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.:	**441-8549**
SRP Section:	**08.03.02 – DC Power Systems (Onsite)**
Application Section:	**8.3.2**
Date of RAI Issue:	**03/14/2016**

Question No. 08.03.02-3

The applicant provided response to RAI 8178, Questions 08.03.02-1 and 08.03.02-2 related to DC System. The staff is requesting response to the follow-up questions below:

a) In response to RAI 08.03.02-1, Question 1, related to battery cell sizing, the staff requests the applicant to provide additional information as to how the number of cells was determined. Please discuss the battery sizing, specified duty cycle, and how the number of cells was determined (58 in this case) for the Class 1E batteries in the APR1400 design, demonstrating with a cell sizing sheet as per guidance provided in IEEE Std. 485.

b) In response to RAI 08.03.02-1, Question 2, related to load difference and replacement of the Division I and Division II of the DC power distribution system, the applicant stated that the load shedding conditions are described in Table 8.3.2-2 (pages 1 and 2), but staff does not find the specific load shedding details in these pages. Please add the specific load shedding conditions with timing such as IP Inverter loads, emergency lighting loads etc., as described in the RAI response. From the Table 8.3.2-2 for non-Class 1E battery and the response of this RAI, the staff cannot determine load requirement vs. the duty cycle (8 hours) alignment. Therefore, the staff requests that these Tables of “Load classification and load currents” be supplemented with the time intervals for continuous (0 to 480 min), momentary (0 to 1 min, and 479-480 min), and Non-continuous/random (0 to 1 min) in the load currents and be aligned with the duty cycle determination. Please revise the DCD to reflect this information and provide DCD markups with your response.

c) In response to RAI 08.03.02-1, Question 3, related to duty cycle, the applicant stated that the random loads were superimposed on the end of the controlling section of the duty cycle. Figure 1 of the duty cycle for Train A, in Attachment 1 (sheet 4), shows that the random load is superimposed as L4 at the end of the duty cycle. Please explain how the applicant determined that the most critical time to assign the random load in

the duty cycle was during the last hour. The staff's concern is that the random load in Table 8.3.2-1 is found significant for Trains C and D and whether the imposition of these random loads at the end of L2 or L3 portion of the duty cycle may impact the battery size.

Also the staff requests that the description of the Class 1E Trains A/B/C/D batteries, description of the divisional pairs (A&C for Division I and B&D for Division II) including the description of the difference in the duty cycles (8 hours vs. 16 hours) be provided as part of the system description section in the DCD, as the Table 8.3.2-1 is not fully self-explanatory. Please revise the DCD to reflect this information and provide DCD markups with your response.

d) In response to RAI 08.03.02-1, Question 4, related to battery sizing, the staff requests that the inverter efficiency as 85% be added to the DCD Table 8.3.2-4 (pages 1 and 2), Electrical Equipment Ratings-Component Data, under Inverter Section. Please revise the DCD to reflect this information and provide DCD markups with your response.

e) In response to RAI 08.03.02-1, Question 5, the staff has the following questions:

(i) The staff finds that Class 1E 125Vdc loads in Table 8.3.2-1 are not tallying with the Figures of Duty Cycle Diagrams provided in the RAI response. For example, the load table for Train A (8 hour duty cycle) shows a continuous load of more than 400 Amp, whereas the duty cycle show L1 as 132.9 Amp, which is much lower. Please clarify. The staff requests that the Tables of "Load classification and load currents" for Class 1E Train A&B power system loads be supplemented with the time intervals for continuous (0 to 480 minute), momentary (0 to 1 min, and 479-480 min), and Non-continuous/random (0 to 1 min or as designed for APR1400) in the load currents and be aligned with the duty cycle determination.

Similarly, provide the Tables for battery Trains C and D for 16 hour duty cycle batteries supplemented with the time interval. Please revise the DCD to reflect this information and provide DCD markups with your response.

(ii) Battery Qualification: The APR14000 DCD, Section 8.3.2.1.2.6 states that the Class 1E batteries are qualified in accordance with IEEE Standard 535-2006, "Standard for Qualification of Class 1E Lead Storage Batteries for Nuclear Power Generating Stations." IEEE Standard 535-2006 was written under the assumption of an 8-hour duty Cycle (See ADAMS Accession No. ML13094A397, "Request for Interpretation of IEEE Standard 535-2006," dated November 17, 2008). Given that IEEE Std. 535-2006 does not apply to duty cycles longer than 8 hours, identify the methodology to be used to qualify these batteries for an extended duty cycle of 16-hours for Trains C and D batteries. Note that IEEE Standard 535-2013 does discuss qualification of duty cycles longer than 8 hours. Please revise the DCD to reflect this information and provide DCD markups with your response.

f) In Response 08.03.02-2, Question 2, the applicant provided the Failure Mode & Effects Analysis in an attached table. The staff requests that this table be included in the revised DCD Section 08.03.02.

Response

The following responses correspond to each of the staff's requests.

a) The number of cells of the Class 1E batteries in the APR1400 design was determined as follows:

- The allowable minimum and maximum battery terminal voltages for 125 Vdc system are 105V and 140V, respectively.

- The number of cells is established by the cell voltage required for satisfactory charging and equalizing the dc bus to the maximum system voltage. This is as follows:

$$\frac{\text{maximum system voltage}}{\text{required voltage per cell}} = \text{number of cells}$$

- The maximum allowable system voltage is 140V and the required voltage for equalize charging is 2.4 V/cell. Then

$$\frac{140\ \text{V}}{2.4\ \text{V}} = 58.33\ \text{cells (use 58 cells)}$$

- The minimum battery voltage is used to calculate the allowable minimum cell voltage.

$$\frac{\text{minimum battery voltage}}{\text{number of cells}} = \text{minimum cell voltage}$$

$$\frac{105\ \text{V}}{58\ \text{cells}} = 1.81\ \text{V/cell}$$

- Therefore, for the 125 Vdc batteries, the selected number of cells is 58.

Each battery is sized based on the duty cycle of the respective subsystems. Each battery is capable of supplying power to the worst-case operating loads for a period of the battery duty cycle. The sizing of the battery is performed in accordance with the IEEE Std. 485-2010.

- The list of Class 1E 125 Vdc battery loads for battery sizing are provided in Table 8.3.2-1 of Attachment 1.

- The duty cycle diagrams of the Class 1E 125 Vdc batteries for battery sizing are provided as Figures 1 through 4 in Attachment 2.

- The cell sizing worksheets per the guidance provided in IEEE Std. 485 for battery sizing are provided as Attachment 3.

b) For the non-Class 1E batteries, DCD Tier 2, Table 8.3.2-2 will be supplemented with the time intervals for continuous, momentary, and non-continuous/random load currents. The revised list of non-Class 1E battery loads is provided as Attachment 4.

c) The recommended practice of IEEE Std. 485-2010 addresses random loads and their application in the battery sizing process. The method described is for loads that may actuate randomly anytime during a duty cycle or for which the actual actuation time in the duty cycle is unknown. However, if more specific information regarding the timing of a random load can be ascertained, it may result in a requirement for a smaller battery, which is typically desirable for economic reasons. This is typically achieved by ascertaining enough information to allow the random load to be reclassified as either a momentary load or a non-continuous load and placed into the load profile appropriately.

Loads that occur at random were taken to occur at the most critical time of the duty cycle in order to simulate the worst-case load on the battery. These also included non-continuous or momentary loads. To determine the most critical time, it was necessary to size the battery without the random load(s) and to identify the section of the duty cycle that controlled the battery size. Then, the random load(s) were superimposed on the end of that controlling section of the duty cycle.

For the conservative battery sizing in the APR1400 design, the most critical time was determined to be in the last hour of the duty cycle.

The calculation results of the Class 1E trains C and D batteries were 8,527 AH and 8,561 AH, respectively and the capacity of trains C and D batteries were selected as 8,800 AH (4,400 AH x 2 banks in parallel).

For Class 1E train C battery sizing, the duty cycle diagrams that applied the imposition of the random loads at the end of the L2 or L3 portion of the duty cycle are provided in Figures 1 and 2 of Attachment 5. The calculation results of the Class 1E train C battery sizing for the imposition of the random loads at the end of L2 or L3 portion were 7,077 AH and 8,223 AH, respectively and were not affected the battery size.

For Class 1E train D battery sizing, the duty cycle diagrams that applied the imposition of the random loads at the end of the L2 or L3 portion of the duty cycle are provided in Figures 3 and 4 of the attachment 5. The calculation results of the Class 1E train D battery sizing for the imposition of the random loads at the end of L2 or L3 portion were 7,111 AH and 8,255 AH, respectively and were not affected the battery size.

For the Class 1E trains A/B/C/D batteries, DCD Tier 2, Table 8.3.2-1 will be supplemented with the time intervals for continuous, momentary, and non-continuous/random load currents. The revised list of Class 1E battery loads is provided as Attachment 1.

d) DCD Tier 2, Table 8.3.2-4 will be revised to incorporate the inverter efficiency of 85%.

e) (i) For the Class 1E trains A/B/C/D batteries, DCD Tier 2, Table 8.3.2-1 will be supplemented with the time intervals for continuous, momentary, and non-continuous/random load currents. The revised list of Class 1E battery loads is provided as Attachment 1.

The load current value 132.9A of L1 for train A is the result of the summation of the individual loads during the time interval (120-479 min) as shown in Table 8.3.2-1 of Attachment 1 (page 2 of 8).

(ii) Battery Qualification:

Instead of IEEE Std. 535-2006, IEEE Std. 535-2013 is applied to provide the methodology to be used to qualify these batteries for an extended duty cycle of 16-hours for trains C and D batteries.

DCD Tier 2, Table 1.9-1, Section 3.11.8, 8.1.3.3, and 8.3.4 will be revised to apply IEEE Std. 535-2013 for the qualification of duty cycles longer than 8 hours as shown in Attachment 7.

f) DCD Tier 2, Table 8.3.2-6 and 8.3.2-7 will be added to provide the Failure Mode & Effects Analysis (FMEA) for the 125 V dc and Class 1E Vital Power System and the 120 Vac Class 1E Vital Instrumentation and Control Power System. The added FMEA table is provided as Attachment 8.

Impact on DCD

DCD Tier 2, Table 8.3.2-1 will be revised as shown in Attachment 1; Table 8.3.2-2 will be revised as shown in Attachment 4; Table 8.3.2-4 will be revised as shown in Attachment 6; Table 1.9-1, Subsection 3.11.8, 8.1.3.3, and 8.3.4 will be revised as shown in Attachment 7; and Table 8.3.2-6 and 8.3.2-7 will be added as shown in Attachment 8.

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 8.3.2-1 (1 of 4)

Class 1E 125 Vdc Power System Loads

1. Train A

125 V DC Load Name	DC Load Classification and Load Currents [A][(5), (6)]			
	Continuous	Noncontinuous	Momentary	Random
MOV Inverter		20[(1)]		
- RCS Valves[(2)]				47.8
Reactor Trip Switchgear System			3[(3)]	
Solenoids for CVCS, FW&MS, SIS Valves	21.2			
Solenoids for Miscellaneous Valves	14.7			
Lamp and Relay, Trip of SWGR and LC	4.9		45[(4)]	
IP Inverter	389.1			
EDG-A Control Power	11.5			

(1) This value is no load current.
(2) This load is a random load of the MOV inverter.
(3) This current is loaded for the first minute.
(4) This current is superimposed on the continuous value for the first minute.
(5) The duty cycle is 8 hours long.
(6) The dc loads can change during the design.

Delete

Replace with "A"

“ A ”

Load Description	Load Current (A) [2]				Remark
	0-1 min	1-120 min	120-479 min	479-480 min	
	1	119	359	1	
MOV Inverter (No Load Current)	20.0	20.0	20.0		
RCS Valves [1]				47.8	Random Load
Reactor Trip Switchgear System	3.0				Momentary Load
Solenoids for CVCS, FW&MS, SIS Valves	21.2	21.2	21.2	21.2	
Solenoids for Miscellaneous Valves	14.7	14.7	14.7	14.7	
Lamp and Relay, Trip of SWGR and LC	49.9	4.9	4.9	4.9	
IP Inverter	389.1	389.1	60.5	60.5	
EDG-A Control Power	11.5	11.5	11.5	11.5	
TOTAL	509.5	461.5	132.9	160.7	

(1) This load is a random load of the MOV inverter.

(2) The dc loads can change during detail design.

Table 8.3.2-1 (2 of 4)

2. Train B

125 V DC Load Name	DC Load Classification and Load Currents [A][(5), (6)]			
	Continuous	Noncontinuous	Momentary	Random
MOV Inverter		20[(1)]		
- RCS Valves(2)				47.8
- CVCS Valves(2)				29.4
Reactor Trip Switchgear System			3[(3)]	
Solenoids for CVCS, FW&MS, SIS Valves	22.5			
Solenoids for Miscellaneous Valves	15.1			
Lamp and Relay, Trip of SWGR and LC	5		45[(4)]	
IP Inverter	330.6			
EDG-B Control Power	11.5			

(1) This value is no load current.

(2) This load is a random load of the MOV inverter.

(3) This current is loaded for the first minute.

(4) This current is superimposed on the continuous value for the first minute.

(5) The duty cycle is 8 hours long.

(6) The dc loads can change during the design.

Delete

Replace with "B"

" B "

Load Description	Load Current (A) [2]				Remark
	0-1 min	1-120 min	120-479 min	479-480 min	
	1	119	359	1	
MOV Inverter (No Load Current)	20.0	20.0	20.0		
RCS Valves [1]				47.8	Random Load
CVCS Valves [1]				29.4	Random Load
Reactor Trip Switchgear System	3.0				Momentary Load
Solenoids for CVCS, FW&MS, SIS Valves	22.5	22.5	22.5	22.5	
Solenoids for Miscellaneous Valves	15.1	15.1	15.1	15.1	
Lamp and Relay, Trip of SWGR and LC	50.0	5.0	5.0	5.0	
IP Inverter	330.6	330.6	60.5	60.5	
EDG-B Control Power	11.5	11.5	11.5	11.5	
TOTAL	452.6	404.6	134.6	191.8	

(1) This load is a random load of the MOV inverter.

(2) The dc loads can change during detail design.

Table 8.3.2-1 (3 of 4)

3. Train C

125 V DC Load Name	DC Load Classification and Load Currents [A][8), (9]			
	Continuous	Noncontinuous	Momentary	Random
MOV Inverter		25[1]		
- IWS Valve 1[2]				229.6
- IWS Valve 2[2]				229.6
- RCS Valve 1[2]				47.8
- RCS Valve 2_LRC (Locked Rotor Current)[2), (3]				581.2
- RCS Valve 2_FLC (Full Load Current)[2), (3]				121.9
AFP Turbine LCP	8.8		60[4]	
Aux. Feedwater Isolation Valves		180[5]		
Reactor Trip Switchgear System			3[6]	
Solenoids for FW&MS, SIS Valves	3.5			
Solenoids for Miscellaneous Valves	3.8			
Lamp and Relay, Trip of SWGR and LC	4.7		35[7]	
IP Inverter	259.6			
EDG-C Control Power	11.5			

(1) This value is no load current.

(2) These loads are random loads of the MOV inverter.

(3) RCS valve load current values are loaded successively just before the end of the duty cycle.

(4) This value is superimposed on the continuous value for the first minute.

(5) This current is loaded for the first 5 minutes every 1 hour.

(6) This current is loaded for the first minute.

(7) This current is superimposed on the continuous value for the first minute.

(8) The duty cycle is 16 hours long.

(9) The dc loads can change during detail design.

Delete

Replace with "C"

" C "

Load Description	Load Current (A) [6]										Remark
	0-1 min	1~5 min	5~60 min	60~65 min	65~480 min	480~485 min	485~957 min	957~958 min	958~959 min	959~960 min	
	1	4	55	5	415	5	472	1	1	1	
MOV Inverter (No Load Current)	25.0	25.0	25.0	25.0	25.0	25.0	25.0				
IWS Valve 1 & 2 [1,2]								229.6		229.6	Random Load
RCS Valve 1 [1]										47.8	Random Load
RCS Valve 2 [1]									581.2 [4]	121.9 [5]	Random Load
AFP Turbine LCP	68.8	8.8	8.8	8.8	8.8	8.8	8.8	8.8	8.8	8.8	
Aux. Feedwater Isolation Valves	180.0 [3]	180 [3]		180 [3]		180 [3]					
Reactor Trip Switchgear System	3.0										Momentary Load
Solenoids for FW&MS, SIS Valves	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	
Solenoids for Miscellaneous Valves	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	
Lamp and Relay, Trip of SWGR and LC	39.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	
IP Inverter	259.6	259.6	259.6	259.6	259.6	259.6	259.6	259.6	259.6	259.6	
EDG-C Control Power	11.5	11.5	11.5	11.5	11.5	11.5	11.5	11.5	11.5	11.5	
Emergency DC Lighting	40.0	40.0	40.0	40.0	40.0						
TOTAL	634.9	536.9	356.9	536.9	356.9 (536.9 [3])	496.9	316.9 (496.9 [3])	521.5	873.1	691.2	

(1) This load is a random load of the MOV inverter.
(2) IWS Valve 1 and 2 will not be operated simultaneously.
(3) This current is loaded for the first 5 minutes every 1 hour.
(4) This current is Locked Rotor Current value of RCS Valve 2.
(5) This current is Full Load Current value of RCS Valve 2.
(6) The dc loads can change during detail design.

Table 8.3.2-1 (4 of 4)

4. Train D

125 V DC Load Name	DC Load Classification and Load Currents [A][(8), (9)]			
	Continuous	Noncontinuous	Momentary	Random
MOV Inverter		25[(1)]		
IWS Valve 3[(2)]				229.6
IWS Valve 4[(2)]				229.6
RCS Valve 3[(2)]				47.8
RCS Valve 4_LRC (Locked Rotor Current)[(2), (3)]				581.2
RCS Valve 4_FLC (Full Load Current)[(2), (3)]				121.9
AFP Turbine LCP	8.8		60[(4)]	
Aux. Feedwater Isolation Valves		180[(5)]		
Reactor Trip Switchgear System			3[(6)]	
Solenoids for FW&MS, SIS Valves	3.5			
Solenoids for Miscellaneous Valves	3.8			
Lamp and Relay, Trip of SWGR and LC	4.7		35[(7)]	
IP Inverter	261.4			
EDG-D Control Power	11.5			

(1) This value is no load current.
(2) These loads are random loads of the MOV inverter.
(3) RCS valve load current values are loaded successively just before the end of the duty cycle.
(4) This value is superimposed on the continuous value for the first minute.
(5) This current is loaded for the first 5 minutes every 1 hour.
(6) This current is loaded for the first minute.
(7) This current is superimposed on the continuous value for the first minute.
(8) The duty cycle is 16 hours long.
(9) The dc loads can change during detail design.

Delete

Replace with "D"

" D "

Load Description	Load Current (A) [6]										Remark
	0-1 min	1~5 min	5~60 min	60~65 min	65~480 min	480~485 min	485~957 min	957~958 min	958~959 min	959~960 min	
	1	4	55	5	415	5	472	1	1	1	
MOV Inverter (No Load Current)	25.0	25.0	25.0	25.0	25.0	25.0	25.0				
IWS Valve 3 & 4 [(1), (2)]								229.6		229.6	Random Load
RCS Valve 3 [(1)]										47.8	Random Load
RCS Valve 4 [(1)]									581.2 [(4)]	121.9 [(5)]	Random Load
AFP Turbine LCP	68.8	8.8	8.8	8.8	8.8	8.8	8.8	8.8	8.8	8.8	
Aux. Feedwater Isolation Valves	180.0 [(3)]	180 [(3)]		180 [(3)]		180 [(3)]					
Reactor Trip Switchgear System	3.0										Momentary Load
Solenoids for FW&MS, SIS Valves	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	
Solenoids for Miscellaneous Valves	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	
Lamp and Relay, Trip of SWGR and LC	39.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	
IP Inverter	261.4	261.4	261.4	261.4	261.4	261.4	261.4	261.4	261.4	261.4	
EDG-D Control Power	11.5	11.5	11.5	11.5	11.5	11.5	11.5	11.5	11.5	11.5	
Emergency DC Lighting	40.0	40.0	40.0	40.0	40.0						
TOTAL	636.7	538.7	358.7	538.7	358.7 (538.7 [(3)])	498.7	318.7 (498.7 [(3)])	523.3	874.9	693.0	

(1) This load is a random load of the MOV inverter.

(2) IWS Valve 3 and 4 will not be operated simultaneously.

(3) This current is loaded for the first 5 minutes every 1 hour.

(4) This current is Locked Rotor Current value of RCS Valve 4.

(5) This current is Full Load Current value of RCS Valve 4.

(6) The dc loads can change during detail design.

Figure 1 - Diagrams of duty cycle for Train A (8 hours) for APR1400 design

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Figure 2 - Diagrams of duty cycle for Train B (8 hours) for APR1400 design

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Figure 3 - Diagrams of duty cycle for Train C (16 hours) for APR1400 design

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Figure 4 - Diagrams of duty cycle for Train D (16 hours) for APR1400 design

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Cell Sizing Worksheets For Class 1E Train A Battery

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Cell Sizing Worksheets For Class 1E Train B Battery

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Cell Sizing Worksheets For Class 1E Train C Battery

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Cell Sizing Worksheets For Class 1E Train C Battery

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Cell Sizing Worksheets For Class 1E Train D Battery

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Table 8.3.2-2 (1 of 5)

Non-Class 1E DC Power System Loads

1. Division I, 125 Vdc Loads

Load Name	DC Load Classification and Load Currents [A][2], [3]		
	Continuous	Noncontinuous	Momentary
Local Control Panel		74.7	
Emergency Lighting	72.4		
Feedwater Pump Turbine Emergency Lube Oil Pump		136	200[1]
Local Alarm Box		0.5	
Personnel Air Lock		3	
Solenoids for CVCS, FW&MS, SIS Valves		7.1	
Solenoids for Miscellaneous Valves		7.3	
EDG Speed Cubicle		7.2	
EDG DMDS Cabinet		80	
SWGR and LC		19.9	119.9[1]
IP Inverter Load Current		969.4	
IP Inverter No Load Current		191.1	

(1) These currents are loaded for the first minute.

(2) The duty cycle is 8 hours long.

(3) The dc loads can change during detail design.

Delete

Replace with "A"

"A"

Load Description	Load Current (A) [1]			
	0~1 min	1~30 min	30~120 min	120~480 min
	1	29	90	360
Local Control Panel	74.7	74.7	74.7	
Emergency Lighting	72.4	72.4	72.4	72.4
Feedwater Pump Turbine Emergency Lube Oil Pump	200.0	136.0	136.0	
Local Alarm Box	0.5	0.5	0.5	
Personnel Air Lock	3.0	3.0	3.0	
Solenoids for CVCS, FW&MS, SIS Valves	7.1	7.1	7.1	
Solenoids for Miscellaneous Valves	7.3	7.3	7.3	
EDG Speed Cubicle	7.2	7.2	7.2	
EDG DMDS Cabinet	80.0	80.0	80.0	
Lamp and Relay, Trip of SWGR and LC	119.9	19.9	19.9	
IP Inverter	969.4	969.4	191.1	
TOTAL	1541.6	1377.6	599.2	72.4

(1) The dc loads can change during detail design.

Table 8.3.2-2 (2 of 5)

2. Division II, 125 Vdc Loads

DC Load Name	DC Load Classification and Load Currents [A][(2), (3)]		
	Continuous	Noncontinuous	Momentary
Local Control Panel		43.4	
Emergency Lighting	59.4		
Feedwater Pump Turbine Emergency Lube Oil Pump		68	100[(1)]
Personnel Air Lock		3	
Solenoids for CVCS, FW&MS Valves		3.9	
Solenoids for Miscellaneous Valves		5.3	
EDG Speed Cubicle		7.2	
EDG DMDS Cabinet		80	
SWGR and LC		19.9	129.9[(1)]
IP Inverter Load Current		1021.8	
IP Inverter No Load Current		191.1	

(1) These currents are loaded for the first minute.

(2) The duty cycle is 8 hours long.

(3) The dc loads can change during the design.

Delete

Replace with "B"

" B "

Load Description	Load Current (A) [(1)]			
	0~1 min	1~30 min	30~120 min	120~480 min
	1	29	90	360
Local Control Panel	43.4	43.4	43.4	
Emergency Lighting	59.4	59.4	59.4	59.4
Feedwater Pump Turbine Emergency Lube Oil Pump	100.0	68.0	68.0	
Personnel Air Lock	3.0	3.0	3.0	
Solenoids for CVCS, FW&MS Valves	3.9	3.9	3.9	
Solenoids for Miscellaneous Valves	5.3	5.3	5.3	
EDG Speed Cubicle	7.2	7.2	7.2	
EDG DMDS Cabinet	80.0	80.0	80.0	
Lamp and Relay, Trip of SWGR and LC	129.9	19.9	19.9	
IP Inverter	1021.8	1021.8	191.1	
TOTAL	1453.9	1311.9	481.1	59.4

(1) The dc loads can change during detail design.

Table 8.3.2-2 (3 of 5)

3. Division II, 250 Vdc Loads

DC Load Name	DC Load Classification and Load Currents [A][(2), (3)]		
	Continuous	Noncontinuous	Momentary
T/G Emergency Bearing Oil Pump		265	1060[(1)]
T/G Emergency Seal Oil Pump		103	257.5[(1)]
UPS Load Current		115.1	
UPS No Load Current		10.6	

(1) These currents are loaded for the first minute.

(2) The duty cycle is 2 hours long.

(3) The dc loads can change during the design.

Delete

Replace with "C"

" C "

Load Description	Load Current (A) [1]		
	0~1 min	1~30 min	30~120 min
	1	29	90
T/G Emergency Bearing Oil Pump	1060.0	265.0	265.0
T/G Emergency Seal Oil Pump	257.5	103.0	103.0
UPS Load Current	115.1	115.1	10.6
TOTAL	1432.6	483.1	378.6

(1) The dc loads can change during detail design.

Table 8.3.2-2 (4 of 5)

4. 125 Vdc Loads, Compound Building

DC Load Name	DC Load Classification and Load Currents [A][(1), (2)]		
	Continuous	Noncontinuous	Momentary
Liquid Radwaste Control Panel		1.4	
Gaseous Radwaste Control Panel		2	
Radioactive Laundry System Control Panel		0.3	
GRS Control Cabinet		12.5	
Local Alarm Box		1	
Plant Chilled Water System Control Panel		0.3	
Emergency Lighting Panel	24		
Miscellaneous Valves		5.6	
Load Center	3		
UPS Load Current		139.9	
UPS No Load Current		17.2	

(1) The duty cycle is 8 hours long.

(2) The dc loads can change during detail design.

Delete

Replace with "D"

" D "

Load Description	Load Current (A) [1]		
	0~30 min	30~120 min	120~480 min
	30	90	360
Liquid Radwaste Control Panel	1.4	1.4	
Gaseous Radwaste Control Panel	2.0	2.0	
Radioactive Laundry System Control Panel	0.3	0.3	
GRS Control Cabinet	12.5	12.5	
Local Alarm Box	1.0	1.0	
Plant Chilled Water System Control Panel	0.3	0.3	
Emergency Lighting Panel	24.0	24.0	24.0
Miscellaneous Valves	5.6	5.6	
Lamp and Relay, Trip of Load Center	3.0	3.0	3.0
UPS Load Current	139.9	17.2	17.2
TOTAL	189.9	67.2	44.2

(1) The dc loads can change during detail design.

Table 8.3.2-2 (5 of 5)

5. 125 Vdc Loads, AAC GTG Building

DC Load Name	DC Load Classification and Load Currents [A][2], [3]		
	Continuous	Noncontinuous	Momentary
AAC GTG DMDS Cabinet		40	
AAC GTG Control Power		13.6	
SWGR and LC		3.1	8.1[1]
UPS Load Current		13.7	
UPS No Load Current		8.3	

(1) This current is loaded for the first minute.

(2) The duty cycle is 4 hours long.

(3) The dc loads can change during the design.

Delete

Replace with "E"

" E "

Load Description	Load Current (A) [1]			
	0~1 min	1~60 min	60~120 min	120~240 min
	1	59	60	120
AAC GTG DMDS Cabinet	40.0	40.0	40.0	
AAC GTG Control Power	13.6	13.6	13.6	
Lamp and Relay, Trip of SWGR and LC	8.1	3.1	3.1	3.1
UPS Load Current	13.7	13.7	8.3	8.3
TOTAL	75.4	70.4	65.0	11.4

(1) The dc loads can change during detail design.

Figure 1 - Diagrams of duty cycle for Train C (16 hours) for APR1400 design

[Case for the imposition of random loads at the end of L2 portion]

TS

Figure 2 - Diagrams of duty cycle for Train C (16 hours) for APR1400 design

[Case for the imposition of random loads at the end of L3 portion]

TS

Figure 3 - Diagrams of duty cycle for Train D (16 hours) for APR1400 design

[Case for the imposition of random loads at the end of L2 portion]

TS

Figure 4 - Diagrams of duty cycle for Train D (16 hours) for APR1400 design

[Case for the imposition of random loads at the end of L3 portion]

TS

Table 8.3.2-4 (1 of 2)

Electrical Equipment Ratings – Component Data

Non-Class 1E DC and I&C Power System

Component	Description	Specification
Battery Charger	AC input	Three phase, 480 Vac ± 10 %, 60 Hz ± 5 %
	DC output	± 0.5 % regulation
	Float voltage range	124-130/248-260 V (125/250 Vdc system)
	Equalizing voltage range	130-140/260-280 V (125/250 Vdc system)
	DC output current rating	1,800 A (auxiliary building, division I) 1,600 A (auxiliary building, division II) 300 A (compound building) 200 A (AAC GTG building), 600 A (TG building)
Battery	Type	Lead Acid
	Number of cells	116 cell for 125 Vdc (auxiliary building) 58 cell for 125 Vdc (compound and AAC GTG building) 116 cell for 250 Vdc (TG building)
	Nominal voltage	125 Vdc/250 Vdc
	Float voltage	2.15-2.17 V/cell
	Equalizing voltage	2.25-2.40 V/cell
	Minimum operating voltage	1.81 V/cell
	Voltage range	105-140 V for 125 Vdc System 210-280 V for 250 Vdc System
	Battery capacity	4,000 AH (division I) 3,600 AH (division II) 700 AH (compound building) 500 AH (AAC GTG building) 3,200 AH (TG building)
Inverter	Rating	60 kVA
	DC input voltage	125 V ± 20 %
	Nominal output ac voltage	120 V
	Output voltage regulation	< ± 2 %
	Voltage distortion	≤ 3 %
	Output frequency	60 Hz ± 0.5 %
Regulating Transformer	Rating	60 kVA
	Input nominal voltage	1 phase 480V
	Output nominal voltage	1 phase 120V

Add

	Efficiency	85 %

Table 8.3.2-4 (2 of 2)

Class 1E DC and I&C Power System

Component	Description	Specification
	Tap	Primary side 432V, 468V, 480V, 492V, and 528V
Battery Charger	AC input	Three phase, 480 Vac ± 10 %, 60 Hz ± 5 %
	DC output	± 0.5 % regulation
	Float voltage range	124-130/248-260 V (125/250 Vdc system)
	Equalizing voltage range	130-140/260-280 V (125/250 Vdc system)
	DC output current rating	700 A (trains A&B), 1,200 A (trains C&D)
Battery	Type	Lead acid
	Number of cells	58 cell × 2 (parallel)
	Nominal voltage	125 Vdc
	Float voltage	2.15-2.17 V/cell
	Equalizing voltage	2.25-2.40 V/cell
	Minimum operating voltage	1.81 V/cell
	Voltage range	105-140 V for 125 Vdc System
	Battery capacity	2,800 AH (trains A&B) 8,800 AH (trains C&D)
Inverter	Rating	40 kVA
	DC input voltage	125V ± 20 %
	Nominal output ac voltage	120V
	Output voltage regulation	< ± 2 %
	Voltage distortion	≤ 3 %
	Output frequency	60 Hz ± 0.5 %
Regulating Transformer	Rating	40 kVA
	Input nominal voltage	1 phase 480V
	Output nominal voltage	1 phase 120V
	Tap	Primary side 432V, 468V, 480V, 492V, and 528V

Add

Efficiency	85 %

2013

Revise

IEEE Std. 535-2006 does not apply to duty cycles longer than 8 hours.

Revise

Table 1.9-1 (20 of 38)

NRC Regulatory Guide	Revision / Issue Date	Conformance or Summary Description of Deviation	DCD Tier 2 Section
1.158 Qualification of Safety-Related Lead Storage Batteries for Nuclear Power Plants	02/1989	The APR1400 conforms with this NRC RG except for the following. • IEEE Standard 535-~~2006~~ is applied instead of IEEE Standard 535-1986 because ~~NRC RG 1.212 endorses the current national qualification standard (IEEE Standard 535-2006).~~	3.11.2, 8.1.3.3
1.159 Assuring the Availability of Funds for Decommissioning Nuclear Reactors	Rev. 2 10/2011	Not applicable (COL)	N/A
1.160 Monitoring the Effectiveness of Maintenance at Nuclear Power Plants	Rev. 3 05/2012	Not applicable (COL)	N/A
1.161 Evaluation of Reactor Pressure Vessels with Charpy Upper Shelf Energy Less Than 50 Ft-Lb	06/1995	Not applicable	N/A
1.162 Format and Contents of Report for Thermal Annealing of Reactor Pressure Vessel	02/1996	Not applicable (COL)	N/A
1.163 Performance-Based Containment Leak-Test Program	09/1995	The APR1400 conforms with this NRC RG.	6.2.1.6, 6.2.6, 6.2.6.1, 6.2.6.4
1.166 Pre-Earthquake Planning and Immediate Nuclear Power Plant Operator Postearthquake Action	03/1997	Not applicable (COL)	N/A
1.167 Restart of Nuclear Power Plant Shut Down by a Seismic Event	03/1997	Not applicable (COL)	N/A
1.168 Verification, Validation, Reviews, and Audits for Digital Computer Software Used in Safety System of Nuclear Power Plants	Rev. 2 07/2013	The APR1400 conforms with this NRC RG.	7.1.2.48, Table 7.1-1

27. IEEE Std. 334-2006, "IEEE Standard for Qualifying Continuous-Duty Class 1E Motors for Nuclear Power Generating Stations," Institute of Electrical and Electronics Engineers, 2006.

28. IEEE Std. 344-2004, "IEEE Recommended Practices for Seismic Qualification of Class 1E Equipment for Nuclear Power Generating Stations," Institute of Electrical and Electronics Engineers, 2004.

29. IEEE Std. 382-2006, "IEEE Standard for Qualification of Safety Related Actuators for Nuclear Power Generating Stations," Institute of Electrical and Electronics Engineers,2006.

30. IEEE Std. 383-2003, "IEEE Standard for Type Test of Class 1E Electric Cables and Field Splices for Nuclear Power Generating Stations," Institute of Electrical and Electronics Engineers, 2003.

31. IEEE Std. 387-1998 (R2007), "IEEE Standard Criteria for Diesel Generator Units Applied as Standby Power Supplies for Nuclear Power Generating Stations," Institute of Electrical and Electronics Engineers, 1995.

32. IEEE Std. 497-2002, "IEEE Standard Criteria for Accident Monitoring Instrumentation for Nuclear Power Generating Stations," Institute of Electrical and Electronics Engineers, 2002.

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33. IEEE Std. 535-~~1986 (R1994)~~, "IEEE Standard for Qualification of Class 1E ~~Lead~~ Storage batteries for Nuclear Power Generating Stations," Institute of Electrical and Electronics Engineers, ~~1986.~~

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34. IEEE Std. 572-2006, "IEEE Standard for Qualification of Class 1E Connection Assemblies for Nuclear Power Generating Stations," Institute of Electrical and Electronics Engineers, 2006.

35. IEEE Std. 627-1980 (R1991), "IEEE Standard for Design Qualification of Safety Systems Equipment Used in Nuclear Power Generating Stations," Institute of Electrical and Electronics Engineers, 1980.

36. IEEE Std. 628-2001, "IEEE Standard Criteria for Design, Installation and Qualification of Raceway Systems," Institute of Electrical and Electronics Engineers, 2001.

- IEEE Std. 382, "IEEE Standard for Qualification of Safety-Related Actuators for Nuclear Power Generating Stations," 2006.
- IEEE Std. 383, "IEEE Standard for Qualifying Class 1E Electric Cables and Field Splices for Nuclear Power Generating Stations," 2003.
- IEEE Std. 384, "IEEE Standard Criteria for Independence of Class 1E Equipment and Circuits," 1992.
- IEEE Std. 387, "IEEE Standard Criteria for Diesel-Generator Units Applied as Standby Power Supplies for Nuclear Power Generating Stations," 1995.
- IEEE Std. 420, "IEEE Standard for the Design and Qualification of Class 1E Control Boards, Panels, and Racks Used in Nuclear Power Generating Stations," 2001
- IEEE Std. 450, "IEEE Recommended Practice for Maintenance, Testing, and Replacement of Vented Lead-Acid Batteries for Stationary Applications," 2010.
- IEEE Std. 484, "IEEE Recommended Practice for Installation Design and Installation of Vented Lead-Acid Batteries for Stationary Applications," 2002.
- IEEE Std. 485, "IEEE Recommended Practice for Sizing Lead-Acid Batteries for Stationary Applications," 2010.
- IEEE Std. 497, "IEEE Standard Criteria for Accident Monitoring Instrumentation for Nuclear Power Generating Stations," 2002.
- IEEE Std. 519, "IEEE Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems," 1992.
- IEEE Std. 535, "IEEE Standard for Qualification of Class 1E ~~Lead~~ Storage Batteries for Nuclear Power Generating Stations," ~~2006.~~

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- IEEE Std. 572, "IEEE Standard for Qualification of Class 1E Connection Assemblies for Nuclear Power Generating Stations," 2006.

51. IEEE Std. 519-1992, "IEEE Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems," Institute of Electrical and Electronics Engineers, 1992.

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52. IEEE Std. 485-2010, "IEEE Recommended Practice for Sizing Lead-Acid Batteries for Stationary Applications," Institute of Electrical and Electronics Engineers, 2010.

53. IEEE Std. 535-~~2006~~, "IEEE Standard for Qualification of Class 1E Vented Lead Acid Storage Batteries for Nuclear Power Generating Stations," Institute of Electrical and Electronics Engineers, ~~2006~~.

54. IEEE Std. 946-2004, "IEEE Recommended Practice for the Design of DC Auxiliary Power Systems for Generating Stations," Institute of Electrical and Electronics Engineers, 2004.

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55. IEEE Std. 484-2002, "IEEE Recommended Practice for Installation Design and Installation of Vented Lead-Acid Batteries for Stationary Applications," Institute of Electrical and Electronics Engineers, 2002.

56. Regulatory Guide 1.100, "Seismic Qualification of Electric and Active Mechanical Equipment and Functional Qualification of Active Mechanical Equipment for Nuclear Power Plants," Rev. 3, U.S. Nuclear Regulatory Commission, September 2009.

57. IEEE Std. 450-2010, "IEEE Recommended Practice for Maintenance, Testing, and Replacement of Vented Lead-Acid Batteries for Stationary Applications," Institute of Electrical and Electronics Engineers, 2010.

58. 10 CFR Part 50, Appendix A, General Design Criterion 1, "Quality Standards and Records," U.S. Nuclear Regulatory Commission.

59. 10 CFR Part 50, Appendix B, Criterion III, "Design Control," U.S. Nuclear Regulatory Commission.

60. 10 CFR Part 21, "Reporting of Defects and Noncompliance," U.S. Nuclear Regulatory Commission.

Added

Table 8.3.2-6 (1 of 2)

Failure Modes and Effects Analysis for
the 125 V dc and Class 1E Vital Power System

Component	Function	Failure Mode	Failure Cause	Failure Effect and Countermeasure	Detection
1. 480 Vac supply to chargers	Power supply to charger	Loss of ac input power	• Loss of 480V load center power • Power supply feeder fault	• Power supply failure to dc MCC from charger • Power from battery is available to supply power without interruption.	Annunciation by charger undervoltage relay
2. Battery chargers	Power supply to 125 Vdc load and charge of battery	• Loss of output power • Opening of output breaker • Undervoltage of output power • Overvoltage of output power	Component failure	• Power supply failure to dc MCC from charger • Severe internal faults may cause high short-circuit currents to flow with resulting voltage reduction on the 125 Vdc bus until the fault is cleared by the isolating circuit breakers. • The 125 Vdc bus receives power from its respective battery without interruption. • If the battery circuit breakers open, the complete loss of voltage on one 125 Vdc bus may result but other redundant system can function as alternative.	• Annunciation by charger trouble detection • Annunciation by charger undervoltage / overvoltage relay
3. 125 Vdc batteries	Back-up power supply to dc MCC	Battery circuit breaker open	Battery failure	• Back-up power loss • In case a charger is available, even though the battery fails to supply to dc MCC, the battery charger allows continued supply of power to dc MCC. • In case both battery and charger are unavailable, other redundant system can function as alternative.	Annunciation by breaker trip

Added

Table 8.3.2-6 (2 of 2)

Component	Function	Failure Mode	Failure Cause	Failure Effect and Countermeasure	Detection
4. 125V dc control centers	Power supply to dc loads	Ground fault	Grounding of a single bus	• The 125V dc system is an ungrounded electrical system and therefore, ground detector is under surveillance and causes alarms. • A single ground does not cause any malfunction or prevent operation of any safety feature.	Annunciation by dc MCC ground detector
		Undervoltage	Charger failure and battery discharge	• The 125V bus is monitored to detect the voltage decay on the bus and initiate an alarm at a voltage setting where the battery can still deliver power for safe and orderly shutdown of the unit. • Upon detection, power can be restored either by correcting the deficiency or by switching to a redundant source.	Annunciation by dc MCC undervoltage relay
5. 125V dc distribution panel	Power supply to dc loads	Main circuit breaker open	Bus shorted	• Voltage on the shorted 125V dc bus system of the affected unit decays until isolated by the isolating circuit breakers. • Remaining redundant channels are available for the safe operation of the unit.	Annunciation by breaker trip [(Local Only)]

Added

Table 8.3.2-7

Failure Modes and Effects Analysis for
the 120 Vac Class 1E Vital Instrumentation and Control Power System

Component	Function	Failure Mode	Failure Cause	Failure Effect and Countermeasure	Detection
1. Inverter	Power supply to vital bus panelboards	• Loss of output power • Loss of input power • Inverter failure	Component failure	• Input power loss of 120V vital bus distribution panel • Regulating transformer supply back-up power • Redundant system is available for the function	Annunciation by inverter undervoltage relay
2. ac instrument and control power distribution panel	Power supply to vital instrument loads	Undervoltage	Bus shorted	• Power supply loss of 120V vital instrument loads • Sufficient redundant system provides adequate protection.	Annunciation by power loss