CP&L

Carolina Power & Light Company

MAR 20 1986

SERIAL: NLS-86-089

Director of Nuclear Reactor Regulation
Attention: Mr. Dan Muller, Director
BWR Project Directorate #2
Division of BWR Licensing
United States Nuclear Regulatory Commission
Washington, DC 20555

BRUNSWICK STEAM ELECTRIC PLANT, UNIT NOS. 1 AND 2
DOCKET NOS. 50-325 & 50-324/LICENSE NOS. DPR-71 & DPR-62
RECOMBINER CAPABILITY REQUIREMENTS
NITROGEN SWITCHOVER SYSTEM

Dear Mr. Muller:

Carolina Power & Light Company (CP&L) met with members of the NRC staff on January 14, 1986. The purpose of this meeting was to discuss several licensing issues concerning the Company's Brunswick facility. One of the issues discussed was the Nitrogen Switchover System which the Company has installed in both Brunswick units in order to meet the intent of the criteria set forth in Generic Letter 84-09.

During the course of the meeting, as reflected in the NRC meeting minutes issued February 18, 1986, CP&L was requested to provide additional information necessary to support staff approval of the Brunswick system. Specifically, the Company was requested to submit a Probabilistic Risk Assessment (PRA) study which was discussed during the meeting. In addition, the additional cost of literal compliance with Criterion 2 (of Generic Letter 84-09), i.e., installation of a new instrument system that uses a nitrogen supply or takes suction from the drywell atmosphere, was requested. The NRC staff will assess the cost estimate and the PRA study to determine if the additional cost is justified compared to any perceived additional margin of safety over the installed system.

An itemized estimate of the cost of modifying the instrument air system by installing a Nitrogen Pumpback System is provided in Attachment 1. The total estimated cost for this system is approximately $3 million. The cost of installing a pumpback system to achieve literal compliance with Criterion 2 of Generic Letter 84-09 was chosen for the estimate based on the availability of information, confidence that the system would operate effectively, and the Company's belief that if a detailed project proposal/evaluation were performed, a pumpback system would ultimately be the alternative selected to satisfy the scenario depicted by the NRC.

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Attachment 2 provides the Probabilistic Risk Assessment of the Nitrogen Switchover System. Carolina Power & Light Company believes that the results of the attached PRA verify the Company's contention that the cost of installing an additional system to prohibit the scenario depicted by the NRC (i.e., an instrument airline rupture just prior to or concurrent with a loss of coolant accident) is not warranted. The probabilistic risks associated by the scenario depicted are significantly less than the current NRC approved technical specifications.

Should you have any questions regarding this submittal, please contact Mr. Stephen D. Floyd at (919) 836-6901.

Yours very truly,

S. R. Zimmerman
Manager
Nuclear Licensing Section

SRZ/RWS/ccc (3547RWS)

Attachments

*cc: Mr. W. H. Ruland (NRC-BNP)
Dr. J. Nelson Grace (NRC-RII)
Mr. E. Sylvester (NRC)

* Attachments with all cc's.

ATTACHMENT 1

NLS-86-089

NITROGEN PUMPBACK SYSTEM COST ESTIMATE

Component Cost	$ 507,000.00
Engineering Cost	876,000.00
Construction Cost	561,000.00
Miscellaneous (H.P., Security, Overhead, etc.)	466,000.00
TOTAL PROJECT COST	$2,410,000.00

Assuming three years until mod installation, mod future cost is:

$2,410,000 (1 + E_{E\&C})^N = 2,410,000 (1 + 0.06)^3 = \$2,870,349$

($E_{E\&C}$ = Engineering and Construction Escalation Rate)

(3547RWS/ccc)

ATTACHMENT 2

NLS-86-089

CAROLINA POWER & LIGHT COMPANY

BRUNSWICK STEAM ELECTRIC PLANT

PROBABILISTIC ANALYSIS OF LOCA-INDUCED AIR LINE BREAKS

(3547RWS/ccc)

BRUNSWICK STEAM ELECTRIC PLANT

NITROGEN STANDBY SYSTEM AIR LINE BREAK PROBABILISTIC ANALYSIS

1. SUMMARY

Carolina Power & Light Company conducted a probabilistic analysis in order to resolve a question regarding whether the existing Brunswick Plant Nitrogen Switchover System satisfies the hydrogen control issue identified by 10 CFR 50.44(c)(3)(ii) and Generic Letter 84-09.

Specifically, the analysis was performed to address probabilistically the risk contributions of a LOCA induced instrument air line rupture within the drywell to the generation of a combustible mixture of hydrogen and oxygen following a core damage event.

This concern was addressed by the following approach.

First, a base case was run which determined that the probability of a combustible hydrogen-oxygen mixture in the drywell (due to core melt) during technical specification allowable de-inerted operating conditions was 5.67E-6/Rx. yr. Then the probability of developing a combustible hydrogen-oxygen mixture due to a LOCA-induced air line rupture in the drywell (following a LOCA induced core melt) was determined to be 5.03E-09/Rx. yr. Finally, a third case was run which determined that the probability of a combustible hydrogen-oxygen mixture in the drywell due to an open or broken instrument air line in the drywell and core damage from any of a number of events was 5.77E-8/Rx. yr.

Since the second and third probabilities were considerably less than the first, CP&L has concluded that the NRC's postulated scenario presents a negligible additional contributor to existing risk. That is, the de-inerting currently permitted by Technical Specifications is <u>the controlling constraint</u> and, therefore, design changes to prevent the NRC postulated scenario from occurring are not cost effective.

2. DISCUSSION

Event tree/fault tree methodology was used to determine the sequence frequencies and failure probability estimates.

The recently developed Brunswick plant safety significance computer model was used to determine the initiating event frequencies for the event trees. This model is essentially a BSEP specific event tree computer model which computes core damage frequency and the Veseley-Fussel importance of accident initiators and basic events. The basic event and initiator data for the model event trees is based on BSEP specific data where available from previous studies, on generic system fault trees, and on surrogate data from other industry sources where BSEP data was not available. Although it is not a full PRA, it does provide representative core damage and V-F importance data.

In this particular study, the model was employed to derive only the initiation frequencies for the event trees. The event trees and fault trees for the scenarios of concern are otherwise independent of the model.

This section details the methodology used to determine the sequence frequencies and failure probability estimates.

2.1 Base Case: Core Damage With De-Inerted Drywell

In order to establish a baseline value for comparison, an event tree was developed which presents the likelihood of generation of a combustible mixture by core damage suffered with the unit at power and with a de-inerted drywell. This event tree is presented as Figure 1.

The sequence of events is as follows:

a. The unit is operating at power and suffers core damage. The frequency for this event is the total core damage frequency directly from the BSEP safety significance model, 2.07E-4/Rx. Yr., as shown in Appendix 1, Table A1.1.

b. As a result of the core damage, hydrogen is generated within the containment in sufficient volume to form a combustible mixture if oxygen concentration exceeds the Technical Specification limit of 4 percent. For conservatism, this probability was estimated to be approximately 0.999.

c. The drywell is not inerted and, therefore, oxygen concentration is approximately 20 percent. The probability of this occurrence is based on the allowed time for oxygen concentration to exceed 4 percent. Technical Specifications allow the containment atmosphere to exceed 4 percent for 24 hours after reaching 15 percent rated thermal power on startup and for 24 hours prior to reaching 15 percent rated thermal power on power reduction or shutdown.

   A review of plant data for 1981 through 1985 gave an approximate average of 5 start-up/shutdown cycles per year per unit where the allowed inerting procedures could have been used. Therefore, the probability of operating at power with a de-inerted containment is:

$$\frac{5\,(24 + 24)}{8766} = 2.74 \times 10^{-2}$$

   The combustible mixture frequency of this base case is 5.67E-6.

2.2 LOCA Initiated Air Line Break and Core Damage

The second portion of this study covers the concern that the unit is operating at power, that the drywell was inerted, and that the unit suffered a LOCA which causes core damage and an instrument air line break in the drywell. Figure 2 is a schematic representation of the situation of concern, and Figure 3 shows the event tree and supporting fault trees.

The sequence of events is as follows:

a. The unit is operating at power with an inerted drywell and suffers an initiating event LOCA which causes core damage. The frequency for this initiating event (7.2E-6/Rx. Yr.) was derived from the safety significance model (Appendix 1).

b. As a result of the LOCA, one of the instrument air lines within the drywell ruptures. The probability of this event is estimated to be 0.999. This is a conservative estimate as the rupture is dependent on the location and energy of the LOCA as well as pipe positions within the drywell.

c. As a result of the core damage, hydrogen is generated within the containment in sufficient volume to form a combustible mixture if oxygen concentration exceeds 4 percent. Again for conservatism, this probability was estimated to be approximately 0.999.

d. In order for the system to pump oxygen into the drywell through the break, the isolation valve must remain open. This could be caused by failure of the Containment Isolation Signal (CIS) logic and failure of the operator to manually close the valve or by the valve sticking in the open position. From the fault tree, the likelihood of this is 7.0E-4. The fault tree data sources are presented in Appendix 2.

The sequence resulting in Class 4, combustible mixture, is the one of interest. The frequency of this sequence is calculated to be 5.03E-9 per reactor year.

2.3 Open Air Line and Core Damage

The third protion of this study covers the concern that the unit is operating at power, that the drywell is inerted, that an instrument air line is open in the drywell, and that the unit suffered core damage from any of a number of events. Figure 4 shows the event tree and supporting fault tree.

The sequence of events is as follows:

a. The unit is operating at power with an inerted drywell and suffers core damage. The frequency for this initiating event, 2.07E-4, again is directly from the BSEP safety significance model as shown in Appendix 1.

b. As a result of the core damage, hydrogen is generated within the containment in sufficient volume to form a combustible mixture if oxygen concentration exceeds 4 percent. Again, the probability is estimated as 0.999.

c. In order for the oxygen concentration to exceed 4 percent, the air line must be open to containment and the isolation valve on that line must be open. Note that in this sequence, the open air line could result from pipe breaks other than that caused by the LOCA or it could result from the line being left disconnected through human error. In addition, this event does not consider the possibility of the CIS logic closing the valve because the open air line could have occurred prior to the core melt initiating event. From the fault tree, the probability for this event is 7.3E-5. Supporting data is listed in Appendix 3.

The Class 3 sequence, combustible mixture, is the one of interest for this tree. The frequency of this sequence is calculated to be 5.77E-8/Rx. Yr.

Since this sequence is based on the total core damage frequency and allows for human error in leaving the air line disconnected, it is reasonable that it should have a higher frequency than the second case.

3. CONCLUSION

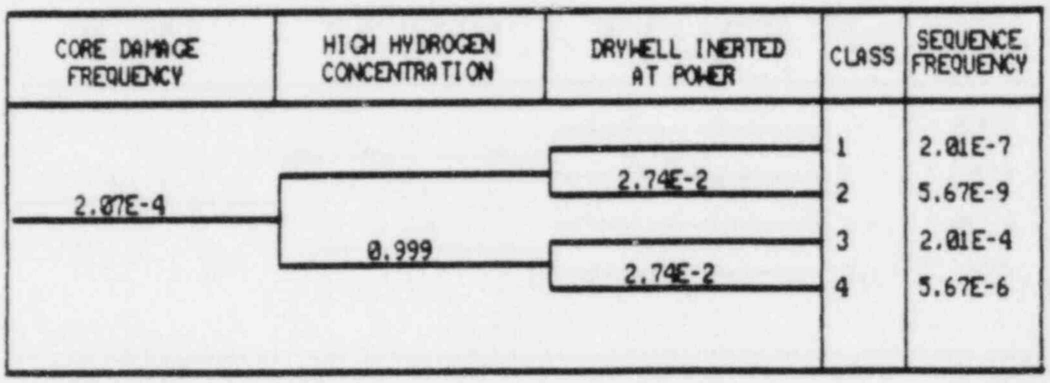
The concern that the existing standby nitrogen system at BSEP could introduce oxygen into the drywell was analyzed probabilistically using event tree/fault tree methodology.

The analysis demonstrates that the likelihood of generating a combustible mixture of hydrogen and oxygen within the drywell as a result of an instrument air line break in conjunction with a core damage event, is less than that which is possible as a result of being de-inerted (as allowed by Technical Specifications) and having a core damage event.

The results of the analysis are listed below:

Scenario	Frequency	Percent of Total Frequency
De-Inerted Drywell and Core Damage	5.67E-6/Rx. Yr.	98.91
LOCA Initiated Air Line Break and Core Damage	5.03E-9/Rx. Yr.	0.09
Open Air Line and Core Damage	5.77E-8/Rx. Yr.	1.00
Total Frequency	5.73E-6	

(3547RWS/pgp)



CLASS:
1. NO H2, 02 < 4%
2. NO H2, 02 > 4%
3. HIGH H2, 02 < 4%
4. COMBUSTIBLE MIXTURE

FIG. 1

DATE: 3-7-86	TITLE: CORE DAMAGE PLUS DE-INERTED DRYWELL EVENT TREE	FN: 02FTH	DRN. BY:

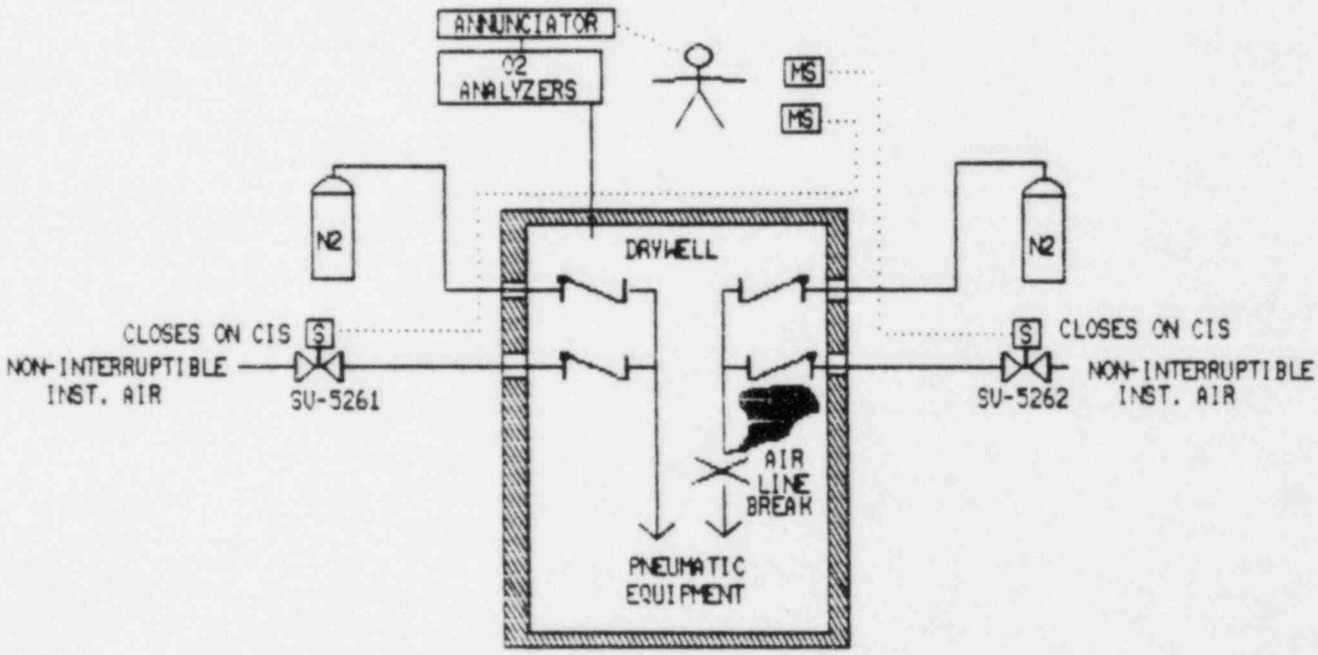
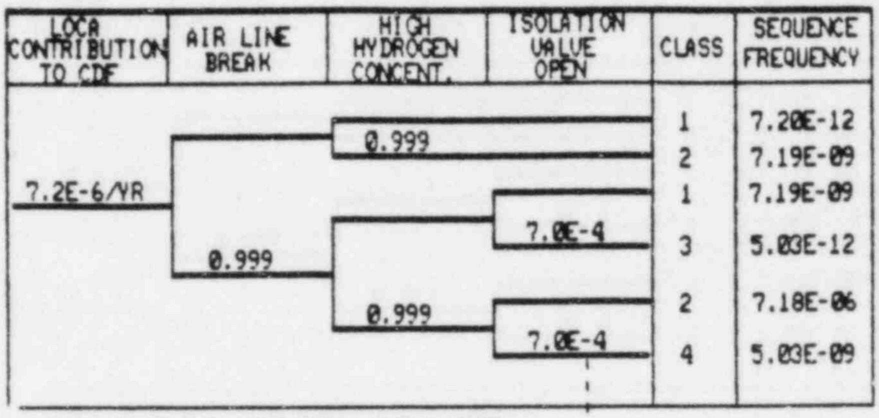


FIG. 2

DATE: 3-14-86	TITLE: NITROGEN STANDBY SYSTEM AIR LINE BREAK	FN: 024FTCA	DRN. BY:



LOCA PLUS AIR LINE BREAK EVENT TREE

CLASS: 1. NO H2, O2 < 4%

2. HIGH H2, O2 < 4%

3. NO H2, O2 > 4%

4. COMBUSTIBLE MIXTURE

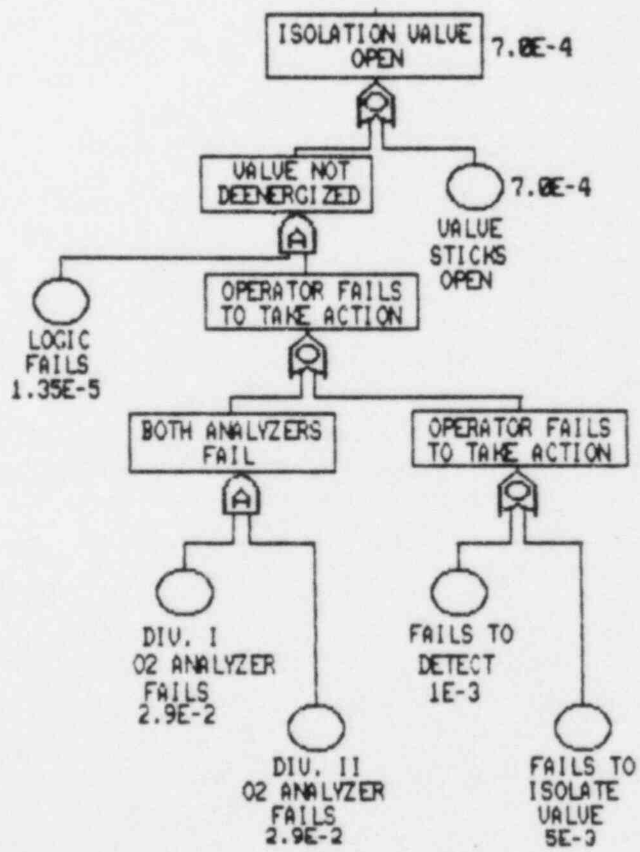


FIG. 3

DATE 3-15-86	TITLE: LOCA + AIR LINE BREAK EVENT TREE & FAULT TREE	FN: 024FTBA	DRN. BY:

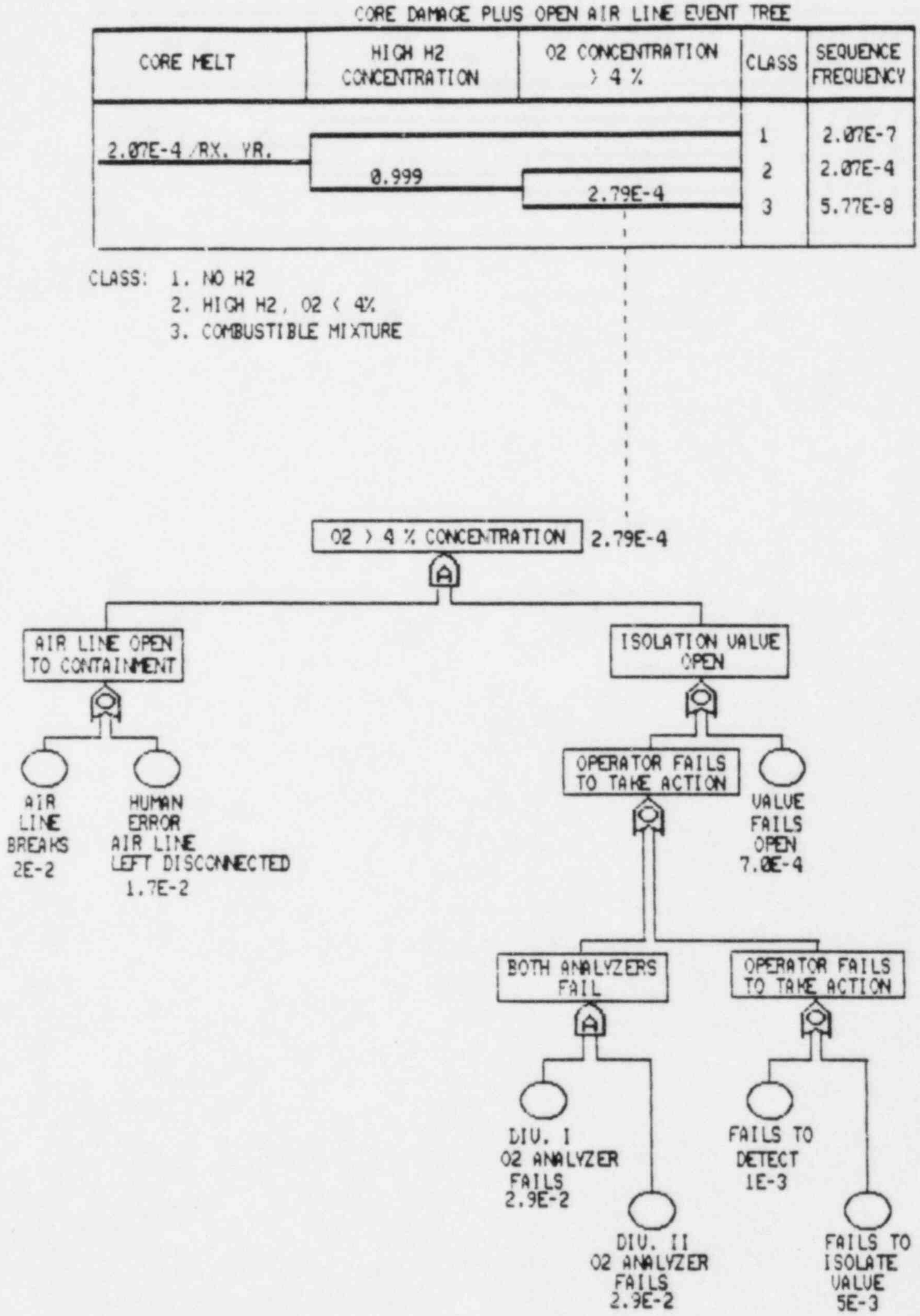


FIG. 4

DATE:3-14-86	TITLE: CORE DAMAGE + OPEN AIR LINE EVENT TREE AND FAULT TREE	FN: O24FTAA	DRN. BY:

APPENDIX 1

APPENDIX 1

Table A1.1 lists the core damage frequency and Vesely-Fussel Importances to core damage of the basic events (BE) calculated by the BSEP safety significance model.

Table A1.2 lists the Basic Events.

The Vesely-Fussel Importance = $\frac{\text{Total Contribution to C.D.F. from B.E.}}{\text{Total C.D.F.}}$

Therefore the Total Contribution to C.D.F. from B.E. = (V-F Importance) (Total C.D.F.)

for Large LOCA, A, V-F I = 0.2762E-01 from Table A1.1
A contribution to C.D.F. = (0.2762E-01) (2.0651E-04) = 5.7038E-6

for Medium LOCA, S1 V-F I = 0.5136E-02 from Table A1.1
S1 contribution to C.D.F. = (0.5136E-02) (2.0651E-04) = 1.06×10^{-6}

for Small LOCA, S2 V-F I = 0.1695E-02 from Table A1.1
S2 contribution to C.D.F. = (0.1695E-02) (2.0651E-04) = 3.5×10^{-7}

for Large LOCA outside containment, AOUT V-F I = 0.4485E-03
AOUT contribution to C.D.F. = (0.4485E-03) (2.0651E-04) = 9.262E-8

Total LOCA contribution to C.D.F. = 7.20 E-6

TABLE A1.1

CORE DAMAGE SUMMARY
USING POINT ESTIMATION

RUN NO. = 1 BY= OFD DATE= 091185

The frequency of core damage for class # 1	7.2391E-05
The frequency of core damage for class # 2	4.9836E-05
The frequency of core damage for class # 3	5.2228E-07
The frequency of core damage for class # 4	8.3672E-05
The frequency of core damage for class # 5	8.8208E-08
The total frequency of core damage	2.0651E-04

POINT ESTIMATION OF BASIC EVENT IMPORTANCES TO CORE DAMAGE

RUN NO. = 1 BY= OFD DATE= 091185

BASIC EVENT	TOTAL CORE DAMAGE	CLASS # 1	CLASS # 2	CLASS # 3	CLASS # 4	CLASS # 5
RPS	0.6630E+00	0.7350E+00	0.0000E+00	0.8577E-01	0.1000E+01	0.0000E+00
TT	0.5969E+00	0.7006E+00	0.3080E+00	0.6493E-01	0.6832E+00	0.0000E+00
SLC	0.4488E+00	0.1454E+00	0.0000E+00	0.0000E+00	0.9818E+00	0.0000E+00
OP1	0.4155E+00	0.4910E+00	0.2156E+00	0.4545E-01	0.4721E+00	0.0000E+00
HPCI	0.3446E+00	0.8897E+00	0.3728E-01	0.7238E+00	0.5413E-01	0.0000E+00
RHR	0.2383E+00	0.0000E+00	0.9743E+00	0.0000E+00	0.7872E-02	0.0000E+00
MSIV	0.2028E+00	0.4530E-01	0.2136E+00	0.6743E-02	0.3341E+00	0.0000E+00
PCS	0.1656E+00	0.0000E+00	0.6861E+00	0.0000E+00	0.0000E+00	0.0000E+00
NTDP	0.1457E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.3596E+00	0.0000E+00
TC	0.1278E+00	0.4461E-01	0.2145E+00	0.3007E-02	0.1490E+00	0.0000E+00
LP	0.8962E-01	0.1575E+00	0.9811E-01	0.4129E-01	0.2625E-01	0.0000E+00
ROP	0.8608E-01	0.1566E+00	0.9581E-01	0.3119E-01	0.1970E-01	0.0000E+00
FWS	0.8411E-01	0.8538E-01	0.1981E+00	0.5221E-02	0.1572E-01	0.0000E+00
QG	0.7553E-01	0.1539E+00	0.8898E-01	0.1188E-02	0.2224E-03	0.0000E+00
RCIC	0.6748E-01	0.1448E+00	0.6923E-01	0.4917E-02	0.0000E+00	0.0000E+00
TM	0.5957E-01	0.1573E-01	0.3640E-01	0.2255E-02	0.1117E+00	0.0000E+00
TDP	0.4907E-01	0.1346E+00	0.7867E-03	0.6687E+00	0.0000E+00	0.0000E+00
MS	0.4756E-01	0.3482E-02	0.1920E+00	0.0000E+00	0.0000E+00	0.0000E+00
AHP	0.4066E-01	0.1111E+00	0.7055E-02	0.4917E-02	0.0000E+00	0.0000E+00
DCR	0.2843E-01	0.7650E-01	0.6689E-02	0.0000E+00	0.0000E+00	0.0000E+00
A	0.2762E-01	0.0000E+00	0.1123E+00	0.2019E+00	0.0000E+00	0.0000E+00
SRVC	0.2682E-01	0.6074E-01	0.2154E-02	0.3958E-01	0.1212E-01	0.0000E+00
TF	0.2212E-01	0.2533E-01	0.1033E-01	0.2255E-02	0.2652E-01	0.0000E+00
TI	0.2154E-01	0.5235E-01	0.1310E-01	0.1436E-05	0.7448E-04	0.0000E+00
DCH	0.1695E-01	0.4460E-01	0.5471E-02	0.0000E+00	0.0000E+00	0.0000E+00
ALP	0.1213E-01	0.3163E-01	0.0000E+00	0.2430E+00	0.0000E+00	0.1000E+01
CS	0.5792E-02	0.7661E-03	0.1857E-01	0.2430E+00	0.0000E+00	0.1000E+01
LPCI	0.5685E-02	0.7661E-03	0.1813E-01	0.2430E+00	0.0000E+00	0.1000E+01
S1	0.5136E-02	0.1026E-03	0.1251E-01	0.6794E+00	0.8938E-03	0.0000E+00
CHS	0.4773E-02	0.1337E-02	0.9706E-03	0.2027E-03	0.1004E-01	0.0000E+00
S2	0.1695E-02	0.2737E-03	0.2571E-02	0.4963E-02	0.2383E-02	0.0000E+00
MDP	0.8629E-03	0.2462E-02	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
TBP	0.4778E-03	0.1338E-03	0.9716E-04	0.2030E-04	0.1005E-02	0.0000E+00
AOUT	0.4485E-03	0.0000E+00	0.8850E-04	0.0000E+00	0.0000E+00	0.1000E+01
OP2	0.3407E-03	0.5724E-04	0.1203E-02	0.1436E-05	0.7448E-04	0.0000E+00
SRVO	0.2844E-03	0.0000E+00	0.4005E-03	0.1860E-02	0.4517E-03	0.0000E+00
BD	0.2339E-03	0.0000E+00	0.0000E+00	0.0000E+00	0.5772E-03	0.0000E+00
RPT	0.1830E-03	0.0000E+00	0.0000E+00	0.7237E-01	0.0000E+00	0.0000E+00
VS	0.3402E-05	0.0000E+00	0.0000E+00	0.1345E-02	0.0000E+00	0.0000E+00

TABLE A1.2

ABBREVIATIONS

Accident Initiator Group (items 1–11):

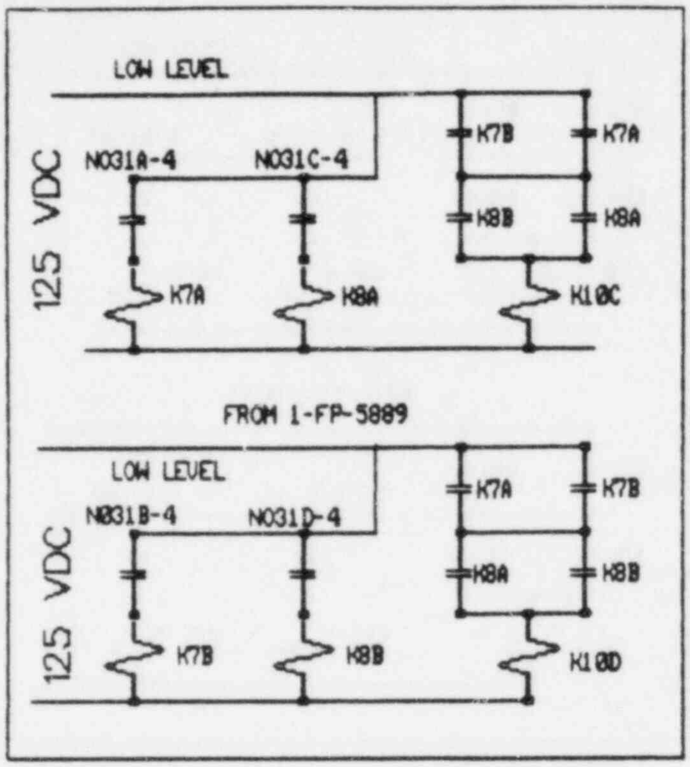
1.	TT	Turbine Trip
2.	MS	Manual Shutdown
3.	TF	Transient, Loss of Feedwater
4.	TM	Transient, MSIV Closure
5.	TC	Transient, Loss of Condenser Vacuum
6.	LP	Loss of Offsite Power Complete
7.	TI	Transient, Inadvertently Open Relief Valve
8.	A	Large LOCA
9.	S1	Medium LOCA
10.	S2	Small LOCA
11.	AOUT	Large LOCA Outside Primary Containment & Unisolated
12.	RPS	Reactor Protection System
13.	FWS	Feedwater System
14.	SRVO	SRV's Open When Challenged
15.	SRVC	SRV's That Opened Reclose
16.	OP1	Operator Maintains Feedwater on
17.	TBP	Turbine Bypass System
18.	CHS	Immediate Availability Condenser as Heat Sink
19.	RCIC	RCIC
20.	HPCI	HPCI
21.	AHP	Alternate High Press. Sources (CRD Pumps SLC Pump) or Late Feedwater Recovery
22.	TDP	Operator Depressurizes Primary System
23.	ALP	Alternate Low Press. Sources (Condensate Pumps, HTR Drain Pumps from CST Thru Condenser?)
24.	RHR	Residual Heat Removal
25.	MSIV	MSIV
26.	PCS	Power Conversion System (Main Condenser and F. W. Condensate System)
27.	SLC	Standby Liquid Control
28.	MDP	Maintain Depressurized Condition (Dependent on Batteries)
29.	CS	Core Spray
30.	RPT	Recirc. Pump Tripped
31.	LPCI	Low Press Coolant Inj
32.	NTDP	ADS not Actuated After ATWS (Don't Flush Boron Out)
33.	BD	Boron not Diluted HPCI & F. W. Controlled
34.	OP2	Early Scram by Operator (After fUKV)
35.	VS	Vapor Suppression (Steam Condensed Suppression Pool)
36.	ROP	Recovery Offsite Power
37.	DG	Diesel Generators
38.	DCR	DC Power for RCIC
39.	DCH	DC Power for HPCI

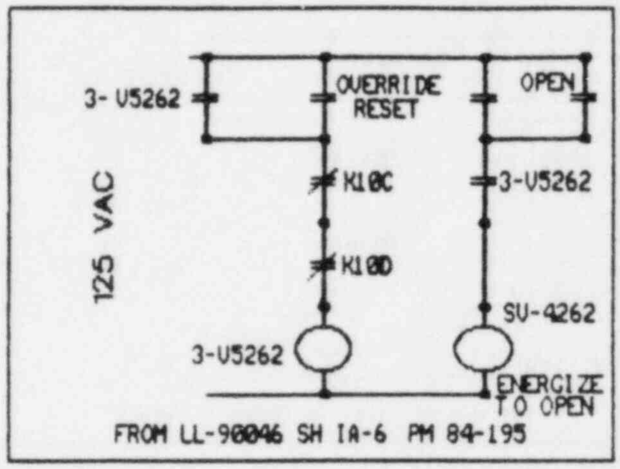
APPENDIX 2

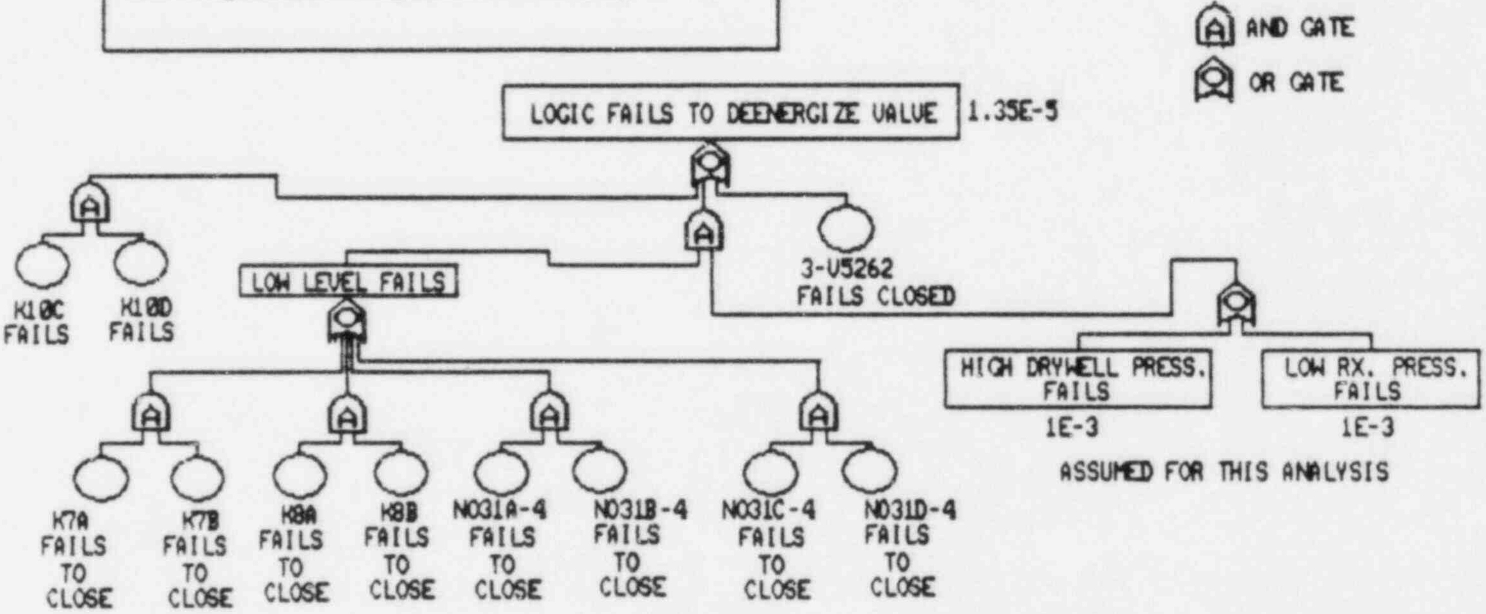
APPENDIX 2

"ISOLATION VALVE OPEN"
FAULT TREE DATA SUPPORT

EVENT DESCRIPTION	MODEL PROBABILITY	
Logic Fails	1.35-E	Fault Tree Page A2.2
IA containment isolation valve fails open	7.0E-04	NUREG/CR-4217, Table IX-A Page A3.4 & 5
Oxygen analyzer 1 fails	2.9E-2	NPRDS BSEP, Page A3.6
Oxygen analyzer 2 fails	2.9E-2	NPRDS BSEP, Page A3.6
Human error - operator fails to detect high oxygen alarm	1.0E-03	NUREG/CR-1278, Page A3.7
Human error - operator fails to close IA isolation valve	5.0E-03	NUREG/CR-1278, Page A3.8







COMPONENTS	COMPONENT UNAVAILABILITY	SOURCE	SET UNAVAILABILITY	COMMENTS
K7A & K7B	2.68E-4	SNPS PRA TABLE A.2-1	7.18E-8	
K8A & K8B	"	"	7.18E-8	
N031A-4 & N031C-4	6.5E-5	NEDC-30036P PAGE E-2	4.22E-9	
N031B-4 & N031D-4	"	"	4.22E-9	
3-V5262	8.04E-8/h τ = 7 days	SNPS PRA TABLE A.2-1	1.35E-5	DOMINANT CONTRIBUTOR
K10C & K10D	"	"	1.82E-10	

DATE: 3-3-86	TITLE: CORE SPRAY LOGIC ANALYSIS	FN: 024FTD	DRN. BY: [signature]

APPENDIX 3

APPENDIX 3

02 > 4% CONCENTRATION
FAULT TREE DATA SUPORT

EVENT DESCRIPTION	MODEL PROBABILITY	SOURCE
Instrument air line break	2.0E-02	NUREG/CR 2728, Table 5.3-1
Human error - IA line left disconnected	1.7E-02	NUREG/CR 1278, Page A3.2
IA containment isolation valve fails open	7.0E-04	NUREG/CR 4217, Table IX-A Pg. A3.4&5
Oxygen analyzer 1 fails	2.9E-2	NPRDS BSEP, Page A3.6
Oxygen analyzer 2 fails	2.9E-2	NPRDS BSEP, Page A3.6
Human error - operator fails to detect high oxygen alarm	1.0E-03	NUREG/CR-1278, Page A3.7
Human error - operator fails to close IA isolation valve	5.0E-03	NUREG/CR-1278, Page A3.8

Reconnecting Instrument Air Tubing After
Testing, Maintenance, or Calibration

PROBLEM WORKSHEET

Page ____ of ____

1. Exercise No. C Problem No. ______ Analyst: K. Paul

2. Performance Shaping Factors:

Instructions		Experience		Stress Level		Tagging Level	
Written:							
≤10 items	X	≤6 months		Low		1	
>10 items		>6 months	X	Optimum	X	2	
Oral				Mod. High		3	
None				High		NA	

3. Written Procedure Step No. or Task Description	4. Dependence	5. Potential Error	6. Table No. & Item No.	7. Tabled HEP & UCBs	8. Stress/ Skill Factor	9. Adjusted HEP	10. Comments*
A		Failure to Use Written Procedures	20-6 #6 & #7	.05 .3			Test or Calibration Maintenance
B		Failure to Use Checkoff Provision Properly	20-6 #8	.5			
C		Omit Step, Checkoff Used Properly	20-7 #1	.001			
D		Omit Step, Checkoff Used Improperly	20-7 #3	.003			
E		Omit Step, Procedures Not Used	20-7 #5	.05			

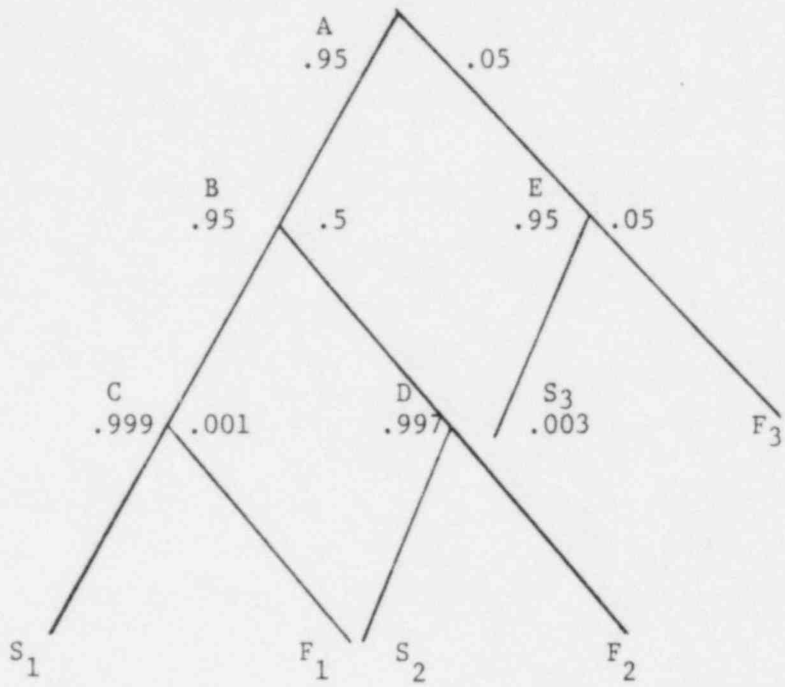
P(F) Testing, Calibration .005
P(F) Maintenance .017

*Cite studies, if available, to back up any disagreement with the stated HEP and EF in the handbook.

Figure A-1 Worksheet To Be Used For Exercises No. 3-6

(3547RWS/pgp)

Testing Calibration



$$P(F) = (0.05 \times .05) + (.95 \times .5 \times .003) + (.95 \times .95 \times .001)$$
$$= .0048275$$
$$\simeq .005$$

Maintenance

A = .3

$$P(F) = (.3 \times .05) + (.97 \times .5 \times .003) + (.97 \times .95 \times .001)$$
$$= .0173765$$
$$\simeq .017$$

NUREG/CR-4217

TABLE IX-A

BWR: DEMAND-DEPENDENT, CATASTROPHIC FAILURES--FAILURE TO OPERATE ON DEMAND (A,K)

Average Failure-Rate Estimate--2.35 x 10^{-3} (8.32 x 10^{-4})

Rank	Factor	Category	Description	R_j	Failure-Rate Adjustment
1	VTYPE	1	Angle	13.35	1.33 (0.76)
		2	Butterfly		1.20 (0.49)
		3	Plug		0.44 (0.35)
		4	Diaphragm		4.14 (3.37)
		5	Gate		1.27 (0.45)
		6	Globe		0.87 (0.37)
		7	Relief/safety		0.31 (0.45)
2	SIZE	1	<2 inches	6.74	0.91 (0.28)
		2	2-10 inches		0.56 (0.14)
		3	10-30 inches		0.54 (0.14)
		4	>30 inches		3.64 (1.73)
3	SYSTEM	1	Containment	4.53	0.36 (0.17)
		2	Nuclear		1.46 (0.48)
		3	Power conversion		1.62 (0.52)
		4	Safety		1.63 (0.77)
		5	Process auxiliary		0.73 (0.59)
4	OTYPE	1	Air	1.63	1.17 (0.42)
		2	Solenoid		1.17 (0.89)
		3	Motor		0.95 (0.36)
		4	Chain		0.72 (0.44)
		5	Manual		1.07 (1.18)

Note: Values in parentheses are standard deviations.

INSTRUMENT AIR CONTAINMENT ISOLATION VALVE

Valve Type: GATE (Assumed)
Valve Size: 2"
System: Containment
Operator Type: Solenoid (Direct Acting, Fail Close)
Manufacturer: Valcor
Model No.: V-526-5683-6

Using Table IX-A of NUREG/CR-4217 (Attached)

Average Failure on Demand: 2.35E-03

Factor	Failure Rate Adjustment
V TYPE	1.27
SIZE	.56
SYSTEM	.36
O TYPE	1.17

U_D = (2.35E-03) (1.27) (.56) (.36) (1.17)

U_D = 7.04E-04

10:07:44 21 FEB 1986

225 CMA-2 02 Analyzer

Failure Rates from NPRDS

[·al Calendar Hours: 63,408

Total Estimated Operating Hours: 46,775

Total Number of Failures Included: 23

Code	Translation	No. Fail	Failures per Million Calendar Hours	Failures per Million Est Operating Hours	MTBF Calendar Hours	MTBF EstOperating Hours
----	----------------	----	--------	-------------	--------	------------
----	----------------	----	--------	-------------	--------	------------
Overall		23	362.730	491.716	2757	2034

For all failures included,

Mean Restoration Time (hours): 81
With Standard Deviation of : 71

Average Out-of-Service Hours : 253
With Standard Deviation of : 381

This data is calculated for failures discovered and hours accumulated through quarter 85-3

There were 5 records in the 2C hit list and 5 were used in these calculations.

02 Analyzer MTBF = 2757 hours
Mean Restoration Time = 81 hours = τ

$$\bar{A} = \tau \frac{1}{MTBF}$$

$$\bar{A} = 81 \frac{1}{2757} = 2.93X10^{-2} \approx 2.9X10^{-2}$$

$$\boxed{\bar{A} \approx 2.9X10^{-2}}$$

Failure to Detect and Diagnose High Oxygen
Alarm in Control Room Within 30 Minutes

PROBLEM WORKSHEET

Page ____ of ____

1. Exercise No. A Problem No. ________ Analyst: K. Paul

2. Performance Shaping Factors:

Instructions		Experience		Stress Level		Tagging Level	
Written:							
≤10 items	____	≤6 months	____	Low	____	1	____
>10 items	____	>6 months	X	Optimum	X	2	____
Oral	____			Mod. High	____	3	____
None	X			High	____	NA	X

3. Written Procedure Step No. or Task Description	4. Dependence	5. Potential Error	6. Table No. & Item No.	7. Tabled HEP & UCBs	8. Stress/ Skill Factor	9. Adjusted HEP	10. Comments*
A			20-3 #4	.001			Nominal Model for Diagnosis

*Cite studies, if available, to back up any disagreement with the stated HEP and EF in the handbook.

Figure A-1 Worksheet To Be Used For Exercise Nos. 3-6

(3547RWS/ccc)

Failure to Close Instrument Air In
Isolation Valve From Control Room

PROBLEM WORKSHEET

Page ____ of ____

1. Exercise No. ___B___ Problem No. ________ Analyst: ___K. Paul___

2. Performance Shaping Factors:

Instructions		Experience		Stress Level		Tagging Level	
Written:							
≤10 items	____	≤6 months	____	Low	____	1	____
>10 items	____	>6 months	____	Optimum	____	2	____
Oral	____			Mod. High	____	3	____
None	____			High	____	NA	____

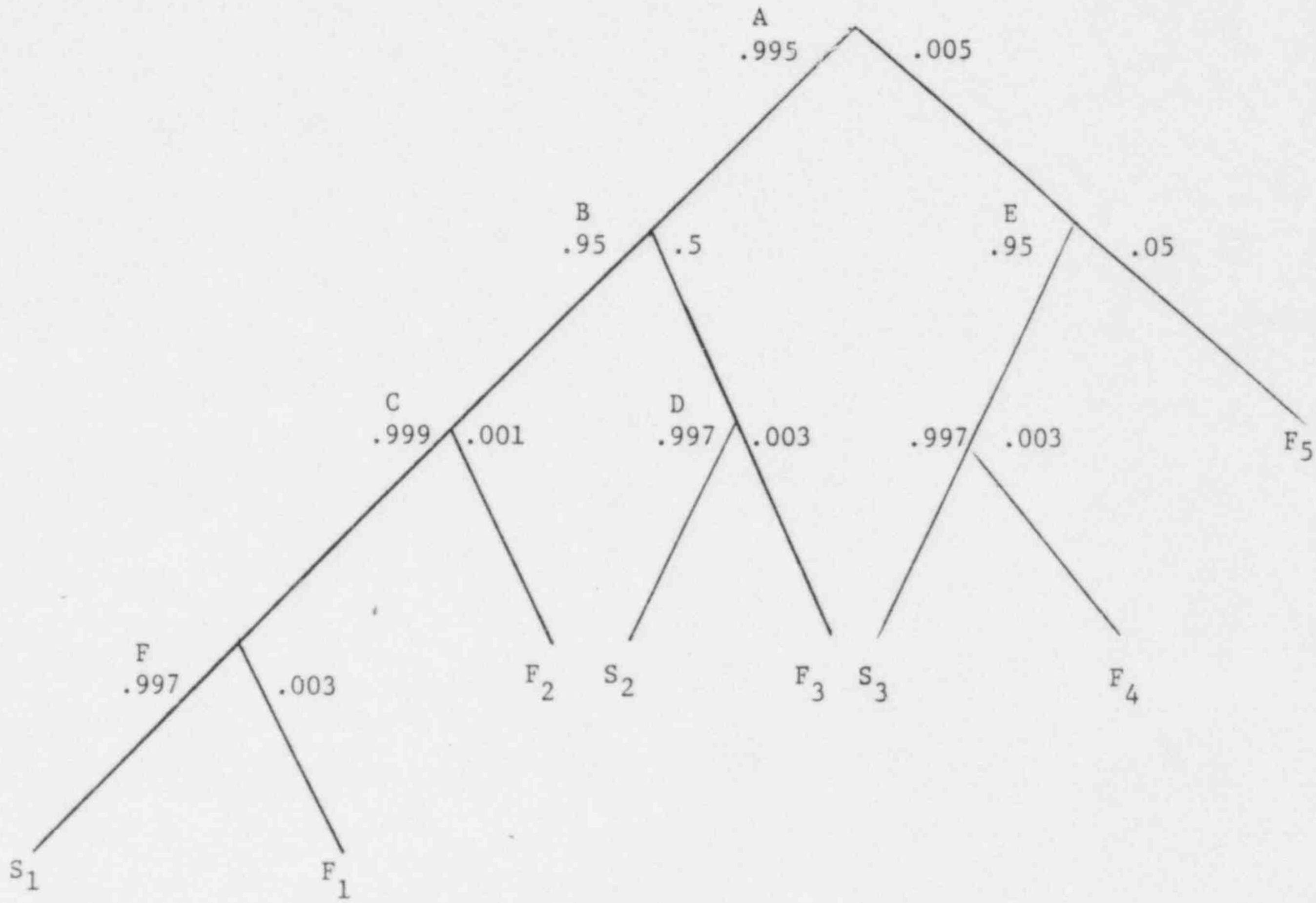
3. Written Procedure Step No. or Task Description	4. Dependence	5. Potential Error	6. Table No. & Item No.	7. Tabled HEP & UCBs	8. Stress/ Skill Factor	9. Adjusted HEP	10. Comments*
A		Failure to Use Written Procedures	20-6 #4	.005			
B		Failure to Use Checkoff Provision Properly	20-6 #8	.5			
C		Omit Step, Checkoff Used Properly	20-7 #1	.001			
D		Omit Step, Checkoff Used Improperly	20-7 #3	.003			
E		Omit Step, Procedures Not Used	20-7 #5	.05			
F		Error of Commission	20-12 #10	.003			

P(F) = .005

*Cite studies, if available, to back up any disagreement with the stated HEP and EF in the handbook.

Figure A-1 Worksheet To Be Used For Exercises No. 3-6

(3547RWS/pgp)



$$
\begin{aligned}
P(F) &= (.005 \times .05) + (.005 \times .95 \times .003) + (.995 \times .5 \times .003) \\
&\quad + (.995 \times .95 \times .001) + (.995 \times .95 \times .999 \times .003) \\
&= .0055349 \\
&\simeq .005
\end{aligned}
$$