ATTACHMENT 6

Calculation Change Notice 2007-0034 for DA-EE-92-098-01 "Diesel Generator A Steady State Loading Analysis"

ATTACHMENT 2, CALCULATION CHANGE NOTICE (CCN) COVERSHEET

A. INITIATION (Use separate form for each product change) Page 1 of 14

SITE (CHECK ONE): CCNPP: ☐ NMP: ☐ REG: ☒

CCN No.: 2007-0034 Revision No.: 0

Calculation ID: DA-EE-92-098-01 Revision No. 5

Title:

ENGINEERING DISCIPLINE: ☐ Civil ☐ Instr & Controls ☐ Nuclear
☒ Electrical ☐ Mechanical ☐ Other

Unit: ☒ 1 ☐ 2 ☐ COMMON

Safety Class ☒ SR ☐ AUGMENTED QUALITY ☐ AQ

B. DESCRIPTION OF CHANGES: SEE ATTACHED MARKUP. CHANGE WORST CASE LOADING BASED ON 60.8 HZ MAXIMUM

C. JUSTIFICATION: SURVEILLANCE PT-12.1 ALLOWS 60.5 HZ MAXIMUM
CR-2007-007128

D. AGGREGATE REVIEW:

Number of Open Change Notices against the Calculation: 0

Conclusion on Aggregate Impact: N/A

☐ YES ☒ NO Should the Calculation be revised to incorporate all AS BUILT CCNs? If Yes, initiate a Calculation to revise it. Tracking ID: _____ If No, provide Justification below:

Justification: CCN PROVIDES DESIGN BASIS

E. REVIEW AND APPROVAL:

Responsible Engineer: Theodore H. Miller Theodore H. Miller 11/2/07
(Printed Name and Signature) Date:

Is Design Verification Required? ☒ Yes ☐ No

If yes, Design Verification Form is JAS ☒ Attached ☒ Filed with: CCN 2007-0033

Independent Reviewer: Kelly Scott Kelly Scott James A. Jackson 11/2/07
(Printed Name and Signature) Date:

Approval: James A. Jackson James A Jackson 11/2/07
(Printed Name and Signature) Date:

Design Analysis

Diesel Generator A Steady State Loading Analysis

Ginna Station
CONSTELLATION ENERGY

DA-EE-92-098-01

Revision 5

8/7/07
Effective Date

Prepared By: _____ Design Engineer — 8/6/07 Date

Reviewed By: _____ Reviewer — 8/7/07 Date

- Modified the "injection phase" BHP associated with the Containment Fan based on the revised containment pressure – time profile (UFSAR Figure 6.2-4, Reference 4.4.9.4). In particular the containment fan BHP was decreased from 256 HP to 239.2 HP for the injection phase (Max containment pressure = 54 psig rather than 60 psig).
- Expanded the scope of the analysis to include an evaluation and document the effect of "off nominal" frequency operation (i.e. monthly test acceptance criteria range is 59.5 Hz to 60.5 Hz).
- Expand the scope of the analysis to include an evaluation and document the effect of "off nominal" voltage operation (i.e. monthly test acceptance criteria range is 470 – 504 volts).
- Expanded the scope of the analysis to include a comparison of the maximum kW demand on the EDG with the test requirements in the "Tech Spec" This comparison was made in order to verify that the maximum EDG demand is less than or equal to the minimum requirements set forth in the "Tech Spec" (i.e. "Verify each DG is synchronized and loaded and operates for > =60 minutes and < 120 minutes at a load >= 1950 kW and < 2250 kW.")
- Modified the ETAP computer model such that it runs on ETAP 5.5.0N. Also expanded the computer model to include the calculation of the continuous current duties imposed on the equipment for informational purposes only.

2.0 CONCLUSIONS

2.1 A Summary of the loadings as well as the percent safety margins is shown in the following table for each of the three accident scenarios:

Table 3 - EDGA Steady State Loading Summary

EDGA Steady State Loading Summary (Off Nominal Frequency and Voltage Considerations Included)				
	P (kW)	Q (kVAR)	S (kVA)	I amps RMS
EDG Load - Injection	1977	947	2192	2720
EDG Rating (2 hour)	2250	1500	2868	3450
Percent Margin Injection Phase	12.1%	36.9%	23.6%	21.2%
EDG Load - HHR	1807	839	1993	2472
EDG Rating - Continous	1950	1500	2500	3000
Percent Margin HHR	7.3%	44.1%	20.3%	17.6%
EDG Load LHR	1505	695	1658	2057
EDG Rating - Continous	1950	1500	2500	3000
Percent Margin LHR	22.8%	53.7%	33.7%	31.4%

Percent Margin=(Rating - Duty) / Rating *100

SEE ATTACHED TABLE

EDGA Steady State Loading Summary (Off Nominal Frequency and Voltage Considerations Included)				
	P (kW)	**Q (kVAR)**	**S (kVA)**	**I amps RMS**
EDG Load - Injection	2016	965	2235	2773
EDG Rating (2 hour)	2250	1500	2868	3450
Percent Margin Injection Phase	10.4%	35.7%	22.1%	19.6%
EDG Load - HHR	1843	855	2032	2521
EDG Rating - Continous	1950	1500	2500	3000
Percent Margin HHR	5.5%	43.0%	18.7%	16.0%
EDG Load _LHR	1535	709	1691	2098
EDG Rating - Continous	1950	1500	2500	3000
Percent Margin LHR	21.3%	52.7%	32.4%	30.1%

Percent Margin=(Rating - Duty) / Rating *100

2.2 As demonstrated in the table above, the most limiting case for the steady state loading on Emergency Diesel Generator A would be the injection phase. The injection phase loading is limiting from an absolute magnitude (kW and kVAR) point of view however from a "kW percent margin" point of view, the high head recirculation phase has less margin between the anticipated duty and the capability of the emergency diesel generator. The percent margin shown for the high head recirculation phase is associated with the time period two hours into a LOCA. As time progresses, the containment pressure will continue to decrease and the corresponding loading on the containment fans will decrease and therefore the percent margin will increase. The percent margin shown in the above table is ~~well~~ within the Regulatory Guide 1.9 requirement of "not less than 5 percent (margin)".

2.3 As demonstrated in Section 7.5.12, the maximum generator loading, during the injection phase with the generator at rated voltage and frequency, would be 1939 KW and 928 KVAR (0.90 pf). This loading is within the continuous rating of the diesel generator set (1950 KW and 1500 kVAR). It is also well within the emergency rating (2250 KW for 2 hour and 2300 KW for ½ hour). The injection phase duration, while variable, will be completed within two hours for a large break LOCA.

2.4 The impact of "off nominal" voltage and/or frequency operation has been evaluated in section 7.6 of this analysis. Operating the EDG at a frequency of ~~60.4 Hz~~ 60.8 would increase the BHP loading by ~~2.0%~~ 4.0%. Operating at a reduced frequency would reduce the BHP loading. Voltage variations in the range anticipated have been shown to have a very small impact on the kW or kVAR operating margins although the current (amps) margin was reduced a few percentage points. Section 7.6 demonstrates that by combining the worst case frequency ~~(60.4 Hz)~~ 60.8 and worst case voltage (465.3 volts) scenarios, the EDG loading increases to ~~1977 kW~~ 2016 kW (Injection Phase). The additional loading due to off-nominal voltage and frequency is already included in Table 3 above.

2.4.1 The "Tech Spec – SR 3.8.1.3" states: "Verify each DG is synchronized and loaded and operates for >= 60 minutes and < 120 minutes at a load >= 1950 kW and < 2250 kW." It is important that the minimum Tech Spec test limit (1950 kW) be greater than the maximum duty imposed on the EDG. After including the effect of "off nominal" voltage and frequency, this criteria is no longer met and a "Tech Spec Change" will be required (Reference CR-2006-004136).

2.4.2 The Main Control Board kW meters that are used during the "Tech Spec" test have a nominal accuracy of +/- 1% however the most recent calibration of these meters (Reference 4.1.7) shows an accuracy better than 0.1 kW in the 1950 kW – 2000 kW region of the meter. Therefore the negative margin between the maximum loading on the EDG and the minimum "Tech Spec" test limit is 27.1kW. A "Tech Spec Change" will be required because the total worst case loading (1977 kW) exceeds the minimum Tech Spec test limit (1950 kW). It is important to recognize that the two hour rating of the EDG is not exceeded, only the testing limit in the Tech Spec.

2.5 This analysis demonstrates that Emergency Diesel Generator A is adequately sized for the worst case steady state accident loading requirements. The following table summarizes the

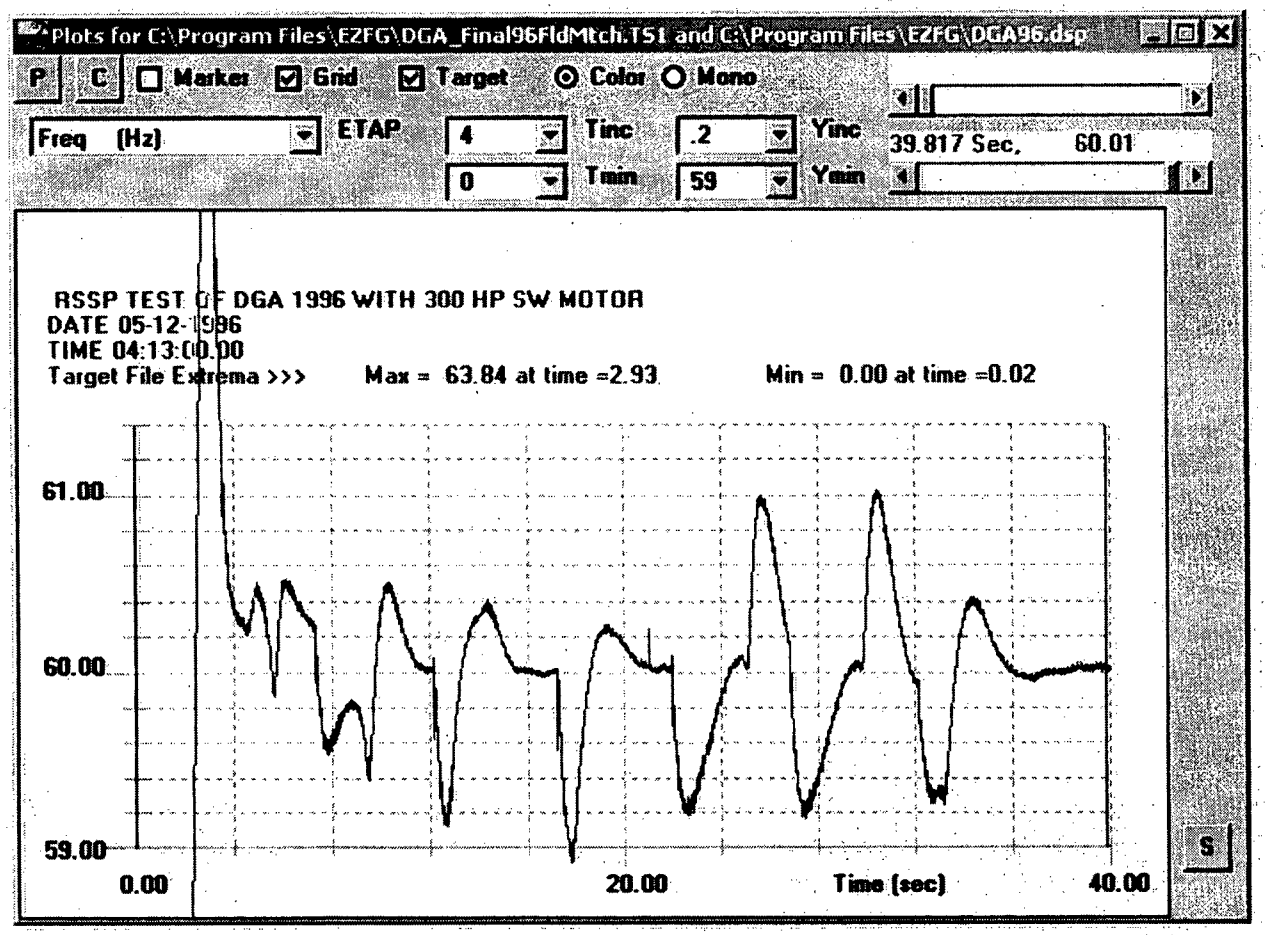

Figure 3 - EDGA Frequency (Hz) during 1996 RSSP2.2

The above figure demonstrates that the final frequency was 60.01 Hz which is within the setting acceptance criteria identified in PT-12.1 (60.0 to 60.1 Hz). As previously mentioned, the final kW load on the EDG during the above test was 1230 kW. While this loading is below the anticipated injection phase loading of 1939 kW, the above test does give a good indication of the EDGs frequency management capability during loaded conditions. The above curve also demonstrates that this capability is not diminished as more load is added during the sequence. The most recent RSSP2.2 test (10/11/06) recorded a steady state frequency of 60.1 Hz after the loads had been sequenced on. Based on the above results and discussions, it is concluded that a reasonable estimate of the EDGs frequency management capability during accident conditions, according to the MCB meter, would be a frequency range between 59.5 Hz and 60.1 Hz ~~(Note that the upper frequency limit was reduced from the 60.5 Hz value noted in PT12.1 based on the 1996 field measurements).~~ The accuracy of the meters on the main control board are +/- 0.3 Hz.so the actual steady state EDG frequency during accident conditions can be expected to be within the following range: Fmax = ~~60.4~~ 60.8 Hz. , F min = 59.2 Hz.

Insert

HOWEVER A FREQUENCY RANGE BETWEEN 59.5 HZ AND 60.5 HZ WILL BE USED.

The mechanical BHP loading of fans and pumps tend to go up as the cube of the speed and since the majority of the load on the EDG is this type of load, it is reasonable to assume that the kW load on the EDG would be 1.02 times greater at 60.4 Hz, as compared to the 60Hz kW loading value. 1.04 60.8

7.6.3 Determining maximum loading for off Nominal Voltage and Frequency

The effect of the stated voltage variations has been shown to be negligible and could therefore reasonably be ignored. Applying the 1.02 multiplying factor to all of the loads (small static loads as well as the motor loads) will tend to compensate for ignoring the small effect associated with voltage variations. Therefore the effect of both voltage variation and frequency variation can be incorporated into the results by simply multiplying each of the loads kW and kVAR values by 1.02. The power factor can be assumed to be unaffected by the small variations in voltage and/or frequency. The following tables summarize the individual loads that are expected if the diesel generator is operating at its worst case voltage and frequency (465.3 volts and 60.4 Hz) 60.8

Table 15 - Load Summary - Injection Phase 8 (when EDG is operating at 465.3 volts and 60.4 Hz)

Injection Phase Loading - Off Nominal Frequency and Voltage Considerations Included			
	Electrical Input to Load (ETAP Calculated)		
Load	P (kW)	Q (kVAR)	S (kVA)
Safety Injection Pump A	296.12	134.91	325.41
Safety Injection Pump C	296.12	134.91	325.41
Residual Heat Removal Pump A	122.94	56.37	135.25
Containment Fan A	196.75	89.76	216.26
Containment Fan D	196.75	89.76	216.26
Service Water Pump A (Spare)	261.22	124.37	289.31
Service Water Pump C	0.00	0.00	0.00
Auxiliary Feedwater Pump A	225.76	96.17	245.39
Containment Spray Pump A	187.68	89.41	207.89
Component Cooling Water Pump A	0.00	0.00	0.00
MCC Loading (total)	143.84	84.59	166.87
EDG Excit &Crankcase Exhaust Motor	16.29	1.03	16.32
Cable Loss (ETAP Calculated)	33.91	45.35	56.63
Total Load Supplied by EDG (Sum)	1977.39	946.64	2192.31
EDG Rating (2 hour)	**2250.00**	**1500.00**	**2868.00**
Percent Margin=(Rating - Duty) / Rating *100	**12.12%**	**36.89%**	**23.56%**

SEE ATTACHED TABLE

Injection Phase Loading - Off Nominal Frequency and Voltage Considerations Included			
	Electrical Input to Load (ETAP Calculated)		
Load	**P (kW)**	**Q (kVAR)**	**S (kVA)**
Safety Injection Pump A	301.93	137.55	331.79
Safety Injection Pump C	301.93	137.55	331.79
Residual Heat Removal Pump A	125.35	57.48	137.90
Containment Fan A	200.61	91.52	220.50
Containment Fan D	200.61	91.52	220.50
Service Water Pump A (Spare)	266.34	126.81	294.99
Service Water Pump C	0.00	0.00	0.00
Auxiliary Feedwater Pump A	230.18	98.06	250.20
Containment Spray Pump A	191.36	91.17	211.97
Component Cooling Water Pump A	0.00	0.00	0.00
MCC Loading (total)	146.66	86.25	170.14
EDG Excit &Crankcase Exhaust Motor	16.61	1.05	16.64
Cable Loss (ETAP Calculated)	34.58	46.24	57.74
Total Load Supplied by EDG (Sum)	2016.16	965.20	2235.29
EDG Rating (2 hour)	**2250.00**	**1500.00**	**2868.00**
Percent Margin=(Rating - Duty) / Rating *100	**10.39%**	**35.65%**	**22.06%**

Table 16 - Load Summary - High Head Recirculation Phase (when EDG is operating at 465.3 volts and 60.8 Hz.)

High Head Recirculation Loading - Off Nominal Frequency and Voltage Considerations Included			
	Electrical Input to Load		
Load	P (kW)	Q (kVAR)	S (kVA)
Safety Injection Pump A	0.00	0.00	0.00
Safety Injection Pump C	296.12	134.91	325.41
Residual Heat Removal Pump A	142.62	65.39	156.89
Containment Fan A	142.78	69.65	158.86
Containment Fan D	142.78	69.65	158.86
Service Water Pump A (Spare)	261.22	124.37	289.31
Service Water Pump C	262.10	104.41	282.14
Auxiliary Feedwater Pump A	226.76	96.17	245.39
Containment Spray Pump A	0.00	0.00	0.00
Component Cooling Water Pump A	124.30	58.43	137.34
MCC Loading (total)	170.43	84.66	190.30
EDG Excit &Crankcase Exhaust Motor	16.29	1.03	16.32
Cable Loss (ETAP Calculated)	23.08	29.85	37.74
Total Load Supplied by EDG (Sum)	1807.47	838.53	1992.50
EDG Rating (2 hour)	**1950.00**	**1500.00**	**2500.00**
Percent Margin=(Rating - Duty) / Rating *100	**7.31%**	**44.10%**	**20.30%**

SEE ATTACHED TABLE

High Head Recirculation Loading - Off Nominal Frequency and Voltage Considerations Included			
	Electrical Input to Load		
Load	**P (kW)**	**Q (kVAR)**	**S (kVA)**
Safety Injection Pump A	0.00	0.00	0.00
Safety Injection Pump C	301.93	137.55	331.79
Residual Heat Removal Pump A	145.41	66.67	159.97
Containment Fan A	145.57	71.02	161.97
Containment Fan D	145.57	71.02	161.97
Service Water Pump A (Spare)	266.34	126.81	294.99
Service Water Pump C	267.24	106.46	287.67
Auxiliary Feedwater Pump A	230.18	98.06	250.20
Containment Spray Pump A	0.00	0.00	0.00
Component Cooling Water Pump A	126.73	59.57	140.04
MCC Loading (total)	173.77	86.32	194.03
EDG Excit &Crankcase Exhaust Motor	16.61	1.05	16.64
Cable Loss (ETAP Calculated)	23.54	30.44	38.48
Total Load Supplied by EDG (Sum)	1842.91	854.97	2031.57
EDG Rating (Cont.)	**1950.00**	**1500.00**	**2500.00**
Percent Margin=(Rating - Duty) / Rating *100	**5.49%**	**43.00%**	**18.74%**

Table 17 - Load Summary - Low Head Recirculation Phase (when EDG is operating at 465.3 volts and 60.4 Hz)

Low Head Recirculation Loading - Off Nominal Frequency and Voltage Considerations Included			
	Electrical Input to Load		
Load	P (kW)	Q (kVAR)	S (kVA)
Safety Injection Pump A	0.00	0.00	0.00
Safety Injection Pump C	0.00	0.00	0.00
Residual Heat Removal Pump A	142.62	65.39	156.89
Containment Fan A	142.78	69.65	158.86
Containment Fan D	142.78	69.65	158.86
Service Water Pump A (Spare)	261.22	124.37	289.31
Service Water Pump C	262.10	104.41	282.14
Auxiliary Feedwater Pump A	225.76	96.17	245.39
Containment Spray Pump A	0.00	0.00	0.00
Component Cooling Water Pump A	124.30	58.43	137.34
MCC Loading (total)	170.70	84.71	190.57
EDG Excit &Crankcase Exhaust Motor	16.29	1.03	16.32
Cable Loss (ETAP Calculated)	16.74	21.26	27.05
Total Load Supplied by EDG (Sum)	1505.27	695.07	1658.00
EDG Rating (2 hour)	**1950.00**	**1500.00**	**2500.00**
Percent Margin=(Rating - Duty) / Rating *100	**22.81%**	**53.66%**	**33.68%**

SEE ATTACHED TABLE

8.0 Results

8.1 The most limiting case for the steady state kW loading on Emergency Diesel Generator A would be the injection phase during a large break LOCA event. Frequency and voltage deviations, from nominal, can increase the EDG loading with the worst case being high frequency and low voltage. The following table demonstrates that under worst case conditions, the injection phase loading on the EDGA will slightly exceed the continuous rating of the EDG. The table also compares the injection phase loading duty with the 2 hour capability of the EDG since the injection phase will be complete within 2 hours.

Table 18 - EDGA Loading and % Margin - Worst Case

Worst Case EDGA Loading - Injection Phase, Off nominal Voltage and Freq						
	Freq (Hz)	EDG Voltage (Volts)	P (kW)	Q (kVAR)	S (kVA)	I amps RMS
EDG Load	60.4	465.30	1977	947	2192	2720
EDG Rating - Continous			1950	1500	2500	3000
% Margin (Continuous Rating)			-1.4%	36.9%	12.3%	9.3%
EDG Rating - 2 Hour			2250	1500	2868	3450
% Margin (2 hour Rating)			12.1%	36.9%	23.6%	21.2%

Percent Margin=(Rating - Duty) / Rating *100

SEE ATTACHED TABLE

Low Head Recirculation Loading - Off Nominal Frequency and Voltage Considerations Included			
	Electrical Input to Load		
Load	**P (kW)**	**Q (kVAR)**	**S (kVA)**
Safety Injection Pump A	0.00	0.00	0.00
Safety Injection Pump C	0.00	0.00	0.00
Residual Heat Removal Pump A	145.41	66.67	159.97
Containment Fan A	145.57	71.02	161.97
Containment Fan D	145.57	71.02	161.97
Service Water Pump A (Spare)	266.34	126.81	294.99
Service Water Pump C	267.24	106.46	287.67
Auxiliary Feedwater Pump A	230.18	98.06	250.20
Containment Spray Pump A	0.00	0.00	0.00
Component Cooling Water Pump A	126.73	59.57	140.04
MCC Loading (total)	174.05	86.37	194.30
EDG Excit &Crankcase Exhaust Motor	16.61	1.05	16.64
Cable Loss (ETAP Calculated)	17.06	21.67	27.58
Total Load Supplied by EDG (Sum)	1534.78	708.70	1690.51
EDG Rating (Cont.)	**1950.00**	**1500.00**	**2500.00**
Percent Margin=(Rating - Duty) / Rating *100	**21.29%**	**52.75%**	**32.38%**

Worst Case EDGA Loading - Injection Phase, Off nominal Voltage and Freq						
	Freq (Hz)	EDG Voltage (Volts)	P (kW)	Q (kVAR)	S (kVA)	I amps RMS
EDG Load	60.8	465.30	2016	965	2235	2774
EDG Rating - Continous			1950	1500	2500	3000
% Margin (Continuous Rating)			-3.4%	35.7%	10.6%	7.5%
EDG Rating - 2 Hour			2250	1500	2868	3450
% Margin (2 hour Rating)			10.4%	35.7%	22.1%	19.6%

Percent Margin=(Rating - Duty) / Rating *100

8.1.1 Even though the worst case kW loading (~~1977~~ 2016 kW) ~~slightly~~ exceeds the continuous rating of the EDG (1950 kW), this is not a violation of the actual EDG capability or rating since it does not exceed the two hour rating (2250 kW) and the injection phase will be completed within two hours.

8.1.2 The worst case loading (~~1977~~ 2016 kW) ~~does however~~ slightly exceeds the minimum "Tech Spec" test limit (1950 kW) and therefore a "Tech Spec" change will be required.

8.2 The results of this analysis (see Table 3) indicate that there is significant margin between the loading duty that will be imposed on EDGA during accident conditions and the inherent capability of the diesel generator set. It is felt that the overall effect of any data uncertainties (motor characteristics, actual flows, pump characteristics, etc.) would be relatively small; recognizing that some of data uncertainties would increase EDG loading while others would decrease the loading.

8.3 The following is a list of conservatisms, inherent in this calculation, that provide additional margin from what has been tabulated above:

1. The service water pump was assumed to be operating at 326 BHP even though the maximum value on the pump curve was 312 BHP.
2. The worst case injection phase loading (~~1977 kW~~ 2016 kW) was determined by assuming that both the voltage and frequency deviations from nominal were in the direction to maximize the kW loading. In addition, the associated meters (V and Hz) were also assumed to have errors in a direction that maximized the kW loading. It is unlikely that these four independent issues would simultaneously hit their worst case positions.

8.4 This analysis demonstrates Diesel Generator A is adequately sized for the worst case steady state accident loading requirements.