50-237 CEC DRESDEN 2

SUMMARY OF MEETING ON INDIVIDUAL PLANT EXAMS FOR EXTERNAL EVENTS

REC'D W/LTR DTD 09/23/93....9310010137

ENCLOSURE 1

LIST OF ATTENDEES

SEPTEMBER 14, 1993, MEETING ON

INDIVIDUAL PLANT EXAMINATIONS FOR EXTERNAL EVENTS

NAME	AFFILIATION
Byron Siegel	NRR/PDIII-2
L. B. Marsh	NRR/CBLA
David Jeng	NRR/DE/ECGB
Robert Rothman	NRR/DE/ECGB
Goutam Bagchi	NRR/DE/ECGB
Phyllis Sobel	NRR/DE/ECGB
Yong Kim	NRR/DE/ECGB
John Chen	RES/SAIB
Charles Ader	RES/SAIB
John Flack	RES/SAIB
Edward Rodrick	RES/SAIB
Nilesh Chokshi	RES/SSEB
Roger Kenneally	RES/SSEB
Carlos Diaz	CECo/NETS
Stephen Stimac	CECo/NETS
S. Kong Wang	CECo/NETS
G. T. Klopp	CECo/NETS
T. Lechton	CECo/NETS
Farid Zikria	NUS
Nayeem Farukhi	NUMARC
George Wrobel	Rochester Gas & Electric

ENCLOSURE 2

COMMONWEALTH EDISON'S APPROACH TO IPEEE

Presented By: T. Lechton
G. Klopp
K. Wang
C. Diaz

September 14, 1993

OVERVIEW

- HISTORY
- TEAM STRUCTURE
- AGENDA
- PURPOSE

HISTORY

6/28/91	Generic Letter 88-20 Supplement 4 issued.
12/24/91	CECo submits response to GL-88-20 Sup.4. Agrees to walkdowns and careful screening analysis. Considers integration with SQUG effort.
7/27/92	NRC acknowledges CECo's proposal of use of alternate method. Additional information sought.

9/18/92 CECo provides details on approach utilizing IPEs, expert walkdowns and focused scope PRAs.

10/15/92 Presentation made by CECo to NRC on use of screening approach.

12/14/92 NRC requested additional information on program to obtain better understanding of methodology and schedule.

SQUG/IPEEE Project Team

G. Wagner
Sponsor

T. Lechton
Team Leader

IPEEE Engineers
- G. Klopp [PRA]
- K. Wang [PRA]
- C. Diaz [Fire Prot.]

SQUG Engineers
- N. Smith
- B. Lory
- P. Donavan

Site Engineers
- J. Wethington [Quad Cities]
- D. Beutel [Zion]
- D. Robinson [Byron]
- D. Christiana [Braidwood]
- L. Wright [Dresden]

Reg. Assurance
- E. White

* The LaSalle IPEEE was performed by Sandia Labs

SQUG/IPEEE PROJECT TEAM

Terri Lechton - BS Mechanical Engineering/MBA
13 Years industry experience in plant testing, operations, and engineering. Certified SRO.

George Klopp - BS/MS Mechanical Engineering
28 Years experience in areas of engineering, plant testing, operations, and PRA. 14 Years experience in PRA. Experience at all 6 CECo nuclear stations. Participated extensively in IDCDR program and NUMARC Accident Management activities. Author of a number of publications on PRA. Listed as IAES expert on PRA.

S. Kong Wang - BS/MS/PhD Nuclear Engineering
8 Years industry experience. Assessed safety-related systems and containment integrity as A/E. Performed analytical studies in LWR severe accidents for a national laboratory.

Carlos Diaz - BS Fire Protection Engineering
9 Years fire protection experience. Performed fire protection studies for 2 national laboratories.

Neil Smith - BS Electrical Engineering/MBA
Registered Professional Engineer. Chairman of SQUG for 11 years. Served on the EPRI Seismic Center Committee, NUMARC Seismic Issue Working Group, and EPRI seismicity Owners Group.

Bruce Lory - BS Mechanical Engineering
14 Years experience in seismic and environmental qualification. Technical Chairman for SQURTS.

Paul Donavan - BS Mechanical Engineering
17 Years industry experience specializing in piping analysis for snubber reduction and pipe transient analysis. Serves on several codes & standards committee for piping.

Jim Wethington - BS Mechanical Engineering
11 Years industry experience, Licensed SRO, Station Mechanical Lead.

Doug Beutel - BS Mechanical Engineering
Registered Professional Engineer. 13 Years industry experience in seismic analysis (11 as A/E).

Don Robinson - BS Electrical Engineering
21 Years industry experience. IPE Program Engineer for Byron Station.

Dan Christiana - BS Mechanical Engineering
15 Years industry experience in engineering , construction, and startup.

Leslie Wright - BS Chemical Engineering
11 Years industry experience in engineering.

MEETING AGENDA
COMMONWEALTH EDISON'S APPROACH TO IPEEE
TUESDAY, SEPTEMBER 14, 1993

1.	Overview of Previous Commitments/ Meetings, and Team Approach Being Used at CECo. (15 mins.)	T. Lechton
2.	Introduction to the IPEEE Matrix Approach for Screening and Evaluation (30 mins.)	G. Klopp
3.	Application of the Approach to Seismic Examples (30 mins.)	K. Wang
4.	Application of the Approach to Fire Examples (30 mins.)	C. Diaz
5.	Overview of Completion Schedule (15 mins.)	T. Lechton
6.	Discussion and Questions (60 mins.)	All

PURPOSE

* Describe the IPE structure & features.
* Describe the derivation of the matrix model.
* Describe general approach to the use of the matrix model for IPEEE.
* Describe the multi-stage screening and evaluation process for the seismic and fire events.
* Show, by example, how the matrix model can be applied to seismic and fire applications.
* Describe planned dates for IPEEE and SQUG walkdowns.
* Obtain feedback on the matrix model approach.
* Obtain NRC confidence in the usage of the matrix model approach as an alternate means of addressing IPEEE.

COMMONWEALTH EDISON
IPEEE PROGRAM

IPE BASED MATRIX FORMULATION FOR IPEEE

GEORGE KLOPP
SENIOR TECHNICAL EXPERT PRA

EDISON IPE FEATURES

1. SUPPORT STATE MODEL

    A. SUPPORT STATE EVENT TREE

    B. SUPPORT SYSTEM FAULT TREES

    C. EXPLICIT SUPPORT SYSTEM DEPENDENCY ON THE INITIATING EVENT

    D. DUAL UNIT REPRESENTATION

    E. FULL SUPPORT SYSTEM INTER-DEPENDENCY MODEL

2. LARGE PLANT RESPONSE TREE MODEL (EVENT TREE MODEL)

   A. FRONT LINE SYSTEMS

   B. EOP MANDATED OPERATOR ACTIONS

   C. REALISTIC SUCCESS CRITERIA

   D. INTEGRATED CONTAINMENT AND CONTAINMENT SYSTEMS RESPONSE MODELLING

3. EXTENSIVE USE OF MAAP CODE (HUNDREDS OF RUNS) TO ENVELOP THE REALISTIC PLANT BEHAVIOR

4. IPE REPRESENTS A HUGE BODY OF KNOWLEDGE ON PLANT SEVERE ACCIDENT BEHAVIOR

5. PLANT RESPONSE TO ALMOST ALL EXTERNALLY INITIATED EVENTS WILL BE AVAILABLE IN THE IPE ITSELF

EDISON IPE STRUCTURE

1. INITIATING EVENT LIST
2. SUPPORT STATE EVENT TREES
3. PLANT RESPONSE TREES
4. SUPPORT SYSTEM FAULT TREES
5. FRONT LINE SYSTEM FAULT TREES
6. HRA FOR TOP EVENT EOP RESPONSES

IPE TYPICAL

INITIATING EVENT LIST

Event	Frequency
1. LARGE LOCA	3E-4/YR
2. MEDIUM LOCA	8E-4/YR
3. SMALL LOCA	3E-3/YR
•	•
•	•
•	•
•	•
•	•
10. LOSS OF DC POWER	8.7E-4/YR

SUPPORT STATE EVENT TREES

1. Number of Trees - function of initiating event groupings.

   (Example: LOCA's tend to use same tree)

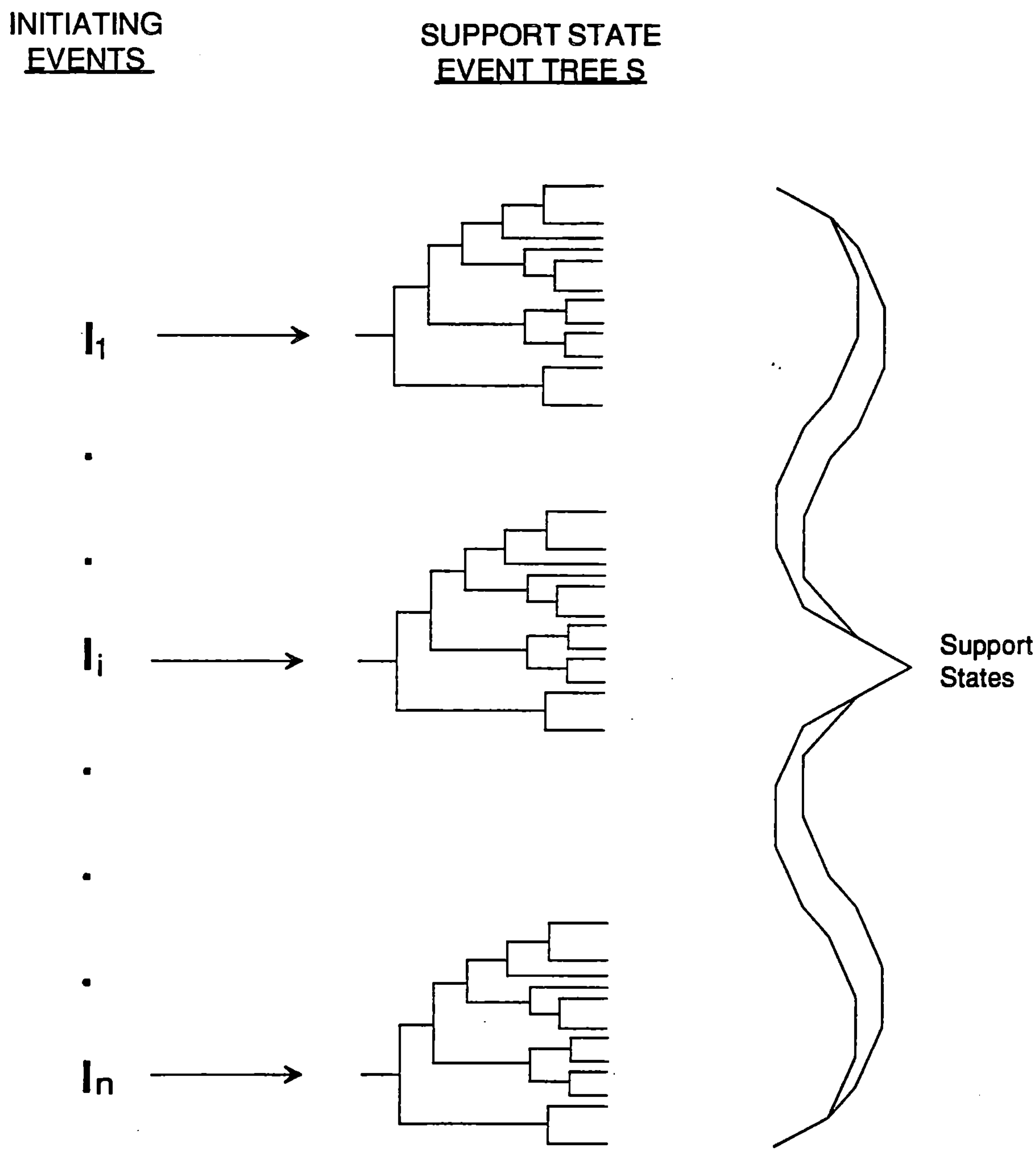
2. Top events or nodes are success/fail for support systems such as:

   - AC power Bus XXX
   - DC power Bus YYY
   - Diesel Generator WWW
   - Service Water Supply
   - Closed Cooling Water Supply

3. Typical Tree - up to 20 nodes

4. Output: Each Event Tree Branch is a Unique Support State

5. Quantify a Support State Event Tree for each initiating event


INITIATING
EVENTS
SUPPORT STATE
EVENT TREES
I_1
I_i
I_n
Support
States

PLANT RESPONSE TREES (PRT)

1. One plant response Tree for each initiating event.

2. Top events, or nodes, are success/fail for Front Line Systems & EOD Mandated Operator Actions such as:

    - High Pressure Injection Functions
    - Auxiliary Feedwater Functions
    - Operator Acts to De-Pressurize RCS
    - Steam Generator PORV Functions
    - Containment Fan Coolers Function

3. Typical PRT has up to 30 Top Events or Nodes

4. Quantify PRT for Each Support State.

5. Output: Each Branch Point is a Plant State. Many duplications.

    Each Branch Point is the culmination of a unique accident sequence.

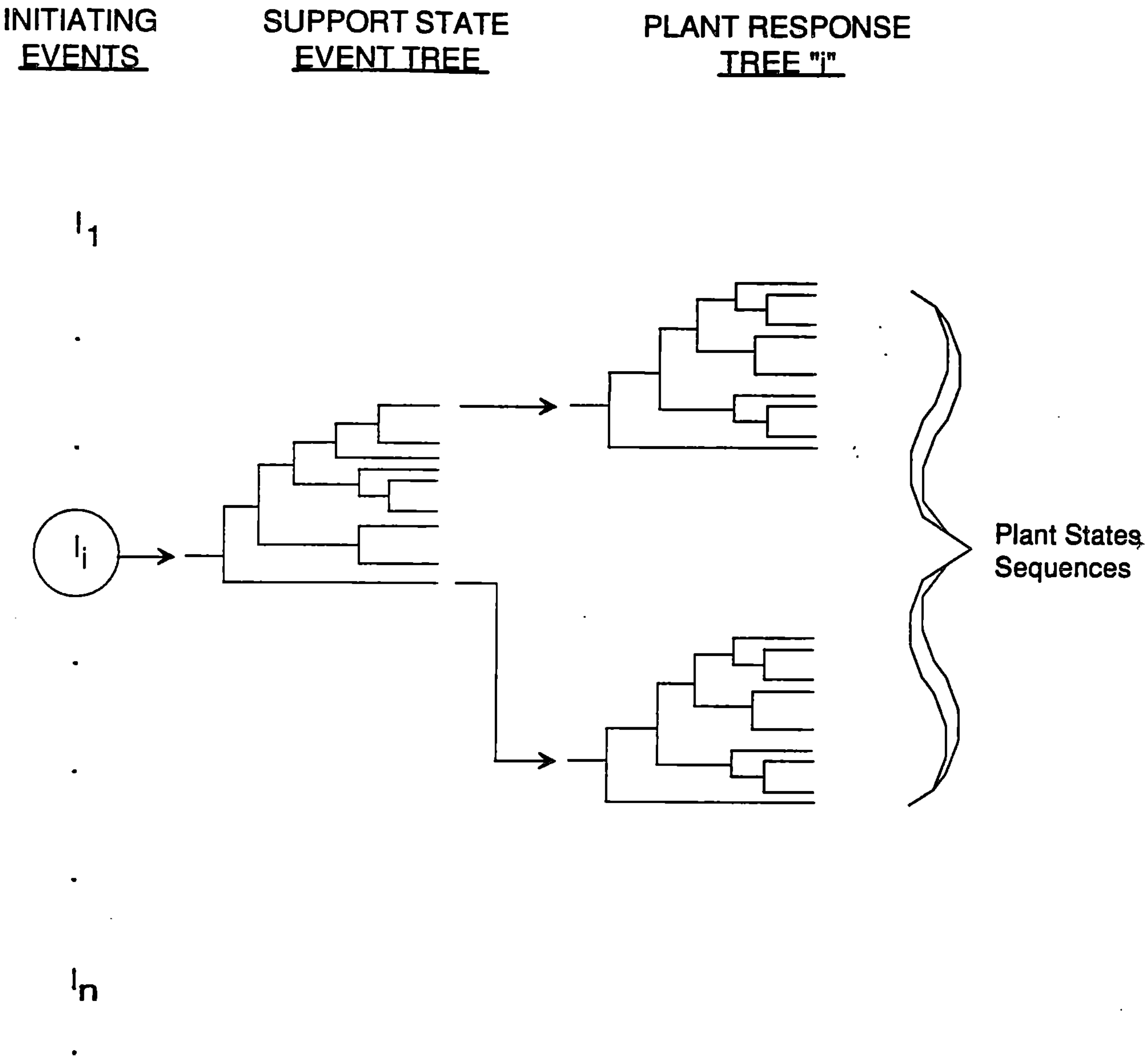

INITIATING EVENTS
SUPPORT STATE EVENT TREE
PLANT RESPONSE TREE "j"
I_1
I_i
I_n
Plant States Sequences

TABLE 4.5.3-1
DOMINANT ACCIDENT SEQUENCES FOR BASE IPE MODEL QUANTIFICATION

Number (1)	Frequency (2)	Percent (3)	Damage State (4)	Event (5)	Value (6)	Description (7)
1	8.18E-06	44.15%	DLCOM	LDC	8.70E-04	LOSS OF DC POWER IE
				SPC	1.03E-02	SPC FAILS; 24, 29, 2R1 AVAILABLE
2	1.67E-06	9.02%	DLCOM	LDC	8.70E-04	LOSS OF DC POWER IE
				OSPC	2.10E-03	OPTR FAILS TO ALIGN FOR SPC
3	5.05E-07	2.73%	MLCOM	MLOCA	8.00E-04	MLOCA IE
				OSPC	6.60E-04	OPTR FAILS TO ALIGN FOR SPC
4	4.28E-07	2.31%	LLCOM	LOOP	9.60E-02	LOSS OF OFFSITE POWER IE
				DGB	9.50E-02	LOSS OF DG2/3, 6 HRS
				24	7.80E-03	LOSS OF BUS 24/24-1 AVAILABLE, 24HR
				OMUP	7.90E-03	OPTR FAILS TO PROVIDE M/U TO IC
				ROP1	1.00E+00	EVENT FAILURE
				LP	1.00E+00	LP B SUCCEEDS [1-(2LI-LL2-)]
				SPC	1.00E+00	EVENT FAILURE
5	3.89E-07	2.10%	MEABM	MLOCA	8.00E-04	MLOCA IE
				OAD	9.80E-03	OPTR FAILS TO INITIATE ADS
				HP2	5.18E-02	HP FAILS; ALL SUPPORTS AVAILABLE MANUAL START
6	3.74E-07	2.02%	LLCOM	LOOP	9.60E-02	LOSS OF OFFSITE POWER IE
				DGB	9.50E-02	LOSS OF DG2/3, 6 HRS
				24	7.80E-03	LOSS OF BUS 24/24-1 AVAILABLE, 24HR
				MUP	6.97E-03	MUP FAILS; 25 FLD
				ROP1	1.00E+00	EVENT FAILURE
				LP	1.00E+00	LP B SUCCEEDS [1-(2LI-LL2-)]
				SPC	1.00E+00	EVENT FAILURE
7	3.71E-07	2.00%	BLABM	DLOOP	1.60E-02	LOSS OF OFFSITE POWER IE
				DGB	9.50E-02	LOSS OF DG2/3, 6 HRS
				DG2	1.56E-01	LOSS OF DG2 AFTER DG2/3, 6 HRS
				DG3	1.19E-01	LOSS OF DG3 AFTER DG2/3 AND DG2, 6 HRS
				SBO?	1.00E+00	SBO IN UNIT 3, SBO IN UNIT 2
				ROP1	2.05E-02	FAILURE TO REC OSP TO PREVENT CM (4-6 HRS)
				OIC2	1.00E+00	OPTR FAILS TO PREVENT LODC FLR OF IC
8	3.03E-07	1.63%	LLCOM	LOOP	9.60E-02	LOSS OF OFFSITE POWER IE
				DGB	9.50E-02	LOSS OF DG2/3, 6 HRS
				OMUP	7.90E-03	OPTR FAILS TO PROVIDE M/U TO IC
				ROP1	1.00E+00	EVENT FAILURE
				LP	1.00E+00	LP B SUCCEEDS [1-(2LI-LL2-)]
				SPC	5.49E-03	SPC FAILS; 24, 28, 29, 2R1 AVAILABLE
9	2.42E-07	1.30%	DLCOM	LDC	8.70E-04	LOSS OF DC POWER IE
				HP1	2.88E-02	HP FAILS; 2M1 FLD
				SPC	1.03E-02	SPC FAILS; 24, 29, 2R1 AVAILABLE
10	2.23E-07	1.20%	MEABM	MLOCA	8.00E-04	MLOCA IE
				HP1	2.88E-02	HP FAILS; ALL SUPPORTS AVAILABLE
				OAD	9.80E-03	OPTR FAILS TO INITIATE ADS
11	2.07E-07	1.12%	MLCOM	MLOCA	8.00E-04	MLOCA IE
				SPC	2.71E-04	SPC FAILS; ALL SUPPORTS AVAILABLE
12	1.97E-07	1.06%	DLCOM	LDC	8.70E-04	LOSS OF DC POWER IE
				SPC	1.03E-02	SPC FAILS; 24, 29, 2R1 AVAILABLE
				SVW	2.43E-02	SMALL TORUS VENT FAILS; 29, 39 AVAILABLE
				SVD	9.70E-01	SMALL DRYWELL VENT FAILS; 29, 39 AVAILABLE
13	1.86E-07	1.00%	LIABM	LOOP	9.60E-02	LOSS OF OFFSITE POWER IE
				OMUP	7.90E-03	OPTR FAILS TO PROVIDE M/U TO IC
				HP1	2.88E-02	HP FAILS; ALL SUPPORTS AVAILABLE
				OAD	1.20E-02	OPTR FAILS TO INITIATE ADS
				ROP1	1.00E+00	EVENT FAILURE
14	1.77E-07	0.96%	BLAYN	DLOOP	1.60E-02	LOSS OF OFFSITE POWER IE
				DGB	9.50E-02	LOSS OF DG2/3, 6 HRS
				DG2	1.56E-01	LOSS OF DG2 AFTER DG2/3, 6 HRS
				DG3	1.19E-01	LOSS OF DG3 AFTER DG2/3 AND DG2, 6 HRS
				SBO?	1.00E+00	SBO IN UNIT 3, SBO IN UNIT 2
				ROP1	2.05E-02	FAILURE TO REC OSP TO PREVENT CM (4-6 HRS)
				OIC2	1.00E+00	OPTR FAILS TO PREVENT LODC FLR OF IC
				ROP2	3.22E-01	FAILURE TO REC OSP TO PREVENT CF (NR IN 0-6 HRS)
15	1.61E-07	0.87%	BLABM	LOOP	9.60E-02	LOSS OF OFFSITE POWER IE
				DGB	9.50E-02	LOSS OF DG2/3, 6 HRS
				DG2	1.56E-01	LOSS OF DG2 AFTER DG2/3, 6 HRS
				241	8.78E-03	LOSS OF BUS 24-1, GIVEN 34-1 CROSSTIE AVAILABLE
				SBO?	1.00E+00	SBO OCCURS IN UNIT 2
				ROP1	2.05E-02	FAILURE TO REC OSP TO PREVENT CM (4-6 HRS)
				OIC2	1.00E+00	OPTR FAILS TO PREVENT LODC FLR OF IC
				LP	1.00E+00	LP A SUCCEEDS [1-(2LI-LL1-)]
16	1.59E-07	0.86%	DIBON	LDC	8.70E-04	LOSS OF DC POWER IE
				241	1.99E-04	LOSS OF BUS 24-1, GIVEN BUS 24 AVAILABLE
				LP	1.00E+00	EVENT FAILURE
				CS	1.00E+00	EVENT FAILURE
17	1.46E-07	0.79%	LLCOM	LOOP	9.60E-02	LOSS OF OFFSITE POWER IE
				OMUP	7.90E-03	OPTR FAILS TO PROVIDE M/U TO IC
				ROP1	1.00E+00	EVENT FAILURE
				SPC	2.71E-04	SPC FAILS; ALL SUPPORTS AVAILABLE

TABLE 4.5.3-1 (Continued)
DOMINANT ACCIDENT SEQUENCES FOR BASE IPE MODEL QUANTIFICATION

Number (1)	Frequency (2)	Percent (3)	Damage State (4)	Event (5)	Value (6)	Description (7)
98	1.21E-08	0.07%	LLCOM	DLOOP OMUP ROP1 OSPC	1.60E-02 7.90E-03 1.00E+00 1.60E-04	LOSS OF OFFSITE POWER IE OPTR FAILS TO PROVIDE M/U TO IC EVENT FAILURE OPTR FAILS TO ALIGN FOR SPC
99	1.16E-08	0.06%	BIABM	LOOP DGB DG2 241 SBO? OIC RVC LP	9.60E-02 9.50E-02 1.56E-01 8.78E-03 1.00E+00 3.70E-02 2.70E-02 1.00E+00	LOSS OF OFFSITE POWER IE LOSS OF DG2/3, 6 HRS LOSS OF DG2 AFTER DG2/3, 6 HRS LOSS OF BUS 24-1, GIVEN 34-1 CROSSTIE AVAILABLE SBO OCCURS IN UNIT 2 OPTR FAILS TO INITIATE IC (SBO, LOOP RVC FAILS; RELIEF VALVES CLOSING (TRANS) LP A SUCCEEDS [1-(2LI-LL1-)]
100	1.16E-08	0.06%	TEERF	ATWS MC RCFM RPT1 WW/DW	2.28E-04 1.37E-01 3.33E-01 6.00E-03 2.16E-01	ATWS INITIATOR MAIN COND FAILS (GIVEN FW FAILS) AFTER ATWS FRAC OF RPS FAILURES THAT ARE MECHANICAL AUTO RPT FAILS; ALL SUPPORTS AVAILABLE FRAC OF CONT FLRS IN DW (VS. WW)

Notes:

1. "Number" refers to accident sequence ranking in the top 100 sequences.
2. "Frequency" is the frequency per year that this sequence is expected to occur.
3. "Percent" is the percent of total core damage represented by this single sequence.
4. "Damage St" is the plant damage state to which this sequence belongs. The fifth character presents the release associated with this type of sequence and is manually assigned at the end of the analysis in presentations of dominant sequences.
5. "Event" is the list of PRT and support system event tree top events which have failed in this sequence.
6. "Value" is frequency (for initiators) or probability (for failures) associated with each event.
7. "Description" defines the "Event" label.

<u>FAULT TREES & HRA</u>

1. Fault trees combine <u>component failures</u> in specific systems to fail system.

2. Fault tree output is frequency of system failure (failure to meet success criteria)

3. HRA, human reliability analysis, evaluates <u>operator performance</u>, task by task, in performing EOP mandated activities.

4. HRA output is frequency of failure to perform task correctly (eg failure of function/system due to operator error).

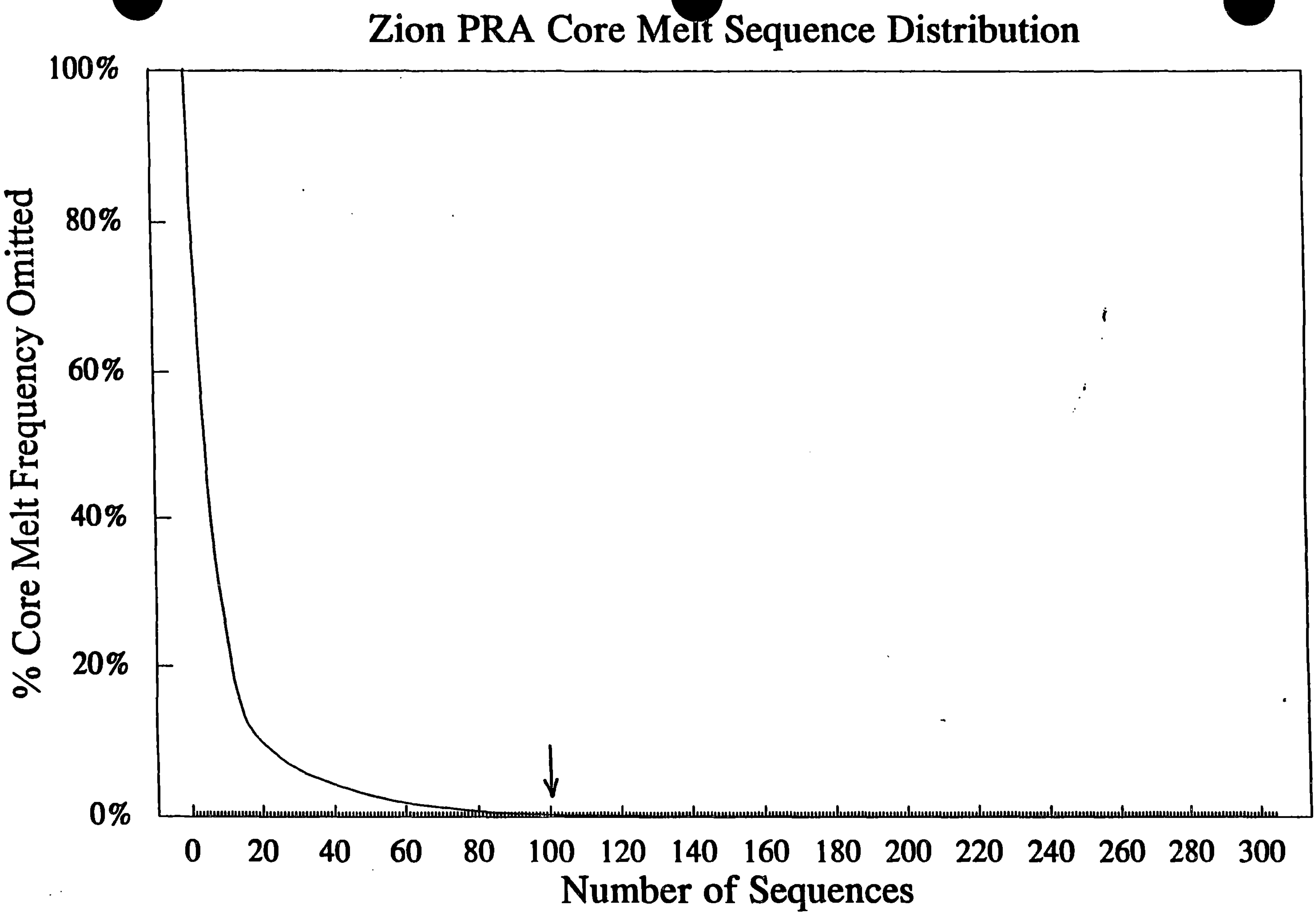
DERIVATION OF MATRIX
MODEL OF IPE

1. The matrix methodology was developed as a tool for living PRA

2. Derivation starts with "Dominant Accident Sequence Report"

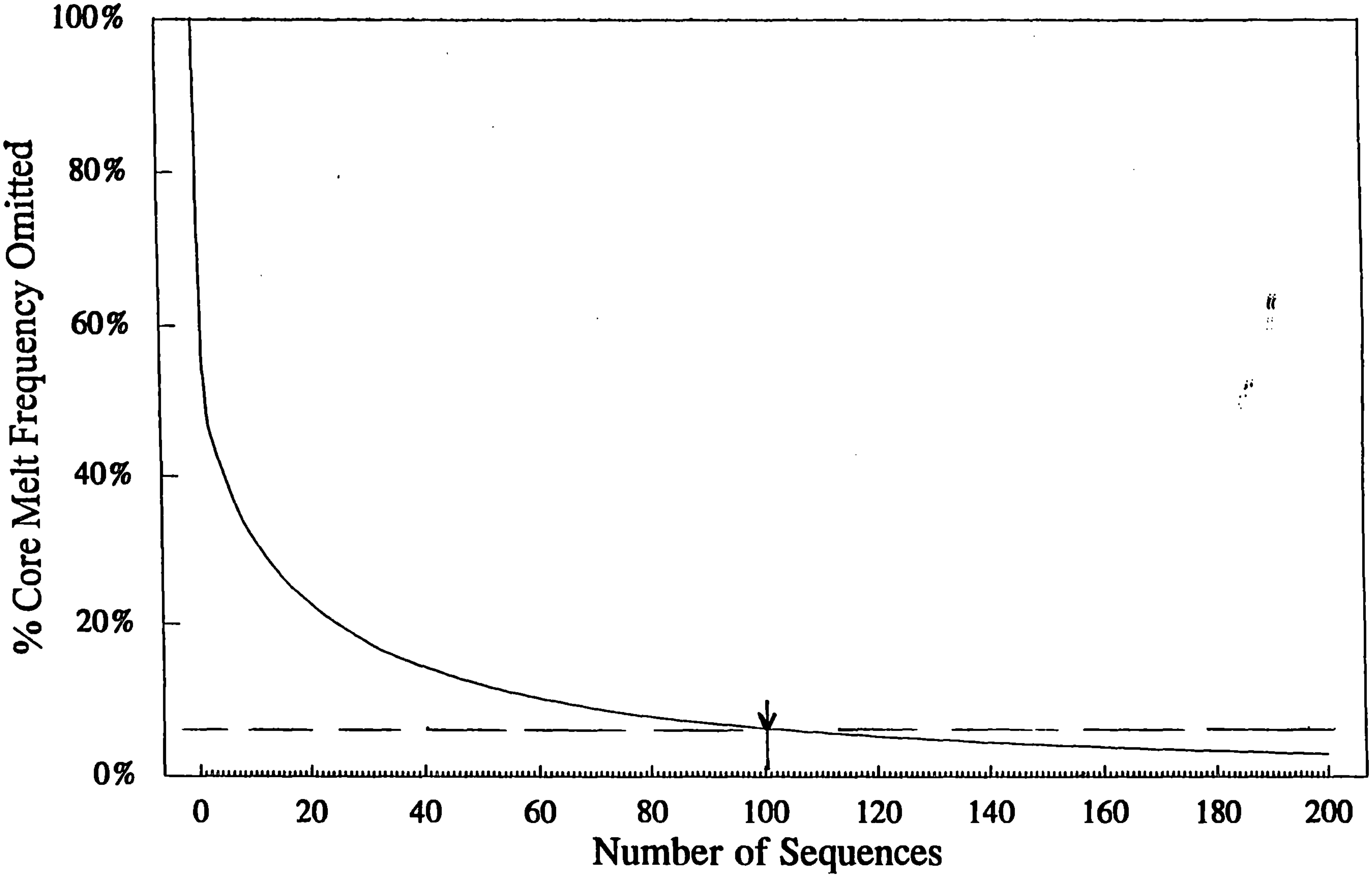
3. Involves Top 100 Sequences

4. Uses Standard, Readily Available, Matrix Mathematic & Personal Computer Tools



Total Core Melt Freq. = 3.99E-06

Dresden PRA Core Melt Sequence Distribution



Total Core Melt Freq. = 1.85E-05

TABLE 4.5.3-1
DOMINANT ACCIDENT SEQUENCES FOR BASE IPE MODEL QUANTIFICATION

Number (1)	Frequency (2)	Percent (3)	Damage State (4)	Event (5)	Value (6)	Description (7)
1	8.18E-06	44.15%	DLCOM	LDC	8.70E-04	LOSS OF DC POWER IE
				SPC	1.03E-02	SPC FAILS; 24, 29, 2R1 AVAILABLE
2	1.67E-06	9.02%	DLCOM	LDC	8.70E-04	LOSS OF DC POWER IE
				OSPC	2.10E-03	OPTR FAILS TO ALIGN FOR SPC
3	5.05E-07	2.73%	MLCOM	MLOCA	8.00E-04	MLOCA IE
				OSPC	6.60E-04	OPTR FAILS TO ALIGN FOR SPC
4	4.28E-07	2.31%	LLCOM	LOOP	9.60E-02	LOSS OF OFFSITE POWER IE
				DGB	9.50E-02	LOSS OF DG2/3, 6 HRS
				24	7.80E-03	LOSS OF BUS 24/24-1 AVAILABLE, 24HR
				OMUP	7.90E-03	OPTR FAILS TO PROVIDE M/U TO IC
				ROP1	1.00E+00	EVENT FAILURE
				LP	1.00E+00	LP B SUCCEEDS [1-(2LI-LL2-)]
				SPC	1.00E+00	EVENT FAILURE
5	3.89E-07	2.10%	MEABM	MLOCA	8.00E-04	MLOCA IE
				OAD	9.80E-03	OPTR FAILS TO INITIATE ADS
				HP2	5.18E-02	HP FAILS; ALL SUPPORTS AVAILABLE MANUAL START
6	3.74E-07	2.02%	LLCOM	LOOP	9.60E-02	LOSS OF OFFSITE POWER IE
				DGB	9.50E-02	LOSS OF DG2/3, 6 HRS
				24	7.80E-03	LOSS OF BUS 24/24-1 AVAILABLE, 24HR
				MUP	6.97E-03	MUP FAILS; 25 FLD
				ROP1	1.00E+00	EVENT FAILURE
				LP	1.00E+00	LP B SUCCEEDS [1-(2LI-LL2-)]
				SPC	1.00E+00	EVENT FAILURE
7	3.71E-07	2.00%	BLABM	DLOOP	1.60E-02	LOSS OF OFFSITE POWER IE
				DGB	9.50E-02	LOSS OF DG2/3, 6 HRS
				DG2	1.56E-01	LOSS OF DG2 AFTER DG2/3, 6 HRS
				DG3	1.19E-01	LOSS OF DG3 AFTER DG2/3 AND DG2, 6 HRS
				SBO?	1.00E+00	SBO IN UNIT 3, SBO IN UNIT 2
				ROP1	2.05E-02	FAILURE TO REC OSP TO PREVENT CM (4-6 HRS)
				OIC2	1.00E+00	OPTR FAILS TO PREVENT LODC FLR OF IC
8	3.03E-07	1.63%	LLCOM	LOOP	9.60E-02	LOSS OF OFFSITE POWER IE
				DGB	9.50E-02	LOSS OF DG2/3, 6 HRS
				OMUP	7.90E-03	OPTR FAILS TO PROVIDE M/U TO IC
				ROP1	1.00E+00	EVENT FAILURE
				LP	1.00E+00	LP B SUCCEEDS [1-(2LI-LL2-)]
				SPC	5.49E-03	SPC FAILS; 24, 28, 29, 2R1 AVAILABLE
9	2.42E-07	1.30%	DLCOM	LDC	8.70E-04	LOSS OF DC POWER IE
				HP1	2.88E-02	HP FAILS; 2M1 FLD
				SPC	1.03E-02	SPC FAILS; 24, 29, 2R1 AVAILABLE
10	2.23E-07	1.20%	MEABM	MLOCA	8.00E-04	MLOCA IE
				HP1	2.88E-02	HP FAILS; ALL SUPPORTS AVAILABLE
				OAD	9.80E-03	OPTR FAILS TO INITIATE ADS
11	2.07E-07	1.12%	MLCOM	MLOCA	8.00E-04	MLOCA IE
				SPC	2.71E-04	SPC FAILS; ALL SUPPORTS AVAILABLE
12	1.97E-07	1.06%	DLCOM	LDC	8.70E-04	LOSS OF DC POWER IE
				SPC	1.03E-02	SPC FAILS; 24, 29, 2R1 AVAILABLE
				SVW	2.43E-02	SMALL TORUS VENT FAILS; 29, 39 AVAILABLE
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				OMUP	7.90E-03	OPTR FAILS TO PROVIDE M/U TO IC
				HP1	2.88E-02	HP FAILS; ALL SUPPORTS AVAILABLE
				OAD	1.20E-02	OPTR FAILS TO INITIATE ADS
				ROP1	1.00E+00	EVENT FAILURE
14	1.77E-07	0.96%	BLAYN	DLOOP	1.60E-02	LOSS OF OFFSITE POWER IE
				DGB	9.50E-02	LOSS OF DG2/3, 6 HRS
				DG2	1.56E-01	LOSS OF DG2 AFTER DG2/3, 6 HRS
				DG3	1.19E-01	LOSS OF DG3 AFTER DG2/3 AND DG2, 6 HRS
				SBO?	1.00E+00	SBO IN UNIT 3, SBO IN UNIT 2
				ROP1	2.05E-02	FAILURE TO REC OSP TO PREVENT CM (4-6 HRS)
				OIC2	1.00E+00	OPTR FAILS TO PREVENT LODC FLR OF IC
				ROP2	3.22E-01	FAILURE TO REC OSP TO PREVENT CF (NR IN 0-6 HRS)
15	1.61E-07	0.87%	BLABM	LOOP	9.60E-02	LOSS OF OFFSITE POWER IE
				DGB	9.50E-02	LOSS OF DG2/3, 6 HRS
				DG2	1.56E-01	LOSS OF DG2 AFTER DG2/3, 6 HRS
				241	8.78E-03	LOSS OF BUS 24-1, GIVEN 34-1 CROSSTIE AVAILABLE
				SBO?	1.00E+00	SBO OCCURS IN UNIT 2
				ROP1	2.05E-02	FAILURE TO REC OSP TO PREVENT CM (4-6 HRS)
				OIC2	1.00E+00	OPTR FAILS TO PREVENT LODC FLR OF IC
				LP	1.00E+00	LP A SUCCEEDS [1-(2LI-LL1-)]
16	1.59E-07	0.86%	DIBON	LDC	8.70E-04	LOSS OF DC POWER IE
				241	1.99E-04	LOSS OF BUS 24-1, GIVEN BUS 24 AVAILABLE
				LP	1.00E+00	EVENT FAILURE
				CS	1.00E+00	EVENT FAILURE
17	1.46E-07	0.79%	LLCOM	LOOP	9.60E-02	LOSS OF OFFSITE POWER IE
				OMUP	7.90E-03	OPTR FAILS TO PROVIDE M/U TO IC
				ROP1	1.00E+00	EVENT FAILURE
				SPC	2.71E-04	SPC FAILS; ALL SUPPORTS AVAILABLE

TABLE 4.5.3-1
DOMINANT ACCIDENT SEQUENCES FOR BASE IPE MODEL QUANTIFICATION

Number (1)	Frequency (2)	Percent (3)	Damage State (4)	Event (5)	Value (6)	Description (7)
8	3.03E-07	1.63%	LLCOM	LOOP DGB OMUP ROP1 LP SPC	9.60E-02 9.50E-02 7.90E-03 1.00E+00 1.00E+00 5.49E-03	LOSS OF OFFSITE POWER IE LOSS OF DG2/3, 6 HRS OPTR FAILS TO PROVIDE M/U TO IC EVENT FAILURE LP B SUCCEEDS [1-(2LI-LL2-)] SPC FAILS; 24, 28, 29, 2R1 AVAILABLE

TABLE 4.5.3-1
DOMINANT ACCIDENT SEQUENCES FOR BASE IPE MODEL QUANTIFICATION

Number (1)	Frequency (2)	Percent (3)	Damage State (4)	Event (5)	Value (6)	Description (7)
8	3.03E-07	1.63%	LLCOM	LOOP	9.60E-02	LOSS OF OFFSITE POWER IE

TABLE 4.5.3-1
DOMINANT ACCIDENT SEQUENCES FOR BASE IPE MODEL QUANTIFICATION

Number (1)	Frequency (2)	Percent (3)	Damage State (4)	Event (5)	Value (6)	Description (7)
8	3.03E-07	1.63%	LLCOM	DGB	9.50E-02	LOSS OF DG2/3, 6 HRS

IDENTIFYING FAILED SUPPORT SYSTEMS
AND DEVELOPING SUPPORT STATE LABELS
FOR THE SUPPORT STATE MATRIX

(I.E. LOOP; SUPPORT STATE # 4;
WITH A COND. FREQUENCY OF 9.5E-2)

TABLE 4.5.3-1
DOMINANT ACCIDENT SEQUENCES FOR BASE IPE MODEL QUANTIFICATION

Number (1)	Frequency (2)	Percent (3)	Damage State (4)	Event (5)	Value (6)	Description (7)
8	3.03E-07	1.63%	LLCOM			
				OMUP	7.90E-03	OPTR FAILS TO PROVIDE M/U TO IC
				ROP1	1.00E+00	EVENT FAILURE
				LP	1.00E+00	LP B SUCCEEDS [1-(2LI-LL2-)]
				SPC	5.49E-03	SPC FAILS; 24, 28, 29, 2R1 AVAILABLE

IDENTIFYING FAILED FRONT-LINE SYSTEMS AND OPERATOR ACTIONS FOR THE PLANT STATE MATRIX SINGLE SEQUENCE INPUT

(I.E. LOOP; SS # 4; PS LLCOM WITH A COND.FREQUENCY OF 4.34E-5)

NEXT:

1. Repeat sequence breakdown for all 100 sequences.

2. Enter initiating event list (same as in base IPE document) as scalar values

3. <u>For each initiator</u>: Develop a support state list & table of <u>conditional</u> frequencies. Enter as a row vector.

4. <u>For each initiator</u>: Develop a list of sequences <u>for each support state & plant state</u> noted above & establish a <u>conditional</u> frequency of sequences (e.g. product of front line system failures & operator actions) Sum sequence conditional frequencies by support states & plant states & enter in matrix.

DEVELOPING THE SUPPORT STATE VECTOR

INITIATING EVENT: LOOP

SS1 . . 4 19

S7 = [. . . 9.5E-2 . . . .]

DEVELOPING THE PLANT STATE MATRIX

INITIATING EVENT: LOOP

SS/PS	LLCOM	BLAYN	** ** **
1	-----	-----	
2	-----	-----	
3	-----	-----	
4	7.12E-5	-----	
** **			

VALUE IS THE SUM OF THE PRODUCTS OF CONDITIONAL FREQUENCIES OF FAILED FRONT LINE SYSTEMS AND OPERATOR ACTIONS FOR LOOP INITIATED SEQUENCES IN SUPPORT STATE 4 FROM THE TOP 100 SEQUENCES FOR PLANT STATE LLCOM

RESULTS:

DRESDEN MATRICE

AS AN

EXAMPLE

DRESDEN STATION IPE: MATRIX FORMULATION

5/21/93; G. T. KLOPP

This matrix formulation follows the same approach used for the Zion Station IPE formulation. Since Dresden's IPE did not employ "support states" per-se, the top 100 sequences have been carefully reviewed for support state occurence. It was found that 20 such states exist with no "impact vector" evaluations at all. Therefore, the 20 states are used as the foundation for the "S" matrices in this work. The 20 states are defined in attachment 1 to this work.

INITIATING EVENT SCALARS:

$I1 := 3\cdot 10^{-4}$	FOR LLOCA	$I6 := 7.4$	FOR GTR
$I2 := 8\cdot 10^{-4}$	FOR MLOCA	$I7 := 9.6\cdot 10^{-2}$	FOR LOOP
$I3 := 3\cdot 10^{-3}$	FOR SLOCA	$I8 := 1.6\cdot 10^{-2}$	FOR DLOOP
$I4 := 1.1\cdot 10^{-7}$	FOR ISLOCA	$I9 := 2.28\cdot 10^{-4}$	FOR ATWS
$I5 := 7.1\cdot 10^{-2}$	FOR IORV	$I10 := 8.7\cdot 10^{-4}$	FOR LODC

SUPPORT STATE ROW MATRICES (VECTORS):

$S1 := .9998$ FOR LLOCA

$S2 := .9998$ FOR MLOCA

$S3 := 0$ FOR SLOCA

$S4 := 0$ FOR ISLOCA

$S5 := .9998$ FOR IORV

$$\begin{array}{ll} \text{SS } 1 & 13 \\ S6 := (.9998 & 2.4\cdot 10^{-6}) \end{array} \quad \text{FOR GTR}$$

$$\begin{array}{lllllllllll} \text{SS } 1 & 3 & 4 & 5 & 7 & 9 & 11 & 12 & 15 & 16 & 19 \\ S7 := (.9998 & 7.41\cdot 10^{-4} & 9.5\cdot 10^{-2} & 1.39\cdot 10^{-1} & 1.3\cdot 10^{-4} & 2.35\cdot 10^{-4} & 1.16\cdot 10^{-4} & 1.48\cdot 10^{-2} & 3.34\cdot 10^{-7} & 7.8\cdot 10^{-3} & 3.25\cdot 10^{-} \end{array}$$

FOR LOOP

$$\begin{array}{llllllll} \text{SS } 1 & 3 & 4 & 6 & 7 & 9 & 17 & 18 \\ S8 := (.9998 & 7.41\cdot 10^{-4} & 9.5\cdot 10^{-2} & 1.76\cdot 10^{-3} & 1.3\cdot 10^{-4} & 2.35\cdot 10^{-4} & 1.6\cdot 10^{-4} & 2.2\cdot 10^{-2}) \end{array} \text{FOR DLOOP}$$

$S9 := .9998$ FOR ATWS

$$\begin{array}{lllll} \text{SS } 2 & 8 & 10 & 14 & 20 \\ S10 := (1.0 & 1.99\cdot 10^{-4} & 1.18\cdot 10^{-4} & 4.14\cdot 10^{-5} & 1.13\cdot 10^{-4}) \end{array} \quad \text{FOR LODC}$$

PLANT STATE MATRICES:

$P1 := 7.48 \cdot 10^{-5}$ FOR LLOCA; ALCOM; SS 1

$$P2 := \begin{array}{l} \begin{array}{cc} \text{PS MLCOM} & \text{MEABM} \end{array} \\ \begin{pmatrix} 9.5 \cdot 10^{-4} & 7.9 \cdot 10^{-4} \end{pmatrix} \end{array}$$

FOR MLOCA; SS 1

$P3 := 0$ FOR SLOCA

$P4 := 0$ FOR ISLOCA

$P5 := 2.44 \cdot 10^{-6}$ FOR IORV; ILCOM; SS 1

$$\begin{array}{ccc} & \begin{array}{cc} \text{PS TLCOM} & \text{TIABM} \end{array} & \text{SS} \\ P6 := & \begin{pmatrix} 1.25 \cdot 10^{-8} & 1.86 \cdot 10^{-9} \\ 5.49 \cdot 10^{-3} & 0 \end{pmatrix} & \begin{array}{c} 1 \\ 13 \end{array} \end{array}$$

FOR GTR

$$\begin{array}{ccc} & \begin{array}{cccccccc} \text{PS LLCOM} & \text{LIABM} & \text{BLABM} & \text{BLAYN} & \text{LICOM} & \text{LLABM} & \text{LIBON} & \text{BIABM} \end{array} & \text{SS} \\ P7 = & \begin{bmatrix} 5.59 \cdot 10^{-6} & 4.16 \cdot 10^{-6} & 0 & 0 & 4.78 \cdot 10^{-7} & 4.09 \cdot 10^{-7} & 0 & 0 \\ 1.79 \cdot 10^{-2} & 0 & 0 & 0 & 2.28 \cdot 10^{-4} & 0 & 0 & 0 \\ 7.12 \cdot 10^{-5} & 2.73 \cdot 10^{-6} & 0 & 0 & 0 & 0 & 0 & 0 \\ 3.4 \cdot 10^{-6} & 2.73 \cdot 10^{-6} & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 2.05 \cdot 10^{-2} & 6.6 \cdot 10^{-3} & 0 & 0 & 0 & 9.99 \cdot 10^{-4} \\ 1.74 \cdot 10^{-2} & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 1.74 \cdot 10^{-2} & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 7.12 \cdot 10^{-5} & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1.0 & 0 \\ 8.7 \cdot 10^{-5} & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 1.49 \cdot 10^{-5} & 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix} & \begin{array}{c} 1 \\ 3 \\ 4 \\ 5 \\ 7 \\ 9 \\ 11 \\ 12 \\ 15 \\ 16 \\ 19 \end{array} \end{array}$$

FOR LOOP

$$
\begin{array}{c|ccccc|c}
\text{PS} & \text{LLCOM} & \text{BLABM} & \text{BLAYN} & \text{BIABM} & \text{LIABM} & \text{SS} \\
\hline
 & 3.4\cdot10^{-6} & 0 & 0 & 0 & 2.73\cdot10^{-6} & 1 \\
 & 1.738\cdot10^{-2} & 0 & 0 & 0 & 0 & 3 \\
 & 7.12\cdot10^{-5} & 0 & 0 & 0 & 0 & 4 \\
P8 := & 0 & 2.126\cdot10^{-2} & 6.6\cdot10^{-3} & 9.99\cdot10^{-4} & 0 & 6 \\
 & 0 & 2.05\cdot10^{-2} & 0 & 0 & 0 & 7 \\
 & 1.487\cdot10^{-2} & 0 & 0 & 0 & 0 & 9 \\
 & 1.487\cdot10^{-2} & 0 & 0 & 0 & 0 & 17 \\
 & 4.35\cdot10^{-5} & 0 & 0 & 0 & 0 & 18
\end{array}
$$

FOR DLOOP

PS TEEQF TEERF

$P9 = \left(2.33\cdot10^{-3} \quad 3.06\cdot10^{-4}\right)$ FOR ATWS; SS 1

$$
\begin{array}{c|cccc|c}
\text{PS} & \text{DLCOM} & \text{DIBON} & \text{DIABM} & \text{DIBMS} & \text{SS} \\
\hline
 & 1.321\cdot10^{-2} & 0 & 1.96\cdot10^{-4} & 7.74\cdot10^{-5} & 2 \\
 & 0 & 1.0 & 0 & 0 & 8 \\
P10 = & 0 & 1.0 & 0 & 0 & 10 \\
 & 0 & 1.0 & 0 & 0 & 14 \\
 & 1.0 & 0 & 0 & 0 & 20
\end{array}
$$

FOR LODC

FEATURES OF MATRIX MODEL

- Retains "Component" level information through access to sequence information. Road map in form of flow charts.

DRESDEN IPE MATRIX FLOW CHARTS

TABLE OF CONTENTS

FLOW CHART #13 ** OPER. ACT. - OSBCS

FLOW CHART #14 ** OPER. ACT. - OAD

FLOW CHART #15 ** OPER. ACT. - OMUP

FLOW CHART #16 ** OPER. ACT. - OIC

FLOW CHART #17 ** OPER. ACT. - OSL

FLOW CHART #18 ** OPER. ACT. - ORP

DRESDEN IPE FLOW CHART #1

SPC (SUPPRESSION POOL COOLING)

NOTE: THIS CHART IS BROKEN DOWN INTO 8 SHEETS ORGANIZED AS FOLLOWS:

SHEET 1:	COMPONENT/FAULT TREES
SHEET 2:	INITIATORS/PRT'S
SHEETS 3 THRU 8:	MATRICES/SEQ.

FLOW CHART # 1

SHEET 1

SS # 1, 5; FT 2LI-LL-8; 2.71E-4

HX PLUGGED	51%
MOV 1501-20A&B	7
MOV 1501-38A&B	7
MOV 1501-11A&B	7
MOV 1501-3A&B	7
PUMPS	3.7

SS # 4,13,16,18; FT 2LI-LLA &LL9; 5.5E-3

HX VLV 2A 1503	34%
VALVE 2 1501-3A	34
MOV 1501-11A & B - 3A & B	20.4
HX PLUGGED	2.5
PUMPS	4.8

SS # 2; FT 2LI-LL9A & B 1.03E-2

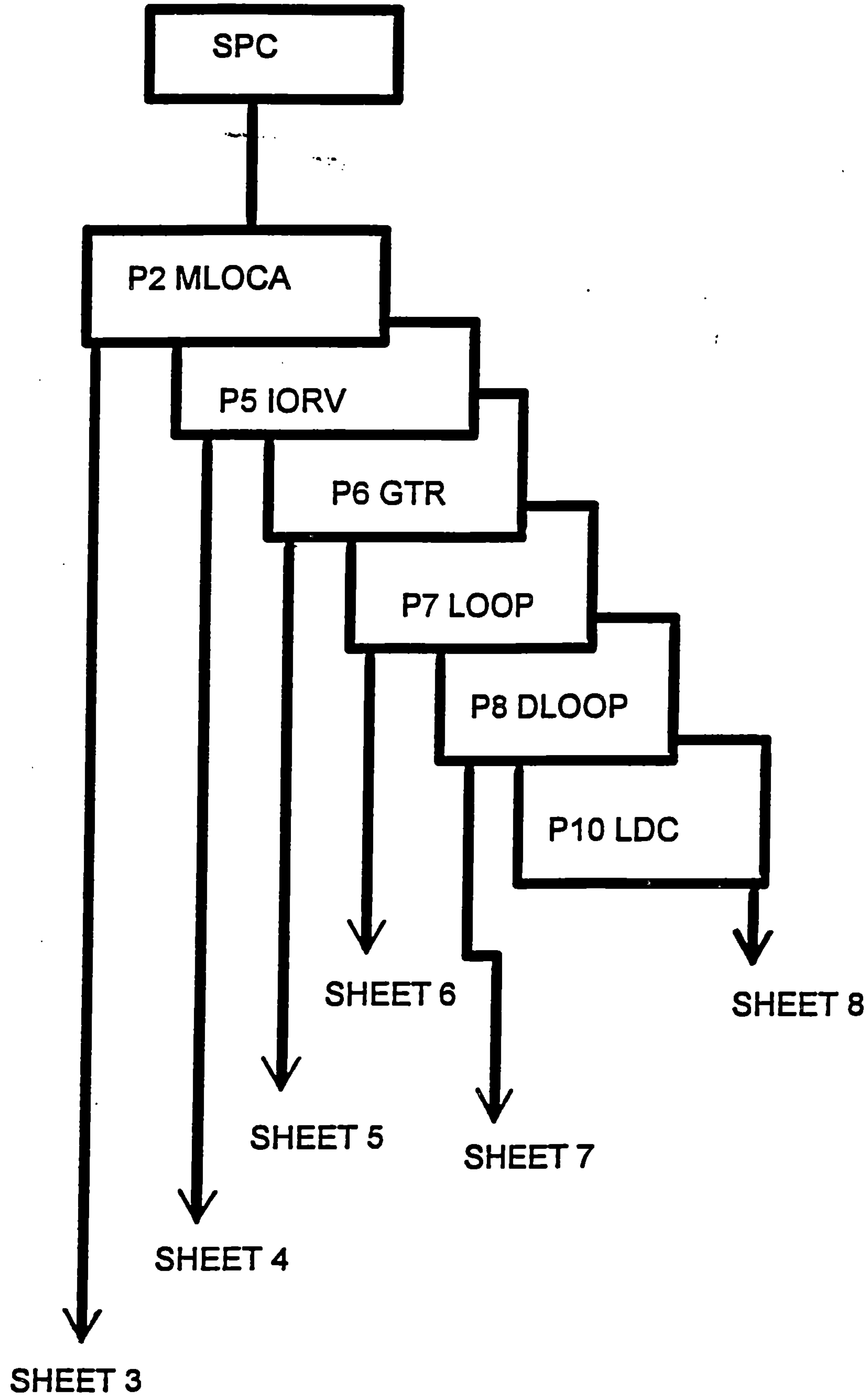
VALVE 2-1501-20A	18.2%
VALVE 2-1501-38A	18.2
HX 2A 1503 VLV	18.2
VALVE 2-1501-3A	18.2
MOV MAINT. 1501-20B 1501-38B 1501-20A	5.5
MOV MAINT. 1501-38A & b 1501-20B	5.5
MOV MAINT 1501-11B 1501-03BM 1501-11AM	5.5
MOV MAINT 1501-3A & B 1501-11B	5.5

SPC

SHEET 2

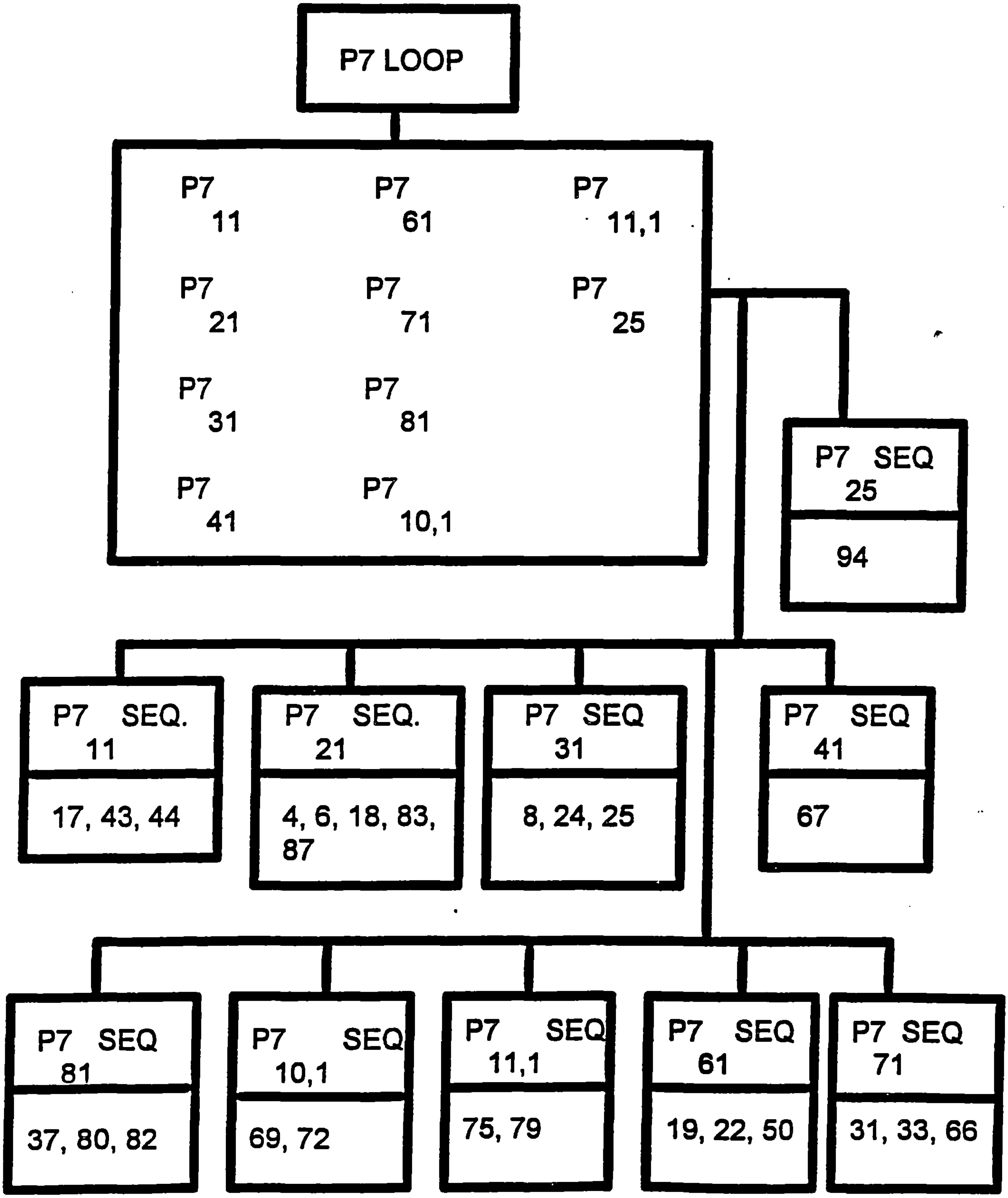
FLOW CHART # 1

SHEET 2



FLOW CHART # 1

SHEET 6



FEATURES OF MATRIX MODEL (CONT'D)

- Fast PRA Manipulation

- Permits rapid screening of changes or variations in terms of impact on result.

- Provides a "Skeleton" on which additions to the model, covering "new" sequences, can be made as required (simply add elements or even matrices if the existing structure does not accommodate.)

DETAILS OF USE FOR IPEEE PROGRAM

1. Apply to seismic & fire initiators
2. Use to "screen out" insignificant contributors
3. Use to add "new" sequences or modify frequencies of existing sequences as required
4. Next 2 speakers will provide detail on the use of the matrix methodology
5. Each speaker will discuss examples of the screening methodology and how it will identify items for detailed analysis

- The matrix approach is the equivalent to a truncated seismic or fire PRA using a best estimate approach. This method does not account for mathematical uncertainties.

- We believe that this approach is more comprehensive and useful than the seismic margins approach and only slightly less detailed than a full, formal PRA.

COMMONWEALTH EDISON
IPEEE PROGRAM

SEISMIC EVALUATION

KONG WANG
SENIOR PRA ENGINEER

SEISMIC IPEEE
SCREENING/EVALUATION

STAGE I

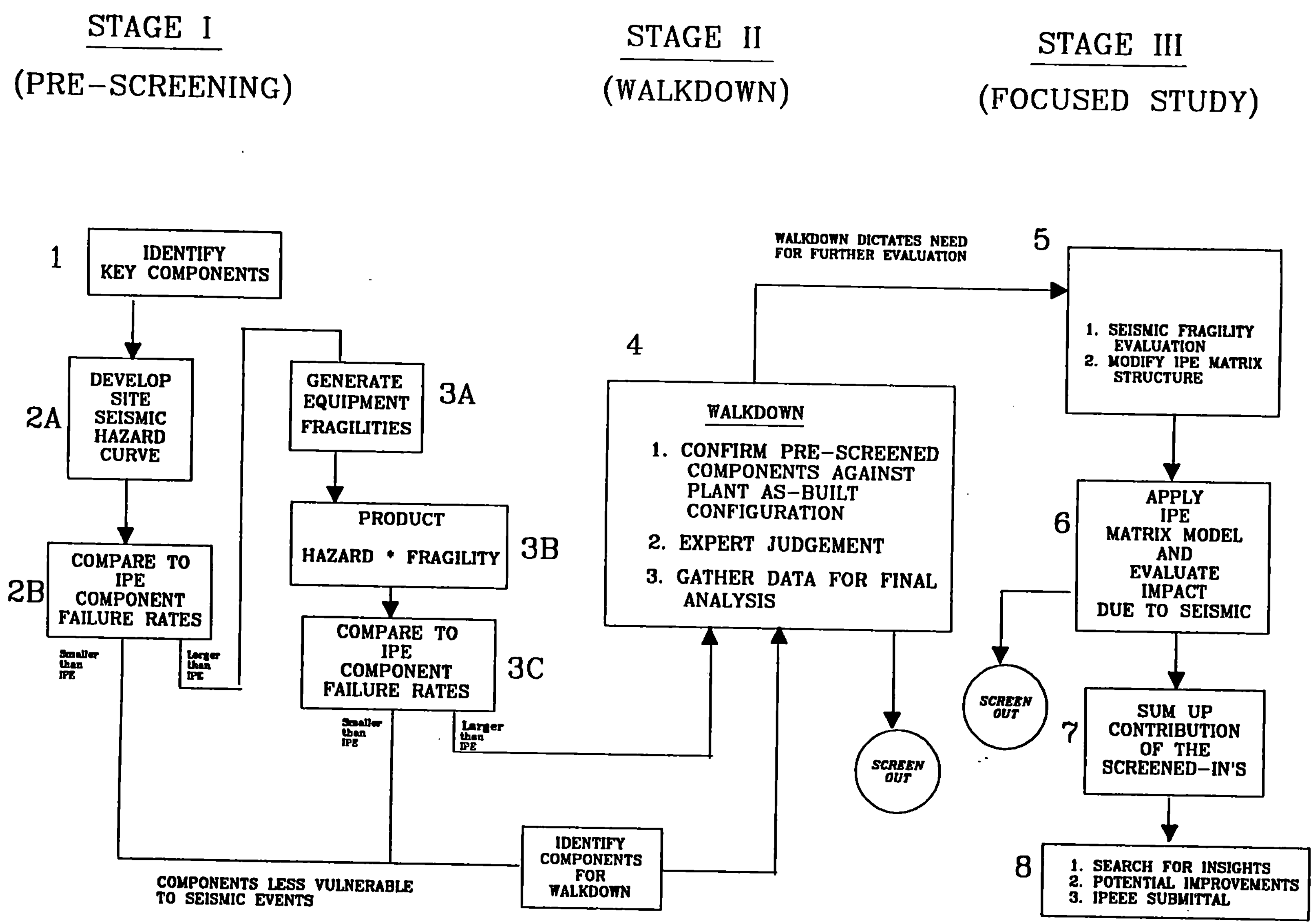
Multiple screening analyses based on IPE data and structures starting with conservative and moving toward realistic screening.

STAGE II

Plant walkdowns and expert judgement.

STAGE III

Focused analyses using deterministic and/or probabilistic methods. Evaluation of the impact of event on CDFs using IPE matrix modelling.



FLOWCHART FOR
SEISMIC IPEEE SCREENING/EVALUATION

* STAGE I: PRE-SCREENING

1. Identify and review reference materials for pre-screening:

   Basic IPE
   FSAR/UFSAR
   Special seismic studies
   Previous PRA work, etc.

STAGE I (Continued)

2A. Develop site seismic hazard curve:

Using the EPRI seismicity curve and past seismic amplification factors, develop the accelerations at various levels for each plant for the screening level event.

Attachment 1

Zion Seismic Hazard Curve

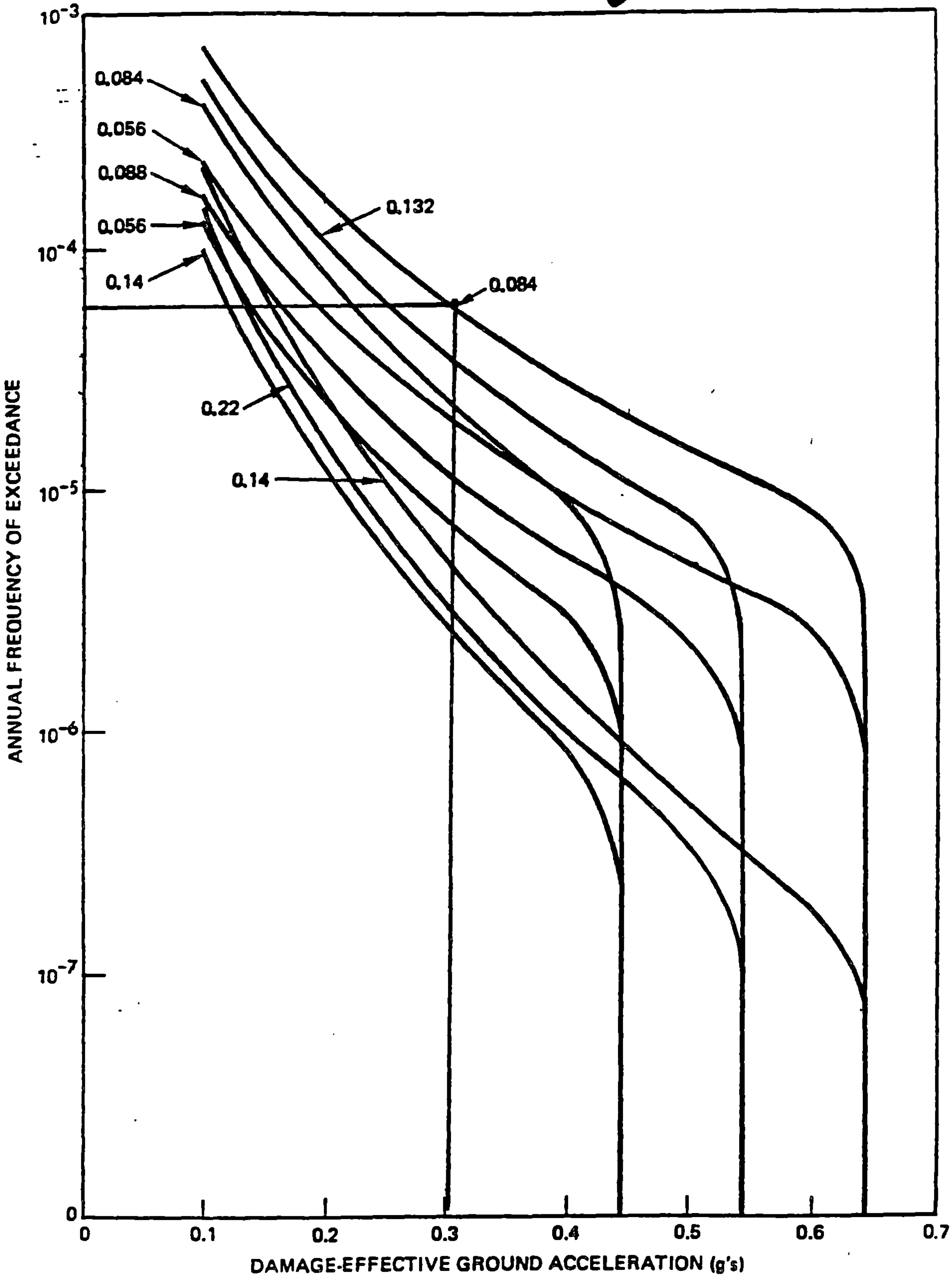


Figure 7.2-1. Seismicity Family

STAGE I (Continued)

2B. Compare to IPE component failure frequencies:

Components with frequencies of annual seismic exceedance smaller than the IPE random failure frequencies are pre-screened out.

This is very conservative since the component failure frequencies due to seismic, i.e., fragilities, are assumed to be "1.0" in this screening stage.

- Example: Diesel Generator

<u>IPE random failure:</u>

Unavail. due to maint.:	1.4E-2
Fail to run:	1.8E-2
Fail to start:	8.2E-3

- Total random failure rate: **4E-2**

  Seismic annual exceedance rate: **5E-5**

  Therefore, DG can be screened out.

-

STAGE I (Continued)

3A. Generate component fragilities

Previous seismic studies and expert judgement.

3B. Generate component failure frequencies due to seismic

frequency = hazard * fragility

3C. Compare to IPE component random failure frequencies for the components which are not pre-screened out during the Step 2B.

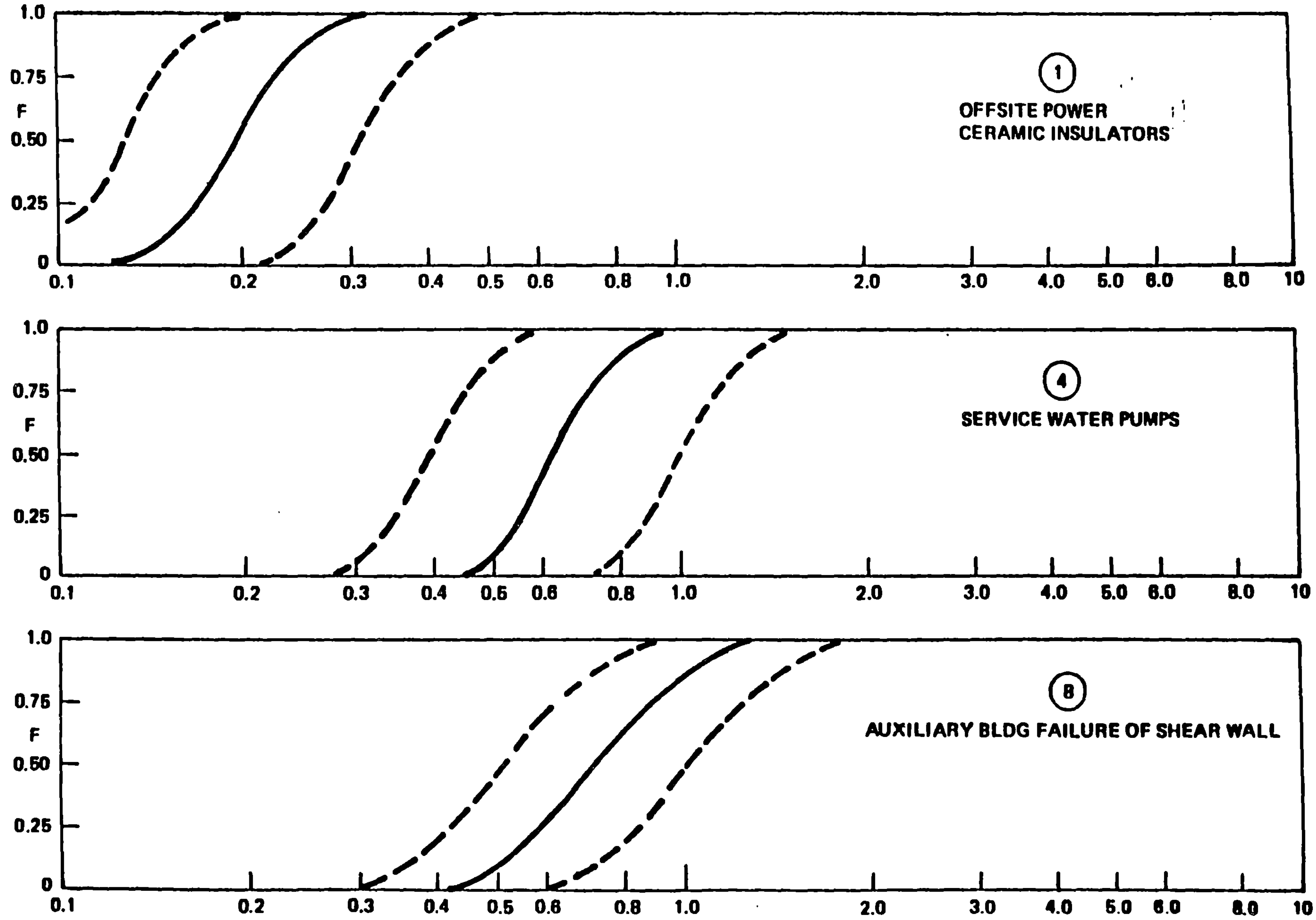


Figure 7.2-2. Fragility Families for Key Components

Attachment J

Example: RCFC duct

IPE Random Failure:

Seg. C unavail. due to maint.:	8.5E-3
Valve 1MOV-SW0009 fail to open:	3.5E-3
1C fan fail to start:	3.3E-3
Div. 17 relay fails:	5.6E-4
Total random failure freq.:	**1.6E-2**

Failure due to seismic:

(annual exceedance freq. X fragility)

= 5E-5 X 5E-2

= **2.5E-6**

Therefore, RCFC duct can be pre-screened out.

STAGE II

4. Walkdowns

* Confirm pre-screened out components configuration

* Anticipate two types of issues:
  1. Confirm plant as-built configuration,

  2. Subtle problems found by seismic experts such as potential tank failures via buckling.

* Expert judgement (e.g., develop component fragilities, estimate spatial interaction, etc.)

* Gather data for final analysis on non-screened out components.

STAGE III

5. Focused analyses

* Topics derived from screening analyses and walkdowns.

* Verification of subtle problems identified during walkdown, e.g., the loss of a tank due to failure of support buckling in conjunction with the loss of other similar identified components will be modeled as modifications to the base IPE along with appropriate random failures.

* Both primary effects(e.g., seismic induced loss of ssc) and secondary effects (e.g., flood from ruptured tank) will be considered in IPEEE work.

STAGE III(Continued)

6. Apply IPE matrix model and evaluate impact due to seismic

   * Develop IPE matrix structure

   * Evaluate impact on IPE matrix structure (i.e., initiating event matrix and support state matrix.)

   * Evaluate impact on plant state matrix (i.e., impact due to the inclusion of the seismic failure as an additional failure cutset on component level.)

   * Evaluate impact on CDFs.

- Example of evaluation using Matrix Modeling:

  Assume a seismic induced failure rate (i.e., hazard X fragility) for LPI pump = 5E-5

- Look into the top 36 dominant accident sequences of the Zion IPE, the sequences associated with LPI system are **2**, **13**, **15**, **25**, and **32**.

-

TABLE 4.5.3-1
DOMINANT ACCIDENT SEQUENCES FOR BASE IPE MODEL QUANTIFICATION

#	FREQUENCY	PERCENT	SS#	BIN	EVENTS	VALUE	DESCRIPTION
1.	6.087E-007	15.21%	1	AE9S	LLOCA	3.000E-004	LARGE LOCA INITIATING EVENT
					ORC	2.160E-003	OPERATOR ACTION - ESTABLISH LOW PRESSURE ECC RECIRCULATION (LLOCA W/SPRAY)
2.	4.092E-007	10.23%	1	AE9S	LLOCA	3.000E-004	LARGE LOCA INITIATING EVENT
					LPI	1.450E-003	1/2 LOW PRESSURE INJ PUMPS TO 2/3 COLD LEGS ALL POWER
					ORT	1.000E+000	RWST REFILL NOT POSSIBLE FOR LARGE LOCA WITH CURRENT EOPs
3.	3.962E-007	9.90%	98	LI9S	DLOOP	1.400E-002	DUAL UNIT LOSS OF OFFSITE POWER INITIATING EVENT
					BUS	2.230E-003	AC POWER WITH DLOSP 148,149 FAIL
					AFW	1.450E-002	1/3 AUX FEED PUMPS TO 4/4 SG NO POWER
					FC	9.847E-001	2/5 FAN COOLERS
					HPR	1.000E+000	1/4 HIGH PRESSURE RECIRCULATION TO 2/4 COLD LEGS NO POWER
					RTK	1.000E+000	EQUIPMENT TO REFILL THE RWST (POWER UNAVAILABLE)
4.	3.891E-007	9.73%	1	RL9T	SGTR	9.020E-003	STEAM GENERATOR TUBE RUPTURE INITIATING EVENT
					ODS	1.150E-003	OPERATOR ACTION - SG DEPRESSURIZATION FOR PRIMARY COOLING
					ORT	3.800E-002	OPERATOR ACTION - REFILL THE RWST
5.	2.751E-007	6.88%	1	RL9T	SGTR	9.020E-003	STEAM GENERATOR TUBE RUPTURE INITIATING EVENT
					OIR	8.140E-004	OPERATOR ACTION - MINIMIZE ECCS FLOW
					ORT	3.800E-002	OPERATOR ACTION - REFILL THE RWST
6.	2.472E-007	6.18%	1	RL9T	SGTR	9.020E-003	STEAM GENERATOR TUBE RUPTURE INITIATING EVENT
					ODS	1.150E-003	OPERATOR ACTION - SG DEPRESSURIZATION FOR PRIMARY COOLING
					RTK	2.510E-002	EQUIPMENT TO REFILL THE RWST (SGTR)
7.	1.748E-007	4.37%	1	RL9T	SGTR	9.020E-003	STEAM GENERATOR TUBE RUPTURE INITIATING EVENT
					OIR	8.140E-004	OPERATOR ACTION - MINIMIZE ECCS FLOW
					RTK	2.510E-002	EQUIPMENT TO REFILL THE RWST (SGTR)
8.	1.526E-007	3.81%	1	ML9S	MLOCA	1.100E-003	MEDIUM LOCA INITIATING EVENT
					LPR	5.200E-004	1/2 LOW PRESSURE RECIRCULATION TO 2/4 COLD LEGS ALL POWER (COND)
					RTK	2.910E-001	EQUIPMENT TO REFILL THE RWST FOR LOCAs
9.	1.448E-007	3.62%	1	AE9S	LLOCA	3.000E-004	LARGE LOCA INITIATING EVENT
					LPR	5.150E-004	1/2 LOW PRESSURE RECIRCULATION TO 1/3 COLD LEGS ALL POWER (COND)
					ORT	1.000E+000	RWST REFILL NOT POSSIBLE FOR LARGE LOCA WITH CURRENT EOPs

Example (Continued)

Seq. #	I.E.	S.S	BIN	LPI Fail. freq
2	LLOCA	1	AE9S	1.45E-3
13	SLOCA	1	SL9S	4.22E-5
15	MLOCA	1	ML9S	1.65E-4
25	LLOCA	1	AE9F	1.45E-3
32	SLOCA	1	SL9S	4.22E-5

Example (Continued)

The elements which contain LPI system in the plant state matrix are: **P(1,1)**, **P(1,4)**, **P(1,7)**, and **P(1,10)**.

PLANT STATES

$$P := \begin{array}{cc} \begin{array}{cccccccc} \mathrm{AE9S} & \ldots\ldots & \mathrm{ML9S} & \ldots\ldots & \mathrm{SL9S} & \ldots\ldots & \mathrm{AE9F} & \ldots\ldots \end{array} & \\ \begin{pmatrix} 4E-3 & .. & 3.3E-4 & .. & 1.5E-5 & .. & 1.4E-4 \\ \vdots & & & & & & \vdots \\ \vdots & & & & & & \vdots \\ \vdots & & \ldots & \ldots & \ldots & \ldots & \ldots \end{pmatrix} & \begin{array}{c} 1 \\ 12 \\ 63 \\ \vdots \end{array} \end{array}$$

SUPPORT STATES

Example (Continued)

Let's look element P(1,1):

P(1,1) represents (at 4E-3) the likelihood of plant state **AE9S** given a **LLOCA** and **support state 1**. For this case in point, there are three sequences of interest: **#1**, **#2**, and **#9**. (Note that only #2 contains LPI.)

<u>Seq. #1</u>
Failure is ORC, operator action to establish ECCS recirculation, with a frequency of 2.16E-3.

<u>Seq. #2</u>
Failures are LPI, with a frequency of 1.45E-3 and ORT, operator action on RWST refill with a frequency of 1.0

<u>Seq. #9</u>
Failures are LPR, with a frequency of 4.3E-4 and ORT with a frequency of 1.0.

Zion

TABLE 4.5.3-1
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					LPI	1.450E-003	1/2 LOW PRESSURE INJ PUMPS TO 2/3 COLD LEGS ALL POWER
					ORT	1.000E+000	RWST REFILL NOT POSSIBLE FOR LARGE LOCA WITH CURRENT EOPs
3.	3.962E-007	9.90%	98	LI9S	DLOOP	1.400E-002	DUAL UNIT LOSS OF OFFSITE POWER INITIATING EVENT
					BUS	2.230E-003	AC POWER WITH DLOSP 148,149 FAIL
					AFW	1.450E-002	1/3 AUX FEED PUMPS TO 4/4 SG NO POWER
					FC	9.847E-001	2/5 FAN COOLERS
					HPR	1.000E+000	1/4 HIGH PRESSURE RECIRCULATION TO 2/4 COLD LEGS NO POWER
					RTK	1.000E+000	EQUIPMENT TO REFILL THE RWST (POWER UNAVAILABLE)
4.	3.891E-007	9.73%	1	RL9T	SGTR	9.020E-003	STEAM GENERATOR TUBE RUPTURE INITIATING EVENT
					ODS	1.150E-003	OPERATOR ACTION - SG DEPRESSURIZATION FOR PRIMARY COOLING
					ORT	3.800E-002	OPERATOR ACTION - REFILL THE RWST
5.	2.751E-007	6.88%	1	RL9T	SGTR	9.020E-003	STEAM GENERATOR TUBE RUPTURE INITIATING EVENT
					OIR	8.140E-004	OPERATOR ACTION - MINIMIZE ECCS FLOW
					ORT	3.800E-002	OPERATOR ACTION - REFILL THE RWST
6.	2.472E-007	6.18%	1	RL9T	SGTR	9.020E-003	STEAM GENERATOR TUBE RUPTURE INITIATING EVENT
					ODS	1.150E-003	OPERATOR ACTION - SG DEPRESSURIZATION FOR PRIMARY COOLING
					RTK	2.510E-002	EQUIPMENT TO REFILL THE RWST (SGTR)
7.	1.748E-007	4.37%	1	RL9T	SGTR	9.020E-003	STEAM GENERATOR TUBE RUPTURE INITIATING EVENT
					OIR	8.140E-004	OPERATOR ACTION - MINIMIZE ECCS FLOW
					RTK	2.510E-002	EQUIPMENT TO REFILL THE RWST (SGTR)
8.	1.526E-007	3.81%	1	ML9S	MLOCA	1.100E-003	MEDIUM LOCA INITIATING EVENT
					LPR	5.200E-004	1/2 LOW PRESSURE RECIRCULATION TO 2/4 COLD LEGS ALL POWER (COND)
					RTK	2.910E-001	EQUIPMENT TO REFILL THE RWST FOR LOCAs
9.	1.448E-007	3.62%	1	AE9S	LLOCA	3.000E-004	LARGE LOCA INITIATING EVENT
					LPR	5.150E-004	1/2 LOW PRESSURE RECIRCULATION TO 1/3 COLD LEGS ALL POWER (COND)
					ORT	1.000E+000	RWST REFILL NOT POSSIBLE FOR LARGE LOCA WITH CURRENT EOPs

INITIATING EVENT SCALAR (I) :

LLOCA $I1 = 3E{-}4$

SUPPORT STATE VECTOR (S) :

LLOCA

$$
\begin{array}{cccccc}
 & & \text{SS 1} & \text{SS 61} & \text{SS 63} & \\
S1 & = (& 0.9996 & 5.2E{-}5 & 2E{-}4 &)
\end{array}
$$

PLANT STATE MATRIX (P):

LLOCA

$$
\begin{array}{ccc}
 & \begin{array}{ccccc} \text{AE9S} & \text{AE7S} & \text{AE9F} & \text{AE7K} & \text{AE7F} \end{array} & \text{SS} \\
P1 = & \left(\begin{array}{ccccc} 4E{-}3 & 0.0 & 1.6E{-}4 & 0.0 & 0.0 \\ 1.0 & 0.0 & 0.0 & 0.0 & 0.0 \\ 0.0 & 1.0 & 0.0 & 3E{-}2 & 4E{-}2 \end{array} \right) & \begin{array}{c} 1 \\ 61 \\ 63 \end{array}
\end{array}
$$

PS labels the columns (AE9S, AE7S, AE9F, AE7K, AE7F).

DERIVATION OF PLANT STATE ELEMENTS

EXAMPLE : P1 (1,1) = 4E−3

SEQUENCE NO.	SUPPORT STATE NO.	PLANT STATE	SYSTEM EVENTS		COMPONENT FAILURE	
1	1	AE9S	ORC	2.16E−3		
2	1	AE9S	LPI	1.45E−3	CHECK VALVE 1SI8957 FTO	1.3E−3
					CHECK VALVE 1SI8958 FTO	7.4E−5
					DIV. 18 & 19 R2 FAIL	7.9E−6
					OTHER CONTRIBUTORS	6.8E−5
			ORT	1.0		
9	1	AE9S	LPR	5.2E−4		
			ORT	1.0		

Example (Continued)

Now, we need to decompose these interim (system) results down to component level. Looking at the ECCS fault tree notebook, for support state 1, we find the dominant failure contributors for LPI failure to be:

Component	Failure Freq.
Check valve 1SI8957 FTO	1.3E-3
Check valve 1SI8958 FTO	7.4E-5
Div. 18 & 19 R2 fail	7.9E-6
Other contributors	6.8E-5
Total	**1.45E-3**
Seismic failure freq.	5E-5
Combined failure freq.	**1.5E-3**

Example (Continued)

Now, let's estimate the impact on the element **P(1,1)** of the plant state matrix due to seismic induced failure of LPI. The element in plant state is represented by

$$P = \sum_{i}^{l} \left(\prod_{j}^{m} \left[\sum_{k}^{n} C_k \right]_j \right)_i$$

where

- l = number of sequences contributing to this element,
- m = number of systems or operator failures defining the sequence,
- n = number of components in the system, and
- C_k = component failure rate for component k.

Example (Continued)

Therefore, element **P(1,1)** is modified to be:

$$P(1,1) =$$

$$
\begin{aligned}
& (2.16E{-}3(ORC))_{seq.\ \#1} \\
+ \quad & (1.5E{-}3(LPI)*1.0(ORT))_{seq.\ \#2} \\
+ \quad & (5.15E{-}4(LPR)*1.0(ORT))_{seq.\ \#9} \\
= \quad & \mathbf{4.12E{-}3}
\end{aligned}
$$

Comparing to the old value of P(1,1) which is 4E-3, this is only an increase of 3% due to seismic induced failure. The final CDF due to the impact of seismic induced failure of LPI can be evaluated by modifying other elements.

7. Final Touch

* Importance of component failures due to seismic events can be ranked by evaluating the impact of the individual component.

* The impact on the final CDF due to all the components which may have higher failure rates than random failure frequencies can be evaluated collectively by modifying all the component failure frequencies and carrying out matrix manipulation.

* Look for insights and potential improvements.

COMMONWEALTH EDISON
IPEEE PROGRAM

FIRE PROTECTION EVALUATION

CARLOS DIAZ
PRINCIPAL FIRE PROTECTION ENGINEER

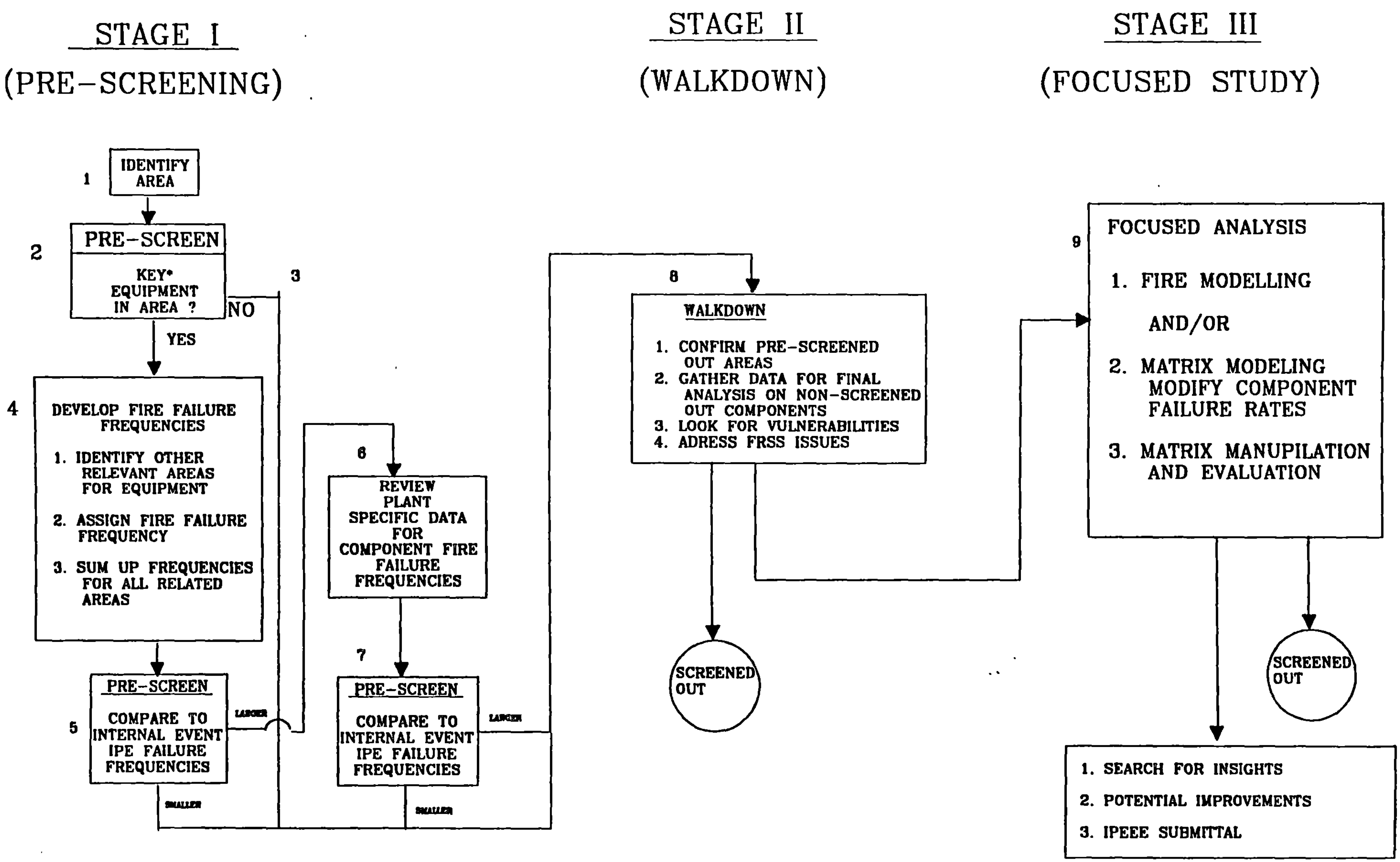
FIRE IPEEE
SCREENING/EVALUATION

Stages

I. Multi-step pre-screening evaluation based on IPE structures.

II. Detailed plant walkdowns aimed at validating assumptions and identifying potential concerns not previously considered.

III. Focused final evaluation using deterministic and/or probabilistic approach.



FLOWCHART FOR
FIRE IPEEE SCREENING/EVALUATION

* EVALUATION PROCESS

Stage I

1. Identification and review of key reference materials for the identification of fire areas and other fire protection features:

Fire Hazards Analysis
Safe Shutdown Analysis
FIVE Methodology

2. Identification of "Key Equipment" in each fire area:

"Key Equipment" will be derived from the IPE components, IPE support systems, and the Safe Shutdown Analysis.

3. First Pre-Screening Phase

Screen out any area which does not contain any "key equipment".

4. Develop Failure Frequency Due to Fire:

For each area that could not be screened out, calculate the failure frequency due to fire for each key component within the area. The FIVE data base will be used to generate the failure frequencies.

5. Second Pre-Screening Phase

Screen out those components whose fire failure rate is less than the random failure rate of the component used in the IPE matrices.

6. Develop Plant Specific Failure Rates Due To Fire

Develop realistic failure rates using specific plant information.

7. Third Pre-Screening Phase

Screen out those components whose failure rate due to fire (as derived from realistic data) is less than the failure rate of the component in the IPE.

STAGE II

8. Validation of Findings From Stages I and II

Walkdown all the areas to:

1) Verify the failure rates due to fire used in stages I & II, and

2) Address the Fire Risk Scoping Study Issues as discussed in the FIVE methodology, and

3) Identify any potential new hazards discerned from physical inspection.

STAGE III

Focused Analysis

1. Where appropriate, construct detailed fire modelling for selected matrix element contributors and evaluate as needed.

and/or

2. Modify the IPE matrixes by including the fire failure rates of those areas not screened out. Modify the matrices to include any new hazards identified in the walkdown.

3. Perform appropriate matrix manipulations to assess the impact of fire modelling through the foregoing stages.

Example of Matrix Modelling:

To illustrate utilization of the matrix approach used in the third stage, we will assume that we are evaluating the 1A RHR pump and that it has not been screened out in stages I &II.

Among the top 36 dominant accident sequences of the Zion IPE, the sequences associate with RHR system are:

Seq. no.	I.E.	S.S	BIN	RHR Failure rate	P(i,j)
2	LLOCA	1	AE9S	1.45E-3	P(1,1)=4.0E-3
8	MLOCA	1	ML9S	5.2E-4	P(1,4)=3.3E-4
9	LLOCA	1	AE9S	5.15E-4	P(1,1)=4.0E-3
13	SLOCA	1	SL9S	4.2E-5	P(1,7)=1.5E-5
15	MLOCA	1	ML9S	1.65E-4	P(1,4)=3.3E-4
20	MLOCA	1	ML9S	5.2E-4	P(1,4)=3.3E-4
25	LLOCA	1	AE9F	1.45E-3	P(1,10)=1.4E-4
32	SLOCA	1	SL9S	4.2E-5	P(1,7)=1.5E-5
36	SLOCA	1	SL9S	4.48E-4	P(1,7)=1.5E-5

By including the failure rate due to fire, the revised failure rates are listed below:

Seq. #	Old RHR failure rate	New RHR failure rate
2	1.45E-3	1.51E-3
8	5.2E-4	5.7E-4
9	5.2E-4	5.7E-4
13	4.2E-5	5.4E-5
15	1.65E-4	2.13E-4
20	5.2E-4	5.7E-4
25	1.45E-3	3.45E-3
32	4.22E-5	5.4E-5
36	4.48E-4	4.88E-4

Now, let's estimate the impact on the plant state matrix. Remember that any element in the plant state matrix can be represented by

$$P = \sum_{i}^{l} \left(\prod_{j}^{m} \left[\sum_{k}^{n} C_k \right]_j \right)_i$$

where l denotes the number of sequences contributing to the element, m denotes the number of systems, components, or operator failures defining the sequences, and C_k denotes the component failure rate for component k. Modifying element P(1,1) results in:

P =

(2.16E-3(Old value of Seq. 1 which is not affected by RHR))$_{\text{seq. 1}}$

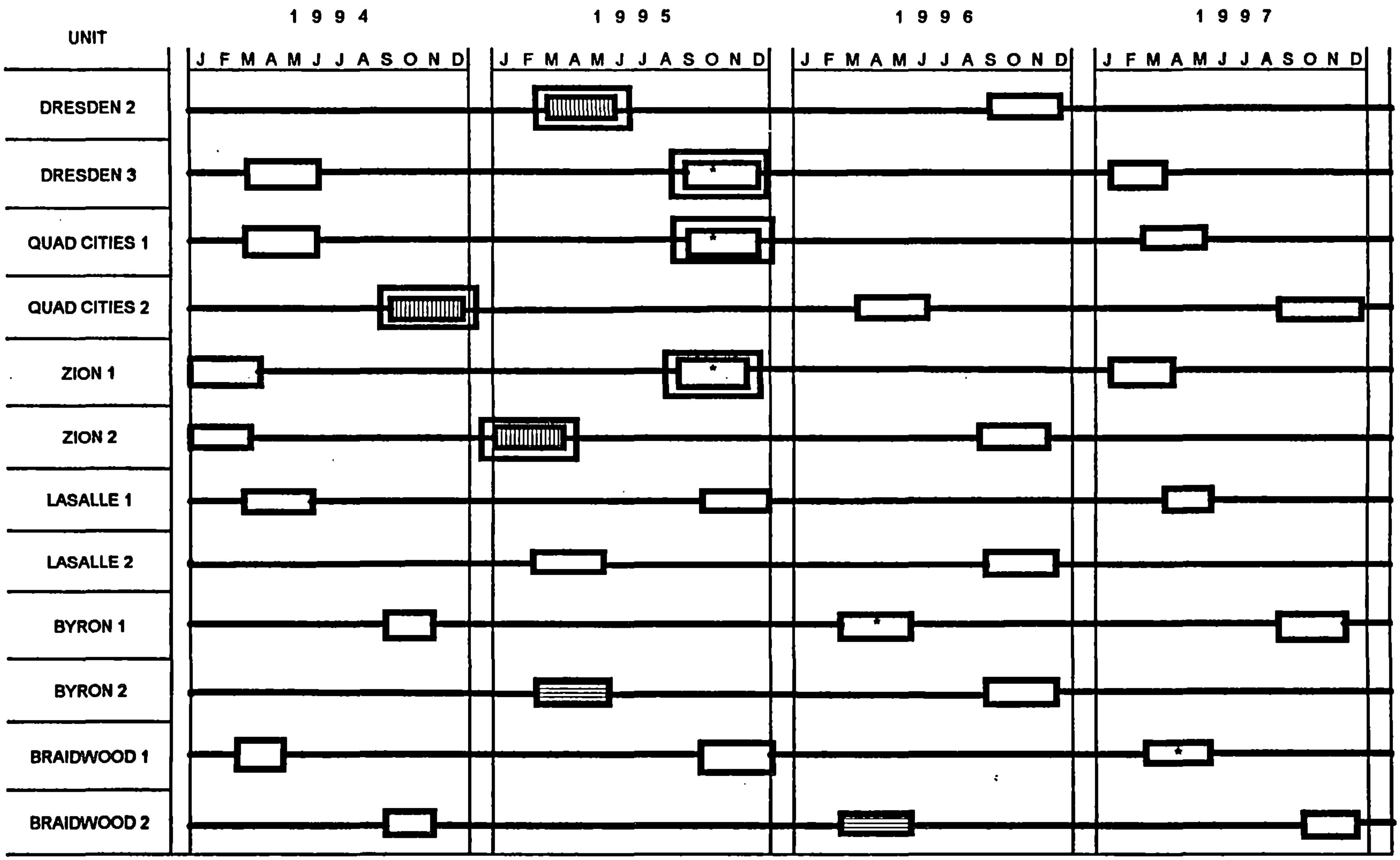
+ (1.51E-3(New LPI) * 1.0(ORT))$_{\text{seq. 2}}$

+ (5.7E-4(New LPR) * 1.0(ORT))$_{\text{seq. 9}}$

= 4.24E-3

Comparing to the old value of P(1,1) which is 4.0E-3, this is only an increase of 6% due to combining RHR pump 1A random failure and fire. Similarly, other elements, i.e., P(1,4), P(1,7), and P(1,10), can be updated as well. The final impact on the plant CDF can thus be estimated by modifying the other elements.

SUMMARY OF NUCLEAR STATION REFUELING SCHEDULE



CECO COMMITTED SUBMITTAL DATES

	IPE	IPEEE
Zion	4/92	6/96
Dresden	1/93	6/96
Quad Cities	12/93	12/96
Byron	4/94	6/96
Braidwood	6/95	6/97

OUTAGE WALKDOWNS


= SQUG/IPEEE


= SQUG


= IPEEE


= Confirmatory IPEEE Walkdown

IPEEE PROJECT/TASK MATRIX

Major Task/Resp. Individuals	Evaluation Process Development	Matrix Development	Pre-Screening Process
Station Representative	② ④ ⑤ ⑥		① ② ③
PRA Engineers	① ② ③ ④ ⑤	① ②	② ④ ⑤ ⑥ ⑦ ⑧
Fire Protection Engineers	① ② ③ ④ ⑤		① ② ③
PRA Augmented Staff		②	
Seismic/Fire Experts	①		⑥ ⑦
Licensing/Reg. Assurance	③		
Site VP	⑤ ⑥		
Proj. Team Leader	③ ④ ⑤		

Evaluation Process Development

① Development of Process
② Station Critique
③ NRC Presentation
④ Development of Project Plan Alternatives
⑤ Presentation to Station/Site VP
⑥ Selection of Method of Implementation

Matrix Development

① IPE Completion
② Develop Matrices

Pre-Screening Process

① Identify Fire Areas
② Identify Equip. in Fire Area
③ Assign Fire Freq.
④ IPE Fire Comparison
⑤ Identify Key Components
⑥ Develop Site Hazard Curves
⑦ Generate Equip. Fragilities
⑧ IPE Seismic Comparison

IPEEE PROJECT/TASK MATRIX

Major Task/Resp. Individuals	Walkdown	Focused Analysis	Documentation
Station Representative	② ③ ⑤ ⑥ ⑦		
PRA Engineers	① ② ③ ④ ⑥ ⑦ ⑧	① ② ③ ④	① ② ③ ④
Fire Protection Engineers	② ③ ⑥ ⑦ ⑧	②	
PRA Augmented Staff		① ② ③ ④	① ② ③ ④
Seismic/Fire Experts	① ④ ⑦ ⑧	②	
Licensing/Reg. Assurance			⑥
Site VP			⑤
Proj. Team Leader			

Walkdown

① Identify Sample of Pre-Screened Items for Walkdown
② Develop Proc./Guidelines
③ Schedule Equip. to Walkdown
④ Schedule Expert Time
⑤ Access Arrangements
⑥ Walkdown Packets Assemble
⑦ Coordinate Walkdown Support
⑧ Record Results

Focused Analysis

① Initial Matrix Run
② Detailed Seismic & Fire Analysis
③ Final Matrix Run
④ Analyze Other External Events [Tornado, Flood, Etc.]

Documentation

① Modify IPE Matrices
② Compile Results
③ Identify Potential Improvements
④ Write Report
⑤ Senior Management Review
⑥ Submit to NRC

SQUG PROJECT TASK MATRIX

Major Task/Resp. Individuals	SSEL Completion	Relay SSEL Completion	Walkdown Planning
Station Representative	①	① ② ④ ⑤ ⑥	① ② ③ ⑤ ⑥ ⑦
Operations Dept.	①		
SSEL Cognizant Eng.	③		
Relay SSEL Cognizant Eng.		④ ⑤ ⑥ ⑦ ⑧	
Seismic Capability Eng.		① ② ⑥	① ② ④ ⑥ ⑦
A/E or Specialty A/E	② ③	④ ⑤ ⑥ ⑦ ⑧	⑥ ⑦
Third Party SQUG Expert		③	④
Licensing/Reg. Assurance			
Site Eng. & Const. Manager		②	
Site VP			② ③
Proj. Team Leader		① ②	① ②
	① Ops. Review On Existing SSEL ② Finish SSEL After Ops. Review ③ Review & Sign-Off SSEL	① Prepare Options for Relay List Completion ② Present/Select Relay List Completion Option ③ Give Relay SSEL SQUG Training ④ Screen Out Non-Essential Relays ⑤ Screen Out Seismically Insensitive Relays ⑥ Evaluate Remaining Relays ⑦ Initial Fill-Out of G.U. Forms ⑧ Review & Sign-Off	① Development of Project Plan of Alternatives ② Presentation to Station/Site VP ③ Selection of Method of Implementation ④ Give Walkdown Training ⑤ Coordinate Walkdown Support at Station ⑥ Prepare, Review & Issue Project/Plan Guidelines to Perform SQUG Walkdowns ⑦ Prepare Walkdown Folders

SQUG PROJECT TASK MATRIX

Major Task/Resp. Individuals	SQUG Walkdown	Anchorage Evaluation	Outlier Resolution	SQUG Report Submittal
Station Representative			① ②	① ③
Mechanical Maintenance	③			
Operations Dept.				
SSEL Cognizant Eng.				
Relay SSEL Cognizant Eng.				
Seismic Capability Eng.	① ② ④	① ② ③	①	①
A/E or Specialty A/E	① ② ④	① ② ③	①	①
Third Party SQUG Expert	①			②
Licensing/Reg. Assurance				③
Site Eng. & Const. Manager				
Site VP				③
Proj. Team Leader				
	① Pilot Walkdown ② Perform Walkdown ③ Anchor Bolt Torque Testing ④ Fill Out SEWS & SVDS	① Sketch Out Anchorage Pattern ② Analyze Anchorage Pattern ③ Document Results	① Develop Solution ② Identify Follow-Up Actions	① Prepare Report ② Independent Audit ③ CECo Approve & Submit Report to NRC

SUMMARY

* CECo's IPEEE program will fulfill NRC's IPEEE objectives.

* Matrix modelling is a proven technology. Applications to PRA date back to the early 1980's (Zion Probabilistic Safety Study).

* Matrix modelling represents an innovative application for evaluating IPEEE.

* CECo's multi-step screening is realistic and conservative.

* Matrix methodology will produce a comprehensive evaluation of seismic and fire events at each of the CECo plants.