ATTACHMENT 2

2D660

WORST CASE LOAD PROFILE

BASED ON THE THEORETICAL MAXIMUM

EQUIPMENT THAT

COULD START SIMULTANEOUSLY

Using the 2D660 Battery Load Profiles developed in Attachment 1, determine the maximum load profiles that could occur if all equipment that could start simultaneously did in fact start simultaneously for the following time segments. This approach is being used to assure that variations in the timing of the MOVs are enveloped by the Technical Specification.

LOAD SEGMENTS

0 - 60 seconds

2 - 10 minutes

10 - 30 minutes

30 - 240 minutes

2 - 5 minutes (Station Blackout)

5 - 6 minutes (Station Blackout)

6 - 10 minutes (Station Blackout)

The composite 2D660 Battery Load Profile for all modes of operation, including Station Blackout, is shown in Table 7 - 1.

1.0 LARGE BREAK LOCA PROFILE

The Table A2 - 1 shows the maximum possible 2D660 Battery Load Profile for a LARGE BREAK LOCA with all equipment starting simultaneously.

1.1 0 - 60 seconds

During this load segment the following equipment cannot be operated simultaneously with the others loads.

1.11 HV-E41-2F001 inrush amperes are not use since HV-E41-2F001 MUST BE out of Locked Rotor before HV-E41-2F006 can be started.

1.12 HV-B21-2F019 inrush amperes are not use since HV-B21-2F019 starts on Reactor Low Level-1 signal while the equipment that starts simultaneously starts on Reactor Low Level-2.

1.13 HV-E41-2F012 inrush amperes are not used since HV-E41-2F012 starts on HPCI Turbine High Steam Pressure which occurs after the equipment that starts simultaneously has started.

1.14 HV-E41-2F075 and HV-E41-2F003 inrush amperes are not used since Reactor Pressure MUST drop to 105.5 psi before HV-E41-2F075 and HV-E41-2F003 can operate. This occurs after all the equipment in this load segment has started.

1.2 2 - 10 Minute

1.21 HV-E41-2F042 and HV-E41-2F004 inrush amperes are not used since the maximum loading in this time segment occurs due to the inrush current when HV-E41-2F003 is seating. This valve seating cannot occur simultaneously with staring HV-E41-2F042 and HV-E41-2F004 because of the stroke time of HV-E41-2F003.

1.3 10 - 30 Minute

All the equipment in this load segment is assumed to operate simultaneously.

1.4 30 - 240 Minute

All the equipment in this load segment is assumed to operate simultaneously.

2.0 LARGE BREAK LOCA HPCI IN PRESSURE CONTROL PROFILE

The Table A2 - 2 shows the maximum possible 2D660 Battery Load Profile for a LARGE BREAK LOCA RCIC IN PRESSURE CONTROL with all equipment starting simultaneously.

2.1 0 - 60 seconds

During this load segment the following equipment cannot be operated simultaneously with the others loads.

2.11 HV-B21-2F019 inrush amperes are not use since HV-B21-2F019 starts on Reactor Low Level-1 signal while the equipment that starts simultaneously starts on Reactor Low Level-2.

2.12 HV-E41-2F003 inrush amperes are not used since Reactor Pressure MUST drop to 105.5 psi before HV-E41-2F003 can operate. This occurs after all the equipment in this load segment has started.

2.2 2 - 10 Minute

2.21 HV-E41-2F042 and HV-E41-2F004 inrush amperes are not used since the maximum loading in this time segment occurs due to the inrush current when HV-E41-2F003 is seating. This valve seating cannot occur simultaneously with staring HV-E41-2F042 and HV-E41-2F004 because of the stroke time of HV-E41-2F003.

2.3 10 - 30 Minute

All the equipment in this load segment is assumed to operate simultaneously.

2.4 30 - 240 Minute

All the equipment in this load segment is assumed to operate simultaneously.

3.0 SMALL BREAK LOCA PROFILE

The Table A2 - 3 shows the potential maximum possible 2D660 Battery Load Profile for a SMALL BREAK LOCA with all equipment starting simultaneously.

3.1 0 - 60 seconds

During this load segment the following equipment cannot be operated simultaneously with the others loads.

3.11 HV-E41-2F001 inrush amperes are not use since HV-E41-2F001 MUST BE out of Locked Rotor before HV-E41-2F006 can be started.

3.13 HV-E41-2F012 inrush amperes are not used since HV-E41-2F012 starts on HPCI Turbine High Steam Pressure which occurs after the equipment that starts simultaneously has started.

3.2 2 - 10 Minute

All the equipment in this load segment is assumed to operate simultaneously.

3.3 10 - 30 Minute

All the equipment in this load segment is assumed to operate simultaneously.

3.4 30 - 240 Minute

All the equipment in this load segment is assumed to operate simultaneously.

4.0 SMALL BREAK LOCA HPCI IN PRESSURE CONTROL PROFILE

The Table A2 - 4 shows the maximum possible 2D660 Battery Load Profile for a SMALL BREAK LOCA RCIC IN PRESSURE CONTROL with all equipment starting simultaneously.

4.1 0 - 60 seconds

All the equipment in this load segment is assumed to operate simultaneously.

4.2 2 - 10 Minute

All the equipment in this load segment is assumed to operate simultaneously.

4.3 10 - 30 Minute

All the equipment in this load segment is assumed to operate simultaneously.

4.4 30 - 240 Minute

All the equipment in this load segment is assumed to operate simultaneously.

5.0 STATION BLACKOUT PROFILE

The Table A2 - 5 shows the maximum possible 2D660 Battery Load Profile for a STATION BLACKOUT with all equipment starting simultaneously.

5.1 0 - 60 seconds

During this load segment the following equipment cannot be operated simultaneously with the others loads.

5.11 HV-E41-2F001 inrush amperes are not use since HV-E41-2F001 MUST BE out of Locked Rotor before HV-E41-2F006 can be started.

5.12 HV-E41-2F012 inrush amperes are not used since HV-E41-2F012 starts on HPCI Turbine High Steam Pressure which occurs after the equipment that starts simultaneously has started.

5.2 2 - 5 Minute

All the equipment in this load segment operates simultaneously.

5.3 5 - 6 Minute

5.31 HV-E41-2F011 inrush amperes are not use since HV-E41-2F011 MUST BE manually opened before the other equipment started in this time segment can start.

5.4 6 - 10 Minute

All the equipment in this load segment operates simultaneously.

5.3 10 - 30 Minute

All the equipment in this load segment operates simultaneously.

5.4 30 - 240 Minute

All the equipment in this load segment operates simultaneously.

EQUIPMENT	MCC	0 -60s		2 - 10 MIN		10-30MIN		30-240MIN							
HV-E41-2F001	2D264	18		0		0		0							
HV-E41-2F006	2D264	205.5		0		0		0							
HV-E41-2F059	2D264	2.8		2.8		0		0							
HV-E41-2F075	2D264	0		0		0		0							
HV-E51-2F084	2D264	0		0		0		0							
HV-E41-2F012	2D264	0		0		0		0							
HV-E41-2F042	2D264	19.3		2.1		0		0							
HV-E41-2F004	2D264			2.1		0		0							
HV-E41-2F003	2D264	65		83.9		0		0							
2P213	2D274	65		0		0		0							
2P216	2D274	11		6		6		6							
HV-B21-2F019	2D274	0		0		0		0							
HV-G33-2F004	2D274	38.2		0		0		0							
2P215	2D274	23		11.4		11.4		11.4							
2D289	2D289	120		120		120		120							
TOTAL		567.8		228.3		137.4		137.4							
2D289		120		120		120		120							
2D264		245.6		7		0		0							
2D274		137.2		17.4		17.4		17.4							

EQUIPMENT	MCC		0 -60s		2 -10 MIN		10-30 MIN		30-240MIN						
HV-E41-2F001	2D264		0		0		0		0						
HV-E41-2F006	2D264		205.5		0		0		0						
HV-E41-2F059	2D264		0		2.8		0		0						
HV-E41-2F075	2D264		0		0		0		0						
HV-E51-2F084	2D264		0		0		0		0						
HV-E41-2F012	2D264		0		0		0		0						
HV-E41-2F042	2D264		19.3		2.1		0		0						
HV-E41-2F004	2D264		0		2.1		0		0						
HV-E41-2F011	2D264		108.7		0		0		0						
HV-E41-2F003	2D264		0		83.9		0		0						
2P213	2D274		0		0		0		0						
HV-E41-2F008	2D274		164.5		0		0		0						
2P216	2D274		6		6		6		6						
HV-B21-2F019	2D274		0		0		0		0						
HV-G33-2F004	2D274		38.2		0		0		0						
2P215	2D274		23		11.4		11.4		11.4						
2D289	2D289		120		120		120		120						
TOTAL			685.2		228.3		137.4		137.4						
2D289			120		120		120		120						
2D264			333.5		90.9		0		0						
2D274			231.7		17.4		17.4		17.4						

EQUIPMENT	MCC		0 - 60s		2 - 10 MIN		10-30 MIN		30-240MIN						
HV-E41-2F001	2D264		18		0		0		0						
HV-E41-2F006	2D264		205.5		0		0		0						
HV-E41-2F059	2D264		2.8		0		0		0						
HV-E41-2F075	2D264		0		0		0		0						
HV-E51-2F084	2D264		0		0		0		0						
HV-E41-2F012	2D264		0		0		0		0						
HV-E41-2F042	2D264		19.3		2.1		0		0						
HV-E41-2F004	2D264		0		19.3		0		0						
HV-E41-2F003	2D264		0		0		0		0						
2P213	2D274		65		0		0		0						
2P216	2D274		11		6		6		6						
HV-B21-2F019	2D274		0		0		0		0						
HV-G33-2F004	2D274		0		0		0		0						
2P215	2D274		23		11.4		11.4		11.4						
2D289	2D289		120		120		120		120						
TOTAL			464.6		158.8		137.4		137.4						
2D289			120		120		120		120						
2D264			245.6		21.4		0		0						
2D274			99		17.4		17.4		17.4						

EQUIPMENT	MCC		0 -60 s		2 - 10 MIN		10-30 MIN		30-240MIN						
HV-E41-2F001	2D264		0		0		0		0						
HV-E41-2F006	2D264		205.5		0		0		0						
HV-E41-2F059	2D264		0		0		0		0						
HV-E41-2F075	2D264		0		0		0		0						
HV-E51-2F084	2D264		0		0		0		0						
HV-E41-2F012	2D264		0		0		0		0						
HV-E41-2F042	2D264		19.3		2.1		0		0						
HV-E41-2F004	2D264		0		19.3		0		0						
HV-E41-2F011	2D264		108.7		0		0		0						
HV-E41-2F003	2D264		0		0		0		0						
2P213	2D274		0		0		0		0						
2P216	2D274		6		6		6		6						
HV-B21-2F019	2D274		0		0		0		0						
HV-G33-2F004	2D274		0		0		0		0						
2P215	2D274		23		11.4		11.4		11.4						
HV-E41-2F008	2D274		164.5		0		0		0						
2D289	2D289		120		120		120		120						
TOTAL			647		158.8		137.4		137.4						
2D289			120		120		120		120						
2D264			224.8		21.4		0		0						
2D274			193.5		17.4		17.4		17.4						

EQUIPMENT	MCC		0 - 60s		2 - 5 MIN		5 - 6 MIN		6-10 MIN		10-30 MIN		30-240MIN		
HV-E41-2F001	2D264		18		0		0		0		0				
HV-E41-2F006	2D264		205.5		205.5		0		0		0				
HV-E41-2F059	2D264		2.8		2.8		0.7		0		0				
HV-E41-2F075	2D264		0		0		0		0		0				
HV-E51-2F084	2D264		0		0		0		0		0				
HV-E41-2F012	2D264		0		0		38.2		0		0				
HV-E41-2F042	2D264		0		0		0		0		0				
HV-E41-2F004	2D264		0		0		0		0		0				
HV-E41-2F011	2D264		0		0		0		0		0				
HV-E41-2F003	2D264		0		0		0		0		0				
2P213	2D274		65		0		65		0		0				
2P216	2D274		11		6		6		6		6				
HV-B21-2F019	2D274		26.4		0		0		0		0				
HV-G33-2F004	2D274		38.2		0		0		0		0				
HV-E41-2F008	2D274		0		0		164.5		0		0				
2P215	2D274		23		11.4		11.4		11.4		11.4				
2D289	2D289		120		120		120		120		120				
TOTAL			509.9		345.7		405.8		137.4		137.4				
2D289			120		120		120		120		120				
2D264			226.3		208.3		38.9		0		0				
2D274			163.6		17.4		246.9		17.4		17.4				

ATTACHMENT 3

2D660

AMPERE-HOURS

The AMPERE-HOURS 2D660 is required to deliver are calculated using the load profiles from Attachment 2. This assures variations in the timing of the MOVs are enveloped.

2D660 BATTERY VOLTAGE AT THE END OF 4 HOURS AT RATED CURRENT AND VOLTAGE LARGE BREAK LOCA

(1) Actual Load (AMPS)	(2) Corrected Load (AMPS) (1) X 1.3875*	(3) Elapsed Time (Min)	(4) Total AMP-HRS Removed
568	788	1	13.1
229	318	10	60.8
138	192	30	124.8
138	192	240	796.8

2D660 BATTERY VOLTAGE AT THE END OF 4 HOURS AT RATED CURRENT AND VOLTAGE LARGE BREAK LOCA HPCI IN PRESSURE CONTROL

(1) Actual Load (AMPS)	(2) Corrected Load (AMPS) (1) X 1.3875*	(3) Elapsed Time (Min)	(4) Total AMP-HRS Removed
686	952	1	15.9
229	318	10	63.6
138	192	30	127.6
138	192	240	799.6

* Corrected Load = (Temperature Correction)(Age Correction)

= (1.11)(1.25) = 1.3875

Temperature Correction = 1.11 for 60°F(From IEEE 485)

Age Correction = 1.25 (IEEE 485)

2D660 BATTERY VOLTAGE AT THE END OF 4 HOURS AT RATED CURRENT AND VOLTAGE SMALL BREAK LOCA

(1) Actual Load (AMPS)	(2) Corrected Load (AMPS) (1) X 1.3875*	(3) Elapsed Time (Min)	(4) Total AMP-HRS Removed
465	645	1	10.8
159	221	10	44.0
138	192	30	108.0
138	192	240	780.0

2D660 BATTERY VOLTAGE AT THE END OF 4 HOURS AT RATED CURRENT AND VOLTAGE SMALL BREAK LOCA HPCI IN PRESSURE CONTROL

(1) Actual Load (AMPS)	(2) Corrected Load (AMPS) (1) X 1.3875*	(3) Elapsed Time (Min)	(4) Total AMP-HRS Removed
647	898	1	15.0
159	221	10	48.2
138	192	30	112.2
138	192	240	784.2

* Corrected Load = (Temperature Correction)(Age Correction)

= (1.11)(1.25) = 1.3875

Temperature Correction = 1.11 for 60°F(From IEEE 485)

Age Correction = 1.25 (IEEE 485)

2D660 BATTERY VOLTAGE AT THE END OF 4 HOURS AT RATED CURRENT AND VOLTAGE STATION BLACKOUT

(1) Actual Load (AMPS)	(2) Corrected Load (AMPS) (1) X 1.3875	(3) Elapsed Time (Min)	(4) Total AMP-HRS Removed
510	708	1	11.8
346	480	5	43.8
406	564	6	53.2
138	192	30	130.0
138	192	240	802.0

2D660 BATTERY VOLTAGE AT THE END OF 4 HOURS AT RATED CURRENT AND VOLTAGE PROPOSED TECHNICAL SPECIFICATION

(1) Actual Load (AMPS)	(2) Corrected Load (AMPS) (1) X 1.3875	(3) Elapsed Time (Min)	(4) Total AMP-HRS Removed
700	972	1	16.2
410	569	10	101.6
150	208	30	171.0
150	208	240	899.0

* Corrected Load = (Temperature Correction)(Age Correction)

= (1.11)(1.25) = 1.3875

Temperature Correction = 1.11 for 60°F(From IEEE 485)

Age Correction = 1.25 (IEEE 485)

2D660 BATTERY VOLTAGE AT THE END OF 4 HOURS AT RATED CURRENT AND VOLTAGE EXISTING TECHNICAL SPECIFICATION

(1) Actual Load (AMPS)	(2) Corrected Load (AMPS) (1) X 1.3875*	(3) Elapsed Time (Min)	(4) Total AMP-HRS Removed
1119	1553	1	25.9
244	339	10	76.7
244	339	30	189.7
244	339	120	698.2
244	339	240	1376.2

* Corrected Load = (Temperature Correction)(Age Correction)

= (1.11)(1.25) = 1.3875

Temperature Correction = 1.11 for 60°F(From IEEE 485)

Age Correction = 1.25 (IEEE 485)

ATTACHMENT 4

2D660

MINIMUM BATTERY TERMINAL

VOLTAGE

2D660
CALCULATE
MINIMUM REQUIRED BATTERY TERMINAL VOLTAGE

The minimum required battery terminal voltage is the voltage required at the END OF DISCHARGE to support the connected load per IEEE 485-1978. This voltage is the minimum Technical Specification voltage requirement.

1.0 The Resistance between the Load Center and MCCs are:

Battery to Load Center	=	0.0024 Ω (From E-AAA-255)
Load Center to 2D264	=	0.0097 Ω (From E-AAA-255)
Load Center to 2D274	=	0.0082 Ω (From E-AAA-255)
Load Center to 2D289	=	0.0156 Ω (From E-AAA-255)

2.0 Determine the voltage at the Load Center while maintaining 210 VDC at the MCCs for the END OF DISCHARGE Load Segment of Battery 2D660 (30 -240 Minutes).

2.1 2D264

The Proposed Technical Specification Profile for the 30 - 240 minute segment is 150 amperes. The largest calculated Class 1E load on 2D264 is 0 A (From Attachment 2) and the largest calculated battery load profile is 137.4 amperes (From Attachment 2). The 12.6 ampere differences between the two profiles is added to the Class 1E MCC 2D264.

$I_{2D264} = 12.6$ A

$V_{LC} = 210 + V_{DROP} = 210 + (0.0097)(12.6) = 210.2$ V

2.2 2D274

The Proposed Technical Specification Profile for the 30 - 240 minute segment is 150 amperes. The largest calculated Class 1E load on 2D274 is 17.4 A (From Attachment 2) and the largest calculated battery load profile is 137.4 amperes (From Attachment 2). The 12.6 ampere differences between the two profiles is added to the Class 1E MCC 2D274.

$I_{2D274} = 12.6$ A + 17.4 A = 30 A

$V_{LC} = 210 + V_{DROP} = 210 + (0.0082)(30) = 210.3$ V

2.3 2D289

The Proposed Technical Specification Profile for the 30 - 240 minute segment is 150 amperes. The largest calculated load on 2D289 is 120 A (From Attachment 2) and the largest calculated battery load profile is 137.4 amperes (From Attachment 2). The 12.6 ampere differences between the two profiles is added to the 2D289.

I_{2D289} = (120A + 12.6A) = 132.6 A

V_{LC} = 210 + V_{DROP} = 210 + (0.0156)(132.6) = 212.1 V

3.0 Determine the Battery Terminal Voltage to maintain 210 VDC at the MCCs for the END OF DISCHARGE Load Segment of Battery 2D660.

Use the Load Center voltage required to maintain 210 V at 2D289 since this voltage requires the higher battery voltage.

$V_{BATTERY}$ = V_{LC} + $V_{Drop\ Batt\ to\ LC}$

I = 150 A

$V_{BATTERY}$ = 212.1 V + (150)(0.0024)

= 212.5 V

4.0 Determine the Volts per cell that must be used in sizing the Class 1E 120 cell battery in order to maintain a battery voltage of 213.8 at END OF DISCHARGE.

VPC = 212.5/120 = 1.7708

USE 1.78 VPC

Lowest Expected Electrolyte Temp: 60 Deg F | Minimum Cell Voltage: 1.78 | Cell MFR: C&D | Cell Type: LCR - 25

Section	Load (Amperes)	Change in Load (Amperes)	Duration of Period (Minutes)	Time to End of Section (Minutes)	Capacity at T Min Rate Amps/Pos Plate	Required Section Size	
						Pos Values	Neg Values
Section 1- First Period Only - If A2 is greater than A1 go to Section 2.							
1	A1 700	A1-0 700	M1 = 1	T=M1 = 1	129.1	5.42	
					Sub Total	5.42	
					Total	5.42	
Section 2- First Two Periods Only - If A3 is greater than A2, go to Section 3.							
1	A1 = 700	A1-0 = 700	M1 = 1	T=M1+M2 = 10	116.3	6.02	
2	A2 = 410	A2-A1 = -290	M2 = 9	T=M2 = 9	117.3	0.00	-2.47
					Sub Total	6.02	-2.47
					Total	3.55	
Section 3- First Three Periods Only - If A4 is greater than A3, go to Section 4.							
1	A1 = 700	A1-0 = 700	M1 = 1	T=M1+M2+M3 = 30	93.2	7.51	
2	A2 = 410	A2-A1 = -290	M2 = 9	T=M2+M3 = 29	94.7	0.00	-3.06
3	A3 = 150	A3-A2 = -260	M3 = 20	T=M3 = 20	105.7	0.00	-2.46
					Sub Total	7.51	-5.52
					Total	1.99	
Section 4 - First Four Periods Only - If A5 is greater than A4, go to Section 5.							
1	A1 = 700	A2-A1 = 700	M1 = 1	T=M1+M2+M3+M 240	29.2	23.97	
2	A2 = 410	A2-A1 = -290	M2 = 9	T=M2+M3+M4 = 239	30.0	0.00	-9.67
3	A3 = 150	A3-A2 = -260	M3 = 20	T=M3+M4 = 230	30.5	0.00	-8.52
4	A4 = 150	A4-A3 = 0	M4 = 210	T=M4 = 210	32.6	0.00	0.00
					Sub Total	23.97	-18.19
					Total	5.78	

Max Section Size: 5.42 + Random Section 0 = Uncorrected Size (US): 5.42

US X Temp Correction 1.11 X Design Margin 1.0 X Aging Factor 1.25 = 7.52

Required Cell Size: 8

2D660SZ.XLS

Dept. Sys Anal Date Oct, 1994 Designed by J P Akus Approved by	PENNSYLVANIA POWER & LIGHT COMPANY CALCULATION SHEET Project: 250 VDC Battery 2D660 - Battery and Battery Charger Sizing Calculation	Calc #. EC-088-0506 Sht No. 18 of 19

ATTACHMENT TO PLA-4375
Page 21 of 23

CHARGER CAPACITY FOR 250 VDC BATTERY 2D660

The Ampere capacity of the Battery charger is calculated as follows:

I1 = Lc + (1.1Ah)/T (From IEEE 946)

I2 = Lc + Ln (From IEEE 946)

I1 = AMPS, CHARGER CAPACITY
I3 = Recommended Charger Rated Output (Larger of I1 or I2)
Lc = CONTINUOUS LOAD AMPS
Ln = Largest noncontinuous load during normal plant operation
Ah = CALCULATED AMP-HRS EMERGENCY DISCHARGE
T = DESIRED DISCHARGE TIME IN HOURS

Emergency Discharge of Battery

Ah = I1T1 + I2T2 + I3T3 + I4T4 (AMP-HRS)

The Technical Specification Load Profiles shall be used for the to determine the Emergency Discharge of the Battery. (From EC-088-1005)

TIME	CURRENT (AMPS)
0 -60 sec	700
60 sec - 10 Min	410
10 - 30 Min	150
30 - 240 Min	150

Ah= (800)(1)/60 + (610)(9)/60 + (535)(20)/60 +(27)(210)/60

Ah 648.2

Continuous Load

The continuous Load amps on the Battery during normal plant operation are:

Load	Amperes
2D289	120

Recharge Time (HRS) 12

Largest Noncontinuous Load

During normal plant operation the following is the largest load expected to be operating. This load operates during system testing.

Load	Amperes
HV-E41-2F006	39

Dept.	Sys Anal	PENNSYLVANIA POWER & LIGHT COMPANY	Calc #. EC-088-0506
ate	Oct, 1994	CALCULATION SHEET	
esigned by	J P Akus	Project:	Sht No. 19 of 19
Approved by		250 VDC Battery 2D660 - Battery and Battery Charger Sizing Calculation	

Determine the required Charger Output Capacity

$I1 = Lc + (1.1Ah)/T$

$I1 =$ 179.4

$I2 = Lc + Ln$

$I2 =$ 159

I3 =	179.4

Therefore for 250 VDC Battery 2D660, the existing one (1), 300 Amp rated Battery Charger is adequate.