POLICY ISSUE
INFORMATION

April 1, 2002

FOR: The Commissioners

FROM: William D. Travers
Executive Director for Operations

SUBJECT: RESULTS OF THE INDUSTRY TRENDS PROGRAM FOR OPERATING POWER REACTORS AND STATUS OF ONGOING DEVELOPMENT

PURPOSE:

To inform the Commission of the results of the NRC's Industry Trends Program (ITP), and the status of ongoing development. The ITP supports the NRC's strategic goals of maintaining safety and enhancing public confidence in the agency's regulatory processes.

SUMMARY:

The NRC staff implemented the ITP in 2001, and is continuing to develop the program as a means to confirm that the nuclear industry is maintaining the safety of operating power plants and to increase public confidence in the efficacy of the NRC's processes. The NRC uses industry-level indicators to identify adverse trends, evaluate them, and take appropriate actions. One important output of this program is to report to Congress each year on the measure of "no statistically significant adverse industry trends in safety performance" as part of the NRC's Performance and Accountability Report. Based on the information currently available from the industry-level indicators originally developed by the former Office for Analysis and Evaluation of Operational Data (AEOD) and the Accident Sequence Precursor (ASP) Program implemented by the Office of Nuclear Regulatory Research (RES), no statistically significant adverse trends have been identified through FY 2001.

The staff is continuing to use the AEOD and ASP indicators while it develops additional indicators that are more risk-informed and better aligned with the cornerstones of safety in the Reactor Oversight Process (ROP). These additional indicators will be developed in phases and qualified for use in the ITP and the annual report to Congress. In addition, the staff is developing risk-informed thresholds for the appropriate indicators, which will be used to

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establish a predictable agency response based on safety significance. The results of this program, along with any actions taken or planned, are reviewed annually during the Agency Action Review Meeting (AARM) and reported to the Commission.

BACKGROUND:

The NRC provides oversight of plant safety performance on a plant-specific basis using both inspection findings and plant-level performance indicators (PIs) as part of its ROP. Individual issues that are identified as having generic safety significance are addressed using other NRC processes, including the generic communications process and the generic safety issue process. As discussed in SECY-01-0111, "Development of an Industry Trends Program for Operating Power Reactors," the NRC's Office of Nuclear Reactor Regulation (NRR) initiated the ITP to complement these processes by monitoring and assessing industry-level trends in safety performance. The purposes of the ITP are to provide a means to confirm that the nuclear industry is maintaining the safety performance of operating reactors and, by clearly demonstrating that performance, to enhance stakeholder confidence in the efficacy of the NRC's processes. The objectives of the ITP are as follows:

(1) Collect and monitor industry-wide data that can be used to assess whether the nuclear industry is maintaining the safety performance of operating plants and to provide feedback for the ROP.

(2) Assess the safety significance and causes of any statistically significant adverse industry trends, determine if they represent an actual degradation in overall industry safety performance, and respond appropriately to any safety issues that may be identified.

(3) Communicate industry-level information to Congress and other stakeholders in an effective and timely manner.

A key output of the ITP is that it provides the basis for agency monitoring and reporting in the Nuclear Reactor Safety arena against the performance goal measure of "no statistically significant adverse industry trends in safety performance," as defined by the NRC's Strategic Plan. The agency reports these results annually to Congress in the "Performance and Accountability Report, Fiscal Year 200X" (NUREG-1542 series). In early FY 2001, NRR assumed responsibility from RES for reporting on this measure as part of its overall responsibilities in the Reactor Safety arena. The current bases for assessing performance against this measure are trends in the industry indicators developed by the former AEOD (these will be referred to as the "ex-AEOD" indicators in the rest of this paper) and trends identified by the ASP program. Notably, these indicators were among those cited as demonstrating improvements in industry safety performance that contributed to the agency's decision to revise the ROP.

In developing the ITP, the staff used the following general concepts for its approach:

(1) The indicators were developed using information available from current NRC programs. In the future, indicators will be developed in stages, and will provide information for each ROP cornerstone of safety.

(2) Industry trend information is derived from quantitative, industry-wide data.

(3) Trends are identified on the basis of long-term data, rather than short-term data. This minimizes the impact of short-term variations in data, which may be attributable to such factors as operating cycle phase, seasonal variations, and random fluctuations.

(4) Trends and contributing factors are assessed for safety significance. The results of inspections, analyses of significant events and abnormal occurrences, and other analyses may be used to facilitate an evaluation of the trends. The agency's response is commensurate with the safety significance.

(5) While additional indicators are being developed, a subset of high-level indicators may be used for the report on adverse trends to Congress in the NRC's Performance and Accountability Report. For reporting on the performance measure of "no statistically significant adverse industry trends in safety performance," indicators will be qualified for use in phases. Until they are qualified, the staff will continue to use the ex-AEOD indicators and ASP results. Additional indicators from the ITP will be incorporated for use in accordance with a controlled process for making such changes to the NRC's Performance Plan. In addition, the staff intends to consider refinements to the performance measure as the indicators and more risk-informed methods of assessing their safety significance are developed.

As discussed in SECY-01-0111, in FY 2001 NRR adopted a statistical approach using "prediction limits" to provide a consistent method to identify potential short-term emergent issues before they manifest themselves as long-term trends. The prediction limits are values established at the beginning of a FY that set an upper bound on expected performance for that year for each indicator. Actual indicator values during the year can then be monitored and compared to the prediction limits. Indicators that exceed the prediction limits are investigated to determine the factors contributing to the data. These factors are assessed for their safety significance and used to determine an appropriate agency response.

DISCUSSION:

The results of the ITP for FY 2001, status of development of risk-informed thresholds and performance measures, and communications efforts are described in this section.

FY 2001 Results

The indicators developed for use in the ITP are available on the NRC's Web site at *http://www.nrc.gov/reactors/operating/oversight/industry-trends.html*. Based on the ex-AEOD indicators and the ASP program results, no statistically significant adverse trends in industry safety performance were identified through FY 2001. Graphs of the trends for each of these indicators are presented in Attachment 1. The performance measure results and graphs were also included in the NRC's "Performance and Accountability Report for FY 2001."

- **Ex-AEOD indicators** - All of the ex-AEOD indicators showed improving or steady trends. However, both the Automatic Scrams While Critical and the Collective Radiation Exposure indicators exceeded their prediction limits for FY 2001. The staff followed the process for investigating adverse trends that was outlined in SECY-01-0111, which included analyzing in detail the data supporting each indicator.

For automatic scrams, the actual FY 2001 plant average was 0.57 scrams, which exceeded the prediction limit of 0.55 scrams (See Figure A1-1). The difference corresponds to approximately 2 extra scrams out of 103 operating plants. As shown in Attachment 2, the staff examined the data for both automatic and manual scrams, including a review of the apparent causes of the scrams and the plant activities in progress at the time of the scrams. No adverse trends were identified. In addition, the staff assessed the safety significance of the data by considering the thresholds established for the plant-level PIs in the ROP. The plant-level green-white threshold is set at 3 scrams per plant, which includes both automatic and manual scrams. Including manual scrams, the industry scram average is 0.85 scrams per plant, which is well below the threshold for individual plants. Therefore, based on the small amount that the prediction limit was exceeded and the low overall industry scram average compared to the plant-level threshold, NRR did not identify any safety issues associated with exceeding the FY 2001 prediction limit for automatic scrams.

For collective radiation exposure, the actual FY 2001 plant average was 122 person-rem, which exceeded the prediction limit of 119 person-rem (See Figure A1-6). The difference corresponds to approximately 309 extra person-rem out of 12,600 person-rem received at all plants. A preliminary analysis shows that the increase in dose from FY 2000 to FY 2001 can be attributed to several factors. First, the majority of plants' collective dose is received during refueling outages, and there were approximately 10 percent more refueling outages in FY 2001 than in FY 2000. Second, approximately 12 PWRs conducted inspections of reactor pressure vessel head penetrations to identify any nozzle cracking and conducted repairs where appropriate, which resulted in higher doses than in FY 2000. Finally, although the use of noble metal chemistry has been effective at maintaining a low deposition rate of radioactive nuclides in the systems of many plants, some BWRs experienced higher than expected plant shutdown doses due to problems with this chemistry control. For example, the outage dose for Quad Cities 1 of 623 person-rem in FY 2001 more than doubled the outage dose estimate. While higher than anticipated, the outage dose is not unusual by historical standards. NRR did not identify any safety issues associated with these factors.

- **ASP Program Results** - The results of the ASP program show improving overall trends in the frequency of all precursors during the period from 1993 through 2000 (See Figure A1-8). In addition, as part of the NRC's "Performance and Accountability Report for FY 2001," RES reported that there were no significant precursors [defined as events that have a probability of core damage of 1/1000 (10^{-3}) or greater]. RES has provided additional information on the results and status of the ASP program in SECY-02-0041, "Status of Accident Sequence Precursor and SPAR Model Development Programs."

- **Indicators Derived from ROP PIs** - The staff developed industry-level indicators from the data that licensees submitted for the plant-level ROP PIs. For FY 2001, there was insufficient data (<4 years) for long-term trending. Nonetheless, based on a review of the indicator data submitted to date, no significant short-term trends have emerged.

- **Operating Experience Indicators** - In November 2001, RES developed additional risk-informed indicators for initiating events, as shown in Attachment 3. This effort involved updating the data that were most recently published in NUREG-5750, “Initiating Events at U.S. Nuclear Power Plants: 1987& 1995.” In general, the number of initiating events has continued to decline over the past decade. Trendlines are shown for those indicators where a statistically significant trendline could be established. No statistically significant adverse trends were identified in these indicators.

In addition, NRR staff reviewed summary results of the ROP for its first 2 years of implementation to assess the information that will be available should there be an adverse trend in the industry-wide indicators, and to provide possible feedback for the ROP. As shown in Attachment 4, the number of plants in the Regulatory Response column of the Action Matrix has gradually increased from initial implementation on April 2, 2000, through the end of CY 2001. The staff believes that this can be attributed to 1) both licensees and the NRC being more focused on the most risk-significant aspects of licensee performance, and 2) the initial accumulation of inspection findings with some safety significance, which are counted for 4 quarters before being removed from consideration in the assessment process.

Risk-Informed Response Thresholds and Performance Measures

In SECY-01-0111, the staff stated that it was working to develop a more objective, predictable approach to be used in the future that would establish risk-informed thresholds, to the extent practicable, which would be used to assess any trends in indicators and to determine the appropriate agency response. The use of thresholds would preclude a scenario in which the improving trends in indicators began to level off, presumably when the design limits of operating plants have been reached. In the SRM related to SECY-01-0111, dated August 2, 2001, the Commission directed the staff to develop risk-informed thresholds for the industry-level indicators “as soon as practicable.”

RES is currently developing risk-informed thresholds for indicators derived from ROP PI data. In general, risk-informed thresholds are possible for the indicators in the initiating events and mitigating systems cornerstones of safety for which NRC risk analysis tools, such as the Standardized Plant Analysis Risk (SPAR) models, are available. However, development of risk-informed thresholds for indicators in other cornerstones and for the ex-AEOD indicators may not be possible. For these indicators, NRR is exploring several possible approaches, including a deterministic approach in which 95% of plants lie below the threshold, a statistical approach based on variability of the data, an approach based on industry average margin to the green-white thresholds for the plant-level ROP PIs, expert judgement, or a combination of several approaches. The staff intends to seek stakeholder input, including input from the Advisory Committee on Reactor Safeguards (ACRS), while developing the thresholds over the next 1 to 2 years.

It is likely that before risk-informed thresholds are established, the indicators derived from the ROP will have accumulated sufficient data (> 4 years) to be trended as part of the ITP. While there may be sufficient data, it is important to recognize that this data includes information submitted by licensees prior to the initial implementation of the ROP on April 2, 2000, which for many PIs represented a best estimate. The staff will evaluate the efficacy of using this data during FY 2002 and will consider qualifying these indicators for use in FY 2003.

Once thresholds are established, the staff may propose revisions or enhancements to the performance goal measure of “no statistically significant adverse industry trends in safety performance.” This performance measure is unique in that it uses multiple indicators, but does not use thresholds. In contrast, most of the performance measures in the NRC’s Performance and Accountability Report rely on data that have thresholds (e.g., no more than one event per year identified as significant precursors of nuclear accidents). The advantage of a performance measure using trends is that adverse trends can be addressed before they become significant problems, but the disadvantage is that resources can be spent on investigating or addressing “adverse” trends that may not actually be safety significant. A better performance measure could be one with risk-informed thresholds, coupled with monitoring of performance to identify potential adverse trends before performance crosses the specified thresholds.

Communications

In August 2001, the NRC published the ITP indicators on the ROP portion of the agency’s public Web site. The indicators were subsequently unavailable while the NRC reviewed the Web site in the wake of the terrorist attacks on September 11, 2001, but they were again posted to the public Web site in January 2002. NRR believes that the operating experience data shown by the industry-level indicators displayed on the Web site, when added to the information on individual plants from the ROP, can enhance stakeholder confidence in the efficacy of the NRC’s oversight of the nuclear industry.

To communicate its development efforts to stakeholders and receive feedback, NRR continued to give briefings on its progress as appropriate during its periodic public meetings with the industry’s ROP working group. No significant issues were identified during these briefings. As risk-informed thresholds are developed for the indicators, the staff intends to continue this dialogue and to engage the ACRS.

In the NRC’s “Performance and Accountability Report for FY 2002,” the staff will continue to report trends using the current set of ex-AEOD PIs and ASP program results. As indicated earlier, additional indicators, including the ROP PIs and operating experience indicators, are being developed and will be qualified for use in phases. As these additional indicators and risk-informed thresholds are developed, the staff plans to evaluate whether changes to the reporting criteria are appropriate. The staff will provide the status of this ongoing development in the next annual report on the ITP, which will be provided in the same time frame as the AARM.

<u>FUTURE DEVELOPMENT EFFORTS:</u>

This section describes the future development of additional operating experience indicators and data sources related to the ITP.

Incorporation of Additional Industry Operating Experience

RES is continuing to develop operational experience data that have the potential to be used for risk-informed industry indicators to enhance the ITP. Within the next 1 to 2 years, RES plans to update the data that have been published in various NUREG-serious reports for system reliability studies, component reliability studies, common-cause failure studies, and other special studies for which industry-wide trends were reported. These are intended to be used as long-term indicators in the mitigating systems cornerstone. In addition, as a means of providing greater stakeholder access to this information, RES is planning to develop a Web-based system to replace the current paper-based system of NUREG-series reports.

Improved Data Collection and Reporting

Licensees report operating experience data to the NRC, including data for the ROP plant-level indicators, licensee event reports, and monthly operating reports. Licensees also report additional data to other organizations such as the Institute of Nuclear Power Operations (INPO). The staff uses all of these as data sources for the indicators used in the ITP. The staff will continue to seek improvements and efficiencies in data collection and reporting by industry for both the ITP and the ROP. For example, NRR and RES are currently working with industry to develop a consistent set of data elements, definitions, and reporting guidelines for the plant-level ROP reliability and unavailability PIs that would encompass the needs of all stakeholders. In addition, NRR and RES are working with the Industry Consolidated Data Advisory Committee of INPO to develop a common collection system for industry operating experience data that can be used by both the NRC and INPO. These development efforts are expected to continue over the next several years.

In addition to reducing unnecessary burden on licensees, improved quality and consistency of operating experience data can improve the quality of both industry and NRC risk analysis tools, including SPAR models, by reducing uncertainties in the data. As stated earlier, the staff anticipates using these tools in developing risk-informed thresholds for the ITP indicators. In addition, improved tools can enhance ongoing staff efforts in a variety of risk-informed applications, such as further risk-informing the ROP plant-level indicators and their thresholds, and Phase 3 of the ROP’s Significance Determination Process.

RESOURCES:

For FY 2002, NRR has budgeted 2.0 FTE and $325K for the development and implementation of the ITP. For FY 2003 through 2005, NRR estimates resource requirements of 1.5 FTE per year, with estimated contract assistance funding requirements of $254K per year. NRR has included these requirements in its budget request submittals. Should additional resources be needed to accomplish these tasks, NRR will reprogram the resources from within the current budget using the NRC’s Planning, Budgeting, and Performance Management (PBPM) process. For FY 2002, RES has budgeted 0.5 FTE and $270K for the development of risk-informed thresholds for indicators in the ITP. For FY 2003, RES budgeted 0.5 FTE and $240K, and for FY 2004 and FY 2005 estimates 0.5 FTE and $50 – 100K will be required. RES is developing the operational experience data and risk models as part of existing programs that are currently budgeted.

COORDINATION:

The Office of Public Affairs has reviewed this paper and concurs with the approach to communicating the industry indicators to stakeholders.

The Office of the Chief Financial Officer has reviewed this paper and concurs with the resource estimates and methods for addressing the Strategic Plan performance measure.

The Office of the General Counsel has reviewed this paper and has no legal objection.

/RA/ by William F. Kane

William D. Travers
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for Operations

Attachments:
1. Ex-AEOD and ASP Indicators
2. Analyses of Automatic and Manual Scrams
3. Indicators of Initiating Events
4. ROP Summary Information

Ex-AEOD and ASP Results

Indicators Originally Developed by the Former Office of AEOD and Accident Sequence Precursor (ASP) Results

(See ADAMS Accession No. ML 020550006)

Automatic Scrams while Critical

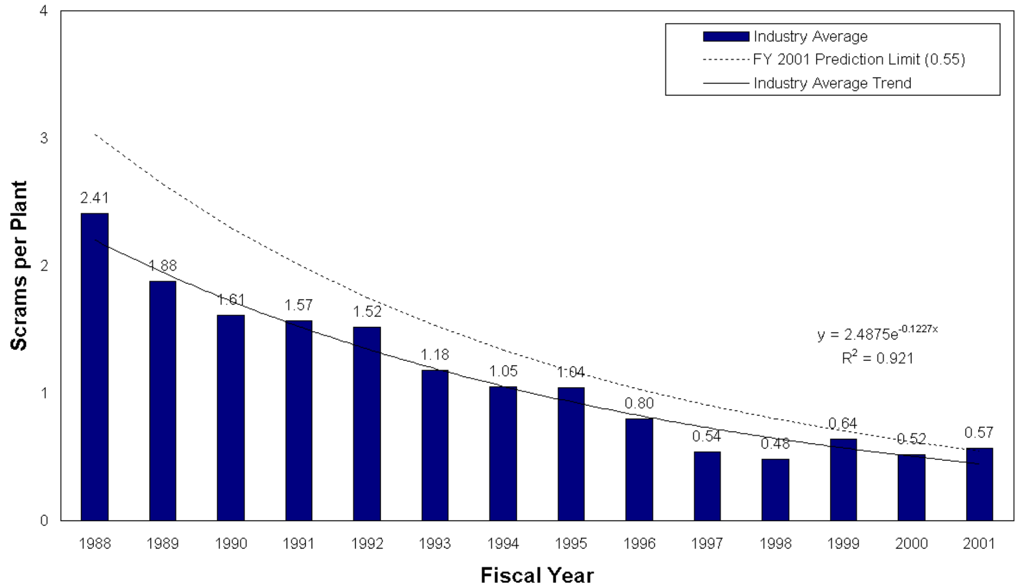


Figure A1-1

Safety System Failures

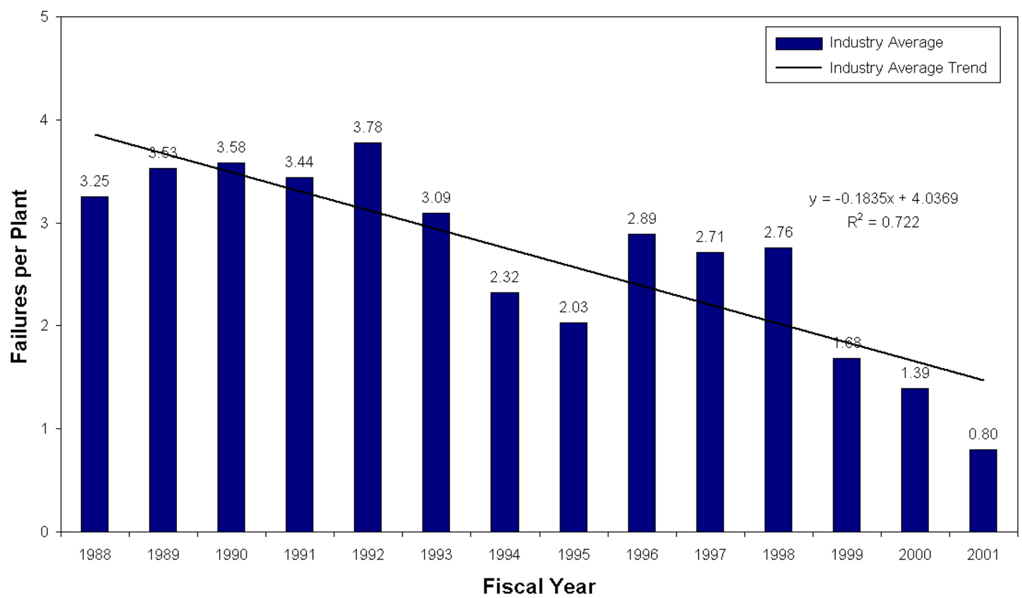


Figure A1-2

Safety System Actuations

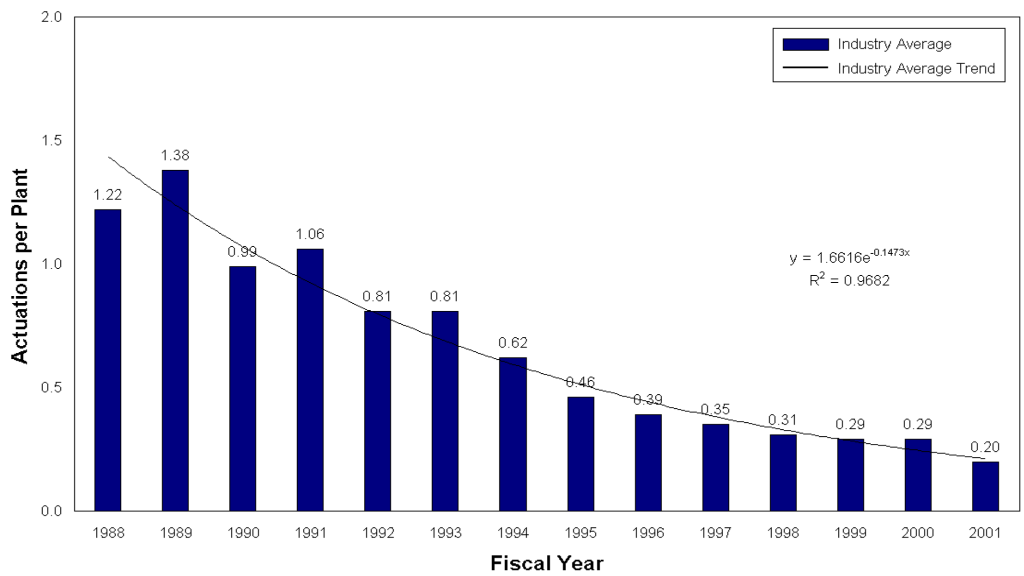


Figure A1-3

Forced Outage Rate (%)

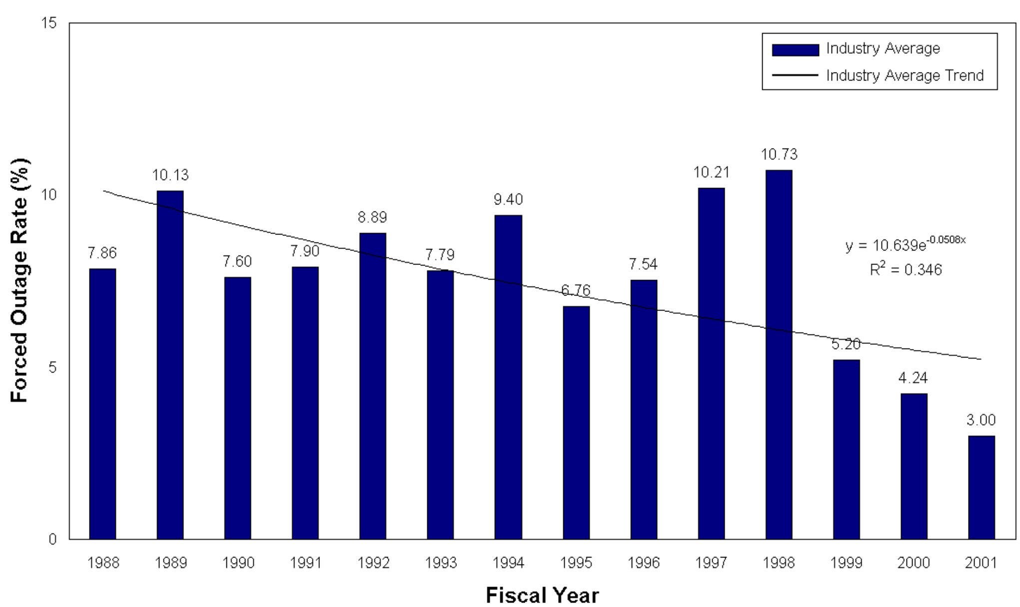


Figure A1-4

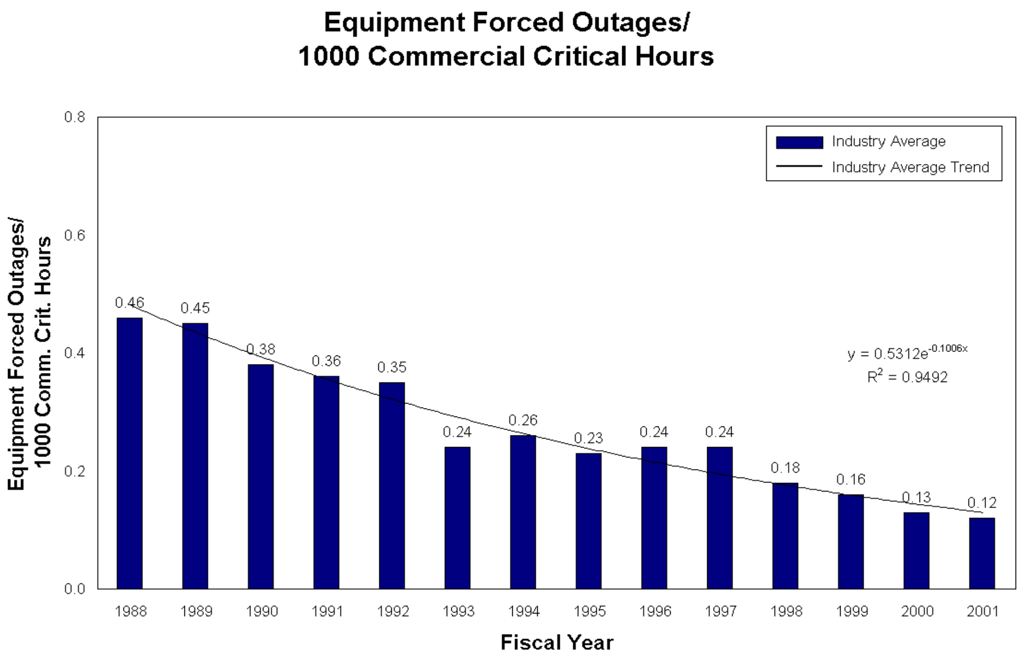


Figure A1-5

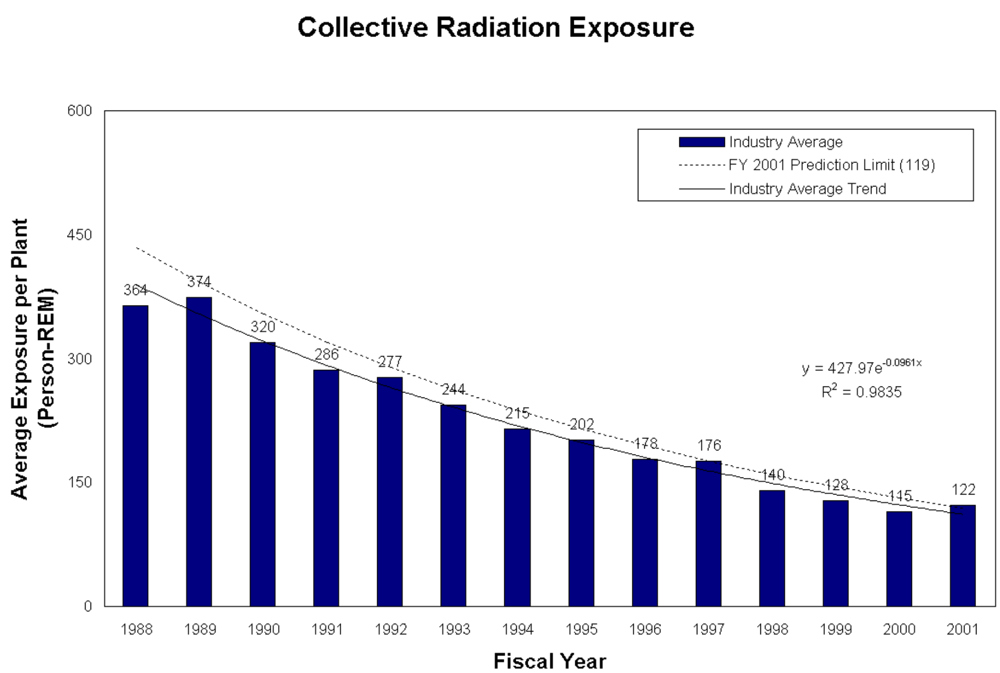


Figure A1-6

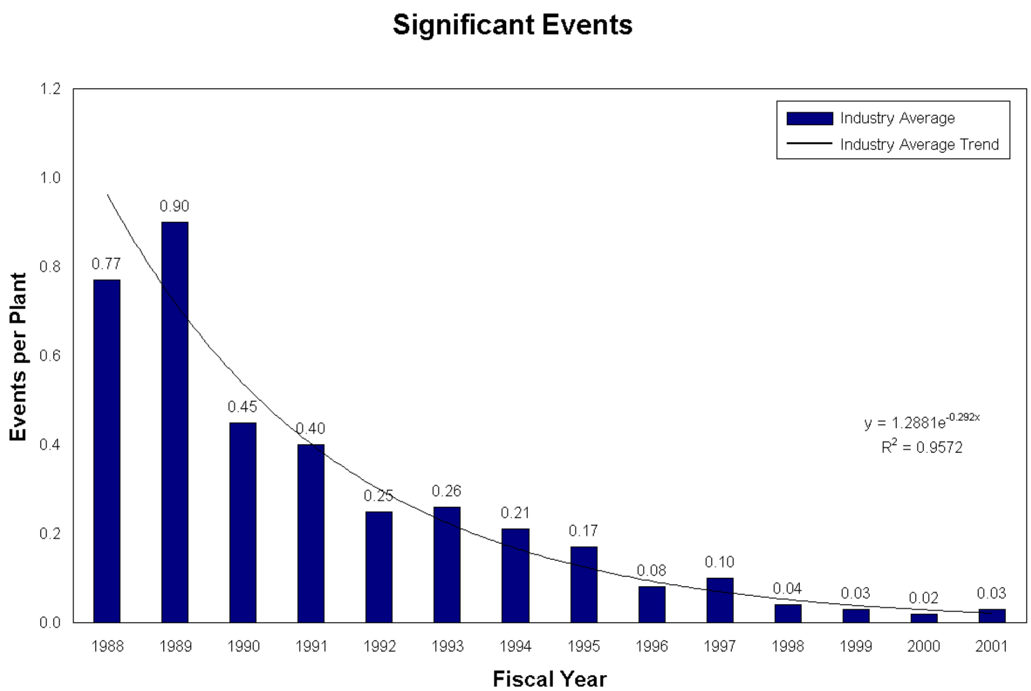

Significant Events
Events per Plant
Fiscal Year
Industry Average
Industry Average Trend
y = 1.2881e-0.292x
R2 = 0.9572
0.0
0.2
0.4
0.6
0.8
1.0
1.2
0.77
0.90
0.45
0.40
0.25
0.26
0.21
0.17
0.08
0.10
0.04
0.03
0.02
0.03
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001

Figure A1-7

Accident Sequence Precursor (ASP) Results

The following graph is provided for illustration only. The ASP program results show improving overall trends in the mean occurrence rate of all precursors during the period from FY 1993 through FY 2000. The results for FY 2000 are preliminary. In addition, as part of the NRC's "Performance and Accountability Report for FY 2001," RES reported that there were no significant precursors [defined as events that have a probability of core damage of 1/1000 (10^{-3}) or greater]. RES has provided additional information on the status of the ASP program in SECY-02-0041, "Status of Accident Sequence Precursor and SPAR Model Development Programs."

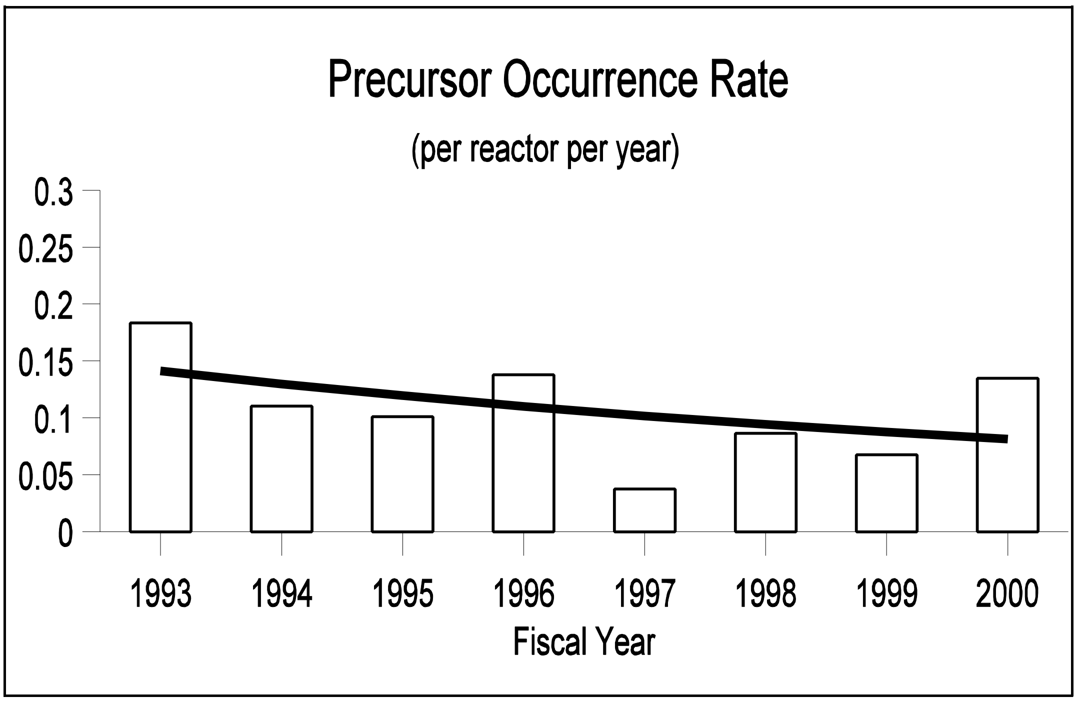


Figure A1-8

Analyses of Automatic and Manual Scrams

(See ADAMS Accession No. ML020560023)

Attachment 2

All Reactor Scrams (Automatic and Manual)

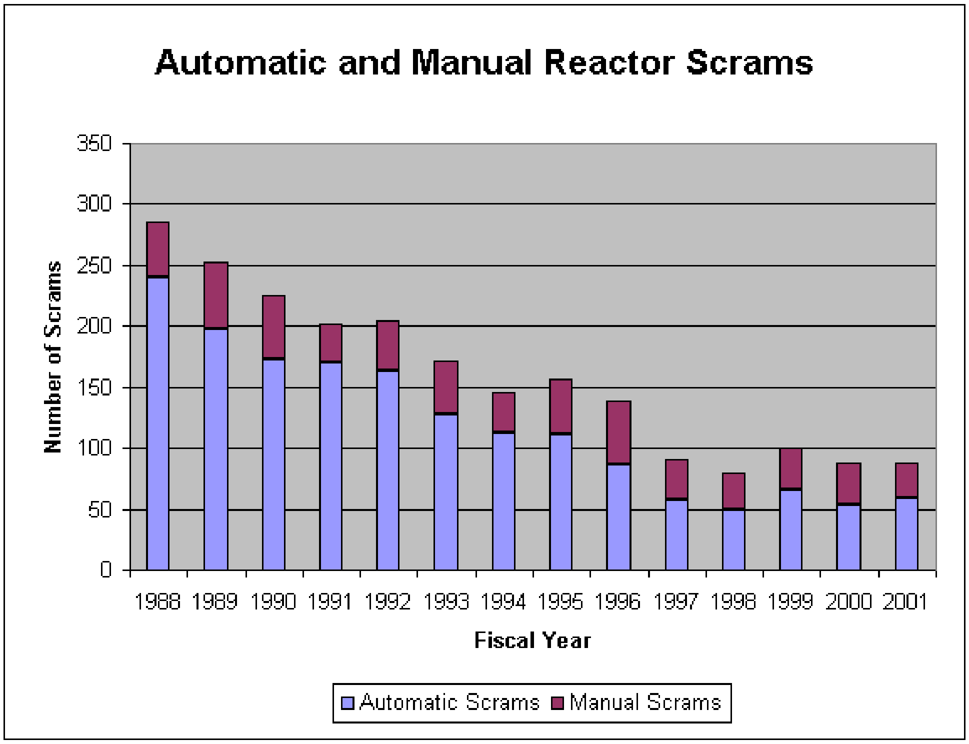


Figure A2-1

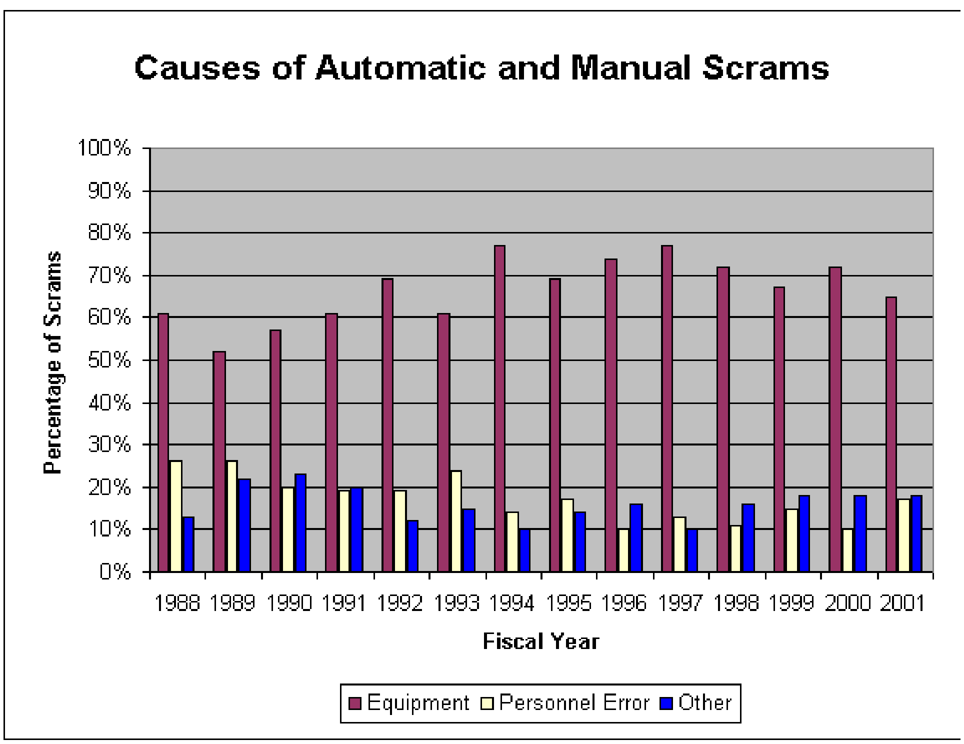


Figure A2-2

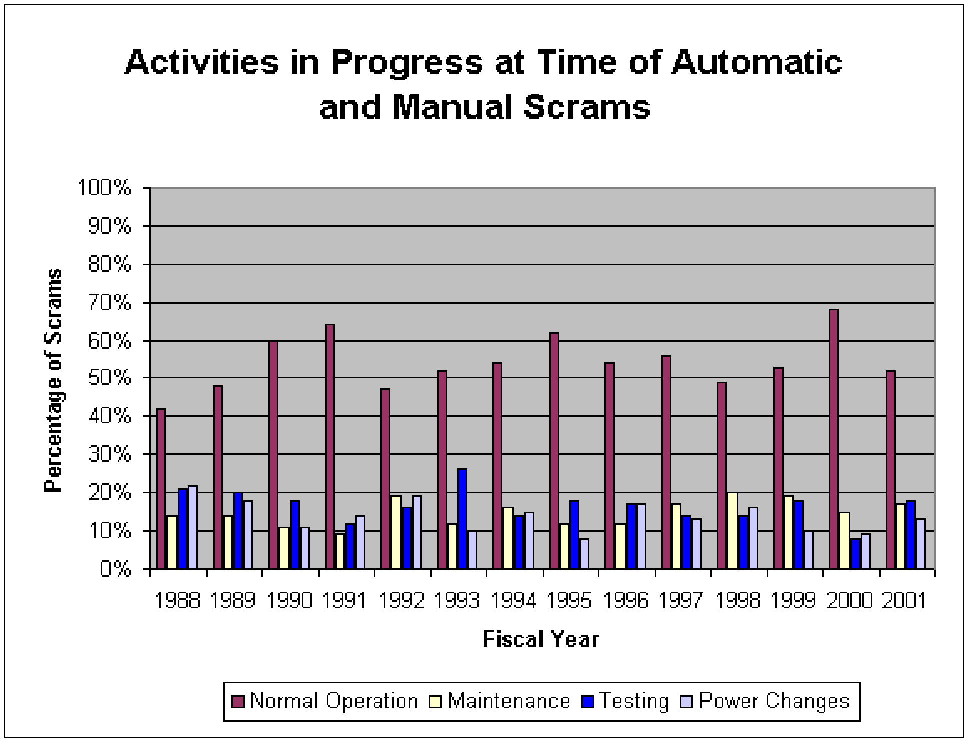


Figure A2-3

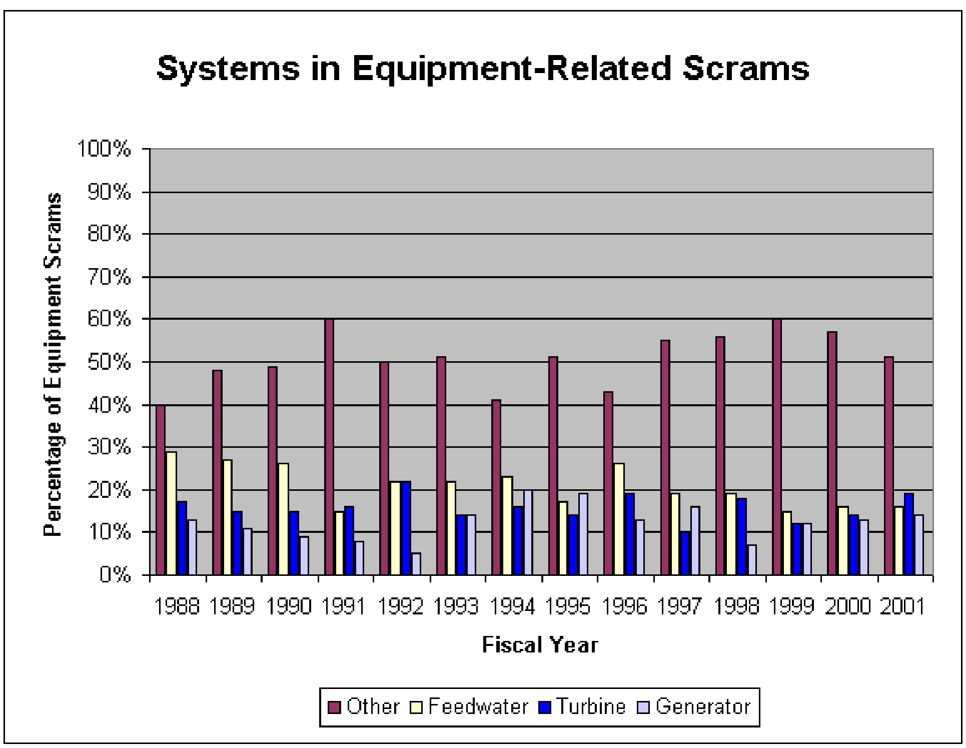


Figure A2-4

Automatic Reactor Scrams

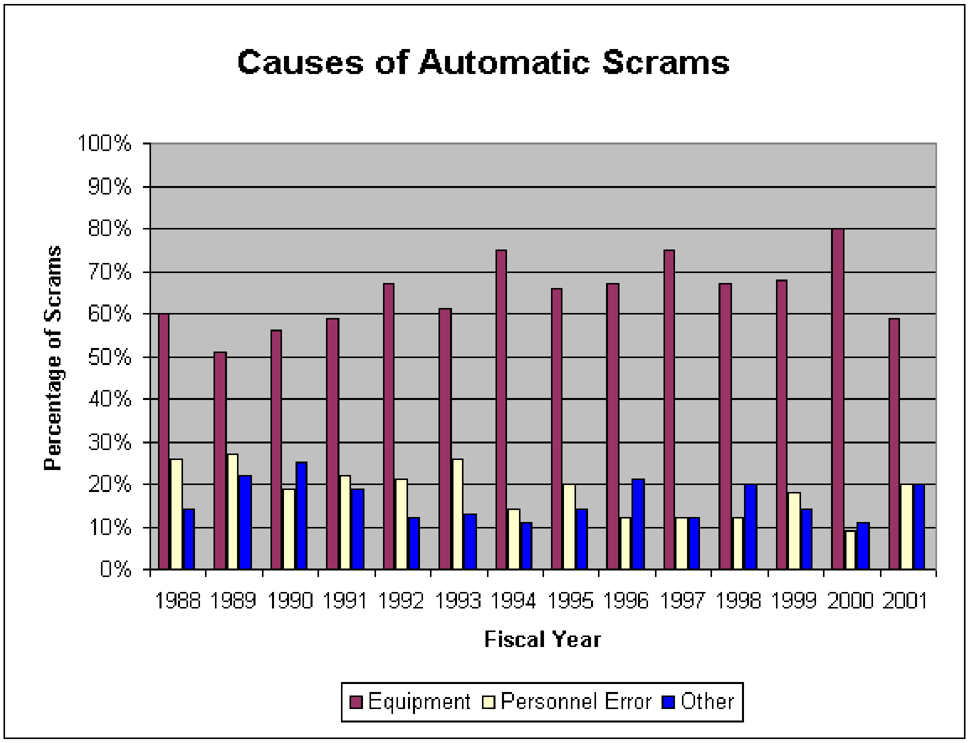


Figure A2-5

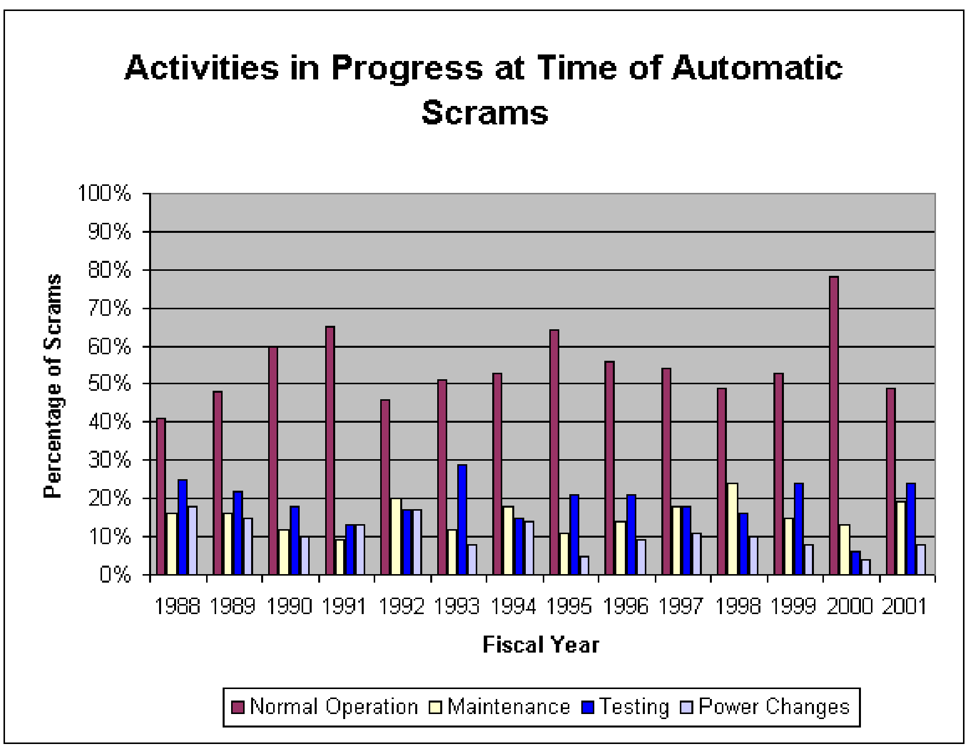


Figure A2-6

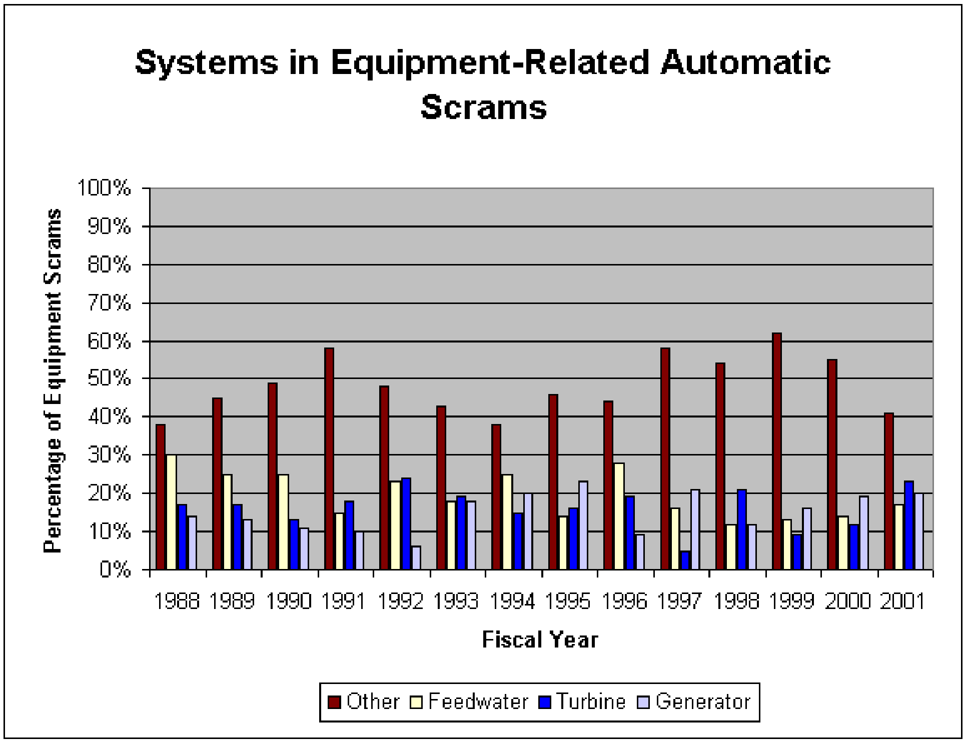

Systems in Equipment-Related Automatic Scrams
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Percentage of Equipment Scrams
1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001
Fiscal Year
Other
Feedwater
Turbine
Generator

Figure A2-7

Manual Reactor Scrams

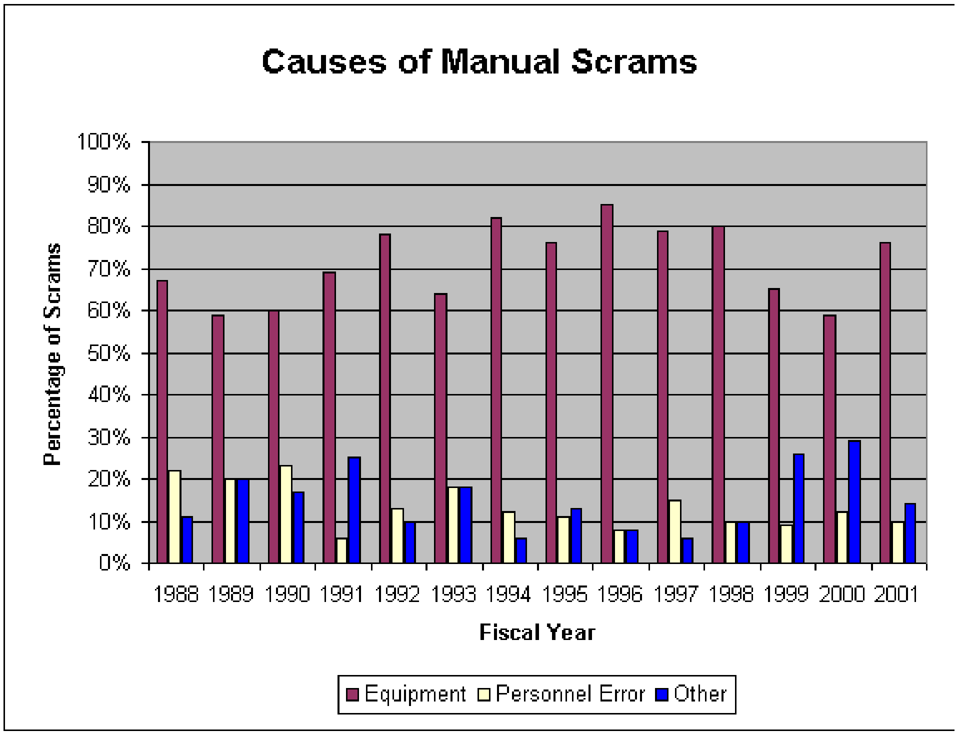


Figure A2-8

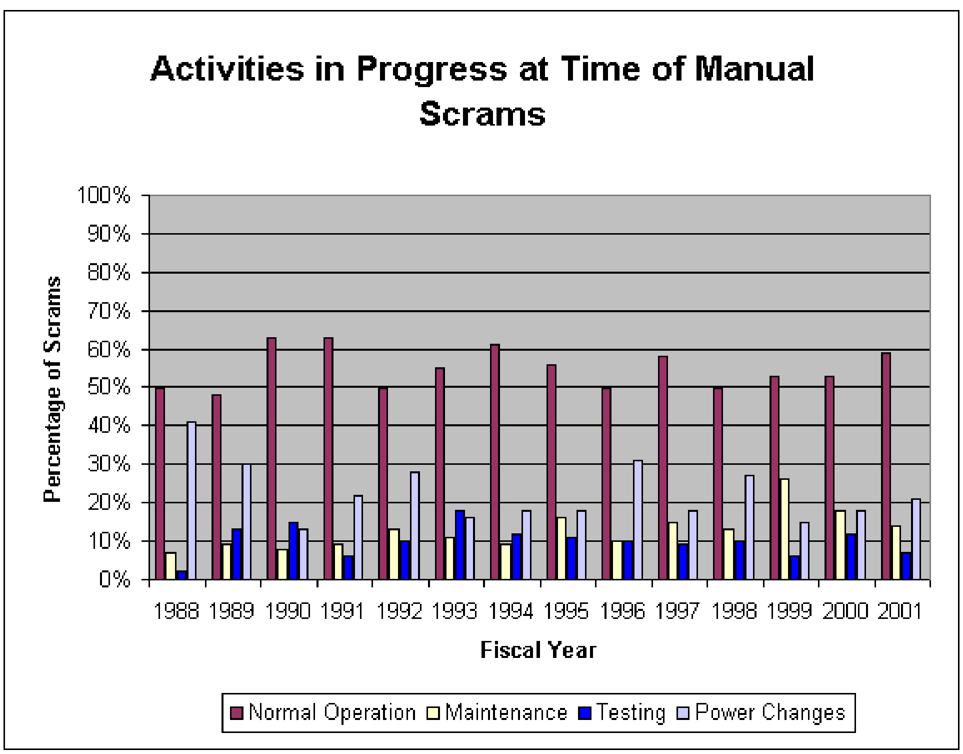
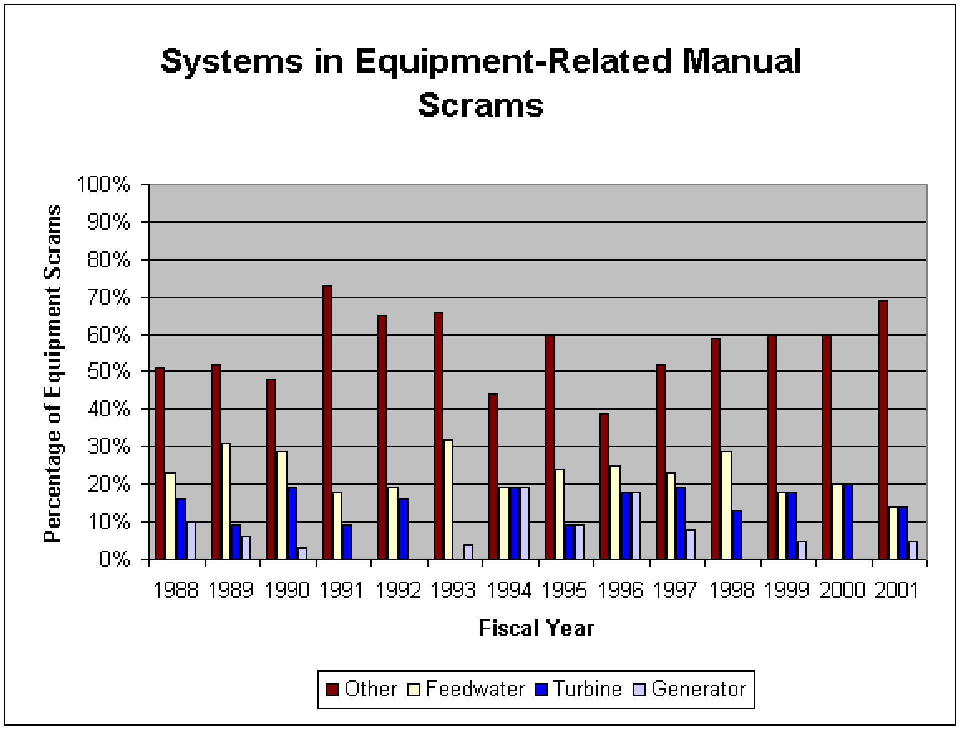


Figure A2-9



Systems in Equipment-Related Manual Scrams
Percentage of Equipment Scrams
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001
Fiscal Year
Other Feedwater Turbine Generator

Figure A2-10

Indicators of Initiating Events

(See ADAMS Accession # ML020550005)

BWR Loss of Instrument/Control Air Initiators

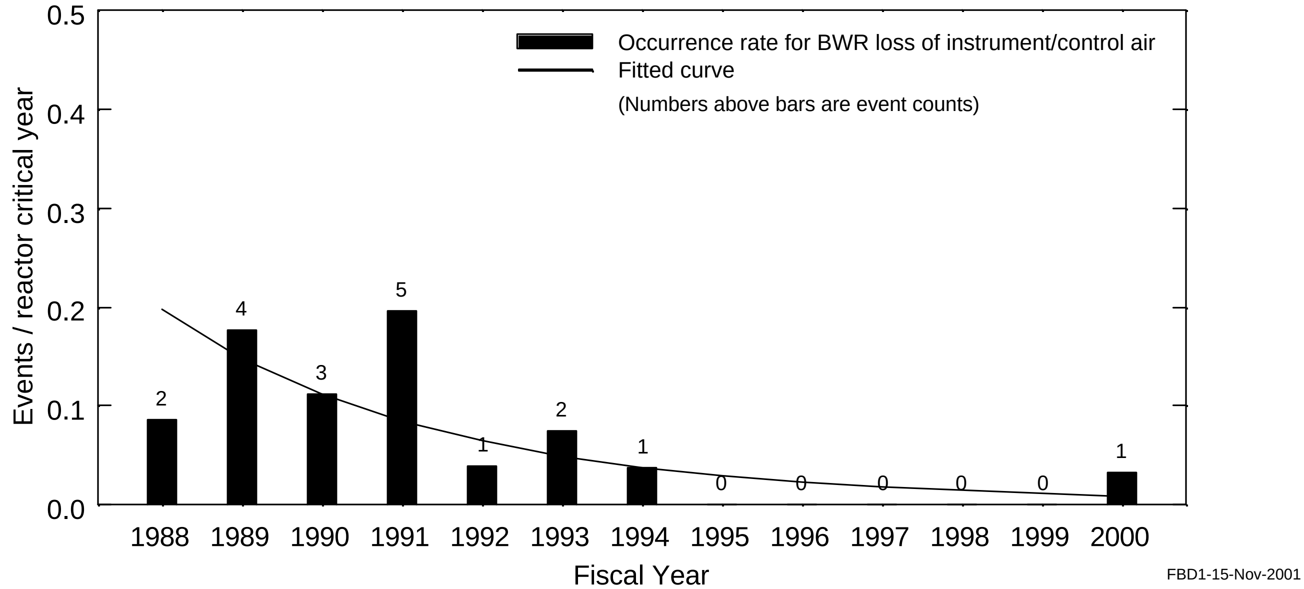


Figure A3-1

PWR Loss of Instrument/Control Air Initiators

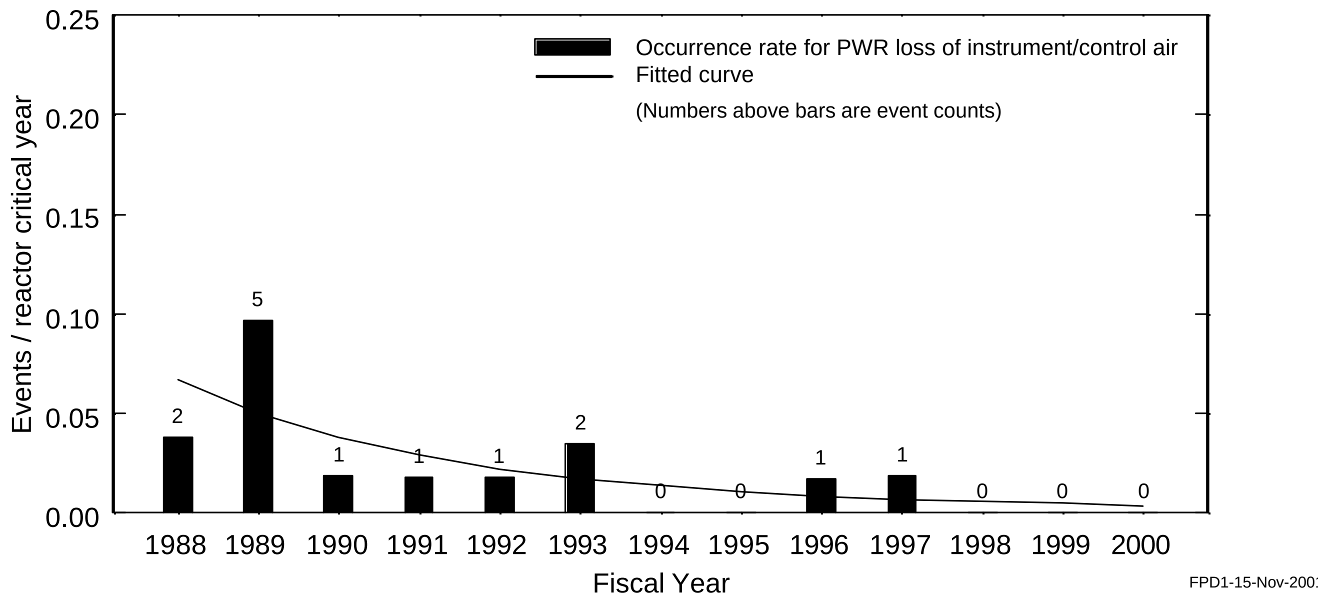


Figure A3-2

Loss of Offsite Power (LOOP) Initiators

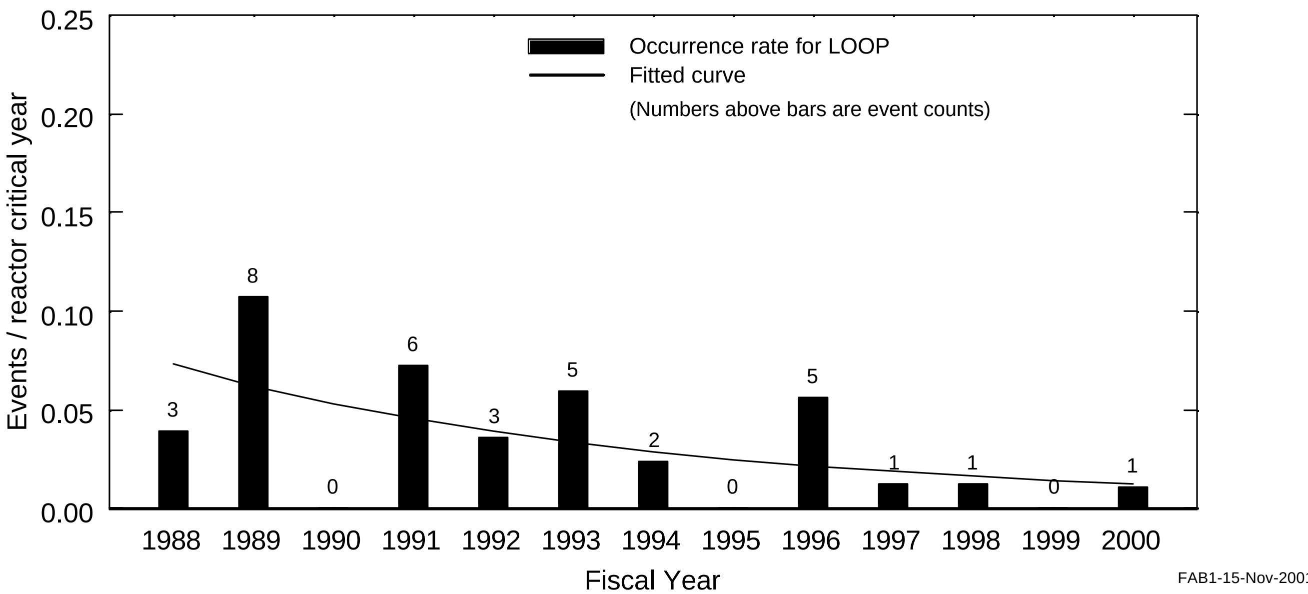
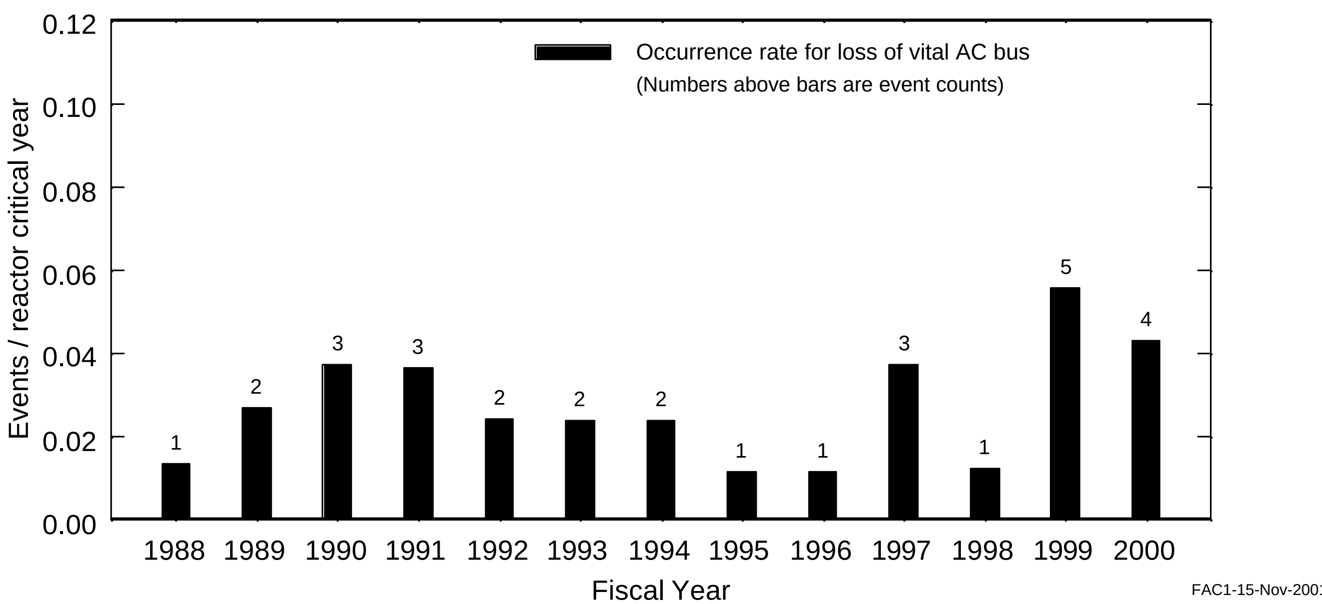


Figure A3-3

Loss of Safety-related Vital AC Bus Initiators



Note: A trendline is not shown for this indicator because the slope is not statistically significant

Figure A3-4

Loss of Safety-related Vital DC Bus Initiators

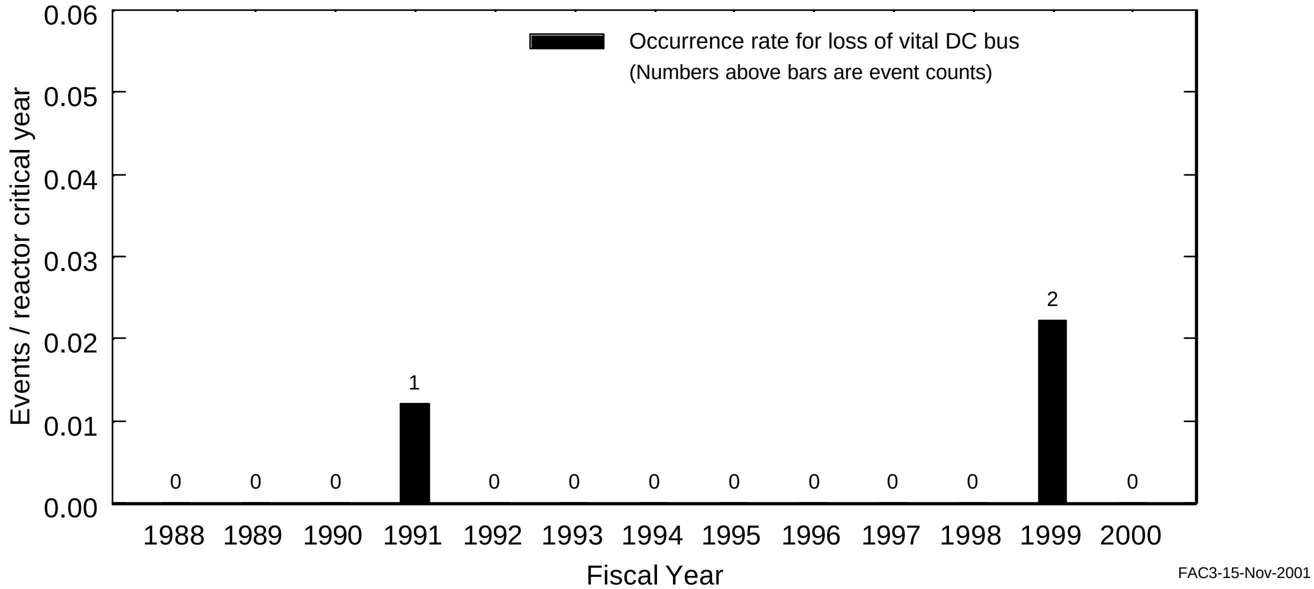


Figure A3-5

Small and Very Small LOCA Initiators

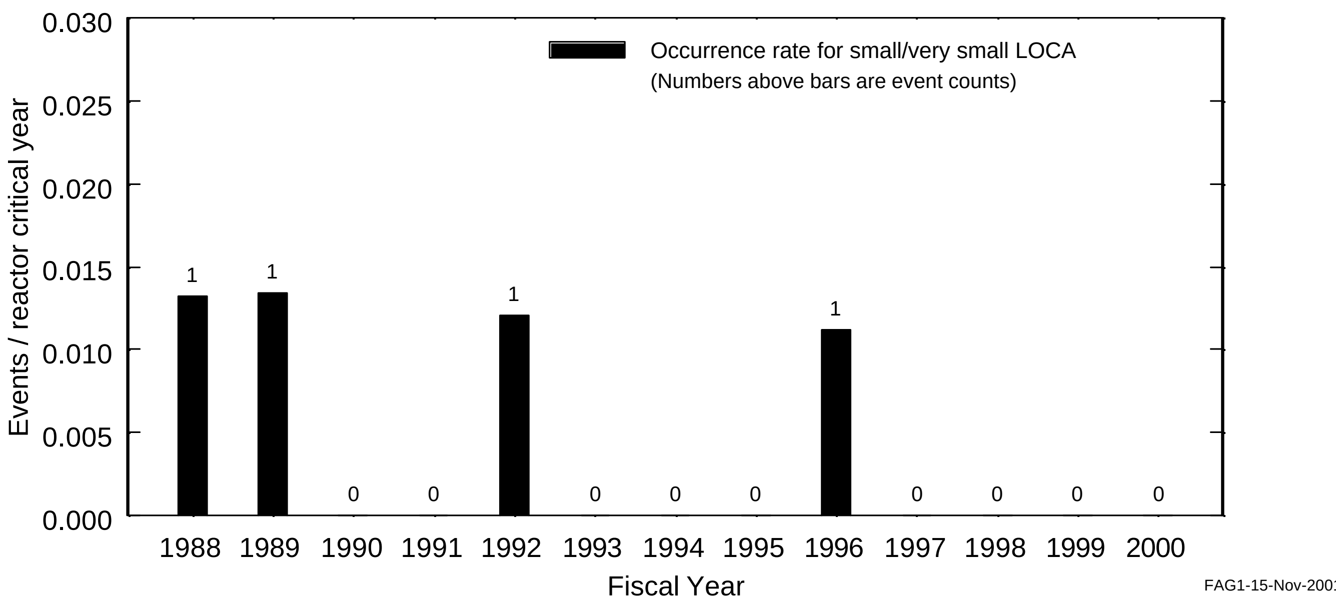


Figure A3-6

Steam Generator Tube Rupture Initiators

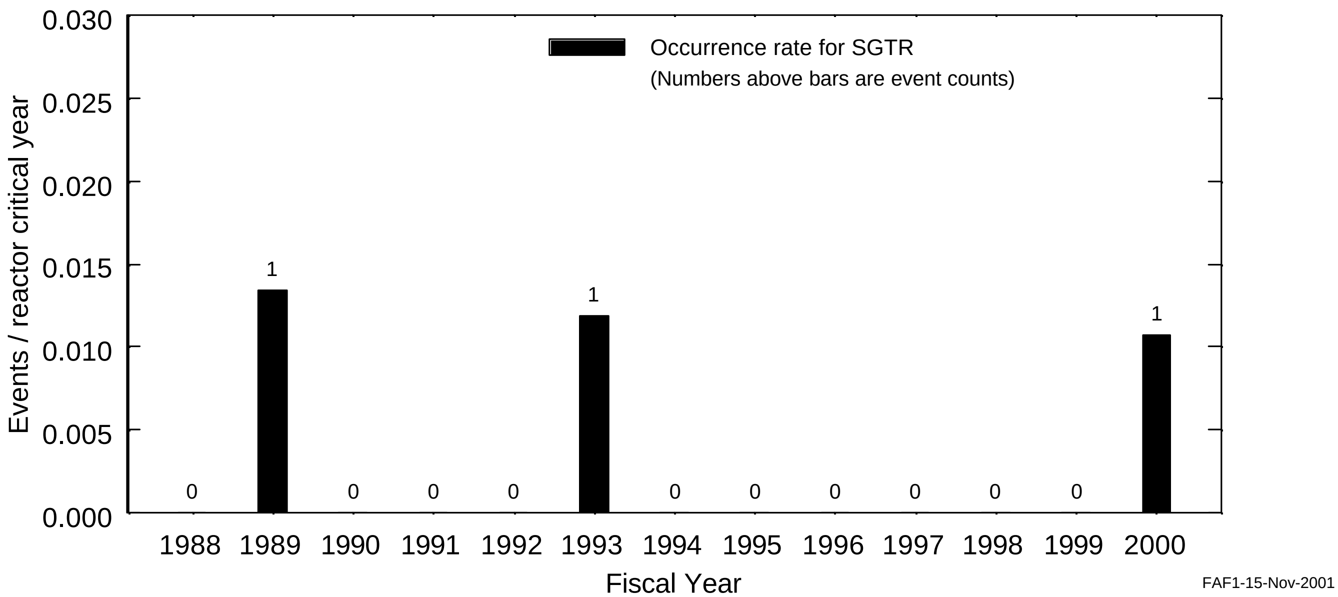


Figure A3-7

General Transient Initiators

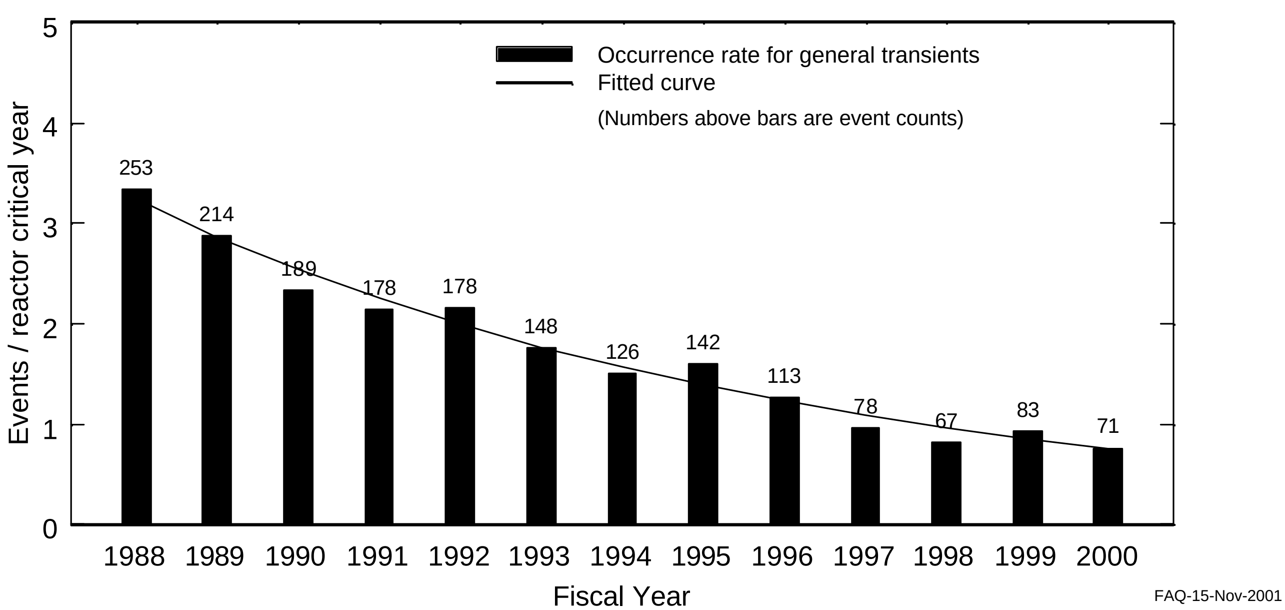


Figure A3-8

BWR General Transient Initiators

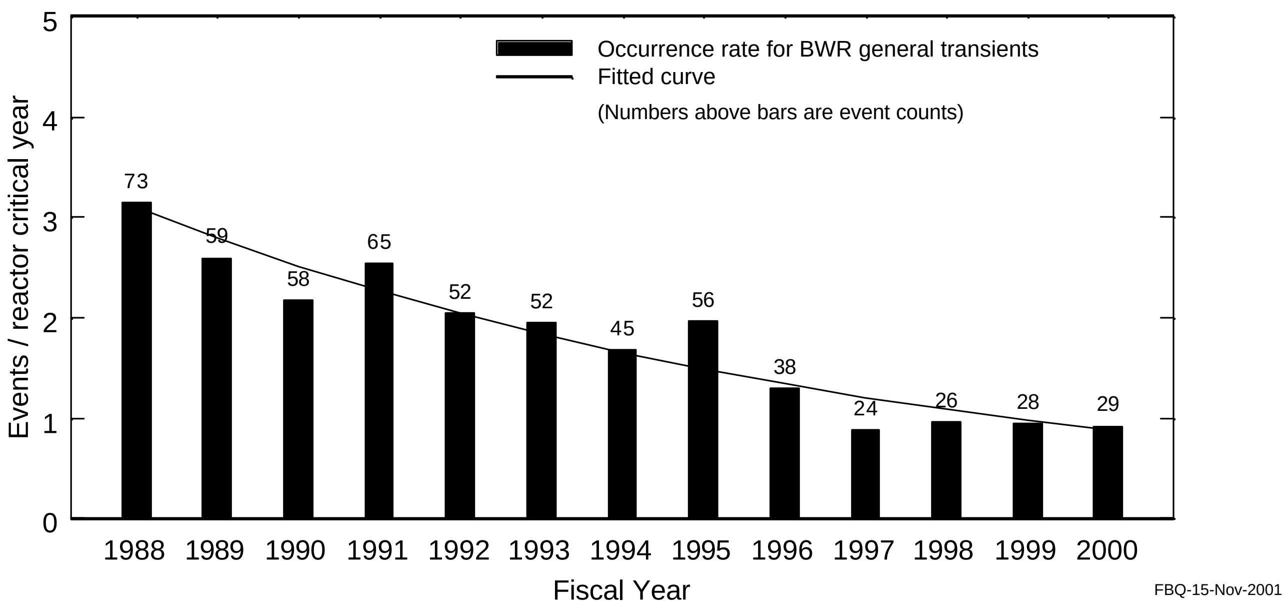


Figure A3-9

PWR General Transient Initiators

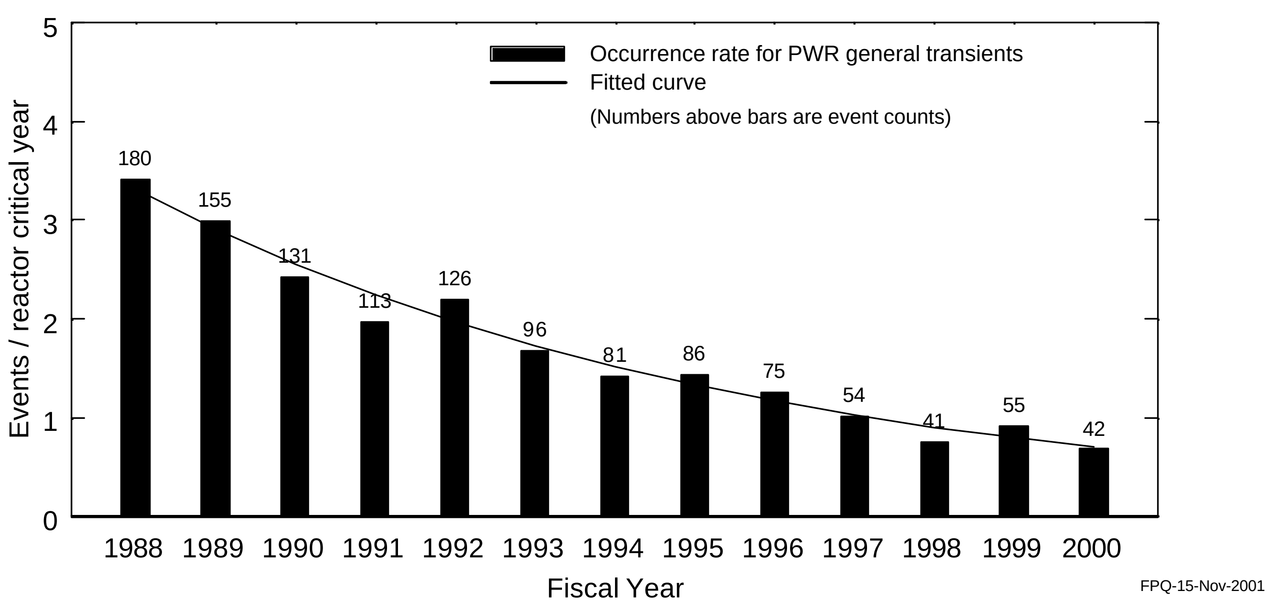


Figure A3-10

BWR Stuck Open Safety Relief Valve Initiators

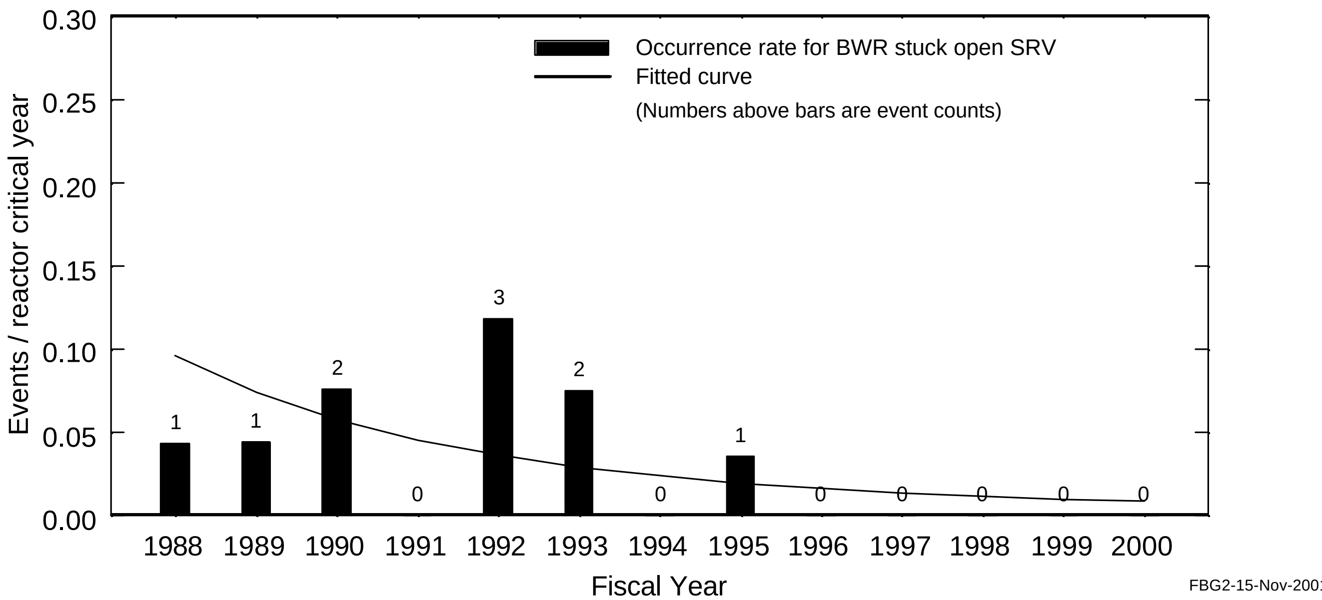


Figure A3-11

Loss of Feedwater Initiators

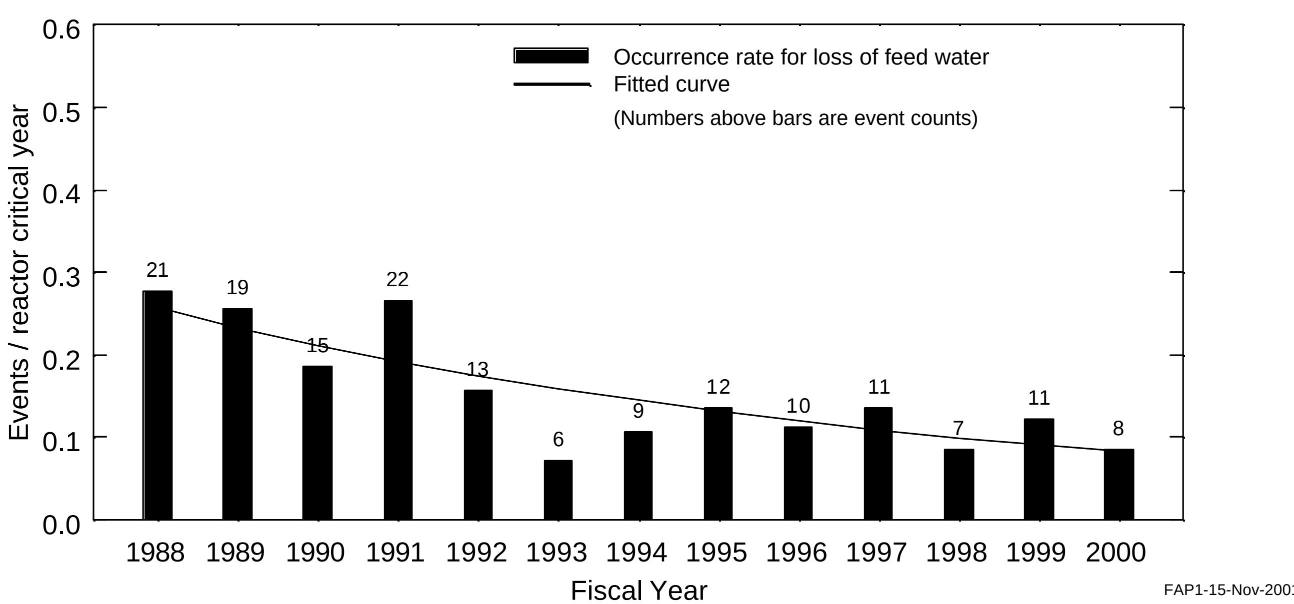


Figure A3-12

Loss of Heat Sink Initiators

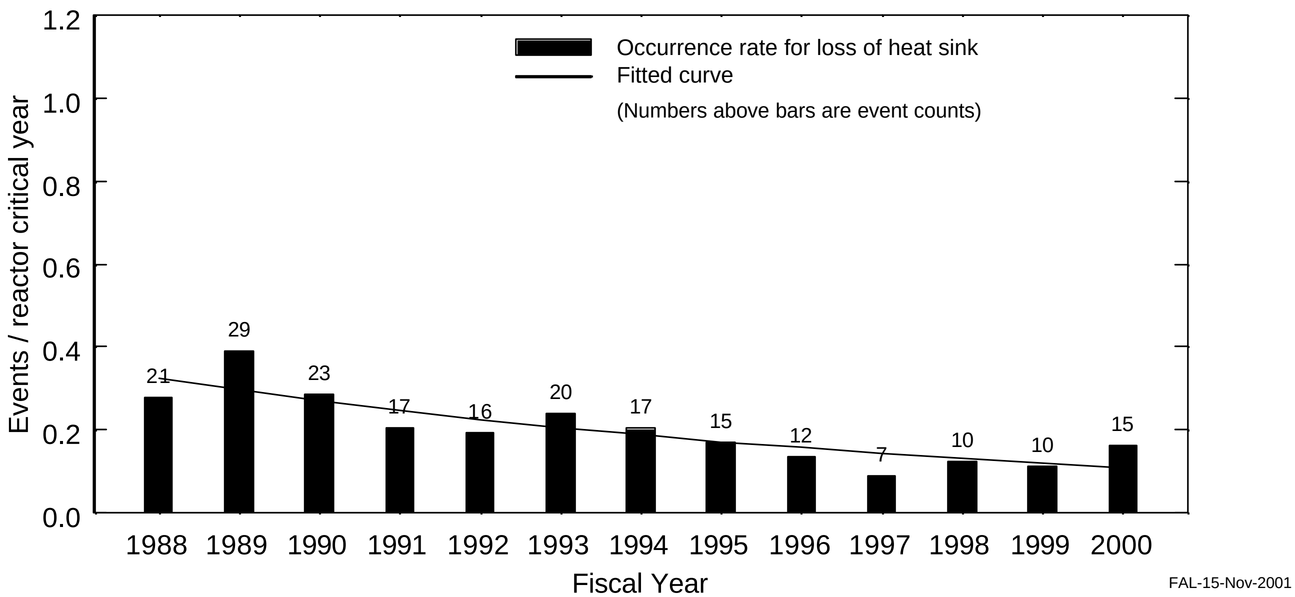


Figure A3-13

BWR Loss of Heat Sink Initiators

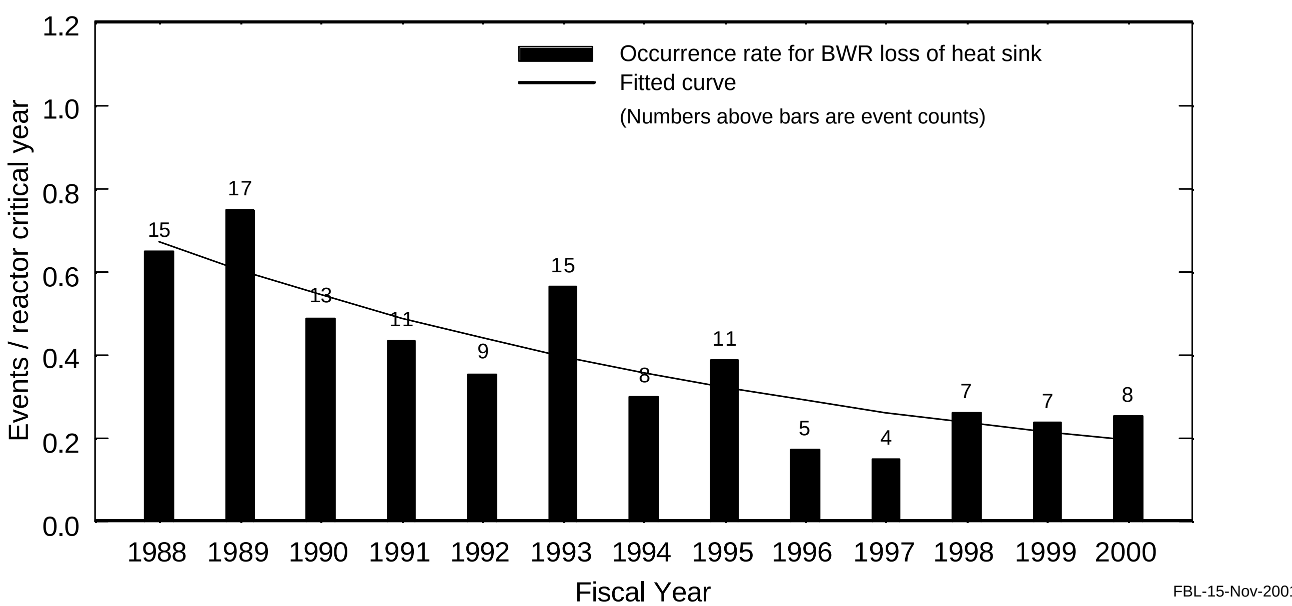


Figure A3-14

PWR Loss of Heat Sink Initiators

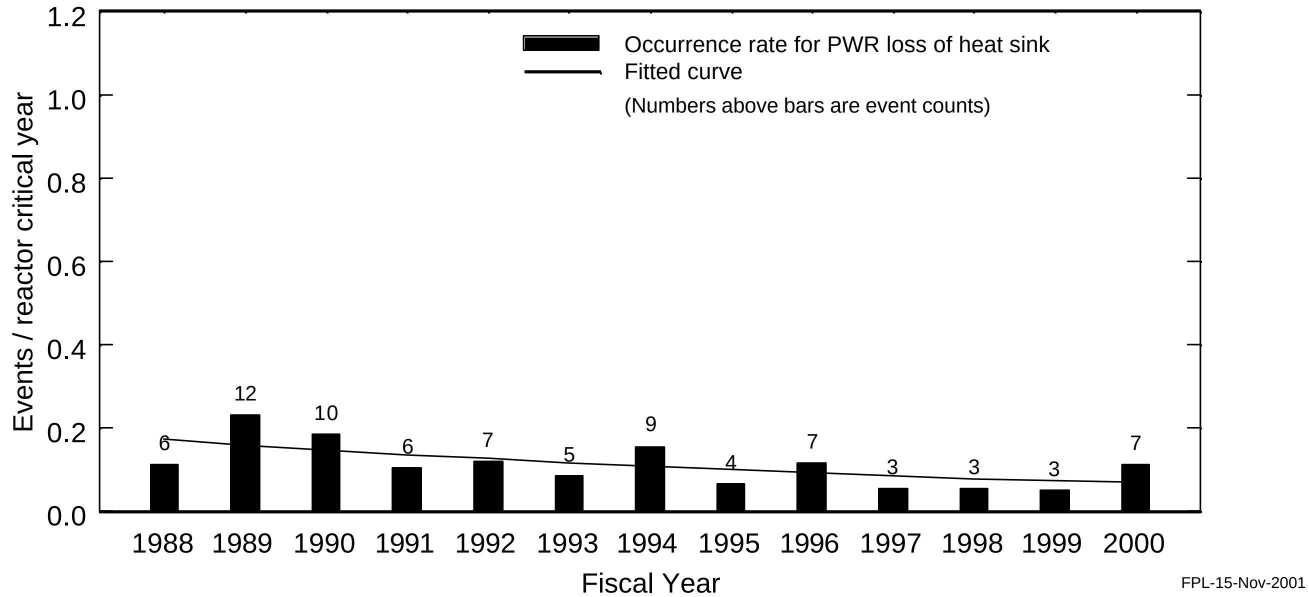


Figure A3-15

U.S Nuclear Power Plant Critical Years FY 1988 through FY 2000

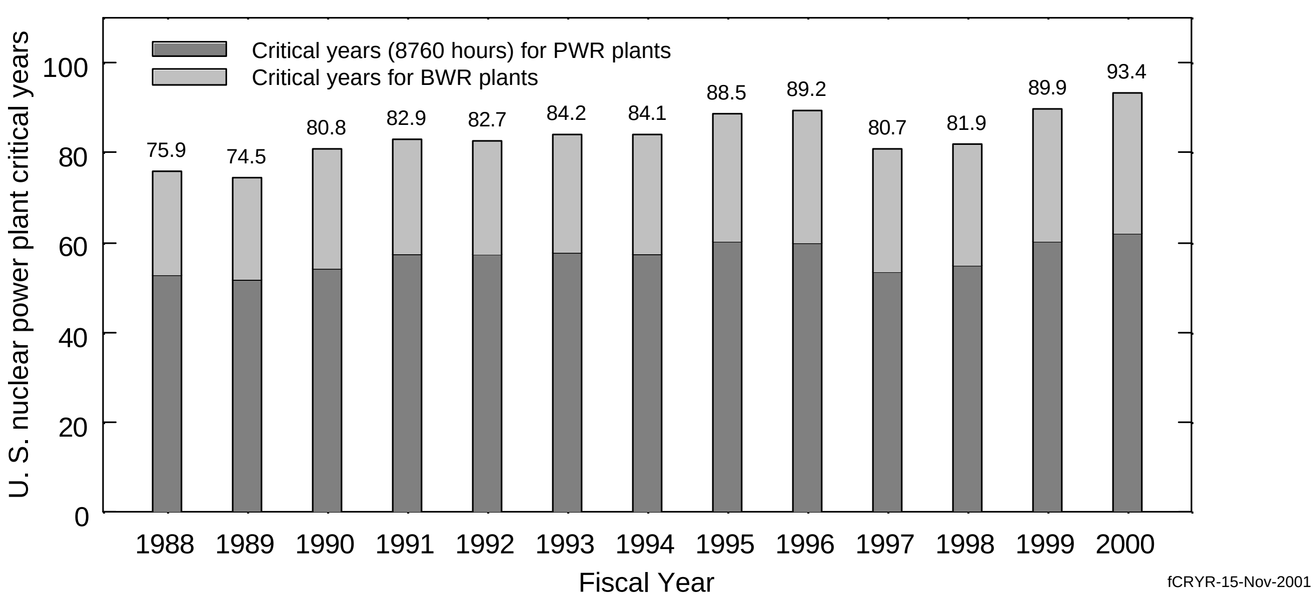


Figure A3-16

ROP Summary Information

(See ADAMS Accession No. ML020530739)

Reactor Oversight Process
Summary Information

The NRC provided oversight of 103 operating power reactors using the Reactor Oversight Process (ROP). NRR examined summary results of its ROP to determine whether it could identify any trends in the ROP's assessment of licensee performance. In particular, the staff examined trends in the number of plants in each column of the NRC's Action Matrix.

On average, approximately 75% of the plants were listed in the Licensee Response column of the ROP Action Matrix, which corresponds to the baseline level of NRC oversight. The chart below shows trends in the numbers of plants that are listed in the Regulatory Response, Degraded Cornerstone, Multiple/repetitive Degraded Cornerstone, and Unacceptable Performance columns of the Action Matrix, which correspond to increasing levels of regulatory engagement with the licensee. A trend of degrading performance would be one that shows a migration of plants from the Licensee Response Column to one of the other columns in the Action Matrix. Although the chart appears to show this sort of trend, the staff believes that this trend can be attributed to several factors associated with initial start up of the ROP as discussed below.

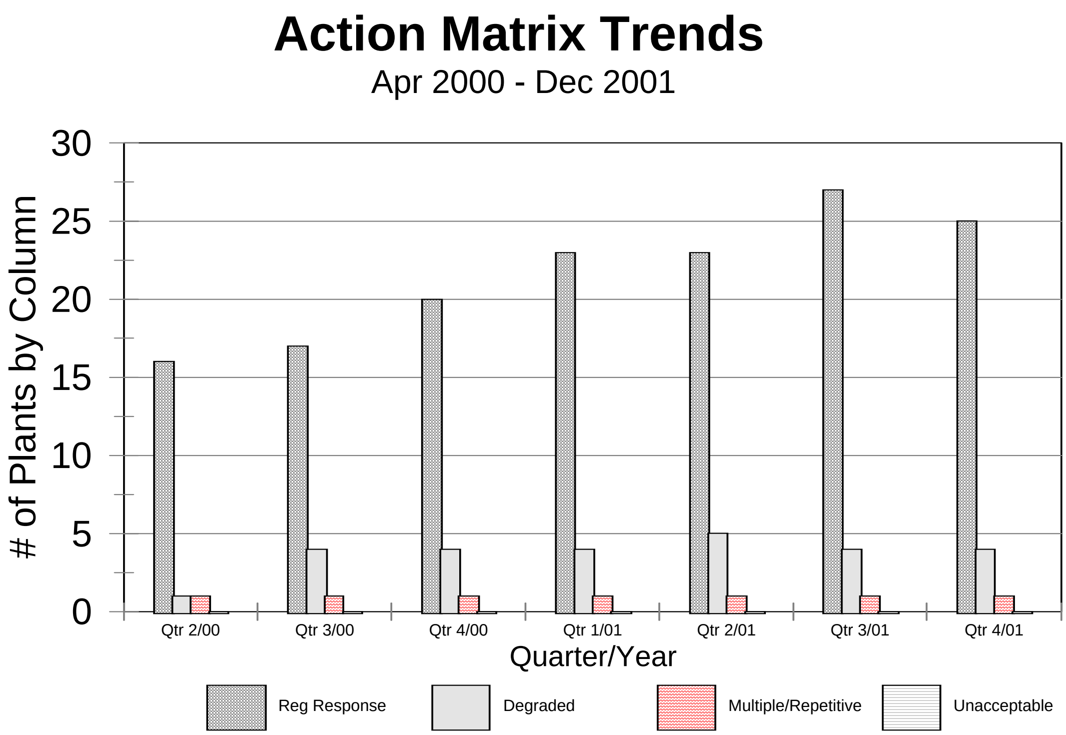


Figure A4-1

Notes for Figure A4-1:

1. This chart includes DC Cook units 1 and 2 beginning in Q2/2001.
2. Data current through March 18, 2002.

The ROP was intended to improve the focus of both licensees and NRC staff on the more risk-significant aspects of licensee performance. The staff has continued to work with industry to improve the ROP since initial implementation, such as enhancements to its risk-informed inspection procedures, improved SDP Phase 2 notebooks, and improvements to the guidance for performance indicators. These ongoing improvements, as well as increasing familiarity with the ROP, have likely enhanced the ability of both the NRC and licensees to identify the most risk-significant aspects of licensee performance.

A second factor contributing to an apparent increase in the number of plants in the Regulatory Response Column is that inspection findings that are determined to have greater than very low safety significance (green) are counted for 4 quarters when determining the appropriate column of the Action Matrix for licensees. Thus, for at least the first 4 quarters from the date of initial implementation of the ROP on April 2, 2000, the number of plants moving out of the Licensee Response Column has increased as inspection findings are accrued by plants under the ROP.

The chart shows an apparent drop in the number of plants in the Regulatory Response Column in the 4^{th} quarter of 2001. However, the 4^{th} quarter numbers will likely increase as the preliminary assignments of the significance of inspection findings in inspection reports are finalized using the Significance Determination Process (SDP). Final SDP results are generally not available until several months after the findings are identified, and are then used as an input to the Action Matrix for the period in which the performance issues occurred.