Idaho National Engineering Laboratory

June 7, 1995

Mr. Robert Palla
US Nuclear Regulatory Commission
Washington, D. C. 20555

TRANSMITTAL OF INFORMATION DISCUSSING AP600 LEVEL 2 HUMAN ACTIONS - JLR-18-95

Dear Mr. Palla:

Please find enclosed a copy of information prepared by Dr. Harold S. Blackman discussing the manner in which Westinghouse quantified Level 2 human actions in the AP600 PRA. As indicated by Dr. Blackman, the Westinghouse assumptions appear optimistic. In fact, requantification calculations performed by Dr. Blackman indicate that failure probabilities may be as much as an order of magnitude higher. Base on the enclosed information, I would recommend that sensitivity calculations be performed to assess the importance of Westinghouse assumptions related to human actions. Perhaps these sensitivity studies could be included in the planned Westinghouse importance analyses or as part of the IRRAS Level 2 database verification work that we are discussing. If you have any questions about the enclosed information, please contact Dr. Blackman (208-526-0245) or me (208-526-2897).

Sincerely,

Joy Rempe

Dr. Joy L. Rempe
Nuclear Accident Analysis Technologies

Enclosure

cc: S. F. Armour, DOE-ID, MS 1219

Lockheed Idaho Technologies Company P. O. Box 1625 Idaho Falls, ID 83415

Date: June 5, 1995

To: J. L. Rempe

From: H. S. Blackman

Subject: HUMAN ACTIONS IN LEVEL 2 AP600 PRA

The approach I have taken to comment on the human actions you identified in your memo of April 11 is as follows. I first reviewed the analysis conducted by Westinghouse for its appropriateness, then conducted one or two additional analyses based on the available information. In general, I found the following three items of concern across all of the failure rates calculated by Westinghouse.

1. Multiple Recovery Paths

2. No Diagnosis

3. Non-Standard Quantification of THERP Trees

Multiple Recovery Paths

Westinghouse applies multiple recoveries for every human action in their analysis. This is of concern, as I believe it to be an unrealistic representation of operating conditions in real plants. It is especially optimistic given that no control room, no procedures, and no agreed upon operating philosophy exists (there is an apparent dichotomy between the SSAR and the PRA). That is, Westinghouse routinely applies recovery values for the shift technical advisor, the senior reactor operator, and also something unique to this work called "slack time". Time is the sole determining factor as to when these various recovery factors are applied. The conditions are as follows:

Time window > 10 minute and slack time >5 minutes- STA recovery applied
Time window > 5 minutes and slack time > or = 0- SRO recovery applied
Slack time > 1 hour - Special recovery applied

In general, where time available is less than 30 minutes Westinghouse does apply only recovery by the STA. In cases where time available exceeds one hour a third opportunity for recovery is provided, that Westinghouse terms "slack time". All of these recoveries are based upon a THERP value for "one-of-a-kind checking with alert factors". This value is intended for use in normal operating conditions, which is generally not the case in most of these recovery situations. This value is probably inappropriately used. I also have never seen this many recoveries credited in any past PRA. This is not to say that Westinghouse could not engineer the system so that three recoveries are possible, but it is to say that I have never seen that accomplished before.

No Diagnosis

Westinghouse asserts that the procedural system in place at current Westinghouse plants eliminates the need for diagnosis, and reduces the operator function to detection and action. The symptomed based procedures do indeed, function this way. Unfortunately operating experience has shown that operators do still diagnose and, in fact, will circumvent procedures, skip ahead to solutions (which I believe Westinghouse plants also allow) when

operators "know" what the event is. Conventional PRA's do include diagnosis for the operator, to account for the cognitive processing that does take place with the operator and to account for decisions that the operator may make, in spite of procedural systems etc. I have a great deal of reservation about the lack of any diagnose in the AP600 PRA. Westinghouse is putting enormous faith in their procedures, administrative controls, and operators which has not been borne out by experience.

Non Standard Quantification of THERP Trees

Although a small matter, Westinghouse has chosen to quantify only the main branches of the THERP trees for the HRA. This does not fully account for all the recovery paths, and success paths. Generally it does not make a huge difference in the calculated value, but none-the-less is less than accurate.

Recalculations

The Table below shows the recalculations performed. As previously mentioned, two levels of recalulations were performed, first was a reduction in the number of recoveries, and an increase in the assumed dependency. Second, for two cases, was a recalculation including a diagnosis task. Obviously, these values are generally higher in terms of the overall failure rate calculated. The column entitled AP600 shows the value provided by Westinghouse, the column AP600-THERP Tree is the recalculation including all recoveries and success paths, the column INEL modified represents the reduction of the number of recoveries and the increase in dependency from moderate to high, and the last column INEL New Model, includes a diagnosis task. I have attached the trees and tables for REN-MAN-02 and CIA-MAN-01 as examples for your review.

Human Error	AP600	AP600-THERP Tree	INEL Modified	INEL New Model
REN-MAN-02	.0024	.0025	.0083	.027
REN-MAN-03	.0034		.0071	
VLN-MAN-01	.000162		.0015	
CID-MAN-01	.0012		.012	
CIA-MAN-01	.0059	.0059	.0075	.03
CIC-MAN-01	.00012		.012	
CIB-MAN-01	.00134		.00266	
CIB-MAN-00	.00184		.0036	
ADN-MAN-01	.000493		.0033	
ADN-REC-01				
LPM-MAN-01	.0022		.0042	
LPM-MAN-02	.0065		.0057	
LPM-MAN-03	.083		.6	

Of particular significance is the increase for the category titled INEL new model, which includes diagnosis. These represent an order of magnitude shift in the failure probability. I have included the trees and tables for both of these examples for your information.

Summary

I believe that the Westinghouse HRA is an optimistic analysis of the operator's role in the AP600 as compared to conventional PRAs. The analysis is a thorough, and

understandable one, however gives an inordinate amount of credit for recovery, and treats the operators as more of an autotron than a thinking human being. The use of certain values for recovery seem inappropriate and the actual quantification of the THERP trees is more of an estimate than a thorough quantification. The importance of time in the Westinghouse recovery methods does make the calculation of time windows particularly important, in that additional recoveries are based upon this value. The thermal-hydraulic run, and the code used, take on a greater importance for the HRA because of this reason. After having said all of this it is important to note that I have not rerun any of these numbers through the complete analysis and therefore have no idea whether any of these changes are risk significant.

INEL New Model

Table 3. ren-man-02

		Main Paths	Median CHEP	Mean CHEP	Error Factor	Nominal HEP	Nominal HEP Source	SRS/DTN	PSF Modifier	PSF Method	Dependency	Error Type
a	A-Crew fails to diagnose	0.00050	0.00050	0.00081	(5.0)	0.00010	Table 12-4 5	SBS	5.0		ZD	
b	B- Operator selects wrong control (same as AP600)		0.013	0.021	(5.0)	0.0026		SBS	5.0		ZD	
c	C-Second operator selects wrong control (same as AP600)	0.0066	0.51	0.51	(5.0)	0.0026		SBS	5.0		HD	
d	D-Operator omits 1/2 steps (same as AP600)		0.038	0.061	(5.0)	0.0076		SBS	5.0		ZD	
e	E- Second operator omits 1/2 steps (same as AP600)	0.019	0.52	0.53	(5.0)	0.0076		SBS	5.0		HD	
	Main Paths Total P(f):	0.026		EF:	(5.0)	Total P(f): 0.027						

Failure Paths and Total Failure Probabilities

Table 3b. ren-man-02

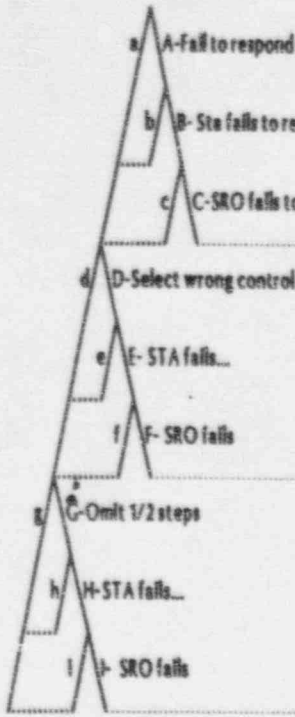
Failure Paths (> = 1E-6)		Calculations (Medians Displayed)	Median Results	Mean Results
1	A	0.0005	0.00050	0.00081
2	aBC	1.0 x 0.013 x 0.51	0.0066	0.011
3	aBcDE	1.0 x 0.013 x 0.49 x 0.038 x 0.52	0.00013	0.00033
4	abDE	1.0 x 0.99 x 0.038 x 0.52	0.019	0.032
		Total Failure Probability	0.027	0.044
		Error Factor	5.0	5.0

Table 3a: HEPs for ren-man-02

	Human Action / Error	Nominal Median HEP	Error Factor	Source/ THERP Table #	Step-by-Step or Dynamic	Modifier for PSFs	Modifier Source	THERP Depend-ency	Median CHEP (Mean CHEP)	Error Factor	Error Type
A	Crew fails to diagnose	0.00010	5.0	Table 12-4# 5	SBS	5.0		ZD	0.00050 (0.00081)	5.0	
B	Operator selects wrong control (same as AP600)	0.0026	5.0		SBS	5.0		ZD	0.013 (0.021)	5.0	
C	Second operator selects wrong control (same as AP600)	0.0026	5.0		SBS	5.0		HD	0.51 (0.51)	5.0	
D	Operator omits 1/2 steps (same as AP600)	0.0076	5.0		SBS	5.0		ZD	0.038 (0.061)	5.0	
E	Second operator omits 1/2 steps (same as AP600)	0.0076	5.0		SBS	5.0		HD	0.52 (0.53)	5.0	

INEL Modified

Table 2. ren-man-02



	Main Paths	Median CHEP	Mean CHEP	Error Factor	Nominal HEP	Nominal HEP Source	SBS/DYN	PSF Modifier	PSF Method	Dependency	Error Type
a A-Fail to respond to 1/5 alarms		0.040	0.065	(5.0)	0.0080		SBS	5.0		ZD	
b B- Sta fails to respond to 1/5 alarms		0.18	0.20	(5.0)	0.0080		SBS	5.0		MD	
c C-SRO fails to respond to 1/5 alarms	0.0037	0.52	0.53	(5.0)	0.0080		SBS	5.0		HD	
d D-Select wrong control		0.013	0.021	(5.0)	0.0026		SBS	5.0		ZD	
e E- STA fails...		0.15	0.16	(5.0)	0.0026		SBS	5.0		MD	
f F- SRO fails	0.0011	0.57	0.60	(5.0)	0.026		SBS	5.0		HD	
g G-Omit 1/2 steps		0.038	0.061	(5.0)	0.0076		SBS	5.0		ZD	
h H-STA fails...		0.18	0.20	(5.0)	0.0076		SBS	5.0		MD	
i I- SRO fails	0.0032	0.52	0.53	(5.0)	0.0076		SBS	5.0		HD	
Main Paths Total P(f):	0.0080		EF:	(5.0)	Total P(f): 0.0083						

Table 2a: HEPs for ren-man-02

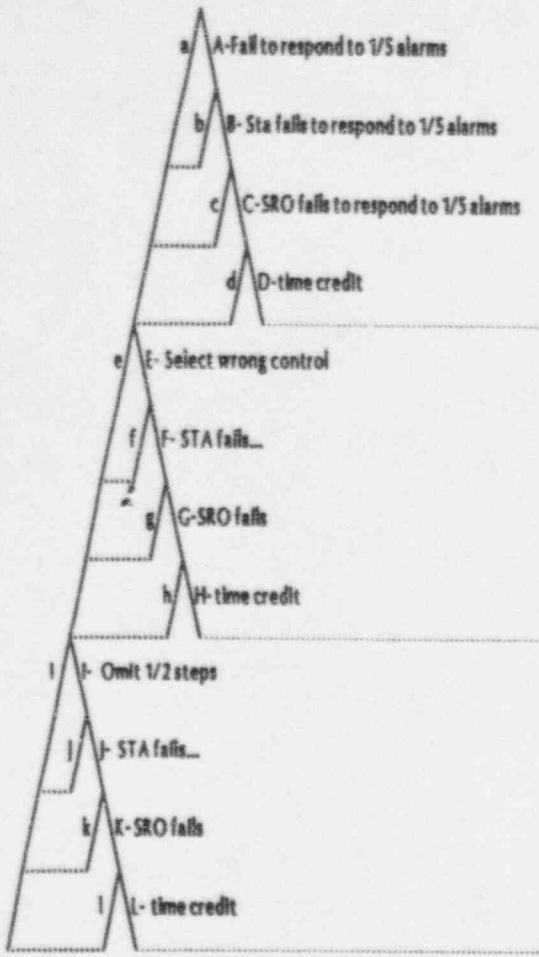
	Human Action / Error	Nominal Median HEP	Error Factor	Source/ THERP Table #	Step-by-Step or Dynamic	Modifier for PSFs	Modifier Source	THERP Dependency	Median CHEP (Mean CHEP)	Error Factor	Error Type
A	Fail to respond to 1/5 alarms	0.0080	5.0		SBS	5.0		ZD	0.040 (0.065)	5.0	
B	Sta fails to respond to 1/5 alarms	0.0080	5.0		SBS	5.0		MD	0.18 (0.20)	5.0	
C	SRO fails to respond to 1/5 alarms	0.0080	5.0		SBS	5.0		HD	0.52 (0.53)	5.0	
D	Select wrong control	0.0026	5.0		SBS	5.0		ZD	0.013 (0.021)	5.0	
E	STA fails...	0.0026	5.0		SBS	5.0		MD	0.15 (0.16)	5.0	
F	SRO fails	0.026	5.0		SBS	5.0		HD	0.57 (0.60)	5.0	
G	Omit 1/2 steps	0.0076	5.0		SBS	5.0		ZD	0.038 (0.061)	5.0	
H	STA fails...	0.0076	5.0		SBS	5.0		MD	0.18 (0.20)	5.0	
I	SRO fails	0.0076	5.0		SBS	5.0		HD	0.52 (0.53)	5.0	

Failure Paths and Total Failure Probabilities

Table 2b. ren-man-02

	Failure Paths (> = 1E-6)	Calculations (Medians Displayed)	Median Results	Mean Results
1	ABC	0.04 x 0.18 x 0.52	0.0037	0.0068
2	ABcDEF	0.04 x 0.18 x 0.48 x 0.013 x 0.15 x 0.57	0.000003	0.000012
3	ABcdGHI	0.04 x 0.18 x 0.48 x 0.99 x 0.038 x 0.18 x 0.52	0.000012	0.000037
4	AbDEF	0.04 x 0.82 x 0.013 x 0.15 x 0.57	0.000037	0.00011
5	AbDeGHI	0.04 x 0.82 x 0.013 x 0.85 x 0.038 x 0.18 x 0.52	0.000001	0.000005
6	AbdGHI	0.04 x 0.82 x 0.99 x 0.038 x 0.18 x 0.52	0.00011	0.00032
7	aDEF	0.96 x 0.013 x 0.15 x 0.57	0.0011	0.0019
8	aDEfGHI	0.96 x 0.013 x 0.15 x 0.44 x 0.038 x 0.18 x 0.52	0.000003	0.000008
9	aDeGHI	0.96 x 0.013 x 0.85 x 0.038 x 0.18 x 0.52	0.000037	0.00010
10	adGHI	0.96 x 0.99 x 0.038 x 0.18 x 0.52	0.0033	0.0058
		Total Failure Probability	0.0083	0.015
		Error Factor	5.0	5.0

Table 1. ren-man-02



Main Paths	Median CHEP	Mean CHEP	Error Factor	Nominal HEP	Nominal HEP Source	SBS/DYN	PSF Modifier	PSF Method	Dependency	Error Type
	0.040	0.065	(5.0)	0.0080		SBS	5.0		ZD	
	0.41	0.65	(5.0)	0.081		SBS	5.0		ZD	
	0.13	0.17	(5.0)	0.081		SBS	1.0		LD	
0.0011	0.54	0.57	(5.0)	0.081		SBS	1.0		HD	
	0.013	0.021	(5.0)	0.0026		SBS	5.0		ZD	
	0.41	0.65	(5.0)	0.081		SBS	5.0		ZD	
	0.13	0.17	(5.0)	0.081		SBS	1.0		LD	
0.00035	0.54	0.57	(5.0)	0.081		SBS	1.0		HD	
	0.038	0.061	(5.0)	0.0076		SBS	5.0		ZD	
	0.41	0.65	(5.0)	0.081		SBS	5.0		ZD	
	0.13	0.17	(5.0)	0.081		SBS	1.0		LD	
0.00098	0.54	0.57	(5.0)	0.081		SBS	1.0		HD	

Main Paths Total P(f): 0.0024 EF: (5.0) Total P(f): 0.0025

Table 1a: HEPs for ren-man-02

	Human Action / Error	Nominal Median HEP	Error Factor	Source/ THERP Table #	Step-by-Step or Dynamic	Modifier for PSFs	Modifier Source	THERP Dependency	Median CHEP (Mean CHEP)	Error Factor	Error Type
A	Fail to respond to 1/5 alarms	0.0080	5.0		SBS	5.0		ZD	0.040 (0.065)	5.0	
B	Sta fails to respond to 1/5 alarms	0.081	5.0		SBS	5.0		ZD	0.41 (0.65)	5.0	
C	SRO fails to respond to 1/5 alarms	0.081	5.0		SBS	1.0		LD	0.13 (0.17)	5.0	
D	time credit	0.081	5.0		SBS	1.0		HD	0.54 (0.57)	5.0	
E	Select wrong control	0.0026	5.0		SBS	5.0		ZD	0.013 (0.021)	5.0	
F	STA fails...	0.081	5.0		SBS	5.0		ZD	0.41 (0.65)	5.0	
G	SRO fails	0.081	5.0		SBS	1.0		LD	0.13 (0.17)	5.0	
H	time credit	0.081	5.0		SBS	1.0		HD	0.54 (0.57)	5.0	
I	Omit 1/2 steps	0.0076	5.0		SBS	5.0		ZD	0.038 (0.061)	5.0	
J	STA fails...	0.081	5.0		SBS	5.0		ZD	0.41 (0.65)	5.0	
K	SRO fails	0.081	5.0		SBS	1.0		LD	0.13 (0.17)	5.0	

Table 1a: HEPs for ren-man-02

Human Action / Error	Nominal Median HEP	Error Factor	Source/ THERP Table #	Step-by-Step or Dynamic	Modifier for PSFs	Modifier Source	THERP Depend-ency	Median CHEP (Mean CHEP)	Error Factor	Error Type
L time credit	0.081	5.0		SBS	1.0		HD	0.54 (0.57)	5.0	

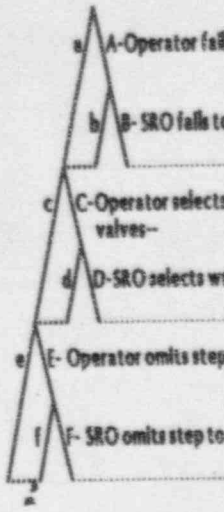
Failure Paths and Total Failure Probabilities

Table1b. ren-man-02

	Failure Paths (> = 1E-6)	Calculations (Medians Displayed)	Median Results	Mean Results
1	ABCD	0.04 x 0.41 x 0.13 x 0.54	0.0011	0.0042
2	ABcEFGH	0.04 x 0.41 x 0.87 x 0.013 x 0.41 x 0.13 x 0.54	0.000005	0.000047
3	ABceIJKL	0.04 x 0.41 x 0.87 x 0.99 x 0.038 x 0.41 x 0.13 x 0.54	0.000015	0.00013
4	AbEFGH	0.04 x 0.6 x 0.013 x 0.41 x 0.13 x 0.54	0.000008	0.000030
5	AbeIJKL	0.04 x 0.6 x 0.99 x 0.038 x 0.41 x 0.13 x 0.54	0.000025	0.000087
6	aEFGH	0.96 x 0.013 x 0.41 x 0.13 x 0.54	0.00035	0.0013
7	aEFgIJKL	0.96 x 0.013 x 0.41 x 0.87 x 0.038 x 0.41 x 0.13 x 0.54	0.000004	0.000042
8	aEfIJKL	0.96 x 0.013 x 0.6 x 0.038 x 0.41 x 0.13 x 0.54	0.000007	0.000027
9	aeIJKL	0.96 x 0.99 x 0.038 x 0.41 x 0.13 x 0.54	0.0010	0.0036
		Total Failure Probability	0.0025	0.0094
		Error Factor	5.0	5.0

AP600 THERP Tree

Table . cia-man01 (Base Case)



	Main Paths	Median CHEP	Mean CHEP	Error Factor	Nominal HEP	Nominal HEP Source	SRS/DTN PSF Modifier	PSF Method	Dependency
a A-Operator fails to respond to 1/2 alarms--		0.0080	0.013	(5.0)	0.0016		5.0		ZD
b B- SRO fails to respond to 1/2 alarms--	0.00080	0.10	0.16	(5.0)	0.10		1.0		ZD
c C-Operator selects wrong control for 1/2 valves--		0.013	0.021	(5.0)	0.0026		5.0		ZD
d D-SRO selects wrong control for 1/2 valves--	0.0013	0.10	0.16	(5.0)	0.10		1.0		ZD
e E- Operator omits step to close 1/2 valves--		0.038	0.061	(5.0)	0.0076		5.0		ZD
f F- SRO omits step to close 1/2 valves--	0.0036	0.10	0.16	(5.0)	0.10		1.0		ZD
Main Paths Total P(f):	0.0057			EF: (5.0)	Total P(f): 0.0059				

Failure Paths and Total Failure Probabilities

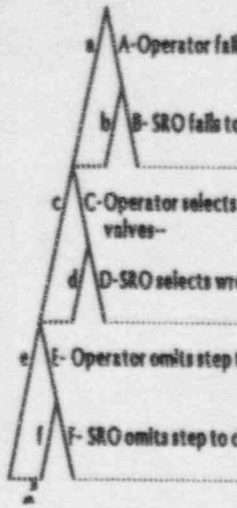
Table . cia-man01 (Base Case)

	Failure Paths (> = 1E-6)	Calculations (Medians Displayed)	Median Results	Mean Results
1	AB	0.008 x 0.1	0.00080	0.0021
2	AbCD	0.008 x 0.9 x 0.013 x 0.1	0.000009	0.000037
3	AbcEF	0.008 x 0.9 x 0.99 x 0.038 x 0.1	0.000027	0.00011
4	aCD	0.99 x 0.013 x 0.1	0.0013	0.0033
5	aCdEF	0.99 x 0.013 x 0.9 x 0.038 x 0.1	0.000044	0.00017
6	acEF	0.99 x 0.99 x 0.038 x 0.1	0.0037	0.0096
		Total Failure Probability	0.0059	0.015
		Error Factor	5.0	5.0

Table : HEPs for cia-man01 (Base Case)

	Human Action / Error	Nominal Median HEP	Error Factor	Source/ THERP Table #	Step-by-Step or Dynamic	Modifier for PSFs	Modifier Source	THERP Dependency	Median CHEP (Mean CHEP)	Error Factor	Error Type
A	Operator fails to respond to 1/2 alarms--	0.0016	5.0			5.0		ZD	0.0080 (0.013)	5.0	
B	SRO fails to respond to 1/2 alarms--	0.10	5.0			1.0		ZD	0.10 (0.16)	5.0	
C	Operator selects wrong control for 1/2 valves--	0.0026	5.0			5.0		ZD	0.013 (0.021)	5.0	
D	SRO selects wrong control for 1/2 valves--	0.10	5.0			1.0		ZD	0.10 (0.16)	5.0	
E	Operator omits step to close 1/2 valves--	0.0076	5.0			5.0		ZD	0.038 (0.061)	5.0	
F	SRO omits step to close 1/2 valves--	0.10	5.0			1.0		ZD	0.10 (0.16)	5.0	

Table . cia-man01 (Base Case)



	Main Paths	Median CHEP	Mean CHEP	Error Factor	Nominal HEP	Nominal HEP Source	SRS/DYN	PSF Modifier	PSF Method	Dependency
a A-Operator fails to respond to 1/2 alarms--		0.0080	0.013	(5.0)	0.0016			5.0		ZD
b B- SRO fails to respond to 1/2 alarms--	0.0010	0.13	0.17	(5.0)	0.081			1.0		LD
c C-Operator selects wrong control for 1/2 valves--		0.013	0.021	(5.0)	0.0026			5.0		ZD
d D-SRO selects wrong control for 1/2 valves--	0.0016	0.13	0.17	(5.0)	0.081			1.0		LD
e E- Operator omits step to close 1/2 valves--		0.038	0.061	(5.0)	0.0076			5.0		ZD
f F- SRO omits step to close 1/2 valves--	0.0046	0.13	0.17	(5.0)	0.081			1.0		LD
Main Paths Total P(f):	0.0073		EF:	(5.0)	Total P(f): 0.0075					

Table : HEPs for cia-man01 (Base Case)

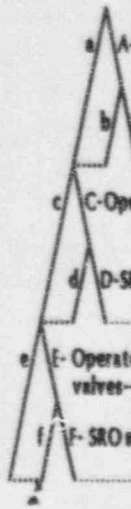
	Human Action / Error	Nominal Median HEP	Error Factor	Source/ THERP Table #	Step-by-Step or Dynamic	Modifier for PSFs	Modifier Source	THERP Dependency	Median CHEP (Mean CHEP)	Error Factor	Error Type
A	Operator fails to respond to 1/2 alarms--	0.0016	5.0			5.0		ZD	0.0080 (0.013)	5.0	
B	SRO fails to respond to 1/2 alarms--	0.081	5.0			1.0		LD	0.13 (0.17)	5.0	
C	Operator selects wrong control for 1/2 valves--	0.0026	5.0			5.0		ZD	0.013 (0.021)	5.0	
D	SRO selects wrong control for 1/2 valves--	0.081	5.0			1.0		LD	0.13 (0.17)	5.0	
E	Operator omits step to close 1/2 valves--	0.0076	5.0			5.0		ZD	0.038 (0.061)	5.0	
F	SRO omits step to close 1/2 valves--	0.081	5.0			1.0		LD	0.13 (0.17)	5.0	

Failure Paths and Total Failure Probabilities

Table . cia-man01 (Base Case)

Failure Paths (> = 1E-6)		Calculations (Medians Displayed)	Median Results	Mean Results
1	AB	0.008 x 0.13	0.0010	0.0022
2	AbCD	0.008 x 0.87 x 0.013 x 0.13	0.000012	0.000039
3	AbcEF	0.008 x 0.87 x 0.99 x 0.038 x 0.13	0.000033	0.00011
4	aCD	0.99 x 0.013 x 0.13	0.0016	0.0036
5	aCdEF	0.99 x 0.013 x 0.87 x 0.038 x 0.13	0.000054	0.00018
6	acEF	0.99 x 0.99 x 0.038 x 0.13	0.0047	0.010
		Total Failure Probability	0.0075	0.017
		Error Factor	5.0	5.0

Table . cia-man01(Base Case)



	Main Paths	Median CHEP	Mean CHEP	Error Factor	Nominal HEP	Nominal HEP Source	SRS/DTN	PSF Modifier	PSF Method	Dependency
a A-Crew fails to diagnose		0.48	0.78	(5.0)	0.48			1.0		ZD
b B- Crew fails to respond to 1/2 alarms	0.0038	0.0080	0.013	(5.0)	0.0016			5.0		ZD
c C-Operator omits step to close 1/2 valves--		0.013	0.021	(5.0)	0.0026			5.0		ZD
d D-SRO omits step to close 1/2 valves--	0.0034	0.51	0.51	(5.0)	0.0026			5.0		HD
e E- Operator selects wrong control for 1/2 valves--		0.038	0.061	(5.0)	0.0076			5.0		ZD
f F- SRO selects wrong control for 1/2 valves--	0.0098	0.52	0.53	(5.0)	0.0076			5.0		HD
Main Paths Total P(f):	0.017		EF:	(5.0)	Total P(f): 0.030					

Failure Paths and Total Failure Probabilities

Table . cia-man01 (Base Case)

Failure Paths (> = 1E-6)		Calculations (Medians Displayed)	Median Results	Mean Results
1	AB	0.48 x 0.008	0.0038	0.010
2	AbCD	0.48 x 0.99 x 0.013 x 0.51	0.0031	0.0082
3	AbCdEF	0.48 x 0.99 x 0.013 x 0.49 x 0.038 x 0.52	0.000060	0.00026
4	AbcEF	0.48 x 0.99 x 0.99 x 0.038 x 0.52	0.0093	0.024
5	aCD	0.52 x 0.013 x 0.51	0.0034	0.0024
6	aCdEF	0.52 x 0.013 x 0.49 x 0.038 x 0.52	0.000066	0.000075
7	acEF	0.52 x 0.99 x 0.038 x 0.52	0.010	0.0071
		Total Failure Probability	0.030	0.053
		Error Factor	5.0	5.0

Table : HEPs for cia-man01 (Base Case)

	Human Action / Error	Nominal Median HEP	Error Factor	Source/ THERP Table #	Step-by-Step or Dynamic	Modifier for PSFs	Modifier Source	THERP Dependency	Median CHEP (Mean CHEP)	Error Factor	Error Type
A	Crew fails to diagnose	0.48	5.0			1.0		ZD	0.48 (0.78)	5.0	
B	Crew fails to respond to 1/2 alarms	0.0016	5.0			5.0		ZD	0.0080 (0.013)	5.0	
C	Operator omits step to close 1/2 valves–	0.0026	5.0			5.0		ZD	0.013 (0.021)	5.0	
D	SRO omits step to close 1/2 valves–	0.0026	5.0			5.0		HD	0.51 (0.51)	5.0	
E	Operator selects wrong control for 1/2 valves–	0.0076	5.0			5.0		ZD	0.038 (0.061)	5.0	
F	SRO selects wrong control for 1/2 valves–	0.0076	5.0			5.0		HD	0.52 (0.53)	5.0	