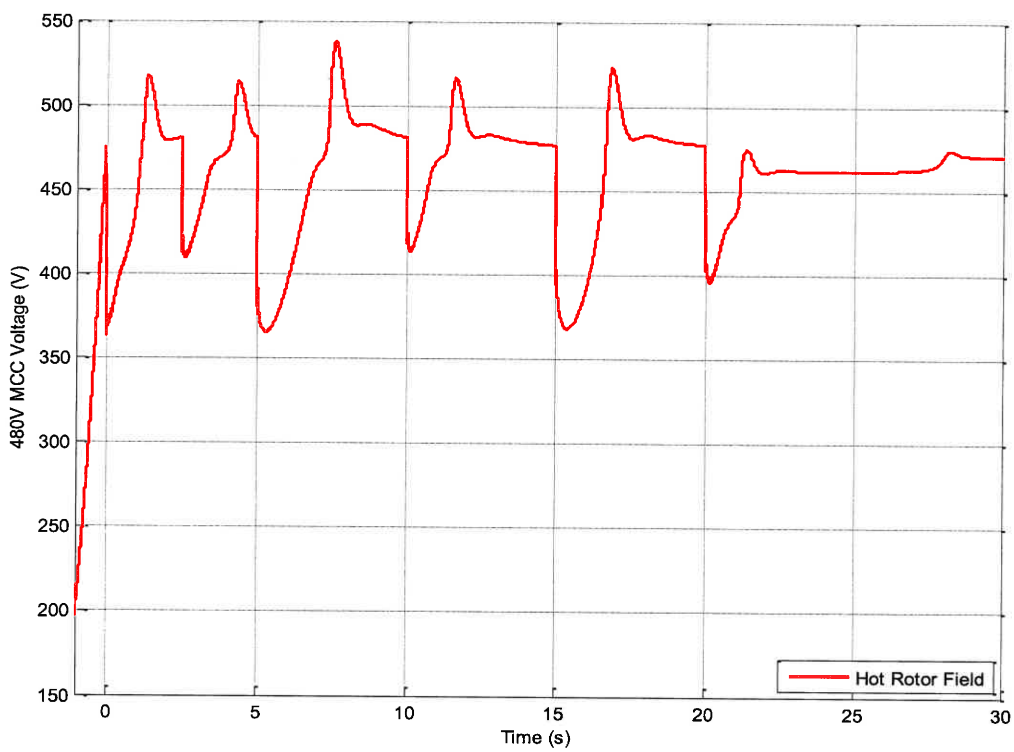


Figure 7-20. 480V MCC Voltage Response for EDG Design Basis LOOP/LOCA with Hot Field – Case 7

7.4.2 Case 8 – 4088 V Set Point and 60.5 Hz Set Point

The initial conditions at breaker closure for this analyzed case are shown in Table 7-17. The only differences between Case 3 and Case 8 are the frequency and voltage set points. The case specific input file is `case_8.m`. The model results are shown in Table 7-18. Figure 7-21 through Figure 7-24 show the calculated EDG transient response. The acceptance criteria indicated in Section 2.1 are satisfied. Figure 7-24 shows the voltage response of the 480V MCC bus. Table 7-19 shows the calculated minimum voltage values at 480V MCC bus.

Table 7-17. Variables Used in System Model Voltage and Speed Setpoint Blocks – Case 8

Parameter Name	Units	Value
Voltage Setpoint Parameters:		
Final Setpoint (Volt_Setpoint)	Volts	4088
Initial Setpoint (V_SP_initial)	Volts	4088
Time of Setpoint Step Change (time_V_SP_step)	Seconds	0
Electronic Governor Setpoint Parameters:		
Final Setpoint (Freq_SetPoint)	RPM	907.5
Initial Setpoint (Fr_SP_initial)	RPM	825
Time of Setpoint Step Change (time_Fr_SP_step)	Seconds	3
K2 Relay Energizing Speed (RPM_K2)	RPM	830
Engine Initial Parameters		
Engine Initial Speed(EngRating_eng(3))	RPM	775

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Table 7-18. Summary of Results for Design Basis LOOP/LOCA Analyses – Case 8

	Step 1	Step 1a	Step 2	Step 3	Step 4	Step 5
Generator Voltage						
Minimum Required Voltage, V (75% Nominal)[1]	3120	3120	3120	3120	3120	3120
Calculated Minimum Voltage, V (% Nominal)	3386 (81.4 %)	3589 (86.3%)	3204 (77.0%)	3626 (87.2%)	3225 (77.5%)	3785 (91.0%)
Voltage Margin, V	266	469	84	506	105	665
Allowable Time[2] to recover to 90% Nominal Voltage (3744 V), sec	1	1	2	2	2	N/A
Calculated Time to Recover to 90% Nominal Voltage, sec	0.65	0.50	1.50	0.44	1.53	N/A
Recovery Time Margin, sec	0.35	0.50	0.50	1.56	0.47	N/A
Generator Frequency						
Minimum Required Frequency, Hz (95% Nominal)[1]	57	57	57	57	57	57
Calculated Minimum Frequency, Hz (% Nominal)	59.2 (98.3%)	60.1 (100.2%)	60.0 (100.0%)	60.2 (100.3%)	59.8 (99.8%)	60.2 (100.3%)
Frequency Margin, Hz	2.2	3.1	3.0	3.2	2.8	3.2
Allowable Time[2] to recover to 98% Nominal Frequency (58.8 Hz), sec	1	1	2	2	2	N/A
Calculated Time to Recover to 98% Nominal Frequency, sec	N/A	N/A	N/A	N/A	N/A	N/A
Recovery Time Margin, sec	N/A	N/A	N/A	N/A	N/A	N/A

Note 1: 4160V is taken as nominal voltage and 60Hz is taken as nominal frequency
Note 2: Voltage should be restored to within 10 percent of nominal and frequency should be restored to within 2 percent of nominal in less than 40 percent of each load sequence time interval.

Table 7-19. 480V MCC Voltage Response Results for Design Basis LOOP/LOCA Analyses – Case 8

	Step 1	Step 1a	Step 2	Step 3	Step 4	Step 5
480V MCC Voltage						
Calculated Minimum Voltage, V (% Nominal)	363[1] (75.6%)	409 (85.3%)	362 (75.5%)	414 (86.2%)	365 (76.0%)	395 (82.3%)

Note 1. The high frequency transient value which occurs for first few cycles of first load step has been ignored.

MPR

MPR Associates, Inc.
320 King Street
Alexandria, VA 22314

Calculation No.	Prepared By	Checked By	Page: 145
0200-0087-RP01	[signature]	I. G. Stamatiou	Revision: 6

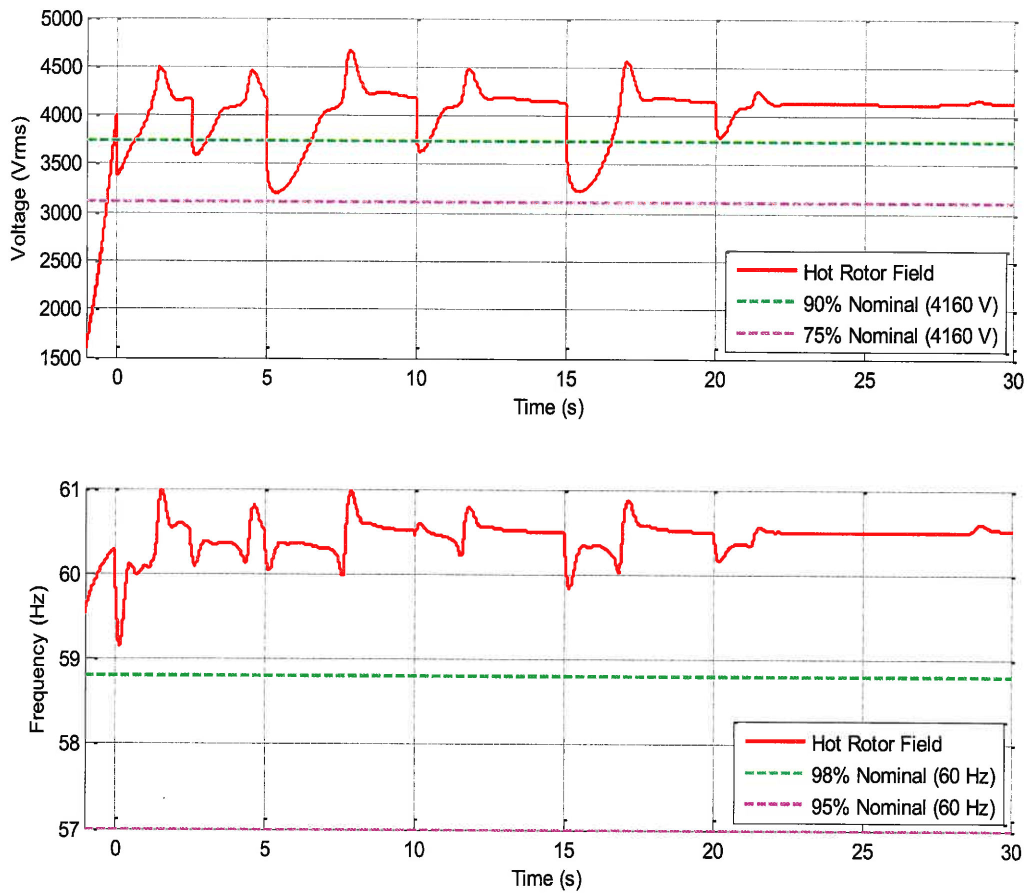
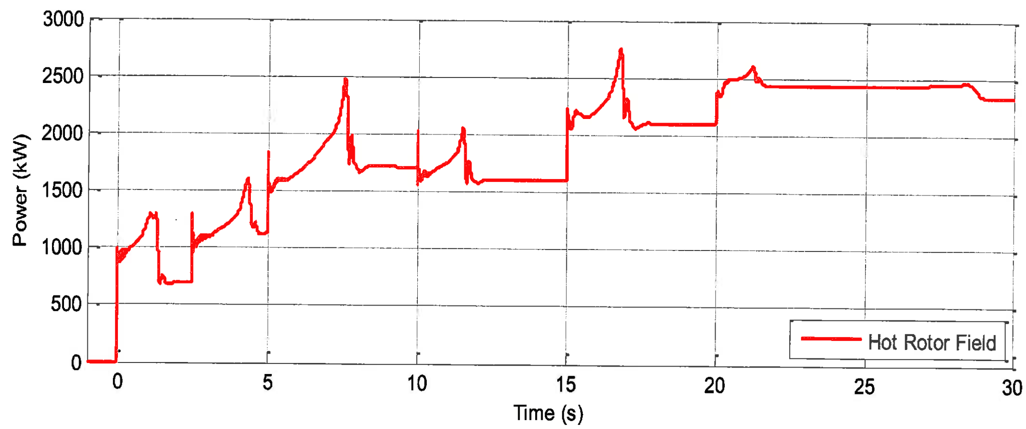


Figure 7-21. Voltage and Frequency Response for EDG Design Basis LOOP/LOCA with Hot Field – Case 8



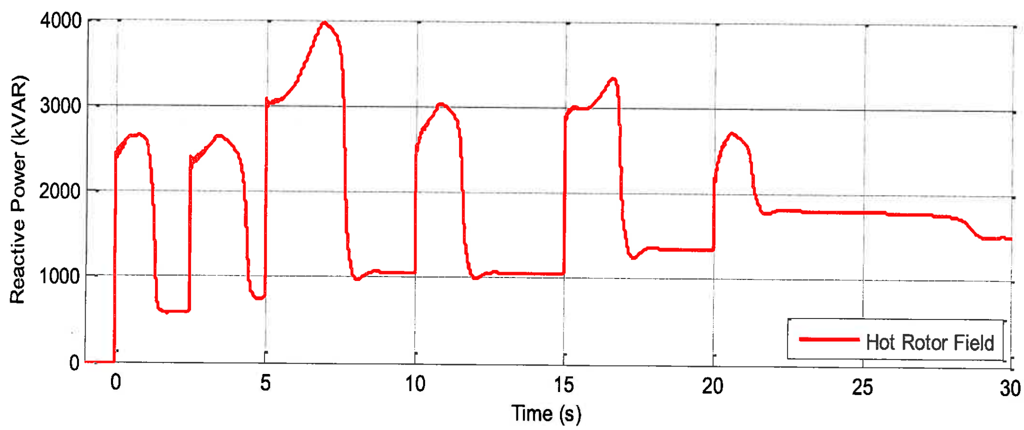


Figure 7-22. Real Power and Reactive Power Response for EDG Design Basis LOOP/LOCA with Hot Field – Case 8

MPR	MPR Associates, Inc. 320 King Street Alexandria, VA 22314		
Calculation No. 0200-0087-RP01	Prepared By	Checked By I. G. Stamatiou	Page: 147 Revision: 6

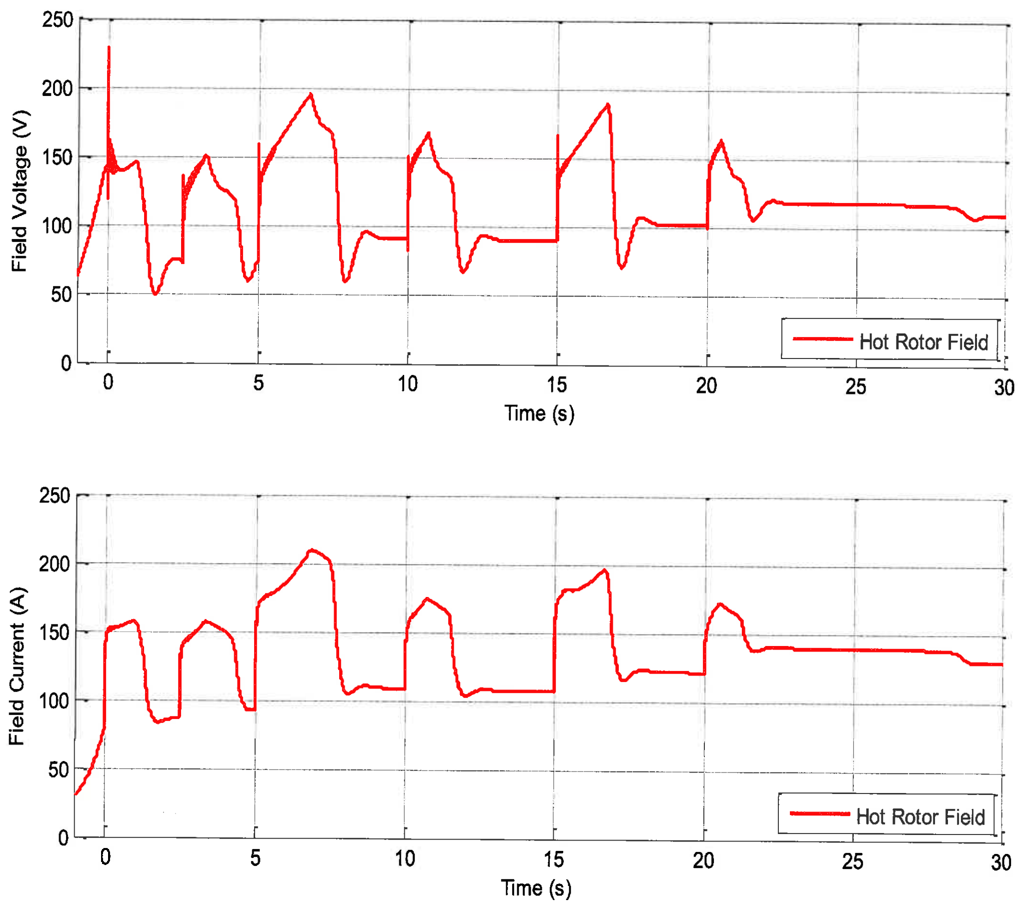


Figure 7-23. Field Voltage and Field Current Response for EDG Design Basis LOOP/LOCA with Hot Field – Case 8

MPR	MPR Associates, Inc. 320 King Street Alexandria, VA 22314		
Calculation No. 0200-0087-RP01	Prepared By [signature]	Checked By I. G. Stamatiou	Page: 148 Revision: 6

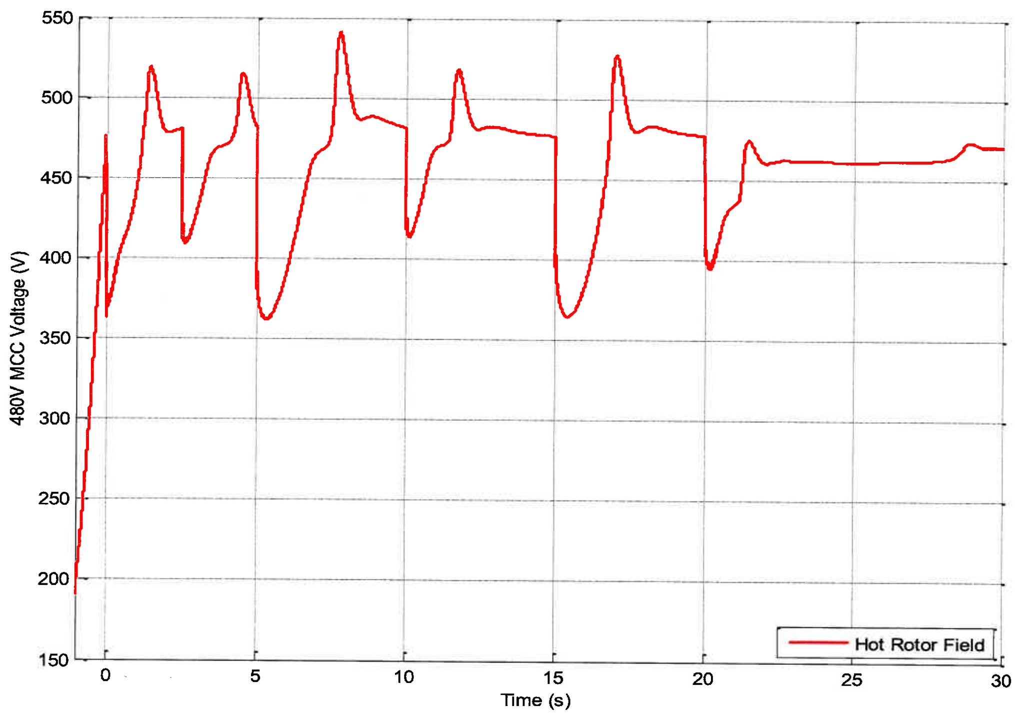


Figure 7-24. 480V MCC Voltage Response for EDG Design Basis LOOP/LOCA with Hot Field – Case 8

Davis-Besse Nuclear Power Station, Unit No. 1

L-15-268

Appendix 2

Contents

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ACTUATED EQUIPMENT TABULATION

EQUIPMENT ITEM NO.	EQUIPMENT DESCRIPTION	SA SIGNAL NO.	FUNCTION	SURVEILL MOD TYPE 1(2)/3(4)	SAM LOGIC MOD TYPE 1(2)/3(4)	PUMP JMPR MOD TYPE 1(2)/3(4)	SEQ. STEP	RC	SCHEME DWG. NO.	VDWG. NO. CH. 1(2)	VDWG. NO. CH. 3(4)
C 30-1	EMER VENT FAN 1	SA 111A	ST	1X 1X	4I		1	2	E58B-8	E-30-14	E-30-35
HV 5439	ECCS RM 105 HV & A/C ISO VLV	SA 111B	C	1X 1X	4I		1	2	E60B-5	E-30-14	E-30-35
HV 5440	ECCS RM 105 HV & A/C ISO VLV	SA 111C	C	1X 1X	4I		1	2	E60B-5	E-30-14	E-30-35
HV 5024	EMER VENT FAN 1 VLV FRM AUX. BLDG.	SA 111D	C	1X 1X	4I		1	2	E58B-11 A&B	E-30-14	E-30-35
SV 5716	ECCS RM 115 ISO DMPR.	SA 111E*	C	2F 2I			1	4	E60B-23	E-30-14	E-30-35
C 30-2	EMER VENT FAN 2	SA 112A	ST	1X 1X	4I		1	2	E58B-8	E-30-24	E-30-28
HV 5441	ECCS RM 115 HV & A/C ISO VLV	SA 112B	C	1X 1X	4I		1	2	E60B-5	E-30-24	E-30-28
HV 5442	ECCS RM 115 HV & A/C ISO VLV	SA 112C	C	1X 1X	4I		1	2	E60B-5	E-30-24	E-30-28
HV 5025	EMER VENT FAN 2 VLV FRM AUX. BLDG.	SA 112D	C	1X 1X	4I		1	2	E58B-11 A&B	E-30-24	E-30-28
SV 5715	ECCS RM 105 ISO DMPR.	SA 112E*	C	2F 2I			1	4	E60B-23	E-30-24	E-30-28
	SPARE	SA 121A					1	3		E-30-14	E-30-35
HV 5008	CTMT PURGE OUT ISO VLV	SA 121B*	C	2F 2I			1	4	E58B-7 A&B	E-30-14	E-30-35
HV 5011A	CTMT AIR SAMPLE ISO VLV	SA 121C*	C	1X 1X			1	2	E58B-14 A-C	E-30-14	E-30-35
HV 5011B	CTMT AIR SAMPLE ISO VLV	SA 121D*	C	1X 1X			1	2	E58B-15 A&B	E-30-14	E-30-35
HV 5011C	CTMT AIR SAMPLE ISO VLV	SA 121E*	C	1X 1X			1	2	E58B-14 A-C	E-30-14	E-30-35
HV 5011D	CTMT AIR SAMPLE ISO VLV	SA 121F*	C	1X 1X			1	2	E58B-15 A&B	E-30-14	E-30-35
HV 5006	CTMT PURGE IN ISO VLV	SA 121G*	C	2F 2I			1	4	E58B-6	E-30-14	E-30-35
HV 5009	MECH PENT RMS 2 & 4 PURGE VLV	SA 121H*	C	2F 2I			1	4	E58B-7 A&B	E-30-14	E-30-35
HV 5016	MECH PENT RMS 1 & 3 PURGE VLV	SA 121I*	C	2F 2I			1	4	E58B-7 A&B	E-30-14	E-30-35
HV 5011E	CTMT AIR SAMPLE RET ISO VLV	SA 121J*	C	1X 1X			1	2	E58B-14 A-C	E-30-14	E-30-35
	SPARE	SA 121K					1	2		E-30-14	E-30-35
SV 5301	CTRM AIR HANDL VLV 1	SA 121L*	C	2F 2I			1	4	E60B-14 A-D	E-30-14	E-30-35
	SPARE	SA 122A					1	3		E-30-24	E-30-28
HV 5010D	CTMT AIR SAMPLE ISO VLV	SA 122B*	C	1X 1X			1	2	E58B-14 A-C	E-30-24	E-30-28
HV 5004	MECH PENT RMS 1 & 3 PURGE VLV	SA 122C*	C	2F 2I			1	4	E58B-7 A&B	E-30-24	E-30-28
HV 5021	MECH PENT RMS 2 & 4 PURGE VLV	SA 122D*	C	2F 2I			1	4	E58B-7 A&B	E-30-24	E-30-28
HV 5005	CTMT PURGE IN ISO VLV	SA 122E*	C	2F 2I			1	4	E58B-7 A&B	E-30-24	E-30-28
HV 5007	CTMT PURGE OUT ISO VLV	SA 122F*	C	2F 2I			1	4	E58B-6	E-30-24	E-30-28
HV 5010A	CTMT AIR SAMPLE ISO VLV	SA 122G*	C	1X 1X			1	2	E58B-15 A&B	E-30-24	E-30-28
HV 5010B	CTMT AIR SAMPLE ISO VLV	SA 122H*	C	1X 1X			1	2	E58B-14 A-C	E-30-24	E-30-28
HV 5010C	CTMT AIR SAMPLE ISO VLV	SA 122I*	C	1X 1X			1	2	E58B-15 A&B	E-30-24	E-30-28
HV 5010E	CTMT AIR SAMPLE RET ISO VLV	SA 122J*	C	1X 1X			1	2	E58B-14 A-C	E-30-24	E-30-28
	SPARE	SA 122K					1	2		E-30-24	E-30-28
SV 5311	CTRM AIR HANDL VLV 2	SA 122L*	C	2F 2I			1	4	E60B-14 A-D	E-30-24	E-30-28
P 58-1	HP INJ PMP 1	SA 211A*	ST	3X 3X		5X 5X	2	1	E52B-5 A&B	E-30-14	E-30-35
HV HP2C	HP INJ 1-1 VLV	SA 211B	O	1X 1X	4I		2	2	E52B-26 A&B	E-30-14	E-30-35
HV HP2D	HP INJ 1-2 VLV	SA 211C	O	1X 1X	4I		2	2	E52B-26 A&B	E-30-14	E-30-35
	SPARE	SA 211D*					2	4		E-30-14	E-30-35

FOR LEGEND, SIGNAL DESCRIPTION & NOTES SEE E-17B SH.7

THIS DWG. WAS REDRAWN ON CADD AND SUPERSEDES REVISION 9.

NO.	DATE	REVISIONS	BY	CH'K	ENGR.	ENGR. SUPV.	GEN. SUPV.
10	4-2-99	GENERAL UPDATE REDRAWN FOR DWG. ENHANCEMENT (NO DWG. CHANGE)(REDRAWN)	JOR	SBW	—	MLD	—

SCALE NONE | DESIGNED -- | DRAWN JOR | DATE 03-12-99

DAVIS-BESSE NUCLEAR POWER STATION
UNIT NO. 1
THE TOLEDO EDISON COMPANY

SAFETY FEATURES ACTUATION SYSTEM
ACTUATED EQUIPMENT TABULATION

Q

DRAWING NO. E-17B SH.1 | REV. 10

DB 04-06-99 DFN=I:/ELEC/E17BSH1.DGN

ACTUATED EQUIPMENT TABULATION

EQUIPMENT ITEM NO.	EQUIPMENT DESCRIPTION	SA SIGNAL NO.	FUNCTION	SURVEILL MOD TYPE 1(2)/3(4)	SAM LOGIC MOD TYPE 1(2)/3(4)	PUMP JMPR MOD TYPE 1(2)/3(4)	SEQ. STEP	RC	SCHEME DWG. NO.	VDWG. NO. CH. 1(2)	VDWG. NO. CH. 3(4)
P 58-2	HP INJ PMP 2	SA 212A*	ST	3X 3X		5X 5X	2	1	E52B-5 C&D	E-30-24	E-30-28
HV HP2A	HP INJ 2-1 VLV	SA 212B	O	1X 1X	4I		2	2	E52B-26 A&B	E-30-24	E-30-28
HV HP2B	HP INJ 2-2 VLV	SA 212C	O	1X 1X	4I		2	2	E52B-26 A&B	E-30-24	E-30-28
	SPARE	SA 212D*					2	4		E-30-24	E-30-28
C 1-1	CTMT CLR FAN 1	SA 221A	SH	1X 1X	4I		5	3	E58B-1 A&B	E-30-14	E-30-35
C 1-3	CTMT CLR FAN 3	SA 221B	SH	1X 1X	4I		5	3	E58B-2 A&B	E-30-14	E-30-35
	SPARE	SA 221C					5	2		E-30-14	E-30-35
	SPARE	SA 221D*					5	4		E-30-14	E-30-35
C 1-2	CTMT CLR FAN 2	SA 222A	SH	1X 1X	4I		5	3	E58B-1 A&B	E-30-24	E-30-28
C 1-3	CTMT CLR FAN 3	SA 222B	SH	1X 1X	4I		5	3	E58B-2 C&D	E-30-24	E-30-28
	SPARE	SA 222C					5	2		E-30-24	E-30-28
	SPARE	SA 222D*					5	4		E-30-24	E-30-28
P 43-1	CC PUMP 1	SA 231A*	ST	3X 3X		5X 5X	1	1	E50B-3 C&D	E-30-14	E-30-35
P 43-3	CC PUMP 3	SA 231B*	ST	3X 3X		5X 5X	1	1	E50B-4 A-F	E-30-14	E-30-35
HV 5070	CTMT VACM RLF ISO VLV	SA 231C	C	1X 1X	4I		1	2	E58B-10 A&B	E-30-14	E-30-35
HV 5071	CTMT VACM RLF ISO VLV	SA 231D	C	1X 1X	4I		1	2	E58B-10 A&B	E-30-14	E-30-35
HV 5072	CTMT VACM RLF ISO VLV	SA 231E	C	1X 1X	4I		1	2	E58B-10 A&B	E-30-14	E-30-35
HV 5073	CTMT VACM RLF ISO VLV	SA 231F	C	1X 1X	4I		1	2	E58B-10 A&B	E-30-14	E-30-35
HV 5074	CTMT VACM RLF ISO VLV	SA 231G	C	1X 1X	4I		1	2	E58B-10 A&B	E-30-14	E-30-35
LY 6453	SG AUTO LVL CTRL	SA 231H	T	1X 1X	4I		1	2	E44B-24	E-30-14	E-30-35
P 43-2	CC PUMP 2	SA 232A*	ST	3X 3X		5X 5X	1	1	E50B-3 A&B	E-30-24	E-30-28
P 43-3	CC PUMP 3	SA 232B*	ST	3X 3X		5X 5X	1	1	E50B-4 A-F	E-30-24	E-30-28
HV 5075	CTMT VACM RLF ISO VLV	SA 232C	C	1X 1X	4I		1	2	E58B-10 A&B	E-30-24	E-30-28
HV 5076	CTMT VACM RLF ISO VLV	SA 232D	C	1X 1X	4I		1	2	E58B-10 A&B	E-30-24	E-30-28
HV 5077	CTMT VACM RLF ISO VLV	SA 232E	C	1X 1X	4I		1	2	E58B-10 A&B	E-30-24	E-30-28
HV 5078	CTMT VACM RLF ISO VLV	SA 232F	C	1X 1X	4I		1	2	E58B-10 A&B	E-30-24	E-30-28
HV 5079	CTMT VACM RLF ISO VLV	SA 232G	C	1X 1X	4I		1	2	E58B-10 A&B	E-30-24	E-30-28
LY 6454	SG AUTO LVL CTRL	SA 232H	T	1X 1X	4I		1	2	E44B-24	E-30-24	E-30-28
P 3-1	SW PUMP 1	SA 241A*	ST	3X 3X		5X 5X	4	1	E48B-6 A&B	E-30-14	E-30-35
P 3-3	SW PUMP 3	SA 241B*	ST	3X 3X		5X 5X	4	1	E48B-11 A-D	E-30-14	E-30-35
TV 1424	SW FROM CC HX 1 ISO VLV	SA 241C*	O	2I 2F			4	4	E48B-30	E-30-14	E-30-35
TV 1429	SW FROM CC HX 3 ISO VLV	SA 241D*	O	2I 2F			4	4	E48B-31 A&B	E-30-14	E-30-35
	SPARE	SA 241E					4	2		E-30-14	E-30-35
P 3-2	SW PUMP 2	SA 242A*	ST	3X 3X		5X 5X	4	1	E48B-6 C&D	E-30-24	E-30-28
P 3-3	SW PUMP 3	SA 242B*	ST	3X 3X		5X 5X	4	1	E48B-11 C-F	E-30-24	E-30-28
TV 1434	SW FROM CC HX 2 ISO VLV	SA 242C*	O	2I 2F			4	4	E48B-30	E-30-24	E-30-28

FOR LEGEND, SIGNAL DESCRIPTION & NOTES SEE E-17B SH.7

THIS DWG. WAS REDRAWN ON CADD AND SUPERSEDES REVISION 9.

REVISIONS

NO.	DATE	REVISIONS	BY	CH'K	ENGR.	ENGR. SUPV.	GEN. SUPV.
10	4-21-99	GENERAL UPDATE REDRAWN FOR DWG. ENHANCEMENT (NO DWG. CHANGE)(REDRAWN)	JOR	SBW	—	WLB	—

SCALE NONE | DESIGNED -- | DRAWN JOR | DATE 03-16-99

DAVIS-BESSE NUCLEAR POWER STATION
UNIT NO. 1
THE TOLEDO EDISON COMPANY

SAFETY FEATURES ACTUATION SYSTEM
ACTUATED EQUIPMENT TABULATION
Q

DRAWING NO. E-17B SH.2 | REV. 10

DB 04-06-99 DFN=I:/ELEC/E17BSH2.DGN

NEWFAX 3/85 N58313

ACTUATED EQUIPMENT TABULATION

EQUIPMENT ITEM NO.	EQUIPMENT DESCRIPTION	SA SIGNAL NO.	FUNCTION	SURVEILL MOD TYPE 1(2)/3(4)	SAM LOGIC MOD TYPE 1(2)/3(4)	PUMP JMPR MOD TYPE 1(2)/3(4)	SEQ. STEP	RC	SCHEME DWG. NO.	VDWG. NO. CH. 1(2)	VDWG. NO. CH. 3(4)
TV 1429	SW FROM CC HX 3 ISO VLV	SA 242D*	O	2I 2F			4	4	E48B-31 A&B	E-30-24	E-30-28
	SPARE	SA 242E					4	2		E-30-24	E-30-28
HV 1530	CS 1 ISO VLV	SA 251A	O	1X 1X	4I		1	2	E52B-21 A&B	E-30-15	E-30-36
	SPARE	SA 251B					1	2		E-30-15	E-30-36
	SPARE	SA 251C*					1	4		E-30-15	E-30-36
HV 1531	CS 2 ISO VLV	SA 252A	O	1X 1X	4I		1	2	E52B-21 A&B	E-30-25	E-30-29
	SPARE	SA 252B					1	2		E-30-25	E-30-29
	SPARE	SA 252C*					1	4		E-30-25	E-30-29
K 5-1	EMER DG 1	SA 261A*	ST	3X** 3X**		5X 5X	1	2	E64B-1 A-F NOTE 3	E-30-15	E-30-36
	SPARE	SA 261B					1	2		E-30-15	E-30-36
	SPARE	SA 261C*					1	4		E-30-15	E-30-36
K 5-2	EMER DG 2	SA 262A*	ST	3X** 3X**		5X 5X	1	2	E64B-2 A-F NOTE 3	E-30-25	E-30-29
	SPARE	SA 262B					1	2		E-30-25	E-30-29
	SPARE	SA 262C*					1	4		E-30-25	E-30-29
HV MU2A	RC LETDOWN DELAY COIL OUT VLV	SA 271A	C	1X 1X	4I		1	2	E49B-18	E-30-15	E-30-36
	SPARE	SA 271B					1	2		E-30-15	E-30-36
	SPARE	SA 271C*					1	4		E-30-15	E-30-36
HV 2012A	CTMT NORM SUMP ISO VLV	SA 271D	C	1X 1X	4I		1	2	E56B-24 A&B	E-30-15	E-30-36
HV 240A	RC PRZR SAMPLE VLV	SA 271E	C	1X 1X	4I		1	2	E52B-15	E-30-15	E-30-36
HV 1399	SW ISO VLV TO CLNG WTR	SA 271F	C	1X 1X	4I		1	2	E48B-9 A&B	E-30-15	E-30-36
HV 1773A	RC DT HDR ISO VLV	SA 271G*	C	2I 2F			1	4	E52B-39	E-30-15	E-30-36
HV 1719A	CTMT VENT HDR ISO VLV	SA 271H*	C	2I 2F			1	4	E52B-39	E-30-15	E-30-36
HV 607	SG 1 SAMPLE ISO VLV	SA 271I*	C	2I 2F			1	4	E46B-23 A&B	E-30-15	E-30-36
	SPARE	SA 271J*					1	4		E-30-15	E-30-36
HV 235A	PRZR QNCH TK SAMPLE ISO VLV	SA 271K*	C	2I 2F			1	4	E52B-32	E-30-15	E-30-36
HV 1544	CF TK 1 H_2O & N_2 FILL ISO VLV	SA 271L*	C	2I 2F			1	4	E52B-29 A&B	E-30-15	E-30-36
HV MU3	RC LETDOWN HI TEMP VLV	SA 272A*	C	2I 2F			1	4	E49B-22 A-C	E-30-25	E-30-29
	SPARE	SA 272B*					1	4		E-30-25	E-30-29
HV 2012B	CTMT NORM SUMP ISO VLV	SA 272C	C	1X 1X	4I		1	2	E56B-25 A&B	E-30-25	E-30-29
HV 240B	RC PRZR VAPOR SAMPLE VLV	SA 272D	C	1X 1X	4I		1	2	E52B-16 A&B	E-30-25	E-30-29
HV 1542	CF TK VENT ISO VLV	SA 272E*	C	2I 2F			1	4	E52B-29 A&B	E-30-25	E-30-29
HV 1395	SW ISO VLV TO CLNG WTR	SA 272F	C	1X 1X	4I		1	2	E48B-9 A&B	E-30-25	E-30-29
HV 1773B	RC DT HDR ISO VLV	SA 272G*	C	2I 2F			1	4	E52B-40	E-30-25	E-30-29
HV 1719B	CTMT VENT HDR ISO VLV	SA 272H*	C	2I 2F			1	4	E52B-40	E-30-25	E-30-29
HV 598	SG 2 SAMPLE ISO VLV	SA 272I*	C	2I 2F			1	4	E46B-23 A&B	E-30-25	E-30-29
	SPARE	SA 272J*					1	4		E-30-25	E-30-29

FOR LEGEND, SIGNAL DESCRIPTION & NOTES SEE E-17B SH.7

THIS DWG. WAS REDRAWN ON CADD AND SUPERSEDES REVISION 10.

NO.	DATE	REVISIONS	BY	CH'K	ENGR.	ENGR. SUPV.	GEN. SUPV.
11	4-21-99	GENERAL UPDATE REDRAWN FOR DWG. ENHANCEMENT (NO DWG. CHANGE)(REDRAWN)	JOR	SBW	—	[signature]	—

SCALE NONE | DESIGNED -- | DRAWN JOR | DATE 03-16-99

DAVIS-BESSE NUCLEAR POWER STATION
UNIT NO. 1
THE TOLEDO EDISON COMPANY

SAFETY FEATURES ACTUATION SYSTEM
ACTUATED EQUIPMENT TABULATION Q

DRAWING NO. E-17B SH.3 | REV. 11

DB 04-06-99 DFN=I:/ELEC/E17BSH3.DGN

NEWFAX 3/85 N58313

ED 7489

ACTUATED EQUIPMENT TABULATION

EQUIPMENT ITEM NO.	EQUIPMENT DESCRIPTION	SA SIGNAL NO.	FUNCTION	SURVEILL MOD TYPE 1(2)/3(4)	SAM LOGIC MOD TYPE 1(2)/3(4)	PUMP JMPR MOD TYPE 1(2)/3(4)	SEQ. STEP	RC	SCHEME DWG. NO.	VDWG. NO. CH. 1(2)	VDWG. NO. CH. 3(4)
HV 235B	PRZR QNCH TK SAMPLE ISO VLV	SA 272K*	C	2I 2F			1	4	E52B-33	E-30-25	E-30-29
HV 1541	CF TK 2 H_2O & N_2 FILL ISO VLV	SA 272L*	C	2I 2F			1	4	E52B-29 A&B	E-30-25	E-30-29
HV DH9B	CTMT EMER SUMP VLV	SA 281A	C	1X 1X	4I		1	2	E52B-19 A-C	E-30-16	E-30-37
	DELETED										
	DELETED										
	DELETED										
	DELETED										
	SPARE	SA 281F					1	2		E-30-16	E-30-37
HV DH7B	BWST OUT VLV	SA 281G	O	1X 1X	4I		1	2	E52B-19 A-C	E-30-16	E-30-37
HV 236	N2 CTMT ISO VLV	SA 281H*	C	2I 2F			1	4	E62B-5	E-30-16	E-30-37
HV 229A	PRZR QNCH TK OUT ISO VLV	SA 281I*	C	2I 2F			1	4	E52B-34	E-30-16	E-30-37
	SPARE	SA 281J*					1	4		E-30-16	E-30-37
	DELETED										
	DELETED										
	DELETED										
	SPARE	SA 281N*					1	4	E30-16	E-30-16	E-30-37
HV 232	PRZR QNCH TK IN ISO VLV	SA 282A*	C	2I 2F			1	4	E52B-36	E-30-26	E-30-30
HV 229B	PRZR QNCH TK OUT ISO VLV	SA 282B*	C	2I 2F			1	4	E52B-35	E-30-26	E-30-30
	DELETED										
HV 1545	CF TK SAMPLE VLV	SA 282D*	C	2I 2F			1	4	E52B-29 A&B	E-30-26	E-30-30
HV DH9A	CTMT EMER SUMP VLV	SA 282E	C	1X 1X	4I		1	2	E52B-19 A-C	E-30-26	E-30-30
	DELETED										
HV DH7A	BWST OUT VLV	SA 282G	O	1X 1X	4I		1	2	E52B-19 A-C	E-30-26	E-30-30
HV 2011	CTMT INSTR AIR ISO VLV	SA 282H*	C	2I 2F			1	4	E62B-4	E-30-26	E-30-30
HV 2010	CTMT SERV AIR ISO VLV	SA 282I*	C	2I 2F			1	4	E62B-4	E-30-26	E-30-30
	SPARE	SA 282J*					1	4		E-30-26	E-30-30
	DELETED										
	SPARE	SA 282L					1	2		E-30-26	E-30-30
HV 5090	CTMT H2 DILUTION IN ISO VLV	SA 291A	C	1X 1X	4I		1	2	E58B-5 A&B	E-30-16	E-30-37
	SPARE	SA 291B					1	2		E-30-16	E-30-37
HV 6831A	RCP STDP DEMIN WTR ISO VLV	SA 291C*	C	2I 2F			1	4	E49B-20	E-30-16	E-30-37
	SPARE	SA 291D*					1	4		E-30-16	E-30-37
HV 5038	CTMT H2 DILUTN OUT ISO VLV	SA 291E	C	1X 1X	4I		1	2	E58B-5 A&B	E-30-16	E-30-37
	SPARE	SA 291F					1	2		E-30-16	E-30-37
	SPARE	SA 291G					1	2		E-30-16	E-30-37
	SPARE	SA 292A					1	2		E-30-26	E-30-30
HV 5065	CTMT H2 DILUTION IN ISO VLV	SA 292B	C	1X 1X	4I		1	2	E58B-5 A&B	E-30-26	E-30-30
HV 6831B	RCP STDP DEMIN WTR ISO VLV	SA 292C*	C	2I 2F			1	4	E49B-19 A&B	E-30-26	E-30-30
	SPARE	SA 292D*						4		E-30-26	E-30-30
HV 5037	CTMT H2 DILUTN OUT ISO VLV	SA 292E	C	1X 1X	4I		1	2	E58B-5 A&B	E-30-26	E-30-30

REVISIONS

NO.	DATE	REVISIONS	BY	CH'K	ENGR.	ENGR. SUPV.	GEN. SUPV.
11	4/21/99	GENERAL UPDATE REDRAWN FOR DWG. ENHANCEMENT (NO DWG CHANGE)(REDRAWN)	JOR	SBW	—	WLS	—

FOR LEGEND, SIGNAL DESCRIPTION & NOTES SEE E-17B SH.7

THIS DWG. WAS REDRAWN ON CADD AND SUPERSEDES REVISION 10.

SCALE NONE	DESIGNED --	DRAWN JOR	DATE 03-17-99

DAVIS-BESSE NUCLEAR POWER STATION
UNIT NO. 1
THE TOLEDO EDISON COMPANY

SAFETY FEATURES ACTUATION SYSTEM
ACTUATED EQUIPMENT TABULATION

Q

DRAWING NO. E-17B SH.4 — REV. 11

DB 04-06-99 DFN=I:/ELEC/E17BSH4.DGN

NEWFAX 3/85 N58313 ED 7489

ACTUATED EQUIPMENT TABULATION

EQUIPMENT ITEM NO.	EQUIPMENT DESCRIPTION	SA SIGNAL NO.	FUNCTION	SURVEILL MOD TYPE 1(2)/3(4)	SAM LOGIC MOD TYPE 1(2)/3(4)	PUMP JMPR MOD TYPE 1(2)/3(4)	SEQ. STEP	RC	SCHEME DWG. NO.	VDWG. NO. CH. 1(2)	VDWG. NO. CH. 3(4)
	SPARE	SA 292F					1	2		E-30-26	E-30-30
	SPARE	SA 292G					1	2		E-30-26	E-30-30
P 42-1	DH PMP 1	SA 311A*	ST	3X 3X		5X 5X	3	1	E52B-6 A&B	E-30-14	E-30-35
	SPARE	SA 311B					3	2		E-30-14	E-30-35
HV 1467	CC FROM DH CLR 1 OUT VLV	SA 311C*	O	2F 2I			3	4	E50B-11	E-30-14	E-30-35
HV 2733	DH PMP 1 SUCT VLV FROM BWST	SA 311D	O	1X 1X	4I		3	2	E52B-23 A&B	E-30-14	E-30-35
HV DH14B	DH CLR 1 OUT VLV	SA 311E*	O	2F 2I			3	4	E52B-25 A&B	E-30-14	E-30-35
HV DH13B	DH CLR 1 BYPASS VLV	SA 311F*	O	2F 2I			3	4	E52B-25 A&B	E-30-14	E-30-35
P 42-2	DH PMP 2	SA 312A*	ST	3X 3X		5X 5X	3	1	E52B-6 C&D	E-30-24	E-30-28
	SPARE	SA 312B					3	2		E-30-24	E-30-28
HV 1469	CC FROM DH CLR 2 OUT VLV	SA 312C*	O	2F 2I			3	4	E50B-11	E-30-24	E-30-28
HV 2734	DH PMP 2 SUCT VLV FROM BWST	SA 312D	O	1X 1X	4I		3	2	E52B-23 A&B	E-30-24	E-30-28
HV DH14A	DH CLR 2 OUT VLV	SA 312E*	O	2F 2I			3	4	E52B-25 A&B	E-30-24	E-30-28
HV DH13A	DH CLR 2 BYPASS VLV	SA 312F*	O	2F 2I			3	4	E52B-25 A&B	E-30-24	E-30-28
HV 1495	CC AUX EQUIP IN VLV	SA 321A*	C	2F 2I			1	4	E50B-15 A&B	E-30-15	E-30-36
	SPARE	SA 321B					1	2		E-30-15	E-30-36
HV 1460	CC VLV TO MAKE UP PUMP	SA 322A*	C	2F 2I			1	4	E50B-12 A&B	E-30-25	E-30-29
	SPARE	SA 322B					1	2		E-30-25	E-30-29
	SPARE	SA 331A					1	2		E-30-15	E-30-36
13	SPARE	SA 331B					1	2		E-30-15	E-30-36
	SPARE	SA 331C*					1	4		E-30-15	E-30-36
	SPARE	SA 331D*					1	4		E-30-15	E-30-36
HV MU59A	RCP 2-1 SEAL RET VLV	SA 331E	C	1X 1X	4I		1	2	E52B-30 A&B	E-30-16	E-30-37
HV MU59B	RCP 2-2 SEAL RET VLV	SA 331F	C	1X 1X	4I		1	2	E52B-30 A&B	E-30-16	E-30-37
HV MU59C	RCP 1-1 SEAL RET VLV	SA 331G	C	1X 1X	4I		1	2	E52B-30 A&B	E-30-16	E-30-37
HV MU59D	RCP 1-2 SEAL RET VLV	SA 331H	C	1X 1X	4I		1	2	E52B-30 A&B	E-30-16	E-30-37
	SPARE	SA 331I*					1	4		E-30-16	E-30-37
HV MU66B	RCP 2-2 SEAL IN ISO VLV	SA 331J*	C	2I 2F			1	4	E52B-18 A&B	E-30-16	E-30-37
HV MU66C	RCP 1-1 SEAL IN ISO VLV	SA 331K*	C	2I 2F			1	4	E52B-18 A&B	E-30-16	E-30-37
	SPARE	SA 332A					1	2		E-30-25	E-30-29
	SPARE	SA 332B					1	2		E-30-25	E-30-29
	SPARE	SA 332C*					1	4		E-30-25	E-30-29
	SPARE	SA 332D*					1	4		E-30-25	E-30-29
HV MU66A	RCP 2-1 SEAL IN ISO VLV	SA 332E*	C	2I 2F			1	4	E52B-18 A&B	E-30-26	E-30-30
HV MU38	RCP SEAL RET ISO VLV	SA 332F*	C	2I 2F			1	4	E49B-19 A,B&C	E-30-26	E-30-30
HV MU66D	RCP 1-2 SEAL IN ISO VLV	SA 332G*	C	2I 2F			1	4	E52B-18 A&B	E-30-26	E-30-30
P 56-1	CS PMP 1	SA 411A*	ST	3X 3X		5X 5X	5	1	E52B-7 A&B	E-30-15	E-30-36
	SPARE	SA 411B					5	2		E-30-15	E-30-36
P 56-2	CS PMP 2	SA 412A*	ST	3X 3X		5X 5X	5	1	E52B-7 A&B	E-30-25	E-30-29
	SPARE	SA 412B					5	2		E-30-25	E-30-29

FOR LEGEND, SIGNAL DESCRIPTION & NOTES SEE E-17B SH.7

THIS DWG. WAS REDRAWN ON CADD AND SUPERSEDES REVISION 11.

NO.	DATE	REVISIONS	BY	CH'K	ENGR.	ENGR. SUPV.	GEN. SUPV.
13	3-9-00	GENERAL UPDATE; CHANGED HV MU59C TO HV MU59D (RCP 1-2) TO CORRECT ERROR ON PREVIOUS REVISION (12), PER ENG. COMMENT	JOR	SBW	—	[signature]	—
12	04-21-99	GENERAL UPDATE REDRAWN FOR DWG. ENHANCEMENT (NO DWG. CHANGE)(REDRAWN)	"INITIALS ON FILE"				

SCALE NONE | DESIGNED -- | DRAWN JOR | DATE 03-18-99

DAVIS-BESSE NUCLEAR POWER STATION
UNIT NO. 1
THE TOLEDO EDISON COMPANY

SAFETY FEATURES ACTUATION SYSTEM
ACTUATED EQUIPMENT TABULATION Q

DRAWING NO. E-17B SH.5 | REV. 13

DB 03-09-00 DFN=I:/ELEC/E17BSH5.DGN

NEWFAX 3/85 N58313

ED 7489

ACTUATED EQUIPMENT TABULATION

EQUIPMENT ITEM NO.	EQUIPMENT DESCRIPTION	SA SIGNAL NO.	FUNCTION	SURVEILL MOD TYPE 1(2)/3(4)	SAM LOGIC MOD TYPE 1(2)/3(4)	PUMP JMPR MOD TYPE 1(2)/3(4)	SEQ. STEP	RC	SCHEME DWG. NO.	VDWG. NO. CH. 1(2)	VDWG. NO. CH. 3(4)
HV 1411A	CC IN ISO VLV TO CTMT	SA 421A	C	1X 1X	4I		1	2	E50B-23 A&B	E-30-15	E-30-36
HV 1407A	CC OUT ISO VLV FROM CTMT	SA 421B	C	1X 1X	4I		1	2	E50B-9 A&B	E-30-15	E-30-36
HV 1567A	CC IN ISO VLV TO CRD	SA 421C	C	1X 1X	4I		1	2	E50B-7 A&B	E-30-15	E-30-36
HV 1328	CC CRD BOOSTER PMP 1 SUCT VLV	SA 421D	C	1X 1X	4I		1	2	E50B-8 A&B	E-30-15	E-30-36
	SPARE	SA 421E*					1	4		E-30-15	E-30-36
HV 1411B	CC IN ISO VLV TO CTMT	SA 422A	C	1X 1X	4I		1	2	E50B-24 A&B	E-30-25	E-30-29
HV 1407B	CC OUT ISO VLV FROM CTMT	SA 422B	C	1X 1X	4I		1	2	E50B-10 A&B	E-30-25	E-30-29
HV 1567B	CC IN ISO VLV TO CRD	SA 422C	C	1X 1X	4I		1	2	E50B-21 A&B	E-30-25	E-30-29
HV 1338	CC CRD BOOSTER PMP 2 SUCT VLV	SA 422D	C	1X 1X	4I		1	2	E50B-8 A&B	E-30-25	E-30-29
	SPARE	SA 422E*					1	4		E-30-25	E-30-29
	SPARE	SA 431A*					1	4		E-30-15	E-30-36
	SPARE	SA 431B					1	2		E-30-15	E-30-36
	SPARE	SA 431C					1	2		E-30-15	E-30-36
	SPARE	SA 431D					1	2		E-30-15	E-30-36
	SPARE	SA 431E*					1	4		E-30-15	E-30-36
	SPARE	SA 431F					1	2		E-30-15	E-30-36
	SPARE	SA 432A*					1	4		E-30-25	E-30-29
	SPARE	SA 432B					1	2		E-30-25	E-30-29
	SPARE	SA 432C					1	2		E-30-25	E-30-29
	SPARE	SA 432D					1	2		E-30-25	E-30-29
	SPARE	SA 432E					1	4		E-30-25	E-30-29
	SPARE	SA 432F					1	2		E-30-25	E-30-29
HV DH9B	CTMT EMER SUMP VLV	SA 511A	A	1X 1X	4I		1	2	E52B-19 A-C NOTE 4	E-30-16	E-30-37
HV DH7B	BWST OUT VLV	SA 511B	A	1X 1X			1	2	E52B-19 A-C NOTE 4	E-30-16	E-30-37
	SPARE	SA 511C*					1	4		E-30-16	E-30-37
	SPARE	SA 511D*					1	4		E-30-16	E-30-37
HV DH9A	CTMT EMER SUMP VLV	SA 512A	A	1X 1X	4I		1	2	E52B-19 A-C NOTE 4	E-30-26	E-30-30
HV DH7A	BWST OUT VLV	SA 512B	A	1X 1X			1	2	E52B-19 A-C NOTE 4	E-30-26	E-30-30
	SPARE	SA 512C*					1	4		E-30-26	E-30-30
	SPARE	SA 512D*					1	4		E-30-26	E-30-30

NO.	DATE	REVISIONS	BY	CH'K	ENGR.	ENGR. SUPV.	GEN. SUPV.
12	4-21-99	GENERAL UPDATE REDRAWN FOR DWG. ENHANCEMENT (NO DWG. CHANGE)(REDRAWN)	JOR	SBW	—	MLS	—

FOR LEGEND, SIGNAL DESCRIPTION & NOTES SEE E-17B SH.7

THIS DWG. WAS REDRAWN ON CADD AND SUPERSEDES REVISION 11.

SCALE NONE	DESIGNED --	DRAWN JOR	DATE 03-18-99

DAVIS-BESSE NUCLEAR POWER STATION
UNIT NO. 1
THE TOLEDO EDISON COMPANY

SAFETY FEATURES ACTUATION SYSTEM
ACTUATED EQUIPMENT TABULATION

Q

DRAWING NO. E-17B SH.6 REV. 12

DB 04-06-99 DFN=I:/ELEC/E17BSH6.DGN

NEWFAX 3/85 N58313

ED 7489

LEGEND

A ..... ALARM/PERMISSIVE
I ..... INTERLOCK
F ..... FUNCTION
ST ..... START
SH ..... START HALF SPEED
SP ..... STOP
O ..... OPEN
C ..... CLOSE
T ..... TRIP
RC ..... RELAY CONTACT CLASSIFICATION (NOTE 2)

SAFETY ACTUATION SIGNAL DESCRIPTION

SA411A
- SEQUENTIAL LETTER
- ACTUATION CHANNEL
- SYSTEM
- INCIDENT
- SAFETY ACTUATION SIGNAL

*ACTUATED EQUIPMENT WITH REMOTE MONITORING CONTACT (SEE NOTE 9 OF DWG. 7749-E-16, SH.1)

NOTES:

1. THIS DRAWING IS MEANT AS AN ATTACHMENT TO DRAWING 7749-E16.
2. THE RELAY CONTACTS ARE CLASSIFIED TO ACTUATE THE CONTROL DEVICES AS FOLLOWS:

   RC 1 ... 4.16 KV & 480 V SWGR
   RC 2 ... 480 V STARTER SIZE ONE
   RC 3 ... 480 V STARTER SIZE FOUR, EXCEPT FOR C1-1, C1-2 AND C1-3 WHICH USE POTTER BRUMFIELD TYPE MDR RELAY (3)
   RC 4 ... 125 V DC SOLENOID VLV

   SEE SECTION 10.6.2.3 OF SPEC 7749-E30
3. BLOCK SIGNAL TO SYSTEM LOGIC WILL AUTOMATICALLY RESET ON AN UNDERVOLTAGE CONDITION.
4. SA511A/B AND SA512A/B PROVIDE A PERMISSIVE SIGNAL TO VALVES DH7A/B AND DH9A/B TO ALLOW THE OPERATOR TO REPOSTION THE VALVES AFTER BLOCKING SFAS LEVEL 2.

   IN ADDITION, SA511A/B AND SA12A/B INITIATE THE CONTROL ROOM ANNUCIATOR TO ALERT THE OPERATOR TO PERFORM THIS FUNCTION.
5. SURVEILLANCE, SAM LOGIC, AND PUMP JUMPER MODULE DEFINITIONS:

   1X - MOTOR OPERATED VALVE MODULE
   2I - SOLENOID OPERATED VALVE MODULE - INTERNALLY WIRED CABINET MODULE
   2F - SOLENOID OPERATED VALVE MODULE - FIELD WIRED CABINET MODULE
   3X - PUMP, FAN AND DIESEL GENERATOR MODULE
   4I - SAM RELAY BOARD - NEEDED ON INTERNALLY WIRED CABINET ONLY
   5X - PUMP JUMPER MODULE

** - 3X MODULES USED FOR DEISEL GENERATOR CIRCUITS MUST HAVE JUMPER INSTALLED AS SHOWN ON VENDOR DRAWING E-30-343.

THIS DWG. WAS REDRAWN ON CADD AND SUPERSEDES REVISION 1.

NO.	DATE	REVISIONS	BY	CH'K	ENGR.	ENGR. SUPV.	GEN. SUPV.
3	3/30/04	INC. DCN E-17B-47 PER ECR 04-0103-00 (CR 03-02725)	SBW	Jue	—	RAF	—
2	4-21-99	GENERAL UPDATE REDRAWN FOR DWG. ENHANCEMENT (NO DWG. CHANGE)(REDRAWN)	JOR	SBW	---	MLB	---

SCALE NONE	DESIGNED --	DRAWN JOR	DATE 03-19-99

DAVIS-BESSE NUCLEAR POWER STATION
UNIT NO. 1
THE TOLEDO EDISON COMPANY

SAFETY FEATURES ACTUATION SYSTEM
ACTUATED EQUIPMENT TABULATION
LEGEND, SIGNAL DESCRIPTION & NOTES

DRAWING NO.	REV.
E-17B SH.7	3

DR 03-26-04 DFN=I:/ELEC/E17BSH7.DGN

for Cases 2-8 reflect the values shown in Table 5-19, Table 5-20, and Table 5-23. The motor model parameters for Case 1 reflect the values shown in Table 5-26, Table 5-27, and Table 5-28.

Table 5-17. Summary Component Cooling Water (CCW) Pump Motor Model Parameters

Induction Motor Parameters	**Units**	**Value**	**Reference**
Motor Rating Vector (rating_M1)			
Rated Voltage (L-L)	kV	4	Reference 39
Full Load Current	Amps	52	Reference 39
Frequency	Hz	60	Reference 39
Full Load Speed	RPM	1180	Reference 39
No. of Poles (Nop_M1)	-	6	Calculated, Equation 2
Locked-Rotor Parameters (Lrotorp_M1)			
Locked-Rotor Current	Amps	319.8	Reference 39
Locked-Rotor Power Factor	pu	0.206	Reference 39
Locked-Rotor Torque	pu	1.14	Note 1
Full Load Parameters (Floadp_M1)			
Full Load Power Factor	pu	0.87	Reference 39
Motor Information (Mtype_M1)			
Distribution of rotor/stator magnetic leakage inductance (p)	pu	2/3	Typical for a Class B motor (see Reference 38)
Rotor Magnetic Leakage "Cage" Factor (K_x)	pu	-0.3	Note 1
Cable Parameters Vector (cablep_M1)			
Length (L)	ft	252	Reference 1, Attachment 20
Cable Resistance (R)	ohms/1000ft	0.1085	Reference 1, Attachment 20
Reactance (X)	ohms/1000ft	0.0437	Reference 1, Attachment 20
Rotor and Load Inertia (J_M1)	($lb \cdot ft^2$)	729	Note 1
Load Parameters Vector (loadp_M1)			
A0	pu	0.106	Note 2
A1	pu	-0.500	Note 2
A2	pu	1.750	Note 2
A3	pu	-0.360	Note 2
T0	pu	0.89	Tuned Value, Note 3

Note 1: These values have been adjusted to match measured performance. These values are assumed but are verified as part of model validation. See assumption 7h.
Note 2: Values are determined from Eq 3 and Reference 37 and are verified as part of model validation.
Note 3: This value was adjusted for the motor load to obtain the outputs of the model close to the rated values at rated voltage and rated (i.e. 100%) load

MPR		MPR Associates, Inc. 320 King Street Alexandria, VA 22314	
Calculation No. 0200-0087-RP01	Prepared By [signature]	Checked By I. G. Stamatiou	Page: 72 Revision: 6

Table 5-18. Summary Makeup (MU) Pump Motor Model Parameters

Induction Motor Parameters	**Units**	**Value**	**Reference**
Motor Rating Vector (rating_M2)			
Rated Voltage (L-L)	kV	4	Reference 40
Full Load Current	Amps	57	Reference 40
Frequency	Hz	60	Assumption 7f
Full Load Speed	RPM	1776	Reference 41
No. of Poles (Nop_M2)	-	4	Calculated, Equation 2
Locked-Rotor Parameters (Lrotorp_M2)			
Locked-Rotor Current	Amps	330.6	Reference 40
Locked-Rotor Power Factor	pu	0.20	Reference 40
Locked-Rotor Torque	pu	1.09	Note 1
Full Load Parameters (Floadp_M2)			
Full Load Power Factor	pu	0.93	Reference 40
Motor Information (Mtype_M2)			
Distribution of rotor/stator magnetic leakage inductance (p)	pu	2/3	Typical for a Class B motor (see Reference 38)
Rotor Magnetic Leakage "Cage" Factor (K_x)	pu	-0.3	Note 1
Cable Parameters Vector (cablep_M2)			
Length (L)	ft	277	Reference 1, Attachment 20
Cable Resistance (R)	ohms/1000ft	0.1085	Reference 1, Attachment 20
Reactance (X)	ohms/1000ft	0.0437	Reference 1, Attachment 20
Rotor and Load Inertia (J_M2)	($lb \cdot ft^2$)	437	Note 1
Load Parameters Vector (loadp_M2)			
A0	pu	0.106	Note 2
A1	pu	-0.500	Note 2
A2	pu	1.750	Note 2
A3	pu	-0.360	Note 2
T0	pu	0.912	Tuned Value, Note 3

Note 1: These values have been adjusted to match measured performance. These values are assumed but are verified as part of model validation. See assumption 7h.
Note 2: Values are assumed to be the same as values known for motor with a similar attached load. These values are verified as part of model validation. See assumption 7i.
Note 3: This value was adjusted for the motor load to obtain the outputs of the model close to the rated values at rated voltage and rated (i.e. 100%) load

1.3 Approach

A computer model of the Davis-Besse EDGs and loads on the essential buses was developed to evaluate the EDG's transient frequency and voltage responses. The EDG transient analysis model was developed using the MATLAB and Simulink computer programs. MATLAB is a computer program that provides an integrated computing environment that combines numeric computation, advanced graphics and visualization, and a high-level programming language. Simulink is a software program developed using the MATLAB programming language that works within the MATLAB program environment. Simulink provides an interactive, graphical environment for modeling, simulating, and proto-typing dynamic systems. MPR has used the MATLAB and Simulink computer programs and the modeling approach implemented by this calculation to perform EDG transient response calculations at several other nuclear plants.

The following approach was used to develop the model and perform the analyses:

- Develop the Model Form. MPR has developed a library of MATLAB/Simulink component models for modeling EDG response to large motor loads. The library was used to develop a system model that adequately represents the equipment installed at Davis-Besse. The model components consist of the diesel engine, governor, generator, excitation system (including voltage regulator) and the essential bus loads. The major motor loads (i.e. the 4kV motor loads) were modeled in detail and the smaller 480V loads were modeled as a combination of lumped static (i.e., constant impedance) and constant KVA loads. Section 5.0 discusses model development while Section 4.0 summarizes model assumptions and limitations.

- Develop the Model Input Parameters. Each component model requires a number of input parameters. The input parameters were determined based on equipment design information, including available factory acceptance test data. There were some parameters that are field adjustable (e.g. governor gain and reset) and some that have significant uncertainty (e.g. the inertia for most of the motor loads). Some of these input parameters were adjusted, or "tuned," based on EDG response data collected by Davis-Besse during surveillance testing of the EDGs. Section 5.2 discusses model parameter development.

- Verification of Model Results. The computer model and associated software used for this analysis is classified under the MPR Quality Assurance (QA) Manual (Reference 19) as "working-level" software. As such, the requirements for use of this software consist of (a) verification that the program inputs are correct, (b) verification that the program is applicable for the task, (c) verification that the program correctly performs the operations that affects the results, and (d) documentation of the analysis, verification, and results.

  Verification that the program inputs are correct was performed during the check and review process of the associated calculations. Verification that the program is applicable for the task was performed as part of the review of the associated calculations.

Verification that the EDG system model (i.e. generator, diesel engine, fuel rack, governor and load models) correctly performs the operations that affect the results was performed by comparing model results to a known test case. The known test case was measured data from EDG surveillance tests. The model was used to predict the frequency and voltage response to the surveillance test load steps for EDG1-1 and EDG1-2 and the model results were compared to the actual measured test results.

Documentation of the analysis, verification, and results are presented in this calculation.

- Analyze Design Basis LOOP/LOCA Load Sequence. Once the correct model function was verified, the model was used to analyze the EDG response to the design basis LOOP/LOCA load sequence. Several different cases were analyzed to bound the expected operating conditions. Section 7.1 discusses the design basis LOOP/LOCA transient loading analyses.

- Analyze Design Basis LOOP Only Load Sequence. The model was also used to analyze the EDG response to the design basis LOOP Only load sequence. Several different cases were analyzed to bound the expected operating conditions. Section 7.2 discusses the design basis LOOP Only transient loading analyses.

- Evaluate and Analyze Appendix R EDG Loading Transients. The Davis-Besse Fire Hazards Analysis Report was reviewed to identify potential motor starting transients that are not bounded by the design basis LOOP/LOCA load sequence. The model was used to analyze the EDG response to the bounding motor starting transients required during Appendix R fire scenarios. Section 7.3 discusses the Appendix R fire scenario EDG transient loading analyses.

- Evaluate Design Basis LOOP/LOCA Loading Sequence with a Battery Charger in Test. Revision 3 added the battery charger in test to the LOOP/LOCA loading sequence. Revision 4 deletes these extra cases and lumps the battery charger in test with the standard design basis LOOP/LOCA loading sequence.

2.0 ACCEPTANCE CRITERIA

Section 8.3.1.1.4.1 of the Davis-Besse USAR (Reference 2) states, in part, that each of the two emergency diesel generators has the capability to:

> "Start and accelerate to rated speed in the required sequence its dedicated engineered safety features loads. At no time during the loading sequence, will the frequency and voltage decrease to less than 95 percent of nominal and 75 percent of nominal, respectively, except that during the first step in the required loading sequence, there may

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Appendix 3

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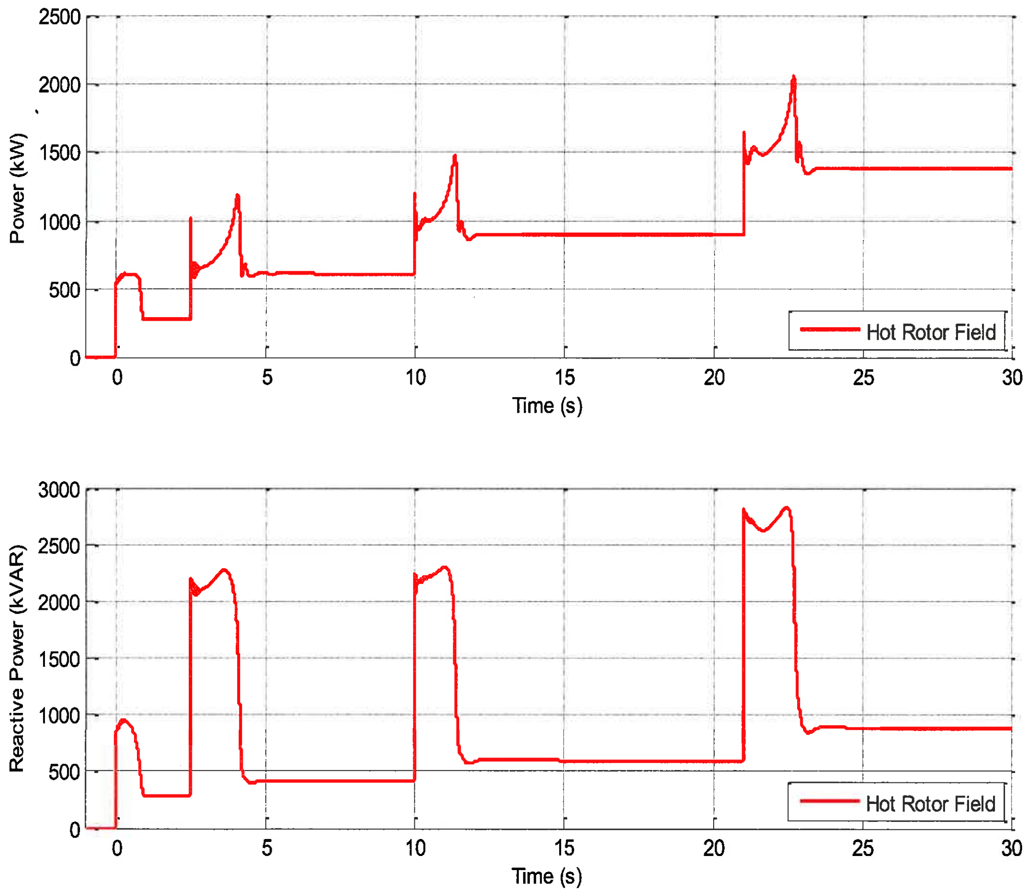

Figure 3-4. Real Power and Reactive Power Response for EDG Design Basis LOOP Only with Hot Field

3.3 Appendix R

MPR reviewed the Davis-Besse Fire Hazards Analysis Report (FHAR) to determine the bounding transient loading scenarios for the EDGs. The Appendix R fire scenarios assume either a LOOP or a LOOP coincident with inadvertent SFAS. Therefore, the initial EDG transient response due to automatic load sequencing during an Appendix R event is bounded by the transient analyses for design basis LOOP/LOCA EDG loading. However, there are fire scenarios that require manual loading or unloading of large motor loads that are not required for normal LOOP and LOOP/LOCA scenarios or that are started with a different initial loading on the EDG.

For the worst case Appendix R loading scenario, two motor starting cases were identified that are not bounded by the design basis LOOP/LOCA load sequencing analyses:

1. Starting the MDFP with the EDG initially loaded to a value that bounds the expected EDG load prior to starting the MDFP during the bounding Appendix R scenario.

2. Starting the HPI pump with the MDFP already running and the EDG loaded to a value that bounds the expected EDG load prior to starting the HPI pump for pressurizer spray during the bounding Appendix R scenario.

These two cases were analyzed and the bounding voltage and frequency for the cases as well as the bounding recovery times were determined. The bounding condition for voltage and frequency occur during the MDFP start with hot generator field and the results for the MDFP start are summarized in Table 3-3. As indicated by the results shown in Table 3-3, the minimum requirements for voltage (75% nominal, based on 4160 V_{rms}) and frequency (95% nominal, based on 60 Hz) are met. Furthermore the voltage and frequency recover to greater than 90% nominal voltage in less than two seconds and 98% nominal frequency in less than four seconds. Therefore, the analysis results indicate that the EDGs are capable of starting the loads required for safe shutdown during Appendix R events.

Figure 3-5 and Figure 3-6 show the plots for the bounding case MDFP start during Appendix R loading sequence.

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Table 3-3 Model Results for Appendix R cases

Parameter Description	**MDFP Motor Start**
Initial Conditions:	
Nominal Voltage, Vrms	4200
Nominal Frequency, Hz	60
Real Load on EDG Prior to Motor Start, kW	2250
Reactive Load on EDG Prior to Motor Start, kVAR	1680
EDG Power Factor Prior to Motor Start	0.8
Generator Voltage:	
Minimum Required Voltage, V (75% Nominal)(1)	3120
Calculated Minimum Voltage, V (% Nominal)	3227 (77.6%)
Voltage Margin, V	107
Allowable time(2) to recover to 90% Nominal Voltage (3744 V), sec	N/A
Calculated Time to Recover to 90% Nominal Voltage, sec	1.74
Recovery Time Margin, sec	N/A
Generator Frequency:	
Minimum Required Frequency, Hz (95% Nominal)(1)	57
Calculated Minimum Frequency, Hz (% Nominal)	58.3 (97.2%)
Frequency Margin, Hz	1.3
Allowable time(2) to recover to 98% Nominal Frequency (58.8 Hz), sec	N/A
Calculated Time to Recover to 98% Nominal Frequency, sec	4.17
Recovery Time Margin, sec	N/A

Note 1: 4160V is taken as nominal voltage and 60Hz is taken as nominal frequency
Note 2: Voltage should be restored to within 10 percent of nominal and frequency should be restored to within 2 percent of nominal in less than 40 percent of each load sequence time interval.

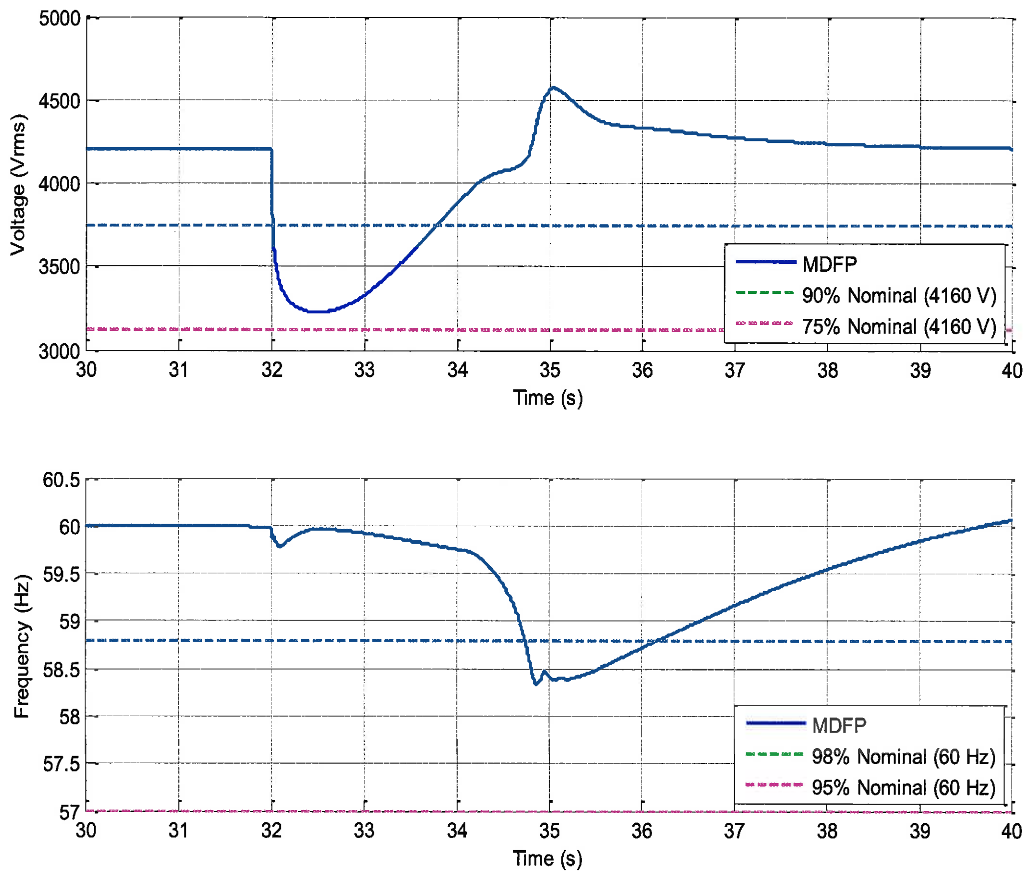
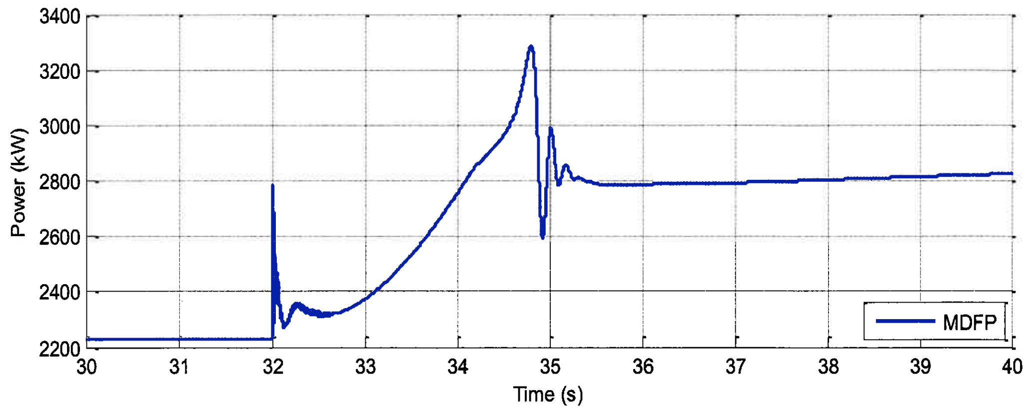


Figure 3-5. Voltage and Frequency Response for EDG Appendix R- MDFP Start



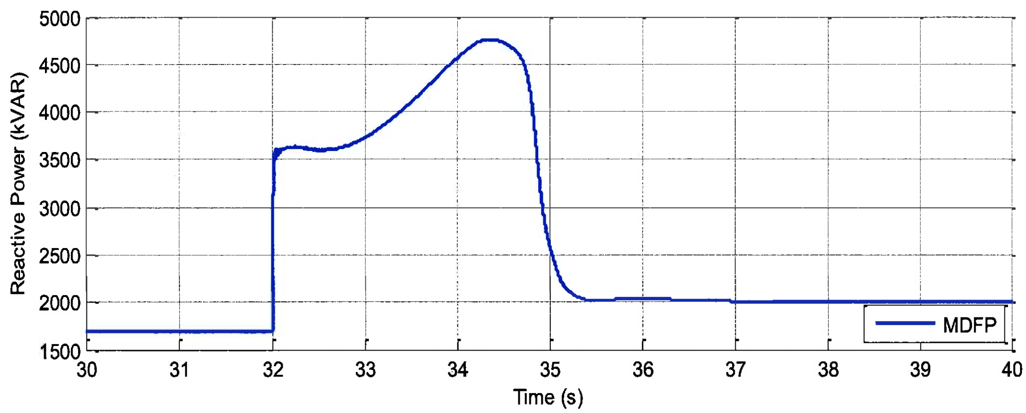


Figure 3-6. Power and Reactive Power Response for EDG Appendix R- MDFP Start

3.4 Design Basis LOOP/LOCA with 4088 V Set Point and Minimum/Maximum Frequency Set Point

The voltage and frequency responses of the Davis-Besse EDGs to design basis LOOP/LOCA load sequencing with 4088 V set point and 59.5/60.5 Hz set points were analyzed using a transient analysis computer model. A hot generator field was used for the bounding case (see further discussion in Section 7.4). The bounding analysis results, including minimum voltage and frequency for each load step and the time to recover to the required values (i.e., USAR design basis criteria), are presented in Table 3-4 and Table 3-5. The simulation results were not

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7.3 Appendix R

MPR reviewed the Fire Hazards Analysis Report (FHAR) (Reference 26) to determine the bounding transient loading scenarios for the EDGs. The Appendix R fire scenarios assume either a LOOP or a LOOP with inadvertent SFAS. Therefore, the initial EDG transient response due to load sequencing caused by an Appendix R event is bounded by the transient analyses for design basis LOOP/LOCA EDG loading. However, there are fire scenarios that require manual loading or unloading of large motor loads that are not required for normal LOOP and LOOP/LOCA scenarios or that are started with a different initial loading on the EDG.

There are two fire scenarios that require starting large motor loads that are not considered for the LOOP/LOCA accident analyses: (1) a fire in Fire Area BF requires starting the backup service water (SW) pump and (2) a fire in Fire Area EE requires starting the motor driven feed pump (MDFP).

The backup SW pump is driven by a 600 hp motor, which is the same rating as the normal SW pumps. The backup SW pump motor and the normal SW pump motors have similar starting characteristics (Reference 27). Therefore, it is judged that the EDG response to starting the backup SW pump will not be significantly different than the EDG response to starting one of the normal SW pumps, which is already analyzed in the design basis LOOP/LOCA analyses presented in Section 7.1.

For a fire in Fire Area EE, the turbine-driven Auxiliary Feedwater (AFW) pumps are inoperable due to the fire. The motor driven feedwater pump (MDFP) is credited for safe shutdown. This pump is driven by an 800 hp motor and is not required for any of the LOOP/LOCA accident scenarios or the other fire scenarios. Furthermore, a fire in Fire Area EE requires starting a decay heat (DH) pump (for decay heat removal during cold shutdown) after the MDFP is started when there is significant load on the EDG. In addition, a revision to the FHAR could be made for the Fire Area EE scenario to use the HPI pump for pressurizer spray. This would be required during cool-down to Cold Shutdown, prior to the transfer to decay heat removal. With this change, the HPI pump would need to be started after the MDFP is already operating when there is significant load on the EDG. Note that the HPI pump would be tripped prior to starting the DH pump for long-term decay heat removal.

The Fire Area EE scenario, with the change described above, will provide the bounding transient analysis loading because: (a) it is the only scenario where the MDFP is started and (b) it requires starting the HPI pump with the EDG heavily loaded. This scenario only applies to train 1 and, therefore, EDG1-1. The worst case Appendix R loading for EDG1-2 does not require any loads that are not already considered in the LOOP/LOCA analysis for EDG1-2. Therefore, a separate analysis for EDG1-2 is not required.

To analyze the EDG transient response to the bounding Appendix R loading scenario, two cases were defined:

1. Starting the MDFP with the EDG initially loaded to a value that bounds the expected EDG load prior to starting the MDFP during the Appendix R scenario.

2. Starting the HPI pump with the MDFP already running and the EDG loaded to a value that bounds the expected EDG load prior to starting the HPI pump for pressurizer spray during the Appendix R scenario.

It is noted that the DH pump is also started after the MDFP is running and with the EDG significantly loaded. However, the DH pump has a smaller starting transient, in comparison to the HPI pump, and the HPI pump case will bound the EDG transient response to starting the DH pump.

The analysis-specific input file also includes the initial voltage and frequency conditions and the voltage and frequency set points. For this evaluation, nominal voltage and frequency are defined as the steady-state voltage and frequency set points. The EDG operating procedure (Reference 4) indicates that the voltage set point is adjusted to achieve a generator voltage of 4200 to 4250 V_{rms} and the frequency set point is adjusted to a nominal value of 60 Hz. Since this evaluation is concerned with the minimum voltage drop and recovery, the nominal voltage for the evaluation is 4200 V_{rms}. The nominal frequency for the evaluation is 60 Hz.

Each case also has a case-specific input file that runs the other input files and defines case-specific parameters.

7.3.1 Case 5 – MDFP Start

During an Appendix R scenario for Fire Area EE, the MDFP is started to support auxiliary feedwater flow to the steam generators. As discussed in Reference 28, when the MDFP is started, the only other large motors in operation are the service water (SW) pump, component cooling water (CCW) pump, and containment air cooler fan motors. Various MCC loads will also be in operation.

During an Appendix R fire scenario, Operations is directed by DB-OP-02000 (Reference 29) to reduce EDG load to below 2250 kW prior to starting the MDFP. Note DB-OP-02000 allows starting the MDFP with up to 2400kW of load for the EDG, but only during a “Feed and Bleed” scenario. This scenario is not a design basis scenario and has been addressed by separate analysis. For conservatism, this analysis was performed with an initial EDG load of 2250 kW at a 0.8 power factor. This initial condition bounds the expected EDG loading condition when the MDFP is started.

The loads used to model this case are summarized in Table 7-11. The large 4kV and 480V loads were taken from the motor model parameter tables found in Section 5.2.6. The MCC loads were taken from the constant impedance and constant kVA load model parameter tables in Section 5.2.6, but were adjusted to obtain an initial load of 2250 kW at 0.8 power factor prior to starting the MDFP. This was achieved by setting constant impedance load input parameters such that kVA equals 1070 and power factor equals 0.82. The timing of the loads is not relevant to this case, since only the MDFP starting transient is being analyzed. The MDFP starting time was selected to ensure that the EDG is at steady-state voltage and frequency when the motor starts. The percentage loading of motors in this analyzed case is taken from Attachment 17 of Reference 1.

The input file for this analyzed case is `case5.m`. For this load case EDG hot field resistance is used as the input parameter.

The EDG terminal voltage and frequency and real and reactive power for the Appendix R case load sequence from the model analysis are shown in Figure 7-11 through Figure 7-13. The minimum voltage and frequency for each load step and the time to recover to the required values (i.e., USAR design basis criteria) are summarized in Table 7-13. The acceptance criteria indicated in Section 2.2 are satisfied for Appendix R MDFP motor starting transient.

Table 7-11. Load Inputs for Appendix R when MDF pump is started – Case 5

Load Step	Time (sec)(1)	Component	Percent Rated Load(2)	Comments
1	0	Component Cooling Water (CCW) Pump Motor	90%	Percent rated load was based on ETAP results.
		Lumped Medium Motors	100%	Modeled as a medium motor.
		Small Motors and MOVs	100%	These loads are modeled as lumped constant impedance and constant kVA.
		480V MCC Constant kVA Loads (Steady-State)	100%	
		480V MCC Static Loads	100%	Load ratings were modified from design conditions to meet the initial requirements for Appendix R.
2	2.5	Makeup (MU) Pump Motor	90%	Percent rated load was based on ETAP results.
3	15	Service Water Pump Motor	96%	Percent rated load was based on ETAP results.
4	20	Containment Air Cooler Fan Motor (Low Speed)	99%	Percent rated load was based on ETAP results.
5	32	Motor Driven Feed (MDF) Pump Motor	91%	Percent rated specified for worst case 10CFR50, Appendix R fire scenario.

Note 1: Time is measured relative to EDG breaker closing.
Note 2: The percentage motor load for Appendix R case is taken from Attachment 17 of Reference 1.

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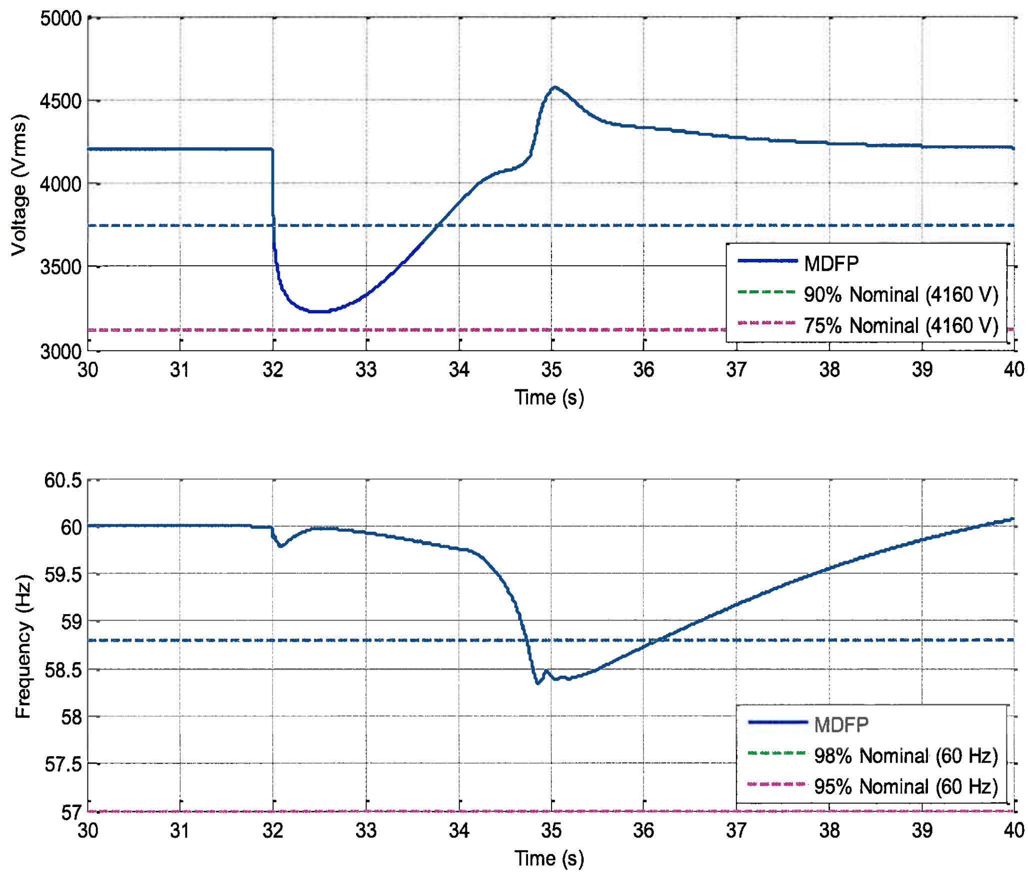

Figure 7-11. Voltage and Frequency Response for EDG Appendix R- MDFP Start- Case 5

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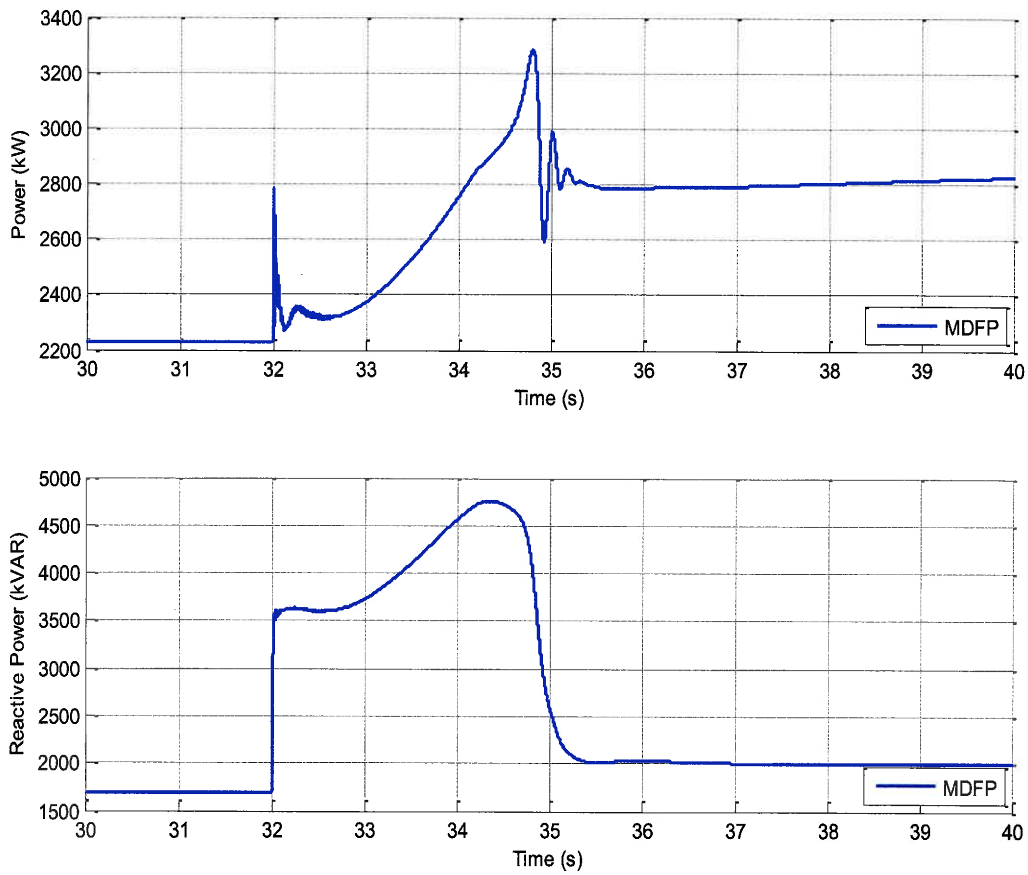

Figure 7-12. Power and Reactive Power Response for EDG Appendix R- MDFP Start – Case 5

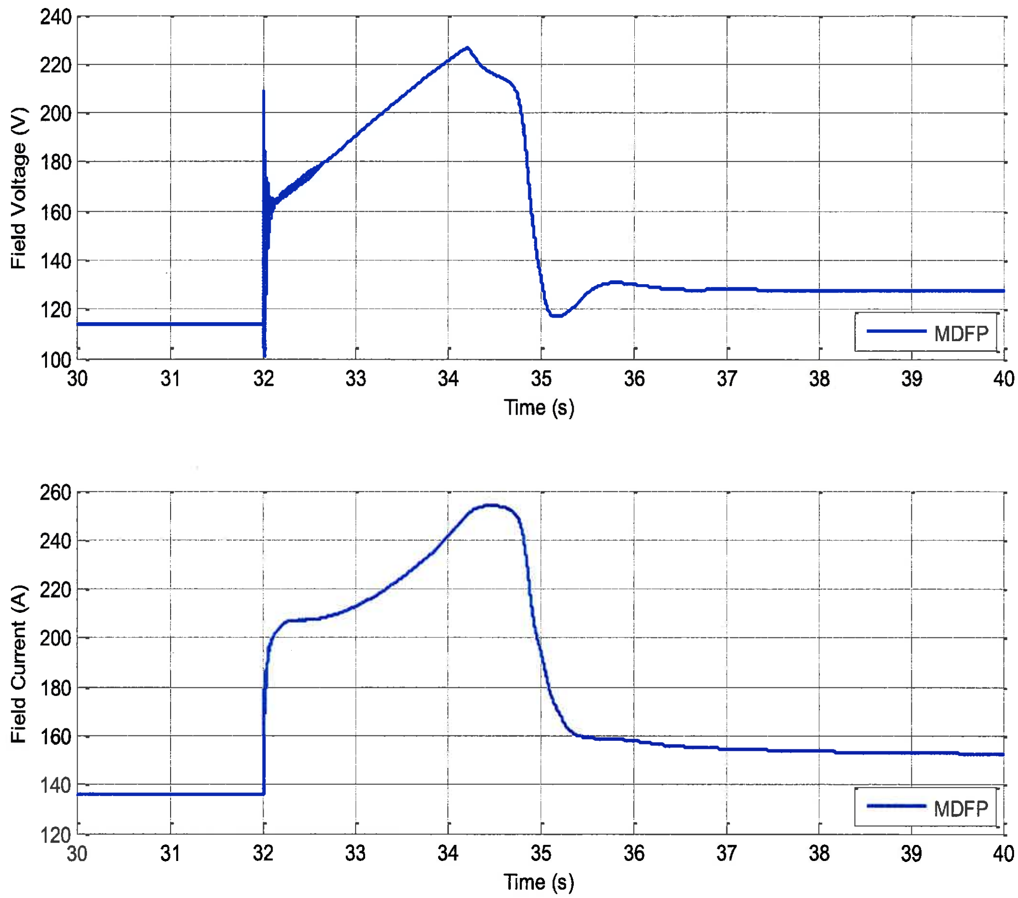

Figure 7-13. Field Voltage and Field Current Response for EDG Appendix R- MDFP Start – Case 5

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Appendix 4

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Table 4-4. MP3-2 Service Water Pump 1-2

Loading Category	Operating Load %	Operating Load % Calculation, Bases, and References	Load Operating Comments and Procedure References
1. Summer	97	Condition Report 02-04514 (DIN #104) describes a condition where the overhaul of Service Water Pumps may have resulted in higher required brake horsepower. Operational Evaluation 2002-0038 (DIN #105) computed an updated brake horsepower based on pump total developed head measured after the overhaul (also Reference DIN#154 and DIN#28). In this case, the calculation resulted in a higher brake horsepower than the peak brake horsepower from the manufacturer's curve. Method #2, in this case, is the preferred method. Equation #2 $L = [(H_2 / H_1)^{3/2} \times (P_1) \times 100] / B$ $H_2 = 190.0$, Pump head (Reference DIN #28) at 9329 gpm. 9329 gpm is the volumetric flow where maximum Bhp occurs on original design curve. (See the test data table on sheet 2 of DIN #106.) $H_1 = 176.0$, Reference pump head on the original design curve (Reference DIN #106) at 9329 gpm. 9329 gpm is the volumetric flow where maximum Bhp occurs. (See the test data table on sheet 2 of DIN #106.) $P_1 = 519.6$, Reference maximum brake horsepower on the original design curve. (See the test data table on sheet 2 of DIN #106.) B = 600 , Reference DIN #53. $97 = [(190.0 / 176.0)^{3/2} \times (519.6) \times 100] / 600$	• Operating conditions per Reference (DIN #15). • The performance curves for the service water motors were revised per notification 600323151 (DIN 135). As a result, the values for actual pump head, design pump head, and max break horsepower were evaluated for their impact. CR 06-01845 (DIN 136) evaluates the changes as acceptable. DINs 115 and 116 have been revised to show the most recent baseline test curves. • Recent test data was reviewed (Att. 3) for these motors to ensure the running FLA are representative values. The data in this calculation remains representative of the recently measured test data via the PDMA software and is within the accuracy of the calculation.
2. Winter	97	Same as Loading Category 1.	• Same as Loading Category 1.
3. Modes 2,3,4	97	Same as Loading Category 1.	• Same as Loading Category 1.
4. Mode 6 Refuel	97	Same as Loading Category 1.	• Same as Loading Category 1.
5. Post LOCA	97	Same as Loading Category 1.	• Same as Loading Category 1.
6. LOCA W/LOOP	97	Same as Loading Category 1.	• Same as Loading Category 1.
7. LOOP Only	97	Same as Loading Category 1.	• Same as Loading Category 1.
8. LOCA Only	97	Same as Loading Category 1.	• Same as Loading Category 1.
9. Appendix R	N/A	N/A	• Not an input to C-EE-015.03-008. Determined by ETAP model.
10. LOCA + Man	97	Same as Loading Category 1.	• Same as Loading Category 1.

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Table 4-7. MP42-2 Decay Heat Pump 1-2

Loading Category	Operating Load %	Operating Load % Calculation, Bases, and References	Load Operating Comments and Procedure References
1. Summer	0	N/A	• Operating conditions per Reference (DIN #7). • Both Decay Heat Pumps are OFF.
2. Winter	0	N/A	• Same as Loading Category 1.
3. Modes 2,3,4	0	N/A	• Operating conditions per Reference (DIN #7). • Both Decay Heat Pumps are OFF. The bounding condition for this category is the case when all four RCPs are operating with the RCS temperature at 440F.
4. Mode 6 Refuel	0	N/A	• Operating conditions per Reference (DIN #7). • Only one Decay Heat Pump is required. Decay Heat Pump 1-1 is ON. Decay Heat Pump 1-2 is OFF. • Both Decay Heat Pump curves show a brake horsepower of 360 at 3000 gpm flow. Thus, pump selection does not depend on performance curves. (DIN #81 and 82)
5. Post LOCA	90	Equation #1 L = (b / B) x 100 b = 360 , Based on the Bhp at a 3000 gpm in this system lineup. (Reference DIN #82). 3000 gpm based on operational limit per Reference DIN #7. B = 400 , Reference DIN #83. 90 = (360 / 400) x 100	• Operating conditions per Reference (DIN #7). • Only one Decay Heat Pump is required. Decay Heat Pump 1-1 is ON. Decay Heat Pump 1-2 is OFF. • Both Decay Heat Pump curves show a brake horsepower of 360 at 3000 gpm flow. Thus, pump selection does not depend on performance curves. (DIN #81 and 82)
6. LOCA W/LOOP	105	Equation #1 L = (b / B) x 100 b = 420 , Based on the Bhp at a 4300 gpm flow rate during a LOCA (Reference DIN #82). 4300 gpm based on maximum calculated flow during a LOCA per Reference DIN #107. B = 400 , Reference DIN #83. 105 = (420 / 400) x 100	• Operating conditions per Reference (DIN #6). • The original motor was replaced with a refurbished motor. However, the OL% calculation performed uses BHP data that is unaffected by a motor replacement. The original calculation remains a conservative estimate of operating load percentage.
7. LOOP Only	0	N/A	• Same as Loading Category 1.
8. LOCA Only	105	Same as Loading Category 6.	• Same as Loading Category 6.

Table 4-7. MP42-2 Decay Heat Pump 1-2

Loading Category	Operating Load %	Operating Load % Calculation, Bases, and References	Load Operating Comments and Procedure References
9. Appendix R	**N/A**	N/A	• Not an input to C-EE-015.03-008. Determined by ETAP model.
10. LOCA + Man	**105**	Same as Loading Category 6.	• Same as Loading Category 6.

Table 4-9. MP43-2 Component Cooling Pump 1-2

Loading Category	Operating Load %	Operating Load % Calculation, Bases, and References	Load Operating Comments and Procedure References
1. Summer	90	Equation #1 L = (b / B) x 100 b = 360 , Based on the peak Bhp per Reference DIN #55. B = 400 , Reference DIN #56. 90 = (360 / 400) x 100	• Operating conditions per Reference (DIN #113). • Only one Component Cooling Water (CCW) Pump is required. Whenever Reactor Coolant Pumps (RCPs) are operating, the CCW Pump providing the RCP cooling water and the Make-up Pump providing the RCP seal injection should be aligned to opposite essential buses. In this case, Make-up Pump 1-1 and CCW Pump 1-2 are running. (DIN #25) • All three CCW pump curves show a peak brake horsepower of 360. Thus, pump selection does not depend on performance curves. (DIN #54, 55, and 64)
2. Winter	90	Same as Loading Category 1.	• Same as Loading Category 1.
3. Modes 2,3,4	0	N/A	• N/A
4. Mode 6 Refuel	0	N/A	• N/A
5. Post LOCA	90	Same as Loading Category 1.	• Same as Loading Category 1.
6. LOCA W/LOOP	90	Same as Loading Category 1.	• Same as Loading Category 1.
7. LOOP Only	90	Same as Loading Category 1.	• Same as Loading Category 1.
8. LOCA Only	90	Same as Loading Category 1.	• Same as Loading Category 1.
9. Appendix R	N/A	N/A	• Not an input to C-EE-015.03-008. Determined by ETAP model.
10. LOCA + Man	90	Same as Loading Category 1.	• Same as Loading Category 1.

Table 4-12. MP56-2 Containment Spray Pump 1-2

Loading Category	Operating Load %	Operating Load % Calculation, Bases, and References	Load Operating Comments and Procedure References
1. Summer	0	N/A	• Operating conditions per Reference (DIN #114). • Containment Spray Pumps are used only during accident conditions.
2. Winter	0	N/A	• Same as Loading Category 1.
3. Modes 2,3,4	0	N/A	• Same as Loading Category 1.
4. Mode 6 Refuel	0	N/A	• Same as Loading Category 1.
5. Post LOCA	0	N/A	• Same as Loading Category 1.
6. LOCA W/LOOP	110	Equation #1 L = (b / B) x 100 b = 220 , Bhp at 1800 gpm. 1800 gpm based on maximum calculated flow per Reference DIN #108. 220 Bhp is based on DIN #28. B = 200 , Reference DIN #210 120 = (220 / 200) x 100	• Operating conditions per Reference (DIN #114).
7. LOOP Only	0	N/A	• Same as Loading Category 1.
8. LOCA Only	110	Same as Loading Category 6.	• Same as Loading Category 6.
9. Appendix R	N/A	N/A	• Not an input to C-EE-015.03-008. Determined by ETAP model.
10. LOCA + Man	110	Same as Loading Category 6.	• Same as Loading Category 6.

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Table 4-14. MP58-2 High Pressure Injection Pump 1-2

Loading Category	Operating Load %	Operating Load % Calculation, Bases, and References	Load Operating Comments and Procedure References
1. Summer	0	N/A	• Operating conditions per Reference (DIN #112). • High Pressure Injection (HPI) pumps are used only during accident conditions.
2. Winter	0	N/A	• Same as Loading Category 1.
3. Modes 2,3,4	0	N/A	• Same as Loading Category 1.
4. Mode 6 Refuel	0	N/A	• Same as Loading Category 1.
5. Post LOCA	0	N/A	• Same as Loading Category 1.
6. LOCA W/LOOP	117	Equation #4b: $L=(\rho/\rho_m)(KW)(\eta)\{100+[(CT)^2+(TR)^2]^{0.5}\}/(0.7457)/(B)$ $(\rho/\rho_m) = 1.0$, Based on measured data conditions the same as analysis conditions. KW = 551.59, Based on results (4/28/02 15:11) from baseline test for HPI pump 1-1 (Reference DIN #84) at 950 gpm. Maximum required flow for LOCA analysis per Reference DIN #5 is bounded by 950 gpm. $\eta = 0.940$, Nameplate rated efficiency per reference DIN #155. CT = 1.0 , Reference DIN #85. Current measurement accuracy is +/- 1.0 %. TR = 0.6 , Reference DIN #85. Voltage measurement accuracy is 0.6 %. B = 600 , Reference DIN #43. $117 = (1.0)(551.59)(0.940)\{100+[(1.0)^2+(0.6)^2]^{0.5}\}/(0.7457)/(600)$	• Operating conditions per Reference (DIN #112). • The original motor was replaced with a refurbished motor. The calculation performed to determine OL% uses measured kW data from the original motor being operated at flow conditions described in DIN #5. The kW value is then converted to an equivalent measure of BHP. This BHP value is divided by the nameplate BHP to determine OL%. Although the new motor will have different kW loading and efficiency than the original motor at the test conditions, the OL% will remain the same. Therefore, the original calculation shown remains a conservative estimate of operating load percentage. • Loading could potentially be reduced post RFO baseline testing for the new ECCS motors. Notification 600586007 has been created to review the baseline testing data for the ECCS motors and recover margin if applicable. The use of the current data is not an open assumption because the data being used is reasonably conservative based on the data available for the motor (testing data from the manufacturer).
7. LOOP Only	0	N/A	• Same as Loading Category 1.

Table 4-14. MP58-2 High Pressure Injection Pump 1-2

Loading Category	Operating Load %	Operating Load % Calculation, Bases, and References	Load Operating Comments and Procedure References
8. LOCA Only	**117**	Same as Loading Category 6.	• Same as Loading Category 6.
9. Appendix R	**N/A**	N/A	• Not an input to C-EE-015.03-008. Determined by ETAP model.
10. LOCA + Man	**117**	Same as Loading Category 6.	• Same as Loading Category 6.

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Table 4-39. MP37-2A Make-up Pump 1-2

Loading Category	Operating Load %	Operating Load % Calculation, Bases, and References	Load Operating Comments and Procedure References
1. Summer	0	N/A	• Operating conditions per (DIN #21). • Only one Make-up Pump is required. Whenever RCPs are operating, the CCW Pump providing the RCP cooling water and the Make-up Pump providing the RCP seal injection should be aligned to opposite essential buses. In this case, Make-up Pump 1-1 and CCW Pump 1-2 are running. (DIN #25). • Rated FLA has increased to 57A. • Recent test data was reviewed (Att. 3) for these motors to ensure the running FLA are representative values. The data in this calculation remains representative of the recently measured test data via the PDMA software and is within the accuracy of the calculation.
2. Winter	0	Same as Loading Category 1.	• Same as Loading Category 1.
3. Modes 2,3,4	100	Method 1 is used due to lack of plant data for this specific bounding condition. Equation #1 L = (b / B) x 100 b = 450 , Based on Bhp at 206 gpm (Reference DIN #28) to makeup RCS inventory during maximum cool down rate of 1.67 F/min (Reference DIN #22). The required flow is bounded on the following basis. A cool down from 600F to 300F reduces the specific volume by approximately 26% (Reference DIN #101). Total RCS volume is approximately 19000 ft^3 (Reference DIN #95). It follows that the loss of volume during a 300F cool down = (26% of 19000ft^3) = 4940 ft^3 = 36975 gallons. Thus, the rate of volume change can be estimated as [(1.67 F/min) x (36975 gallons) / (300 F)] = 206 gpm. B = 450 , Reference DIN #80. 100 = (450 / 450) x 100	• Operating conditions per Reference (DIN #22). • The cross-connect between the makeup trains is isolated. In this analysis case, Make-up Pump 1-1 is providing normal flow to provide RCP seal injection. Make-up Pump 1-2 is providing inventory to compensate for fluid contraction.
4. Mode 6 Refuel	0	N/A	• Operating conditions per DIN #22. • Both Make-up Pumps OFF.
5. Post LOCA	0	N/A	• Post LOCA only the pump that was running before the LOCA will be running. Bus C1 is more heavily loaded, so it is conservative to have MP37-1A running in load category 5. See C-EE-015.03-008 for scenario basis.

Table 4-39. MP37-2A Make-up Pump 1-2

Loading Category	Operating Load %	Operating Load % Calculation, Bases, and References	Load Operating Comments and Procedure References
6. LOCA W/LOOP	**124**	Equation #1 L = (b / B) x 100 b = 560 , Based on the calculated flow rate during a LOCA with one Make-up Pump running. See Note 1 on Reference DIN #94. B = 450 , Reference DIN #80. 124 = (560 / 450) x 100	• Operating conditions per Reference (DIN #6).
7. LOOP Only	**96**	Equation #3e $L = (a/A) \times \{100 + [(M)^2+(R)^2+(OV)^2+(CT)^2]^{0.5}\}$ a = 52 , Reference DIN #39, verified against ATT. 3. A = 57 , Reference DIN #141. M = 1.5 , Reference DIN #67. R = 2.40 , Scale divisions at every 5 amps. R = 100 x (0.25 x 5) / 52 = 2.40 OV=4 , OV = 100 x (4160 – 4000) / 4000 = 4.0 CT=1.3 , Reference DIN #23 (Ratio Factor at 50% rated current) $96 = (52/57) \times \{100+[(1.5)^2+(2.4)^2+(4)^2+(1.3)^2]^{0.5}\}$	• See comments for Loading Category 1.
8. LOCA Only	**0**	N/A	• Same as Loading Category 5.
9. Appendix R	**N/A**	N/A	• Not an input to C-EE-015.03-008. Determined by ETAP model.
10. LOCA + Man	**0**	N/A	• Operating conditions per (DIN #6).

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Appendix 5

Contents

4.0 ASSUMPTIONS AND LIMITATIONS

4.1 Assumptions

MPR makes the following assumptions in this transient analysis. Some have sufficient basis and do not require verification. Those that do require verification are verified via model validation.

1. For each individually modeled load, the steady-state load at the end of each time step of the surveillance tests is not known (i.e., motor load currents were not measured). For load steps with a single motor load, the steady-state motor load was calculated as the increase in generator load for the time step. For the first and fifth time step, there are multiple loads that are started. The sharing of steady-state load between the various modeled loads was assumed. This assumption only applies to the model verification analyses. The verification analysis results indicate that the modeled EDG load adequately represents the measured surveillance test data. This assumption has sufficient basis and does not require verification.

2. Due to elimination of mechanical governor interference during EDG fast start, it is assumed that the frequency at EDG breaker closure during the design basis LOOP/LOCA and LOOP Only load sequence analyses is no greater than 60Hz. In the analyses performed, the frequency at breaker closure was verified to be between 59.5 and 60.0 Hz. This assumption is conservative and does not require verification.

3. The nominal set point of the EDG voltage permissive relay is 3990V (95% of 4200V). For this analysis the EDG terminal voltage at the time the output breaker closes was assumed to be 3990V. The tolerance of the EDG breaker closure permissive relay is not discussed in the calculation because its impact on the voltage and frequency response during transient loading is insignificant. The EDG transient loading calculation uses the nominal setpoint of this relay. This is conservative. The EDG field circuit is "flashed" at 400 rpm and the stator voltage buildup occurs at a rate of approximately 1000 V / sec (please refer to the EDG surveillance test data for a fast start). By the time the breaker closure permissive relay pickups and the EDG output breaker closes, the EDG stator voltage is well above the value assumed in the EDG transient analysis calculation.

4. The diesel engine model uses the assumptions described below. These assumptions were verified to be reasonable by the model verification analyses and do not require verification.

   a. The diesel engine model assumes that the torque output of the engine is proportional to fuel rack position as long as the air/fuel ratio is sufficient for all of the fuel to burn. If the air/fuel ratio drops below a "critical" value (defined in Reference 6), the engine torque output is limited to the torque produced at the "critical" air/fuel ratio, i.e. any additional fuel injected above this value is assumed to have no beneficial effect. It is noted that the turbocharger compressor for the EMD diesel engines installed at Davis-

Besse is gear driven off the engine crank shaft at low loads; therefore, air-limited operation is not expected to be a concern.

b. The time constant of the turbocharger is assumed to be 2 seconds, based on experience from testing of similar turbochargers and modeling of similar EDGs.

c. The engine torque response to a change in fuel rack position is assumed to be delayed by one half of the time it takes for all cylinders to complete a normal 2-stroke cycle.

5. The Woodward EGB-13P actuator has a maximum travel of 45 degrees, but is likely limited to a smaller range of travel by the fuel rack. The analyses assume that the full governor travel used for the EMD engines is 35 degrees. Furthermore, 4 degrees actuator output is assumed to correspond to 1.96 inches of fuel rack (minimum fuel), and 39 degrees actuator output is assumed to correspond to 0.62 inches of fuel rack (maximum fuel). This assumption was verified to be reasonable by the model verification analyses and does not require verification.

6. The generator model uses the assumptions described below. These assumptions were verified to be reasonable by the model verification analyses and do not require verification.

   a. Stator winding leakage reactance X_l is assumed to be 0.12. Typical values of X_l for salient pole generators with damper windings range from 0.1 to 0.2.

   b. Direct axis, sub-transient short circuit time constant τ''_d is assumed to be 0.02 sec. Typical values for salient pole generators with damper windings range from 0.01 to 0.05.

   c. Quadrature axis sub-transient reactance X''_q is assumed to be 0.2. Typical values of X''_q for salient pole generators with damper windings range from 0.12 to 0.25.

   d. Quadrature axis open circuit sub-transient time constant τ''_{qo} is assumed to be 0.05. Typical values of τ''_{qo} for salient pole generators with damper windings range from 0.02 to 0.05.

7. The load models use the assumptions described below.

   a. MCC loads are not explicitly modeled but are modeled as lumped loads instead. Constant impedance loads (e.g. heaters), constant kVA loads (e.g. battery chargers and rectifiers), small motors (i.e. < 2 hp) and MOVs are modeled as static lumped loads. The small motors and MOVs are lumped together and modeled as a constant kVA. Medium motors (i.e. > 2 hp; < 15 hp) are modeled as a lumped induction motor.

   b. The cable lengths of the constant impedance loads are assumed to be zero. Accordingly, the cable impedance is zero and the voltage drop in the cable is zero. For evaluating the transient response, this is a conservative assumption since cable impedance will decrease the current drawn by the load. The adequacy of the voltage at the equipment terminals is beyond scope of this evaluation, but is evaluated in Davis-Besse Calculation C-EE-015.03-008 (Reference 1).

c. For constant kVA loads, a representative cable is included, since cable losses will increase the total current draw to the lumped load. Since the loads are installed in various MCCs, it is assumed that a single cable impedance can be used to represent the cable losses to the constant kVA loads. Based on a review of the cable lengths to the various MCCs, a representative cable length and impedance were selected. The cable length and impedance values were taken from the highest impedance cable to an MCC that has a significant amount of lumped kVA load (i.e. an MCC that only carries a very small percentage of the constant kVA load would not be considered). Losses from the MCC to the load were not explicitly included; however, this approach is reasonable, since all the lumped kVA load current is assumed to go through a single cable. This is a conservative approach, since the various loads are located in multiple MCCs and have multiple cables.

d. Full load operation of medium motors (i.e. > 2 hp; < 15 hp) is assumed to begin 1.0 second after motor start. This is considered reasonable for motors of this size and does not require further verification.

e. The rotor magnetic leakage "cage" factor, K_x, is assumed to be -0.25 for the new CS Pump, DH Pump, and HPI Pump motor models. This value produces a negative slope of the current versus slip curve for an induction motor. Based on MPR's experience modeling induction motors, -0.25 is a typical value for K_x.

f. For motors for which an explicit frequency rating was not found, the motor is assumed to be rated for a 60 Hz supply. This is considered reasonable as this is the standard domestic electric grid frequency.

g. As discussed in Assumption 7a, the medium motors (2 < hp <15) are not explicitly modeled, but are lumped together and modeled as a single 480 V induction motor. For the lumped motor load, the locked rotor current is assumed to be 625% of the running current (this is a reasonable assumption for motors of this size), the locked rotor torque is 1.16 rated torque (this is a reasonable assumption for motors of this size and this value can be tuned) and, since the motors are small to medium sized, the locked rotor power factor is 0.5. The synchronous speed is assumed to be 1200 rpm, and the number of poles in the motor is assumed to be 6 (this is an arbitrary assumption). The full load speed is assumed to be 1175 rpm. This represents a 2% slip, and is a reasonable value for a motor of this size. These assumptions are similar to those made in Calculation C-EE-015.03-008, R5 (Reference 1).

h. Not all motor model inputs were able to be determined from available manufacturer and/or test data. When parameters were not able to be identified, values were assumed and subsequently tuned during motor model tuning. These values are identified in the motor model parameters table for each motor, and are verified via model validation.

i. Motor load torque vs. speed curves were not available for every motor. When sufficient data was not available, the parameters used to model these curves were copied from motor models with known load torque vs. speed curves of a similar size and attached load. This assumption is verified via model validation.

8. The SBSR excitation model used the assumptions described below. These assumptions were verified to be reasonable by the model verification analyses and do not require verification.

   a. The magnitude of the generator load current is assumed to have a negligible effect on the value of saturable reactor impedance

   b. The impedances of saturable reactor as a function of control current calculated from test data of one SBSR excitation system, can be utilized for another similar SBSR excitation system after including the correction factor for change in linear reactor impedances.

9. The production battery chargers will have input power and power factor close to those of the prototype.

4.2 Limitations

The following limitations apply to the analysis results:

1. The analysis results apply to EDG1-1 and EDG1-2 in their existing physical conditions. EDG performance degradation or significant changes in governor and voltage regulator tuning could cause the EDGs to perform differently than predicted by this analysis.

2. The analysis results apply to the loading for the EDGs as indicated in this calculation. Changes to the loads require an evaluation to ensure the analysis results are bounding. Physical changes to large motor loads (i.e. >200 hp) that are explicitly modeled, such as a motor replacement, require evaluation and may require re-analysis.

3. The analysis results apply to the loading sequence indicated in this calculation. Changes to the loading sequence require evaluation and may require re-analysis.

4. The analysis results are based on a minimum voltage set point of 4200 V_{rms}, which is the lowest voltage set point allowed by the EDG operating procedure. If the EDG voltage set point is lowered below 4200 V_{rms}, the minimum voltages for load steps 1 through 5 for LOOP/LOCA and for load step 1 and 2 for LOOP Only would be lower than the values

predicted by this analysis. A reduction in the minimum voltage setpoint to below 4200 V_{rms} requires an evaluation and may require re-analysis.

5.0 MODEL DEVELOPMENT

5.1 System Model Development

System model development consisted of:

- Integrating the component models already implemented in MATLAB/Simulink (i.e. the engine, generator, loads developed in MATLAB/Simulink from model equations) into a system model
- Implementing the system model using the MATLAB/Simulink software, and
- Determining input parameters that apply to the various components of the system – Davis-Besse EDGs and connected loads.

A high-level block diagram of the model with the 2301A governor is shown in Figure 5-1. The system model interconnects the diesel engine model, the generator model, the exciter model, the load models and the governor model. These component models are discussed in Section 5.2.

The system block includes two input blocks for frequency and voltage set-point. The voltage setpoint is initialized and can be stepped to a final value. Likewise, the electronic governor setpoint is initialized and can be stepped to a final value. The model inputs for voltage and frequency set points are summarized in Table 5-1.

During an EDG start, the voltage and frequency build-up until the breaker closure permissive is reached. At Davis-Besse there is only a voltage permissive. Based on review of test data with the 2301A governor, the EDG frequency has already reached and exceeded setpoint by the time the breaker closes. However, the voltage is still building when the breaker closes.

To model this behavior, the voltage regulator model's field flashing circuit is used. When the model starts, the generator field is not flashed and the initial engine speed (or frequency) setpoint (FR_SP_initial) is set to a value slightly less than the steady state speed setpoint (Freq_SetPoint). The engine speed is allowed to reach a steady-state condition and then the speed setpoint is stepped to the nominal steady-state speed setpoint. When the speed setpoint is stepped, the voltage regulator model is set to flash the field. The result is that the engine speed (and frequency) is approximately at nominal when the generator voltage reaches the voltage permissive for the EDG breaker. For the purposes of this analysis, it is assumed that the frequency at breaker closure is no greater than 60 Hz.