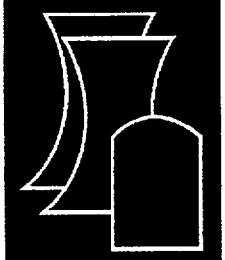

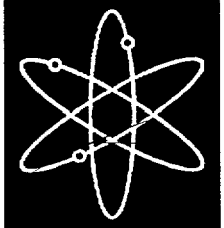

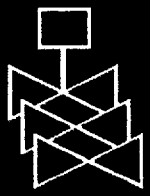

Component Performance Study - Turbine-Driven Pumps, 1987-1998

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Component Peformance Study - Turbine-Driven Pumps, 1987-1998

Commercial Power Reactors

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ABSTRACT

This report documents an analysis of the performance of safety-related turbine-driven pump assemblies (turbine driver, pump, and governor subcomponents) used in the pressurized water reactor (PWR) auxiliary feedwater (AFW) system and in the boiling water reactor (BWR) reactor core isolation cooling (RCIC) and high pressure coolant injection (HPCI) systems in U.S. commercial power reactor plants.

A risk-based analysis of operating data and an engineering analysis of trends and patterns were performed to provide insights into the performance of turbine driven pump components on an industry basis and comparison of results with data used by plant-specific probabilistic risk assessments. The data used in this report was from the 1987-1995 period for engineering analysis of the PWR AFW system and the BWR RCIC and HPCI systems. Failure probability estimates used combined engineered safety features data (1987-1998) and surveillance test data (1987-1995) for the PWR AFW system and for the BWR RCIC and HPCI systems.

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EXECUTIVE SUMMARY

This study provides the performance evaluation based on industry experience during the 1987 through 1998 period for turbine-driven pumps (TDPs) in the pressurized water reactor (PWR) auxiliary feedwater (AFW) system and in the boiling water reactor (BWR) reactor core isolation cooling (RCIC) and high pressure coolant injection (HPCI) systems. The objectives of component performance studies are (1) to determine the reliability of risk-important components and compare the results with estimates in probabilistic risk assessments (PRAs) and individual plant examinations (IPEs) and (2) to review the operational data from an engineering perspective to determine trends and patterns and gain insights into component performance.

TDP failure and estimated demand data was obtained from two databases. The Nuclear Plant Reliability Data System (NPRDS) provided data on component failures and surveillance test frequencies for the 1987-1995 period. The Sequence Coding and Search System (SCSS) provided engineering safety features (ESF) failure and demand data for the 1987-1998 period and some surveillance test failure data for the 1987-1995 period reported in Licensee Event Reports (LERs).

For the PWR AFW system and the BWR RCIC and HPCI systems, the TDP probability of failure on demand estimates were based on the combined ESF and surveillance test data for failures and demands from SCSS and NPRDS data sources. The ESF data (LERs) was from the 1987-1998 period, while the surveillance test data (NPRDS) was from the 1987-1995 period. For the BWR HPCI system, the probability of failure on demand over the 1987-1995 period showed a decreasing trend. However, data over the entire period (1987-1998) was evaluated as more meaningful and is consistent with the NUREG/CR-4550 generic mean value for TDPs (3E-3). Table ES-A lists the TDP probability of failure on demand estimates developed in this study for the AFW, RCIC, and HPCI systems and the generic values from NUREG/CR-4550, which was the input to NUREG-1150. Table ES-B provides the standby failure rates for each system.

TABLE ES-A
TDP PROBABILITY OF FAILURE ON DEMAND (1987-1998)

SYSTEM/SOURCE	LOWER BOUND	MEAN	UPPER BOUND
NUREG-4550	1.1E-3	3E-2	1.1E-1
AFW system	1.3E-3	1.6E-2	4.6E-2
RCIC system	9.1E-6	2.0E-2	8.7E-2
HPCI system(1987-1998)	1.6E-3	3.3E-2	9.7E-2

TABLE ES-B
TDP STANDBY FAILURE RATE (1987-1995)

SYSTEM/SOURCE	LOWER BOUND	MEAN	UPPER BOUND
AFW system	1.4E-5/hour	1.8E-5/hour	2.1E-5/hour
RCIC system	9.1E-6/hour	1.3E-5/hour	1.7E-5/hour
HPCI system	2.1E-5/hour	2.9E-5/hour	3.8E-5/hour

The TDP mean probabilities of failure on demand used in plant-specific IPE studies were compared with the results of this study. For BWR RCIC and HPCI systems (1987-1995 data), all of the IPE mean values for the TDP failure on demand probability were within the range of this study and NUREG/CR-4550. For the AFW system, more than 90% of the IPE mean values were also within the range of this study and NUREG/CR-4550. Figures ES-1, ES-2, and ES-3 show these comparisons for the AFW, RCIC, and HPCI systems, respectively.

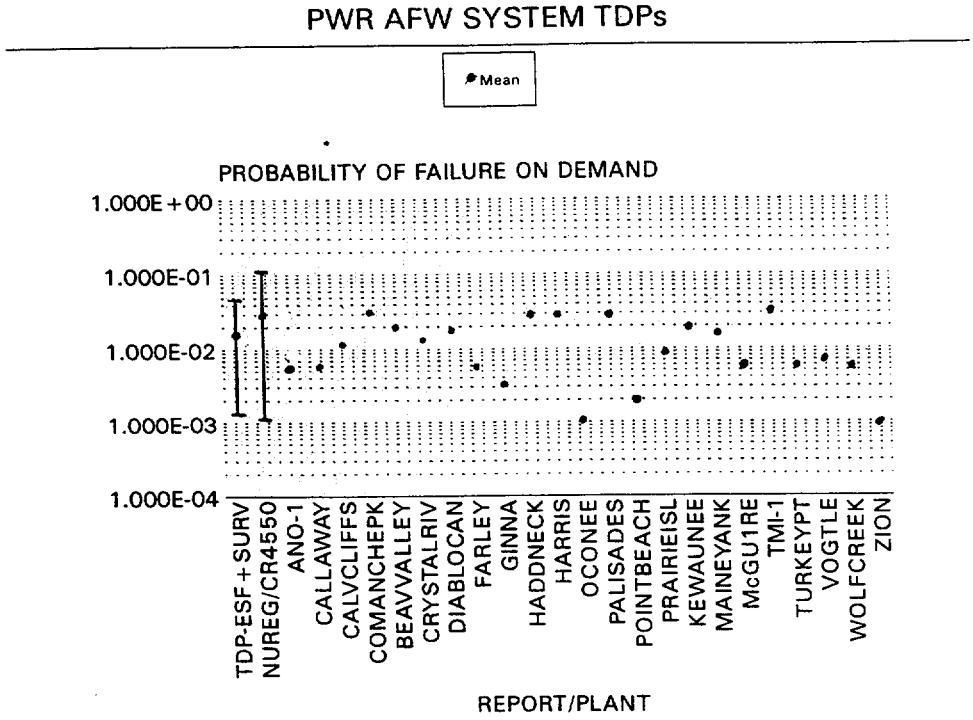


FIGURE ES-1
PWR AFW SYSTEM TDP PROBABILITY OF FAILURE ON DEMAND
COMPARISON WITH VALUES USED IN IPEs

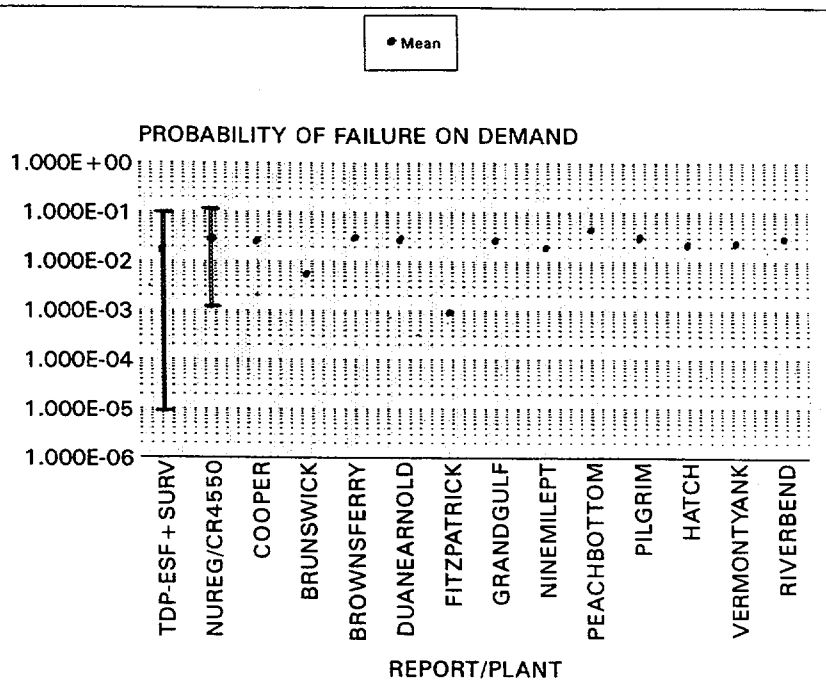


FIGURE ES-2
BWR RCIC SYSTEM TDP PROBABILITY OF FAILURE ON DEMAND COMPARISON WITH VALUES USED IN IPEs

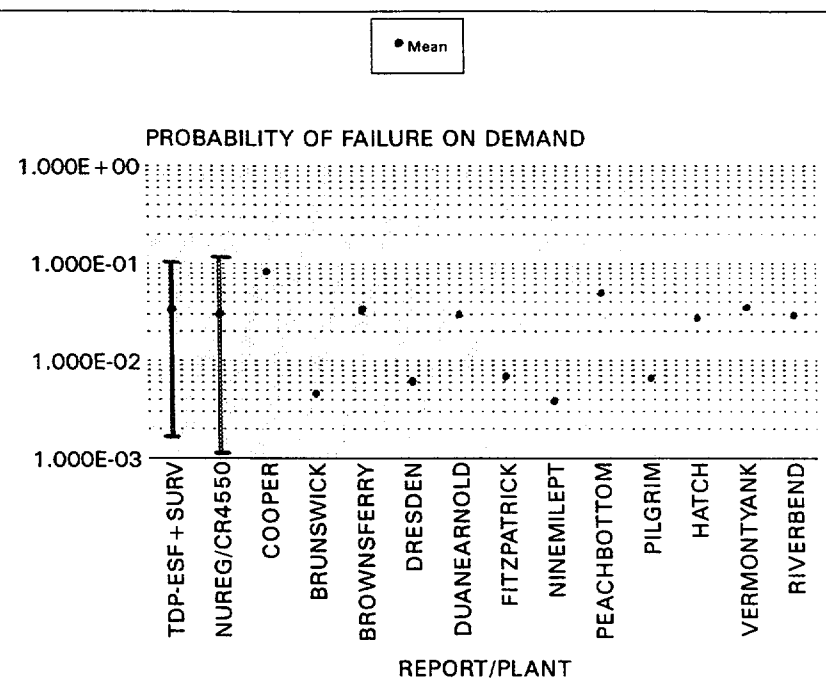


FIGURE ES-3
BWR HPCI SYSTEM TDP PROBABILITY OF FAILURE ON DEMAND COMPARISON WITH VALUES USED IN IPEs

Failure trends for the PWR AFW system during the 1987-1995 period were relatively constant, except for an upward peak in 1989 and 1990. For BWRs (RCIC and HPCI systems combined), there was a marked decreasing trend after 1991. Figure ES-4 shows the TDP failure trends for the 1987-1995 period.

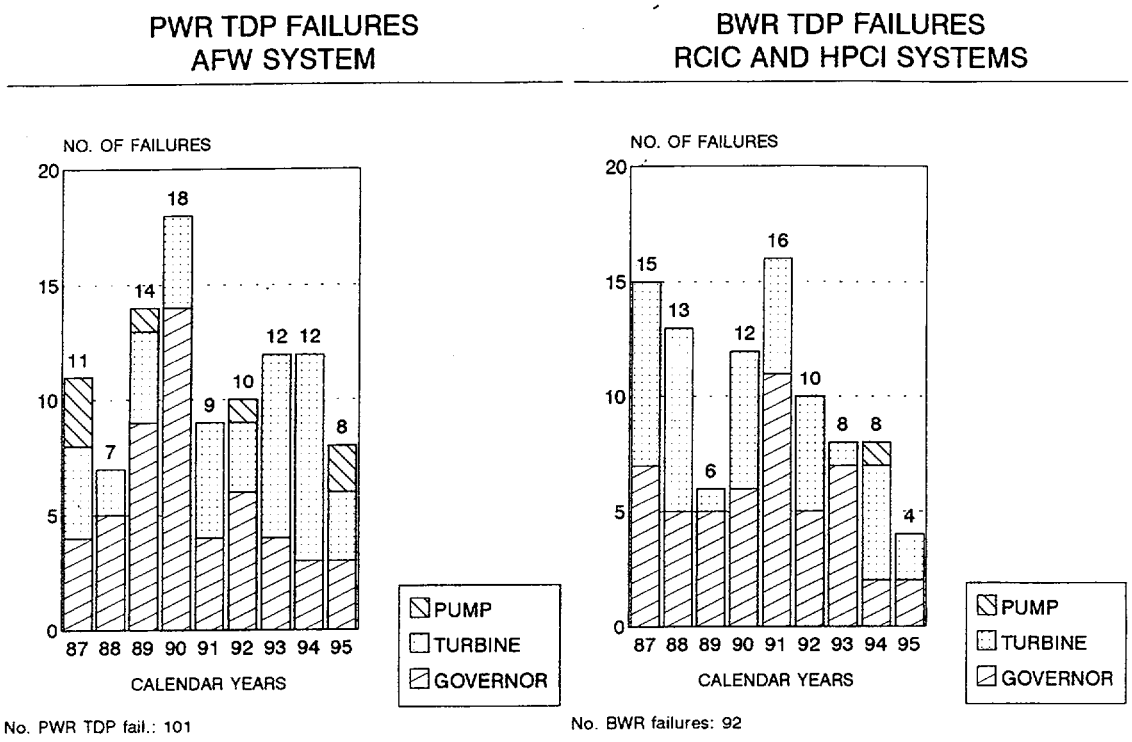


FIGURE ES-4
TDP FAILURE TRENDS

Failure rates, as a function of component-years, were compared among the PWR and BWR plant age groups (three groups, of approximately equal size, from older to newer plants by commercial operation date). For both PWRs and BWRs, the review of plant age groups did not show evidence of an increase in failure rates for any of the plant age groups due to "aging" mechanisms.

The evaluation of TDP subcomponent failure patterns demonstrated that failures of governor subcomponents were significant contributors to the TDP failures in the BWR RCIC system, while both turbine and governor subcomponent failures were significant contributors to the PWR AFW system and BWR HPCI system. Pump subcomponent failures were relatively insignificant.

Failures of TDP assemblies in AFW and RCIC systems were mainly due both to age/wear and maintenance/procedural deficiencies, whereas maintenance/procedural deficiencies was singularly predominant for the HPCI system. Figure ES-5 shows the TDP assembly failure causes for the AFW, RCIC, and HPCI systems.

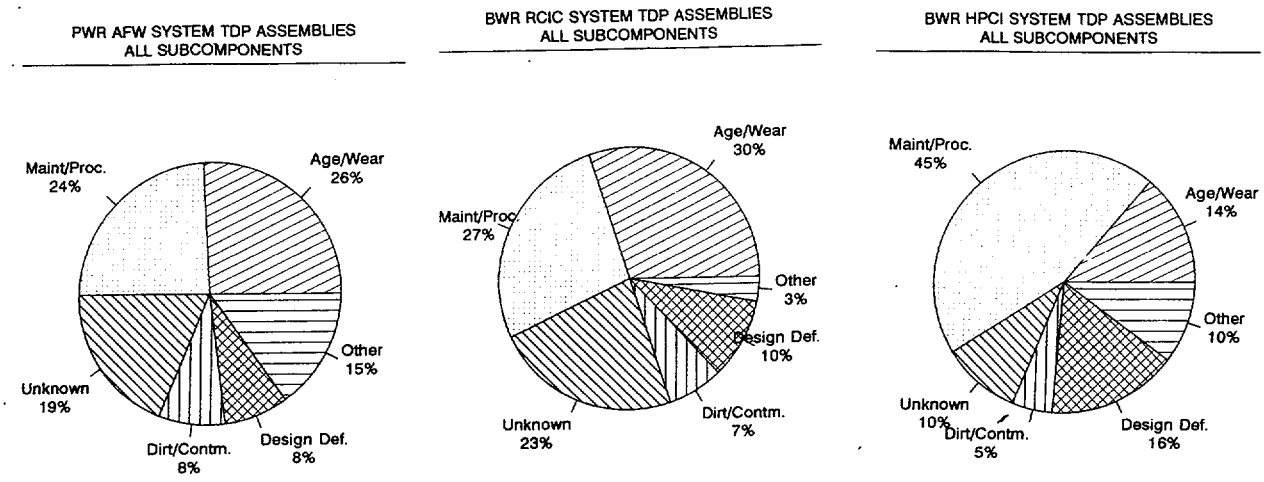


FIGURE ES-5
TDP ASSEMBLY FAILURE CAUSES

ACKNOWLEDGMENTS

We thank our colleague Dr. Dale M. Rasmuson for his technical assistance in the review and presentation of the statistical data.

ACRONYMS

AFW	auxiliary feedwater system
AOV	air-operated valve
ASME	American Society of Mechanical Engineers
BWR	boiling water reactor
EPIX	Equipment Performance and Information Exchange
ESF	engineered safety features
HPCI	high pressure coolant injection system
INEEL	Idaho National Engineering and Environmental Laboratory
INPO	The Institute of Nuclear Power Operations
IPE	Individual plant examination
LER	Licensee Event Report
MDP	motor-driven pump
MOV	motor-operated valve
NPRDS	Nuclear Plant Reliability Data System
NRC	United States Nuclear Regulatory Commission
ORNL	Oak Ridge National Laboratory
PRA	probabilistic risk assessment
PWR	pressurized water reactor
RCIC	reactor core isolation cooling system
RI	risk-important
SCSS	Sequence Coding and Search System
TDP	turbine-driven pump

COMPONENT PERFORMANCE STUDY – TURBINE-DRIVEN PUMPS, 1987-1998

1. INTRODUCTION

1.1 Purpose

This study provides the performance evaluation of turbine-driven pump (TDP) assemblies in the pressurized water reactors (PWR) auxiliary feedwater system and in the boiling water reactors (BWR) reactor core isolation cooling (RCIC) and high pressure coolant injection systems during the period 1987 through 1998. The objectives of this study are (1) to determine the reliability of TDP assemblies and compare the results with estimates in probabilistic risk assessments (PRAs) and individual plant examinations (IPEs) and (2) to review the operational data from an engineering perspective to determine trends and patterns and gain insights into component performance.

An engineering analysis of the factors affecting TDP reliability was performed to determine trends and patterns in the TDP operating data for the 1987-1995 period. This study was based on the actual operating history of TDPs for these safety-related systems. The reliability parameters calculated in this study are the probability of failure to start on demand and failure rate per standby hours (standby failure rate). Supplemental failure and demand data for 1996-1998 from operational events (engineered safety features actuations reported in Licensee Event Reports) was added to the 1987-1995 data for estimating the TDP probabilities of failure on demand.

1.2 Background

The U.S. Nuclear Regulatory Commission (NRC) has undertaken to ensure that the stated NRC policy to expand the use of probabilistic risk assessment (PRA) within the agency is implemented in a consistent and predictable manner. As part of this effort, the Office of Nuclear Regulatory Research (RES), Division of Risk Analysis and Application (DRAA), has begun monitoring and reporting on the functional reliability of risk-important systems in commercial nuclear power plants. The approach is to compare estimates and associated assumptions in PRAs to actual operating experience. The first phase is identifying risk-important systems from a PRA perspective and doing a reliability and trending analysis of these systems. As a significant part of this effort, a risk-related performance study of the turbine-driven pumps for the AFW, RCIC, and HPCI systems was performed.

Over the past decade, the NRC has issued several studies applicable to TDP risk-important systems, TDP components or their subcomponent failures, failure on demand probabilities, and trends and patterns.

- NUREG-1275, Vol. 10, "Operating Experience Feedback Report – Reliability of Safety-Related Steam Turbine-Driven Standby Pumps," October 1994 (Ref. 1), documented a detailed analysis of failure initiators, causes, and design features for steam turbine assemblies (turbines and their related components such as governors and valves) that are used as drivers for standby pumps in the auxiliary feedwater systems of pressurized water reactor plants, and in the high pressure safety injection and reactor core isolation cooling systems of boiling water reactor plants (1974-1992).

- NUREG/CR-5500, Vol.4, "Reliability Study: High Pressure Coolant Injection (HPCI) System Performance, 1987-1993," September 1999 (Ref. 2), documented an analysis of the performance of the BWR HPCI system during the period 1987-1993. A risk-based analysis and an engineering analysis of trends and patterns were performed from HPCI system operational events data (reported by LERs) to provide insights into the performance of the HPCI system throughout the industry and at a plant-specific level.

- NUREG/CR-5500, Vol.7, Reliability Study: Reactor Core Isolation Cooling System, 1987-1993," September 1999 (Ref. 3), documented an analysis of the performance of the BWR RCIC system during the period 1987-1993. A risk-based analysis and an engineering analysis of trends and patterns were performed from RCIC system operational events data (reported by LERs) to provide insights into the performance of the RCIC system throughout the industry and at a plant-specific level.

- NUREG/CR-5500, Vol. 1, "Reliability Study: Auxiliary/Emergency Feedwater System, 1987-1995," dated August 1998 (Ref. 4), documented an analysis of the performance of the PWR AFW system during the period 1987-1995. A risk-based analysis and an engineering analysis of trends and patterns were performed from AFW system operational events data (reported by LERs) to provide insights into the performance of the AFW system throughout the industry and at a plant-specific level

1.3 Overall Study Structure

This study is arranged in four sections.

(1) Section 1 is the introduction.

(2) Section 2 describes the scope of the study, risk-important systems, the TDP assembly and its subcomponent boundaries, and the methodology used for operational data collection and analysis.

(3) Section 3 provides the risk-based analysis of operational data, the calculation results for estimating the TDP probabilities of failure on demand and the standby failure rate for TDPs, the contingency test analysis for the data population, the comparison of TDP probability values with those in IPEs and other sources, and the regulatory implications of this component performance study.

(4) Section 4 provides the engineering analyses (failure trend analysis, component trends in time, the failure characteristics and their causes, a brief discussion and listing of NRC regulatory initiatives related to TDPs, and engineering insights resulting from the various analyses).

The appendices provide related data used in this study and evaluation results. Appendix I provides the estimated probabilities of failure on demand and the calculated standby failure rates. Appendix II contains tables of data for the combined total and for each plant age group used to plot the component trends in time and an evaluation of aging effects on TDPs. Appendix III provides data used for engineering analysis and insights into failure trends and patterns. Appendix IV provides operational data inputs for reported failures and estimated demands from the NPRDS database and LERs (SCSS database).

2. SCOPE OF STUDY

2.1 Risk-Important Systems and Components

The PWR risk-important (RI) system that uses the TDP is the auxiliary/emergency feedwater (AFW) system (Westinghouse, Babcock & Wilcox, and Combustion Engineering reactor plants). The main safety function of the AFW system is to provide feedwater to the steam generators to maintain a heat sink in the event of a loss of main feedwater, a reactor trip, loss of offsite power, or a small break loss of coolant accident. The AFW system is typically a multi-train system, one train with a TDP and one or more trains with motor-driven pumps (MDPs). However, some plants have more TDP trains and a few plants have no TDP trains (motor-driven pump trains and/or diesel-driven pump trains).

The BWR RI systems that use TDPs are the reactor core isolation cooling (RCIC) and the high pressure coolant injection (HPCI) systems. The RCIC system is a single train system that supplies high pressure makeup water to the reactor vessel when the reactor is isolated from the main condenser and the condensate and feedwater system is not available. The HPCI system is a single train system that maintains adequate reactor vessel inventory for core cooling in the event of small break loss-of-coolant-accidents (LOCAs), and assists in the depressurization of the reactor vessel to allow the low pressure emergency core cooling systems (ECCS) to inject on intermediate break LOCAs. It also provides a backup function to the isolation condenser or the RCIC system under reactor isolation conditions.

2.2 TDP Assembly Description and Boundaries

For this study, a TDP assembly is comprised of a pump, a turbine driver, and a governor subcomponents. The pump is typically a horizontal, split-case, single stage centrifugal pump. Most plant designs use a single stage "Terry Turbine" (now supplied by Dresser-Rand), whose piece parts include a turbine trip and throttle valve, a mechanical overspeed trip mechanism, and a lubrication system. The various types of governors, used for turbine speed control in AFW, RCIC, and HPCI system TDPs, are mostly manufactured by the Woodward Corporation. For the AFW system TDPs, the governors are predominantly mechanical/hydraulic, pressure compensated, and have a pneumatic remote-speed setting capability. For the RCIC and HPCI systems, the TDPs typically have Woodward type EG-M electric/electronic governors and EGR actuators. Piece parts of all governors include a turbine stop valve and a governor valve, while the EG-M usually includes a ramp generator/signal converter and other electrical controls. The turbine and various type governor subcomponents are included in NUREG-1275, Vol. 10 (Ref. 1).

The component boundaries are the TDP assembly, its subcomponents, and the piece parts described above, that are supplied as part of the TDP assembly. Other system components, such as steam inlet valves to the turbine, pump suction and discharge valves, flow instrumentation and controls, and remote electrical controls, are considered outside the component boundary in this study.

2.3 DATA COLLECTION

Data collection and reporting for the NPRDS were terminated at the end of 1996. Therefore, the NPRDS does not have any failure information for 1997 and later. Furthermore, the 1996 failure data reported in NPRDS was not as consistent as for the 1987-1995 period (the industry was transitioning for the

termination of NPRDS). The Institute for Nuclear Power Operations (INPO) has recently implemented a new component database called Equipment Performance and Information Exchange (EPIX). This system is intended to replace the NPRDS system that yields additional information, such as demands. In its present stage of development, the EPIX system was not considered to be sufficiently mature to provide a complete data source for the 1996-1998 period for this study. Where applicable in the development of probability of failure on demand estimates for this study, the SCSS database of ESF failure and demand data (reported in LERs) were used for the 1996-1998 period.

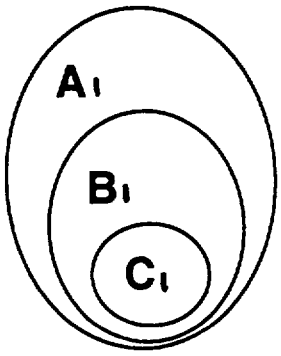
The NPRDS database was used to obtain the number of TDP assembly subcomponents and the estimated testing frequency for each subcomponent in each plant. The number and testing frequency of Application Coded pump subcomponents were compared with the number and testing frequency of Application Coded turbine driver and governor subcomponents for each TDP assembly. This was done for the AFW system in PWRs and for the RCIC and HPCI systems in BWRs for each plant. The comparison was made to assure that number of TDP assemblies was correct for each plant, since each assembly has one pump, one governor, and one turbine driver. The values developed in Appendix IV were also used in developing other appendices.

The term "Application Coded" used in this study refers to risk-important components or subcomponents that are functionally designated within a specific system by the NPRDS. An example using the RCIC system TDP subcomponents that were separately Application Coded in NPRDS is as follows:

COMP. ASSY	SUBCOMP.	REACTOR TYPE	RI SYSTEM	APPLICATION CODE DESCRIPTION
TDP	Pump	BWR	RCIC	RCIC Turbine Driven Pump
TDP	Turbine	BWR	RCIC	RCIC Turbine Driver
TDP	Governor	BWR	RCIC	RCIC Governor

A detailed review and evaluation was performed of the LERs and the NPRDS failure histories to determine the total number of TDP failures for this study. Only "complete" (i.e., catastrophic) failures were included in the failure count. For TDP subcomponents, the NPRDS "fail to start" (FS) and "fail to run" (FR) failure modes were both included for estimating probability of failure on demand. For the TDP governor subcomponent, the "failure to control (FC)

and "failure to run" (FR) failure modes were used. Because these failure modes occurred in a relatively short period, these various subcomponent failure modes were considered as equivalent to "fail to start." Figure 1 shows the relationship between various NPRDS database failure data subsets.



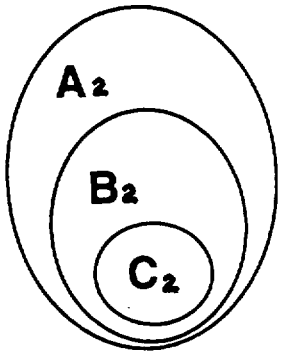
A1 All TDP assembly subcomponent failures as "complete"/catastrophic failure category (1987-1995)

B1 Subset - TDP failures for risk-important systems

C1 Subset - TDP failures occurring during surveillance tests

FIGURE 1
NPRDS DATABASE TDP FAILURES

The SCSS database was used to determine the number of TDP failures, reported in LERs, that occurred during surveillance tests or that were associated with an engineered safety features (ESF) actuation. The NPRDS database was used to obtain the number of surveillance test failures for each TDP subcomponent. Surveillance test failures reported in LERs were excluded from the NPRDS failure counts, but included in the LER failure counts. This was done to prevent a "double count" of failures. Figure 2 shows the relationship between various SCSS database (reported by LERs) failure data subsets.



A2 All TDP assembly failures (1987-1998)

B2 Subset - TDP failures for risk-important systems

C2 Subset TDP failures associated with ESFs or occurring during surveillance tests

FIGURE 2
SCSS DATABASE TDP FAILURES

TDP failures that occurred during surveillance testing were directly linked with surveillance test demands to assure that surveillance test probability of failure on demand estimates were valid. Similarly, ESF failures were linked with ESF demands to estimate ESF probability of failure on demand. For the few

plant AFW systems with more than one TDP (i.e, more than one train with a TDP), those TDPs that might have been actuated during pre-test or post-test system train alignment were not included in the surveillance test failure counts used in this study.

When it was analytically determined that the ESF failures and demands were in the same population as the surveillance test failures and demands, the total number of demands was the sum of the ESF demands and the surveillance test demands.

The first step in estimating ESF demands was to determine ESF actuations and then determine which component types and how many components of each type were actuated by this type of demand. Other demands that may have occurred during plant operation, startup, or shutdown but did not result in ESF actuations were not included in the ESF demand determination, nor were any associated failures included. However, inadvertent and spurious demands and manual actuations associated with an ESF (e.g., a reactor trip) were considered ESF demands. The SCSS database was used for the PWR AFW system and the BWR RCIC and HPCI systems for LERs that were coded with "ESF Actuations" and those coded as "SCRAMS and Shutdowns." The full text of each LER was reviewed to determine whether the selected systems were actuated, the number and type of trains (e.g., for AFW, the turbine-driven pump train(s) and/or the motor-driven pump train(s) actuated by the ESF), and the best estimate of the number of TDPs actuated, based on the plant-specific train configuration.

The second step in estimating the total number of demands was to use NPRDS testing frequencies as the basis for surveillance test demands. This was done for the NPRDS Application Coded, functionally designated TDP assembly subcomponents in the AFW, RCIC, and HPCI systems (see Section 2.1 for the description of the TDP assembly). The review of the NPRDS testing frequency was performed for each subcomponent of the TDP assembly (i.e., pump, turbine driver, and governor). When the NPRDS reported testing frequency differed among the subcomponents, an estimate was made for the TDP assembly testing frequency that included American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code, Section XI Inservice Testing interval requirements (as required by the Technical Specifications), the system, and the subcomponent function in the TDP assembly. When no frequency was provided by NPRDS, a minimum frequency of once per quarter was used. Demands associated with a surveillance test that occurred during train alignment and return to the "as found" condition of a system/train were not included in the total number of demands, nor were corollary failures included in the failure count. Although the Technical Specifications generally require a full flow test once per refueling cycle, no additional demands were included because the monthly

or quarterly surveillance test frequencies used in this study were assumed to envelope these refueling cycle demands.

The total number of demands for the TDPs in a specific system was the sum of ESF TDP demands and surveillance test demands, where the latter is the sum of the products of the TDPs and their estimated testing frequencies over the 9-year period (1987-1995) and the former (ESFs) covers the 12-year period (1987-1998).

The probability of failure on demand for TDPs was estimated by dividing total TDP failures by total TDP demands (ESF failures + surveillance test failures ÷ ESF demands + surveillance test demands) as long as the ESF data and the surveillance test data were analyzed to be in the same population.

2.4 Operational Data Analysis

A contingency test analysis was performed to **reject** or to **not reject** the hypothesis that failure and demand data from surveillance testing of Application Coded TDPs were in the same population as ESF failure and demand data. The analysis used surveillance test data for the TDPs in the PWR AFW system and in the BWR RCIC and HPCI systems during the 1987-1995 period and ESF data from1987-1998.

The approximate method for contingency test tables (chi-square, 1 degree of freedom, 0.95 quantile) was used for the **reject/not reject** hypothesis that the ESF and surveillance test data are from the same population ($\chi^2 < 3.84$). The contingency test table provides a short-cut method of computing chi-square using the following 2X2 table and formula:

$$\chi^2 = \frac{n\,(ad - bc)^2}{k}$$, where $n = a + b + c + d$ and $k = (a+b)(c+d)(a+c)(b+d)$

	ESFs	SURVEILLANCE TEST	TOTAL
No. of FAILURES	*a*	*b*	*(a + b)*
No. of SUCCESSES	*c*	*d*	*(c + d)*
TOTAL (DEMANDS)	*(a + c)*	*(b + d)*	*n*

Alternate Method (formula to correct for continuity)

$$\chi^2 = \frac{n\,(|ad-bc| - n/2)^2}{k}$$

Bayes Method

The Bayes method (Ref. 6), as applied to this study for TDPs by plant system, assumes that the probability of failure on demand varies from plant to plant according to a beta distribution. The parameters for this distribution were estimated from the pooled data by maximum likelihood. For each plant, this distribution was used as a Bayes prior distribution, and updated with the plant-specific failure data. This method was used in this study for the PWR AFW system and the BWR RCIC and HPCI systems. It is also used to evaluate the acceptability of combining data populations (ESF and surveillance test) when the simple contingency test rejects the hypothesis that the data are in the same population.

Standby Failure Rate

The average standby failure rate (λ) for TDPs in each system is based on the data for the 9-year period 1987-1995, using the following equation:

$$\lambda = \frac{f}{(nc)(coy)(8760)}, \text{ failures per component-hour}$$

where: f = the number of failures during the period, nc= the number of TDPs in each plant for the system, coy = the actual number of calendar operating years during the 9-year period, and 8760 = the number of hours in a calendar year

3. RISK-BASED ANALYSIS

This section presents the risk-based analysis of operational data, the estimated TDP probabilities of failure on demand and estimated standby failure rate, the contingency test analysis for the data population, a comparison of TDP probability values with those in IPEs and other sources, and the regulatory implications of this component performance study.

3.1 Calculation Results

Appendix I provides tables applicable to the TDP probability of failure on demand by the selected systems in the 69 PWR and 31 BWR plants. The results are as follows:

The simple contingency test for the PWR AFW system TDPs rejected the hypothesis that ESF data and surveillance test data were in the same population. The Bayes Method of comparison supported combining data populations (see 2.4, above). Therefore, the Bayes 90% intervals used for this study combined ESF data from 1987-1998 with surveillance test data from 1987-1995.

For BWR RCIC and HPCI systems the contingency tests did not reject the hypothesis that the ESF failures and demands were in the same population as the surveillance test failures and demands (see Section 2.4). Therefore, the Bayes 90% intervals for ESF + surveillance test (1987-1995) + ESF (1996-1998) probability of failure on demand was used.

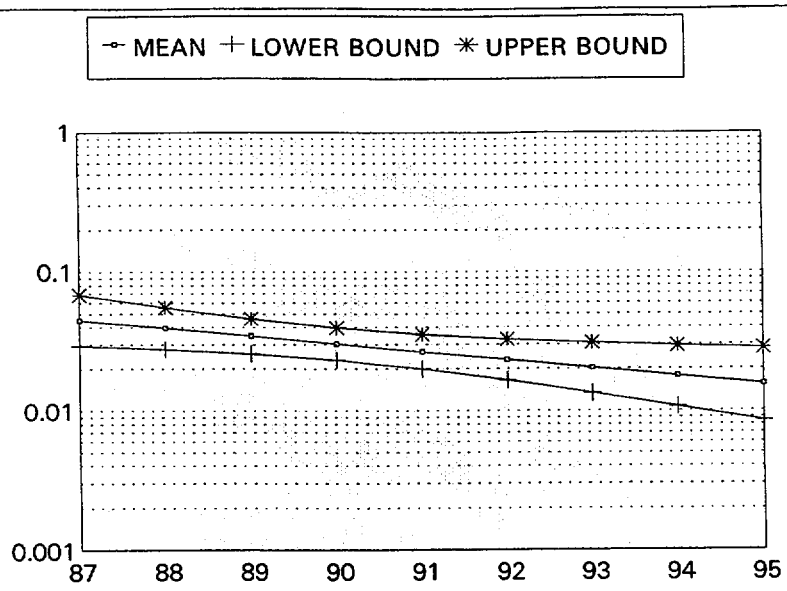
The generic failure probabilities used in PRAs are presently provided in terms of probability of failure on demand and probability of failure per operating hour. In this study, probability of failure on demand was used for TDPs because data was available to match failures to demands. Data on run times from LERs and NPRDS was not available to compare with generic failure to run data. The generic failure probability on demand ("failure to start") values used in this study are from NUREG/CR-4550 (Ref. 5), which was the input to NUREG-1150.

Table A shows the TDP probability of failure on demand values for 1987-1998 for AFW, RCIC, and HPCI systems.

TABLE A
TDP PROBABILITY OF FAILURE ON DEMAND (1987-1998)

SYSTEM/SOURCE	LOWER BOUND	MEAN	UPPER BOUND
NUREG/CR-4550	1.1E-3	3E-2	1.1E-1
AFW system	1.3E-3	1.6E-2	4.6E-2
RCIC system	9.1E-6	2.0E-2	8.7E-2
HPCI system	1.6E-3	3.3E-2	9.7E-2

The results shown in Table A indicated that the Bayes 90% interval probabilities of failure on demand were within the referenced NUREG/CR-4550 value range for TDPs used in this study. For the PWR AFW and BWR RCIC systems, the probability of failure on demand over the 1987-1995 period showed a relatively constant trend. For the BWR HPCI system, the trend was decreasing (see Figure 3). The majority of the data for calculating the trends was surveillance test data. Since there was no new data for surveillance test failures and demands for the most recent three years (1996-1998) of the study, it is not certain whether these trends continued. The ESF data alone is sufficient to conclude that significant increases in the failure probability have not occurred, but is insufficient to determine whether the trends for 1996-1998 were constant or declining. Therefore, Table A uses the mean values over the entire period as the estimate for the probability of failure on demand.



BWR HPCI SYSTEM TDP PROBABILITY OF FAILURE ON DEMAND
YEARLY TREND - 1987-1995
FIGURE 3

Table B shows the average standby failure rates based on 1987-1995 failure data for combined ESF and surveillance tests.

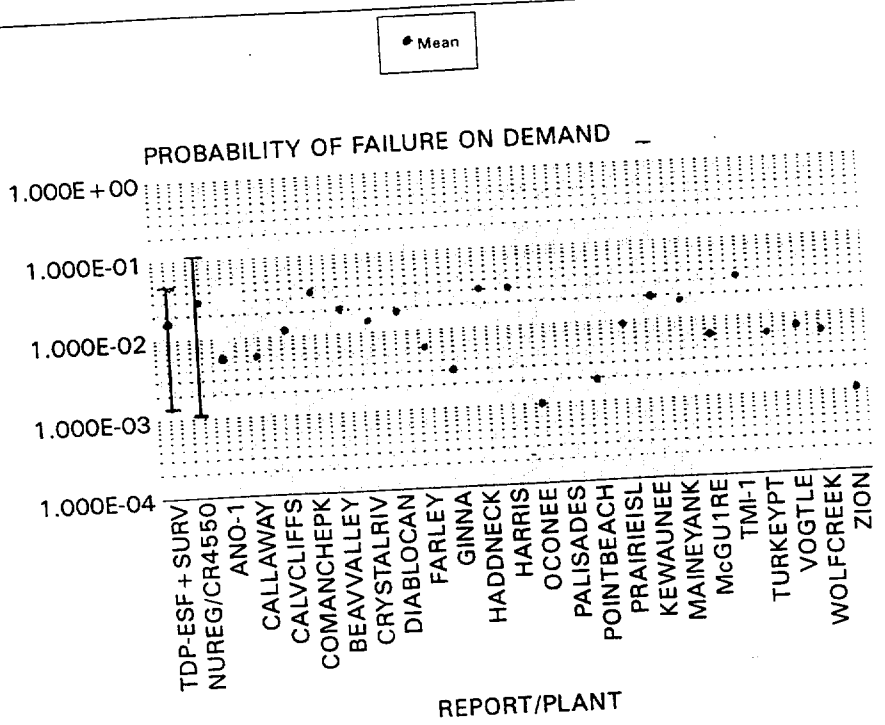
TABLE B
TDP STANDBY FAILURE RATE (1987-1995)

SYSTEM/SOURCE	LOWER BOUND	MEAN	UPPER BOUND
AFW system	1.4E-5/hour	1.8E-5/hour	2.1E-5/hour
RCIC system	9.1E-6/hour	1.3E-5/hour	1.7E-5/hour
HPCI system	2.1E-5/hour	2.9E-5/hour	3.8E-5/hour

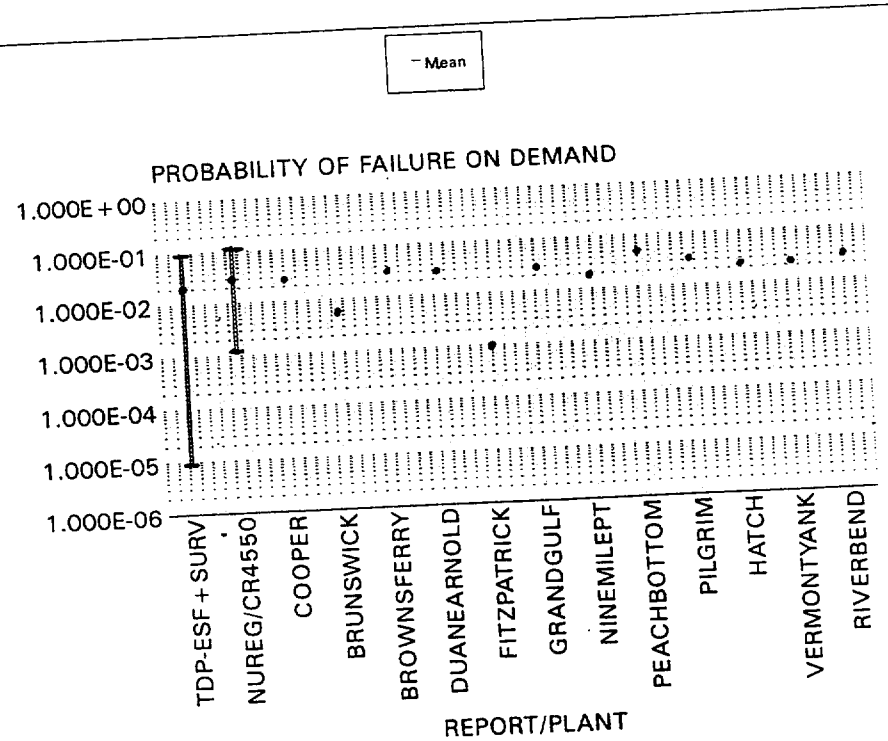
3.2 Comparison With IPEs and Other Sources

The TDP failure probabilities on demand developed for the PWR AFW system and the BWR RCIC and HPCI systems were compared with a selected group of plant-specific individual plant examinations (IPEs),as shown in Figures 4, 5, and 6, respectively. The sample of IPEs selected was from those with available data that identified a "failure to start" probability of failure on demand for TDPs.

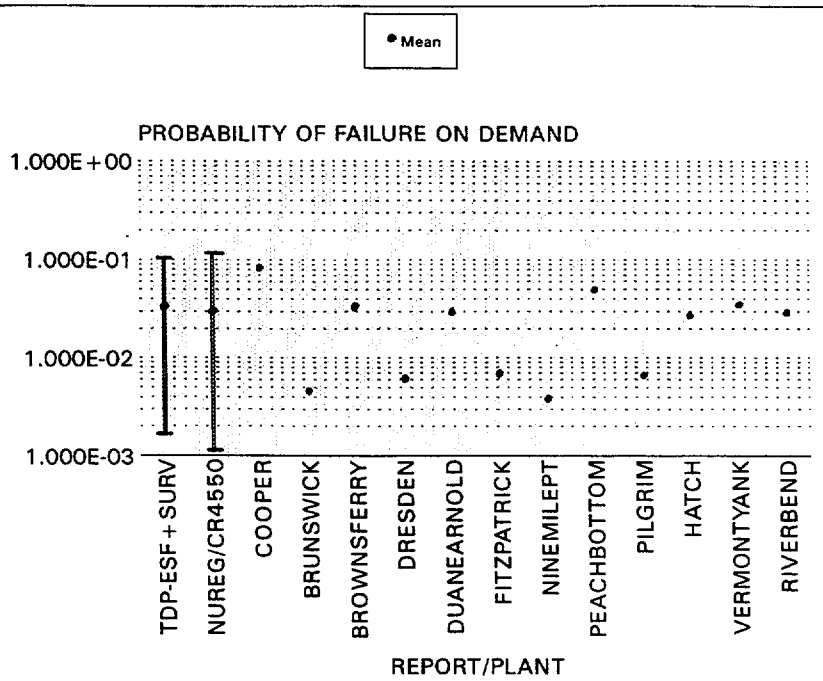
For the BWR RCIC and HPCI systems (1987-1995 data), all of the IPE mean values for the TDP failure on demand probability were within the range of this study and NUREG/CR-4550. Although the 1995 HPCI probability range is narrower, it is provided for information only for comparison with plant IPE mean values. For the AFW system, more than 90% of the IPE mean values were also within the range of this study and NUREG/CR-4550.



PWR AFW SYSTEM TDP PROBABILITY OF FAILURE ON DEMAND
COMPARISON WITH VALUES USED IN IPEs
FIGURE 4



BWR RCIC SYSTEM TDP PROBABILITY OF FAILURE ON DEMAND
COMPARISON WITH VALUES USED IN IPEs
FIGURE 5



BWR HPCI SYSTEM TDP PROBABILITY OF FAILURE ON DEMAND COMPARISON WITH VALUES USED IN IPEs FIGURE 6

4. ENGINEERING ANALYSIS

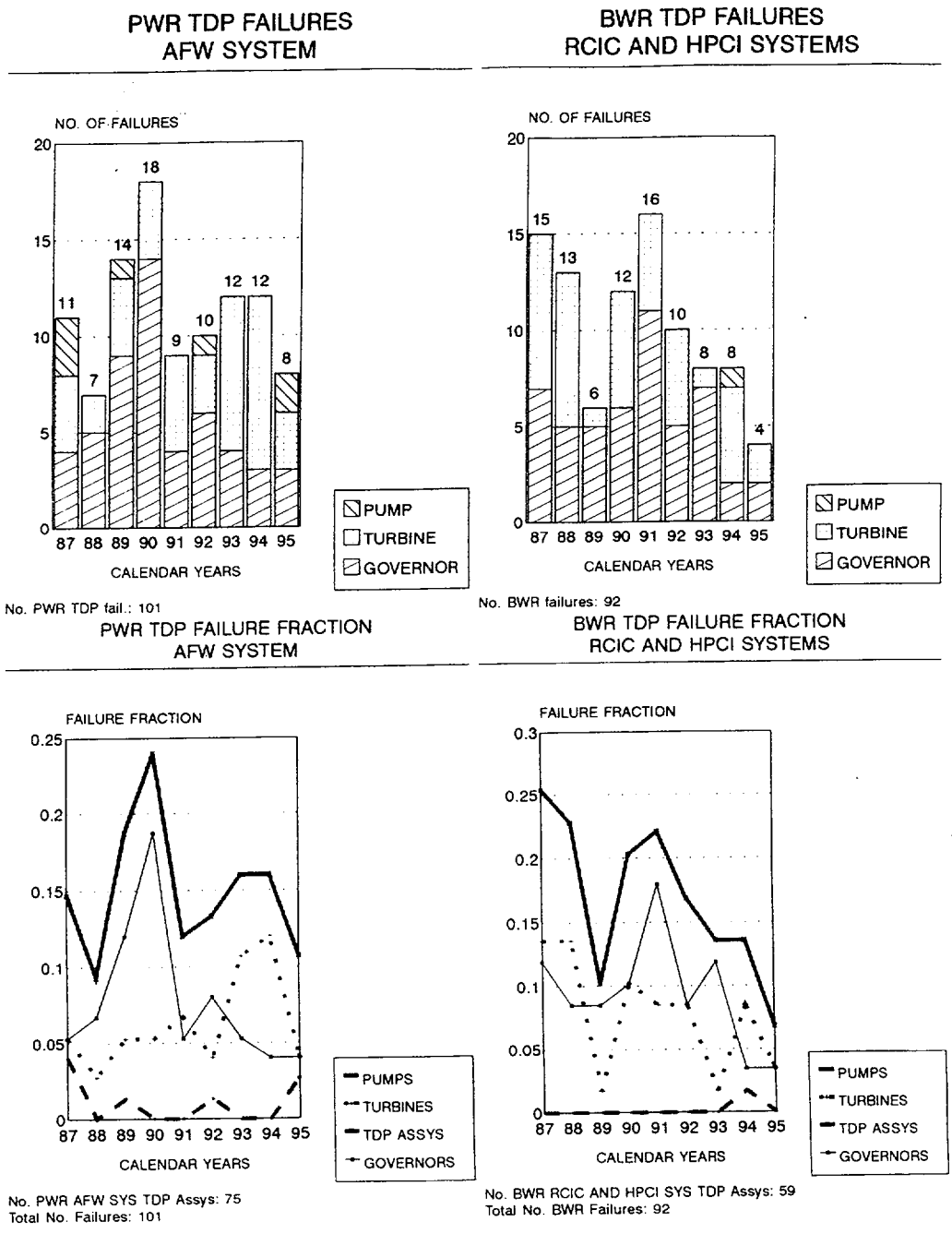
This section provides the engineering analyses, including failure trend analysis, component trends in time, failure characteristics and their causes, a brief discussion and listing of NRC regulatory initiatives related to TDPs, and engineering insights from the various analyses.

4.1 Failure Trend Analysis

Appendix III provides applicable data for trending of TDP failures. Failure trends of TDPs for failures and failure fractions during the 1987-1995 period, are shown in Figure 7.

As indicated in Section 2.3, NPRDS failure data for 1996 was reported inconsistently by licensees and, therefore, was determined to be insufficient for trending purposes. Without NPRDS data, LER data from 1996 through 1998 was insufficient for trending purposes. Therefore, failure data for trending in this study used NPRDS and LER failure data for the 1987-1995 period.

Failure trends of TDPs for the PWR AFW system showed no discernible trend, except for an upward peak in 1989 and 1990, with an average failure fraction (number of failures over the 9-year period divided by the number of TDPs and multiplied by 9 years) of 0.15. For the BWR systems (RCIC and HPCI combined), there was a marked decreasing failure trend after 1991, with an average failure fraction of 0.17, similar to AFW TDPs.



PWR AND BWR TDP FAILURE TRENDS
FIGURE 7

4.2 Component Trends in Time Methodology

The initial assumption made in this study is that the rate of failure events over time (λ) is constant. Several evaluation methods were used to check this assumption. The reason for checking was to determine if any significant age- related increase in λ occurred among older plants. In order to conclude that an increase in λ due to "aging" occurred, it would be necessary for the following conditions to be present:

1. There was an increase in λ over time (a nonconstant failure rate that was increasing) and,
2. λ was higher for the older plants and,
3. The dominant contributor to failure was due to age/wear mechanisms.

When individual failure events are arranged in chronological order, a cumulative plot helps to show whether λ is constant throughout the period.

This study used an average failure rate, $\lambda_{AVE.}$, equal to the total number of TDP failures (ESF failure data and surveillance test failure data) for the 1987-1995 period, divided by the cumulative number of TDP component-years of operation during the period. Failure data from the 1996-1998 period was not included since it was for ESF failure and limited surveillance test data only.

The cumulative number of failures was plotted against the number of TDP component-years since the beginning of the study period (1987) for comparison with $\lambda_{AVE.}$ This was done for PWRs and BWRs for combined plant age groups (total PWR and total BWR plants) and for plant age groups A, B, and C. These groups use 109 plants as a basis for all component studies, of which 100 plants had TDPs (69 PWR plants with AFW system TDPs, 31 BWR plants with RCIC system TDPs, and 28 BWR plants with HPCI system TDPs). The following table gives the definition of each plant age group and its apportionment, with the 109 plant basis:

PLT AGE GROUP	COMMERCIAL OPERATION DATE	TOTAL NUMBER OF PLANTS	NUMBER OF PWR PLANTS	NUMBER OF BWR PLANTS
A	12/31/74 and earlier	36	24	12
B	1/1/75 through 3/31/84	37	25	12
C	4/84 and later	36	24	12

The assumption (i.e., null hypothesis) that $\lambda_{AVE.}$ is constant during the study period for each plant age group and for the combined plant age groups was evaluated. The failure rates ($\lambda_{AVE.}$) are the slope of the plots for each plant age group. Comparison between plant age groups were made to determine whether there was any indication of plant aging (e.g., higher slope for the older plant age groups than for the newer plant age groups). A statistical test for the null hypothesis that the failure rate is constant is the Laplace test. For this test, *L/2* is defined as the midpoint of the cumulative number of component-years during the 1987-1995 period. If λ is constant, about half of the events should occur before *L/2* and half afterwards. The criteria for not rejecting the null hypothesis is that the statistic ***U*** is approximately normal for a number of failures ≥ 3 (***U*** is within $\pm$ 1.645 for the 0.95th and 0.05th quantiles, respectively, of the standard distribution). For a nonconstant failure rate (rejected null hypothesis) that is increasing (***U*** >+1.645), possible aging exists. The formula for the ***U*** statistic is :

$$U = \frac{\bar{T} - L/2}{L\sqrt{1/12n}}$$

where: n = no. of failures, Ti = interval between failures in component-years, $\bar{T} = \Sigma Ti / n$

The mean time between failures was provided for information, using the reciprocal of the $\lambda_{AVE.}$ applicable to each PWR and BWR plant age group and the combined plant age groups.

Results

Appendix II provides tables applicable to component trends in time evaluations of TDPs. These analyses were performed to determine whether the failure rates were constant over time and whether the failure rates between older and newer plant age groups increased as an indication of possible "aging." The plots of cumulative TDP failures over time compared to the applicable average failure rate ($\lambda_{AVE.}$) plots for PWRs and BWRs indicated the following:

PWRs (see Figure 8) - For the AFW system, a review of plant age groups did not show evidence of an increase in λ for any of the plant age groups due to an "aging" mechanism.

- For plant age group A, the assumed hypothesis that the failure rate was constant was rejected. The value of ***U*** at the 10% significance level was +2.181 (>+1.645) and indicated a nonconstant failure rate (increasing) and possible "aging."

- For plant age group B, the hypothesis of a constant failure rate was also rejected. The value of ***U*** at the 10% significance level was -2.618

(< -1.645). Although the failure rate was nonconstant, it was decreasing. Therefore, there is no evidence of "aging."

- For plant age group C, the hypothesis of a constant failure rate was not rejected. The value of ***U*** was -0.27 (very close to zero) and did not provide any evidence of a nonconstant failure rate.

- When the average failure rates were compared among the plant age groups, plant age effects were assumed to be reflected by highest average failure rates for the older plant age group A, ranging to the lowest average failure rate for plant age group C. However, the reverse order occurred, where $\lambda_{AVE.}$ for A (0.10) was lower than B (0.15), and both were lower than C (0.22). Therefore, there was no evidence of increasingly higher failure rates as a function of plant age groups.

- When the failure causes for PWR TDP assemblies were reviewed, age/wear causes (26%), maintenance/procedural deficiencies (24%) and "other" causes (24%) were found to be more significant (see Figure 11). Therefore, age/wear mechanisms were not the predominant cause of failure.

BWRs (see Figure 9) - For the combined RCIC and HPCI systems TDPs, the review of plant age groups did not show evidence of an increase in λ for any of the plant age groups due to an "aging" mechanism.

- For plant age group A, the hypothesis of a constant failure rate was not rejected. The value of ***U*** at the 10% significance level was -0.54 (>-1.645) and did not provide any evidence of a nonconstant failure rate.

- For plant age group B, the hypothesis of a constant failure rate was rejected. The value of ***U*** at the 10% significance level was -0.1.81 (< -1.645). Although the failure rate was nonconstant, it was decreasing. Therefore, there is no evidence of "aging."

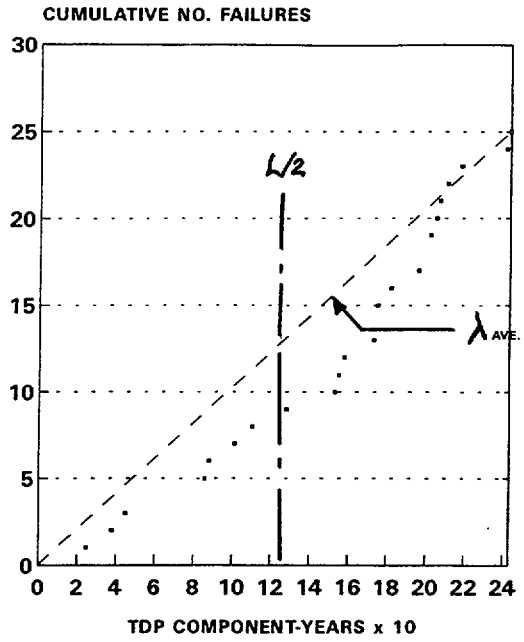
- For plant age group C, the hypothesis was not rejected. The value of ***U*** was -1.60 (>-1.645) and did not provide evidence of a nonconstant failure rate.

- When the average failure rates were compared among the plant age groups, plant age effects were assumed to be reflected by highest average failure rates for the older plant age group A, ranging to the lowest average failure rate for plant age group C. Both plant age groups A (0.20) and B (0.22) were higher than C (0.11), While plant

age group B was slightly higher than A. Therefore, there was no evidence of increasingly higher failure rates as a function of plant age groups.

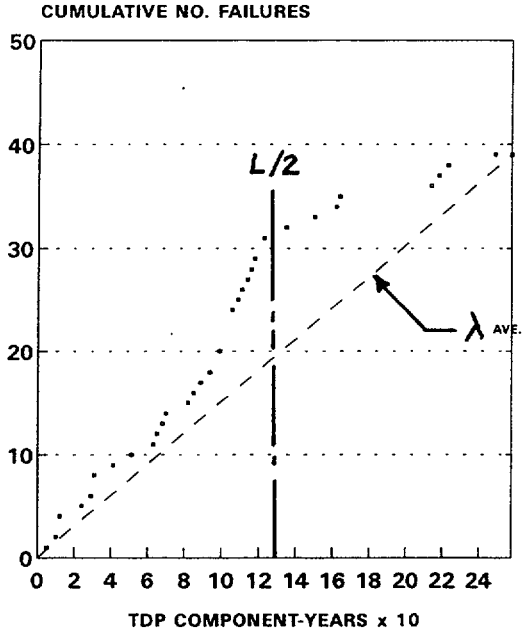
- The more significant failure causes for BWR RCIC TDP assemblies were age/wear (30%), maintenance/procedural deficiencies (27%) and "unknown" causes (23%), while for the BWR HPCI TDPs, maintenance/procedural deficiencies (45%) was the more significant (see Figures 12 and 13). Therefore, age/wear mechanisms were not the predominant cause of TDP failure.

PWR PLANT AGE GRP "A"



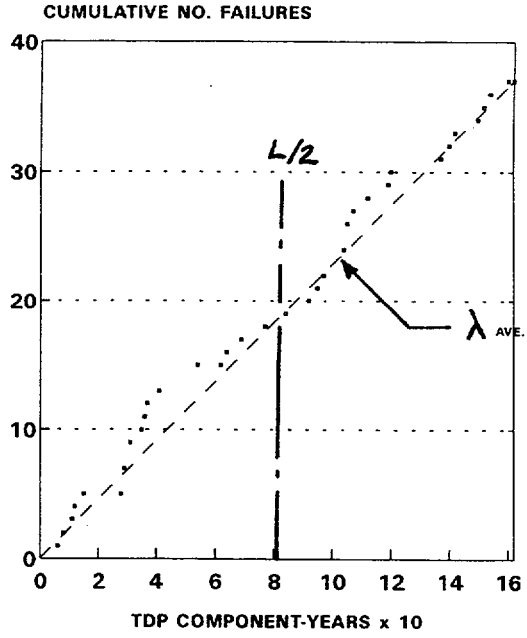
PERIOD: 1987-1995
No. fail.: 25

PWR PLT AGE GRP "B"



PERIOD: 1987-1995
No. failures: 39

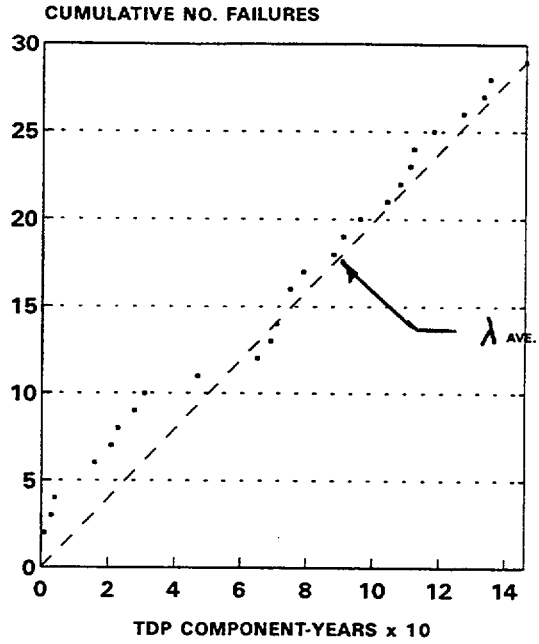
PWR PLT AGE GRP "C"



PERIOD: 1987-1995.
No. failures: 37

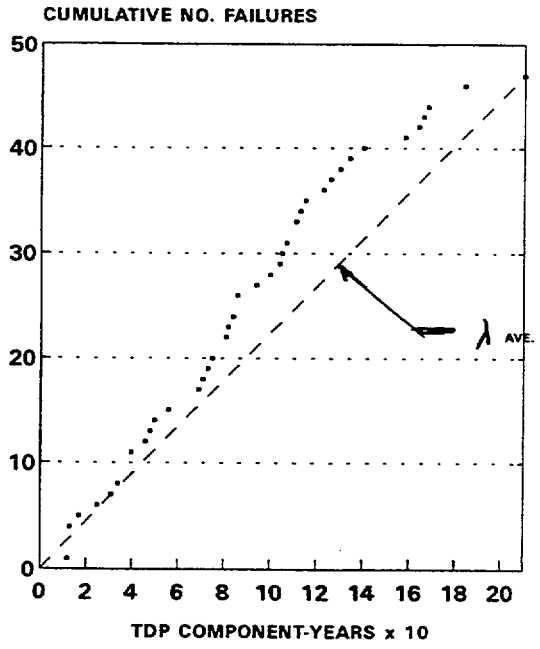
PWR AFW SYSTEM TDP COMPONENT TRENDS IN TIME
FIGURE 8

BWR PLT AGE GRP "A"



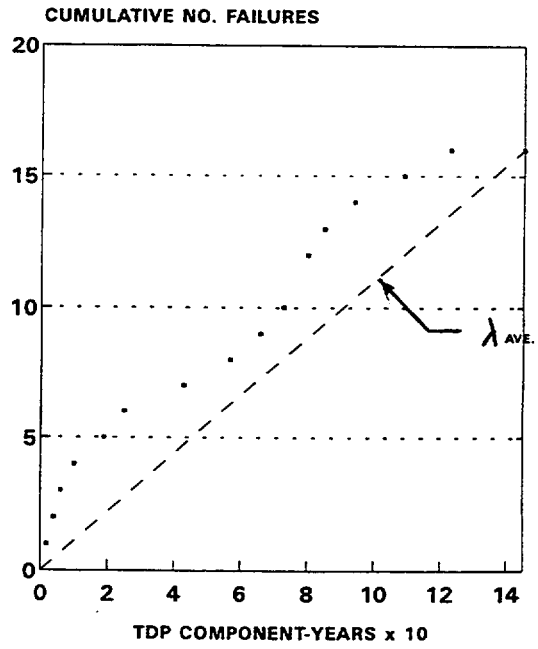
PERIOD: 1987-1995
No. failures: 29

BWR PLT AGE GRP "B"



PERIOD: 1987-1995
No. failures: 47

BWR PLT AGE GRP "C"



PERIOD: 1987-1995
No. failures: 16

BWR RCIC/HPCI SYSTEMS TDP COMPONENT TRENDS IN TIME
FIGURE 9

4.3 Failure Characteristics and Their Causes

Methodology

The TDP assembly failures and causes were identified at the subcomponent level in the NPRDS database. LER reported failures in the SCSS database provided sufficient information to identify failed subcomponents and causes within the LER narrative and to group these failures using the NPRDS cause categories. The apportionments were determined to provide insights into the predominant subcomponent failures and their causes by reactor type (PWR and BWR).

The subcomponent parts were also grouped by PWR and BWR, with the percentage of failure causes for the subcomponent calculated. The cause categories of failure used are similar to those defined in NPRDS.

The failure cause categories used in this study were as follows:

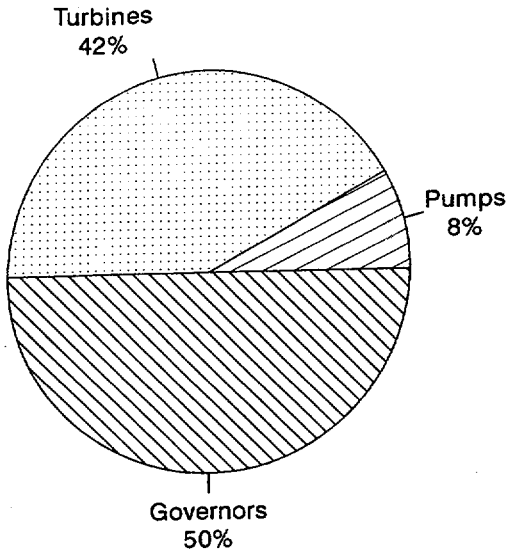
-Age/Wear (AW)
-Design Deficiency (DD)
-Unknown (UK)
-Out-of-Adjustment (OA)
-Other Devices (OD)
-Dirt/Contamination/Corrosion (DC)
-Manufacturing Defect (MF)
-Debris/Foreign Material (DF)
-Setpoint Drift (SD)
-Maintenance/Procedural Deficiencies (MP)

Results

Figure 10 shows the TDP subcomponent failure apportionment for the PWR AFW system and the BWR RCIC and HPCI systems. For BWRs, the evaluation of TDP subcomponent failure patterns determined that governor failures (70%) were predominant in the RCIC system, while turbine failures (53%) and governor failures (47%) were approximately equal for the HPCI system. Pump subcomponent failures were relatively insignificant (3% for RCIC and no failures for HPCI). For PWRs, the evaluation of AFW system subcomponent failure patterns determined that governor failures (50%) and turbine failures (42%) were predominant, with few pump failures (8%).

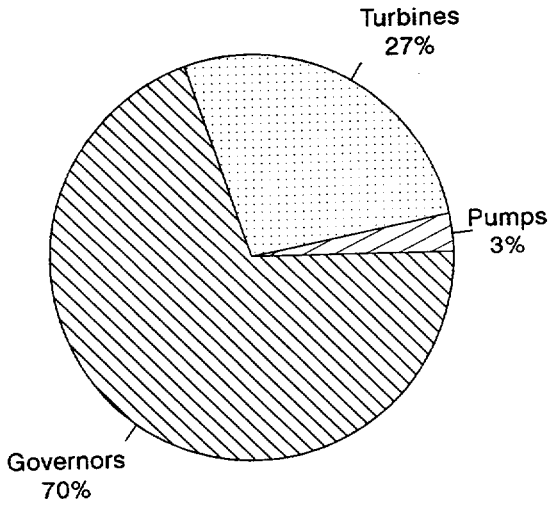
Failure causes for all TDP assemblies are shown in Figures 11,12,and 13. For the PWR AFW system, the causes were mainly age/wear (26%) and maintenance/procedural deficiencies(24%). For the BWR RCIC system, the causes were also mainly age/wear (30%) and maintenance/procedural deficiencies (27%), while for the HPCI system the cause was predominantly maintenance/procedural deficiencies (45%).

PWR AFW SYSTEM TDPs



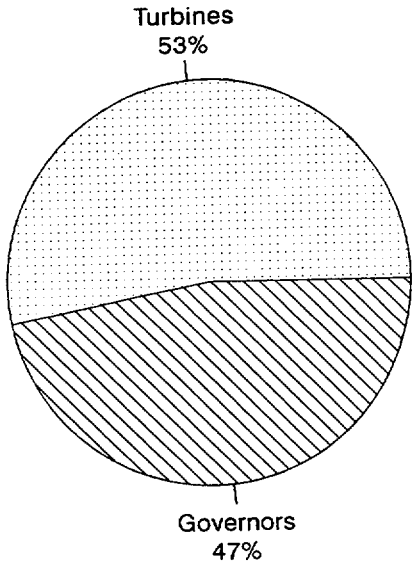
No. failures: 101

BWR RCIC SYSTEM TDPs



No. Failures: 30

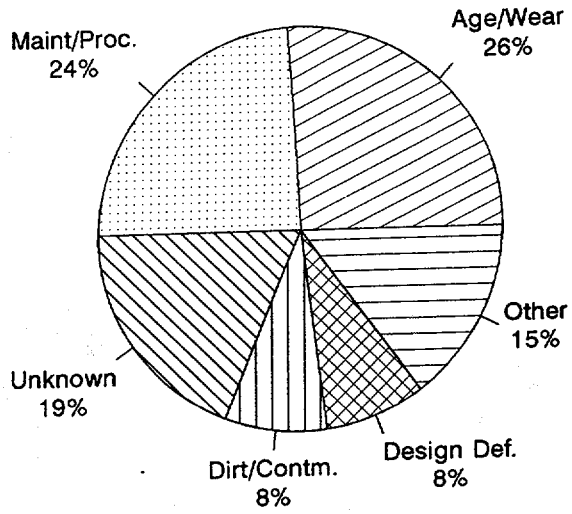
BWR HPCI SYSTEM TDPs



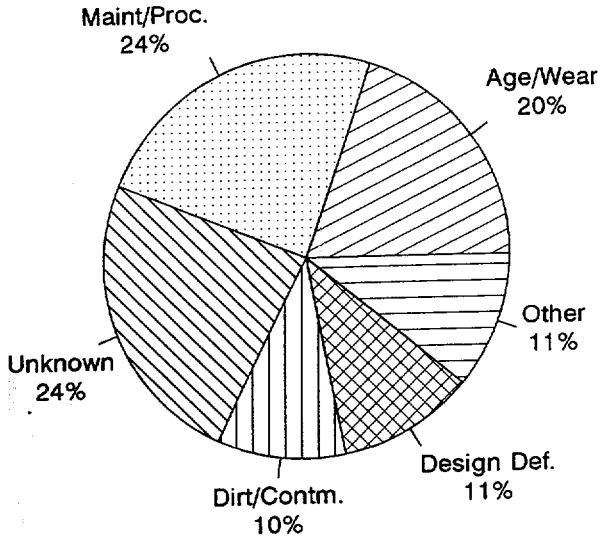
No. failure: 62

TDP SUBCOMPONENT FAILURE APPORTIONMENT
FIGURE 10

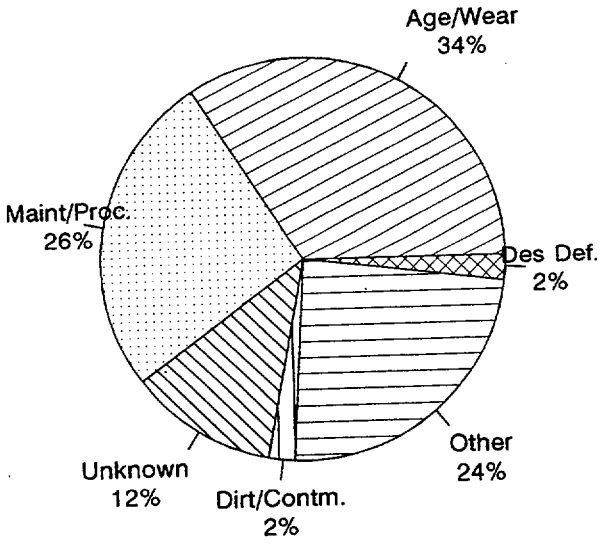
PWR AFW SYSTEM TDP ASSEMBLIES
ALL SUBCOMPONENTS



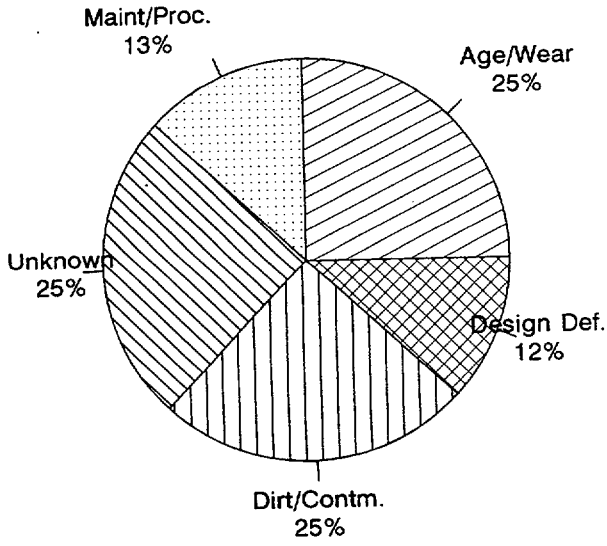
PWR AFW SYSTEM TDP ASSEMBLIES
GOVERNOR SUBCOMPONENT



PWR AFW SYSTEM TDPs
TURBINE SUBCOMPONENT

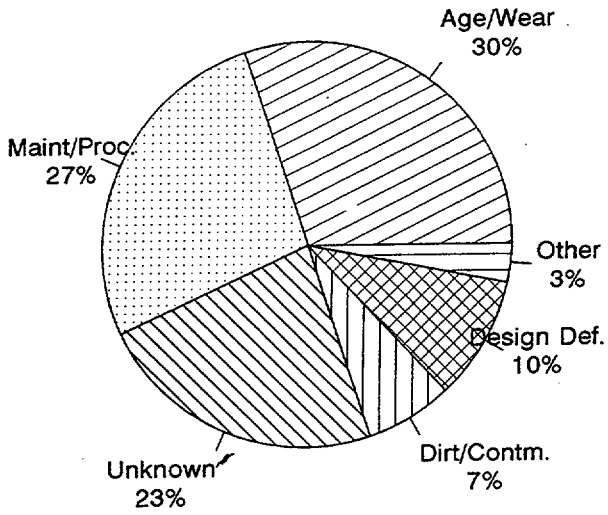


PWR AFW SYSTEM TDPs
PUMP SUBCOMPONENT

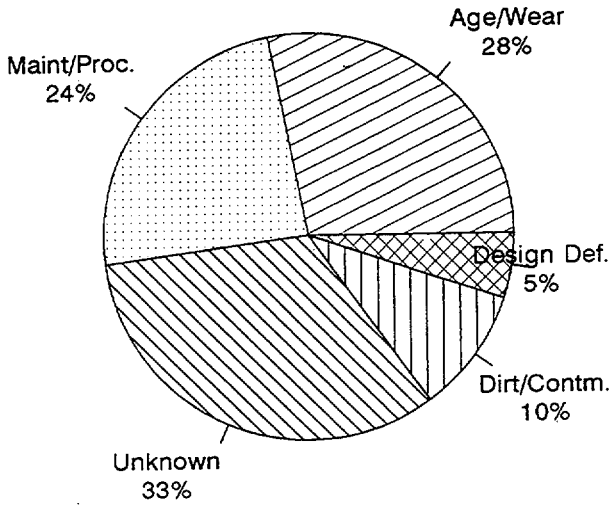


PWR AFW SYSTEM TDP FAILURE CAUSES
FIGURE 11

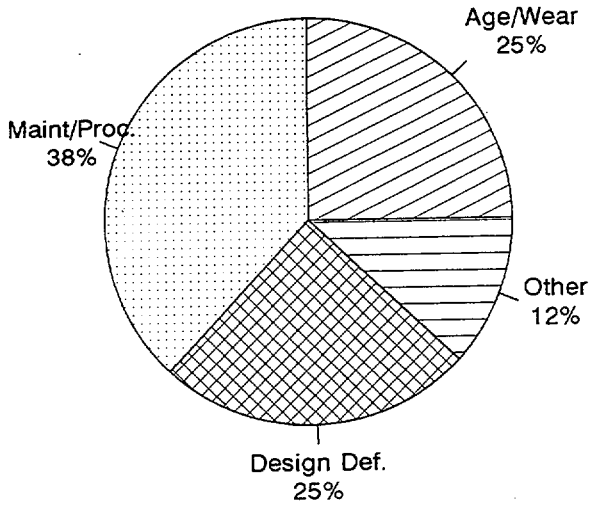
BWR RCIC SYSTEM TDP ASSEMBLIES
ALL SUBCOMPONENTS



BWR RCIC SYSTEM TDPs
GOVERNOR SUBCOMPONENT

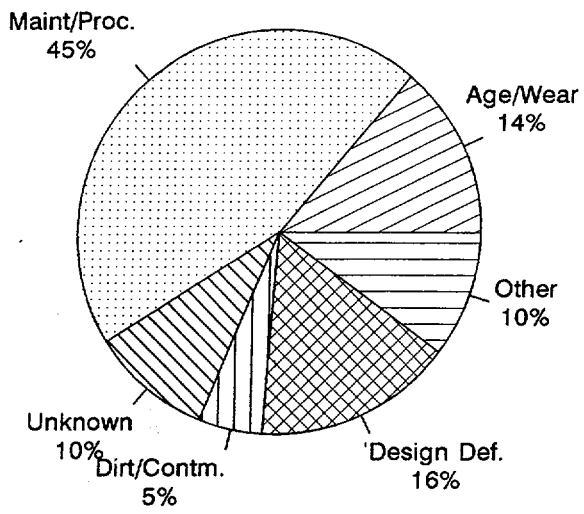


BWR RCIC SYSTEM TDPs
TURBINE SUBCOMPONENT

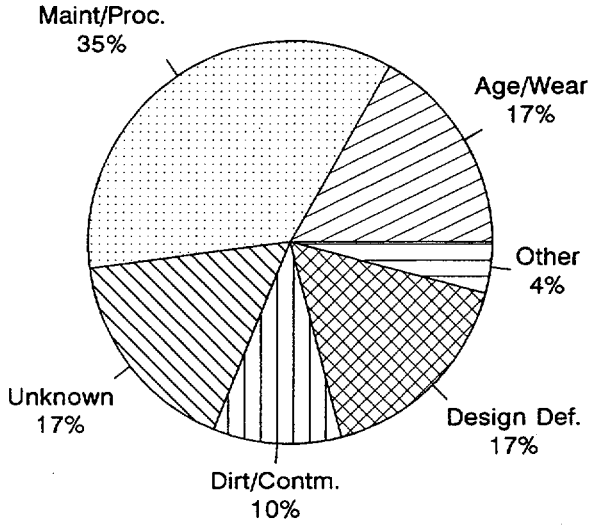


BWR RCIC SYSTEM TDP FAILURE CAUSES
FIGURE 12

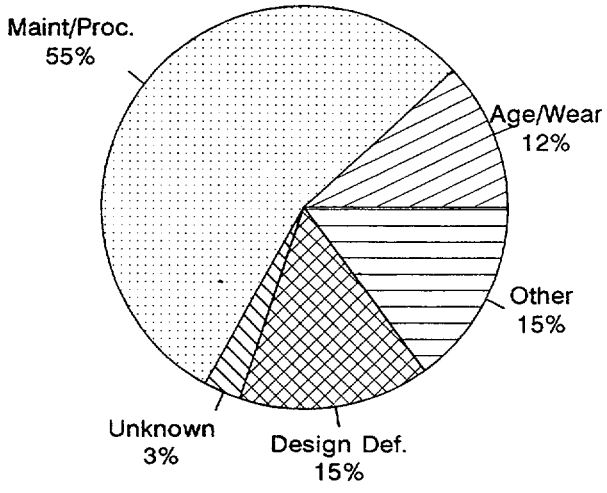
BWR HPCI SYSTEM TDP ASSEMBLIES
ALL SUBCOMPONENTS



BWR HPCI SYSTEM TDPs
GOVERNOR SUBCOMPONENT



BWR HPCI SYSTEM TDPs
TURBINE SUBCOMPONENT



BWR HPCI SYSTEM TDP FAILURE CAUSES
FIGURE 13

4.4 Related Issues - Information Notices

The review of NRC regulatory initiatives related to TDP assemblies and their subcomponents included Generic Letters, Circulars, Bulletins, and Information Notices (INs). This review determined that no regulatory initiatives, other than the 12 INs (some with supplements) listed in Table C, were applicable to TDP assemblies and their subcomponents during the 1987-1998 period. IN 86-14 and its supplements were included in the review, since they were issued near the beginning of the study period and addressed overspeed trips in the AFW, RCIC, and HPCI systems. Other than overspeed trips, the INs were generally concerned with potential problems, rather than complete (i.e., catastrophic) failures that were a basis for this study. One complete failure, reported in LER 278-90010, was directly related to the overspeed trip failure described in IN 88-67. As a potential generic issue, IN 97-65 addressed preconditioning of PWR AFW system TDPs. However, no evidence of preconditioning was found in the LERs reviewed within the scope of this study.

TABLE C
NRC INFORMATION NOTICES (INs) CONCERNING TDP ASSEMBLIES (1986-1998)

IN 86-14	PWR Auxiliary Feedwater Pump Turbine Control Problems
IN 86-14 (Supp. 1)	Overspeed Trips of AFW, HPCI, and RCIC Turbines
IN 86-14 (Supp. 2)	Overspeed Trips of AFW, HPCI, and RCIC Turbines
IN 88-09	Instability of Woodward PG-PL Type Governors
IN 88-67	PWR Auxiliary Feedwater Pump Turbine Overspeed Trip Failure
IN 89-14	Inadequate Dedication Process for Commercial Grade Components Which Lead to Common Mode Failure of a Safety System
IN 89-58	Turbine-Driven Auxiliary Feedwater Pump Disablement from Closure of One Parallel Steam Supply Valve
IN 90-45	Auxiliary Feedwater Pump Turbine Overspeed and System Overpressurization
IN 90-51	EGM Governor Voltage Dropping Resistor Failures
IN 90-51 (Supp. 1)	EGM Governor Voltage Dropping Resistor Failures
IN 90-76	Failure of Turbine Overspeed Trip Mechanism Because of Inadequate Spring Tension
IN 93-51	Repetitive Overspeed Tripping of Turbine-Driven Auxiliary Feedwater Pumps
IN 94-66	Overspeed of Turbine-Driven Pumps Caused By Governor Valve Stem Binding
IN 96-66 (Supp. 1)	Overspeed of Turbine-Driven Pumps Caused By Governor Valve Stem Binding
IN 94-84	Air Entrainment in Terry Turbine Lubricating System
IN 97-16	Preconditioning of Plant Structures, Systems, and Components Before ASME Code Inservice Testing or Technical Specification Surveillance Testing
IN 98-24	Stem Binding in Turbine Governor Valves in Reactor Core Isolation Cooling (RCIC) and Auxiliary Feedwater (AFW) Systems

5. SUMMARY OF RESULTS

5.1 Failure Probabilities

For the PWR AFW system, the TDP probability of failure on demand estimate was based on ESF failure and demand data from LERs for the period 1987-1998. The resulting mean probability estimate was 1.6E-2. This value is generally consistent with the generic mean value for TDPs (3E-2) from NUREG/CR-4550, which was the input to NUREG-1150.

For the BWR RCIC and HPCI systems, the TDP probability of failure on demand estimates were based on the combined ESF and surveillance test data for failures and demands from LER and NPRDS data sources. The ESF data (reported by LERs) was from the 1987-1998 period, and the surveillance test data (NPRDS) was from the 1987-1995 period. The resulting mean probability estimates for RCIC and HPCI systems TDPs were 2.2E-2 and 3.3E-2, respectively. These mean values were consistent with the generic mean value for TDPs (3E-2) from NUREG/CR-4550. For the BWR HPCI system, the probability of failure on demand over the 1987-1995 period showed a decreasing trend. However, data over the entire period (1987-1998) was evaluated as more meaningful and is consistent with the NUREG/CR-4550 generic mean value for TDPs (3E-3).

The TDP mean probabilities of failure on demand used in plant-specific IPE studies were compared with the results of this study. For the BWR RCIC and HPCI systems, all of the IPE mean values for the TDP failure on demand probability were within the range of this study and NUREG/CR-4550. For the AFW system, 90% of the IPE mean values were also within the probability of failure on demand range estimated in this study and NUREG/CR-4550.

5.2 Engineering Insights

The engineering insights gained from this study are as follows:

- Failure trends for the PWR AFW system during the 1987-1995 period were relatively constant, except for an upward peak in 1989 and 1990. For BWRs (RCIC and HPCI systems combined), there was a marked decreasing trend after 1991.

- Failure rates, as a function of component-years, varied among the PWR and BWR plant age groups (three groups, of approximately equal size, from older to newer plants by commercial operation date). For both PWRs and BWRs, the review of plant age groups did not show evidence of an increase in failure rates for any of the plant age groups due to "aging" mechanisms.

- The evaluation of TDP subcomponent failure patterns demonstrated that failures of governor subcomponents were significant contributors to the TDP failures in the BWR RCIC system, whereas both turbine and governor subcomponent failures were significant contributors to TDP failures in the PWR AFW system and BWR HPCI system. Pump subcomponent failures were relatively insignificant.

- Failures of TDP assemblies in AFW and RCIC systems were mainly due to age/wear and maintenance/procedural deficiencies causes, while the maintenance/procedural deficiencies cause was singularly predominant for the HPCI system.

6. REFERENCES

1. NUREG-1275, "Operating Experience Feedback Report — Reliability of Safety-Related Steam Turbine-Driven Pumps," Vol. 10, October 1994.

2. NUREG/CR-5500, "Reliability Study: High-Pressure Coolant Injection (HPCI) System, 1987-1993, Vol.4," September 1999.

3. NUREG/CR-5500, "Reliability Study: Reactor Core Isolation Cooling System, 1987-1993," Vol. 7, September 1999.

4. NUREG/CR-5500, "Reliability Study: Auxiliary/Emergency Feedwater System, 1987-1995," Vol. 1, August 1998.

5. NUREG/CR-4550, SAND86-2084, "Analysis of Core Damage Frequency: Internal Events Methodology," Vol. 1, Rev. 1, January 1990.

6. Martz, Harry F., and Ray A. Waller, "Bayesian Reliability Analysis," Malabar, FL, Krieger, Section 7.6, 1991.

APPENDIX I

FAILURE PROBABILITIES

TDP ASSEMBLY

APPENDIX I - TDP ASSEMBLY FAILURE PROBABILITIES

APPENDIX I - TABLE I
AFW SYSTEM TDP ASSEMBLIES
PROBABILITY OF FAILURE ON DEMAND

	NO. FAIL.	NO. DEMANDS	PROBABILITY OF FAILURE ON DEMAND 90% CONFID. INTERVALS PLCB	PHAT	PUCB	BAYES 90% INTERVALS PLO	MEAN	PUP
I. 1987-1995 PERIOD ESF + SURV. TEST	101	6751	1.2E-2	1.5E-2	1.7E-2	1.3E-3	1.6E-2	4.4E-2
2. 1987-1998 PERIOD ESF + SURV. TEST (ITEM 1.) + ESF (1996-1998)	106	6881	1.3E-2	1.5E-2	1.8E-2	**1.3E-3**	**1.6E-2**	**4.6E-2 (APRIOR = 1.19688; BPRIOR = 71.2030)**

NOTES:

1. **No. of PWR plants with AFW system TDP assemblies: 69.**

2. **In calculating the statistics for the table of outcome by plant, 65% for ESFs (1987-1998) and 50% for Surveillance Tests (1987-1995) of the cells had expected counts of less than 5. Therefore, the Chi-Square may not be a valid test for either of these populations..**

3. **For the 1987-1995 period, the contingency test rejected the hypothesis that the ESF failures and demands were in the same population as the Surveillance Test failures and demands. However, the ESF and Surveillance Test probability of failure on demand ranges overlapped, and the combination of data (ESF + Surveillance Test) was evaluated as acceptable for use as "pooled data."**

4. **Ave. Standby Failure Rate (λ), failures per comp.-hour: λ_L = 1.4E-5/hour; λ = 1.8E-5/hour and λ_U = 2.1E-5/hour (Based on 1987-1995 failure data for combined ESF and surveillance tests).**

APPENDIX I - TABLE II
RCIC SYSTEM TDP ASSEMBLIES
PROBABILITY OF FAILURE ON DEMAND

	NO. FAIL.	NO. DEMANDS	PROBABILITY OF FAILURE ON DEMAND 90% CONFID. INTERVALS PLCB	PHAT	PUCB	BAYES 90% INTERVALS PLO	MEAN	PUP
I. 1987-1995 PERIOD ESF + SURV. TEST	30	1937	1.1E-2	1.6E-2	2.1E-2	9.7E-6	2.0E-2	8.6E-2
2. 1987-1998 PERIOD ESF + SURV. TEST (ITEM 1.) + ESF (1996-1998)	30	1955	1.1E-2	1.6E-2	2.1E-2	**9.1E-6 (APRIOR = 0.354231; BPRIOR = 17.2357)**	**2.0E-2**	**8.7E-2**

NOTES:

1. **No. BWR plants with RCIC system TDP assemblies: 31.**

2. **In calculating the statistics for the table of outcome by plant, 50% of the cells had expected counts of less than 5. Therefore, the Chi-Square may not be a valid test.**

3. **The contingency test did not reject the hypothesis that the ESF failures and demands were in the same population as the surveillance test failures and demands (1987-1995 data). In addition, another contingency test that compared the combined 1987-1995 data with the later ESF data (1996-1998) also did not reject the hypothesis that this data was in the same population. Therefore, the Bayes 90% intervals for ESF + Surveillance Test (1987-1995) + ESF (1996-1998) probability of failure on demand is recommended as the more useful values as "pooled data.".**

4. **Ave. Standby Failure Rate (λ), failures per comp.-hour: λ_L = 9.1E-6/hour; λ = 1.3E-5/hour and λ_U = 1.7E-5/hour.**

APPENDIX I - TABLE III
HPCI SYSTEM TDP ASSEMBLIES
PROBABILITY OF FAILURE ON DEMAND

	NO. FAIL.	NO. DEMANDS	PROBABILITY OF FAILURE ON DEMAND 90% CONFID. INTERVALS PLCB	PHAT	PUCB	BAYES 90% INTERVALS PLO	MEAN	PUP
I. 1987-1995 PERIOD ESF + SURV. TEST	62	2191	2.2E-2	2.8E-2	3.5E-2	1.6E-3	3.3E-2	9.8E-2
2. 1987-1998 PERIOD ESF + SURV. TEST (ITEM 1.) + ESF (1996-1998)	**62**	**2209**	**2.2E-2**	**2.8E-2**	**3.5E-2**	**1.6E-3 (APRIOR = 0.975897; BPRIOR = 28.9098)**	**3.3E-2**	**9.7E-2**

NOTES:

1. **No. BWR plants with HPCI system TDP assemblies: 28.**

2. **In calculating the statistics for the table of outcome by plant, 50% of the cells had expected counts of less than 5. Therefore, the Chi-Square may not be a valid test.**

3. **The contingency test did not reject the hypothesis that the ESF failures and demands were in the same population as the surveillance test failures and demands (1987-1995). In addition, another contingency test that compared the combined 1987-1995 data with the later ESF data (1996-1998) also did not reject the hypothesis that this data was in the same population. Therefore, the Bayes 90% intervals for ESF + Surveillance Test (1987-1995) + ESF (1996-1998) probability of failure on demand is recommended as the more useful values as "pooled data.".**

4. **Ave. Standby Failure Rate (λ), failures per comp.-hour: λ_L = 2.1E-5/hour 2.9E-5/hour, and λ_U = 3.8E-5/hour.**

APPENDIX II

TDP ASSEMBLY

COMPONENT TRENDS IN TIME

APPENDIX II
TDP ASSEMBLY COMPONENT TRENDS IN TIME - TDP ASSEMBLIES

APPENDIX II - TABLE I
PWR AFW SYSTEM TDP ASSEMBLY FAILURES VERSUS COMPONENT-YEARS
ALL PLANT AGE GROUPS
ESF AND SURVEILLANCE TEST FAILURES

EVENT DATE	NO. FAIL.	CUMULATIVE TDP-YEARS	EVENT DATE	NO. FAIL.	CUMULATIVE TDP-YEARS	EVENT DATE	NO. FAIL.	CUMULATIVE TDP-YEARS
1/87	0	6	1/90	1	218	1/93	2	444
2/87	1	12	2/90	2	224	2/93	2	450
3/87	0	17	3/90	2	231	3/93	1	456
4/87	1	23	4/90	0	237	4/93	0	462
5/87	3	29	5/90	2	243	5/93	1	468
6/87	1	34	6/90	0	249	6/93	3	474
7/87	1	40	7/90	2	255	7/93	0	480
8/87	0	46	8/90	4	261	8/93	0	486
9/87	0	52	9/90	2	268	9/93	1	492
10/87	2	58	10/90	1	274	10/93	1	498
11/87	1	63	11/90	1	280	11/93	1	504
12/87	1	69	12/90	1	286	12/93	0	510
1/88	2	75	1/91	3	292	1/94	0	516
2/88	1	81	2/91	0	299	2/94	0	522
3/88	0	87	3/91	2	305	3/94	1	528
4/88	0	93	4/91	1	311	4/94	0	534
5/88	2	98	5/91	0	318	5/94	1	540
6/88	0	104	6/91	0	324	6/94	2	546
7/88	0	110	7/91	0	330	7/94	2	552
8/88	1	116	8/91	1	337	8/94	1	558
9/88	1	122	9/91	2	343	9/94	2	564
10/88	0	128	10/91	0	349	10/94	1	570
11/88	0	134	11/91	0	356	11/94	1	576
12/88	0	140	12/91	0	362	12/94	1	582
1/89	2	146	1/92	1	368	1/95	1	588
2/89	3	152	2/92	1	375	2/95	0	594
3/89	1	158	3/92	0	381	3/95	0	600
4/89	1	164	4/92	0	387	4/95	0	606
5/89	2	170	5/92	0	394	5/95	1	612
6/89	1	176	6/92	1	400	6/95	1	618
7/89	1	182	7/92	1	406	7/95	1	624
8/89	0	188	8/92	3	413	8/95	1	630
9/89	0	194	9/92	2	419	9/95	0	636
10/89	2	200	10/92	1	425	10/95	0	642
11/89	1	206	11/92	0	432	11/95	2	648
12/89	0	212	12/92	0	438	12/95	1	654
Totals:							101	

NOTES:

1. $\lambda_{AVE.} = \frac{101}{654}$ = 0.154 failures per component-year (1987-1995).
2. The mean time between failures = 1/0.154 = 6.5 component-years.
3. This combined data is for information only. Tables II, III, and IV are used for evaluation.

APPENDIX II - TABLE II
PWR AFW SYSTEM TDP ASSEMBLY FAILURES VERSUS COMPONENT-YEARS
PLANT AGE GROUPS "A"
ESF AND SURVEILLANCE TEST FAILURES

EVENT DATE	NO. FAIL.	CUMULATIVE TDP-YEARS	EVENT DATE	NO. FAIL.	CUMULATIVE TDP-YEARS	EVENT DATE	NO. FAIL.	CUMULATIVE TDP-YEARS
1/87	0	2	1/90	0	83	1/93	0	164
2/87	0	4	2/90	2	86	2/93	0	167
3/87	0	7	3/90	1	88	3/93	0	169
4/87	0	9	4/90	0	90	4/93	0	171
5/87	0	11	5/90	0	92	5/93	1	173
6/87	0	14	6/90	0	94	6/93	2	175
7/87	0	16	7/90	0	97	7/93	0	178
8/87	0	18	8/90	0	99	8/93	0	180
9/87	0	20	9/90	1	101	9/93	1	182
10/87	0	22	10/90	0	104	10/93	0	184
11/87	1	25	11/90	0	106	11/93	0	187
12/87	0	27	12/90	0	108	12/93	0	189
1/88	0	29	1/91	1	110	1/94	0	191
2/88	0	32	2/91	0	112	2/94	0	193
3/88	0	34	3/91	0	115	3/94	1	196
4/88	0	36	4/91	0	117	4/94	0	198
5/88	1	38	5/91	0	119	5/94	0	200
6/88	0	41	6/91	0	122 - *L/2*	6/94	2	202
7/88	0	43	7/91	0	124	7/94	1	205
8/88	1	45	8/91	0	126	8/94	1	207
9/88	0	47	9/91	1	128	9/94	0	209
10/88	0	50	10/91	0	131	10/94	1	211
11/88	0	52	11/91	0	133	11/94	0	214
12/88	0	54	12/91	0	135	12/94	0	216
1/89	0	56	1/92	0	137	1/95	1	218
2/89	0	58	2/92	0	140	2/95	0	221
3/89	0	61	3/92	0	142	3/95	0	223
4/89	0	63	4/92	0	144	4/95	0	225
5/89	0	65	5/92	0	146	5/95	0	228
6/89	0	68	6/92	0	148	6/95	0	230
7/89	0	70	7/92	0	151	7/95	0	232
8/89	0	72	8/92	1	153	8/95	0	234
9/89	0	74	9/92	1	155	9/95	0	237
10/89	0	76	10/92	1	158	10/95	0	239
11/89	0	79	11/92	0	160	11/95	1	241
12/89	0	81	12/92	0	162	12/95	1	243
Totals:							25	

NOTES:

1. $\lambda_{AVE.} = \frac{25}{243} = 0.103$ failures per component-year (1987-1995).
2. The mean time between failures = 1/0.103 = 9.7 component-years.
3. Failures are for the PWR AFW system only in Plant Age Group "A" (12/31/74 and older Commercial License dates).
4. *L/2* indicates the midpoint of the cumulative TDP-years, for use in the LaPlace Test (see text).
5. See Figure 8 in text.

APPENDIX II - TABLE III
PWR AFW SYSTEM TDP ASSEMBLY FAILURES VERSUS COMPONENT-YEARS
PLANT AGE GROUPS "B"
ESF AND SURVEILLANCE TEST FAILURES

EVENT DATE	NO. FAIL.	CUMULATIVE TDP-YEARS	EVENT DATE	NO> FAIL.	CUMULATIVE TDP-YEARS	EVENT DATE	NO. FAIL.	CUMULATIVE TDP-YEARS
1/87	0	2	1/90	1	89	1/93	0	176
2/87	1	5	2/90	0	92	2/93	0	179
3/87	0	7	3/90	1	94	3/93	0	181
4/87	1	10	4/90	0	97	4/93	0	183
5/87	2	12	5/90	2	99	5/93	0	186
6/87	0	14	6/90	0	102	6/93	0	188
7/87	0	17	7/90	0	104	7/93	0	190
8/87	0	19	8/90	4	106	8/93	0	193
9/87	0	22	9/90	1	109	9/93	0	195
10/87	1	24	10/90	1	111	10/93	0	197
11/87	0	27	11/90	1	114	11/93	0	200
12/87	1	29	12/90	1	116	12/93	0	202
1/88	2	31	1/91	1	118	1/94	0	204
2/88	0	34	2/91	0	121	2/94	0	207
3/88	0	36	3/91	2	123	3/94	0	209
4/88	0	39	4/91	0	126	4/94	0	211
5/88	1	41	5/91	0	128 - *L/2*	5/94	1	214
6/88	0	44	6/91	0	131	6/94	0	216
7/88	0	46	7/91	0	133	7/94	1	218
8/88	0	48	8/91	1	135	8/94	0	221
9/88	1	51	9/91	0	138	9/94	1	223
10/88	0	53	10/91	0	140	10/94	0	225
11/88	0	56	11/91	0	143	11/94	0	228
12/88	0	58	12/91	0	145	12/94	0	230
1/89	0	60	1/92	0	147	1/95	0	232
2/89	1	63	2/92	1	150	2/95	0	235
3/89	1	65	3/92	0	152	3/95	0	237
4/89	1	68	4/92	0	155	4/95	0	239
5/89	1	70	5/92	0	157	5/95	0	242
6/89	0	72	6/92	0	160	6/95	0	244
7/89	0	75	7/92	1	162	7/95	0	246
8/89	0	77	8/92	1	164	8/95	1	249
9/89	0	80	9/92	0	167	9/95	0	251
10/89	1	82	10/92	0	169	10/95	0	253
11/89	1	85	11/92	0	172	11/95	0	256
12/89	0	87	12/92	0	174	12/95	0	258
Totals:							39	

NOTES:

1. $\lambda_{AVE.} = \frac{39}{258} = 0.151$ failures per component-year (1987-1995).
2. The mean time between failures = 1/0.151 = 6.6 component-years.
3. Failures are for the PWR AFW system only in Plant Age Group "B" (1/1/75 through 3/31/84 Commercial License dates).
4. *L/2* indicates the midpoint of the cumulative TDP-years, for use in the LaPlace Test (see text).
5. See Figure 8 in text.

APPENDIX II - TABLE IV
PWR AFW SYSTEM TDP ASSEMBLY FAILURES VERSUS COMPONENT-YEARS
PLANT AGE GROUPS "C"
ESF and SURVEILLANCE TEST FAILURES

EVENT DATE	NO. FAIL.	CUMULATIVE TDP-YEARS	EVENT DATE	NO. FAIL.	CUMULATIVE TDP-YEARS	EVENT DATE	NO. FAIL.	CUMULATIVE TDP-YEARS
1/87	0	1	1/90	0	46	1/93	2	104
2/87	0	2	2/90	0	47	2/93	2	105
3/87	0	3	3/90	0	48	3/93	1	107
4/87	0	4	4/90	0	50	4/93	0	109
5/87	0	5	5/90	0	52	5/93	0	110
6/87	1	6	6/90	0	53	6/93	1	112
7/87	1	8	7/90	2	54	7/93	0	114
8/87	0	9	8/90	0	56	8/93	0	115
9/87	0	10	9/90	0	58	9/93	0	117
10/87	1	11	10/90	0	59	10/93	1	119
11/87	1	12	11/90	0	61	11/93	1	120
12/87	0	13	12/90	0	62	12/93	0	122
1/88	0	14	1/91	1	64	1/94	0	124
2/88	1	15	2/91	0	65	2/94	0	125
3/88	0	17	3/91	0	67	3/94	0	127
4/88	0	18	4/91	1	69	4/94	0	129
5/88	0	19	5/91	0	70	5/94	0	130
6/88	0	21	6/91	0	72	6/94	0	132
7/88	0	22	7/91	0	74	7/94	0	134
8/88	0	23	8/91	0	75	8/94	0	135
9/88	0	24	9/91	1	77	9/94	1	137
10/88	0	26	10/91	0	79	10/94	0	139
11/88	0	27	11/91	0	80 - *L/2*	11/94	1	140
12/88	0	28	12/91	0	82	12/94	1	142
1/89	2	29	1/92	1	84	1/95	0	144
2/89	2	31	2/92	0	85	2/95	0	145
3/89	0	32	3/92	0	87	3/95	0	147
4/89	0	33	4/92	0	89	4/95	0	149
5/89	1	35	5/92	0	90	5/95	1	150
6/89	1	36	6/92	1	92	6/95	1	152
7/89	1	37	7/92	0	94	7/95	1	154
8/89	0	39	8/92	1	95	8/95	0	155
9/89	0	40	9/92	1	97	9/95	0	157
10/89	1	41	10/92	0	99	10/95	0	159
11/89	0	43	11/92	0	100	11/95	1	160
12/89	0	44	12/92	0	102	12/95	0	162
Totals:							37	

NOTES:

1. $\lambda_{AVE.} = \frac{37}{162} = 0.228$ failures per component-year 1987-1995).
2. The mean time between failures = 1/0.228 = 4.4 component-years.
3. Failures are for the PWR AFW system only in Plant Age Group "C" (4/1/84 and later Commercial License dates).
4. *L/2* indicates the midpoint of the cumulative TDP-years, for use in the LaPlace Test (see text
5. See Figure 8 in text.

APPENDIX II - TABLE V
BWR RCIC AND HPCI SYSTEM TDP ASSEMBLY FAILURES VERSUS COMPONENT-YEARS
ALL PLANT AGE GROUPS
ESF AND SURVEILLANCE TEST FAILURES

EVENT DATE	NO. FAIL.	CUMULATIVE TDP-YEARS	EVENT DATE	NO> FAIL.	CUMULATIVE TDP-YEARS	EVENT DATE	NO. FAIL.	CUMULATIVE TDP-YEARS
1/87	2	4	1/90	1	165	1/93	2	336
2/87	2	8	2/90	2	169	2/93	1	341
3/87	1	12	3/90	1	174	3/93	0	345
4/87	0	17	4/90	0	179	4/93	0	350
5/87	1	21	5/90	0	184	5/93	1	355
6/87	1	25	6/90	2	188	6/93	0	360
7/87	4	29	7/90	1	193	7/93	1	364
8/87	0	33	8/90	1	198	8/93	1	369
9/87	1	38	9/90	2	203	9/93	0	374
10/87	0	42	10/90	1	208	10/93	1	379
11/87	2	46	11/90	0	212	11/93	0	383
12/87	1	50	12/90	1	217	12/93	1	388
1/88	1	54	1/91	3	222	1/94	2	393
2/88	0	59	2/91	0	226	2/94	1	398
3/88	1	64	3/91	0	231	3/94	1	402
4/88	2	68	4/91	2	236	4/94	0	407
5/88	0	73	5/91	1	241	5/94	0	412
6/88	1	78	6/91	2	246	6/94	0	417
7/88	1	82	7/91	1	250	7/94	0	421
8/88	1	87	8/91	2	255	8/94	1	426
9/88	3	91	9/91	0	260	9/94	1	431
10/88	1	96	10/91	2	265	10/94	0	436
11/88	0	101	11/91	2	269	11/94	2	440
12/88	2	105	12/91	1	274	12/94	0	445
1/89	1	110	1/92	0	279	1/95	1	450
2/89	1	114	2/92	1	283	2/95	0	455
3/89	0	119	3/92	0	288	3/95	1	462
4/89	0	123	4/92	4	293	4/95	0	467
5/89	1	128	5/92	0	298	5/95	0	472
6/89	0	132	6/92	1	302	6/95	0	477
7/89	0	137	7/92	1	307	7/95	0	481
8/89	0	142	8/92	2	312	8/95	0	486
9/89	1	146	9/92	0	317	9/95	0	491
10/89	0	151	10/92	1	322	10/95	0	496
11/89	0	156	11/92	0	326	11/95	0	500
12/89	2	160	12/92	0	331	12/95	2	505
Totals:							92	

NOTES:

1. $\lambda_{AVE.} = \frac{92}{505} = 0.182$ failures per component-year 1987-1995).
2. The mean time between failures = 1/0.182 = 5.5 component-years.
3. This combined data is for information only. Tables VI, VII, and VIII are used for evaluation.

APPENDIX II - TABLE VI

BWR RCIC AND HPCI SYSTEM TDP ASSEMBLY FAILURES VERSUS COMPONENT-YEARS

PLANT AGE GROUP "A"

ESF AND SURVEILLANCE TEST FAILURES

EVENT DATE	NO. FAIL.	CUMULATIVE TDP-YEARS	EVENT DATE	NO. FAIL.	CUMULATIVE TDP-YEARS	EVENT DATE	NO. FAIL.	CUMULATIVE TDP-YEARS
1/87	2	1	1/90	0	52	1/93	1	104
2/87	1	3	2/90	0	54	2/93	0	105
3/87	1	4	3/90	0	55	3/93	0	106
4/87	0	6	4/90	0	57	4/93	0	107
5/87	0	7	5/90	0	58	5/93	1	108
6/87	0	8	6/90	0	60	6/93	0	110
7/87	0	10	7/90	0	61	7/93	1	111
8/87	0	11	8/90	0	62	8/93	1	112
9/87	0	13	9/90	0	64	9/93	0	113
10/87	0	14	10/90	1	65	10/93	0	115
11/87	2	16	11/90	0	67	11/93	0	116
12/87	0	17	12/90	0	68	12/93	0	117
1/88	0	18	1/91	1	69	1/94	1	118
2/88	0	20	2/91	1	71	2/94	0	119
3/88	1	21	3/91	0	*72 - L/2*	3/94	0	121
4/88	1	23	4/91	0	74	4/94	0	122
5/88	0	24	5/91	2	75	5/94	0	123
6/88	0	26	6/91	0	76	6/94	0	124
7/88	0	27	7/91	0	78	7/94	0	125
8/88	1	28	8/91	1	79	8/94	1	127
9/88	0	30	9/91	0	81	9/94	0	128
10/88	1	31	10/91	0	82	10/94	0	129
11/88	0	33	11/91	0	84	11/94	0	130
12/88	0	34	12/91	0	85	12/94	0	131
1/89	0	35	1/92	0	86	1/95	1	133
2/89	0	37	2/92	1	88	2/95	0	134
3/89	0	38	3/92	0	89	3/95	1	135
4/89	0	40	4/92	1	91	4/95	0	136
5/89	0	41	5/92	0	92	5/95	0	137
6/89	0	43	6/92	0	94	6/95	0	139
7/89	0	44	7/92	0	95	7/95	0	140
8/89	0	45	8/92	1	96	8/95	0	141
9/89	1	47	9/92	0	98	9/95	0	142
10/89	0	48	10/92	0	99	10/95	0	143
11/89	0	50	11/92	0	101	11/95	0	145
12/89	0	51	12/92	0	102	12/95	1	146
Totals:							29	

NOTES:

1. $\lambda_{AVE.} = \frac{29}{146} = 0.198$ failures per component-year (1987-1995).
2. The mean time between failures = 1/0.198 = 5.1 component-year.
3. Failures are for the BWR RCIC and HPCI systems only.
4. *L/2* indicates the midpoint of the cumulative TDP-years, for use in the LaPlace Test (see text)
5. See Figure 9 in text.

APPENDIX II - TABLE VII
BWR RCIC AND HPCI SYSTEM TDP ASSEMBLY FAILURES VERSUS COMPONENT-YEARS
PLANT AGE GROUP "B"
ESF AND SURVEILLANCE TEST FAILURES

EVENT DATE	NO. FAIL.	CUMULATIVE TDP-YEARS	EVENT DATE	NO. FAIL.	CUMULATIVE TDP-YEARS	EVENT DATE	NO. FAIL.	CUMULATIVE TDP-YEARS
1/87	0	2	1/90	1	71	1/93	1	140
2/87	0	4	2/90	1	73	2/93	0	142
3/87	0	6	3/90	1	75	3/93	0	144
4/87	0	8	4/90	0	77	4/93	0	146
5/87	0	10	5/90	0	79	5/93	0	148
6/87	1	12	6/90	2	81	6/93	0	150
7/87	3	13	7/90	1	82	7/93	0	152
8/87	0	15	8/90	1	84	8/93	0	154
9/87	1	17	9/90	2	86	9/93	0	156
10/87	0	19	10/90	0	88	10/93	1	158
11/87	0	21	11/90	0	90	11/93	0	160
12/87	0	23	12/90	0	92	12/93	0	162
1/88	1	25	1/91	1	94	1/94	1	164
2/88	0	27	2/91	0	96	2/94	1	166
3/88	0	29	3/91	0	98	3/94	1	168
4/88	1	31	4/91	1	100	4/94	0	170
5/88	0	33	5/91	0	102	5/94	0	172
6/88	1	34	6/91	1	104	6/94	0	174
7/88	0	36	7/91	1	105 - *L/2*	7/94	0	176
8/88	0	38	8/91	1	107	8/94	0	178
9/88	3	40	9/91	0	109	9/94	0	180
10/88	0	42	10/91	2	111	10/94	0	182
11/88	0	44	11/91	1	113	11/94	2	184
12/88	1	46	12/91	1	115	12/94	0	186
1/89	1	48	1/92	0	117	1/95	0	188
2/89	1	50	2/92	0	119	2/95	0	190
3/89	0	52	3/92	0	121	3/95	0	192
4/89	0	54	4/92	1	123	4/95	0	194
5/89	1	56	5/92	0	125	5/95	0	196
6/89	0	58	6/92	1	126	6/95	0	198
7/89	0	59	7/92	0	128	7/95	0	200
8/89	0	61	8/92	1	130	8/95	0	202
9/89	0	63	9/92	0	132	9/95	0	204
10/89	0	65	10/92	1	134	10/95	0	206
11/89	0	67	11/92	0	136	11/95	0	208
12/89	2	69	12/92	0	138	12/95	1	210
Totals:							47	

NOTES:

1. $\lambda_{AVE.} = \frac{47}{210} = 0.224$ failures per component-year (1987-1995).
2. The mean time between failures = 1/0.224 = 4.5 component-years.
3. Failures are for the BWR RCIC and HPCI systems only.
4. *L/2* indicates the midpoint of the cumulative TDP-years, for use in the LaPlace Test (see text
5. See Figure 9 in text.

APPENDIX II - TABLE VIII

BWR RCIC AND HPCI SYSTEM TDP ASSEMBLY FAILURES VERSUS COMPONENT-YEARS

PLANT AGE GROUP "C"

ESF AND SURVEILLANCE TEST FAILURES

EVENT DATE	NO. FAIL.	TDP-YRS OF OPER.	EVENT DATE	NO. FAIL.	TDP-YRS OF OPER.	EVENT DATE	NO. FAIL.	TDP-YRS OF OPER.
1/87	0	1	1/90	0	41	1/93	0	92
2/87	1	2	2/90	1	43	2/93	1	94
3/87	0	2	3/90	0	44	3/93	0	95
4/87	0	3	4/90	0	46	4/93	0	97
5/87	1	4	5/90	0	47	5/93	0	98
6/87	0	5	6/90	0	48	6/93	0	100
7/87	1	6	7/90	0	50	7/93	0	101
8/87	0	7	8/90	0	51	8/93	0	102
9/87	0	8	9/90	0	53	9/93	0	104
10/87	0	8	10/90	0	54	10/93	0	105
11/87	0	9	11/90	0	56	11/93	0	107
12/87	1	10	12/90	1	57	12/93	1	108
1/88	0	11	1/91	0	58	1/94	0	110
2/88	0	12	2/91	0	60	2/94	0	111
3/88	0	14	3/91	0	61	3/94	0	112
4/88	0	15	4/91	0	63	4/94	0	114
5/88	0	16	5/91	0	64	5/94	0	115
6/88	0	18	6/91	1	66	6/94	0	116
7/88	1	19	7/91	0	67	7/94	0	118
8/88	0	20	8/91	0	68	8/94	0	119
9/88	0	21	9/91	0	70	9/94	1	121
10/88	0	22	10/91	0	71 - *L/2*	10/94	0	122
11/88	0	24	11/91	1	73	11/94	0	124
12/88	1	25	12/91	0	74	12/94	0	125
1/89	0	26	1/92	0	75	1/95	0	126
2/89	0	28	2/92	0	77	2/95	0	128
3/89	0	29	3/92	0	78	3/95	0	129
4/89	0	30	4/92	2	80	4/95	0	131
5/89	0	31	5/92	0	81	5/95	0	132
6/89	0	32	6/92	0	82	6/95	0	134
7/89	0	34	7/92	0	84	7/95	0	135
8/89	0	35	8/92	1	85	8/95	0	136
9/89	0	36	9/92	0	87	9/95	0	138
10/89	0	38	10/92	0	88	10/95	0	139
11/89	0	39	11/92	0	90	11/95	0	141
12/89	0	40	12/92	0	91	12/95	0	142
Totals:							16	

NOTES:

1. $\lambda_{AVE.} = \frac{16}{142} = 0.113$ failures per component-year (1987-1995).
2. The mean time between failures = 1/0.113 = 8.8 component-years.
3. Failures are for the BWR RCIC and HPCI systems only.
4. *L/2* indicates the midpoint of the cumulative TDP-years, for use in the LaPlace Test (see text
5. See Figure 9 in text.

APPENDIX III

TDP ASSEMBLY

ENGINEERING INSIGHTS

APPENDIX III
TDP ASSEMBLY - ENGINEERING INSIGHTS

APPENDIX III - TABLE I
PWR AFW SYSTEM - FAILURES AND FAILURE FRACTIONS FOR TDP ASSEMBLIES AND SUBCOMPONENTS

PUMPS	1987	1988	1989	1990	1991	1992	1993	1994	1995	Total
No. Surv. Test Failures:	3	0	1	0	0	1	0	0	2	7
No. ESF Failures:	0	0	0	0	0	0	0	0	0	0
Total No. Failures:	3	0	1	0	0	1	0	0	2	7
No. Pumps:		----------75----------								
Failure Fraction	040	0	.013	0	0	.013	0	0	.027	
Ave. Failure Fraction		----------.010----------								

TURBINES	1987	1988	1989	1990	1991	1992	1993	1994	1995	Total
No. Surv. Test Failures:	3	2	2	4	5	3	7	9	2	37
No. ESF Failures:	1	0	2	0	0	0	1	0	1	5
Total No. Failures:	4	2	4	4	5	3	8	9	3	42
No. Turbines:		----------75----------								
Failure Fraction	.053	.027	.053	.053	.067	.040	.107	.120	.040	
Ave. Failure Fraction		----------.062----------								

GOVERNORS	1987	1988	1989	1990	1991	1992	1993	1994	1995	Total
No. Surv. Test Failures:	1	3	6	12	2	4	4	2	2	36
No. ESF Failures:	3	2	3	2	2	2	0	1	1	16
Total No. Failures:	4	5	9	14	4	6	4	3	3	52
No. Governors:		----------75----------								
Failure Fraction	.053	.067	.120	.187	.053	.080	.053	.040	.040	
Ave. Failure Fraction		----------.077----------								

TDP ASSY (Includes above subcomponents)	1987	1988	1989	1990	1991	1992	1993	1994	1995	Total
No. Surv. Test Failures:	7	5	9	16	7	8	11	11	6	80
No. ESF Failures:	4	2	5	2	2	2	1	1	2	21
Total No. Failures:	11	7	14.	18	9	10	12	12	8	101
No. TDP Assys:		----------75----------								
Failure Fraction	.147	.093	.187	.240	.120	.133	.160	.160	.107	
Ave. Failure Fraction		----------.150----------								

Note: See Figure 7 in text

APPENDIX III - TABLE II
BWR RCIC AND HPCI SYSTEMS - FAILURES AND FAILURE FRACTION FOR TDP ASSEMBLIES AND SUBCOMPONENTS

PUMPS	1987	1988	1989	1990	1991	1992	1993	1994	1995	Total
No. Surv.Test Failures:	0	0	0	0	0	0	0	1	0	1
No. ESF Failures:	0	0	0	0	0	0	0	0	0	0
Total No. Failures:	0	0	0	0	0	0	0	1	0	1
No. Pumps:		----------59----------								
Failure Fraction:	0	0	0	0	0	0	0	.017	0	
Ave. Failure Fraction:		----------.002----------								

TURBINES	1987	1988	1989	1990	1991	1992	1993	1994	1995	Total
No. Surv. Test Failures:	8	7	1	6	5	5	1	4	2	39
No. ESF Failures:	0	1	0	0	0	0	0	1	0	2
Total No. Failures:	8	8	1	6	5	5	1	5	2	41
No. Turbine Drivers:		----------59----------								
Failure Fraction:	.136	.136	.017	.102	.085	.085	.017	.085	.034	
Ave. Failure Fraction:		----------.077----------								

GOVERNORS	1987	1988	1989	1990	1991	1992	1993	1994	1995	Total
No. Surv. Test Failures:	6	5	5	6	10	5	7	2	2	48
No. ESF Failures:	1	0	0	0	1	0	0	0	0	2
Total No. Failures:	7	5	5	6	11	5	7	2	2	50
No. Governors:		----------59----------								
Failure Fraction:	.119	.085	.085	.102	.180	.085	.119	.034	.034	
Ave. Failure Fraction:		----------.094----------								

TDP ASSYs	1987	1988	1989	1990	1991	1992	1993	1994	1995	Total
No. Surv. Test Failures:	14	12	6	12	15	10	8	7	4	88
No. ESF Failures:	1	1	0	0	1	0	0	1	0	4
Total No. Failures:	15	13	6	12	16	10	8	8	4	92
No. TDP Assys:		----------59----------								
Failure Fraction:	.254	.228	.102	.203	.221	.169	.136	.136	.068	
Ave. Failure Fraction:		----------.173----------								

NOTE: See Figure 7 in text.

APPENDIX III - TABLE III
PWR AFW SYSTEM TDP ASSEMBLY AND SUBCOMPONENTS
FAILURE CAUSE APPORTIONMENT

	GOVERNORS		TURB. DRIVERS		PUMPS		TDP ASSEMBLIES	
FAILURE CAUSE	No. Fail.	%	No. Fail.	%	No. Fail.	%	Fail.	%
Age/Wear/Fat.	10	20	14	34	2	25	26	26
Maint./Proc.	12	24	11	26	1	13	24	24
Unknown	12	24	5	12	2	25	19	19
Dirt/Contam.	5	10	1	2	2	25	8	8
Design Defic.	6	11	1	2	1	12	8	8
Other	6	11	10	24	0	0	16	15
Totals:	51	50	42	42	8	8	101	100

NOTE: See Figures 10 and 11.

APPENDIX III - TABLE IV
BWR RCIC SYSTEM TDP ASSEMBLY AND SUBCOMPONENTS
FAILURE CAUSE APPORTIONMENT

	GOVERNORS		TURB. DRIVERS		PUMPS		TDP ASSEMBLIES	
FAILURE CAUSE	No. Fail.	%	No. Fail.	%	No. Fail.	%	Fail.	%
Age/Wear/Fat.	6	28	2	25	1	100	9	30
Maint./Proc.	5	24	3	38	0	0	8	27
Unknown	7	33	0	0	0	0	7	23
Dirt/Contam.	2	10	0	0	0	0	2	7
Design Defic.	1	5	2	25	0	0	3	10
Other	0	0	1	12	0	0	1	3
Totals:	21	70	8	27	1	3	30	100

NOTE: See Figures 10 and 12.

APPENDIX III - TABLE V
BWR HPCI SYSTEM TDP ASSEMBLY AND SUBCOMPONENTS
FAILURE CAUSE APPORTIONMENT

	GOVERNORS		TURB. DRIVERS		PUMPS		TDP ASSEMBLIES	
FAILURE CAUSE	No. Fail.	%	No. Fail.	%	No. Fail.	%	Fail.	%
Age/Wear/Fat.	5	17	4	12	0	0	9	14
Maint./Proc.	10	35	18	55	0	0	28	45
Unknown	5	17	1	3	0	0	6	10
Dirt/Contam.	3	10	0	0	0	0	3	5
Design Defic.	5	17	5	15	0	0	10	16
Other	1	4	5	15	0	0	6	10
Totals:	29	47	33	53	0	0	62	100

NOTE: See Figures 10 and 132.

APPENDIX IV

DATA SOURCE INPUTS FOR REPORTED FAILURES AND ESTIMATED DEMANDS

TDP ASSEMBLIES

ABBREVIATIONS USED IN APPENDIX IV - TABLES I THROUGH IV

APPL CODE - Application Coded (YES. All TDP Assys used in study are Application Coded)

PLT ID NO. - Numerical identifier assigned to each selected plant used with NPRDS failure histories. When source is from LERs, a 3-digit docket number is used.

DATA SRC - Data Source, either as NPRDS failure history (FHIS) or as a 5-digit LER number, as applicable.

PLT AGE - Plant Age Group (A, B, or C) that indicates the plant commercial license date as follows:

A - 12/31/74 and earlier. B - 1/1/75 through 3/31/86 C - 4/1/86 and later

PLT SYS - The AFW, RCIC, or HPCI that has TDPs.

NO. FAIL - Number of same subcomponents failed with same failure mode, system, date, etc.

DISC DATE - For NPRDS failures, this is the discovery date and for LERs, this is the event date, shown by month and year only (i.e., 0189 is January 1989).

SUB COMP - Subcomponent of the TDP Assembly (PMP- Pump, TUB - Turbine Driver, and GOV- Governor)

ESF/SURV. Engineered Safety Features Demand or Surveillance Test Demand

FAIL MODE - Failure Modes used are as follows:

Failure to Start (FS) - Pump; Turbine Driver, and Governor
Failure to Run (FR) - Pump; Turbine Driver; and Governor
Failure to Control (FC) - Governor

FAIL CAUS - Failure causes are as follows:

Age/Wear (AW)	Dirt/Contamination/Corrosion (DC)
Design Deficiency (DD)	Manufacturing Defect (MF)
Unknown (UK)	Debris/Foreign Material (DF)
Out-of-Adjustment (OA)	Setpoint Drift (SD)
Other Devices (OD)	Maint./Proced. Deficiencies (MP)

APPENDIX IV
TDP ASSEMBLY - DATA SOURCE INPUT FOR REPORTED FAILURES AND ESTIMATED DEMANDS

APPENDIX IV - TABLE I

PWR TDP ASSEMBLIES - AFW SYSTEM DATA SOURCE INPUTS- FAILURES

ITEM NO.	APPL CODE	PLT ID	DATA SRC.	PLT AGE	PLT SYS	NO. FAIL	DISC DATE	SUB COMP	ESF/ SURV.	FAIL MODE	FAIL CAUS
1	YES	48	FHIS	B	AFW	1	0287	TUB	SURV.	FS	AW
2	YES	389	87003	B	AFW	1	0487	GOV	ESF	FR	MP
3	YES	282	87007	A	AFW	1	0587	PMP	SURV.	FR	DC
4	YES	72	FHIS	B	AFW	1	0587	PMP	SURV.	FR	AW
5	YES	48	FHIS	B	AFW	1	0587	GOV	SURV.	FR	AW
6	YES	400	87035	C	AFW	1	0687	TUB	SURV.	FR	MP
7	YES	382	87020	C	AFW	1	0787	GOV	ESF	FR	UK
8	YES	414	87026	C	AFW	1	1087	PMP	SURV.	FR	AW
9	YES	74	FHIS	B	AFW	1	1087	TUB	SURV.	FR	AW
10	YES	414	87029	C	AFW	1	1187	GOV	ESF	FR	MP
11	YES	344	87037	B	AFW	1	1287	TUB	ESF	FS	MP
12	YES	302	88002	B	AFW	1	0188	GOV	ESF	FC	MP
13	YES	338	88002	B	AFW	1	0188	GOV	ESF	FR	DD
14	YES	89	FHIS	C	AFW	1	0288	GOV	SURV.	FR	UK
15	YES	369	88008	B	AFW	1	0588	TUB	SURV.	FR	MP
16	YES	28	FHIS	A	AFW	1	0588	TUB	SURV.	FR	UK
17	YES	8	FHIS	A	AFW	1	0888	GOV	SURV.	FR	AW
18	YES	58	FHIS	B	AFW	1	0988	GOV	SURV.	FC	DC
19	YES	413	89007	C	AFW	1	0189	PMP	SURV.	FS	DC
20	YES	400	89001	C	AFW	1	0189	TUB	ESF	FR	MP
21	YES	424	89005	C	AFW	1	0289	GOV	ESF	FR	DC
22	YES	49	FHIS	B	AFW	1	0289	TUB	SURV.	FS	AW
23	YES	87	FHIS	C	AFW	1	0289	GOV	SURV.	FC	UK
24	YES	48	FHIS	B	AFW	1	0389	GOV	SURV.	FC	AW
25	YES	368	89006	B	AFW	1	0489	GOV	ESF	FR	SD
26	YES	368	89008	B	AFW	1	0589	GOV	ESF	FR	SD
27	YES	412	89015	C	AFW	1	0589	GOV	SURV.	FC	MP
28	YES	85	FHIS	C	AFW	1	0689	GOV	SURV.	FC	AW
29	YES	414	89017	C	AFW	1	0789	GOV	SURV.	FR	DC

APPENDIX IV - TABLE I (CONTINUED)
PWR TDP ASSEMBLIES - AFW SYSTEM DATA SOURCE INPUTS- FAILURES

ITEM NO.	APPL CODE	PLT ID	DATA SRC.	PLT AGE	PLT SYS	NO. FAIL	DISC DATE	SUB COMP	ESF/ SURV.	FAIL MODE	FAIL CAUS
30	YES	400	89017	C	AFW	1	1089	TUB	ESF	FR	UK
31	YES	64	FHIS	B	AFW	1	1089	TUB	SURV.	FR	AW
32	YES	60	FHIS	B	AFW	1	1189	GOV	SURV.	FC	SD
33	YES	389	90001	B	AFW	1	0190	GOV	ESF	FR	DC
34	YES	35	FHIS	A	AFW	1	0290	GOV	SURV.	FC	MP
35	YES	40	FHIS	A	AFW	1	0290	GOV	SURV.	FC	MP
36	YES	40	FHIS	A	AFW	1	0390	GOV	SURV.	FR	DD
37	YES	82	FHIS	B	AFW	1	0390	GOV	SURV.	FC	DC
38	YES	70	FHIS	B	AFW	1	0590	GOV	SURV.	FC	MP
39	YES	76	FHIS	B	AFW	1	0590	PMP	SURV.	FR	UK
40	YES	412	90008	C	AFW	1	0790	GOV	ESF	FR	MP
41	YES	103	FHIS	C	AFW	1	0790	GOV	SURV.	FR	DD
42	YES	44	FHIS	B	AFW	1	0890	GOV	SURV.	FC	AW
43	YES	83	FHIS	B	AFW	1	0890	GOV	SURV.	FC	MP
44	YES	361	90012	B	AFW	2	0890	TUB	SURV.	FR	MP
45	YES	2	FHIS	A	AFW	1	0990	TUB	SURV.	FR	AW
46	YES	48	FHIS	B	AFW	1	0990	TUB	SURV.	FS	AW
47	YES	70	FHIS	B	AFW	1	1090	GOV	SURV.	FR	AW
48	YES	59	FHIS	B	AFW	1	1190	GOV	SURV.	FC	UK
49	YES	368	90024	B	AFW	1	1290	GOV	SURV.	FR	MP
50	YES	2	FHIS	A	AFW	1	0191	TUB	SURV.	FS	OA
51	YES	58	FHIS	B	AFW	1	0191	TUB	SURV.	FR	MP
52	YES	96	FHIS	C	AFW	1	0191	TUB	SURV.	FR	AW
53	YES	49	FHIS	B	AFW	1	0391	TUB	SURV.	FR	UK
54	YES	316	91004	B	AFW	1	0391	GOV	ESF	FC	UK
55	YES	103	FHIS	C	AFW	1	0491	GOV	SURV.	FR	DD
56	YES	316	91006	B	AFW	1	0891	GOV	ESF	FR	UK
57	YES	106	FHIS	C	AFW	1	0991	TUB	SURV.	FS	MF
58	YES	40	FHIS	A	AFW	1	0991	GOV	SURV.	FR	OD

APPENDIX IV - TABLE I (CONTINUED)
PWR TDP ASSEMBLIES - AFW SYSTEM DATA SOURCE INPUTS- FAILURES

ITEM NO.	APPL CODE	PLT ID	DATA SRC.	PLT AGE	PLT SYS	NO. FAIL	DISC DATE	SUB COMP	ESF/ SURV.	FAIL MODE	FAIL CAUS
59	YES	103	FHIS	C	AFW	1	0192	GOV	SURV.	FS	AW
60	YES	361	92008	B	AFW	1	0292	TUB	SURV.	FR	MP
61	YES	87	FHIS	C	AFW	1	0692	GOV	SURV.	FC	AW
62	YES	344	92020	B	AFW	1	0792	GOV	ESF	FR	UK
63	YES	35	FHIS	A	AFW	1	0892	PMP	SURV.	FS	UK
64	YES	272	92019	B	AFW	1	0892	GOV	ESF	FC	DD
65	YES	424	92007	C	AFW	1	0892	GOV	SURV.	FR	UK
66	YES	32	FHIS	A	AFW	1	0992	TUB	SURV.	FR	MP
67	YES	87	FHIS	C	AFW	1	0992	GOV	SURV.	FC	MP
68	YES	32	FHIS	A	AFW	1	1092	TUB	SURV.	FR	DF
69	YES	103	FHIS	C	AFW	1	0193	GOV	SUR.	FR	AW
70	YES	105	FHIS	C	AFW	1	0193	TUB	SURV.	FR	DD
71	YES	498	93007	C	AFW	1	0293	TUB	SURV.	FR	OD
72	YES	499	93004	C	AFW	1	0293	TUB	ESF	FR	OD
73	YES	85	FHIS	C	AFW	1	0393	TUB	SURV.	FS	AW
74	YES	35	FHIS	A	AFW	1	0593	GOV	SURV.	FR	MP
75	YES	103	FHIS	C	AFW	1	0693	TUB	SURV.	FS	UK
76	YES	41	FHIS	A	AFW	1	0693	GOV	SURV.	FR	MP
77	YES	35	FHIS	A	AFW	1	0693	TUB	SURV.	FR	OD
78	YES	40	FHIS	A	AFW	1	0993	TUB	SURV.	FR	OD
79	YES	425	93007	C	AFW	1	1093	GOV	SURV.	FC	DD
80	YES	93	FHIS	C	AFW	1	1193	TUB	SURV.	FS	MP
81	YES	304	94002	A	AFW	1	0394	TUB	SURV.	FR	OD
82	YES	49	FHIS	B	AFW	1	0594	TUB	SURV.	FR	AW
83	YES	27	FHIS	A	AFW	1	0694	TUB	SURV.	FR	AW
84	YES	89	FHIS	A	AFW	1	0694	GOV	SURV.	FR	AW
85	YES	28	FHIS	A	AFW	1	0794	TUB	SURV.	FS	AW
86	YES	62	FHIS	B	AFW	1	0794	TUB	SURV.	FR	AW

APPENDIX IV - TABLE I (CONTINUED)
PWR TDP ASSEMBLIES - AFW SYSTEM DATA SOURCE INPUTS- FAILURES

ITEM NO.	APPL CODE	PLT ID	DATA SRC.	PLT AGE	PLT SYS	NO. FAIL	DISC DATE	SUB COMP	ESF/ SURV.	FAIL MODE	FAIL CAUS
87	YES	28	FHIS	A	AFW	1	0894	TUB	SURV.	FR	AW
88	YES	423	94011	C	AFW	1	0994	GOV	ESF	FR	UK
89	YES	49	FHIS	B	AFW	1	0994	TUB	SURV.	FR	DC
90	YES	10	FHIS	A	AFW	1	1094	TUB	SURV.	FR	MP
91	YES	423	94014	C	AFW	1	1194	TUB	SURV.	FR	MP
92	YES	106	FHIS	C	AFW	1	1294	GOV	SURV.	FC	DD
93	YES	280	95001	A	AFW	1	0195	GOV	SURV.	FC	MF
94	YES	107	FHIS	C	AFW	1	0595	TUB	ESF	FR	MP
95	YES	445	95004	C	AFW	1	0695	TUB	ESF.	FR	OD
96	YES	423	95014	C	AFW	1	0795	TUB	SURV	FS	OD
97	YES	49	FHIS	B	AFW	1	0895	PMP	SURV.	FS	MP
98	YES	305	95001	C	AFW	1	1195	PMP	SURV.	FS	MP
99	YES	305	95007	A	AFW	1	1195	PMP	SURV.	FS	DD
100	YES	35	FHIS	A	AFW	1	1295	GOV	SURV.	FC	DF

Total No. Failures: 101

APPENDIX IV - TABLE IA
PWR TDP ASSEMBLIES - AFW SYSTEM DATA SOURCE INPUTS - ESF FAILURES (1996-1998)

ITEM NO.	APPL CODE	PLT ID	DATA SRC.	PLT AGE	PLT SYS.	NO. FAIL	DISC DATE	SUB COMP	ESF/ SURV.	FAIL MODE	FAIL CAUS
1	YES	482	96001	C	AFW	1	0196	PMP	ESF	FR	AW
2	YES	250	96002	A	AFW	1	0296	GOV	ESF	FC	AW
3	YES	389	96002	B	AFW	1	0696	TUB	ESF	FS	OD
4	YES	281	97001	A	AFW	1	0297	GOV	ESF	FC	DD
5	YES	250	97007	A	AFW	1	0797	TUB	ESF	FS	DD

Total No. Additional ESF Failures (1996-1998): 5

APPENDIX IV - TABLE II
BWR TDP ASSEMBLIES - RCIC SYSTEM DATA SOURCE INPUTS- FAILURES

ITEM NO.	APPL CODE	PLT ID	DATA SRC.	PLT AGE	PLT SYS	NO. FAIL	DISC DATE	SUB COMP	ESF/ SURV.	FAIL MODE	FAIL CAUS
1	YES	265	87002	A	RCIC	1	0187	TUB	SURV.	FR	DD
2	YES	321	87011	B	RCIC	1	0787	GOV	ESF	FC	MP
3	YES	271	87018	A	RCIC	1	1187	TUB	SURV.	FR	AW
4	YES	265	88003	A	RCIC	1	0388	GOV	SURV.	FC	UK
5	YES	17	FHIS	A	RCIC	1	0488	TUB	SURV.	FR	DD
6	YES	325	88020	B	RCIC	1	0988	GOV	SURV.	FC	MP
7	YES	101	FHIS	C	RCIC	1	1288	TUB	SURV.	FR	DD
8	YES	373	90007	B	RCIC	1	0690	GOV	SURV.	FC	DC
9	YES	77	FHIS	B	RCIC	1	0690	GOV	SURV.	FC	DC
10	YES	293	81001	A	RCIC	1	0190	GOV	SURV.	FC	AW
11	YES	254	91009	A	RCIC	1	0491	GOV	SURV.	FC	MP
12	YES	53	FHIS	B	RCIC	1	0691	TUB	SURV.	FS	MP
13	YES	81	FHIS	C	RCIC	1	0691	TUB	SURV.	FR	MP
14	YES	373	91012	B	RCIC	1	0791	GOV	SURV.	FC	UK
15	YES	293	91020	A	RCIC	1	0891	GOV	SURV.	FC	UK
16	YES	331	91007	B	RCIC	1	0891	GOV	SURV.	FC	MP
17	YES	373	91017	B	RCIC	1	1091	GOV	SURV.	FC	UK
18	YES	77	FHIS	B	RCIC	1	1091	GOV	SURV.	FC	DD
19	YES	373	92005	B	RCIC	1	0492	GOV	SURV.	FC	UK
20	YES	78	FHIS	C	RCIC	1	0492	GOV	SURV	FC	AW
21	YES	265	92020	A	RCIC	1	0892	GOV	SURV	FC	UK
22	YES	57	FHIS	B	RCIC	1	0193	GOV	SURV.	FC	MP
23	YES	374	93002	C	RCIC	1	0293	GOV	SURV.	FC	UK
24	YES	293	93013	A	RCIC	1	0593	GOV	SURV.	FC	AW
25	YES	373	93016	B	RCIC	1	0893	GOV	SURV.	FC	AW
26	YES	374	93010	C	RCIC	1	1293	GOV	SURV.	FC	AW
27	YES	265	94001	A	RCIC	1	0194	PMP	SURV.	FR	AW
28	YES	458	94023	C	RCIC	1	0994	TUB	ESF	FR	AW

APPENDIX IV - TABLE II (CONTINUED)
BWR TDP ASSEMBLIES - RCI C SYSTEM DATA SOURCE INPUTS - FAILURES

ITEM NO.	APPL CODE	PLT ID	DATA SRC.	PLT AGE	PLT SYS	NO. FAIL	DISC DATE	SUB COMP	ESF/ SURV.	FAIL MODE	FAIL CAUS
29	YES	373	94013	B	RCIC	1	1194	GOV	SURV.	FR	OD
30	YES	254	95001	A	RCIC	1	0195	TUB	SURV.	FR	OD

Total No. of RCIC Failures: 30

NOTE: There are no RCIC TDP Assembly failures associated with ESF actuations for the 1996-1998 period.

APPENDIX IV - TABLE III
BWR TDP ASSEMBLIES - HPCI SYSTEM DATA SOURCE INPUTS- FAILURES

ITEM NO.	APPL CODE	PLT ID	DATA SRC.	PLT AGE	PLT SYS	NO. FAIL	DISC DATE	SUB COMP	ESF/ SURV.	FAIL MODE	FAIL CAUS
1	YES	265	87003	A	HPCI	1	0187	GOV	SURV.	FC	UK
2	YES	63	FHIS	C	HPCI	1	0287	TUB	SURV.	FR	MP
3	YES	249	87002	A	HPCI	1	0287	TUB	SURV.	FR	SD
4	YES	265	87006	A	HPCI	1	0387	GOV	SURV.	FC	DC
5	YES	352	87015	C	HPCI	1	0587	GOV	SURV.	FC	DC
6	YES	366	87004	B	HPCI	1	0687	GOV	SURV.	FC	DD
7	YES	331	87023	B	HPCI	1	0787	TUB	SURV.	FR	MP
8	YES	333	87010	B	HPCI	1	0787	TUB	SURV.	FS	MP
9	YES	341	87030	C	HPCI	1	0787	GOV	SURV.	FC	DD
10	YES	277	87020	B	HPCI	1	0987	GOV	SURV.	FC	UK
11	YES	298	87024	A	HPCI	1	1187	TUB	SURV.	FR	DD
12	YES	352	87066	C	HPCI	1	1287	TUB	SURV.	FR	MP
13	YES	366	88001	B	HPCI	1	0188	TUB	SURV.	FS	MP
14	YES	331	88002	B	HPCI	1	0488	TUB	SURV.	FC	MP
15	YES	331	88004	B	HPCI	1	0688	GOV	SURV.	FC	MP
16	YES	69	FHIS	C	HPCI	1	0788	TUB	SURV.	FR	MP
17	YES	298	88022	A	HPCI	1	0888	GOV	SURV.	FC	AW
18	YES	73	FHIS	B	HPCI	1	0988	TUB	SURV.	FR	MP
19	YES	321	88013	B	HPCI	1	0988	TUB	ESF	FC	DD
20	YES	237	88017	A	HPCI	1	1088	TUB	SURV.	FC	AW
21	YES	321	88017	B	HPIC	1	1288	GOV	SURV.	FC	MP
22	YES	331	89002	B	HPCI	1	0189	GOV	SURV.	FC	AW
23	YES	331	89007	B	HPCI	1	0289	GOV	SURV.	FC	AW
24	YES	277	89009	B	HPCI	1	0589	GOV	SURV.	FC	MP
25	YES	293	89028	A	HPCI	1	0989	GOV	SURV.	FC	UK
26	YES	331	89016	B	HPCI	1	1289	GOV	SURV.	FC	DD
27	YES	278	89009	B	HPCI	1	1289	TUB	SURV.	FS	MP
28	YES	321	90001	B	HPCI	1	0190	GOV	SURV.	FC	AW

APPENDIX IV - TABLE III (CONTINUED)
BWR TDP ASSEMBLIES - HPCI SYSTEM DATA SOURCE INPUTS- FAILURES

ITEM NO.	APPL CODE	PLT ID	DATA SRC.	PLT AGE	PLT SYS	NO. FAIL	DISC DATE	SUB COMP	ESF/ SURV.	FAIL MODE	FAIL CAUS
29	YES	388	90001	C	HPCI	1	0290	GOV	SURV.	FC	MP
30	YES	387	90007	B	HPCI	1	0290	TUB	SURV.	FS	DD
31	YES	333	90010	B	HPCI	1	0390	GOV	SURV.	FC	MP
32	YES	73	FHIS	B	HPCI	1	0790	TUB	SURV.	FS	AW
33	YES	278	90010	B	HPCI	1	0890	TUB	SURV.	FR	DD
34	YES	324	90013	B	HPCI	1	0990	GOV	SURV.	FC	MP
35	YES	278	90011	B	HPCI	1	0990	TUB	SURV.	FS	MP
36	YES	293	90017	A	HPCI	1	1090	TUB	SURV.	FS	MP
37	YES	68	FHIS	C	HPCI	1	1290	TUB	SURV.	FR	AW
38	YES	321	91001	B	HPCI	1	0191	GOV	ESF.	FC	UK
39	YES	265	91003	A	HPCI	1	0191	GOV	SURV.	FC	DD
40	YES	278	91005	B	HPCI	1	0491	TUB	SURV.	FS	OD
41	YES	254	91012	A	HPCI	1	0591	TUB	SURV.	FS	MP
42	YES	341	91020	C	HPCI	1	1191	GOV	SURV.	FC	MP
43	YES	387	91015	B	HPCI	1	1191	TUB	SURV.	FC	UK
44	YES	324	91020	B	HPCI	1	1191	GOV	SURV.	FC	MP
45	YES	254	92002	A	HPCI	1	0292	TUB	SURV.	FC	MP
46	YES	249	92011	A	HPCI	1	0492	TUB	SURV.	FC	MP
47	YES	388	92002	C	HPCI	1	0492	TUB	SURV.	FC	DD
48	YES	278	92004	B	HPCI	1	0692	TUB	SURV.	FR	AW
49	YES	352	92015	C	HPCI	1	0792	TUB	SURV.	FC	MP
50	YES	26	FHIS	B	HPCI	1	0892	GOV	SURV.	FC	MP
51	YES	26	FHIS	B	HPCI	1	1092	GOV	SURV.	FC	DD
52	YES	265	93002	A	HPCI	1	0193	GOV	SURV.	FC	DC
53	YES	254	93010	A	HPCI	1	0793	GOV	SURV.	FC	MP
54	YES	237	93016	A	HPCI	1	0893	TUB	SURV.	FR	MP
55	YES	278	94001	B	HPCI	1	0194	GOV	SURV.	FC	AW
56	YES	333	94001	B	HPCI	1	0294	TUB	SURV.	FR	OD
57	YES	366	94002	B	HPCI	1	0394	TUB	SURV.	FR	MF

APPENDIX IV - TABLE III (CONTINUED)
BWR TDP ASSEMBLIES - HPCI SYSTEM DATA SOURCE INPUTS- FAILURES

ITEM NO.	APPL CODE	PLT ID	DATA SRC.	PLT AGE	PLT SYS	NO. FAIL	DISC DATE	SUB COMP	ESF/ SURV.	FAIL MODE	FAIL CAUS
58	YES	237	94021	A	HPCI	1	0894	TUB	SURV.	FR	OD
59	YES	321	94013	B	HPCI	1	1194	TUB	SURV.	FR	MP
60	YES	254	95004	A	HPCI	1	0395	GOV	---	FS	MF
61	YES	254	95008	A	HPCI	1	1295	TUB	---	FS	MP
62	YES	331	95012	B	HPCI	1	1295	GOV	---	FC	UK

Total No. HPCI TDP Assembly Failures: 62

NOTE: There were no HPCI TDP Assembly failures associated with ESF actuations for the 1996-1998 period.

APPENDIX IV - TABLE IV
PWR TDP ASSEMBLIES - AFW SYSTEM DATA SOURCES - ESF DEMANDS

ITEM NO.	DKT NO.	LER NO.	PLANT SYS.	EVENT DATE	NO. ESFs	NO. TDPs	NO. TDP DEMANDS
1	206	87003	AFW	0387	1	1	1
2	206	89012	AFW	0589	1	1	1
3	206	89019	AFW	0789	1	1	1
4	206	89023	AFW	0989	1	1	1
5	206	91010	AFW	0591	1	1	1
6	206	91017	AFW	1091	1	1	1
7	213	90017	AFW	0990	1	2	2
8	213	90018	AFW	0990	1	2	2
9	213	95016	AFW	0795	1	2	2
10	244	88005	AFW	0688	1	1	1
11	244	89004	AFW	0689	1	1	1
12	244	90012	AFW	0990	1	1	1
13	244	92002	AFW	0292	1	1	1
14	244	92003	AFW	0292	1	2	2
15	244	93006	AFW	1193	1	1	1
16	244	94007	AFW	0494	1	1	1
17	244	95008	AFW	0895	1	1	1
18	247	91001	AFW	0191	1	1	1
19	250	87001	AFW	0187	1	3	3
20	250	88004	AFW	0388	1	3	3
21	250	89005	AFW	0289	1	3	3
22	250	89020	AFW	1289	1	3	3
23	250	90011	AFW	0690	1	3	3
24	250	95007	AFW	1095	1	3	3
25	251	87001	AFW	0187	1	2	2
26	251	88009	AFW	0888	1	2	2
27	251	88010	AFW	0888	1	3	3
28	251	89011	AFW	0989	1	3	3
29	251	90003	AFW	0490	1	3	3
30	251	90008	AFW	0890	1	3	3
31	251	91006	AFW	1091	1	3	3
32	251	92007	AFW	0992	1	3	3
33	255	87009	AFW	0387	1	1	1
34	261	88001	AFW	0188	1	1	1
35	269	88009	AFW	0788	1	1	1
36	269	89001	AFW	0189	1	1	1
37	269	89002	AFW	0189	1	1	1
38	269	91011	AFW	1091	1	1	1
39	269	94002	AFW	0294	1	1	1
40	270	87004	AFW	0487	1	1	1
41	270	89004	AFW	0489	1	1	1
42	270	92004	AFW	1092	1	1	1
43	270	93001	AFW	0493	1	1	1
44	270	94002	AFW	0494	1	1	1
45	270	94005	AFW	1294	1	1	1
46	272	90030	AFW	0990	1	1	1
47	272	94011	AFW	0794	1	1	1
48	275	91002	AFW	0291	1	1	1
49	275	91007	AFW	0491	1	1	1
50	275	93011	AFW	1293	1	1	1

APPENDIX IV - TABLE IV (CONTINUED)
PWR TDP ASSEMBLIES - AFW SYSTEM DATA SOURCES - ESF DEMANDS

ITEM NO.	DKT NO.	LER NO.	PLANT SYS.	EVENT DATE	NO. ESFs	NO. TDPs	NO. TDP DEMANDS
51	275	94020	AFW	1294	1	1	1
52	275	95009	AFW	0995	1	1	1
53	280	92001	AFW	0192	1	1	1
54	280	93001	AFW	0193	1	1	1
55	280	93002	AFW	0293	1	1	1
56	280	94006	AFW	0594	1	1	1
57	280	95001	AFW	0195	1	1	1
58	280	95003	AFW	0495	1	1	1
59	281	88010	AFW	0588	1	1	1
60	281	89010	AFW	0989	1	1	1
61	281	92010	AFW	0992	1	1	1
62	281	93003	AFW	0893	1	1	1
63	281	93004	AFW	0893	1	1	1
64	281	93005	AFW	0893	1	1	1
65	281	95004	AFW	0595	1	1	1
66	281	95005	AFW	0595	1	1	1
67	282	89010	AFW	0789	1	1	1
68	282	93005	AFW	0293	1	1	1
69	285	87036	AFW	1187	1	1	1
70	285	92023	AFW	0792	1	1	1
71	285	94001	AFW	0294	1	1	1
72	286	88006	AFW	1088	1	1	1
73	286	89015	AFW	1089	1	1	1
74	286	90002	AFW	0290	1	1	1
75	286	90004	AFW	0690	1	1	1
76	286	91004	AFW	0391	1	1	1
77	286	92015	AFW	0992	1	1	1
78	287	91007	AFW	0791	1	1	1
79	287	92001	AFW	0192	1	1	1
80	287	92003	AFW	0692	1	1	1
81	287	93001	AFW	0193	1	1	1
82	287	94002	AFW	0894	1	1	1
83	287	94003	AFW	0894	1	1	1
84	289	89004	AFW	0889	1	1	1
85	289	91003	AFW	0991	1	1	1
86	289	92001	AFW	0192	1	1	1
87	295	94005	AFW	0494	1	1	1
88	302	88001	AFW	0188	1	1	1
89	302	88002	AFW	0188	1	1	1
90	302	88006	AFW	0288	1	1	1
91	302	89003	AFW	0189	1	1	1
92	302	89022	AFW	0689	1	1	1
93	302	89023	AFW	0689	1	1	1
94	302	90016	AFW	1090	1	1	1
95	302	91003	AFW	0491	1	1	1
96	302	91014	AFW	1191	1	1	1
97	302	91016	AFW	1191	1	1	1
98	302	91018	AFW	1291	1	1	1
99	302	92015	AFW	0792	1	1	1
100	302	92027	AFW	1292	1	1	1

APPENDIX IV - TABLE IV (CONTINUED)
PWR TDP ASSEMBLIES - AFW SYSTEM DATA SOURCES - ESF DEMANDS

ITEM NO.	DKT NO.	LER NO.	PLANT SYS.	EVENT DATE	NO. ESFs	NO. TDPs	NO. TDP DEMANDS
101	304	88014	AFW	1288	1	1	1
102	305	91010	AFW	1091	1	1	1
103	305	92017	AFW	0992	1	1	1
104	305	93001	AFW	0193	1	1	1
105	305	93018	AFW	1093	1	1	1
106	306	90004	AFW	0990	1	1	1
107	306	90005	AFW	0990	1	1	1
108	306	94002	AFW	0794	1	1	1
109	306	95003	AFW	0695	1	1	1
110	311	90029	AFW	0690	1	1	1
111	311	93002	AFW	0193	1	1	1
112	311	93005	AFW	0393	1	1	1
113	311	94008	AFW	0694	1	1	1
114	313	87002	AFW	0587	1	1	1
115	313	87003	AFW	0887	1	1	1
116	313	87004	AFW	0887	1	1	1
117	313	87005	AFW	0887	1	1	1
118	313	88003	AFW	0288	1	1	1
119	313	89002	AFW	0189	1	1	1
120	313	89041	AFW	1289	1	1	1
121	313	89048	AFW	1289	1	1	1
122	313	91003	AFW	0491	1	1	1
123	313	91005	AFW	0591	1	1	1
124	313	92003	AFW	0492	1	1	1
125	313	94002	AFW	0494	1	1	1
126	313	95004	AFW	0495	1	1	1
127	315	87008	AFW	0787	1	1	1
128	315	87021	AFW	1087	1	1	1
129	315	88001	AFW	0188	1	1	1
130	315	89001	AFW	0189	1	1	1
131	315	91004	AFW	0591	1	1	1
132	316	87004	AFW	0687	1	1	1
133	316	87007	AFW	0787	1	1	1
134	316	87008	AFW	0787	1	1	1
135	316	90012	AFW	1290	1	1	1
136	316	90013	AFW	1290	1	1	1
137	316	91004	AFW	0391	1	1	1
138	316	91006	AFW	0891	1	1	1
139	316	91010	AFW	1191	1	1	1
140	316	93007	AFW	0893	1	1	1
141	316	95005	AFW	0895	1	1	1
141	317	87012	AFW	0787	1	1	1
142	317	91003	AFW	1091	1	1	1
143	317	91008	AFW	1291	1	1	1
144	317	92008	AFW	1192	1	1	1
145	317	94001	AFW	0194	1	2	2
146	317	94006	AFW	0694	1	2	2
147	317	94007	AFW	0794	1	2	2
148	317	95002	AFW	0695	1	1	1
149	317	95005	AFW	1195	1	2	2
150	317	95006	AFW	1195	1	1	1

APPENDIX IV - TABLE IV (CONTINUED)
PWR TDP ASSEMBLIES - AFW SYSTEM DATA SOURCES - ESF DEMANDS

ITEM NO.	DKT NO.	LER NO.	PLANT SYS.	EVENT DATE	NO. ESFs	NO. TDPs	NO. TDP DEMANDS
151	318	87002	AFW	0587	1	1	1
152	318	87007	AFW	1187	1	1	1
153	318	87008	AFW	1287	1	1	1
154	318	88002	AFW	0188	1	1	1
155	318	88002	AFW	0188	1	1	1
156	318	88004	AFW	0488	1	1	1
157	318	92005	AFW	0891	1	1	1
158	318	93002	AFW	0693	1	2	2
159	318	94001	AFW	0194	1	1	1
160	318	94007	AFW	0994	1	1	1
161	318	95002	AFW	0195	1	2	2
162	327	88044	AFW	1188	1	1	1
163	327	88045	AFW	1188	1	1	1
164	327	88047	AFW	1288	1	1	1
165	327	89005	AFW	0289	1	1	1
166	327	90009	AFW	0590	1	1	1
167	327	90012	AFW	0690	1	1	1
168	327	90022	AFW	0990	1	1	1
169	327	90030	AFW	1190	1	1	1
170	327	92027	AFW	1292	1	1	1
171	327	94011	AFW	0794	1	1	1
172	327	94014	AFW	1194	1	1	1
173	327	95008	AFW	0695	1	1	1
174	328	88014	AFW	0388	1	1	1
175	328	88023	AFW	0588	1	1	1
176	328	88024	AFW	0588	1	1	1
177	328	88027	AFW	0688	1	1	1
178	328	88028	AFW	0688	2	1	2
179	328	89008	AFW	0789	1	1	1
180	328	91001	AFW	0191	1	1	1
181	328	91006	AFW	1191	2	1	2
182	328	92001	AFW	0292	1	1	1
183	328	92012	AFW	0992	1	1	1
184	328	95007	AFW	1295	1	1	1
185	334	88007	AFW	0688	1	1	1
186	334	88008	AFW	0688	1	1	1
187	334	88009	AFW	0688	1	1	1
188	334	88014	AFW	0988	1	1	1
189	334	89001	AFW	0189	1	1	1
190	334	89002	AFW	0289	1	1	1
191	334	90007	AFW	0390	1	1	1
192	334	91006	AFW	0291	1	1	1
193	334	91022	AFW	0791	1	1	1
194	334	91023	AFW	0791	1	1	1
195	334	91029	AFW	1191	1	1	1
196	334	92009	AFW	1092	1	1	1
197	334	93013	AFW	1093	1	1	1
198	334	94005	AFW	0694	1	1	1
199	335	87011	AFW	0587	1	1	1
200	335	87017	AFW	1287	1	1	1

APPENDIX IV - TABLE IV (CONTINUED)
PWR TDP ASSEMBLIES - AFW SYSTEM DATA SOURCES - ESF DEMANDS

ITEM NO.	DKT NO.	LER NO.	PLANT SYS.	EVENT DATE	NO. ESFs	NO. TDPs	NO. TDP DEMANDS
201	335	88003	AFW	0388	1	1	1
202	335	90007	AFW	0590	1	1	1
203	335	91002	AFW	0291	1	1	1
204	335	91005	AFW	0791	1	1	1
205	335	91006	AFW	0991	1	1	1
206	338	87017	AFW	0787	1	1	1
207	338	87020	AFW	1187	1	1	1
208	338	88002	AFW	0188	1	1	1
209	338	88005	AFW	0188	1	1	1
210	338	89005	AFW	0289	1	1	1
211	338	94005	AFW	0994	1	1	1
212	339	88001	AFW	1188	1	1	1
213	339	90003	AFW	0890	1	1	1
214	339	90010	AFW	1190	1	1	1
215	339	93002	AFW	0493	1	1	1
216	344	87001	AFW	0187	1	1	1
217	344	87024	AFW	0887	1	2	2
218	344	87037	AFW	1287	1	1	1
219	344	88026	AFW	0888	1	2	2
220	344	88028	AFW	0988	1	2	2
221	344	88044	AFW	1188	1	2	2
222	344	89010	AFW	0989	1	2	2
223	344	89017	AFW	0889	1	2	2
224	344	90033	AFW	0790	1	2	2
225	344	90034	AFW	0890	1	2	2
226	344	91004	AFW	0291	1	2	2
227	344	92020	AFW	0792	1	2	2
228	344	92027	AFW	0992	1	2	2
229	344	92028	AFW	0992	1	2	2
230	346	87001	AFW	0187	1	2	2
231	346	87006	AFW	0387	1	2	2
232	346	91008	AFW	1291	1	2	2
233	346	93005	AFW	1093	1	2	2
234	348	87003	AFW	0187	1	1	1
235	348	89007	AFW	1189	1	1	1
236	361	87031	AFW	1287	1	1	1
237	361	90016	AFW	1290	1	1	1
238	361	92012	AFW	0792	1	1	1
239	362	87011	AFW	0687	1	1	1
240	362	89011	AFW	0189	1	1	1
241	362	89006	AFW	0489	1	1	1
242	362	90002	AFW	0290	1	1	1
243	362	92004	AFW	0792	1	1	1
244	362	93004	AFW	0793	1	1	1
245	368	87007	AFW	0987	1	1	1
246	368	87008	AFW	1187	1	1	1
247	368	88011	AFW	0888	1	1	1
248	368	88020	AFW	1288	2	1	2
249	368	89006	AFW	0489	1	1	1
250	368	89019	AFW	0889	1	1	1

APPENDIX IV - TABLE IV (CONTINUED)
PWR TDP ASSEMBLIES - AFW SYSTEM DATA SOURCES - ESF DEMANDS

ITEM NO.	DKT NO.	LER NO.	PLANT SYS.	EVENT DATE	NO. ESFs	NO. TDPs	NO. TDP DEMANDS
251	368	89020	AFW	0989	1	1	1
252	368	89024	AFW	1289	1	1	1
253	368	91005	AFW	0291	1	1	1
254	369	87017	AFW	0887	1	1	1
255	369	88008	AFW	0588	1	1	1
256	369	88021	AFW	0888	1	1	1
257	369	89025	AFW	0989	1	1	1
258	369	91001	AFW	0291	1	1	1
260	369	92009	AFW	0692	1	1	1
261	369	92008	AFW	0792	1	1	1
262	369	93012	AFW	1293	1	1	1
263	369	95005	AFW	0995	1	1	1
264	370	87019	AFW	1187	1	1	1
265	370	89002	AFW	0389	1	1	1
266	370	92006	AFW	0492	1	1	1
267	370	93008	AFW	1293	1	1	1
268	382	87008	AFW	0387	1	1	1
269	382	87012	AFW	0487	1	1	1
270	382	87016	AFW	0587	1	1	1
271	382	87020	AFW	0787	1	1	1
272	382	88016	AFW	0688	1	1	1
273	382	88033	AFW	1288	1	1	1
274	382	89013	AFW	0789	1	1	1
275	382	89024	AFW	1289	1	1	1
276	382	90002	AFW	0390	1	1	1
277	382	91019	AFW	0890	1	1	1
278	382	91022	AFW	1190	1	1	1
279	382	93001	AFW	0393	1	1	1
280	389	87001	AFW	0387	1	1	1
281	389	89007	AFW	0989	1	1	1
282	389	90001	AFW	0190	1	1	1
283	389	90006	AFW	1290	1	1	1
284	389	91001	AFW	0391	1	1	1
285	395	87015	AFW	0687	1	1	1
286	395	87027	AFW	1087	1	1	1
287	395	88002	AFW	0288	1	1	1
288	395	88006	AFW	0588	1	1	1
290	395	88007	AFW	0688	1	1	1
291	395	88009	AFW	0788	1	1	1
292	395	89020	AFW	1289	1	1	1
293	400	87017	AFW	0387	1	1	1
294	400	87035	AFW	0687	1	1	1
295	400	87042	AFW	0787	1	1	1
296	400	87062	AFW	1187	1	1	1
297	400	89001	AFW	0189	1	1	1
298	400	89003	AFW	0289	1	1	1
299	400	89005	AFW	0289	1	1	1
300	400	89019	AFW	1289	1	1	1

APPENDIX IV - TABLE IV (CONTINUED)
PWR TDP ASSEMBLIES - AFW SYSTEM DATA SOURCES - ESF DEMANDS

ITEM NO.	DKT NO.	LER NO.	PLANT SYS.	EVENT DATE	NO. ESFs	NO. TDPs	NO. TDP DEMANDS
301	400	89021	AFW	1289	1	1	1
302	400	91010	AFW	0691	1	1	1
303	400	92009	AFW	0792	1	1	1
304	400	92010	AFW	0792	1	1	1
305	400	93007	AFW	0593	1	1	1
306	400	95007	AFW	0995	1	1	1
307	412	87005	AFW	0787	1	1	1
308	412	87020	AFW	0987	1	1	1
309	412	87023	AFW	0987	1	1	1
310	412	87026	AFW	1087	1	1	1
311	412	87028	AFW	1087	1	1	1
312	412	87032	AFW	1087	1	1	1
313	412	87035	AFW	1187	1	1	1
314	412	89003	AFW	0289	1	1	1
315	412	89019	AFW	0689	1	1	1
316	412	90008	AFW	0790	1	1	1
317	412	91005	AFW	1191	1	1	1
318	412	93002	AFW	0193	1	1	1
319	412	94006	AFW	0694	1	1	1
320	412	95006	AFW	0895	1	1	1
321	413	87026	AFW	0787	1	1	1
322	413	87027	AFW	0787	1	1	1
323	413	91018	AFW	0991	1	1	1
324	414	87002	AFW	0187	1	1	1
325	414	87003	AFW	0187	1	1	1
326	414	87007	AFW	0287	1	1	1
327	414	87010	AFW	0387	1	1	1
328	414	87018	AFW	0587	1	1	1
329	414	87019	AFW	0587	1	1	1
330	414	87025	AFW	0987	1	1	1
331	414	87027	AFW	0987	1	1	1
332	414	87029	AFW	1187	1	1	1
333	414	88012	AFW	0388	1	1	1
334	414	88019	AFW	0588	1	1	1
335	414	88021	AFW	0688	1	1	1
336	414	88022	AFW	0688	1	1	1
337	414	88023	AFW	0688	1	1	1
338	414	88024	AFW	0688	1	1	1
339	414	88025	AFW	0688	1	1	1
340	414	88031	AFW	1188	1	1	1
341	414	89001	AFW	0189	1	1	1
342	414	89002	AFW	0189	1	1	1
343	414	89003	AFW	0289	1	1	1
344	414	90013	AFW	1090	1	1	1
345	414	91008	AFW	0591	1	1	1
346	414	92001	AFW	0192	1	1	1
347	414	92006	AFW	1292	1	1	1
348	414	93003	AFW	0993	1	1	1
349	414	94006	AFW	0994	1	1	1
350	414	94007	AFW	1094	1	1	1

APPENDIX IV - TABLE IV (CONTINUED)
PWR TDP ASSEMBLIES - AFW SYSTEM DATA SOURCES - ESF DEMANDS

ITEM NO.	DKT NO.	LER NO.	PLANT SYS.	EVENT DATE	NO. ESFs	NO. TDPs	NO. TDP DEMANDS
351	414	95001	AFW	0295	1	1	1
352	414	95004	AFW	0495	1	1	1
353	423	87026	AFW	0587	1	1	1
354	423	87027	AFW	0687	1	1	1
355	423	87031	AFW	0687	1	1	1
356	423	90003	AFW	1290	1	1	1
357	423	93004	AFW	0393	1	1	1
358	423	94011	AFW	0994	1	1	1
359	424	87009	AFW	0387	1	1	1
360	424	87010	AFW	0387	1	1	1
361	424	87011	AFW	0387	1	1	1
362	424	87014	AFW	0487	1	1	1
363	424	87018	AFW	0487	1	1	1
364	424	87025	AFW	0587	1	1	1
365	424	87041	AFW	0687	1	1	1
366	424	87050	AFW	0787	1	1	1
367	424	87063	AFW	1187	1	1	1
368	424	87066	AFW	1187	1	1	1
369	424	88001	AFW	0188	1	1	1
370	424	88006	AFW	0288	1	1	1
371	424	89005	AFW	0289	1	1	1
372	424	90016	AFW	0790	1	1	1
373	424	91002	AFW	0291	1	1	1
374	424	92006	AFW	0692	1	1	1
375	424	92008	AFW	0992	1	1	1
376	424	93009	AFW	0793	1	1	1
377	424	95002	AFW	0795	1	1	1
378	425	89018	AFW	0489	1	1	1
379	425	89020	AFW	0589	1	1	1
380	425	89021	AFW	0589	1	1	1
381	425	89023	AFW	0789	1	1	1
382	425	89024	AFW	0789	1	1	1
383	425	89027	AFW	1089	1	1	1
384	425	90016	AFW	1190	1	1	1
385	425	91005	AFW	0291	1	1	1
386	425	92002	AFW	0392	1	1	1
387	425	93006	AFW	0993	1	1	1
388	425	94001	AFW	0194	1	1	1
389	425	94002	AFW	0194	1	1	1
390	443	90015	AFW	0690	1	1	1
391	443	90025	AFW	1190	1	1	1
392	443	91001	AFW	0291	1	1	1
393	443	91002	AFW	0391	1	1	1
394	443	91008	AFW	0691	1	1	1
395	443	91009	AFW	0791	1	1	1
396	443	92017	AFW	0992	1	1	1
397	443	92024	AFW	1192	1	1	1
398	443	92025	AFW	1292	1	1	1
399	443	93003	AFW	0193	1	1	1
400	443	93009	AFW	0593	1	1	1

APPENDIX IV - TABLE IV (CONTINUED)
PWR TDP ASSEMBLIES - AFW SYSTEM DATA SOURCES - ESF DEMANDS

ITEM NO.	DKT NO.	LER NO.	PLANT SYS.	EVENT DATE	NO. ESFs	NO. TDPs	NO. TDP DEMANDS
401	443	93012	AFW	0793	1	1	1
402	443	93018	AFW	0993	1	1	1
403	445	90013	AFW	0590	1	1	1
404	445	91005	AFW	0291	1	1	1
405	445	92014	AFW	0692	1	1	1
406	445	95003	AFW	0695	1	1	1
407	445	95004	AFW	0695	1	1	1
408	482	87022	AFW	0587	1	1	1
409	482	87027	AFW	0687	1	1	1
410	482	87030	AFW	0787	1	1	1
411	482	87037	AFW	0987	1	1	1
412	482	90023	AFW	1090	1	1	1
413	482	91006	AFW	0591	1	1	1
414	482	92016	AFW	0992	1	1	1
415	482	95006	AFW	1195	1	1	1
416	483	88011	AFW	0988	1	1	1
417	483	89008	AFW	0689	1	1	1
418	483	90015	AFW	1190	1	1	1
419	498	88022	AFW	0288	1	1	1
420	498	89001	AFW	0189	1	1	1
421	498	89015	AFW	0789	1	1	1
422	498	90006	AFW	0690	1	1	1
423	498	90014	AFW	0690	1	1	1
424	498	90015	AFW	0790	1	1	1
425	498	90016	AFW	0790	1	1	1
426	498	90020	AFW	0790	1	1	1
427	498	90023	AFW	0990	1	1	1
428	498	90025	AFW	1190	1	1	1
429	498	91012	AFW	0491	1	1	1
430	498	91021	AFW	1091	1	1	1
431	498	91022	AFW	1091	1	1	1
432	498	92003	AFW	0392	1	1	1
433	498	94009	AFW	0294	1	1	1
434	498	94015	AFW	0994	1	1	1
435	498	95001	AFW	0195	1	1	1
436	498	95009	AFW	0895	1	1	1
437	498	95013	AFW	1295	1	1	1
438	499	88022	AFW	0288	1	1	1
439	499	89009	AFW	0489	1	1	1
440	499	89011	AFW	0489	1	1	1
441	499	89013	AFW	0489	1	1	1
442	499	89016	AFW	0689	1	1	1
443	499	90002	AFW	0290	1	1	1
444	499	90004	AFW	0390	1	1	1
445	499	90005	AFW	0490	1	1	1
446	499	90013	AFW	0990	1	1	1
447	499	91001	AFW	0191	1	1	1
448	499	91003	AFW	0391	1	1	1
449	499	91004	AFW	0391	1	1	1
450	499	92001	AFW	0192	1	1	1

APPENDIX IV - TABLE IV (CONTINUED)
PWR TDP ASSEMBLIES - AFW SYSTEM DATA SOURCES - ESF DEMANDS

ITEM NO.	DKT NO.	LER NO.	PLANT SYS.	EVENT DATE	NO. ESFs	NO. TDPs	NO. TDP DEMANDS
451	499	92003	AFW	0292	1	1	1
452	499	92010	AFW	1292	1	1	1
453	499	93001	AFW	0193	1	1	1
454	499	93004	AFW	0293	1	1	1
455	499	94007	AFW	0694	1	1	1
456	499	95003	AFW	0395	1	1	1
457	499	95008	AFW	1195	1	1	1
459	529	87010	AFW	0687	1	1	1
460	529	89003	AFW	0289	1	1	1
461	529	93004	AFW	1193	1	1	1
462	529	95005	AFW	0795	1	1	1
463	530	89001	AFW	0389	1	1	1
464	530	93001	AFW	0293	1	1	1
Totals:							**524**

APPENDIX IV - TABLE IVA
PWR TDP ASSEMBLIES - AFW SYSTEM DATA SOURCES - ESF DEMANDS (1996-1998)

ITEM NO.	DKT NO.	LER NO.	PLANT SYS.	EVENT DATE	NO. ESFs	NO. TDPs	NO. TDP DEMANDS
1	244	96002	AFW	0396	1	1	1
2	244	96012	AFW	0896	1	1	1
3	247	96003	AFW	0396	1	1	1
4	247	96012	AFW	0596	1	1	1
5	247	97002	AFW	0197	1	1	1
6	247	97018	AFW	0797	1	1	1
7	250	96002	AFW	0296	1	3	3
8	250	96006	AFW	0396	1	3	3
9	250	97004	AFW	0497	1	3	3
10	250	97006	AFW	0797	1	3	3
11	250	97007	AFW	0797	1	3	3
12	250	98001	AFW	0298	1	3	3
13	269	96004	AFW	0296	1	1	1
14	269	97008	AFW	0797	1	1	1
15	270	98007	AFW	1198	1	1	1
16	275	96012	AFW	0896	1	1	1
17	275	96017	AFW	1196	1	1	1
18	280	97003	AFW	0297	1	1	1
19	280	98002	AFW	0298	1	1	1
20	280	98013	AFW	1198	1	1	1
21	280	98014	AFW	1198	1	1	1
22	281	97001	AFW	0297	1	1	1
23	281	97004	AFW	1297	1	1	1
24	282	96012	AFW	0696	1	1	1
25	282	97008	AFW	0697	1	1	1
26	282	98008	AFW	0698	1	1	1
27	285	96002	AFW	0396	1	1	1
28	285	97003	AFW	0497	1	1	1
29	286	96015	AFW	1096	1	1	1
30	286	97001	AFW	0197	1	1	1

APPENDIX IV - TABLE IVA (CONTINUED)
PWR TDP ASSEMBLIES - AFW SYSTEM DATA SOURCES - ESF DEMANDS(1996-1998)

ITEM NO.	DKT NO.	LER NO.	PLANT SYS.	EVENT DATE	NO. ESFs	NO. TDPs	NO. TDP DEMANDS
31	286	97023	AFW	0997	1	1	1
32	286	97025	AFW	0997	1	1	1
33	286	98003	AFW	0598	1	1	1
34	286	98006	AFW	0898	1	1	1
35	287	96001	AFW	0396	1	1	1
36	289	97007	AFW	0697	1	1	1
37	302	96017	AFW	0596	1	1	1
38	302	98003	AFW	0298	1	1	1
39	302	98009	AFW	0898	1	1	1
40	305	96003	AFW	0496	1	1	1
41	305	98005	AFW	0298	1	1	1
42	306	96001	AFW	0396	1	1	1
43	306	96002	AFW	0496	1	1	1
44	306	97003	AFW	0597	1	1	1
45	306	98005	AFW	1198	1	1	1
46	313	96005	AFW	0596	1	1	1
47	313	96007	AFW	0996	1	1	1
48	313	98005	AFW	1298	1	1	1
49	315	96002	AFW	0396	1	1	1
50	315	96004	AFW	0996	1	1	1
51	316	97001	AFW	0397	2	1	2
52	317	97009	AFW	1097	1	1	1
53	318	96001	AFW	0296	1	1	1
54	318	96005	AFW	1196	1	1	1
55	318	98004	AFW	0298	1	1	1
56	323	97002	AFW	0397	1	1	1
57	323	97003	AFW	0797	1	1	1
58	323	97005	AFW	1097	1	1	1
59	327	96010	AFW	1196	1	1	1
60	327	97012	AFW	0897	1	1	1
61	327	98001	AFW	0598	1	1	1
62	328	96005	AFW	1096	1	1	1
63	328	96006	AFW	1296	1	1	1
64	328	96007	AFW	1296	1	1	1
65	328	98001	AFW	0898	1	1	1
66	328	98002	AFW	1098	1	1	1
67	334	96008	AFW	0596	1	1	1
68	334	97005	AFW	0397	1	1	1
69	334	97025	AFW	0897	1	1	1
70	338	96005	AFW	0896	1	1	1
71	339	96003	AFW	1196	1	1	1
72	346	97010	AFW	0597	1	2	2
73	346	98006	AFW	0698	1	2	2
74	346	98011	AFW	1098	1	2	2
75	368	98002	AFW	0598	1	1	1
76	369	97009	AFW	0997	1	1	1
77	369	98002	AFW	0298	1	1	1
78	370	97001	AFW	0597	1	1	1
79	370	98001	AFW	0298	1	1	1
80	382	96006	AFW	0596	1	1	1
81	382	98014	AFW	0798	1	1	1
82	389	96001	AFW	0196	1	1	1

APPENDIX IV - TABLE IVA (CONTINUED)
PWR TDP ASSEMBLIES - AFW SYSTEM DATA SOURCES - ESF DEMANDS (1996-1998)

ITEM NO.	DKT NO.	LER NO.	PLANT SYS.	EVENT DATE	NO. ESFs	NO. TDPs	NO. TDP DEMANDS
83	389	96002	AFW	0696	1	1	1
84	389	98006	AFW	0998	1	1	1
85	395	97002	AFW	0497	1	1	1
86	400	96008	AFW	0496	1	1	1
87	400	96018	AFW	0996	1	1	1
88	400	97001	AFW	0197	1	1	1
89	400	97019	AFW	0797	1	1	1
90	400	98007	AFW	1098	1	1	1
91	414	96001	AFW	0296	1	1	1
92	414	97005	AFW	0697	1	1	1
93	414	97006	AFW	0798	1	1	1
94	424	96006	AFW	0596	1	1	1
95	424	96012	AFW	1196	1	1	1
96	425	96006	AFW	1096	1	1	1
97	425	96008	AFW	1096	1	1	1
98	425	98003	AFW	0598	1	1	1
99	425	98005	AFW	0698	1	1	1
100	425	98007	AFW	0898	1	1	1
101	425	98008	AFW	0998	1	1	1
102	443	96001	AFW	0196	1	1	1
103	443	98014	AFW	1298	1	1	1
104	445	96002	AFW	0196	1	1	1
105	482	96001	AFW	0196	1	1	1
106	482	96006	AFW	0696	1	1	1
107	498	97012	AFW	1197	1	1	1
108	499	97004	AFW	0397	1	1	1
109	499	97005	AFW	0397	1	1	1
110	499	97006	AFW	0497	1	1	1
111	499	97007	AFW	1197	1	1	1
112	499	98002	AFW	0998	1	1	1
113	528	98002	AFW	0298	1	1	1
114	529	96001	AFW	0196	1	1	1
Totals:							**130**

APPENDIX IV - TABLE V
BWR TDP ASSEMBLIES - RCIC SYSTEM DATA SOURCES - ESF DEMANDS

ITEM NO.	DKT NO.	LER NO.	PLANT SYS.	EVENT DATE	NO. ESFs	NO. TDPs	NO. TDP DEMANDS
1	263	87003	RCIC	0487	1	1	1
2	263	91019	RCIC	0891	1	1	1
3	265	87013	RCIC	1087	1	1	1
4	277	89012	RCIC	0589	1	1	1
5	277	89033	RCIC	1289	1	1	1
6	277	92010	RCIC	0792	1	1	1
7	277	93004	RCIC	0393	1	1	1
8	278	92008	RCIC	1092	1	1	1
9	293	91024	RCIC	1091	1	1	1
10	293	93004	RCIC	0893	1	1	1
11	293	93022	RCIC	0993	1	1	1
12	298	87003	RCIC	0187	1	1	1
13	298	87009	RCIC	0287	1	1	1
14	298	87011	RCIC	0587	1	1	1
15	298	88021	RCIC	0888	1	1	1
16	298	89011	RCIC	1089	1	1	1
17	298	89026	RCIC	1189	1	1	1
18	298	89033	RCIC	1289	1	1	1
19	298	93038	RCIC	1293	1	1	1
20	298	94004	RCIC	0394	1	1	1
21	321	87011	RCIC	0787	1	1	1
22	321	87013	RCIC	0887	1	1	1
23	321	88013	RCIC	0988	1	1	1
24	321	88018	RCIC	1288	1	1	1
25	321	90013	RCIC	0690	1	1	1
26	321	91001	RCIC	0191	1	1	1
27	321	91017	RCIC	0991	1	1	1
28	321	92021	RCIC	0892	1	1	1
29	321	92024	RCIC	0992	1	1	1
30	321	93013	RCIC	1093	1	1	1
31	321	93016	RCIC	1293	1	1	1
32	324	87001	RCIC	0187	1	1	1
33	324	87004	RCIC	0387	1	1	1
34	324	88018	RCIC	1188	1	1	1
35	324	89009	RCIC	0689	1	1	1
36	324	90009	RCIC	0890	1	1	1
37	324	90015	RCIC	0990	4	1	4
38	324	90016	RCIC	1090	4	1	4
39	324	91001	RCIC	0191	1	1	1
40	324	92001	RCIC	0292	1	1	1
41	325	87019	RCIC	0787	1	1	1
42	325	91009	RCIC	0391	1	1	1
43	325	91018	RCIC	0791	1	1	1
44	325	92003	RCIC	0192	1	1	1
45	325	92005	RCIC	0292	1	1	1
46	325	95015	RCIC	0795	1	1	1
47	325	95018	RCIC	0995	1	1	1
48	331	87008	RCIC	0687	1	1	1
49	331	89003	RCIC	0289	1	1	1
50	331	89008	RCIC	0389	1	1	1
51	333	89020	RCIC	1189	1	1	1
52	333	90009	RCIC	0390	1	1	1

APPENDIX IV - TABLE V (CONTINUED)
BWR TDP ASSEMBLIES - RCIC SYSTEM DATA SOURCES - ESF DEMANDS

ITEM NO.	DKT NO.	LER NO.	PLANT SYS.	EVENT DATE	NO. ESFs	NO. TDPs	NO. TDP DEMANDS
53	333	93009	RCIC	0493	1	1	1
54	333	95013	RCIC	0995	1	1	1
55	341	87017	RCIC	0587	1	1	1
56	341	87025	RCIC	0687	1	1	1
57	341	88004	RCIC	0188	1	1	1
58	341	92012	RCIC	1192	1	1	1
59	341	93010	RCIC	0893	1	1	1
60	341	95004	RCIC	0495	1	1	1
61	352	87048	RCIC	0987	1	1	1
62	352	91009	RCIC	0491	1	1	1
63	353	90015	RCIC	0990	1	1	1
64	353	93001	RCIC	0193	1	1	1
65	353	94010	RCIC	1094	1	1	1
66	354	87017	RCIC	0287	1	1	1
67	354	87034	RCIC	0787	1	1	1
68	354	87037	RCIC	0887	1	1	1
69	354	87039	RCIC	0887	1	1	1
70	354	88012	RCIC	0488	1	1	1
71	354	88027	RCIC	1088	1	1	1
72	354	88029	RCIC	1188	1	1	1
73	354	90003	RCIC	0390	1	1	1
74	366	87003	RCIC	0187	1	1	1
75	366	87006	RCIC	0787	1	1	1
76	366	87007	RCIC	0737	1	1	1
77	366	87008	RCIC	0887	1	1	1
78	366	87009	RCIC	0887	1	1	1
79	366	88011	RCIC	0488	1	1	1
80	366	88017	RCIC	0588	1	1	1
81	366	88020	RCIC	0888	1	1	1
82	366	89005	RCIC	0989	1	1	1
83	366	92009	RCIC	0692	1	1	1
84	366	95001	RCIC	0795	1	1	1
85	373	92003	RCIC	0392	1	1	1
86	373	92008	RCIC	0692	1	1	1
87	373	93015	RCIC	0993	1	1	1
88	374	92005	RCIC	0392	1	1	1
89	374	92012	RCIC	0892	1	1	1
90	374	92013	RCIC	0992	1	1	1
91	374	92016	RCIC	1192	1	1	1
92	374	94008	RCIC	1094	1	1	1
93	374	94010	RCIC	1294	1	1	1
94	374	95001	RCIC	0195	1	1	1
95	387	87013	RCIC	0487	1	1	1
96	387	91008	RCIC	0791	1	1	1
97	388	87006	RCIC	0487	1	1	1
98	397	87002	RCIC	0387	1	1	1
99	397	88003	RCIC	0288	1	1	1
100	397	89002	RCIC	0189	1	1	1
101	397	91032	RCIC	11/91	1	1	1
102	397	93027	RCIC	0893	1	1	1
103	397	95002	RCIC	0295	1	1	1
104	410	88001	RCIC	0188	1	1	1

APPENDIX IV - TABLE V (CONTINUED)
BWR TDP ASSEMBLIES - RCIC SYSTEM DATA SOURCES - ESF DEMANDS

ITEM NO.	DKT NO.	LER NO.	PLANT SYS.	EVENT DATE	NO. ESFs	NO. TDPs	NO. TDP DEMANDS
105	410	88012	RCIC	0388	1	1	1
106	410	88014	RCIC	0388	1	1	1
107	410	89014	RCIC	0489	1	1	1
108	410	91023	RCIC	1291	1	1	1
109	416	89010	RCIC	0789	1	1	1
110	416	89016	RCIC	1189	1	1	1
111	416	90028	RCIC	1290	1	1	1
112	416	91007	RCIC	0791	1	1	1
113	416	95007	RCIC	0795	1	1	1
114	416	95008	RCIC	0795	1	1	1
115	440	87012	RCIC	0387	1	1	1
116	440	87064	RCIC	0987	1	1	1
117	440	87072	RCIC	1087	1	1	1
118	440	88012	RCIC	0488	1	1	1
119	440	90001	RCIC	0190	1	1	1
120	440	92017	RCIC	0992	1	1	1
121	440	95006	RCIC	0895	1	1	1
122	440	95006	RCIC	0995	1	1	1
123	440	95008	RCIC	0995	1	1	1
124	458	88018	RCIC	0888	1	1	1
125	458	88021	RCIC	0988	1	1	1
126	458	89004	RCIC	0289	1	1	1
127	458	89008	RCIC	0289	1	1	1
128	461	87001	RCIC	0187	1	1	1

APPENDIX IV - TABLE VA
BWR TDP ASSEMBLIES - RCIC SYSTEM DATA SOURCES - ESF DEMANDS (1996-1998)

ITEM NO.	DKT NO.	LER NO.	PLANT SYS.	EVENT DATE	NO. ESFs	NO. TDPs	NO. TDP DEMANDS
1	260	97001	RCIC	0497	1	1	1
2	271	98016	RCIC	0698	1	1	1
3	296	96002	RCIC	0496	1	1	1
4	296	96003	RCIC	0596	1	1	1
5	333	96003	RCIC	0296	1	1	1
6	333	99010	RCIC	0996	1	1	1
7	333	98004	RCIC	0598	1	1	1
8	333	98008	RCIC	0898	1	1	1
9	366	97007	RCIC	0497	1	1	1
10	366	97010	RCIC	1197	1	1	1
11	388	96004	RCIC	0796	1	1	1
12	397	98002	RCIC	0398	1	1	1
13	397	98003	RCIC	0398	1	1	1
14	416	98001	RCIC	0198	1	3	3
15	440	97001	RCIC	0197	1	1	1
16	440	98002	RCIC	0798	1	1	1

APPENDIX IV - TABLE VI
BWR TDP ASSEMBLIES - HPCI SYSTEM DATA SOURCES - ESF DEMANDS

ITEM NO.	DKT NO.	LER NO.	PLANT SYS.	EVENT DATE	NO. ESFs	NO. TDPs	NO. TDP DEMANDS
1	220	87014	HPCI	1087	1	1	1
2	220	87015	HPCI	1087	1	1	1
3	220	87016	HPCI	1087	1	1	1
4	220	87024	HPCI	1287	1	1	1
5	220	87028	HPCI	1287	1	1	1
6	220	90015	HPCI	0790	1	1	1
7	220	90017	HPCI	0890	1	1	1
8	220	90020	HPCI	0890	1	1	1
9	220	90026	HPCI	1190	1	1	1
10	220	91002	HPCI	0291	1	1	1
11	220	91012	HPCI	0991	1	1	1
12	220	91014	HPCI	1291	1	1	1
13	220	92003	HPCI	0592	1	1	1
14	220	92004	HPCI	0292	1	1	1
15	220	92008	HPCI	0492	1	1	1
16	220	92009	HPCI	0892	1	1	1
17	220	93002	HPCI	0193	1	1	1
18	220	94002	HPCI	0494	1	1	1
19	220	94005	HPCI	0794	1	1	1
20	220	94007	HPCI	1194	1	1	1
21	220	95002	HPCI	0495	1	1	1
22	237	90002	HPCI	0190	1	1	1
23	249	89001	HPCI	0389	1	1	1
24	260	90005	HPCI	0590	1	1	1
25	260	94004	HPCI	0494	1	1	1
26	263	87009	HPCI	0487	1	1	1
27	263	91009	HPCI	0491	1	1	1
28	265	87013	HPCI	1087	1	1	1
29	265	87017	HPCI	1187	1	1	1
30	265	88027	HPCI	1188	1	1	1
31	271	95009	HPCI	0495	1	1	1
32	277	89012	HPCI	0589	1	1	1
33	277	89033	HPCI	1289	1	1	1
34	277	93004	HPCI	0393	1	1	1
35	278	90008	HPCI	0790	1	1	1
36	278	92008	HPCI	1092	1	1	1
37	293	90013	HPCI	0990	1	1	1
38	293	91024	HPCI	1291	1	1	1
39	293	93004	HPCI	0894	1	1	1
40	293	93022	HPCI	0993	1	1	1
41	298	87003	HPCI	0187	1	1	1
42	298	87009	HPCI	0287	1	1	1
43	298	88021	HPCI	0888	1	1	1
44	298	89026	HPCI	1189	1	1	1
45	298	90011	HPCI	1090	1	1	1
46	298	93038	HPCI	1293	1	1	1
47	298	94004	HPCI	0394	1	1	1
48	321	87011	HPCI	0787	1	1	1
49	321	87013	HPCI	0887	1	1	1
50	321	88018	HPCI	1288	1	1	1

APPENDIX IV - TABLE VI
BWR TDP ASSEMBLIES - HPCI SYSTEM DATA SOURCES - ESF DEMANDS

ITEM NO.	DKT NO.	LER NO.	PLANT SYS.	EVENT DATE	NO. ESFs	NO. TDPs	NO. TDP DEMANDS
51	321	89013	HPCI	0988	1	1	1
52	321	90013	HPCI	0690	1	1	1
53	321	91001	HPCI	0191	1	1	1
54	321	91007	HPCI	0291	1	1	1
55	321	91017	HPCI	0991	1	1	1
56	321	92021	HPCI	0892	1	1	1
57	321	92024	HPCI	0992	1	1	1
58	321	93013	HPCI	1093	1	1	1
59	321	93016	HPCI	1293	1	1	1
60	324	87001	HPCI	0187	1	1	1
61	324	87004	HPCI	0387	1	1	1
62	324	88018	HPCI	1188	1	1	1
63	324	89001	HPCI	0289	1	1	1
64	324	89009	HPCI	0689	1	1	1
65	324	90009	HPCI	0890	1	1	1
66	324	90015	HPCI	0990	1	1	1
67	324	90016	HPCI	1090	1	1	1
68	324	91001	HPCI	0191	1	1	1
69	324	91017	HPCI	0991	1	1	1
70	324	91021	HPCI	1291	1	1	1
71	324	92001	HPCI	0292	1	1	1
72	325	87017	HPCI	0687	1	1	1
73	325	87019	HPCI	0787	1	1	1
74	325	91009	HPCI	0391	1	1	1
75	325	91018	HPCI	0791	1	1	1
76	325	92003	HPCI	0192	1	1	1
77	325	94015	HPCI	1294	1	1	1
78	325	95015	HPCI	0795	1	1	1
79	325	95018	HPCI	0995	1	1	1
80	331	89003	HPCI	0289	1	1	1
81	331	89011	HPCI	0889	1	1	1
82	333	90009	HPCI	0390	1	1	1
83	333	93009	HPCI	0493	1	1	1
84	333	95013	HPCI	0995	1	1	1
85	341	88004	HPCI	0188	1	1	1
86	341	92012	HPCI	1192	1	1	1
87	341	93010	HPCI	0893	1	1	1
88	341	95004	HPCI	0495	1	1	1
89	352	87042	HPCI	0687	1	1	1
90	352	87048	HPCI	0987	1	1	1
91	352	91018	HPCI	0791	1	1	1
92	353	89013	HPCI	1189	1	1	1
93	353	90006	HPCI	0390	1	1	1
94	353	93005	HPCI	0393	1	1	1
95	353	94010	HPCI	1094	1	1	1
96	353	95006	HPCI	0395	1	1	1
97	354	87017	HPCI	0287	1	1	1
98	354	87030	HPCI	0787	1	1	1
99	354	87034	HPCI	0787	1	1	1
100	354	87037	HPCI	0887	1	1	1
101	354	87039	HPCI	0887	1	1	1

APPENDIX IV - TABLE VI (CONTINUED)
BWR TDP ASSEMBLIES - HPCI SYSTEM DATA SOURCES - ESF DEMANDS

ITEM NO.	DKT NO.	LER NO.	PLANT SYS.	EVENT DATE	NO. ESFs	NO. TDPs	NO. TDP DEMANDS
102	354	88012	HPCI	0488	1	1	1
103	354	88022	HPCI	0888	1	1	1
104	354	88027	HPCI	1088	1	1	1
105	354	88029	HPCI	1188	1	1	1
106	354	90003	HPCI	0390	1	1	1
107	354	90029	HPCI	1190	1	1	1
108	354	91008	HPCI	0591	1	1	1
109	354	91017	HPCI	0891	1	1	1
110	366	87003	HPCI	0187	1	1	1
111	366	87006	HPCI	0787	1	1	1
112	366	87008	HPCI	0487	1	1	1
113	366	87009	HPCI	0887	1	1	1
114	366	88011	HPCI	0488	1	1	1
115	366	88017	HPCI	0588	1	1	1
116	366	88020	HPCI	0888	1	1	1
117	366	89005	HPCI	0989	1	1	1
118	366	90001	HPCI	0190	1	1	1
119	366	92009	HPCI	0692	1	1	1
120	366	94007	HPCI	0894	1	1	1
121	366	95001	HPCI	0795	1	1	1
122	387	91008	HPCI	0791	1	1	1
123	388	87006	HPCI	0487	1	1	1

APPENDIX IV - TABLE VIA
BWR TDP ASSEMBLIES - HPCI SYSTEM DATA SOURCES - ESF DEMANDS (1996-1998)

ITEM NO.	DKT NO.	LER NO.	PLANT SYS.	EVENT DATE	NO. ESFs	NO. TDPs	NO. TDP DEMANDS
1	220	96004	HPCI	0596	1	1	1
2	220	96011	HPCI	1196	1	1	1
3	249	96004	HPCI	0596	1	1	1
4	260	97001	HPCI	0497	1	1	1
5	265	97001	HPCI	0297	1	1	1
6	293	96005	HPCI	0496	1	1	1
7	296	96002	HPCI	0496	1	1	1
8	296	96003	HPCI	0596	1	1	1
9	333	96003	HPCI	0296	1	1	1
10	333	96010	HPCI	0996	1	1	1
11	333	98004	HPCI	0598	1	1	1
12	333	98008	HPCI	0898	1	1	1
13	352	98001	HPCI	0198	1	1	1
14	366	97007	HPCI	0497	1	3	3
15	366	97010	HPCI	1197	1	1	1
16	388	96004	RCIC	0796	1	1	1

APPENDIX IV - TABLE VII
PWR TDP ASSEMBLY - AFW SYSTEM DATA SOURCE INPUTS - ESTIMATED SURVEILLANCE TEST DEMANDS

ITEM NO.	PLANT ID NO.	PLANT SYSTEM	NO. TDPS	SURV TST FREQ/YR	DEMANDS PER YR	NO. YRS/ PERIOD	SYS TOTAL TDP-DEM.
1	1	AFW	1	12	12	9	108
2	2	AFW	2	4	8	9	72
3	6	AFW	1	12	12	9	108
4	8	AFW	1	4	4	9	36
5	10	AFW	3	12	36	9	324
6	13	AFW	1	12	12	9	108
7	16	AFW	1	12	12	9	108
8	19	AFW	1	12	12	9	108
9	20	AFW	1	12	12	9	108
10	21	AFW	1	12	12	9	108
11	23	AFW	1	4	4	9	36
12	24	AFW	1	12	12	9	108
13	27	AFW	1	12	12	9	108
14	28	AFW	1	12	12	9	108
15	29	AFW	1	12	12	9	108
16	30	AFW	1	4	4	9	36
17	31	AFW	1	12	12	9	108
18	32	AFW	1	12	12	9	108
19	33	AFW	1	12	12	9	108
20	35	AFW	1	12	12	9	108
21	38	AFW	1	12	12	9	108
22	39	AFW	1	12	12	9	108
23	40	AFW	1	12	12	9	108
24	41	AFW	1	12	12	9	108
25	42	AFW	1	12	12	9	108
26	43	AFW	1	4	4	9	36
27	44	AFW	1	12	12	9	108
28	45	AFW	1	4	4	9	36
29	46	AFW	1	12	12	9	108
30	47	AFW	1	12	12	9	108
31	48	AFW	2	12	24	9	216
32	49	AFW	2	12	24	9	216
33	51	AFW	1	12	12	9	108
34	54	AFW	1	4	4	9	36
35	55	AFW	1	4	4	9	36
36	58	AFW	1	12	12	9	108
37	59	AFW	1	12	12	9	108
38	60	AFW	1	4	4	9	36
39	61	AFW	1	12	12	9	108
40	62	AFW	1	12	12	9	108
41	64	AFW	2	12	24	9	216
42	65	AFW	2	4	8	9	72
43	66	AFW	1	12	12	9	108
44	70	AFW	1	12	12	9	108
45	71	AFW	1	4	4	9	36
46	72	AFW	1	12	12	9	108
47	74	AFW	1	12	12	9	108
48	75	AFW	1	12	12	9	108
49	76	AFW	1	12	12	9	108
50	79	AFW	1	12	12	9	108

APPENDIX IV - TABLE VII (CONTINUED)
PWR TDP ASSEMBLY - AFW SYSTEM DATA SOURCE INPUTS -
ESTIMATED SURVEILLANCE TEST DEMANDS

ITEM NO.	PLANT ID NO.	PLANT SYSTEM	NO. TDPS	SURV TST FREQ/YR	DEMANDS PER YR	NO. YRS/ PERIOD	SYS TOTAL TDP-DEM.
51	82	AFW	1	12	12	9	108
52	83	AFW	1	4	4	9	36
53	85	AFW	1	4	4	8.7	35
54	87	AFW	1	12	12	8.1	97
55	88	AFW	1	12	12	9	108
56	89	AFW	1	12	12	9	108
57	91	AFW	1	12	12	9	108
58	92	AFW	1	4	4	8.6	34
59	93	AFW	1	4	4	6.6	26
60	95	AFW	1	4	4	5.3	21
61	96	AFW	1	4	4	5.3	21
62	103	AFW	1	4	4	9	36
63	104	AFW	1	12	12	9	108
64	105	AFW	1	4	4	6.5	26
65	106	AFW	1	4	4	7.7	31
66	107	AFW	1	4	4	9	36
67	108	AFW	1	4	4	9	36
68	109	AFW	1	4	4	8	32
Totals:			**75**				**6227**

APPENDIX IV - TABLE VIII
BWR TDP ASSEMBLY - RCIC SYSTEM DATA SOURCE INPUTS
ESTIMATED SURVEILLANCE TEST DEMANDS

ITEM NO.	PLANT ID NO.	PLANT SYSTEM	NO. TDPS	SURV TST FREQ/YR	DEMANDS PER YR	NO. YRS/ PERIOD	SYS TOTAL TDP-DEM
1	12	RCIC	1	4	4	9	36
2	14	RCIC	1	12	12	9	108
3	15	RCIC	1	4	4	9	36
4	17	RCIC	1	4	4	9	36
5	18	RCIC	1	4	4	9	36
6	22	RCIC	1	4	4	9	36
7	25	RCIC	1	12	12	9	108
8	26	RCIC	1	12	12	9	108
9	34	RCIC	1	12	12	9	108
10	36	RCIC	1	4	4	9	36
11	37	RCIC	1	12	12	9	108
12	50	RCIC	1	12	12	9	108
13	52	RCIC	1	12	12	9	108
14	53	RCIC	1	12	12	9	108
15	56	RCIC	1	4	4	9	36
16	57	RCIC	1	12	12	9	108
17	63	RCIC	1	4	4	7	28
18	67	RCIC	1	4	4	9	36
19	68	RCIC	1	4	4	5.9	24
20	69	RCIC	1	4	4	9	36
21	73	RCIC	1	12	12	9	108
22	77	RCIC	1	4	4	9	36
23	78	RCIC	1	4	4	9	36
24	80	RCIC	1	4	4	9	36
25	81	RCIC	1	4	4	9	36
26	84	RCIC	1	4	4	9	36
27	86	RCIC	1	4	4	7.7	31
28	90	RCIC	1	4	4	9	36
29	94	RCIC	1	4	4	8.1	32
30	101	RCIC	1	4	4	9	36
31	102	RCIC	1	4	4	8.1	32
Totals:			**31**				**1803**

APPENDIX IV - TABLE IX
BWR TDP ASSEMBLY - HPCI SYSTEM DATA SOURCE INPUTS
ESTIMATED SURVEILLANCE TEST DEMANDS

ITEM NO.	PLANT ID NO.	PLANT SYSTEM	NO. TDPS	SURV TST FREQ/YR	DEMANDS PER YR	NO. YRS/ PERIOD	SYS TOTAL TDP-DEM
1	3	HPCI	1	12	12	9	108
2	4	HPCI	1	4	4	9	36
3	5	HPCI	1	12	12	9	108
4	7	HPCI	1	4	4	9	36
5	9	HPCI	1	12	12	9	108
6	12	HPCI	1	4	4	9	36
7	14	HPCI	1	12	12	9	108
8	15	HPCI	1	4	4	9	36
9	17	HPCI	1	12	12	9	108
10	18	HPCI	1	4	4	9	36
11	22	HPCI	1	4	4	9	36
12	25	HPCI	1	12	12	9	108
13	26	HPCI	1	12	12	9	108
14	34	HPCI	1	12	12	9	108
15	36	HPCI	1	12	12	9	108
16	37	HPCI	1	12	12	9	108
17	50	HPCI	1	12	12	9	108
18	52	HPCI	1	12	12	9	108
19	53	HPCI	1	12	12	9	108
20	56	HPCI	1	12	12	9	108
21	57	HPCI	1	12	12	9	108
22	63	HPCI	1	4	4	7	28
23	67	HPCI	1	4	4	9	36
24	68	HPCI	1	4	4	5.9	24
25	69	HPCI	1	4	4	9	36
26	73	HPCI	1	4	4	9	36
27	80	HPCI	1	4	4	9	36
28	81	HPCI	1	4	4	9	36
Totals:			**28**				**2068**

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11. ABSTRACT *(200 words or less)*

This report documents an analysis of the performance of safety-related turbine-driven pump assemblies (turbine-driver, pump, and governor subcomponents) used in the pressurized water reactor (PWR) auxiliary feedwater (AFW) system and in the boiling water reactor (BWR) reactor core isolation cooling (RCIC) and high pressure coolant injection (HPCI) systems in U.S. commercial power reactor plants.

A risk-based analysis of operating data and an engineering analysis of trends and patterns was performed to provide insights into the performance of turbine-driven pump components on an industry basis and comparison of results with data used by plant-specific probabilistic risk assessments. The data used in this report was from the 1987-1995 period for engineering analysis of the PWR AFW system and BWR RCIC and HPCI systems. Failure probability estimates used combined engineered safety features data (1987-1998) and surveillance test data (1987-1995).

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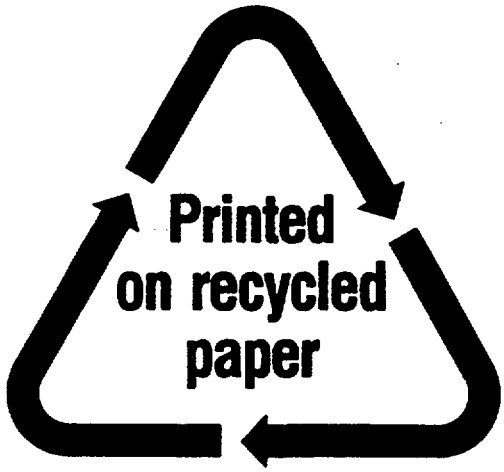

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