

ACRS-1715
Date issued
MAR 25 1980

MINUTES OF THE ACRS SUBCOMMITTEE ON
RELIABILITY AND PROBABILISTIC ASSESSMENT
WASHINGTON, DC
FEBRUARY 6, 1980

8005140049

CONFIDENTIAL
MAR 25 1980

The ACRS Subcommittee on Reliability and Probabilistic Assessment met with representatives of the NRC Staff on February 6, 1980 to discuss the following:

1. The development of a response to Congressman Udall's July 27, 1979 letter concerning consistency of actual component failure experience with that projected in WASH-1400, and the probabilities of occurrence of the September 24, 1977 Davis-Besse and the March 20, 1978 Rancho Seco events using WASH-1400 methodology.

2. The development of a response to Commissioner Gilinsky's December 18, 1979 letter concerning nuclear plant risks versus risks from other electricity generating methods.

3. Development of quantitative safety goals for nuclear power plants.

A notice of the meeting appeared in the Federal Register on January 22, 1980 (Attachment A). A copy of the detailed presentation schedule is attached (Attachment B). A list of attendees at the Subcommittee meeting is attached (Attachment C). A list of documents provided to the Subcommittee is attached (Attachment D). There were no written or oral public statements from members of the public. The entire meeting was open to members of the public.

MEETING WITH THE NRC STAFF (OPEN SESSION)

1.0 Subcommittee Chairman's Opening Remarks

Dr. Okrent, Subcommittee Chairman, introduced the members of the Subcommittee and noted the purpose of the meeting. He pointed out that the meeting was being conducted in accordance with the provisions of the Federal Advisory Committee Act and the Government in the Sunshine Act and that Mr. Gary Quittschreiber was the Designated Federal Employee for the meeting. He stated that no requests for oral statements nor written statements from members of the public had been received with regard to the meeting.

THIS DOCUMENT CONTAINS
POOR QUALITY PAGES

2.0 NRC Staff Comments Regarding Consistency of Actual Component Failure Experience with that Projected in WASH-1400

W. Vesely, NRC Staff, concluded that new component failure rate data and WASH-1400 point estimates for component failure rates are consistent, but that error spreads for active components should be a factor of 10 instead of 3. In addition, there is a plant-to-plant variability of 10 to 30 above the generic failure rate. He indicated that the NRC Staff is reevaluating WASH-1400 with the new data and it appears that core melt could be about a factor of 3 greater than shown in WASH-1400.

F. Rowsome added that he believed the frequency of core damage events for the industry is probably higher than suggested in WASH-1400 but that compensatory conservatism would reduce the magnitude of releases and consequences.

3.0 ACRS Fellows Comments Regarding Consistency of the Actual Component Failure Experience with that Projected in WASH-1400

E. Abbott, ACRS Fellow, discussed the difficulty one has in comparing component failure rates from different sources. He noted that the rates are frequently based on different things, e.g., NPRDS may report a pump packing leak as a failure, when in fact the pump could still deliver proper flow if called on to operate. He noted that most LERs are a result of entering the limiting conditions for operation (LCO) in the technical specifications; therefore, if equipment fails when the LCO is not applicable, the failure is not reported. Another problem with trying to determine failure rates from LER reports is that they report only failures and not successes. D. Okrent suggested that the present NPRDS rulemaking procedure could be modified to provide better failure rate data collection if the Committee wished to provide comments in this regard.

E. Epler noted that of the dozens of traumatic events which have occurred at nuclear power plants, he could not find any where component failure was the major contributor.

4.0 NRC Staff Comments Regarding the Probabilities of Occurrence of the September 24, 1977 Davis-Besse and the March 20, 1978 Rancho Seco Events

F. Rowsome, NRC Staff, discussed the sequence of events that occurred at Rancho Seco on March 20, 1978 and at Davis-Besse on September 24, 1977 (Attachments 1-5). He pointed out that the probability one assigns to a historical event is entirely dependent on how broad a class of events one takes to represent the event. One can get a probability of any number between one and zero depending on how narrowly one draws the class of events for which the probabilities are defined. WASH-1400 did not provide for the Rancho Seco event where loss of non nuclear instrumentation power was lost. WASH-1400 did predict the loss of feedwater transient, but the probability was not appropriate to B&W plants because of design differences. Rowsome indicated that it is exceedingly unlikely that the application of WASH-1400 techniques would have unfolded the precise details of the sequence of the specific events. He noted that in the Rancho Seco event the auxiliary feedwater system was started when the steam generator level indication just happened to drift down. If the indication had not accidentally drifted down there would have been no signal for cooling water and no instruments telling them they needed cooling water and a possible core melt could have occurred. Epler suggested this should be looked at in more detail.

It was the opinion of F. Rowsome that using the WASH-1400 methodology to make absolute predictions on bottom line risk is the least trustworthy application of the WASH-1400 techniques. He suggested the tools be used to draw qualitative inferences on the strengths and weaknesses of systems as an independent way of finding errors in design, operating procedures, maintenance techniques, etc.

F. Rowsome noted that system reliability is a "tricky measure of risk" because accident scenarios differ from plant to plant, such that it is not a uniform measure that can be applied to relate to risk. He suggested that PAS not attempt to provide the Subcommittee with a probability for the Rancho Seco and Davis-Besse events since nothing comparable to these events were covered in WASH-1400. He said he could arrive at any number between 10^{-2} and 10^{-4} for these events depending on the breadth of the classification of events.

5.0 ACRS Fellows Comments Regarding the Probabilities of Occurrence of the September 24, 1977 Davis-Besse and the March 20, 1978 Rancho Seco Events

W. Kastenberg discussed the ACRS Fellows conclusions regarding the probabilities of the Rancho Seco, Davis-Besse, and Three Mile Island-2 events using WASH-1400 methodology. He provided the following as best estimates for these events (Attachments 6-8).

Davis-Besse	1.2×10^{-3} /B&W reactor year
Rancho Seco	1.2×10^{-4} /B&W reactor year
TMI-2	1.5×10^{-4} /B&W reactor year

S. Ditto felt that the probability of 8.6×10^{-3} per year that the ACRS Fellows used for loss of NNI-Y in determining the probability of the Rancho Seco event was too small.

W. Kastenberg discussed the WASH-1400 methodology for determining operator errors, when called upon in an emergency, as a function of time (Attachment 9). His calculations assumed the operator had correct information and procedures. Rowsome felt people were reading more into the WASH-1400 human error rate calculations than what had been intended.

6.0 NRC Staff Discussion of Recent Findings on Coal/Nuclear Risk Comparisons

R. Gotchy, NRC Staff, discussed some of the conclusions reached in the CONAES, SAI, Technicon, and NUREG-0232 comparisons of coal with nuclear (Attachment 10). He noted that some of these studies have not factored in the latest known information uncovered during the GESMO hearings but that in the end it really doesn't make much difference. He felt that most of the studies being done simply take the results from previous studies.

R. Gotchy indicated that he has briefly reviewed the SAI coal/nuclear study and that there is no bottom line since it's primarily a matrix for interfacing different models. He said the SAI work simply quotes work that others have done. He noted an error in the dose conversion factor in ICRP for lead-210, which is a daughter of radon, coming from mining and milling. He indicated this as a dominant source of population exposure for uranium mining and milling operations. He indicated that the previous calculations were a factor of five to six higher

than they should have been due to an error in the consideration of critical organs.

H. Lewis noted that he was not an advocate of comparing coal and nuclear risks but that if it is to be done one should consider the low-probability/high consequence event of the coal cycle CO₂ greenhouse effect. L. Lave noted that arguments can be made that the CO₂ would lead to warming effects of the earth which may increase the productivity of the land. Gotchy added that it may also delay the next ice age and for these unknown effects, it is best not to consider it. Gotchy indicated that there is a large ongoing campaign to discredit the health effects of SO₂. Lave noted that there are some good scientists who are interpreting the SO₂ health effects as unproven, small, and even zero. Saunders compared the controversy with cigarette smoking, where you can get experts supporting both views.

7.0 ACRS Fellows Findings on Comparisons of Nuclear Plant Risks Versus Other Methods of Generating Electricity

D. Johnson, ACRS Fellow, summarized the report prepared by the ACRS Fellows comparing risks associated with generating electrical power by coal, oil, hydro, and nuclear. In summary, he concluded that even though the various fuel cycles have components that are not quantified at present, that there appears to be a general consensus on the ranges and numbers of health effects and basic conclusions. It was pointed out that even though there are several studies comparing risks of the different technologies that they are not necessarily independent.

8.0 Development of Quantitative Safety Goals for Nuclear Power Plants

It was the general feeling of the ACRS consultants at the meeting that there is no single quantitative safety goal number that can be found acceptable. Lave suggested desegregating the events into various consequences and probabilities and looking at ranges of estimates with emphasis on verifiability. He also suggested an alternative was to not set absolute number goals but rather use comparisons among other electrical generating technologies and let people decide whether they desire electricity on that basis. P. Slovik suggested that risk benefit analysis or decision analysis might be used to decide the safety goals. Members of the Subcommittee indicated a full blown decision analysis taking several months to perform would not replace the need for specific quantitative safety goals.

9.0 Problems Identified as Possible Safety Issues

The following problems were identified as possible safety issues:

1. J. Ebersole discussed the possible use of quantitative criteria as a tool for solving problems. He postulated a failure of the Browns Ferry Plant's steam line to the high pressure feedwater in the auxiliary building, which houses all the supportive and emergency equipment, just upstream of the DC driven external valve outside containment. Ebersole postulated a pipe failure in the vicinity of the external valve which would disable the valve and the safety equipment in the room. A single failure of the valve inside containment along with the above sequence would lead to a lack of core cooling.

2. C. Michelson postulated the possibility of spilling coffee in the operating console and suggested that one should look at the effects.

3. J. Ebersole noted that light bulbs in the control room could fall out during a seismic event and cause short circuits in open cabinets.

4. J. Ebersole expressed a concern that PORVs are depended on for feed and bleed and may, in fact, be gagged shut.

10.0 Concluding Remarks

D. Okrent suggested that the most fruitful path for the Subcommittee to follow in developing safety goals would be for someone to write down some "proposed approaches" and then for the Subcommittee to review and comment. Okrent noted that he intended to have something ready for the Committee to look at by early Summer 1980.

The meeting was adjourned at 5:50 pm on February 6, 1980.

For additional details, a complete transcript of the meeting is available in the Nuclear Regulatory Commission Public Document Room, 1717 H Street, N.W., Washington, D. C. 20555, or from International Verbatim Reporters, Inc., 499 South Capitol Street, S. W., Washington, D.C. 20002.

generators (OTSG) and other features of Babcock and Wilcox designed nuclear plants.

Regulatory Activities, March 5, 1980, Washington, DC. The Subcommittee will review regulatory guides and revisions to existing regulatory guides; also, it may discuss pertinent activities which affect the current licensing process and/or reactor operation.

ACRS Full Committee Meetings

February 10-12, 1980

A. *NRC Bulletins and Orders resulting from the Three Mile Island, Unit 2, Nuclear Power Plant Accident.

B. *ACRS Annual Report on the NRC Safety Research Program.

C. *Proposed criteria for Mark I Dynamic Containment.

D. *Proposed operation of the Three Mile Island, Unit 1, Nuclear Power Plant.

E. *Proposed modification of NRC Criteria for Siting Nuclear Facilities.

F. *Proposed ACRS report on nuclear power plant component failure rates and probabilistic assessment of nuclear plant incidents.

G. *Recent operating occurrences at nuclear facilities.

March 6-8, 1980

Agenda to be announced.

April 10-12, 1980.

Agenda to be announced.

Dated: January 17, 1980.

John C. Hoyle,

Advisory Committee Management Officer.

[FR Doc. 80-1927 Filed 1-21-80; 8:45 am]

BILLING CODE 7590-01-M

Advisory Committee on Reactor Safeguards, Subcommittee on Reliability and Probabilistic Assessment; Meeting

The ACRS Subcommittee on Reliability and Probabilistic Assessment will hold an open meeting on February 6, 1980, in Room 1046, 1717 H St., NW., Washington, DC 20555.

The agenda for subject meeting shall be as follows: Wednesday, February 6, 1980; 8:30 a.m. until the conclusion of business.

The Subcommittee will meet in executive session with its consultants and fellows to explore and exchange opinions regarding the topics being discussed. The Subcommittee will also hear some brief presentations and hold discussions with representatives of the NRC Staff. The following topics will be discussed:

1. Consistency of actual component failure experience with that projected in WASH-1400.

2. Probabilities of the Sep. 24, 1977 Davis Besse and the March 20, 1978

Rancho Seco events using WASH-1400 methodology.

3. Risk comparison of nuclear plants with other methods of electricity generation.

4. Quantitative safety goals for nuclear power plants.

Further information regarding topics to be discussed, whether the meeting has been cancelled or rescheduled, the Chairman's ruling on requests for the opportunity to present oral statements allotted therefor can be obtained by a prepaid telephone call to the cognizant Designated Federal Employee, Mr. Gary Quittschreiber, (telephone 202/634-3267) between 8:15 a.m. and 5:00 p.m., EST.

Dated: January 16, 1980.

John C. Hoyle,

Advisory Committee Management Officer.

[FR Doc. 80-1928 Filed 1-21-80; 8:45 am]

BILLING CODE 7590-01-M

[Docket No. 40-4492]

Federal-American Partners Uranium Mill, Gas Hills Mining District, Fremont County, Wyo.; Availability of Environmental Report and Intent To Prepare a Draft Environmental Impact Statement Concerning Renewal of a Source Material License

AGENCY: U.S. Nuclear Regulatory Commission (NRC).

ACTION: Notice of availability of environmental report and intent to prepare a draft environmental impact statement and to hold a scoping meeting.

SUMMARY: 1. Description of the Proposed Action—Federal-American Partners (FAP) has operated a uranium mill in the Gas Hills Mining District of Wyoming since 1959 under NRC Source Material License No. SUA-667. FAP is currently applying to renew this Source Material License and to obtain approval for a mill expansion and use of a new tailings disposal system. The mill is located in Fremont County on the Gas Hills route approximately 80 kilometers (50 miles) east of Riverton, Wyoming. FAP's proposed plans call for the expansion of the mill process capacity from 860 metric tons of ore (950 short tons) per day to 2,680 metric tons of ore (2,950 short tons) per day and disposal of tailings into a mined out pit approximately one mile from the mill.

2. Pursuant to the National Environmental Policy Act of 1969 and the regulations of the Commission in 10 CFR Part 51, FAP has filed an environmental report in support of their applications. The environmental report

and any subsequent documents will be available for inspection and copying at the Public Document Room, 1717 H Street, N.W., Washington, D.C. 20555. Copies of the environmental report are also being provided to the State Planning Coordinator, Office of the Governor, 2320 Capitol Avenue, Cheyenne, Wyoming 82002.

3. The scoping process will include a meeting to be held in the Lodge Room of the Elks, 207 E. Main Street, Riverton, Wyoming, on February 13, 1980 at 7:00 p.m. This meeting will provide for a briefing of interested parties concerning the proposed action and alternatives and opportunity for comment on the scope of the proposed statement. The participation of the public and all interested government agencies is invited. Copies of this notice will be mailed to all affected federal, state and local agencies, and other interested persons. Written comments concerning the scope of the proposed statement will be accepted until February 29, 1980.

4. After the environmental report has been analyzed, a draft environmental impact statement will be prepared. The DEIS is expected to be available to the public for review and comment in June, 1980.

Questions about the proposed action, DEIS, or scoping meeting and any written comments should be directed to D. M. Gillen, U.S. Nuclear Regulatory Commission, Division of Waste Management, 483-SS, Washington, D.C. 20555, phone (301) 427-4103.

Dated at Silver Spring, Maryland, this 14th day of January, 1980.

For the Nuclear Regulatory Commission.

Ross A. Scarano,

Chief, Uranium Recovery Licensing Branch, Division of Waste Management.

[FR Doc. 80-1932 Filed 1-21-80; 8:45 am]

BILLING CODE 7590-01-M

[Docket Nos. 50-275 OL, 50-323 OL]

Pacific Gas & Electric Co. (Diablo Canyon Nuclear Power Plant, Units 1 and 2); Change of Place of Argument

January 16, 1980.

The location of the oral argument in this cause scheduled for 9:30 a.m., Wednesday, January 23, 1980, has been changed from the U.S. Tax Court to the United States District Court, Courtroom No. 12, 19th Floor, Federal Building and Courthouse, 450 Golden Gate Avenue, San Francisco, California.

It is so ordered.

Attachment A

TENTATIVE PRESENTATION
 SCHEDULE
 ACRS SUBCOMMITTEE MEETING
 RELIABILITY AND PROBABILISTIC ASSESSMENT
 FEBRUARY 6, 1980
 1717 H Street, NW, WASHINGTON, DC
 ROOM 1046

WEDNESDAY, FEBRUARY 6, 1980

<u>Approximate Time</u>	<u>Presentation Time</u>	
8:30 - 8:40	10 min	<u>D. Okrent - ACRS</u> Opening Statement, introductory remarks
8:40 - 9:05	15 min	<u>W. Vesely - NRC/PAS</u> NRC Staff conclusions regarding consistency of actual component failure experience with that projected in WASH-1400
9:05 - 9:35	15 min	<u>E. Abbott - ACRS Fellow</u> Findings concerning the consistency of actual component failure experience with that projected in WASH-1400
9:35-10:15		Open Executive Session to discuss Subcommittee conclusions on component failure rates
10:15-10:25		Coffee Break
10:25-10:50	15 min	<u>F. Rowsome - NRC/PAS</u> NRC Staff conclusions regarding the probabilities of occurrence of the September 24, 1977 Davis-Besse and the March 20, 1978 Rancho Seco events predicted on the basis of WASH-1400 failure rates and methodology.
10:50-11:15	15 min	<u>W. Kastenberg - ACRS Fellow</u> Findings concerning the probabilities of the September 24, 1977 Davis-Besse and the March 20, 1978 Rancho Seco events using WASH-1400 methodology.
11:15-12:00		Open Executive Session to discuss the probabilities of the Davis-Besse and Rancho Seco events
12:00-12:30	15 min	<u>R. Gotchy - NRC/DSE and W. Rhyne - SAI</u> Discuss any expected changes to NUREG-0332 conclusions as a result of the preliminary findings of the latest coal/nuclear risk report findings.
12:30-1:30		Break for Lunch

Attachment B

<u>Approximate Time</u>	<u>Presentation Time</u>	
1:30 - 2:30	10 min each	<u>W. Kastenber/D. Johnson/J. Griesmeyer</u> <u>ACRS Fellows</u> Findings concerning the comparisons of nuclear plant risks vs other methods of generating electricity
2:30 - 3:50		Open Executive Session to discuss Subcommittee's conclusions on nuclear plant vs other electricity generating risks
3:50 - 4:00		Coffee Break
4:00 - 5:00	15 min each	<u>R. Wilson/L. Lave/P. Slovik - ACRS Consultants</u> <u>Comments on the development of quantitative</u> <u>safety goals for nuclear power plants</u>
5:00 - 6:00		General discussion on quantitative safety goals
6:00		Adjournment

ATTENDEES LIST

ACRS Members

D. Okrent, Chairman
J. Ebersole
W. Kerr
J. C. Mark
C. P. Siess
M. Bender
H. Lewis
S. Lawroski

ACRS Staff

G. R. Quittschreiber, DFE*

ACRS Consultants

S. Saunders
S. Ditto
E. P. Epler
N. D. Singpurwalla
W. C. Lipinski
P. Slovic
R. Wilson
L. Lave
C. Michelson

ACRS Fellows

W. Kastenberg
D. Johnson
E. Abbott
J. M. Griesmeyer

NRC Staff

W. Vesely
R. Bernero
R. Rowsome
F. Manning
P. F. Riehm
R. Gotchy

Designated Federal Employee *

Miscellaneous

A. R. DuCharme, Sandia Labs
A. S. Heller, B&W
R. Leyse, EPRI
D. H. Risher, W
M. A. Linn, TV
S. R. Blazo, Bechtel
D. Walker, OPS
W. K. Brunot
J. Dann, McGraw-Hill

DOCUMENTS PROVIDED TO THE SUBCOMMITTEE
FOR THIS MEETING

1. Viewgraphs shown at the meeting are provided as Attachments 1-10. A complete set of all handouts are provided in the meeting transcript and in the ACRS Office file for this meeting.
2. ACRS Fellows Report, "Analysis of Feedwater Transient Sequences in B&W Nuclear Steam Supply Systems," dated February 1980.
3. Nuclear Regulatory Commission Staff Report, "Evaluation of Davis-Besse and Rancho Seco Feedwater Transients on September 24, 1977 and March 28, 1978 using WASH-1400 Data"
4. Memorandum from F. Rowsome to R. Fraley, "ACRS Query on Material Relevant to Udall Letter: Davis-Besse and Rancho Seco Transients," dated February 1980.

ALTERNATE QUESTIONS

- o DID WASH-1400 CONSIDER OR PREDICT ACCIDENTS OF THIS TYPE?
- o COULD WASH-1400 METHODS HAVE ALERTED ANALYSTS TO THE POSSIBILITY OF SUCH ACCIDENTS IF THE METHODS HAD BEEN APPLIED TO THE AFFECTED PLANTS?
- o WHAT IMPROVEMENTS IN WASH-1400 METHODS OR DATA ARE NEEDED TO PROPERLY CONSIDER SUCH SEQUENCES IN RISK ASSESSMENT?
- o CAN WASH-1400 METHODS SERVE A USEFUL FUNCTION IN ANALYZING ACTUAL EXPERIENCES?



Roussier

DID WASH-1400 CONSIDER OR PREDICT TMI, DB, OR RS INCIDENTS?

I. TMI OR DB

- o ACCIDENT CLASSES INVOLVING TRANSIENT-CAUSED STUCK-OPEN PRESSURIZER RELIEF VALVES ARE CONSIDERED
- o THE CONTINGENCIES AND FREQUENCY IN WASH-1400 IS INAPPROPRIATE TO B&W PLANTS

II. RS

- o ACCIDENT CLASSES INVOLVING COMMON MODE TRANSIENT INITIATION AND DEGRADED RELIABILITY IN RESPONSE SYSTEMS ARE CONSIDERED
- o THE COMMON MODE DEPENDENCE ON NON-SAFETY GRADE INSTRUMENTATION POWER SUPPLIES OF MAIN AND AUXILIARY FEEDWATER SYSTEMS IS NOT PRESENT AT SURRY

2

COULD WASII-1400 METHODS HAVE ALERTED ANALYSTS TO
THE POSSIBILITY OF SUCH ACCIDENTS IF PERFORMED ON
THE AFFECTED PLANS?

I. TMI & DB

FREQUENT EXPOSURE TO TRANSIENT-INDUCED
LOCA COULD HAVE BEEN PREDICTED

II. RS

COMMON-MODE FAILURE OF MAIN FEEDWATER,
INSTRUMENTS, AND AUTOSTART OF AUXILIARY
FEEDWATER COULD HAVE BEEN PREDICTED

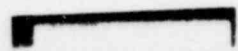
WHAT IMPROVEMENTS IN WASH-1400 METHODS AND DATA ARE NEEDED TO PROPERLY TREAT SUCH SEQUENCES IN RISK ASSESSMENT?

- o BETTER METHODS TO PREDICT OPERATOR BEHAVIOR (ERRORS OF COMMISSION AS WELL AS OMISSION)

NOTE THAT BETTER QUALITATIVE SEQUENCE PREDICTION CAN BE ACHIEVED BY MERELY ATTACHING TO RISK ASSESSMENT A THOROUGH QUALITATIVE REVIEW OF POSSIBLE OPERATOR BEHAVIORS - IMPROVED QUANTITATIVE DATA IS CRITICAL ONLY TO QUANTITATIVE RISK PREDICTION

- o SYSTEMATIZE SEARCH FOR COMMON CAUSE FAILURES
- o TREAT PARTIAL OR BRIEF FAILURES

F



CAN WASH-1400 METHODS SERVE A USEFUL FUNCTION IN
EVALUATING OCCURRENCES?

- o FAA & NASA USE FAULT TREE ANALYSIS THIS WAY
- o KEMENY AND ROGOVIN USED EVENT TREE ANALYSIS
TO ORGANIZE THE "WHAT IF" EXERCISE: ALTERNATE
SEQUENCES
- o RISK ASSESSMENT SUGGESTS THAT A MESSAGE OF THE
RANCHO SECO MAY HAVE BEEN MISSED:

SUSCEPTIBILITY TO COMMON-MODE MAIN FEED
TRIP, OPERATOR CONFUSION, AND AFWS AUTOSTART
FAILURE

DAVIS-BESSE

P_T	FREQUENCY OF FEEDWATER TRANSIENT	3/YEAR
P_P	PROBABILITY PORV LIFTS (GAGGED OR <u>NOT GAGGED</u>)	0.5/DEMAND
$1-P_K$	PROBABILITY OF TRIP ($1-P_K \cong 1$)	1/DEMAND
$P_{Q'}$	PROBABILITY PORV FAILS OPEN	3×10^{-2} /DEMAND
$1-P_U$	PROBABILITY OF HPIS ACTUATION	1/DEMAND
$P_{U'}$	PROBABILITY OPERATORS DEFEAT HPIS	0.027/DEMAND
$1-P_{Q''}^N$	PROBABILITY OPERATORS BLOCK PORV WITHIN REQUIRED TIME (> 20 MIN)	0.999/DEMAND
		<hr/> ~ 1.2×10^{-3} /YR

RANCHO SECO

P_T	FREQUENCY OF TRANSIENT (LOSS OF NNI \rightarrow FWT)	8.6×10^{-3} /YEAR
$1-P_P$	PROBABILITY PORV DOES NOT LIFT (GAGGED OR NOT)	0.5/DEMAND
$1-P_K$	PROBABILITY OF REACTOR TRIP ($1-P_K$) \approx 1	1/DEMAND
$1-P_{P'}$	PROBABILITY CODE SAFETY VALVE OPENS ($1-P_{P'}$) \approx 1	1/DEMAND
$1-P_{Q'}$	PROBABILITY CODE SAFETY VALVE SHUTS ($1-P_{Q'}$) \approx 1	1/DEMAND
$P_{U'}$	PROBABILITY OPERATOR THROTTLES HPIS	0.027/DEMAND
		<hr/>
		$\sim 1.2 \times 10^{-4}$

THREE MILE ISLAND

P_T	FREQUENCY OF FEEDWATER TRANSIENT	3/YEAR
P_P	PROBABILITY PORV LIFTS (GAGGED OR <u>NOT GAGGED</u>)	0.5/DEMAND
$1-P_K$	PROBABILITY OF TRIP ($1-P_K \cong 1$)	1/DEMAND
$P_{Q'}$	PROBABILITY PORV FAILS OPEN	3×10^{-2} /DEMAND
$1-P_U$	PROBABILITY OF HPIS ACTUATION	1/DEMAND
$P_{U'}$	PROBABILITY OPERATORS DEFEAT HPIS	0.027/DEMAND
$P_{Q''}^N$	PROBABILITY OPERATORS FAIL TO BLOCK PORV WITHIN REQUIRED TIME (15 MIN)	0.125/DEMAND
		$\sim 1.5 \times 10^{-4}$ /YR.

OPERATOR FAILURE

<u>P</u>	
0.9	5 MINUTES AFTER LARGE LOCA
0.1	30 MINUTES AFTER LARGE LOCA
0.01	SEVERAL HOURS LATER
0.2 - 0.3	IN HIGH STRESS (AVE)

DB, RS, TMI: 3 OPERATORS THROTTLING HPIS FOR 1/2 HR.

$$P_U = (P)^N = (.3)^3 = 0.027$$

DB, BLOCK PORV IN TIME (≥ 20 MIN)

$$1 - P_{Q''}^N = 1 - P^N = 1 - (0.1)^3 = 0.999$$

TMI, Do NOT BLOCK PORV IN TIME (≤ 15 MIN)

$$P_{Q''}^N = P^N = (.5)^3 = 0.125$$

Gotchy

DOSE COMMITMENTS PER GWy(e) FOR THE URANIUM FUEL CYCLE

OPERATION	OCCUPATIONAL			GENERAL PUBLIC			
	NUREG 0332	GESMO	CONAES & COSPUP	NUREG 0332	GESMO	CONAES & COSPUP	CONAES & COSPUP Corrected for Rn*
MINING	88	250	250	140	630	600	80
MILLING	88	120	80	40-1750	120	120	20
CONVERSION	0.9	1	1	9	9	10	-
ENRICHMENT	0.9	0.7	0.7	0.3	0.2	0.2	-
FUEL FABRICATION	12	12	12	0.6	0.6	0.6	-
REACTOR OPERATIONS	560	570	1240	130-160	77	76	-
REPROCESSING (U,PU)	28	25	25	460-510	360	360	-
TRANSPORTATION, IRRAD. FUEL STORAGE, WASTE MGT.	6	4	4	13	0.5	0.2	-
TOTAL:							
W/O REPROC.:	760	960	1600	330-2100	840	800	190
W/ REPROC.:	780	980	1600	790-2600	1200	1000**	550

*Corrected for typographical error in ICRP-2; used as dose conversion factor for Pb-210 (from decay of radon) in food.

**Apparent typographical error in CONAES Table 9.5; correctly adds to 1200 (same as GESMO).

NOTE: NUREG-0332 was an update of GESMO, correcting for Rn-222 doses from Pb-210, and using a 100 year Environmental Dose Commitment (EDC) rather than the 40 year EDC used in GESMO and in the recent Table S-3 (10 CFR 51) Hearings.