RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

APR1400 Design Certification

Korea Electric Power Corporation / Korea Hydro & Nuclear Power Co., LTD

Docket No. 52-046

RAI No.:	**95-8080**
SRP Section:	**08.03.01 – AC Power Systems (Onsite)**
Application Section:	**8.3.1**
Date of RAI Issue:	**07/22/2015**

Question No. 08.03.01-8

GDC 17 requires that “the onsite electric power supplies, including the batteries, and the onsite electric distribution system, shall have sufficient independence, redundancy, and testability to perform their safety functions assuming a single failure.”

DCD Tier 2, Section 8.3.1.1.2.2 states that “The Class 1E onsite ac power system consists of two redundant load groups (division I and division II), with four independent trains (A, B, C, and D), as shown in Figure 8.3.1-1. One of the two divisions (trains A and C or trains B and D), including associated Class 1E EDGs and electrical distribution systems, is required to supply the loads for safe shutdown during a LOCA concurrent with a LOOP.” It further states that “The four independent Class 1E buses of the onsite power system and the connection between the onsite and offsite power systems are provided with physical separation and electrical isolation.”

Please explain how the four Class 1E buses (trains) are functionally independent. It is noted that loading of safety buses, train A and C and train B and D, are not identical. Explain how these are not identical, and clarify if the minor variation of loading for four DGs is evaluated as acceptable for shutdown of the plant, when a divisional pair is considered for safety function/safe shut-down. Under the worst case scenario, if an EDG of the Division II is under maintenance/out of service, explain how the single failure (1 EDG fail to start) in Division I can perform the required safety functions or bring the plant to a safe shutdown.

In Section 8.3.1.1.1, it is noted that a non-Class 1E gas turbine generator AAC source (Alternate alternating current) is connected to Class 1E safety bus 1A of Division I (one train of one division), and Safety bus 1B (one train of other division) of Division 2. Explain why the AAC source is not connected to safety buses 1C of Division I and 1D of Division II.

DCD Tier 2, Section 8.3.1.1.2.3 states that “The onsite power system is designed with the physical and electrical independence from an offsite power system so that single failure does not prevent separation of the redundant portions of the onsite power system from the offsite power system.” Please explain what is meant by redundant portions of the onsite power system.

Response

The following provides answers to each of the staff's requests:

Functional independence of the Class 1E buses (trains)

The four electrical trains (A, B, C, and D) of the Class 1E onsite power system are functionally independent from the following perspectives:

- Each Class 1E train is made up of dedicated systems and components to the particular train, including ac and dc power distribution systems and a Class 1E emergency diesel generator (EDG).
- Each train has its own control and protection schemes and there is no physical or functional interfaces with the other trains (no signal exchanges or interlocks).
- For each Class 1E EDG, a dedicated and functionally independent load sequencer and control scheme are provided. In the event of an accident condition which requires EDG operation, (e.g., LOOP, SIAS, CSAS or AFAS), a start of each Class 1E EDG is initiated irrespective of the conditions of the other trains.

Difference in the loading of safety buses, train A and C and train B and D

According to the updated EDG load information, the 4.16 kV load data of train A and C safety buses are identical to those of train B and D safety buses. DCD Tier 2, Table 8.3.1-2 and Table 8.3.1-3 will be updated to reflect the identical loading as shown in the attachment.

For the 480 V loads, the difference between division I (train A and train C) and division II (train B and train D) is minimal, only 21.6 kW. This difference is mainly due to different design conditions for the train A and train B HVAC system. For example, train A and B battery room electric duct heaters are powered by their respective Class 1E 480 V load centers and are 77 kW and 109 kW respectively. The capacity difference is owing to the location of the rooms. The train A and B battery room electric duct heaters maintain the required design temperature of the battery room and the DC & IP equipment room of each train. The battery room and the DC & IP equipment room of train A are located at the inner side of the auxiliary building, while those same rooms of train B are located at the outermost area of the auxiliary building; thus, the rooms are affected considerably by the outdoor temperature. Such an ambient temperature gradient has a design impact on the electric duct heater size and capacity. Consequently, the train B electric duct heater requires a higher capacity than the train A.

Based on the above, it can be concluded that the minor variation in loading for the four EDGs is insignificant and is only due to different local environmental design conditions of the train A and train B HVAC systems. There is no meaningful difference in safe shutdown loads between the redundant divisions.

Maintenance/out of service of an EDG in Division II concurrent with a single failure of an EDG in Division I

Redundant divisions of the Class 1E power system, trains A and C for division I and trains B and D for division II, are provided to meet the single failure criterion. Because of the high risk profile

of the emergency power system, availability of the EDGs is maximized by avoiding on-line maintenance or being taken out-of-service during normal operating conditions.

If an EDG becomes unavailable in one division, the plant does not fulfill the limiting condition for operation (LCO) 3.8.1 and the inoperable EDG needs to be restored within 72 hours in accordance with the Technical Specification (TS) 3.8.1 (Action B.4). If restoration of the EDG is not completed within the completion time (72 hours), the plant will proceed to the shutdown condition (Action G.1). This LCO completion time is a temporary relaxation of the single failure criterion, which is consistent with overall system reliability considerations and provides a limited time to fix equipment or otherwise make it operable. Therefore, consideration of a second or multiple failures is beyond the design basis of the APR1400.

Should a LOCA with a loss of offsite power (LOOP) occur during the LCO completion time (72 hours), the plant would have sufficient emergency power with two available EDGs (combination of train A and train C or train B and train D) to mitigate the accident and safely shutdown the plant.

In a LOOP condition, the plant can transition to a safe shutdown condition on a minimum of one EDG, as long as the one available EDG is either train A or train B based on the loads listed in DCD Tier2, Table 8.3.1-2. Though in some configurations the plant maintains the capability of mitigating a DBA (e.g., LOCA) under a LOOP condition and failure of two EDGs (such as train A and train C or train B and train D), it is considered to be a beyond design basis condition.

If both train A and train B EDGs are not available with a LOOP, the alternate alternating current (AAC) source would be connected to train A or train B in order to enable a controlled cooldown of the plant to a safe shutdown condition.

Explain why the AAC source is not connected to safety buses 1C of Division I and 1D of Division II.

As described in DCD Tier 2 Section 8.3.1.1.2, only the Class 1E safety bus 1A of Division I and Class 1E safety bus 1B of Division II are designated as the dedicated Class 1E 4.16 kV switchgears for safe shutdown during a LOOP or an SBO.

For instance, the following loads, that are required to bring and maintain the plant to the safe shutdown condition, are only connected to the Class 1E safety bus 1A and 1B: the shutdown cooling pumps, the auxiliary charging pump, and the spent fuel pool pumps.

Based on this, only the Class 1E safety bus 1A of Division I and Class 1E safety bus 1B of Division II have connection provision to the AAC GTG, which will be connected to and supply one of the safety buses as appropriate during an SBO.

What is meant by redundant portions of the onsite power system

The term “redundant portions” was in reference to the redundant divisions of the onsite power system. The concept of the redundant divisions of the onsite power system is described in DCD Tier 2, Subsection 8.1.2.

Impact on DCD

DCD Tier 2, Table 8.3.1-2 and 8.3.1-3 will be revised as shown in the Attachment.

Impact on PRA

There is no impact on the PRA.

Impact on Technical Specifications

There is no impact on the Technical Specifications.

Impact on Technical/Topical/Environmental Reports

There is no impact on any Technical, Topical, or Environmental Report.

Table 8.3.1-2 (1 of 5)

Cooling Tower Fan 1A	4,160	750 (bhp)		0.9	621.7	621.7	621.7	10

add

Train A

Equipment	Volts	Component Estimated (bhp/kW/ kVA)(1)	Power Factor	Motor Efficiency	Equivalent Load (kW)	LOOP Load (kW)	DBA Concurrent with a LOOP Load (kW)	Load Sequence Time (Seconds)(2)
Medium Voltage								
Safety Injection Pump 1	4,160	898.5 (bhp)		0.9	744.8		744.8	5
Shutdown Cooling Pump 1	4,160	940 (bhp)		0.9	779.2		779.2	~~10~~ 23
shift Motor-driven Auxiliary Feedwater Pump A	4,160	1,151 (bhp)		0.9	954.1	954.1	954.1	15
Component Cooling Water Pump 1A	4,160	2,000 (bhp)		0.9	1657.8	1657.8	1657.8	~~20~~ 28
Essential Service Water Pump 1A	4,160	1,021 (bhp)		0.9	846.3	846.3	846.3	~~25~~ 33
Essential Chiller 1A	4,160	930 (bhp)		0.9	~~770.9~~	~~770.9~~	~~770.9~~ 760.9	~~30~~ 38
Subtotal, Loading for Load Sequence of Medium Voltage						~~4,229.1~~ 4,840.8	~~5,753.1~~ 6,364.8	
Load Sequence Group A(3), (4) – Low Voltage								
480V LC – CH A Battery Charger	480	125 kVA	~~0.85~~ 0.9		~~106.3~~	~~106.3~~	~~106.3~~ 112.5	
480V LC – EDG Room Elec. Heating Coil 11A	480	211 kW	1.0		211	211	211	
480V LC – Control Room Elec. Heating Coil 01A	480	225 kW	1.0		225	225	225	
480V LC – Control Room HV01A Fan Supply AHU	480	104 (bhp)		0.9	86.2	86.2	86.2	
480V LC – Battery Room Elec. Duct Heater	480	77 kW	1.0		77	77	77	
480V LC – Aux. Charging Pump	460	100 (bhp)		0.9	~~83~~	~~83~~	~~83~~ 82.9	
480V LC – Essential Chilled Water Pump 01A	460	81.3 (bhp)		0.9	67.4	67.4	67.4	
480V LC – CCW HX EDH A	460	180 kW	1.0		180	180	180	

Table 8.3.1-2 (2 of 5)

Train A

Equipment	Volts	Component Estimated (bhp/kW /kVA)(1)	Power Factor	Motor Efficiency	Equivalent Load (kW)	LOOP Load (kW)	DBA Concurrent with a LOOP Load (kW)	Load Sequence Time (Seconds)(2)
Load Sequence Group A(3), (4) – Low Voltage								
480V LC – Cooling Tower Makeup Pump ~~A~~ 3A	460	139.8		0.9	~~116~~	~~116~~	~~116~~ 115.9	
480V MCC Loads(4)	480	522.2 kW	1.0	1.0	522.2	522.2	522.2	
Subtotal, Loading for Load Sequence Group B						~~1674.1~~	~~1674.1~~	0
Manual Load Group(5)								1,680.1
480V LC – Pressurizer Heaters Back-up Group B1	480	300 kW	1.0		300	300	300	
480V LC – Spent Fuel Pool Cooling Pump	480	93.4 (bhp)		0.9	77.4	77.4	77.4	
Subtotal, Loading for Manual Load						377.4	377.4	
EDG Loads of Train A								
Total Diesel Load on LOOP excluding Manual Load						~~5,903.2~~	6,520.9	
Total Diesel Load on LOOP including Manual Load						~~6,280.6~~	6,898.3	
Total Diesel Load on DBA/LOOP excluding Manual Load							~~7,427.2~~	8,044.9
Total Diesel Load on DBA/LOOP including Manual Load							~~7,804.3~~	8,422.3

Cooling Tower Fan 2A	4,160	750 (bhp)		0.9	621.7	621.7	621.7	15

add

Train C

Equipment	Volts	Component Estimated (bhp/kW /kVA)(1)	Power Factor	Motor Efficiency	Equivalent Load (kW)	LOOP Load (kW)	DBA Concurrent with a LOOP Load (kW)	Load Sequence Time (Seconds)(2)
Medium Voltage								10
Safety Injection Pump 3	4,160	898.5 (bhp)		0.9	744.8		744.8	~~5~~
Containment Spray Pump 1	4,160	920 (bhp)		0.9	762.6		762.6	~~10~~ 23
Component Cooling Water Pump 2A	4,160	2,000 (bhp)		0.9	1,657.8	1,657.8	1,657.8	~~15~~ 28
Essential Service Water Pump 2A	4,160	1,021 (bhp)		0.9	846.3	846.3	846.3	~~20~~ 33
Essential Chiller 2A	4,160	930 (bhp)		0.9	~~770.9~~ 760.9	~~770.9~~ 760.9	~~770.9~~ 760.9	~~25~~ 38
Subtotal, Loading for Load Sequence of Medium Voltage						~~3,275.0~~ 3,886.7	~~4,782.4~~ 5,394.1	
Load Sequence Group C(3), (4) – Low Voltage								
480V LC – CH C Battery Charger	480	~~240~~ 210	~~0.85~~ 0.9		~~204~~ 189	~~204~~ 189	~~204~~ 189	
480V LC – EDG Room Elec. Heating Coil 11C	480	240 kW	1.0		240	240	240	
480V LC – Control Room HV01C Fan	460	104 (bhp)		0.9	86.2	86.2	86.2	
480V LC – Control Room Elec. Heating Coil 01A	480	225 kW	1.0		225	225	225	
480V LC – Essential Chilled Water Pump 02A	460	81.3 (bhp)		0.9	67.4	67.4	67.4	

Supply AHU

add

480V LC - Battery Room Elec. Duct Heater	480	74 kW	1.0		74	74	74	

Table 8.3.1-2 (4 of 5)

Train C

Equipment	Volts	Component Estimated (bhp/kW/ kVA)(1)	PF	Motor Efficiency	Equivalent Load (kW)	LOOP Load (kW)	DBA Concurrent with a LOOP Load (kW)	Load Sequence Time (Seconds) (2)
Load Sequence Group C(3), (4) – Low Voltage								
480V LC – Cooling Tower Makeup Pump C	460	139.8		0.9	~~116~~	~~116~~	~~116~~ 115.9	
480V MCC (4EA) Loads (4)	480	375.7 kW	1.0	1.0	375.7	375.7	375.7	
Subtotal, Loading for Load Sequence Group C						~~1,314.3~~	~~1,314.3~~ 1,373.2	0
Manual Load Group(5)								
Subtotal, Loading for Manual Load						0	0	
EDG Loads of Train C								
Total Diesel Load on LOOP excluding Manual Load						~~4,589.3~~	5,259.9	
Total Diesel Load on LOOP including Manual Load						~~4,589.3~~		6,767.3
Total Diesel Load on DBA/LOOP excluding Manual Load							~~6,096.7~~	
Total Diesel Load on DBA/LOOP including Manual Load							~~6,096.7~~	

4A

Table 8.3.1-2 (5 of 5)

(1) Conversion into equivalent kilowatts for rated horsepower involves multiplying rated horsepower by the conversion factor 0.746 kW/hp. When unit of brake horsepower (bhp) is assumed, a motor efficiency of 0.9 is used in addition to this conversion factor to calculate equivalent load. Unless designated as bhp, all horsepower is rated.

(2) The following components and times apply to accident scenarios coincident with a LOOP.

Train A Sequencer	
480V load center load group A	0.0 second
Safety injection pump 1	5.0 seconds
Shutdown cooling pump 1	~~10.0~~ seconds
Motor-driven AFW pump A (if required)	15.0 seconds
Component cooling water pump 1A	~~20.0~~ seconds
Essential service water pump 1A	~~25.0~~ seconds
Essential chiller 1A	~~30.0~~ seconds
Train C Sequencer	
480V load center load group C	0.0 second
Safety injection pump 3	~~5.0~~ seconds
Containment spray pump 1	~~10.0~~ seconds
Component cooling water pump 2A	~~15.0~~ seconds
Essential service water pump 2A	~~20.0~~ seconds
Essential chiller 2A	~~25.0~~ seconds

add Cooling Tower Fan 1A 10.0 seconds

23.0

shift

28.0
33.0
38.0

add Cooling Tower Fan 1C 15.0 seconds

10.0

23.0
28.0
33.0
38.0

(3) The 480V loads are energized immediately upon closure of the EDG incoming breaker.

(4) Although motor-operated valves (MOVs) are connected to the Class 1E MCC buses, they are considered to be zero for purpose of EDG sizing due to their intermittent and short operating time.

480V HVAC loads were classified into summer season loads and winter season loads, and the worst-case loads of winter season were allocated in the 480V MCC loads for EDG sizing.

(5) Manual loads are added to the Class 1E buses by operator in case plant conditions require their usage.

Table 8.3.1-3 (1 of 5)

Cooling Tower Fan 1B	4,160	750 (bhp)		0.9	621.7	621.7	621.7	10

Train B

Equipment	Volts	Component Estimated (bhp/kW /kVA)(1)	Power Factor	Motor Efficiency	Equivalent Load (kW)	LOOP Load (kW)	DBA Concurrent with a LOOP Load (kW)	Load Sequence Time (Seconds)(2)
Medium Voltage								
Safety Injection Pump 2	4,160	898.5 (bhp)		0.9	744.8		744.8	5
Shutdown Cooling Pump 2	4,160	940 (bhp)		0.9	779.2		779.2	~~10~~ 23
Motor-driven Auxiliary Feedwater Pump B	4,160	1,151 (bhp)		0.9	954.1	954.1	954.1	15
Component Cooling Water Pump 1B	4,160	2,000 (bhp)		0.9	1,657.8	1,657.8	1,657.8	~~20~~ 28
Essential Service Water Pump 1B	4,160	1,021 (bhp)		0.9	846.3	846.3	846.3	~~25~~ 33
Essential Chiller 1B	4,160	930 (bhp)		0.9	~~770.9~~ 760.9	~~770.9~~ 760.9	~~770.9~~ 760.9	~~30~~ 38
Subtotal, Loading for Load Sequence of Medium Voltage						~~4,229.1~~ 4,840.8	~~5,753.1~~ 6,364.8	
Load Sequence Group B(3), (4) – Low Voltage								
480V LC CH B Battery Charger	480	125 kVA	~~0.85~~ 0.9		~~106.3~~ 112.5	~~106.3~~ 112.5	~~106.3~~ 112.5	
480V LC – EDG Room Elec. Heating Coil 11B	480	211 kW	1.0		211	211	211	
480V LC – Control Room Elec. Heating Coil 01B	480	225 kW	1.0		225	225	225	
480V LC – Control Room HV01B Fan	480	104 (bhp)		0.9	86.2	86.2	86.2	
480V LC – Battery Room Elec. Duct Heater	480	109 kW	1.0		109	109	109	
480V LC – Aux. Charging Pump	460	100 (bhp)		0.9	~~83~~ 82.9	~~83~~ 82.9	~~83~~ 82.9	
480V LC – Essential Chilled Water Pump 01B	460	81.3 (bhp)		0.9	67.4	67.4	67.4	

add

shift

Supply AHU

Table 8.3.1-3 (2 of 5)

Train B

Equipment	Volts	Component Estimated (bhp/kW /kVA)(1)	Power Factor	Motor Efficiency	Equivalent Load (kW)	LOOP Load (kW)	DBA Concurrent with a LOOP Load (kW)	Load Sequence Time (Seconds)(2)
Load Sequence Group B(3), (4) – Low Voltage								
480V LC – CCW HX EDH B	480	180 kW	1.0		180	180	180	
480V LC – Cooling Tower Makeup Pump B	460	139.8		0.9	~~116~~	~~116~~	~~116~~	
480V MCC Loads(4)	480	511.9 kW	1.0	1.0	511.9	511.9	511.9	
Subtotal, Loading for Load Sequence Group B						~~1,695.8~~	~~1,695.8~~	0
Manual Load Group(5)								
480V LC – Pressurizer Heaters Backup Group B2	480	300 kW	1.0		300	300	300	
480V LC – Spent Fuel Pool Cooling Pump B	480	93.4		0.9	77.4	77.4	77.4	
Subtotal, Loading for Manual Load						377.4	377.4	
EDG Loads of Train B								
Total Diesel Load on LOOP excluding Manual Load						~~5,924.9~~		
Total Diesel Load on LOOP including Manual Load						~~6,302.3~~		
Total Diesel Load on DBA/LOOP excluding Manual Load							~~7,448.9~~	
Total Diesel Load on DBA/LOOP including Manual Load							~~7,826.3~~	

3B

115.9

1,701.8

6,542.6

6,920.0

8,066.6

8,444.0

Cooling Tower Fan 2B	4,160	750 (bhp)		0.9	621.7	621.7	621.7	15

add

Train D

Equipment	Volts	Component Estimated (bhp/kW /kVA)[1]	Power Factor	Motor Efficiency	Equivalent Load (kW)	LOOP Load (kW)	DBA Concurrent with a LOOP Load (kW)	Load Sequence Time (Seconds)[2]
Medium Voltage								
Safety Injection Pump 4	4,160	898.5 (bhp)		0.9	744.8		744.8	~~5~~ 10
Containment Spray Pump 2	4,160	920 (bhp)		0.9	762.6		762.6	~~10~~ 23
Component Cooling Water Pump 2B	4,160	2,000 (bhp)		0.9	1,657.8	1,657.8	1,657.8	~~15~~ 28
Essential Service Water Pump 2B	4,160	1,201 (bhp)		0.9	846.3	846.3	846.3	~~20~~ 33
Essential Central Chiller 2B	4,160	930 (bhp)		0.9	~~770.9~~ 760.9	~~770.9~~	~~770.9~~	~~25~~ 38
Subtotal, Loading for Load Sequence of Medium Voltage						~~3,275.0~~ 3,886.7	~~4,782.4~~ 5,394.1	
Load Sequence Group D[3], [4] – Low Voltage								
480V LC – CH D Battery Charger	480	~~240~~ kVA 210	~~0.85~~ 0.9		~~204~~ 189	~~204~~	~~204~~	
480V LC – EDG Room Elec. Heating Coil 11D	480	240 kW	1.0		240	240	240	
480V LC – Control Room HV01D Fan	460	104 (bhp)		0.9	86.2	86.2	86.2	
480V LC – Control Room Elec. Heating Coil 01D	480	225 kW	1.0		225	225	225	
480V LC – Essential Chilled Water Pump 02 B	460	81.3 (bhp)		0.9	67.4	67.4	67.4	

Supply AHU

add

480V LC - Battery Room Elec. Duct Heater	480	74 kW	1.0		74	74	74	

Table 8.3.1-3 (4 of 5)

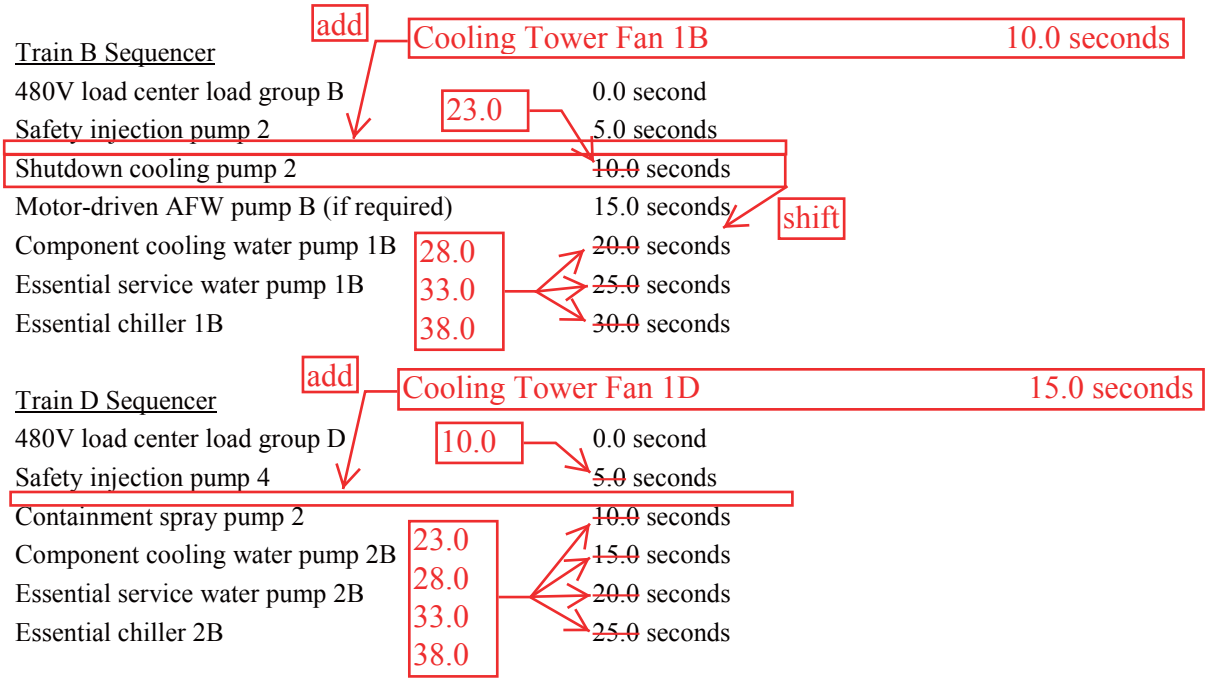
Train D

Equipment	Volts	Component Estimated (bhp/kW /kVA)(1)	Power Factor	Motor Efficiency	Equivalent Load (kW)	LOOP Load (kW)	DBA Concurrent with a LOOP Load (kW)	Load Sequence Time (Seconds)(2)
Load Sequence Group D[3], [4] – Low Voltage								
480V LC – Cooling Tower Makeup Pump ~~D~~ 4B	460	139.8		0.9	~~116~~	~~116~~	~~116~~ 115.9	
480V MCC (4EA) Loads[4]	480	~~625.6~~ kW 375.6	1.0	1.0	~~625.6~~	~~625.6~~	~~625.6~~ 375.6	
Subtotal, Loading for Load Sequence Group D						~~1,564.2~~	~~1,564.2~~	0
Manual Load Group[5]							1,373.1	
Subtotal, Loading for Manual Load						0	0	
EDG Loads of Train D							5,259.8	
Total Diesel Load on LOOP excluding Manual Load						~~4,839.2~~		
Total Diesel Load on LOOP including Manual Load						~~4,839.2~~		6,767.2
Total Diesel Load on DBA/LOOP excluding Manual Load							~~6,346.6~~	
Total Diesel Load on DBA/LOOP including Manual Load							~~6,346.6~~	

Table 8.3.1-3 (5 of 5)

(1) Conversion into equivalent kilowatts for rated horsepower involves multiplying rated horsepower by the conversion factor 0.746 kW/hp. When unit of brake horsepower (bhp) is assumed, a motor efficiency of 0.9 is used in addition to this conversion factor to calculate equivalent load. Unless designated as bhp, all horsepower is rated.

(2) The following components and times apply to accident scenarios coincident with LOOP.



(3) The 480V loads are energized immediately upon closure of the EDG incoming breaker.

(4) Although motor-operated valves (MOVs) are connected to the Class 1E MCC buses, they are considered to be zero for purpose of EDG sizing due to their intermittent and short operating time.

480V HVAC loads were classified into summer season loads and winter season loads, and the worst-case loads of winter season were allocated in the 480V MCC loads for EDG sizing.

(5) Manual loads are added to the Class 1E buses by operator in case plant conditions are required their usage.