Attachment D

CALCULATION NOTE COVER SHEET

Section To Be Completed By Author(s):

Calc-Note Number: DR-CN-92-006 **Revision Number:** 0

Title:

RECOVERY OF POWER PROBABILITIES FOR DRESDEN IPE

Project: DRESDEN IPE
Shop Order: N\A

Purpose: TO DOCUMENT THE SOURCE OF THE PROBABILITIES USED FOR TWO NODES IN THE DRESDEN LOSS OF OFFSITE POWER AND STATION BLACKOUT PLANT RESPONSE TREES.

Results Summary: THE DRESDEN STATION IS CONSIDERED TO BE IN THE ~~OF~~ OFFSITE POWER RECOVERY CLUSTER GROUP #1. ACTUAL PROBABILITIES OF NOT RECOVERING POWER AT SPECIFIC TIMES ARE SHOWN IN SECTION 4.

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CALC-NOTE NUMBER: DR-CN-92-006 REV. 0

CALCULATION NOTE METHODOLOGY CHECKLIST

CHECKLIST TO BE COMPLETED BY AUTHOR(S): (CHECK APPROPRIATE RESPONSE)

1.	Is the Subject and/or the Purpose of the Design Analysis Clearly Stated?	(YES) NO
2.	Are the Required Inputs and Their Sources Provided?	(YES) NO N/A
3.	Are the Assumptions Clearly Identified and Justified?	(YES) NO N/A
4.	Are the Methods and Units Clearly Identified?	(YES) NO N/A
5.	Are the Results of Literature Searches, if Conducted, and Other Background Data provided?	(YES) NO N/A
6.	Are all the Pages Sequentially Numbered and Identified by the Calculation Note Number?	(YES) NO
7.	Is the Project or Shop Order Clearly Identified?	YES NO (N/A)
8.	Has the Required Computer Calculation Information Been Provided?	YES NO (N/A)
9.	Were the Computer Codes Used Under Configuration Control?	YES NO (N/A)
10.	Are the Results and Conclusions Clearly Stated?	(YES) NO
11.	Were Approved Design Controlled Practices Followed Without Exception?	(YES) NO

NOTE: IF 'NO' TO ANY OF THE ABOVE, PAGE NUMBER CONTAINING JUSTIFICATION:__________

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1.0 INTRODUCTION

The purpose of this calculation note is to document the source of the probabilities used for two nodes in the Dresden Loss of Offsite Power and Station Blackout Plant Response Tree notebooks (References 1 and 2). The two nodes in question are:

ROP1 - Recovery of Offsite Power in Time to Preclude Core Damage

ROP2 - Recovery of Offsite Power in Time to Preclude Containment Failure

The methodology used to determine these probabilities is contained in this document and is based on the information found in NUREG-1032 "Evaluation of Station Blackout Accidents at Nuclear Power Plants" (Reference 3).

The steps to determine these probabilities include:

- Determine the "Offsite Power Cluster Group" that Dresden should be included in by implementing the selection criteria found in NUREG-1032.
- Determine the probability of recovering power in time to prevent core damage (ROP1) using the frequency distributions contained in NUREG-1032.
- Determine the conditional probability of power recovery for the time corresponding to ROP2, given failure of power recovery at the time corresponding to ROP1.

Each of these steps will be discussed in detail in the following sections.

2.0 DETERMINATION OF POWER CLUSTER SUBGROUPS

The Offsite Power Cluster Grouping is an attempt to account for any relationship between switchyard design characteristics, local weather, power recovery procedures, and the duration of loss of offsite power events at a given plant. The methodology used to determine the appropriate Offsite Power Cluster Group is based on the selection criteria found in Tables A.2, A.3, A.6 and Tables A.8 through A.11 of NUREG-1032. The Offsite Power Cluster Group is determined by the unique combination of four subgroups. These subgroups, defined by grid design and local weather, are shown below:

1. Switchyard Configuration Group (I1, I2, I3)
2. Grid Reliability/Recovery Group (G1, G2, G3, G4)
3. Severe-Weather-Induced Loss of Offsite Power Frequency/ Recovery Group (SR1, SR2, SR3, SR4, SR5, SR6, SR7, SR8, SR9, SR10)
4. Extremely Severe-Weather-Induced Loss of Offsite Power Frequency Group (SS1, SS2, SS3, SS4, SS5)

Two factors, grid and switchyard design, are potentially significant with regard to frequency and duration of loss of offsite power events. The impact of these design factors is determined by declaring yes or no to the following statements. The unique blend of yes and no responses define the impact of these features and the subsequent Switchyard Configuration Group to which the plant belongs.

A. Independence of offsite power sources to the nuclear plant.

1. All offsite power sources are connected to the plant through one switchyard. **NO**
2. All offsite power sources are connected to the plant through two or more switchyards, and the switchyards are electrically connected. **YES**
3. All offsite power sources are connected to the plant through two or more switchyards or separate incoming transmission lines, but at least one of the AC sources is electrically independent of the others. **NO**

B. Automatic and manual transfer schemes for the Class 1E buses when the normal source of AC power fails and when the backup sources of offsite power fail.

1. If the normal source of AC power fails, there are no automatic transfers and there is one or more manual transfers to preferred or alternate offsite power sources. **NO**

2. If the normal source of AC power fails, there is one automatic transfer but no manual transfers to preferred or alternate offsite power sources. **NO**

   a. All of the Class 1E buses in a unit are connected to the same preferred power source after the automatic transfer of power sources. **YES**

   b. The Class 1E buses in a unit are connected to separate offsite power sources after the automatic transfer of power sources. **NO**

3. After loss of the normal AC power source, there is one automatic transfer. If this source fails, there may be one or more manual transfers of power sources to preferred or alternate offsite power sources. **YES**

   a. All of the Class 1E buses in a unit are connected to one preferred power source after the first automatic transfer. **YES**

   b. The Class 1E buses in a unit are connected to separate offsite power sources after the first automatic transfer. **NO**

4. If the normal source of AC power fails, there is an automatic transfer to a preferred source of power. If this preferred source of power fails, there is an automatic transfer to another source of offsite power. **NO**

   a. All of the Class 1E buses in a unit are connected to the same preferred power source after the first automatic transfer. **NO**

   b. The Class 1E buses in a unit are connected to separate offsite power sources after the first automatic transfer of power source. **NO**

The responses to the above statements are based on information contained in the Electric Power Systems Notebook (Reference 4) and show that Dresden falls into Switchyard Configuration Group I2. All group designations based on design factors are shown in Table 1 of Appendix A.

2.1 Grid Reliability/Recovery Group

The Grid Reliability/Recovery Group combines the inherent reliability of the local power grid and the ability of the plant to rapidly recover from the loss of power into a single factor. From the Dresden Initiating Events Notebook (Reference 5), the frequency of grid related losses is 2.7E-3 per year. Dresden has never experienced a grid related loss of offsite power. NUREG-1032 implies use of a grid loss frequency of 1E-2 per year if no loss of power events have occurred at the individual site. However, use of either frequency will place Dresden in Grid Group G1. Table 2 of Appendix A shows the relationship of grid loss frequency to Grid Group.

The next step in determining the Grid Reliability/Recovery Group is to identify the recovery group. The recovery group qualitatively identifies the plants ability to recover power within 1/2 hour following a grid blackout. The plant must have the capability and procedures to recover offsite (nonemergency) AC power to the site within 1/2 hour following a grid blackout to be considered in the R1 group. By default, all other plants not in the R1 group are contained in the R2 group. Dresden does not have specific procedures in place for recovering power in this time frame and therefore falls into the R2 recovery group. This combination of factors leads to a Grid Reliability/Recovery Group of GR5 as identified by Table 3 of Appendix A.

2.2 Severe Weather/Recovery Group

The severe weather/recovery group combines the likelihood of loss of offsite power due to severe weather events with the ability of the plant to recover from the event in a rapid manner into a single factor. From the Dresden Initiating Events Notebook, the frequency of severe weather related loss of offsite power events at the Dresden station is 8.4E-3 per year. This frequency in combination with the recovery group R2, identified earlier in section 2.1, defines a Severe Weather/Recovery Group of SR7. Tables 4 and 5 in Appendix A show the manner in which severe weather frequency and plant recovery ability are grouped to arrive at the SR7 group designation.

2.3 Extremely Severe Weather Loss of Offsite Power Frequency Group

This group is determined strictly by the frequency of extremely severe weather, postulated in this case. This event consists of losses of offsite power caused by extreme weather such as hurricanes, very high winds (greater than 125 mph) and major damage to switchyards due to tornado strikes. Restoration of offsite power following these events is assumed to require at least 24 hours. The Dresden Initiating Events Notebook gives a frequency of 1E-4 per year for this type of event. The group designators associated with each occurrence frequency range are shown in Table 6 of Appendix A. With an occurrence frequency of 1E-4, Dresden is considered to be in group SS1.

3.0 DETERMINATION OF OFFSITE POWER CLUSTER GROUP

The subgroups previously defined in section two permit determination of the offsite power cluster group. These subgroups I2, G1, SR7 and SS1 can be inserted into the matrix shown in Table 7 of Appendix A to determine the proper cluster group. The results of this process show that Dresden should be included in Offsite Power Cluster Group 1.

4.0 PROBABILITY OF NOT RECOVERING POWER AT TIME X (ROP1)

NUREG-1032 gives frequency distributions for durations of loss of offsite power events for each of the cluster groups (table A.11 of Reference 3). The probability of not recovering power at each hour was derived using the median values of the frequency distribution data contained in this table. The frequency at each time interval was divided by the frequency at time = 0 hours to normalize the values and thus render probabilities. Since the information contained in NUREG-1032 did not have values for every hour, values for each missing hour through 16 hours were obtained by using log extrapolations, which provide a good fit to the to the loss of offsite power frequency duration curves presented in Figure A.15 of NUREG-1032. The values for each of the intermediate hours not given was estimated by the following equation:

10^((LOG(x)+LOG(y))/2)
where x = probability at each hour
and y = probability at the next succeeding hour given

This equation gives a value for a point midway between two known times x and y. The results of applying this equation can then be used again to determine a new intermediate value and the equation reapplied until all the unknown values are determined. This information is summarized in the following table for Offsite Power Cluster Group 1 for events of up to 16 hours duration.

DURATION (HR)	Loss of offsite power frequency (Table A.11 of NUREG-1032)		Probability of not recovering power
	Freq	Normalized	
0	0.0845	1.000E+00	1.000E+00
1/2	N/A	N/A	4.981E-01
1	N/A	N/A	2.481E-01
2	0.0052	6.154E-02	6.154E-02
3	N/A	N/A	4.267E-02
4	0.0025	2.959E-02	2.959E-02
5	N/A	N/A	2.463E-02
6	N/A	N/A	2.050E-02
7	N/A	N/A	1.706E-02
8	0.0012	1.420E-02	1.420E-02
9	N/A	N/A	1.273E-02
10	N/A	N/A	1.141E-02
11	N/A	N/A	1.023E-02
12	N/A	N/A	9.167E-03
13	N/A	N/A	8.217E-03
14	N/A	N/A	7.365E-03
15	N/A	N/A	6.601E-03
16	0.0005	5.917E-03	5.917E-03

5.0 CONDITIONAL PROBABILITY OF NOT RECOVERING POWER AT TIME X+i (ROP2)

The Station Blackout Plant Response trees ask the power recovery question twice. The first, ROP1, is the non-recovery probability corresponding to the latest time that power can be recovered to prevent core damage. The second, ROP2, is the non-recovery probability corresponding is the latest time that power can be recovered to prevent containment failure. However, ROP2 is a conditional probability influenced by the previous failure of ROP1. ROP2 is therefore the probability that power is not restored at X+i hours, given that it was not restored at X hours (ROP1). Since ROP1 accounts for that portion of the non-recovery probability in the 0 to X hour period, ROP2 must only account for the fractional non-recovery probability that occurs in the intervening period between X and X+i hours. This relationship can be expressed mathematically by the following equation:

$$\text{ROP2} = \frac{\text{probability of non-recovery at time X (ROP1)}}{\text{probability of non-recovery at time X+i}}$$

Because of the many combinations of times for which ROP2 must be calculated, only the methodology is presented here. The results of the individual calculations will be contained in their respective nodes in the Loss of Offsite Power and Station Blackout Event trees.

6.0 REFERENCES

1. Loss of Offsite Power Event Tree Notebook, Dresden Station Units 2 and 3, prepared by IPEP, (To be provided at a later date).

2. Station Blackout Event Tree Notebook, Dresden Station Units 2 and 3, prepared by IPEP, (To be provided at a later date).

3. Baranowsky, P.W., et. al., "Evaluation of Station Blackout Events at Nuclear Power Plants", U.S. NRC Report NUREG-1032, June 1988.

4. Electric Power Systems Notebook, Dresden Station Units 2 and 3, prepared by IPEP, (To be provided at a later date).

5. Initiating Events Notebook, Dresden Station Units 2 and 3, prepared by IPEP, (to be provided at a later date).

APPENDIX A

TABLE 1

DEFINITION OF SWITCHYARD CONFIGURATION GROUPS	
GROUP	FACTOR
I1	A1, A2, or A3 and B4
I2	A1 or A2 and B2b or B3
I3	A1 or A2 and B1 or B2a

TABLE 2

DEFINITION OF FREQUENCY OF GRID GROUPS	
GROUP	FREQUENCY OF GRID LOSS PER SITE YEAR
G1	less than 1.67E-2
G2	1.67E-2 to 5.0E-2
G3	5.0E-2 to 0.167
G4	equal to or greater than 0.167

TABLE 3

DEFINITION OF GR GROUPS		
FREQUENCY GROUP	RECOVERY GROUP	GRID RELIABILITY/RECOVERY GROUP (GR)
G1	R1	GR1
G2	R1	GR2
G3	R1	GR3
G4	R1	GR4
G1	R2	GR5
G2	R2	GR6
G3	R2	GR7

TABLE 4

DEFINITION OF FREQUENCY OF SEVERE-WEATHER GROUPS	
GROUP	FREQUENCY PER SITE YEAR
S1	less than 3.0E-3
S2	3.0E-3 to 1.0E-2
S3	1.0E-2 to 3.0E-2
S4	3.0E-2 to 0.1
S5	0.1 to 0.33

TABLE 5

DEFINITION OF SR GROUPS		
FREQUENCY GROUP	RECOVERY GROUP	SEVERE-WEATHER/RECOVERY GROUP
S1	R1	SR1
S2	R1	SR2
S3	R1	SR3
S4	R1	SR4
S5	R1	SR5
S1	R2	SR6
S2	R2	SR7
S3	R2	SR8
S4	R2	SR9
S5	R2	SR10

TABLE 6

DEFINITION OF EXTREMELY-SEVERE-WEATHER-INDUCED GROUPS	
GROUP	FREQUENCY PER SITE YEAR
SS1	less than 3.0E-4
SS2	3.04E-4 to 8.3E-4
SS3	8.3E-4 to 3.0E-3
SS4	3.0E-3 to 1.0E-2
SS5	greater than or equal to 1.0E-2

TABLE 7

CLASSIFICATION OF OFFSITE POWER CLUSTER GROUPS				
CLUSTER GROUP	I	GR	SR	SS
1	1,2 1,2 1,2	1,3,5 1,3,5 1,3,5	1,2,6,7 1,6 3	1,2 3 1,2
2	1,2 1,2 1,2 1,2 3 3 3 3	1,3,5 1,3,5 1,3,5 1,3,5 1,3,5 1,3,5 1,3,5 1,3,5	8 4 2,3,7 1,6 1,2,6,7 3,8 3 4	1,2,3 1-4 3,4 4 1-4 1,2 3,4 1-4
3	same as cluster 2 and 1	7	same as cluster 2 and 1	same as cluster 2 and 1
4	1,2,3	1,3,5,7	10	1-5

NUREG 1032 DISTRIBUTIONS
PROBABILITY OF NOT RECOVERING POWER

	CLUSTER GROUPS				
TIME	1	2	3	4	5
0	1.000E+00	1.000E+00	1.000E+00	1.000E+00	1.000E+00
1	2.481E-01	3.682E-01	4.105E-01	4.663E-01	6.622E-01
2	6.154E-02	1.356E-01	1.685E-01	2.174E-01	4.385E-01
3	4.267E-02	9.553E-02	1.198E-01	1.668E-01	3.567E-01
4	2.959E-02	6.731E-02	8.509E-02	1.279E-01	2.902E-01
5	2.463E-02	5.852E-02	6.648E-02	1.184E-01	2.393E-01
6	2.050E-02	5.088E-02	5.194E-02	1.097E-01	1.974E-01
7	1.706E-02	4.424E-02	4.058E-02	1.016E-01	1.628E-01
8	1.420E-02	3.846E-02	3.170E-02	9.403E-02	1.343E-01
9	1.273E-02	3.569E-02	2.725E-02	8.462E-02	1.142E-01
10	1.141E-02	3.312E-02	2.343E-02	7.615E-02	9.717E-02
11	1.023E-02	3.074E-02	2.014E-02	8.265E-02	7.030E-02
12	9.167E-03	2.852E-02	1.731E-02	6.167E-02	7.030E-02
13	8.217E-03	2.647E-02	1.488E-02	5.550E-02	5.979E-02
14	7.365E-03	2.456E-02	1.279E-02	4.994E-02	5.086E-02
15	6.601E-03	2.280E-02	1.100E-02	4.494E-02	4.326E-02
16	5.917E-03	2.115E-02	9.455E-03	4.044E-02	3.679E-02
17	5.304E-03	1.963E-02	8.128E-03	3.640E-02	3.130E-02
18	4.754E-03	1.822E-02	6.987E-03	3.275E-02	2.662E-02
19	4.261E-03	1.691E-02	6.007E-03	2.948E-02	2.264E-02
20	3.820E-03	1.569E-02	5.164E-03	2.652E-02	1.926E-02
21	3.424E-03	1.456E-02	4.439E-03	2.387E-02	1.638E-02
22	3.069E-03	1.351E-02	3.816E-03	2.148E-02	1.393E-02
23	2.751E-03	1.254E-02	3.280E-03	1.933E-02	1.185E-02
24	2.465E-03	1.63E-02	2.820E-03	1.740E-02	1.008E-02