UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

AUG 0 9 1984

MEMORANDUM FOR: Hugh L. Thompson, Director
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Themis Speis, Director
Division of Safety Technology

Robert M. Bernero, Director
Division of Systems Integration

Richard H. Vollmer, Director
Division of Engineering

FROM: Darrell G. Eisenhut, Director
Division of Licensing

SUBJECT: 1983 REACTOR TRIP STATISTICS

Introduction

The purpose of this memorandum is to transmit the results of a study of 1983 reactor trip statistics performed by the Operating Reactors Assessment Branch (ORAB). As you may know, ORAB has been tracking reactor trips as part of their assessment of operating experience. The study is based on a review of reactor trip reports filed by licensees per 10 CFR 50.72. The results of the study are provided in the enclosed report.

Discussion

The results of the study show that in 1983 the all-plant average automatic trip frequency was 5.6 trips/plant/year and the average manual trip frequency was .9 trips/plant/year. When low power (<15% of rated power) trips are excluded the automatic trip frequency drops to 4.3 trips/plant/year. This latter result is consistent with a recent industry study of reactor trips in 1983.

The report indicates that the majority of trips are the result of anticipated transients which cause plant parameters to reach an RPS trip setting, rather than spurious electrical problems. A further breakdown indicates tha equipment failures and personnel activities cause trips in about equal numbers.

Several correlations of the trip frequency data have been made and are provided in the report. They include trip frequency versus plant type, annual critical hours, plant age and pre-trip power level. Two of the more significant results of these studies are that: 1) BWRs had a slightly lower trip frequency than PWRs in 1983; and 2) that trip frequency is high in the first few years of commercial operation and then generally decreases with time.

Conclusion

We consider reactor trip frequency and causes to be useful indicators of operational experience and will continue to monitor trips on a daily basis. The Office of Analysis and Evaluation of Operational Data (AEOD) has initiated a program to track reactor trips via LERs and prompt reports and will analyze the data for trends and patterns. As with other programs, NRR interaction with AEOD regarding reactor trip experience will be coordinated through DL.

Darrell G. Eisenhut, Director
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Enclosure:
Study of 1983 Reactor Trip
Statistics

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ENCLOSURE

TRIPS OF U.S. POWER REACTORS IN 1983

INTRODUCTION AND SUMMARY

Reactor trip statistics for 1983 have been compiled for domestic power reactors based on event reports filed by licensees in accordance with 10 CFR 50.72. A total of 499 unplanned reactor trips occurred in 77 operating plants (units) with an average frequency of 6.5 trips per plant per year. An average of five trips/plant/year occurred from power levels above 15% of rated power. Eighty-seven percent (87%) of these trips were automatic; the other 13% were initiated manually by operators. This translates to an automatic trip frequency for trips above 15% power of 4.3 trips/plant/year, which is consistent with the results of an industry study of the reactor trip frequency in 1983.

The highest number of trips at a single plant for the year was 21. Three plants did not have any trips during the year; however, it is important to note that two of these plants operated less then 16% of the year, while the third operated 74% of the year.

DATA AND ANALYSIS

Design and Plant-Specific Trip Frequencies

Trip frequencies for the various plant types are compared in Table 1. The data shows that in 1983, differences in automatic trip frequencies among the PWR plant types were small, while the spread in manual trip frequencies among the PWR plant types is somewhat larger. The manual trip frequency averaged for Babcock & Wilcox designed reactors is an order of magnitude below those of the other vendors; and thus, appears abnormally low. One possible explanation of this difference is that since most PWR trips reportedly originate from secondary-side perturbations and the Babcock & Wilcox designed NSSS transient response to the secondary-side changes is more rapid, in many cases there would be less time available for the operator to intervene and manually trip the plant prior to an automatic trip. Further study would be necessary to fully identify the reasons for the difference in manual trip frequency.

The data in Table 1 also indicate that in 1983, PWRs had a higher automatic trip frequency than BWR plants. The reasons for this difference are not apparent. Additional study would be necessary to identify the causes of the difference.

The relatively higher trip frequency shown in Table 1 for PWRs designed by Combustion Engineering (CE) is considered to be somewhat inflated. The reason is that the CE plant population used in the averaging process is small (11 plants) and includes three very new plants whose trip frequencies were up to several times the plant average. In addition, it is important to note that our review of the causes of the many trips in these new plants shows no correlation between the higher trip frequencies and the arrival of the relatively new digital protection system design included in these plants.

Annual trip frequencies for all operating plants are shown on an individual basis in Appendix A. The graph in Figure 1 shows the spread in trip frequencies among individual plants. In this figure, individual plant trip frequency is correlated with the length of time the plant operated during 1983. The data plotted indicate that on the average, and up to a point, the likelihood of having a higher trip frequency increases with the amount of time the plant is operated during the year. Plants whose performance is considered outside the "normal range" are shown above the dashed line in Figure 1. The number of years each of these plants has been in commercial operation is shown in parentheses below each data point. It is clear that these atypical plants are the very new ones; and that a trip frequency which is two to three times the average can be expected in a plant one to two years old. When these plants are excluded from the overall plant average trip frequency, it drops by 17% from 6.5 trips/plant/year to 5.4.

Reported Causes of Trips

The brief descriptions in the 10 CFR 50.72 event reports indicate that 40% of all trips were due solely to equipment malfunctions; 47% were related to personnel activities during testing, maintenance or other functions; and 13% by manual initiation. It is important to note that many of the trips related to personnel activities also involved equipment problems. Of the trips caused by equipment malfunction, 82% appear to be the result of actual challenges to the trip logic of the reactor protective system (RPS), while 18% were due to spurious actuations resulting from unidentified electrical problems in the plant. Of the trips caused by personnel activities, 73% involved actual RPS challenges and 27% resulted from spurious signals attributed to errors during testing, maintenance, or troubleshooting. Turbine trips resulting in anticipatory reactor trips were treated as transient initiators.

Correlation of Trip Frequency with Plant Age

As indicated in Figure 1, plants experience above average trip frequencies in the first few years of operation. In fact, the 1983 average trip frequency for plants in commercial operation less than three years was 13 trips/plant/year; For plants in commercial operation less than two years, the frequency was 14.5 trips/plant/year. Figure 2 better illustrates the relationship between plant age and trip frequency. In this figure, trip frequency is plotted versus years of commercial operation for a selected group of plants which operated between 60% and 80% of the year. The result indicates that within a certain band, trip frequency tends to decrease as a plant logs operating experience.

Correlation of Trip Frequency with Pre-Trip Reactor Power Level

Figure 3 shows the frequency of trips from various pre-trip power levels. As shown in the figure, 34% of all trips occurred at power levels above 95% of rated power and 16% occurred at levels below 5% of rated power. The number of trips was much less for any intermediate interval of 5% of rated power. The relatively high number of trips from near full power may simply reflect the frequency of operation at that level. The situation at low power reflects difficulties in plant control during startup and also, perhaps, the higher frequency of testing and maintenance performed during low or zero power operation.

The correlation in Figure 3 has been found to agree quite well with the results of a French study of reactor trip frequency.

CONCLUSION

Domestic power reactor trip statistics for 1983 have been compiled and tabulated. The overall frequency of automatic trips is 5.6 trips/plant/year. The average frequency of manual trips is .9 trips/plant/year. The following conclusions have been drawn from the results of the study:

1. The frequency of trips in Boiling Water Reactors (BWRs) in 1983 was less than the frequency in Pressurized Water Reactors (PWRs).

2. The frequency of manual trips in Babcock and Wilcox designed reactors in 1983 was significantly lower than those of reactors designed by the other three reactor vendors.

3. Most trips result from actual challenges of the Reactor Protection System as opposed to spurious actuations.

4. Trip frequencies tend to be much higher than the average during the first few years of commercial operation, and generally decrease with time.

5. A significant fraction of all plant trips occur during operation below 5% of rated power.

TABLE 1

BREAKDOWN OF 1983 REACTOR TRIPS BY PLANT TYPE

PLANT TYPE	NO. OF PLANTS*	AVERAGE TRIP FREQUENCY (TRIPS/PLANT/YEAR)									AVERAGE % OF YEAR PLANTS OPERATED**
		Manual Trips			Automatic Trips			All Trips			
		<15% Power	≥15% Power	All Power Levels	<15% Power	≥15% Power	All Power Levels	<15% Power	≥15% Power	All Power Levels	
PWRS											
Westinghouse	32	.19	.50	.69	2.0	4.3	6.3	2.2	4.8	7.0	70.1
Combustion Engineering	11	.27	1.23	.5	1.6	4.4	6.0	1.9	5.6	7.5	55.8
Babcock & Wilcox	7	0.0	.14	.14	1.1	5.2	6.3	1.1	5.3	6.4	69.2
All PWRs	50	.16	.64	.80	1.6	4.6	6.2	1.8	5.2	7.0	66.8
BWR	26	.35	.65	1.0	.70	3.9	4.6	1.1	4.5	5.6	62.6
LWR	76	.22	.68	.90	1.3	4.3	5.6	1.5	5.0	6.5	65.3
HTGR	1	0.0	0.0	0.0	0.0	3.0	3.0	0.0	3.0	3.0	69.4
All Plants	77	.22	.68	.9	1.3	4.3	5.6	1.5	5.0	6.5	65.4

*Excludes Humboldt Bay, Dresden-1, San Onofre-1, TMI-1, and plants with only low power licenses.
**Based on number of hours reactor critical during year reported in NRC "Grey Book."

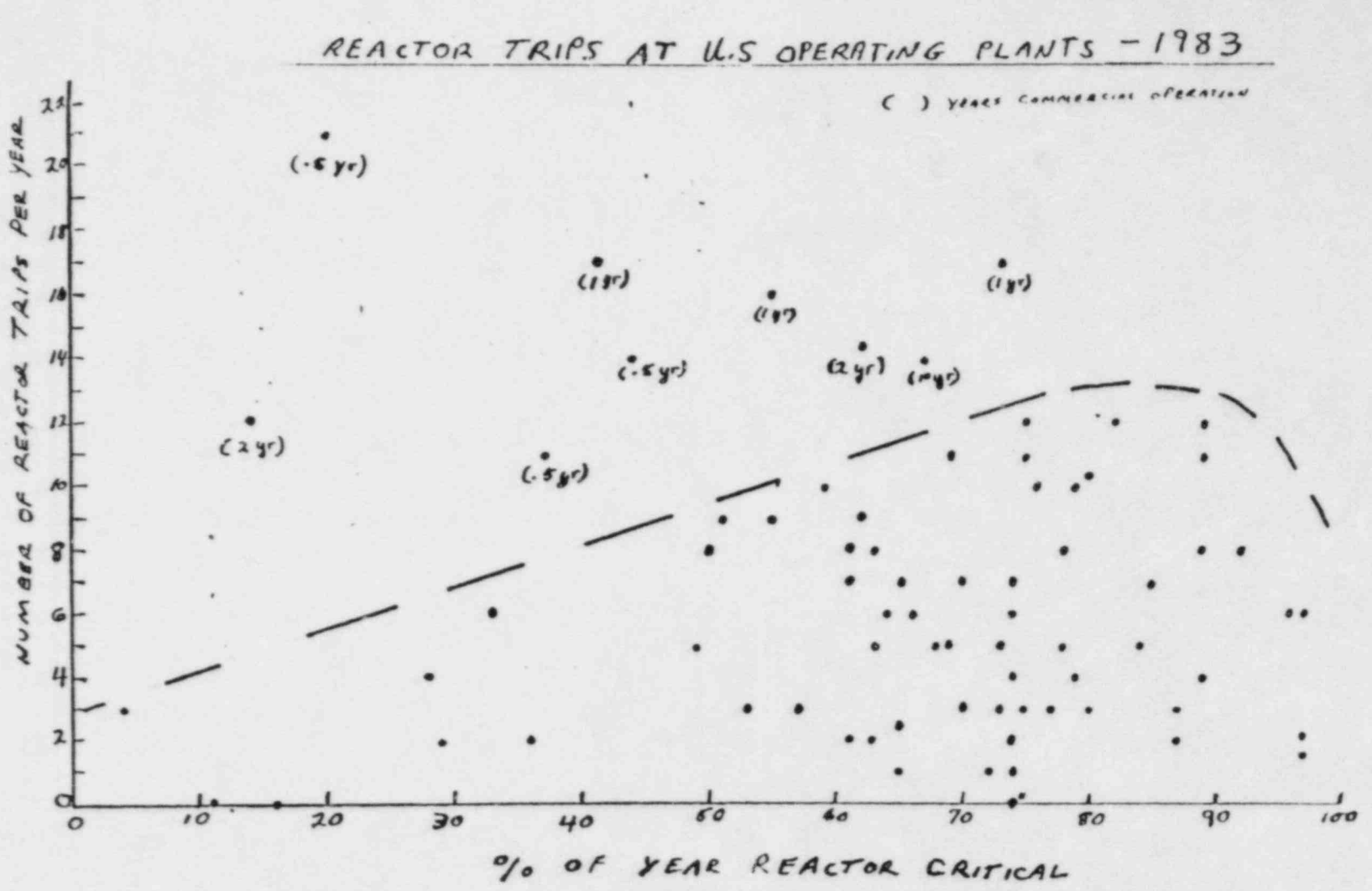
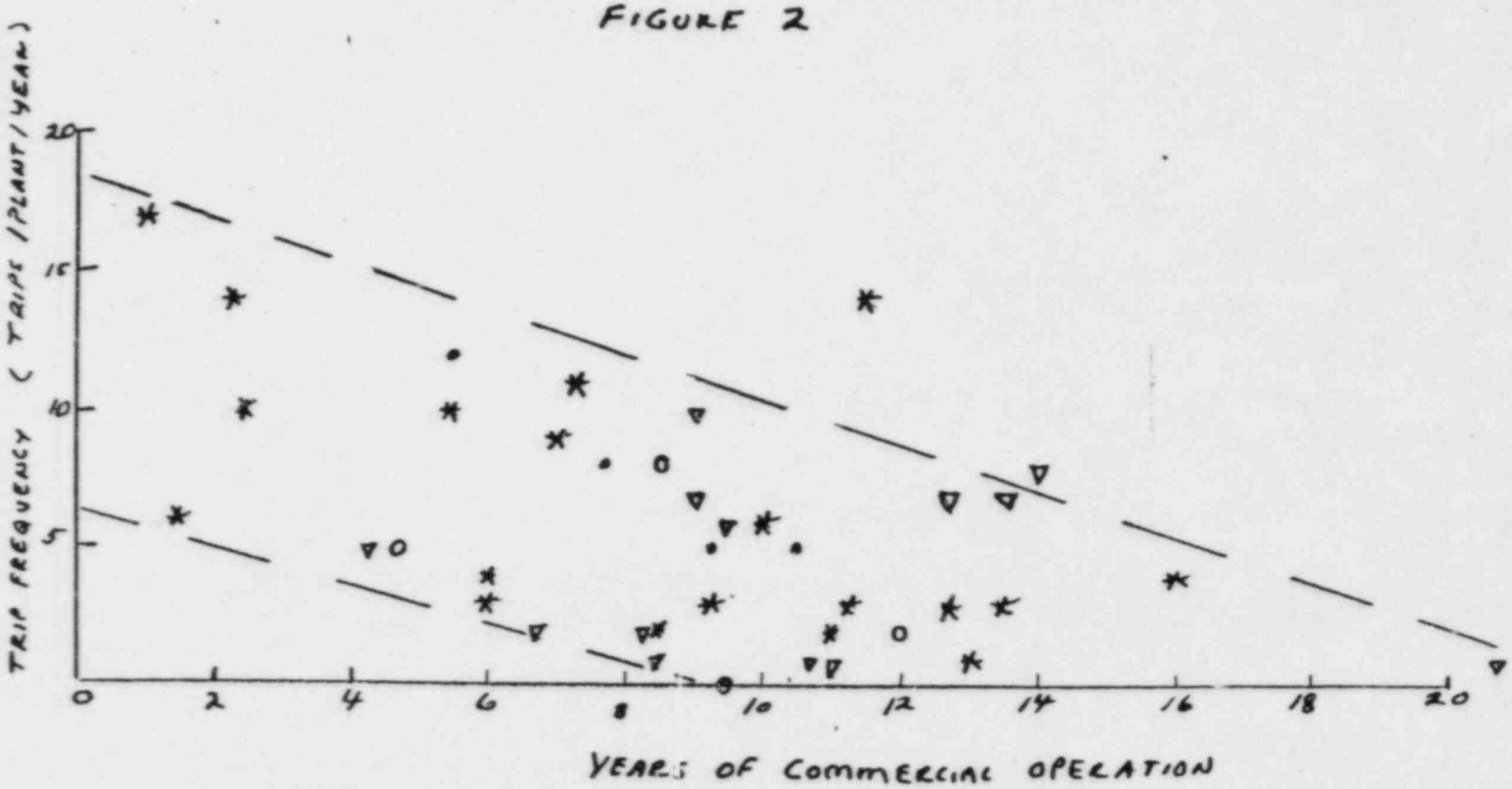

REACTOR TRIPS AT U.S OPERATING PLANTS - 1983
( ) YEARS COMMERCIAL OPERATION
NUMBER OF REACTOR TRIPS PER YEAR
(.6 yr)
(1yr)
(1yr)
(1yr)
(.5yr)
(2yr)
(1yr)
(2yr)
(.5yr)
0
2
4
6
8
10
12
14
16
18
20
22
0
10
20
30
40
50
60
70
80
90
100
% OF YEAR REACTOR CRITICAL

FIGURE 1

REACTOR TRIP FREQUENCY IN 1983
VS
YEARS OF COMMERCIAL OPERATION

FIGURE 2



BREAKDOWN OF REACTOR TRIPS
BY PRE-TRIP REACTOR POWER
(1983 DATA)

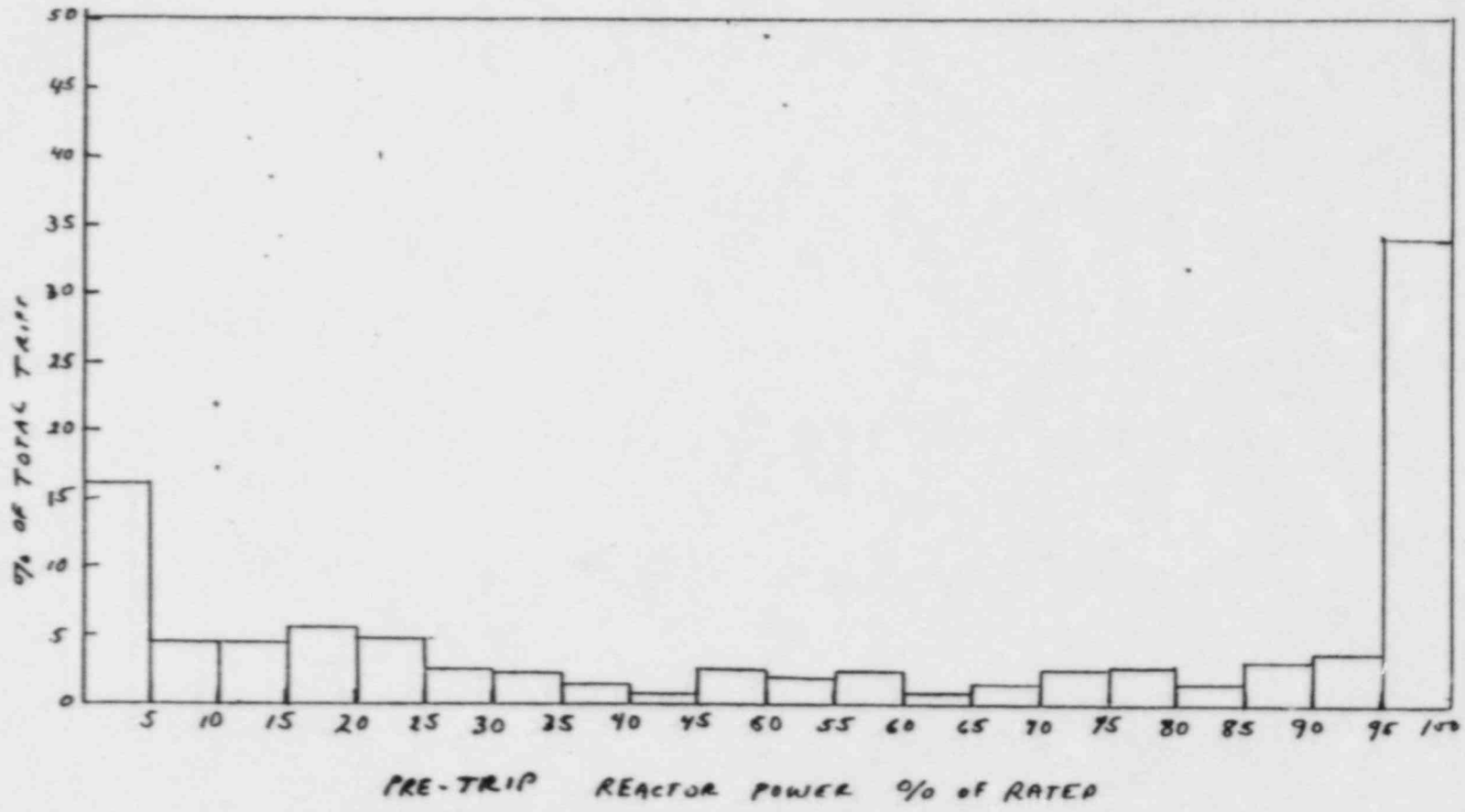


FIGURE - 3

APPENDIX A

INDIVIDUAL PLANT TRIP FREQUENCIES

TABLE A-1

REACTOR TRIPS IN WESTINGHOUSE DESIGNED PWRs 1983

PLANT	TRIP FREQUENCY (TRIPS PER YEAR) AUTOMATIC	MANUAL	TOTAL	TRIPS ABOVE 15% POWER (% OF TOTAL TRIPS)	% OF YEAR REACTOR CRITICAL
Bvr. Valley 1	8	3	11	82	69.2
Cook 1	2	0	2	100	65.5
Cook 2	10	0	10	50	79.6
Farley 1	3	0	3	67	79.6
Farley 2	4	0	4	75	88.6
Ginna	3	0	3	33	76.6
Haddam Neck	3	1	4	25	79.3
Indian Pt. 2	12	0	12	67	88.9
Indian Pt. 3	3	0	3	33	3.8
Kewaunee	7	0	7	43	84.8
McGuire 1	14	0	14	93	61.5
McGuire 2	8	0	8	67	?
North Anna 1	1	3	4	75	73.8
North Anna 2	12	0	12	50	81.6

PLANT	TRIP FREQUENCY (TRIPS PER YEAR) AUTOMATIC	MANUAL	TOTAL	TRIPS ABOVE 15% POWER (% OF TOTAL TRIPS)	% OF YEAR REACTOR CRITICAL
Point Bch. 1	1	0	1	100	74.3
Point Bch. 2	3	0	3	67	72.7
Prairie Is. 1	3	0	3	67	87.4
Prairie Is. 2	2	0	2	100	87.3
Robinson 2	2	1	3	33	76.9
Salem 1	8	1	9	45	61.9
Salem 2	12	0	12	58	14.3
Sequoyah 1	8	2	10	80	78.8
Sequoyah 2	6	0	6	84	73.8
Summer 1	14	3	17	76	73.4
Surry 1	10	0	10	70	59.2
Surry 2	14	0	14	86	67.3
Trojan	8	1	9	56	51.2

PLANT	TRIP FREQUENCY (TRIPS PER YEAR) AUTOMATIC	MANUAL	TOTAL	TRIPS ABOVE 15% POWER (% OF TOTAL TRIPS)	% OF YEAR REACTOR CRITICAL
Turkey Pt. 3	1	1	2	100	74.3
Turkey Pt. 4	6	3	9	78	54.6
Yankee Rowe	4	4	8	100	92.0
Zion 1	6	0	6	50	66.2
Zion 2	3	0	3	33	74.7
W PWR AVERAGE	6.3	.7	7.0	68	70.1

TABLE A-2

REACTOR TRIPS IN CE DESIGNED PWRs 1983

PLANT	TRIP FREQUENCY (TRIPS PER YEAR) AUTOMATIC	MANUAL	TOTAL	TRIPS ABOVE 15% POWER (% OF TOTAL TRIPS)	% OF YEAR REACTOR CRITICAL
ANO-2	5	0	5	60	63
Calvert Cl. 1	7	1	8	100	78.4
Calvert Cl. 2	9	3	12	83	89.3
Ft. Calhoun	0	0	0	---	74.2
Maine Yankee	5	0	5	80	84.4
Millstone 2	2	0	2	100	35.7
Palisades	2	0	2	100	60.9
San Onofre 2	13	3	16	75	55.6
San Onofre 3	14	7	21	52	20.3
St. Lucie 1	0	0	0	---	15.6
St. Lucie 2	9	2	11	75	36.8
CE AVERAGE	6.0	1.5	7.5	74	55.8

TABLE A-3

REACTOR TRIPS IN B&W DESIGNED PWRs 1983

PLANT	TRIP FREQUENCY (TRIPS PER YEAR) AUTOMATIC	MANUAL	TOTAL	TRIPS ABOVE 15% POWER (% OF TOTAL TRIPS)	% OF YEAR REACTOR CRITICAL
ANO-1	8	0	8	88	50.5
Crystal Rv. 3	7	1	8	63	61.2
Davis Besse	12	0	12	84	75.4
Oconee 1	5	0	5	100	78.3
Oconee 2	5	0	5	100	73.1
Oconee 3	2	0	2	100	96.9
Rancho Seco	5	0	5	60	49.2
B&W AVERAGE	6.3	.14	6.4	82	69.2

TABLE A-4

REACTOR TRIPS IN BWRs AND HGTR 1983

PLANT	TRIP FREQUENCY (TRIPS PER YEAR) AUTOMATIC	MANUAL	TOTAL	TRIPS ABOVE 15% POWER (% OF TOTAL TRIPS)	% OF YEAR REACTOR CRITICAL
Big Rock Pt.	0	1	1	0	71.8
Brns. Ferry 1	3	1	4	100	27.6
Brns. Ferry 2	8	2	10	70	76.1
Brns. Ferry 3	2	0	2	100	62.5
Brunswick 1	2	0	2	50	28.6
Brunswick 2	5	0	5	100	67.9
Cooper	4	2	6	100	64.3
Dresden 2	7	0	7	72	61.3
Dresden 3	6	1	7	86	73.7
Duane Arnold	5	2	7	86	64.8
FitzPatrick	1	0	1	100	71.6
Hatch 1	10	1	11	91	75.0
Hatch 2	3	2	5	100	69.2
LaCrosse	7	1	8	63	62.9
LaSalle 1	13	4	17	76	41.3

PLANT	TRIP FREQUENCY (TRIPS PER YEAR) AUTOMATIC	MANUAL	TOTAL	TRIPS ABOVE 15% POWER (% OF TOTAL TRIPS)	% OF YEAR REACTOR CRITICAL
Millstone 1	5	1	6	67	96.6
Monticello	1	0	1	100	96.7
Nine Mi. Pt. 1	3	0	3	33	57
Oyster Creek	0	0	0	---	11.5
Peach Btm 2	2	1	3	100	52.6
Peach Btm 3	3	3	6	50	32.8
Pilgrim 1	8	0	8	88	88.9
Quad Cities 1	3	3	6	50	95.7
Quad Cities 2	1	0	1	100	64.5
Susquehanna 1	13	1	14	86	43.9
Vermont Yankee	3	1	4	75	70.3
AVERAGE BWR	4.6	1	5.6	79	62.6
		HGTR			
Ft. St. Vrain	3	0	3	100	69.4

FROM:
Zack T. Pate
INPO

TO:
Dircks

ACTION CONTROL	DATES
COMPL DEADLINE	~~8/1/84~~ 8/15/84
	New Compl. date/date per K.B.
INTERIM REPLY	
FINAL REPLY	s/ Stello for 8/15/84
FILE LOCATION	

CONTROL NO. 14637

DATE OF DOCUMENT 7/16/84

PREPARE FOR SIGNATURE OF
☐ CHAIRMAN
☒ EXECUTIVE DIRECTOR
OTHER

DESCRIPTION ☒ LETTER ☐ MEMO ☐ REPORT ☐ OTHER

Concerns re number of screens per plant

SPECIAL INSTRUCTIONS OR REMARKS

ASSIGNED TO	DATE	INFORMATION ROUTING
Denton, NRR	7/18/84	Dircks Case/Denton
Thompson	7/18/84	Roe PPAS
Grimes		Rehm
Warner	7/20	Stello
		Heltemes

NRC FORM 232
(5-80)

EXECUTIVE DIRECTOR FOR OPERATIONS
PRINCIPAL CORRESPONDENCE CONTROL