Tennessee Valley Authority, Post Office Box 2000, Spring City, Tennessee 37381-2000

June 7, 2012

10 CFR 50.34(b)

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

Watts Bar Nuclear Plant Unit 2
Docket No. 50-391

Subject: Watts Bar Nuclear Plant (WBN) Unit 2 – NUREG-0847 Supplemental Safety Evaluation Report (SSER) Related to the Operation of Watts Bar Nuclear Plant, Unit 2, Appendix HH Open Item 26 - Diesel Generator Response (TAC No. ME0853)

References:
1. NRC letter to TVA dated November 18, 2011, "Watts Bar Nuclear Plant, Unit 2 - Request for Additional Information Regarding Supplemental Safety Evaluation Report Open Item 26"
2. TVA letter to NRC dated April 6, 2011, "Watts Bar Nuclear Plant (WBN) Unit 2 - Safety Evaluation Report Supplement 22 (SSER22) - Response to NRC Required Action Items"

The purpose of this letter is to provide the additional information requested by the NRC in Reference 1 related to Emergency Diesel Generator (EDG) response and performance during loss of offsite power events, electrical system response to gradual submergence of equipment after a loss of coolant accident, and specific impacts of a loss of ventilation during station blackout conditions.

The requested information is provided in the enclosure and associated attachments and shows that the plant design conforms to the applicable regulatory requirements.

There are no new regulatory commitments contained in this letter. If you have any questions, please contact Gordon Arent at (423) 365-2004.

D030
NRR

I declare under penalty of perjury that the foregoing is true and correct. Executed on the 7th day of June, 2012.

Respectfully,

R.A. Hruby, Jr.

Raymond A. Hruby, Jr.
General Manager, Technical Services
Watts Bar Unit 2

Enclosure: Response to Action Item 26 From Appendix HH of NUREG-0847, Supplement 22

cc (Enclosure):

U. S. Nuclear Regulatory Commission
Region II
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NRC Resident Inspector Unit 2
Watts Bar Nuclear Plant
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Spring City, Tennessee 37381

NRC Question:

The licensee has attempted to demonstrate design margin based on 'hot and cold' engine capability and 'step load' capability. These ratings are not normally cited for DGs in nuclear power plant applications. The Final Safety Analysis Report (FSAR) states that the DG rating is 4400 kW continuous and 4840 kW for 2 hours out of 24 at a power factor of 0.8.

1 Based on the above information, the staff has the following questions:

a) Explain the variations in the worst-case loading provided in different responses and provide a summary of current calculations depicting DG loading, including procedurally required loads that may be manually connected.

TVA Response:

Based on discussion with the NRC Region II staff, Calculation EDQ 00099920080014, "Diesel Generator Loading Analysis" (Reference 1), has been rewritten to improve readability. Because of the ongoing plant modifications and NRC inspections, EDG loading is being constantly adjusted to account for the modifications and NRC comments. This explains the variations in the worst-case loading provided in different responses. Excerpts from Reference 1 are attached as Attachment 1. The loading computations are split in two sections:

The first section delineates the load carrying capability (steady-state running load) and margin available for the worst case EDG loading for two separate events. As stated in the Final Safety Analysis Report (FSAR), load carrying capability is based on a 2-hour rating of 4840 kW from 0 to 2 hours and on a continuous rating of 4400 kW from 2 hours to the end. Table 1, provided in Attachment 1, depicts worst case EDG loading with available margin when serving loads during a loss of offsite power (LOOP) concurrent with a loss of coolant accident (LOCA). Table 2 depicts worst case EDG loading with available margin when serving loads during a LOOP only.

The second section delineates the motor starting capability of each EDG for the same two separate events. Table 1 depicts the maximum transient load carrying capability when serving loads during a LOOP concurrent with a LOCA. As stated in the FSAR, this transient load carrying capability is based on a rating of 4785 kW for the first 3 minutes (0-180 seconds) and on 5073 kW from 180 seconds to the end. Table 2 depicts the maximum transient loading when serving loads during a LOOP only.

To demonstrate compliance with Regulatory Guide 1.9 (i.e., voltage does not decrease to less than 75% of nominal), the TVA design approach is not to allow the maximum step load increase in kVA to exceed the manufacturer's guaranteed performance characteristics. Thus the "Step Load" capability is defined as the maximum transient step load increase in kVA that the generator/exciter can accept without exceeding the minimum voltage limit prescribed by Regulatory Guide 1.9. This generator "Step Load" capability was determined to be 8000 kVA, and TVA has demonstrated that the starting kVA of any motor will not exceed 8000 kVA .

In addition, Attachment 2 provides EDG loading with one unit in LOOP plus LOCA and the second unit in LOOP only. The first set of tables in Attachment 2 provides EDG steady state running loads in the above scenario. The second set of tables in Attachment 2 provides EDG

maximum transient loads showing both real power as well as apparent power in the above scenario. The values in these Tables are extracted from Reference 1.

NRC Question:

b) *Provide verification or test documents from manufacturer or Appendix B qualified supplier of DG engine and DG generator certifying the 'hot, cold and step load' capabilities.*

TVA Response:

The document that established the "Cold" Engine (first 3 minutes [180 seconds] of load sequence) and "Hot" Engine (fully turbocharged, 180 seconds to the end) capability was provided to the NRC as Attachment 1 to TVA letter to the NRC dated December 6, 2010. For staff's convenience the document is attached as Attachment 3. This document established the maximum kW capability of the WBN DGs for starting motors in incremental steps during a design basis accident load sequence. This document concluded that WBN DG maximum kW capability for motor starting in the site service environment (intake air temperature less than 115° F and elevation less than 800 feet) is:

"Cold" Engine (first 3 minutes of load sequence):	4785 kW
"Hot" Engine (fully turbocharged):	5073 kW

This document was reviewed and concurred by MKW Power Systems, Inc., the Appendix B qualified supplier of DG engine and DG generator for WBN, as delineated on page 1 of Attachment 3.

NRC Question:

2. *In Table 8.3-14 of FSAR Amendment 106, TVA listed the major electrical equipment that could become submerged following a loss-of-coolant accident (LOCA). The listed equipment is either automatically de-energized or is not required to function after a LOCA. In Sections 8A and 8B, TVA summarized the analysis of submerged (post-LOCA) electrical equipment powered from the auxiliary power system and from the instrumentation and control power system. The analysis concluded that submerged electrical equipment will not degrade the 6.9-kV or 480-V Class 1E instrumentation and control power systems. Identify the equipment and the related power source(s) and explain the consequences of gradual submergence of AC and DC powered equipment that is not qualified or not required post accident but may be energized and results in simultaneous high impedance faults on the electrical system.*

TVA Response:

During a post LOCA and borated containment spray condition, some equipment inside the primary containment will be submerged or affected by the containment spray. This condition has the potential to produce multiple failures on the Class 1E 6.9 kV, 480 VAC, 120 VAC, and 125 VDC power systems. TVA evaluated the effect of this condition on the following power sources:

(Note: TVA assumed that if the equipment was located below the flood level, it was energized and was therefore affected by submergence. Therefore, the consequences of gradual submergence of AC and DC powered equipment that was not qualified or not required post accident but may be energized and results in simultaneous high impedance faults on the electrical system was bounded in the TVA analysis. TVA analysis further assumes that the protective device feeding the submerged equipment was loaded to its trip setting which was conservative.)

- 120 VAC Vital Instrument Power Boards 2-I, 2-II, 2-III and 2-IV
- 125 VDC Vital Battery Boards III and IV
- 120 VAC Hydrogen Mitigation System Panels 2-DPL-268-1-A and 2-DPL-268-2-B
- 6.9 kV Shutdown Boards 2A-A and 2B-B
- 480 V Shutdown Boards 2A1-A, 2A2-A, 2B1-B and 2B2-B
- 480 V Reactor Vent Boards 2A-A and 2B-B
- 480 V Reactor MOV Boards 2A1-A, 2A2-A, 2B1-B and 2B2-B

This evaluation was documented in the TVA submergence calculation for Unit 2 (Reference 2), excerpt provided in Attachment 4. The equipment fed from each of the above power sources was identified in this evaluation. A determination was made if the equipment was going to be energized and if it was going to be submerged as a result of the event. The evaluation concluded the following:

- The additional loading on the 120 VAC vital Class 1E power system due to the submerged equipment does not cause any secondary protective devices to trip nor does it overload the power supply (inverters).
- The additional loading on the 125 VDC Class 1E power system due to the submerged equipment does not cause any secondary protective devices to trip nor does it adversely affect the battery sizing. The available voltage at the battery terminals is more than the minimum required voltage.
- The loading on the 120 VAC Hydrogen Mitigation System Panels due to the submerged equipment does not cause any secondary protective devices to trip nor does it overload the transformer.
- The additional loading on the 6.9 kV and 480 VAC Class 1E power system due to the submerged equipment does not cause any secondary protective devices to trip nor does it overload the power transformers.
- There is no adverse affect on the Class 1E power systems due to containment spray on the shutdown and non safe shutdown components located inside the containment.

<u>*NRC Question:*</u>

3. *To demonstrate compliance with station blackout (SBO) rule, TVA performed a steady-state heat-up analyses in accordance with NUMARC 87-00 guidelines to determine the effects of loss of ventilation in main control room complex, turbine-driven auxiliary feedwater pump room, north and south main steam valve rooms, 125V vital battery rooms, 125 vital battery board rooms, cable spreading room, pipe chase, 480 V board rooms, and 6.9 kV and 480 V shutdown board room. From*

these analyses, provide a detailed list of equipment that is subjected to temperature above the design temperature for normal operation and the results of assessment performed for the equipment to show its continued operability during an SBO event.

TVA Response:

Table A below provides normal operating temperature, maximum abnormal operating temperature and calculated SBO temperature that were calculated using the NUMARC 87-00 guidelines for each of the rooms listed in the RAI (Reference 3). TVA defines the "maximum abnormal operating temperature" as the environmental service conditions which result from outside temperature excursions. This condition can exist for up to 12 hours per excursion for non-reactor building spaces.

For the four rooms, North Main Steam valve room, South Main Steam valve room, Turbine-driven auxiliary feed pump room, and pipe chase, where the calculated SBO temperatures are higher than abnormal operating temperatures, a list of equipment in the rooms that are affected is provided. In addition, the associated assessment for each room is provided in the remarks column of the table.

References:

1. TVA Calculation EDQ00099920080014, "Diesel Generator Loading Analysis"
2. TVA Calculation EDQ00299920080020, "Submergence Calculation – Unit 2"
3. TVA Calculation EPM-MA-041592, "Station Black-out Coping Evaluation"
4. TVA Drawing Series 47E235, "Environmental Data Drawing"
5. TVA Calculation GENSTP3-001, "Upper Boundary Temperature for Mild Environments Related to Environmental Qualification of Electrical Equipment"
6. TVA Calculation EDN00299920110004, "Material Aging Calculation for Auxiliary Feedwater Level Control Valves in the South Steam Valve Rooms (729-A01 & 729-A11) for Station Blackout (SBO) Conditions"

List of Attachments:

1. Excerpts from calculation EDQ00099920080014, Rev. 15
2. EDG Loading Tables depicting EDG loads with one unit in LOOP+LOCA and the second unit in LOOP
3. EDG Motor Starting Capability
4. Excerpt from Unit 2 Submergence Evaluation

Table A – Response to RAI Item # 3 Effects of Loss of Ventilation during SBO

Index	Room	Normal Operating Temperature (°F)	Maximum Abnormal Operating Temperature (°F)	Calculated SBO Temperature (°F)	Equipment required to be operational during SBO condition.	Remark
1	Main Control Room Complex	80	104	104	Panels powered from one of the 8 Vital Inverter Boards and all electrical equipment in TSC is energized.	Main Control Room Complex temperatures are not above the abnormal operating temperatures as provided on Environmental Data Drawing 47E235-16 (Reference 4) Reference 3, Appendix G, Page 63
2	Turbine Driven Auxiliary Feedwater Pump Room	104	110	127.7	TDAFWP Room Exhaust Fan DC Motor driven fan 2-FAN-030-0214	Note that the average temperature for the room is 116.4 °F and maximum temperature of 127.7°F at the end of four hours. Per TVA Calculation GENSTP3-001 (Reference 5), motors in a mild environment are capable of operating for 24 hours at 140 °F. Reference 3, Page 25
3	North Main Steam Valve Room	135	140	160.8	NONE	There is no equipment in the North Main Steam Valve that is required to operate during SBO. Reference 3, Page 25
	South Main Steam Valve Room	140	140	177.9	TDAFWP LCVs 2-LCV-30-174-B & 2-LCV-30-175-A	TVA Calculation EDN00299920110004 (Reference 6) was performed to evaluate accident degradation equivalency based on a steady state temperature of 200 °F for the four hour duration of the SBO event. The calculation concluded that the life of safety-related age-degradable materials in AFW LCVs in the South Main Steam Valve Room is not significantly impacted by operation for four hours at 200 °F during a SBO event. Reference 3, Page 25

Table A – Response to RAI Item # 3 Effects of Loss of Ventilation during SBO						
Index	**Room**	**Normal Operating Temperature (°F)**	**Maximum Abnormal Operating Temperature (°F)**	**Calculated SBO Temperature (°F)**	**Equipment required to be operational during SBO condition.**	**Remark**
4	Vital 125 VDC Station Battery & Battery Board Rooms (Rooms I, II, III, IV)	85	104	104	Battery, Battery Output Cable, Individual Battery Board, and Vital Instrument Panel.	The Station Battery & Battery Board Room temperatures are not above the maximum abnormal temperature as provided on Environmental Data Drawing 47E235-3. Also note that the battery rooms can withstand 120 °F for the period of 24 hours. Reference 3, Appendix G, Page 81
5	Cable Spreading Room	95	104	103	NONE	Adjacent room temperatures are higher during normal operation but lower during SBO; therefore, the transmission load removes heat out of the room during a SBO condition Reference 3, Appendix G, Page 76
6	Pipe Chase	104	110	121.9	Containment Isolation Valve 2-FCV-62-63	The pipe chase temperature will gradually rise during an SBO. Hence, it is feasible that this valve could be manually closed, if necessary, by brief excursion into the pipe chase even if the temperature is about 122 °F. This would not be required unless core damage was imminent and core uncovery is not expected during the 4-hour SBO event. Reference 3, Page 25

Table A – Response to RAI Item # 3 Effects of Loss of Ventilation during SBO						
Index	**Room**	**Normal Operating Temperature (°F)**	**Maximum Abnormal Operating Temperature (°F)**	**Calculated SBO Temperature (°F)**	**Equipment required to be operational during SBO condition.**	**Remark**
7	480 V Board Rooms	83	104	104	4 of the 6 Vital Inverters.	The 480V Board Room temperatures are not above maximum abnormal temperatures as provided on Environmental Data Drawing 47E235-3. Reference 3, Appendix G, Page 69 & 70.
8	6.9 KV & 480 V Shutdown Board Rooms	87	104	104	Auxiliary compartments which contain meters and relays.	The 6.9 kV & 480V Shutdown Board Room temperatures are not above maximum abnormal temperatures as provided on Environmental Data Drawing 47E235-7. Reference 3 Appendix G, Page 73

Attachment 1

Excerpts from calculation EDQ00099920080014, Rev. 16

5.0 COMPUTATIONS AND ANALYSES

5.1 The Electrical Transient Analysis Program (ETAP) Version 5.5.6N (Reference 3.15) is used to perform the DG loading analysis. The data for the connected load and their operating time is contained in ETAP database. The Motor Dynamic Starting Analysis tool in ETAP is used to analyze the loading (kW and kVA) on each of the Emergency Diesel Generators. The DGs are modeled as infinite swing sources that will adjust their MVAR output to maintain constant voltage. The electrical loading on each WBN Diesel Generator (DG) is calculated and compared to the DG ratings.

Attachment 2 provides a detailed set of instructions on how the case studies are performed to determine the loading (kW and kVA) on each of the WBN Emergency Diesel Generators using the ETAP software. In the ETAP analysis motors are modeled to start dynamically in accordance with the ETAP motor model, static loads just turn on and MOVs load is applied for the duration of their stroke time in accordance with the ETAP MOV model.

5.2 Automatically & Manually Sequenced Loads

Automatically sequenced loads are added based on the starting times stated in Appendix A. Manually operated loads are administratively controlled in accordance with abnormal operating instruction AOI-35 and will not be automatically sequenced onto or off the Diesel Generators. The operator has the responsibility to maintain the loading within the Diesel Generator ratings. The only required manual load additions are the hydrogen mitigation system and hydrogen recombiners (for Unit 1 only; Unit 2 Hydrogen Recombiners have been deleted by EDCR 52329, Ref. 3.20) which are added prior to (or after) two hours. These loads have been included with the DGs loading analyses, starting 30 minutes after t = 0, which is conservative. The manual loads are as follows (refer ETAP database for load):

Load ID	UNID	Rating (kW)	Description
203-9E	1-DXF-268-1-A	35.75	Perm Hydrogen Mitigation Sys 1A-A
205-12C	1-DXF-268-2-B	35.75	Perm Hydrogen Mitigation Sys 1B-B
243-2D	1-HTR-83-1-A	75	Hydrogen Elec Recombiner 1A-A
244-2D	1-HTR-83-2-B	75	Hydrogen Elec Recombiner 1B-B
207-9E	2-DXF-268-1-A	35.75	Perm Hydrogen Mitigation Sys 2A-A
209-12C	2-DXF-268-2-B	30	Perm Hydrogen Mitigation Sys 2B-B

5.3 Random Loads

The DGs and associated largest random loads are listed as follows:

DG	Load ID	UNID	Rating (HP)	Description
1A-A				
	127-2C	0-MTR-31-80/2-A *	177	Cont Room A/C A-A Cprsr
	127-4D	0-MTR-26-1-A **	200	Station Fire Pump 1A-A (LOOP)
	128-9D	0-MTR-31-45-A	75	Shdn Bd Room AHU A-A
	203-11D	0-MTR-31-12-A	60	Cont Room AHU A-A
1B-B				
	131-3C	0-MTR-31-49/2-B *	237	Shdn Bd Room A/C B-B Cprsr
	131-4D	0-MTR-26-4-B **	200	Station Fire Pump 1B-B (LOOP)
	132-9D	0-MTR-31-55-B	75	Shdn Bd Room AHU C-B
	205-11D	0-MTR-31-11-B	60	Cont Room AHU B-B

2A-A				
	135-2C	0-MTR-31-128/2-A *	250	Elec Bd Room A/C A-A Cprsr
	135-4D	0-MTR-26-9-A **	200	Station Fire Pump 2A-A (LOOP)
	136-8D	0-MTR-31-44-A	75	480V Shutdown BD Rm AHU B-A
2B-B				
	139-2B	0-MTR-31-129/2-B *	250	Elec Bd Room A/C B-B Cprsr
	139-4D	0-MTR-26-11-B **	200	Station Fire Pump 2B-B (LOOP)
	140-9D	0-MTR-31-61-B	75	480V Shutdown Bd Rm AHU D-B

* Control Room, Shdn Bd Room and Elec Bd Rooms A/C Compressors have a time delay of 6 minutes (360s) to prevent successive re-start after loss of power (Ref. 3.18 & 3.19).

** Fire Pump starts as random load only for Loss of Offsite Power (LOOP) after a time delay of 40s on DG 1A-A, 50s on DG 1B-B, 60s on DG 2A-A and 70s on DG 2B-B.

5.4 For each diesel generator, three cases are analyzed: Loss of Offsite Power (LOOP), LOOP with Safety Injection Phase A (SIA) and LOOP with Safety Injection Phase B (SIB). Therefore, a total of 12 cases are evaluated in this calculation. The loads and their operating time data is extracted from ETAP database (Attachment 5) and documented on Appendix A - Diesel Generator Loading & Starting Times.

5.5 The ETAP output reports (Appendices B, C, D, & E) generated for this calculation (R0) are saved on a Compact Disc (CD) attached for separate electronic storage in EDMS as Abode "pdf" files found under this calculation number and revision.

5.6 Random load of largest motor (75hp, Section 5.3) is considered starting on top of the maximum transient loading which comes at 35s for period 0 to 180s for SIA and 184s for period >3min for SIB (Section 5.9). Since the loads are already considered running in the analysis, the difference between the starting and running loads is added to the maximum transient loading to account for the random load. Starting kW is determined using the equation

$KW_{START} = \sqrt{3} \times V_{RATED} \times I_{LR} \times LRPF$ (refer ETAP database for I_{LR}, LRPF and running kW)

Diesel Generator 1A-A (128-9D): Starting 155.66kW, Running 48.91kW, Δ 106.75kW
Diesel Generator 1B-B (132-9D): Starting 155.77kW, Running 51.72kW, Δ 104.05kW
Diesel Generator 2A-A (136-8D): Starting 155.77kW, Running 51.72kW, Δ 104.05kW
Diesel Generator 2B-B (140-9D): Starting 155.77kW, Running 51.72kW, Δ 104.05kW

The larger size random load of 177hp (Cont Room A/C A-A Cprsr) for DG 1A-A, 237hp (Shdn Bd Room B-B Cprsr) for DG 1B-B and 250hp (Elec Bd Room A/C Compressor) for DG 2A-A and 2B-B could start anytime after a time delay of 6 minutes. The worst case transient kW load (out of all four DGs) for period ≥6min which appears at 360s for SIB is approximately 4400kW (see Time v/s MW plots in Appendix F). The calculated worst case starting kW for the random load (250hp motor) is 349.2kW ($\sqrt{3}$x0.460x1826x0.24). The running load included in the analysis for this motor is 141.3kW. The additional load which will come due to random start of this motor is 207.9≈208kW (349.2−141.3) resulting in peak load of 4608 (4400+208)kW at 360s. Therefore, the worst case transient loading with 250hp motor as random load is bounded by the worst case transient loading with 75hp motor as random load evaluated in Section 5.9.

Similarly the worst case transient kW loading (real power output) during LOOP is approx. 3500kW for 0-180 seconds and 3800kW for 180 seconds to end (App. F) which includes running load of 152.6kW for the 200hp fire pump. Starting load of this motor is calculated as 253.8kW ($\sqrt{3}$x0.460x1180x0.27). Starting of this 200hp motor as random load will add 101.2≈102kW (delta between starting and running load) resulting in worst case transient kW loading of 3602 (3500+102)kW for 0-180 seconds and 3902 (3800+102)kW for 180 seconds to end. This transient loading is bounded by the worst case transient loading evaluated in Section 5.9.

5.7 Since ETAP motor starting analysis does not allow breakers to change state, the transformers are all energized prior to any load additions. This is acceptable as per Section 4.10.

5.8 In the ETAP analysis, ERCW pump motors are considered to be operating at 98% (Ref. 3.7). However, the increased head and flow demand for the upgraded and refurbished ERCW pumps will place more demand on the motor but not exceeding 805 brake horsepower (Ref. DCN 52920). This will result in increase of ERCW loading by 16.9+j6.5kVA (increase for 5hp is calculated proportionately from ETAP loading at 100% and 101%). This load is added to the ETAP load to calculate the total load on the DGs.

5.9 DG Load Computations

The following computations show the total load on each DG and the available margin. Table 1 shows the maximum kW and kVA loading on each DG out of all three cases (LOOP, LOOP+SIA, and LOOP+SIB) and the event/time at which the maximum load occurs (App. F). Table 2 shows the DG loading under LOOP only (no accident). The load information extracted from ETAP plots also includes the manually added loads at 1800 seconds (Section 5.2). However, since the most limiting rating applies after 2 hours, these loads are excluded from the computations for 0-2 hours (Note 6).

5.9.1. Load Computations (Load Carrying Capability)

The following computations in Tables 1 and 2 show the maximum steady state (running) load of each DG during LOOP+LOCA and LOOP only for the first 2 hours of the events. These tables represent the total steady-state running load of all sequenced loads plus base continuous load on each DG. Load listed in Table 1 is from the ETAP reports for the worst load scenario during LOOP+LOCA with SIB and in Table 2 is just with LOOP event.

TABLE 1 (DG Loading LOOP+LOCA)

Maximum Steady-State Running Load, 0 hrs to 2 hrs*

	1A-A	1B-B	2A-A	2B-B	Short-Time Rating	Minimum Margin (%)
kW (ETAP Plot)	4318.45	4188.12	4115.96	4228.79	4840	12.4
Event/Time	SIB 1810s	SIB 1810s	SIB 1810s	SIB 1810s		
Manual Action (Note 1)	(-)110.75	(-)110.75	(-)35.75	(-)30.00		
DCN 53437 (Note 3)	7.44	3.72	7.44	3.72		
Spare Charger (Note 3)		29.32		29.32		
Charger Ct limit (Note 8)	15.60	15.60	15.60	15.60		
DCN55076 (Note 4)	1.87	1.87	1.87	1.87		
ERCW****	16.90	16.90	16.90	16.90		
CCP (Note 9)	(-)29.00	(-)29.00	(-)29.00	(-)29.00		
24V CAP Chgr (Note 12)			9.4			
Total	4220.51	4115.78	4102.42	4237.20		
kVA (ETAP Plot)	4958.06	4832.16	4724.42	4861.87		
Event/Time	SIB 1810s	SIB 1810s	SIB 1810s	SIB 1810s	6050	19.3
Manual Action (Note 1)	(-)110.75	(-)110.75	(-)35.75	(-)30.00		
DCN 53437 (Note 3)	(-)6.28	(-)3.14	(-)6.28	(-)3.14		
Spare Charger (Note 3)		39.10		39.10		
Charger Ct limit (Note 8)	19.50	19.50	19.50	19.50		
DCN 55076 (Note 4)	1.66	1.66	1.66	1.66		
ERCW****	18.11	18.11	18.11	18.11		
CCP (Note 9)	(-)30.41	(-)30.41	(-)30.41	(-)30.41		
24V CAP Chgr (Note 12)			14.1			
Total	4849.89	4766.23	4705.35	4876.69		

Maximum Steady-State Running Load, 2 hrs to End)**

	1A-A	1B-B	2A-A	2B-B	Continuous Rating	Minimum Margin (%)
kW (ETAP Plot)	4318.45	4188.12	4115.96	4228.79	4400	6.9
Event/Time	SIB 7200s	SIB 7200s	SIB 7200s	SIB 7200s		
Manual Action (Note 2)	(-)75.00	(-)75.00	7.44	3.72		
DCN 53437 (Note 3)	7.44	3.72				
Spare Charger (Note 3)		29.32		29.32		
Charger Ct limit (Note 8)	15.60	15.60	15.60	15.60		
DCN 55076 (Note 4)	1.87	1.87	1.87	1.87		
ERCW****	16.90	16.90	16.90	16.90		
CCP (Note 9)	(-)29.00	(-)29.00	(-)29.00	(-)29.00		
CCSP (Note 10)		(-)290.9		(-)290.9		
AFW (Note 11)	(-)162.6	(-)162.6	(-)162.6	(-)162.6		
24V CAP Chgr (Note 12)			9.4			
Total	4093.66	3698.03	3975.57	3813.70		
kVA (ETAP Plot)	4958.06	4832.16	4724.42	4861.87	5500	14.5
Event/Time	SIB 7200s	SIB 7200s	SIB 7200s	SIB 7200s		
Manual Action (Note 2)	(-)75.00	(-)75.00	(-)6.28	(-)3.14		
DCN53437 (Note 3)	(-)6.28	(-)3.14				
Spare Charger (Note 3)		39.10		39.10		
Charger Ct limit (Note 8)	19.50	19.50	19.50	19.50		
DCN55076 (Note 4)	1.66	1.66	1.66	1.66		
ERCW****	18.11	18.11	18.11	18.11		
CCP (Note 9)	(-)30.41	(-)30.41	(-)30.41	(-)30.41		
CCSP (Note 10)		(-)317.74		(-)317.74		
AFW (Note 11)	(-)186.24	(-)186.24	(-)186.24	(-)186.24		
24V CAP Chgr (Note 12)			14.1			
Total	4699.40	4298.0	4554.86	4402.71		

TABLE 2 (DG Loading LOOP Only)

Maximum Steady-State Running Load, 0 hrs to 2 hrs*

	1A-A	1B-B	2A-A	2B-B	Short-Time Rating	Minimum Margin (%)
kW (ETAP Plot)	3490.60	3416.70	3543.76	3626.33	4840	23.7
Event/Time	LOOP 1810s	LOOP 1810s	LOOP 1810s	LOOP 1810s		
EGT Htrs & Fans (Note 7)	24.70	24.70	24.70	24.70		
DCN 53437 (Note 3)	7.44	3.72	7.44	3.72		
Spare Charger (Note 3)		29.32		29.32		
Charger Ct limit (Note 8)	15.60	15.60	15.60	15.60		
DCN55076 (Note 4)	1.87	1.87	1.87	1.87		
ERCW****	16.90	16.90	16.90	16.90		
CCP (Note 9)	(-)29.00	(-)29.00	(-)29.00	(-)29.00		
24V CAP Chgr (Note 12)			9.4			
Total	3528.11	3479.81	3590.67	3689.44		
kVA (ETAP Plot)	3936.49	4123.98	3963.21	4064.93	6050	31.0
Event/Time	LOOP 1810s	LOOP 1810s	LOOP 1810s	LOOP 1810s		
EGT Htrs & Fans (Note 7)	3.46	3.46	3.46	3.46		
DCN 53437 (Note 3)	(-)6.28	(-)3.14	(-)6.28	(-)3.14		
Spare Charger (Note 3)		39.10		39.10		
Charger Ct limit (Note 8)	19.50	19.50	19.50	19.50		
DCN 55076 (Note 4)	1.66	1.66	1.66	1.66		
ERCW****	18.11	18.11	18.11	18.11		
CCP (Note 9)	(-)30.41	(-)30.41	(-)30.41	(-)30.41		
24V CAP Chgr (Note 12)			14.1			
Total	3942.53	4172.26	3983.35	4113.21		

Maximum Steady-State Running Load, 2 hrs to End)**

	1A-A	1B-B	2A-A	2B-B	Continuous Rating	Minimum Margin (%)
kW (ETAP Plot)	3490.60	3416.70	3543.76	3626.33	4400	22.08
Event/Time	LOOP 7200s	LOOP 7200s	LOOP 7200s	LOOP 7200s		
EGT Htrs & Fans (Note 7)	24.70	24.70	24.70	24.70		
DCN 53437 (Note 3)	7.44	3.72	7.44	3.72		
Spare Charger (Note 3)		29.32		29.32		
Charger Ct limit (Note 8)	15.60	15.60	15.60	15.60		
DCN55076 (Note 4)	1.87	1.87	1.87	1.87		
ERCW****	16.90	16.90	16.90	16.90		
CCP (Note 9)	(-)29.00	(-)29.00	(-)29.00	(-)29.00		
CCSP (Note 10)		(-)290.9		(-)290.9		
AFP (Note 11)	(-)162.6	(-)162.6	(-)162.6	(-)162.6		
24V CAP Chgr (Note 12)			9.4			
Total	3365.51	3026.31	3428.07	3235.94		
kVA (ETAP Plot)	3936.49	4123.98	3963.21	4064.93	5500	30.96
Event/Time	LOOP 7200s	LOOP 7200s	LOOP 7200s	LOOP 7200s		
EGT Htrs & Fans (Note 7)	3.46	3.46	3.46	3.46		
DCN 53437 (Note 3)	(-)6.28	(-)3.14	(-)6.28	(-)3.14		
Spare Charger (Note 3)		39.10		39.10		
Charger Ct limit (Note 8)	19.50	19.50	19.50	19.50		
DCN 55076 (Note 4)	1.66	1.66	1.66	1.66		
ERCW****	18.11	18.11	18.11	18.11		
CCP (Note 9)	(-)30.41	(-)30.41	(-)30.41	(-)30.41		
CCSP (Note 10)		(-)317.74		(-)317.74		
AFP (Note 11)	(-)186.24	(-)186.24	(-)186.24	(-)186.24		
24V CAP Chgr (Note 12)			14.1			
Total	3756.29	3668.28	3797.11	3609.23		

5.9.2 Load Computations (Motor Starting Capability)

The acceptability of the electric demand placed on the DGs is based on the maximum motor starting capability (Ref. Sec. 4.6) for each associated time period which is labeled as **Cold Engine** and **Hot Engine** capabilities. These capabilities are compared with the maximum transient loading (starting + running) to determine acceptability. If the maximum transient loading is less than the limit, then the DG is considered to maintain acceptable voltage and frequency.

TABLE 1 (DG Loading LOOP+LOCA)

<u>Maximum Transient Loading (Real Power), 0 to 180 sec</u>

	1A-A	1B-B	2A-A	2B-B	Cold Engine Capability
kW (ETAP Plot)	3937.65	3520.30	3459.14	3878.36	4785
Event/Time	SIA 35s	SIA 35s	SIA 35s	SIA 35s	
Random***	106.75	104.05	104.05	104.05	
DCN 53437 (Note 3)	7.74	3.72	7.74	3.72	
Spare charger (Note 3)		29.32		29.32	
Charger Ct limit (Note 8)	15.60	15.60	15.60	15.60	
DCN 55076 (Note 4)	1.87	1.87	1.87	1.87	
ERCW****	16.90	16.90	16.90	16.90	
CCP (Note 9)	(-)29.00	(-)29.00	(-)29.00	(-)29.00	
24V CAP Chgr (Note 12)			9.4		
Total	4057.51	3662.76	3585.7	4020.82	

<u>Maximum Transient Loading (Real Power), 180 sec to End</u>

	1A-A	1B-B	2A-A	2B-B	Hot Engine Capability
kW (ETAP Plot)	4736.24	4498.05	4481.74	4755.44	5073
Event/Time	SIB 184s	SIB 184s	SIB 184s	SIB 184s	
Random***	106.75	104.05	104.05	104.05	
DCN 53437 (Note 3)	7.44	3.72	7.44	3.72	
Spare Charger (Note 3)		29.32		29.32	
Charger Ct limit (Note 8)	15.60	15.60	15.60	15.60	
DCN 55076 (Note 4)	1.87	1.87	1.87	1.87	
ERCW****	16.90	16.90	16.90	16.90	
CCP (Note 9)	(-)29.00	(-)29.00	(-)29.00	(-)29.00	
CCSP (Note 10)		(-)290.9		(-)290.9	
AFP (Note 11)	(-)162.6	(-)162.6	(-)162.6	(-)162.6	
24V CAP Chgr (Note 12)			9.4		
Total	4693.20	4187.01	4445.4	4444.40	

<u>Maximum Step Load Increase (Apparent Power), 0 sec to End</u>

	1A-A	1B-B	2A-A	2B-B	Generator Step Load Capability
kVA (ETAP Plot)	4111.29	4397.35	3885.44	3944.21	8000
Event/Time	SIB 0s	SIB 0s	SIB 0s	SIB 0s	

TABLE 2 (DG Loading LOOP Only)

Maximum Transient Loading (Real Power), 0 to 180 sec

	1A-A	1B-B	2A-A	2B-B	Cold Engine Capability
kW (ETAP Plot)	3354.31	3140.65	3243.48	3626.65	4785
Event/Time	LOOP 90s	LOOP 90s	LOOP 90s	LOOP 90s	
EGT Htrs & Fans (Note 7)	24.70	24.70	24.70	24.70	
Random***	106.75	104.05	104.05	104.05	
DCN 53437 (Note 3)	7.44	3.72	7.44	3.72	
Spare charger (Note 3)		29.32		29.32	
Charger Ct limit (Note 8)	15.60	15.60	15.60	15.60	
DCN 55076 (Note 4)	1.87	1.87	1.87	1.87	
ERCW****	16.90	16.90	16.90	16.90	
CCP (Note 9)	(-)29.00	(-)29.00	(-)29.00	(-)29.00	
24V CAP Chgr (Note 12)			9.4		
Total	3498.57	3307.81	3394.44	3793.81	

Maximum Transient Loading (Real Power), 180 sec to End

	1A-A	1B-B	2A-A	2B-B	Hot Engine Capability
kW (ETAP Plot)	3649.44	3767.84	3840.36	3817.07	5073
Event/Time	LOOP 360s	LOOP 360s	LOOP 360s	LOOP 360s	
EGT Htrs & Fans (Note 7)	24.70	24.70	24.70	24.70	
Random***	106.75	104.05	104.05	104.05	
DCN 53437 (Note 3)	7.44	3.72	7.44	3.72	
Spare Charger (Note 3)		29.32		29.32	
Charger Ct limit (Note 8)	15.60	15.60	15.60	15.60	
DCN 55076 (Note 4)	1.87	1.87	1.87	1.87	
ERCW****	16.90	16.90	16.90	16.90	
CCP (Note 9)	(-)29.00	(-)29.00	(-)29.00	(-)29.00	
CCSP (Note 10)		(-)290.9		(-)290.9	
AFP (Note 11)	(-)162.6	(-)162.6	(-)162.6	(-)162.6	
24V CAP Chgr (Note 12)			9.4		
Total	3631.1	3481.5	3828.72	3530.73	

Maximum Step Load Increase (Apparent Power), 0 sec to End

	1A-A	1B-B	2A-A	2B-B	Generator Step Load Capability
kVA (ETAP Plot)	3641.55	3725.29	3718.84	3721.55	8000
Event/Time	LOOP 20s	LOOP 20s	LOOP 20s	LOOP 20s	
EGT Htrs & Fans (Note 7)	3.46	3.46	3.46	3.46	
Random***	106.75	104.05	104.05	104.05	
CCP (Note 9)	(-)30.41	(-)30.41	(-)30.41	(-)30.41	
Total	3721.35	3802.39	3795.94	3798.65	

* Automatic load-sequencing only, no operator actions included.

** Includes all operator actions (load additions). It is noted that some manual load additions may occur prior to 2 hour. However, for the purpose of determining the worst-case design margin, all operator actions (maximum load addition) are taken after 2 hours when the most limiting rating applies.

*** Section 5.6

**** Section 5.8

Note 1: The load shown in the ETAP plots (Appendix F) includes manually added load of 110.75kW (75kW for Hydrogen Elec Recombiners and 35.75kW for Perm Hydrogen Mitigation system) for DG 1A-A and 1B-B, 35.75kW and 30kW (Perm Hydrogen Mitigation System) for DG 2A-A and 2B-B respectively at 30 minutes (Section 5.2 & Appendix G). Therefore, to determine the load due to automatic load sequencing, the manually added loads are subtracted from the load shown in the ETAP plots.

Note 2: Includes a manually added load of 35.76kW for Perm Hydrogen Mitigation System only. Load for Hydrogen Elec Recombiners (75kW) is not included since these are not required for unit shutdown. Per AOI-35 (Ref. 3.21) and Unit 1 Technical Specifications (TS, Ref. 3.4), even with both the H_2 Elec Recombiners inoperable, safety function is maintained provided H_2 igniters (Hydrogen Mitigation Sys) are operable. Hydrogen Elec Recombiners for Unit 2 have been deleted by EDCR 52329.

Note 3: DCN 53437 adds two new 125VDC vital spare battery chargers 8-S & 9-S and replaces the existing battery chargers I, II, III, IV, 6-S & 7-S. The new charger load is 29.32+j25.86kVA or 39.1kVA (see calculation record of revision for R3) compared to the existing charger load of 25.6+j33.6kVA or 42.24kVA. The change in load is +3.72kW, -3.14kVA. The transfer switch will allow only one spare charger in each pair (6-S, 8-S and 7-S, 9-S) to be used at a time. In the analysis one normal and one spare battery charger is considered to be operational on each DG. The spare charger load is also added to calculated load for DG 1B-B and 2B-B to account for the alternate feed to spare battery charger 6-S or 8S/7-S or 9-S in accordance with Section 4.13 since this load is not included in the ETAP runs.

Note 4: DCN 55076 replaces all the 125VDC DG battery chargers. The increase in load for each charger is 1.87kW, 1.66kVA (see calculation record of revision for R6)

Note 5: DCN 52711 replaces the Main Control Room Chillers A-A, B-B and Shutdown Board Room Chillers A-A, B-B. These chillers are fed from DGs 1A-A, 1B-B and 2A-A. Loading impact of the replacement of these chillers is documented in the calculation record of revision for R5. Based on the analysis, steady state (run) kW loading of the new chillers is less compared to the existing chillers and will thus result in reduction of steady state loading. The slight increase in steady state KVA loading for shutdown board room chillers is insignificant compared to the total load. The worst case loading on DG 2B-B is not impacted by this modification.

The transient loading (start) of the new chillers is higher compared to the existing chillers. However, based on a review of the existing transient loading from ETAP plots in Appendix F and the new chillers loading, the loading at 360s, when the chillers are loaded on the DG, is still enveloped by the worst case transient loading at 184s.

Note 6: For the purpose of determining the worst case design margin, all operator actions (load additions and removal) are taken after 2 hours when the most limiting rating applies.

Note 7: Added a load of 20kW for EGT Humidity Heaters (Bus 203-6D and 205-5D) and 4.7+j3.46kVA for CB Emergency Air CU Fans (Bus 203-2A and 205-2A) for DG 1A-A and 1B-B. These loads could operate upon Blackout conditions.

Note 8: Battery charger input load considered in Tables 1 and 2 is 29.32+j25.86kVA or 39.1kVA. With the battery charger in current limit mode the input current will increase from the rated 47.02A (page 2C) to 58.78A (47.02x1.25) and the power factor may slightly improve from 0.75 to 0.76 (based on proportional increase from 0.74 to 0.75 with load increase from 75% to 100%, Ref. 3.25). Based on this

information, the charger load in the current limit mode is calculated as 37.12+j31.75kVA or 48.85kVA. Thus the increase in charger load from 100% load to current limit mode will be 7.80kW / 9.75kVA. There are two chargers on each DG, therefore, the total load increase on each DG will be 15.60kW /19.50kVA.

Note 9: Calculation EPMGDU041593 summarizes the results of EPMHV070189 for the Centrifugal Charging Pumps (CCP). Review of the new curves in Attachment 8 (which are nearly identical) shows that at the maximum flow (212 gpm) the horsepower would be 500 HP (or 515 HP at the motor). At the accident condition of 560 gpm both pumps would remain below 640 horsepower (or 659 HP at the motor). Based on this and a nameplate horsepower rating of 600 HP, the accident value listed in table 7.1 of EPMGDU041593 will be changed from 116% to 110% (Section 2.5). This will reduce the HP on the Centrifugal Charging Pump motors from 695 HP to 659 HP (36HP). The total load decrease on each DG will be 29kW / 30.41kVA (value determined from ETAP).

Note 10: CCSP pumps 1B-B and 2B-B are not required to operate during accident condition per Section 4.15, therefore, these pumps will be turned off after 2 hours into the accident events, hence the total load on each DG 1B-B and 2B-B will be decreased 290.9KW/127.8 KVAR (value determined from ETAP) (Calculated value of 317.74 KVA). All other CCSP pumps 1A-A, 2A-A and C-S pumps will continue to operate on their respective boards to support accident events.

Note 11: For the limiting case large break LOCA with all ECCS Pumps running, the steam generators will remain filled and Aux Feedwater Pump (AFW) will operate on mini flow at 170 gpm with a HP of less than 400HP after two hours (Appendix 4 of EPMGDU041593 and Section 3.2.1C of WBN System Description for WBNSDD-N3-3B-4002). This will reduce the HP on the Aux Feedwater Pump motors from 600HP to 400HP. The total load decrease on each DG will be 162.6kW / 186.24kVA.

Note 12: PER 464997 accounts the load for alternate feeder of 24V CAP Battery Charger No 1 fed from 480V RMOV Board 2A1-A/16F1 (Node 239 - 16F1) for Diesel Generator 2A-A. The total load increase on DG 2A-A will be 9.4kW / 14.1 kVA (value determined from ETAP).

5.10 Effect of Frequency Variation on DG loading

The following computations determine the total steady state load on each DG and the available margin when DG frequency is increased to 60.1Hz from the rated frequency of 60Hz. Loading shown in the following table for 60Hz has been extracted from "Maximum Steady-State Running Load, 2Hrs to End" from Table 1 of Section 7.2. The highest steady state loading has been used which envelopes all other steady state loading scenarios.

The Hz variation factor = (Maximum Hz/Rated Hz)^3 Section 3.2 of Ref. 3.26
= $(60.1/60)^3$
= 1.005

Maximum Steady-State Running Load, 2 hrs to End)

	1A-A	1B-B	2A-A	2B-B	Continuous Rating	Minimum Margin (%)
Total KW at 60 Hz	4093.66	3698.03	3975.57	3813.70	4400	6.9
Total KW at 60.1 Hz Load multiplication factor = 1.005	4114.13	3716.52	3995.45	3832.77	4400	6.4

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6.0 SUPPORTING GRAPHICS

See Appendix F for DGs 1A-A, 1B-B, 2A-A and 2B-B load profiles.

7.0 SUMMARY OF RESULTS

7.1 The following is a summary of DG loads compared to the DG ratings and the margin available (See Section 4.5 for DG ratings and 5.9.1 for computed DG loading):

7.1.1 Load Computations (Load Carrying Capability)

Table 1 (DG Loading LOOP+LOCA)

Maximum Steady-State Running Load, 0 hrs to 2 hrs*

	1A-A	1B-B	2A-A	2B-B	Short-Time Rating	Minimum Margin (%)
kW Event/Time	4220.51 SIB 1810s	4115.78 SIB 1810s	4102.42 SIB 1810s	4237.2 SIB 1810s	4840	12.4
kVA Event/Time	4849.89 SIB 1810s	4766.23 SIB 1810s	4705.35 SIB 1810s	4876.69 SIB 1810s	6050	19.3

Maximum Steady-State Running Load, 2 hrs to End)**

	1A-A	1B-B	2A-A	2B-B	Continuous Rating	Minimum Margin (%)
kW Event/Time	4093.66 SIB 7200s	3698.03 SIB 7200s	3975.57 SIB 7200s	3813.70 SIB 7200s	4400	6.9
kVA Event/Time	4699.40 SIB 7200s	4298.0 SIB 7200s	4554.86 SIB 7200s	4402.71 SIB 7200s	5500	14.5

Table 2 (DG Loading LOOP Only)

Maximum Steady-State Running Load, 0 hrs to 2 hrs*

	1A-A	1B-B	2A-A	2B-B	Short-Time Rating	Minimum Margin (%)
kW Event/Time	3528.11 LOOP 1810s	3479.81 LOOP 1810s	3590.67 LOOP 1810s	3689.44 LOOP 1810s	4840	23.7
kVA Event/Time	3942.53 LOOP 1810s	4172.26 LOOP 1810s	3983.35 LOOP 1810s	4113.21 LOOP 1810s	6050	31.0

Maximum Steady-State Running Load, 2 hrs to End)**

	1A-A	1B-B	2A-A	2B-B	Continuous Rating	Minimum Margin (%)
kW Event/Time	3365.51 LOOP 7200s	3026.31 LOOP 7200s	3428.07 LOOP 7200s	3235.94 LOOP 7200s	4400	22.08
kVA Event/Time	3756.29 LOOP 7200s	3668.28 LOOP 7200s	3797.11 LOOP 7200s	3609.23 LOOP 7200s	5500	30.96

* Automatic load-sequencing only, no operator actions included.

** Includes all operator actions (load additions).

The blackout loading includes common accident loads including Emergency Gas Treatment System (EGTS), Control Room Emergency Ventilation System (CREVS), and Auxiliary Building Gas Treatment System (ABGTS).

7.1.2 Load Computations (Motor Starting Capability)

Table 1 (DG Loading LOOP+LOCA)

Maximum Transient Loading (Real Power), 0 to 180 sec

	1A-A	1B-B	2A-A	2B-B	Cold Engine Capability
kW Event/Time	4057.51 SIA 35s	3662.76 SIA 35s	3585.7 SIA 35s	4020.82 SIA 35s	4785

Maximum Transient Loading (Real Power), 180 sec to End

	1A-A	1B-B	2A-A	2B-B	Hot Engine Capability
kW Event/Time	4693.20 SIB 184s	4187.01 SIB 184s	4445.4 SIB 184s	4444.4 SIB 184s	5073

Maximum Step Load Increase (Apparent Power), 0 sec to End

	1A-A	1B-B	2A-A	2B-B	Generator Step Load Capability
kVA Event/Time	4111.29 SIB 0s	4397.35 SIB 0s	3885.44 SIB 0s	3944.21 SIB 0s	8000

Table 2 (DG Loading LOOP)

Maximum Transient Loading (Real Power), 0 to 180 sec

	1A-A	1B-B	2A-A	2B-B	Cold Engine Capability
kW Event/Time	3498.57 LOOP 90s	3307.81 LOOP 90s	3394.44 LOOP 90s	3793.81 LOOP 90s	4785

Maximum Transient Loading (Real Power), 180 sec to End

	1A-A	1B-B	2A-A	2B-B	Hot Engine Capability
kW Event/Time	3631.10 LOOP 360s	3481.50 LOOP 360s	3828.72 LOOP 360s	3530.73 LOOP 360s	5073

Maximum Step Load Increase (Apparent Power), 0 sec to End

	1A-A	1B-B	2A-A	2B-B	Generator Step Load Capability
kVA Event/Time	3721.35 LOOP 20s	3802.39 LOOP 20s	3795.94 LOOP 20s	3798.65 LOOP 20s	8000

The blackout loading includes common accident loads including Emergency Gas Treatment System (EGTS), Control Room Emergency Ventilation System (CREVS), and Auxiliary Building Gas Treatment System (ABGTS).

7.2 Effect of Frequency Variation on DG Loading

Maximum Steady-State Running Load, 2 hrs to End)
(See Section 5.10)

	1A-	1B-B	2A-A	2B-B	Continuous Rating	Minimum Margin (%)
Total KW at 60 Hz	4093.66	3698.03	3975.57	3813.70	4400	6.9
Total KW at 60.1 Hz	4114.13	3716.52	3995.45	3832.77	4400	6.4

8.0 CONCLUSIONS

Following conclusions have been drawn based on the DG loading analysis and the results in Section 7.0:

8.1 The calculated loading for the automatically sequenced loads plus the required manual action loading is within the DG ratings and motor starting capability for all DGs, all time periods, and all design basis events (LOOP, LOOP + SI Phase A, and LOOP + SI Phase B).

There is adequate margin and load diversity to allow manually applied loads (i.e. hydrogen mitigation system) to be started prior to or after 2 hours.

8.2 All DGs will maintain acceptable Voltage and Frequency throughout the load sequence for all time periods and all DBEs.

8.3 The loading on all DGs with the DG operating at 60.1 Hz is within the DG continuous rating specified in Section 4.5.

9.0 SPECIAL REQUIREMENTS/LIMITING CONDITIONS

None

Attachment 2

EDG Loading Tables depicting EDG loads with one unit in LOOP+LOCA and the second unit in LOOP

EDG Load Carrying Capability

Unit 1 in accident (LOOP+LOCA) and Unit 2 non-accident (LOOP only)

Table 1

Maximum Steady-State Running Load, 0 hrs to 2 hrs*

	1A-A	1B-B	2A-A	2B-B	Short-Time Rating
kW	4220.51	4115.78	3590.67	3689.44	4840
kVA	4849.89	4766.23	3983.35	4113.21	6050

Maximum Steady-State Running Load, 2 hrs to End)**

	1A-A	1B-B	2A-A	2B-B	Continuous Rating
kW	4093.66	3698.03	3428.07	3235.94	4400
kVA	4699.40	4298.0	3797.11	3609.23	5500

Unit 2 in accident (LOOP+LOCA) and Unit 1 non-accident (LOOP only)

Table 2

Maximum Steady-State Running Load, 0 hrs to 2 hrs*

	1A-A	1B-B	2A-A	2B-B	Short-Time Rating
kW	3528.11	3479.81	4102.42	4237.2	4840
kVA	3942.53	4172.26	4705.35	4876.69	6050

Maximum Steady-State Running Load, 2 hrs to End)**

	1A-A	1B-B	2A-A	2B-B	Continuous Rating
kW	3365.51	3026.31	3975.57	3813.70	4400
kVA	3756.29	3668.28	4554.86	4402.71	5500

* Automatic load-sequencing only, no operator actions included.

** Includes all operator actions (load additions).

EDG Motor Starting Capability

Unit 1 in accident (LOOP+LOCA) and Unit 2 non-accident (LOOP only)

Table 1

Maximum Transient Loading (Real Power), 0 to 180 sec

	1A-A	1B-B	2A-A	2B-B	Cold Engine Capability
kW	4057.51	3662.76	3394.44	3793.81	4785

Maximum Transient Loading (Real Power), 180 sec to End

	1A-A	1B-B	2A-A	2B-B	Hot Engine Capability
kW	4693.20	4187.01	3828.72	3530.73	5073

Maximum Step Load Increase (Apparent Power), 0 sec to End

	1A-A	1B-B	2A-A	2B-B	Generator Step Load Capability
kVA	4111.29	4397.35	3795.94	3798.65	8000

Unit 2 in accident (LOOP+LOCA) and Unit 1 non-accident (LOOP only)

Table 2

Maximum Transient Loading (Real Power), 0 to 180 sec

	1A-A	1B-B	2A-A	2B-B	Cold Engine Capability
kW	3498.57	3307.81	3585.7	4020.82	4785

Maximum Transient Loading (Real Power), 180 sec to End

	1A-A	1B-B	2A-A	2B-B	Hot Engine Capability
kW	3631.10	3481.50	4445.4	4444.4	5073

Maximum Step Load Increase (Apparent Power), 0 sec to End

	1A-A	1B-B	2A-A	2B-B	Generator Step Load Capability
kVA	3721.35	3802.39	3885.44	3944.21	8000

Attachment 3

EDG Motor Starting Capability

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DATE: July 15, 1994

COMPANY: TVA - Corp. Engineering

FAX NUMBER: 615/365-1504

ATTENTION: Mark D. Bowman

REFERENCE: EDG Motor Starting Capability

FROM: Donald D. Galeazzi

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PAGES (INCLUDING COVER SHEET): 4

Dear Mr. Bowman:

I have reviewed the DIESEL GENERATOR MAXIMUM KW CAPABILITY analysis for the Sequoyah and Watts Bar EDG's which you transmitted to me on 6/23/94. The analysis is acceptable and therefore derating of the EDG motor starting capability is not required for the specified 115°F engine intake air temperature.

Yours very truly,

MKW POWER SYSTEMS, INC.

Donald D. Galeazzi

Tennessee Valley Authority

DIESEL GENERATOR MAXIMUM KW CAPABILITY

Sequoyah Nuclear Plant (SQN)
Watts Bar Nuclear Plant (WBN)

The intent of this document is to establish the maximum KW capability of the SQN/WBN diesel generators (DG) for starting motors in incremental steps during a design basis load sequence. The SQN/WBN DGs (TVA Contracts 71C61-92652 and 74C63-83090) are powered by two EMD 16-645E4B diesel engines operating in tandem. The generators are manufactured by Electric Products and have a guaranteed efficiency of 96.6% at full rated load. The DG set ratings at 900 rpm, 90°F intake air, and elevations less than 10,000 feet are:

2000 hr/yr: 6640 (BHP-tandem) x 0.746 (KW/HP) x 0.966 = 4785 KW
30 min/yr: 7040 (BHP-tandem) x 0.746 (KW/HP) x 0.966 = 5073 KW

Each engine is equipped with a turbocharger which is driven by the engine gear train during the first three minutes of operation. After three minutes, the engine exhaust gas is sufficient to drive the turbocharger off the engine gear train by means of an over-riding clutch. Therefore, there are two levels of engine capability; one for a "cold" turbocharger and one for a "hot" turbocharger.

MK/PSD Report 6981-8B[1] establishes that the maximum KW capability of the "cold" engine for motor starting (in small steps such as during a load sequence) is the 2000 hour rating at 90°F. The maximum KW capability of the "hot" engine is the 30 minute rating at 90°F. MK/PSD Report 6981-8A[2] establishes that any derating of the engine capability for motor starting transients (short durations of approximately 2 to 5 seconds) is dependent solely on the density of the intake air charge. This density is affected by air temperature as well as elevation.

The baseline temperature/elevation for the EMD 16-645E4B engine ratings is 90°F @ 10,000 feet above sea level. Both SQN and WBN DG buildings are situated at less than 800 feet elevation with maximum intake air temperatures of less than 115°F. The U.S. Standard Atmosphere[3] yields a density ratio of 0.7385 @ 10,000 feet compared to sea level conditions. The density ratio at 800 feet is approximately 0.98. Thus, there is an increase in air density of about 33% at 800 feet versus 10,000 feet. The decrease in air density caused by an increase in temperature from 90°F to 115°F is approximately 4%. It is seen that the increase

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1 MK/PSD Report No. 6981-8B, 12-21-88, TVA Contract 88NJL-74472A, "Report Addressing and Resolving Attachment 1 and Attachment 2 of TVA No. 968398 (Including Review of Loading)"

2 MK/PSD Report No. 6981-8A, 12-21-88, TVA Contract 88NJL-74472A, "Establish the Rating of the Emergency Diesel Generator and Provide Deration Curves for Elevated Ambient Combustion Air Temperatures"

3 Mark's Standard Handbook for Mechanical Engineers, Copyright 1978, 1967, 1958 by McGraw-Hill, Inc., Table 11.4.1, "U.S. Standard Atmosphere"

in intake air density gained at SQN/WBN site elevation is considerably greater than any decrease caused by elevated intake air temperature. Therefore, no derating of the DG maximum KW capability is required.

Based on the above discussion, the SQN/WBN DG maximum KW capability for motor starting in the site service environment (intake air temperature less than 115°F and elevation less than 800 feet) is:

"Cold" Engine (first 3 minutes of load sequence):	<u>4785 KW</u>
"Hot" Engine (fully turbocharged):	<u>5073 kW</u>

Attachment 4

Excerpt from Unit 2 Submergence Evaluation

6.0 COMPUTATION AND ANALYSIS

This calculation uses the same methodology as discussed in Unit 1 calculation WBNEEBMSTI080009 (Ref. 3.8). Two major effects are identified in Section 8.5 of Technical Instruction EEB-TI-8 (Ref. 3.6) that increase power supply current due to submerged electrical equipment. One effect is leakage currents flowing through the water, and the other is additional mechanical drag imposed on rotating equipment. The control power circuits are primary concerned with leakage currents, and motor circuits are concerned with additional mechanical drag.

The electrical equipment (both safety and non-safety components) inside primary containment that receive power from Class 1E boards were compiled by power sources and are listed in Appendix F. Cables which will be submerged but the associated power components located above the maximum submergence level of 720' are not listed in Appendix F (Section 5.8). Schematics for each identified component were reviewed to determine if the circuit for the submerged component is energized during an accident. Equipment is considered to be operating when a contact that may short as a result of flooding can start the equipment. If the circuit could be energized, then the additional loading on the power supply due to submergence is determined based on the type of load. For example if a submerged motor starts or a running motor is submerged, loading based on its lock rotor current is considered. Similarly for static loads like heaters it is considered to draw current equivalent to its protective device rating i.e. breaker trip rating, fuse rating or maximum trip current of the thermal overload. The load on control circuits that do not start equipment but pickup a relay or a status indicating light is neglected since this load is negligible compared to the operating loads. The effect of all submerged loads on a power supply is determined and the total load (accident plus submerged load) compared with the protective device's ratings. The affect of increased loading due to submergence on available board/bus voltage of the AC and DC auxiliary power system has also been evaluated. The components located above elevation 720' and affected by borated containment spray are evaluated in Appendix E.

In some cases, the loads that were identified as being energized were eliminated from the submergence load by determining that the components were at elevation above the flood level of 720 ft. This determination was accomplished by reviewing connection/physical drawings. However, components located above the elevation level of 720' and affected by the borated containment spray are evaluated in Appendix E.

Based on a review of calculations EDQ00299920080018 (Ref. 3.4) and EDQ00299920080019 (Ref. 3.7) and applicable wiring and schematic drawings for the affected components upon flooding inside the containment, analysis for AC and DC power supply systems has been performed in the following appendices:

Appendix A	120V AC Class 1E Vital Instrument Power System
Appendix B	125V DC Class 1E Vital Power System
Appendix C	Miscellaneous type loads inside primary containment that are supplied power from Hydrogen Mitigation System Panels 2-DPL-268-1-A and 2-DPL-268-2-B
Appendix D	6.9kV/480V Auxiliary Power System
Appendix E	Effect of borated containment spray on all the additional equipment located above the submergence level elevation of 720'. The evaluation addresses both the effects of borated spray on the various types of electrical equipment installed within containment and the effects on the class 1E distribution system
Appendix F	Lists the electrical equipment (both safety and non- safety components) inside primary containment that receive power from Class 1E boards

7.0 SUPPORTING GRAPHICS

None

8.0 SUMMARY OF RESULTS

8.1 The maximum loading due to accident and submerged (non-safety) load on 120V AC Vital Instrument Boards 2-I, 2-II, 2-III and 2-IV (Ref. Appendix A – Tables 1 thru 5) is less than their associated inverter load limits of 14kVA for inverters 2-I & 2-II and 10.5kVA for 2-III & 2-IV (Appendix A of calc. WBNEEBMSTI120016; Ref. 3.1). Since the analysis in calc. EDQ00023620070003 (Ref. 2.2) considers the inverters to be loaded up to the load limit, there is no affect on the 125V DC system bus loading or the voltage due to submergence of loads.

The submerged loads on the 120V AC vital Class 1E power system do not cause the secondary protective devices to trip.

8.2 The maximum battery loading due to the accident and submerged load on 125V DC Vital Battery Boards III and IV is acceptable. Also the calculated battery terminal voltage with the increased loading is more than the minimum required voltage (Table 1 of Appendix B)

The submerged loads on the 125V DC vital Class 1E power system do not cause the secondary protective devices to trip.

8.3 The maximum loading due to accident and submerged (non-safety) load on 120V AC Hydrogen Mitigation System Panels is less than their associated breaker rating (Ref. Appendix C). There is no affect of submergence of heaters fed from this panel on the loading or the bus voltages in the auxiliary power system since load equal to full transformer rating is already included in the existing analysis in calc. EDQ00099920070002 (Ref. 2.3).

The submerged loads on these panels do not cause the secondary protective devices to trip.

8.4 The maximum loading due to accident and submerged (non-safety) load on 6.9kV and 480V boards is less than their associated transformer rating (Ref. Appendix D).

The submerged loads on the 480V Class 1E power system do not cause the secondary protective devices to trip. Locked rotor currents of the submerged loads plus the accident loads are well within the long time trip setting of the incoming breakers. The only equipment powered from 6.9kV Shutdown Boards located inside the containment is Pressurizer heaters which are tripped on LOCA. There is insignificant impact of additional loading due to submergence of components on the AC auxiliary power system voltages as discussed in Appendix D. Also there is no afect of submergence of heaters fed from heat trace panel on loading or the bus voltages on the auxiliary power system since load equal to full transformer rating is already included in the existing analysis in calc. EDQ00099920070002 (Ref. 3.3). | **R1**

8.5 The effects of borated containment spray on various types of electrical equipment located inside the containment and the Class 1E distribution system is discussed in Appendix E. This containment spray has no adverse impact on the continued operation of safety related buses.

9.0 CONCLUSIONS

The following conclusions are drawn based on the analysis in this calculation and the Section 8.0:

9.1 The additional loading on the 120V AC vital Class 1E power system due to submerged equipment does not cause any secondary protective devices to trip nor does it overload the power supplies (inverters). The maximum load on inverters due to additional submerged load is within their specified rating. It also has no impact on the existing 125V DC power system analysis.

9.2 The additional loading on the vital 125V DC Class 1E power system due to submerged equipment does not cause any secondary protective devices to trip nor does nor does it adversely affect the battery sizing. The available voltage at the battery terminals is more than the minimum required voltage.

9.3 The loading on the 120V AC Hydrogen Mitigation System Panels due to submerged equipment does not cause any secondary protective devices to trip nor does it overload the transformer. There is no impact on the bus loading or bus voltages in the existing AC auxiliary power system analysis.

9.4 The additional loading on the 6.9kV and 480V Class 1E power system due to submerged equipment does not cause any secondary protective devices to trip nor does it overload the power transformers. The effect of the non-safe shutdown submerged loads on the AC auxiliary power system is insignificant as explained in Appendix D.

The loading on the 120V AC Safety Injection Heat Trace Distribution Panel A1 (0-DPL-234-A1/SIS) due to submerged equipment does not cause any secondary protective devices to trip. There is a slight overloading of the transformer but it is considered insignificant (see Appendix C). There is no impact on the bus loading or bus voltages in the existing AC auxiliary power system analysis

9.5 There is no adverse impact on the Class 1E systems (480V, 125VDC, 120VAC) due to Borated Containment Spray on the shutdown and non safe shutdown components located inside the containment.

10.0 SPECIAL REQUIREMENTS / LIMITING CONDITIONS

None

11.0 APPENDICES

11.1 Appendix A - 120V AC Vital Class 1E Power System Load
Table 1 - 120V AC Vital Instrument Power Boards 2-I, 2-II, 2-III and 2-IV
Table 2 - 120V AC Vital Instrument Power Board 2-I (2-BD-235-1-D)
Table 3 - 120V AC Vital Instrument Power Board 2-II (2-BD-235-2-E)
Table 4 - 120V AC Vital Instrument Power Board 2-III (2-BD-235-3-F)
Table 5 - 120V AC Vital Instrument Power Board 2-IV (2-BD-235-4-G)

11.2 Appendix B - 125V DC Vital Class 1E Power System Load
Table 1 - 125V DC Vital Battery Boards III and IV
Table 2 - 125V DC Vital Battery Board III (1-BD-235-3-F)
Table 3- 125V DC Vital Battery Board IV (1-BD-235-4-G)

11.3 Appendix C - Hydrogen Mitigation System Panels 2-DPL-268-1-A and 2-DPL-268-2-B Load

11.4 Appendix D - AC Auxiliary Power System Evaluation (6.9kV & 480V Shutdown Boards, 480V RMOV Boards, 480V Reactor Vent Boards)
11.5 Appendix E - Borated Containment Spray Evaluation
11.6 Appendix F - Electrical Equipment List