POLICY ISSUE
(Information)

March 27, 2009 SECY-09-0048

FOR: The Commissioners

FROM: Eric J. Leeds, Director
Office of Nuclear Reactor Regulation

SUBJECT: FISCAL YEAR 2008 RESULTS OF THE INDUSTRY TRENDS PROGRAM FOR OPERATING POWER REACTORS AND STATUS OF THE ONGOING DEVELOPMENT OF THE PROGRAM

PURPOSE:

This paper informs the Commission of the results of the U.S. Nuclear Regulatory Commission (NRC) Industry Trends Program (ITP) for fiscal year (FY) 2008. This paper also updates the Commission on the status of ongoing program development.

BACKGROUND:

The NRC staff implemented the ITP in 2001. The NRC uses industry-level indicators to monitor for adverse trends. After assessing adverse trends for safety significance, the NRC responds as necessary to any identified safety issues, including adjusting the inspection and licensing programs if necessary. One important output of the ITP is the annual agency performance measures reported to Congress on the number of statistically significant adverse industry trends in safety performance. This outcome measure is part of the NRC Performance and Accountability Report (PAR). In addition, the NRC annually reviews the results of the ITP and any actions taken or planned during the Agency Action Review Meeting. The NRC reports the findings of this review to the Commission. This paper is the eighth annual report to the Commission on the ITP.

NRC Inspection Manual Chapter (IMC) 0313, “Industry Trends Program,” contains ITP details, including definitions of indicators monitored and program descriptions.

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DISCUSSION:

Using the ITP, the staff monitors industry safety performance to identify and address adverse industry trends. The indicators are comprehensive and based on the best available data. An adverse trend exists if the slope of the regression line fitted to the long-term indicator data is a positive value.

The ITP also uses precursor events identified by the Accident Sequence Precursor (ASP) program to assess industry performance. Staff analyzes the occurrence rate of precursors to determine if an adverse trend exists. Staff uses the ASP results as one of the agency's monitored indicators.

In addition to the long-term indicators, the ITP uses a statistical approach based on prediction limits to identify potential short-term, year-to-year emergent issues before they become long-term trends.

The ITP provides a complement to the Reactor Oversight Process (ROP). The ITP monitors industry-level performance while the ROP provides oversight of individual plant conditions and events.

PROGRAM STATUS:

In FY 2007, the staff completed the development of the Baseline Risk Index for Initiating Events (BRIIE), an indicator that monitors 9 risk-significant initiating events for boiling water reactors and 10 events for pressurized water reactors (the additional event category is steam generator tube rupture). The indicator weights each initiating event according to its relative contribution to industry core damage frequency. The staff reported the status of BRIIE development in SECY-07-0063, "Fiscal Year 2006 Results of the Industry Trends Program for Operating Reactors and Status of the Ongoing Development of the Program," dated April 3, 2007. In its staff requirements memorandum (SRM), "Briefing on Results of the Agency Action Review Meeting (AARM)—Reactors," dated June 14, 2007, the Commission directed that "the staff should provide to the Commission for approval a paper that describes the Baseline Risk Index for Initiating Events and plans for its use as a new industry-wide indicator. As part of this paper, the staff should discuss its communication plan."

Staff provided the Commission paper describing the BRIIE and the related communication plan in SECY-07-0184, "Industry Trends Program for Operating Power Reactors—Baseline Risk Index for Initiating Events," dated October 22, 2007. In this paper, the staff recommended that the Commission approve implementation of the BRIIE as a new performance indicator for the ITP. In its SRM of December 21, 2007, related to SECY-07-0184, the Commission approved the staff's recommendation. However, the Commission directed the staff to develop a public communication strategy to explain the meaning of the BRIIE, its underlying concept, and its intended use before making the information publicly available and before beginning the practice of reporting the BRIIE results to Congress. The Commission also directed that, when making the BRIIE publicly available, the staff should provide supporting data where appropriate and update the NRC public Web site to discuss the BRIIE.

These initiatives were completed in May 2008.

In SECY-08-0041, "Fiscal Year 2007 Results of the Industry Trends Program for Operating Power Reactors and Status of the Ongoing Development of the Program," the staff committed to incorporate the BRIIE concept into NRC IMC 0313 and to formally report BRIIE results as an ITP indicator in this Commission paper. The staff also committed, in SECY-06-0076, "Fiscal Year 2005 Results of the Industry Trends Program for Operating Power Reactors and Status of the Ongoing Development of the Program," to revise IMC 0313 to include a process to ensure revised or updated data (such as data from inspection findings and ASP results) are included, as appropriate, in the performance indicator for Significant Events. The agency issued the revision to IMC 0313 on May 29, 2008, to address both the new process and the BRIIE concept.

The following sections provide the ITP and BRIIE results for FY 2008.

FY 2008 LONG-TERM INDUSTRY TREND:

Based on the ITP indicators and the ASP program results, the staff did not identify any statistically significant adverse trends in industry safety performance through the end of FY 2008. The graphs in Enclosure 1 show the long-term ITP indicator trends and the ASP precursor data. The ASP program considers an event with a conditional core damage probability (CCDP) or increase in core damage probability (ΔCDP) greater than or equal to 1×10^{-6} to be a precursor.

Figure 14 of Enclosure 1 is a graph depicting the occurrence rate of total precursors by fiscal year. It shows the occurrence rate for all precursors by fiscal year during the period FY 1988 - FY 2007. The staff evaluated precursor data from FY 2001 to FY 2007 to identify statistically significant adverse trends. A review of the data reveals (1) a statistically significant decreasing trend for all precursors during this 7-year period, and (2) a statistically significant decreasing trend for precursors with a CCDP or ΔCDP greater than or equal to 1×10^{-4} during this same period. The staff chose FY 2001 as the starting point for trend analyses to provide a data period with a consistent ASP program scope and to align it with the first full year of the ROP. ASP program changes in FY 2001 (e.g., inclusion of Significance Determination Process findings and external initiated events) significantly increased the number of precursors identified compared to those identified in previous years. The data period for trending analyses ends in FY 2007 (the last full year of completed ASP analyses) but will become a rolling 10-year period in the future.

The ASP program also provides the basis for the safety performance measure of zero "number of *significant* accident sequence precursors of a nuclear reactor accident." This is one measure associated with the safety goal established in the NRC's Strategic Plan. A *significant* precursor is an event that has a probability of at least 1 in 1,000 (greater than or equal to 1×10^{-3}) of leading to a reactor accident. A review of the data reveals that the mean occurrence rate of *significant* precursors does not exhibit a statistically significant trend for the period FY 2001-FY 2008. The staff identified no *significant* precursors in FY 2008.

The staff reported the results of the ASP program to the Commission in SECY-08-0145, "Status of the Accident Sequence Precursor Program and the Development of Standardized Plant Analysis Risk Models," dated October 1, 2008.

FY 2008 SHORT-TERM INDUSTRY PERFORMANCE:

In addition to the long-term trend monitoring, the staff uses a statistical approach based on prediction limits to identify potential short-term, year-to-year emergent issues before they become long-term trends. Enclosure 2 shows the short-term results and the prediction limits for each of the ITP indicators. None of the indicators exceeded its prediction limit in FY 2008. Short-term FY 2008 data did not reveal any issues that warranted additional analysis or significant adjustments to the nuclear reactor safety inspection or licensing programs.

FY 2008 BRIIE RESULTS:

The BRIIE concept provides a two-level approach to industry performance monitoring: (1) it tracks several types of events that could potentially start ("initiate") a challenge to a plant's safety systems; (2) it assigns a value to each initiating event according to its relative importance to the plant's overall risk of damage to the reactor core; and (3) it calculates an overall indicator of industry safety performance.

The first level (referred to as Tier 1 performance monitoring) tracks and counts the number of times the initiating events that have an impact on plant safety occur in nuclear power plants during the year. Nine initiating event categories are monitored for boiling water reactors; ten for pressurized water reactors. The number of times that each event occurs is compared with a predetermined number of occurrences for that event. If the predetermined number is exceeded, one can infer possible degradation of industry safety performance. This annual tracking allows the NRC to intervene and engage the nuclear industry before any long-term adverse trends in performance emerge.

The second level (referred to as Tier 2 performance monitoring) addresses the risk to plant safety and core damage that each of the initiating events contributes. Each of the events is assigned an importance value, a ranking according to its relative contribution to overall risk to plant safety. The greater the contribution of the event to overall risk, the higher the importance value that is assigned to the event. Using statistical methods, the importance values are combined with the number of times the events occur during the year to calculate a number that indicates how much the overall industry risk of damage to the reactor core has changed from a baseline value. A report is made as part of the NRC PAR if the BRIIE combined industry value reaches or exceeds a threshold value of 1×10^{-5} per reactor critical year along with actions that have already been taken or are planned in response.

Enclosure 3 provides the Tier 1 and Tier 2 BRIIE results. None of the initiating events tracked in Tier 1 exceeded its prediction limit in FY 2008. As shown in Enclosure 3, Figure 15, BRIIE Tier 2 (Change in CDF), the BRIIE combined industry value in FY 2008 (-5.2×10^{-6} per reactor critical year) is well below the established threshold of 1×10^{-5} per reactor critical year.

RESOURCES:

NRR staff estimates resource needs of approximately 0.5 Full-Time Equivalent (FTE) staff and $425,000 for ongoing ITP implementation in each of FY 2009 and FY 2010. The resources are included in the FY 2009 budget and FY 2010 budget request as part of the Reactor Oversight Process (ROP) in Subprogram: Reactor Oversight; Planned Activity: Reactor Performance Assessment. The Office of Nuclear Regulatory Research (RES) provides indirect support to the ITP in the areas of operating experience data and models developed and budgeted under other RES programs such as the simplified plant analysis risk program, the ASP program, and the reactor operating experience data collection and analysis program. The ITP uses the results of RES work in the ASP program to assess industry performance although the RES work is funded and performed completely separate from the ITP. RES has included 5.3 FTE and $487,000 in both the FY 2009 budget and FY 2010 budget request for their work. The resources budgeted in the Office of Nuclear Reactor Regulation and RES are adequate for ongoing ITP implementation. Resources required in future years beyond FY 2010 would be addressed during the Planning, Budgeting, and Performance Management (PBPM) process of the respective year.

COORDINATION:

The Office of the Chief Financial Officer has reviewed this paper and concurs. The Office of the General Counsel has reviewed this paper and has no legal objection.

/RA/

Eric J. Leeds, Director
Office of Nuclear Reactor Regulation

Enclosures:
1. Fiscal Year 2008 Long-Term Industry Trends Results
2. Fiscal Year 2008 Short-Term Industry Performance
3. Fiscal Year 2008 BRIIE Results

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FISCAL YEAR 2008 LONG-TERM INDUSTRY TRENDS RESULTS

No statistically significant adverse trends were observed in the Industry Trends Program performance indicator data from the most recent 10 years (fiscal year (FY) 1999 to FY 2008) as indicated by the following graphs.

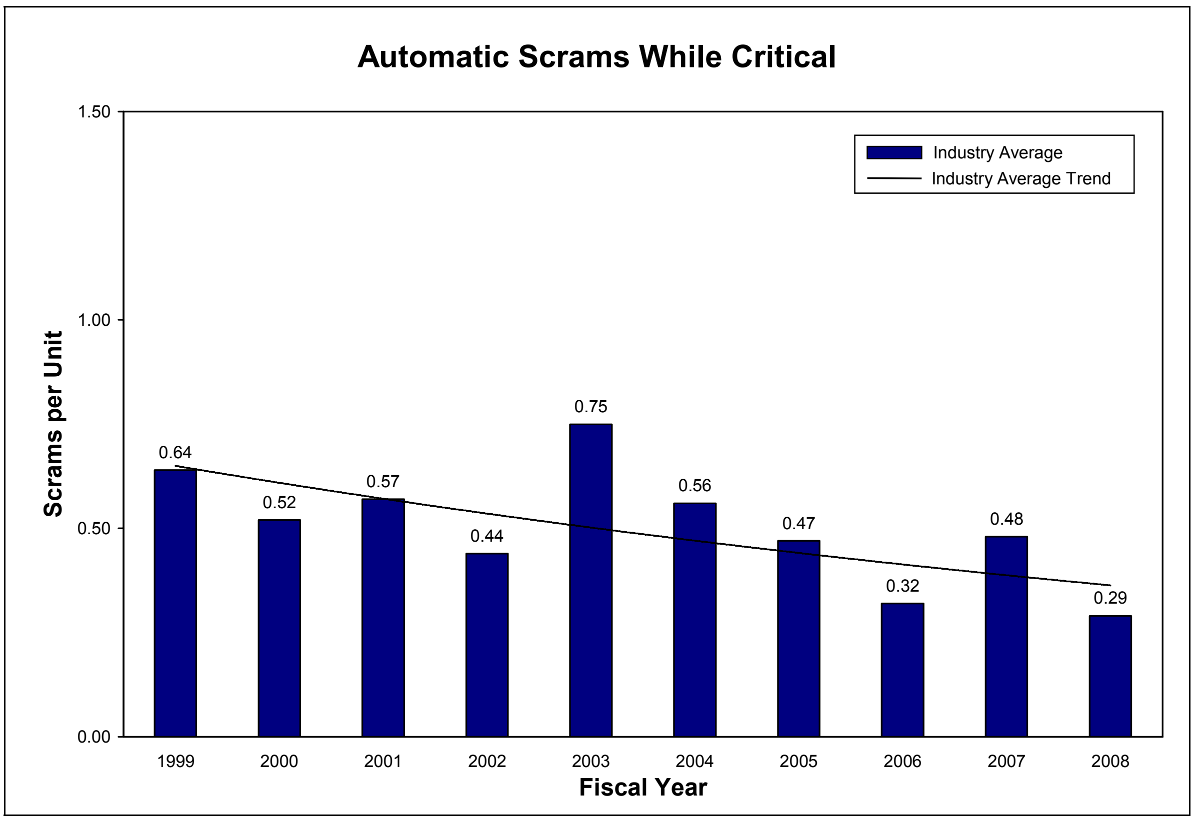


Figure 1. Automatic Scrams While Critical

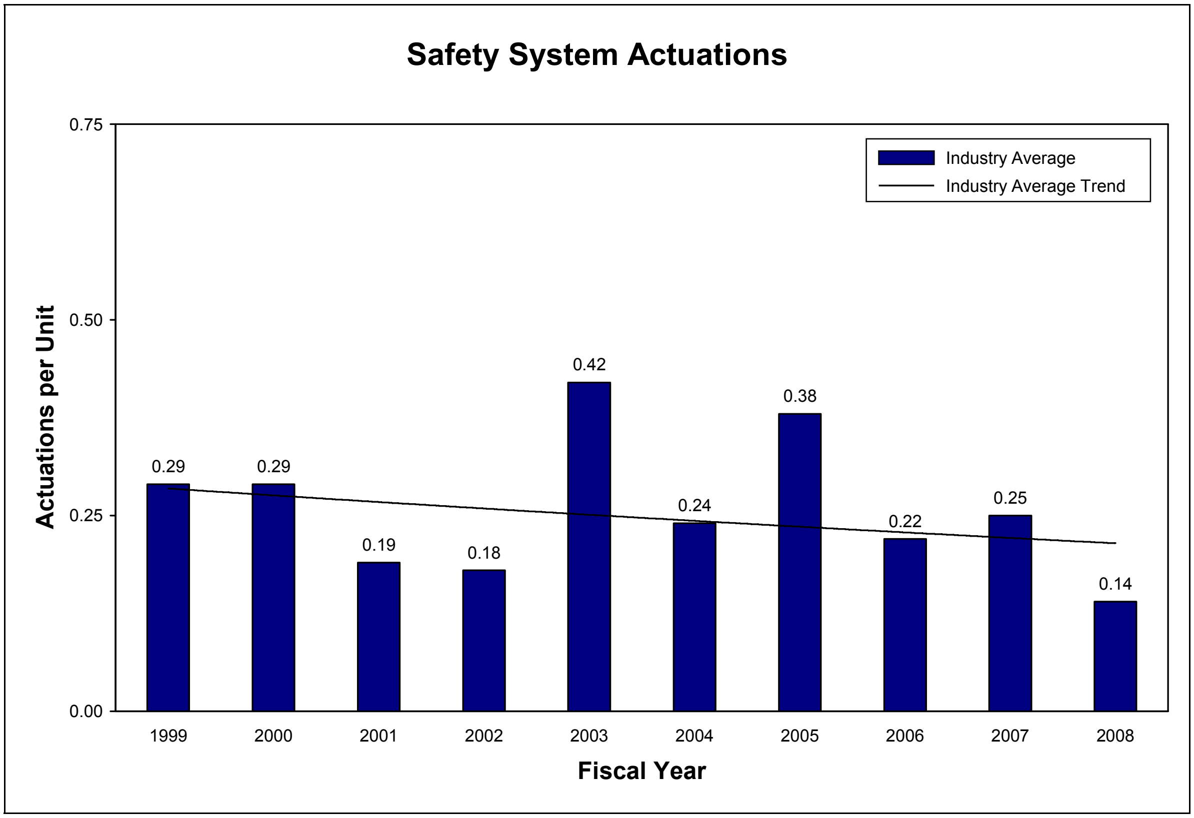


Figure 2. Safety Systems Actuations

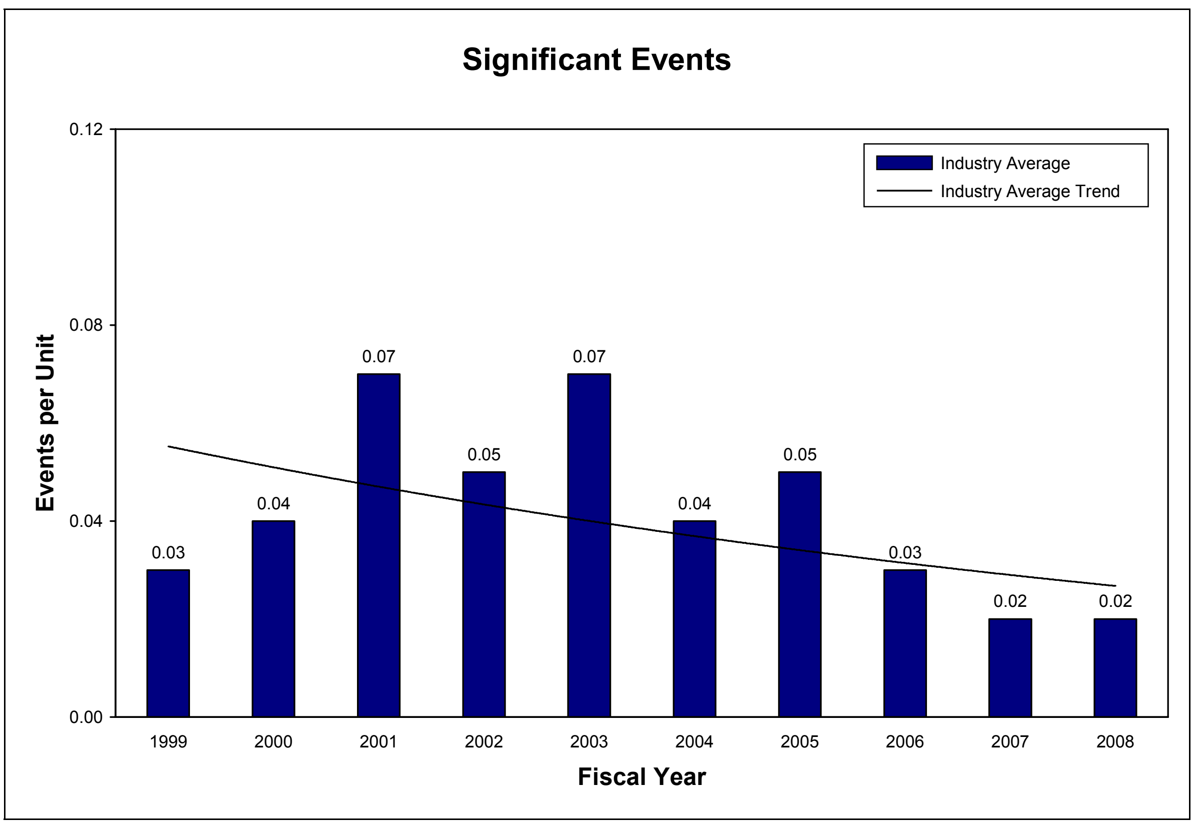


Figure 3. Significant Events

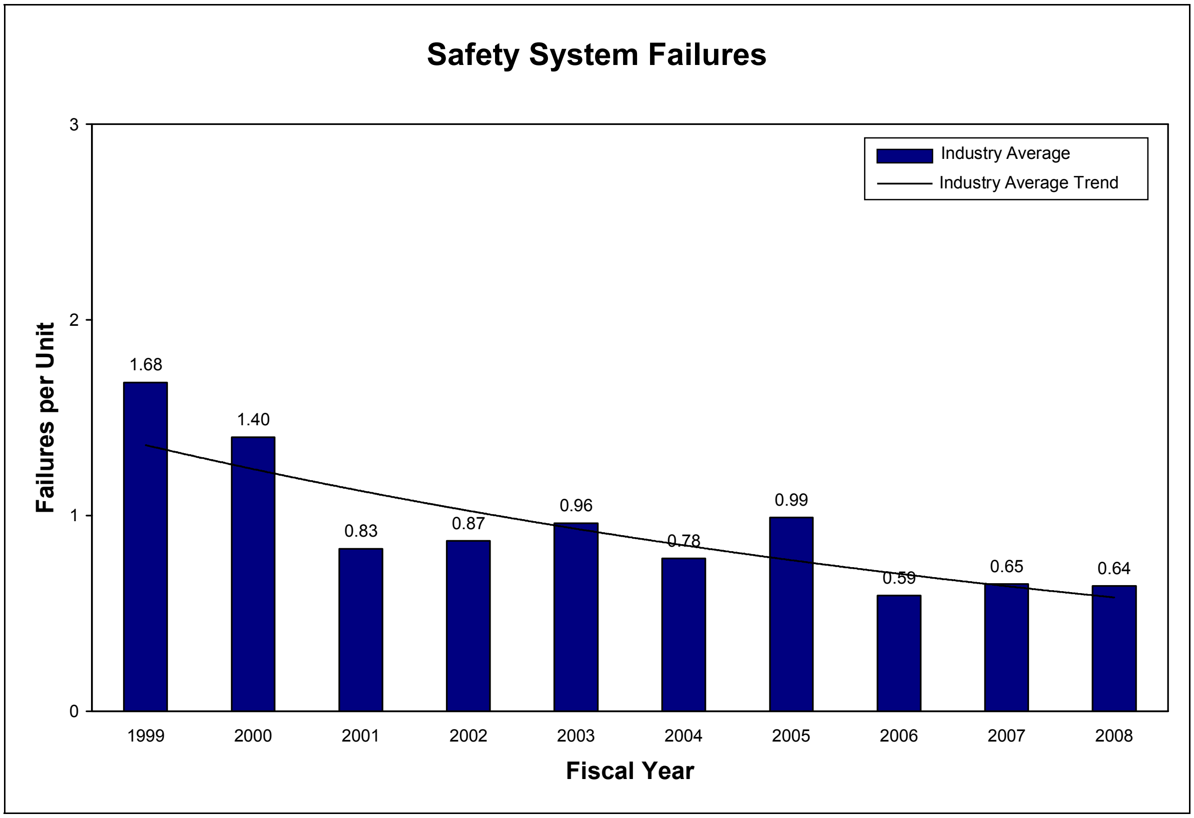


Figure 4. Safety System Failures

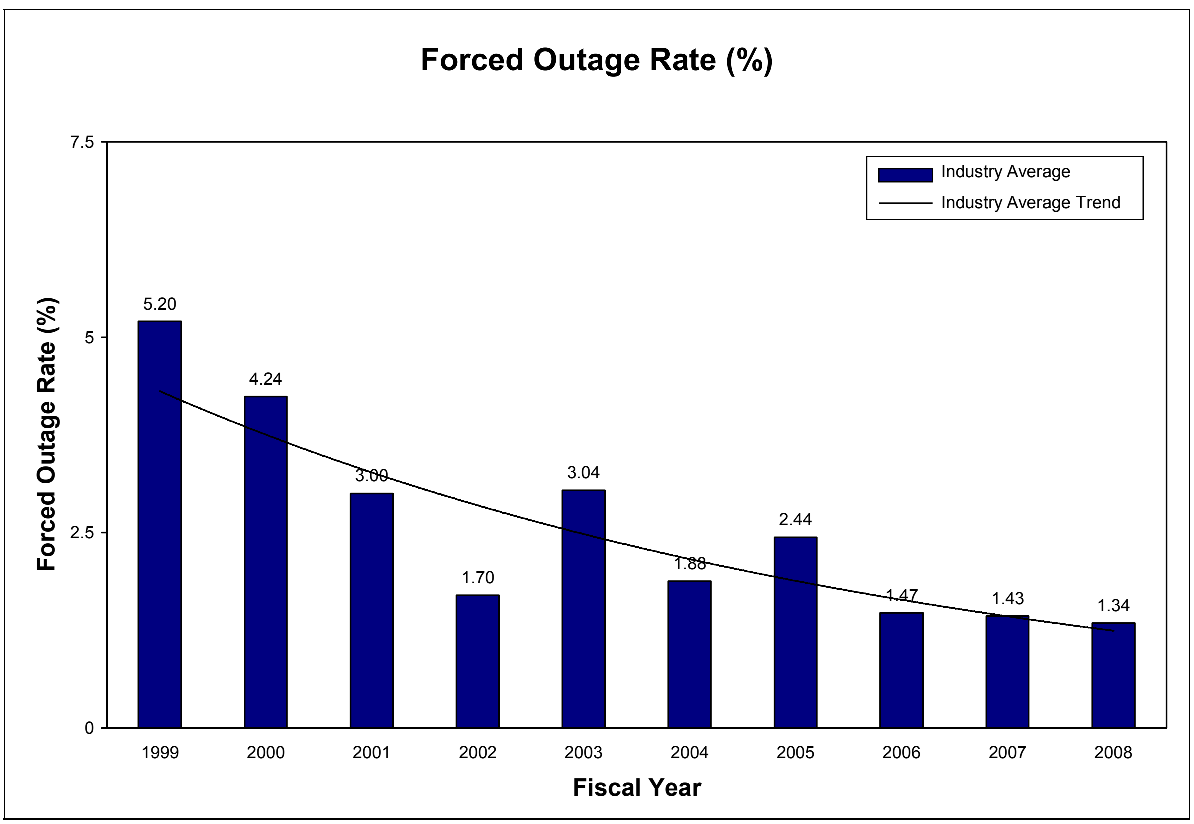


Figure 5. Forced Outage Rate

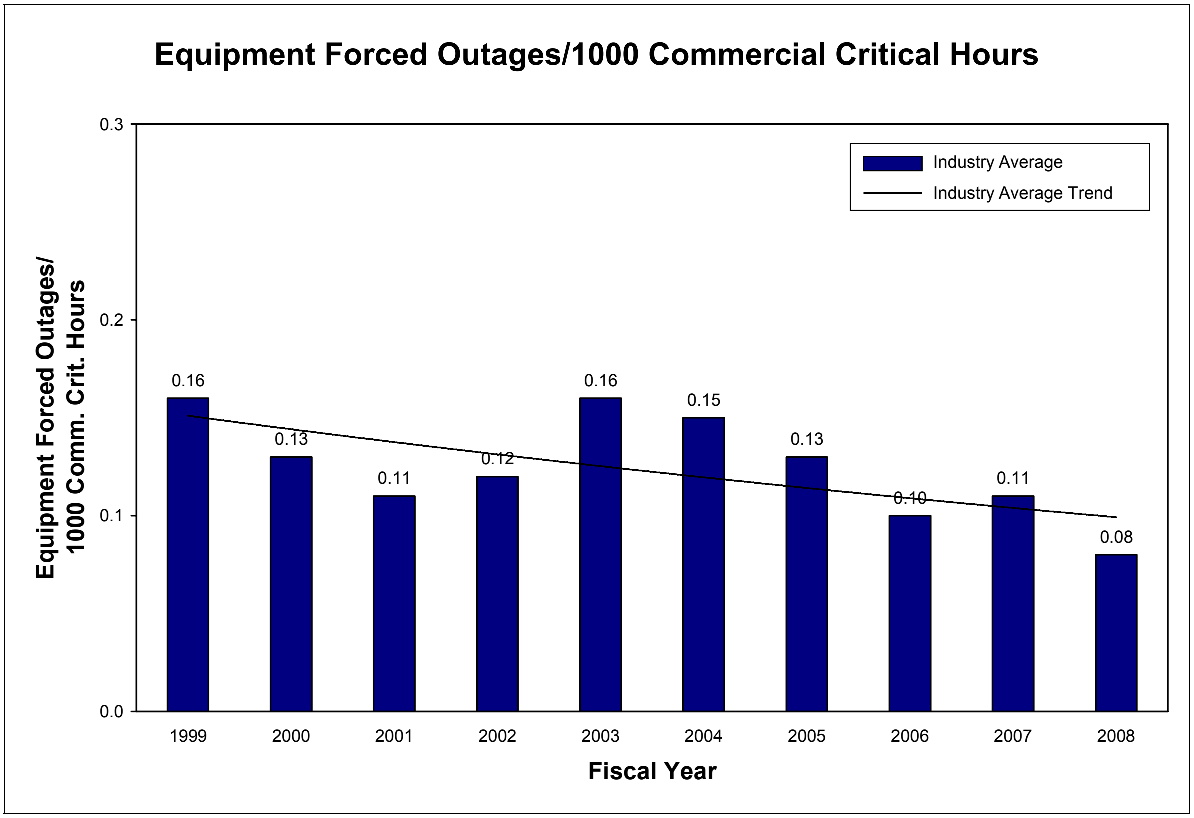


Figure 6. Equipment Forced Outages per 1000 Commercial Critical Hours

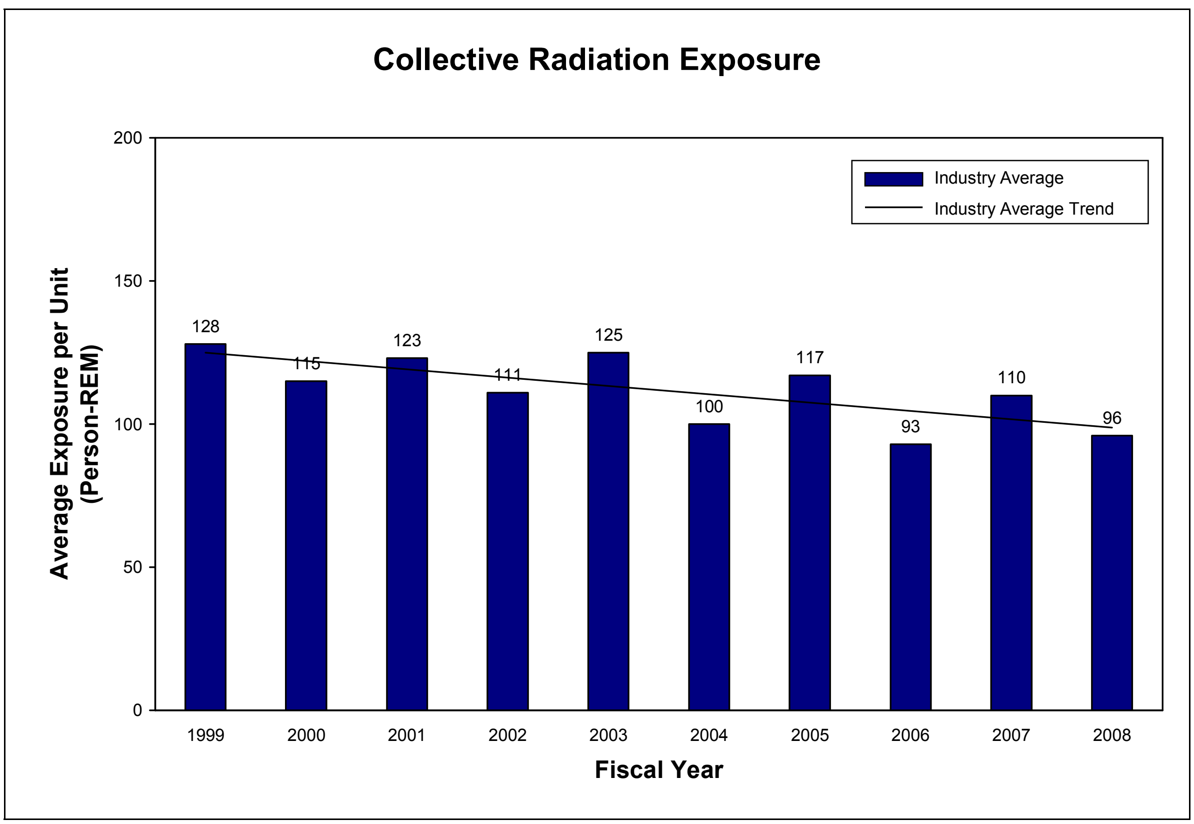


Figure 7. Collective Radiation Exposure

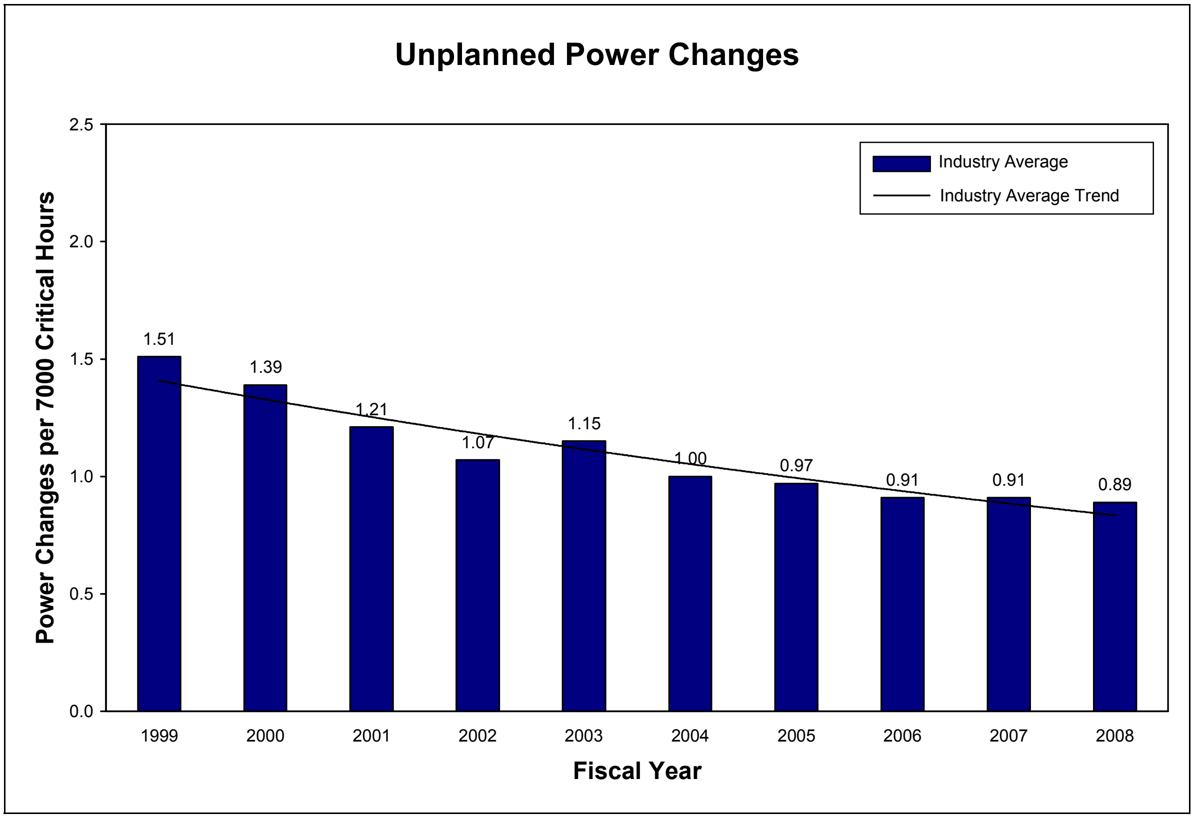


Figure 8. Unplanned Power Changes

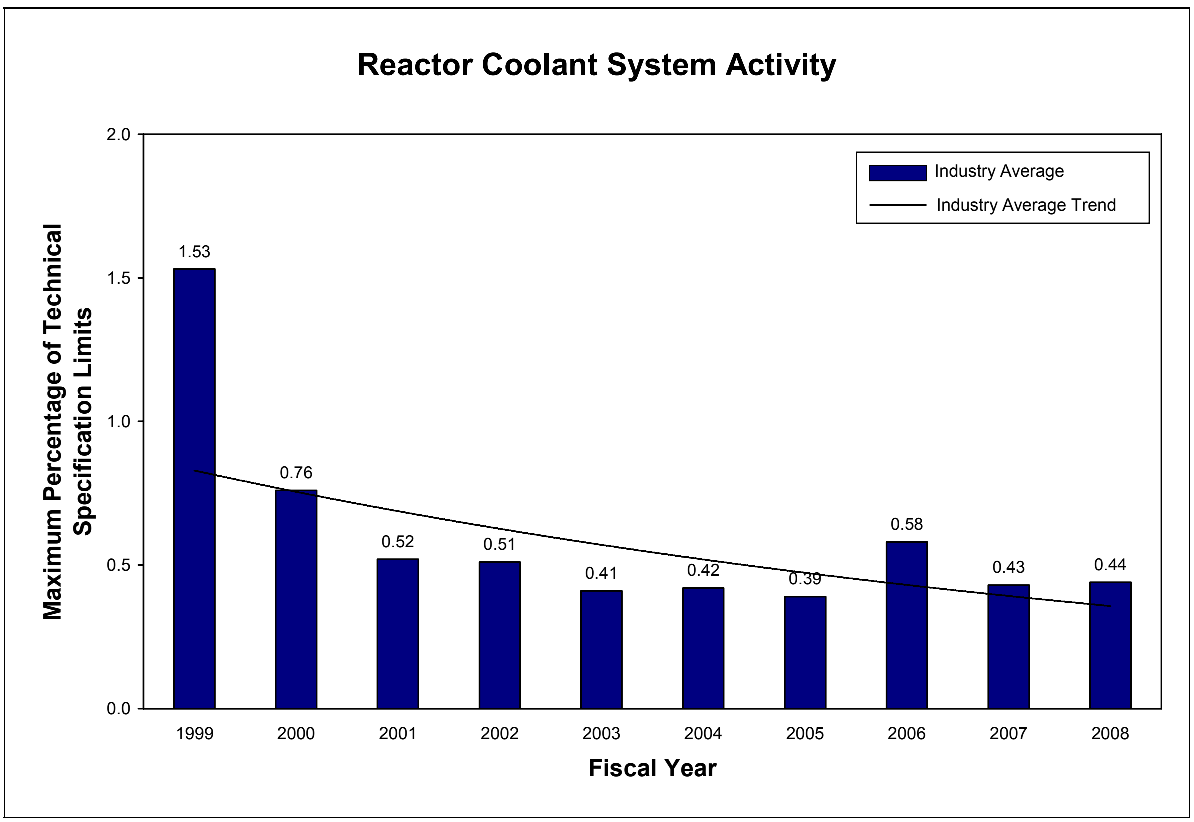


Figure 9. Reactor Coolant System Activity

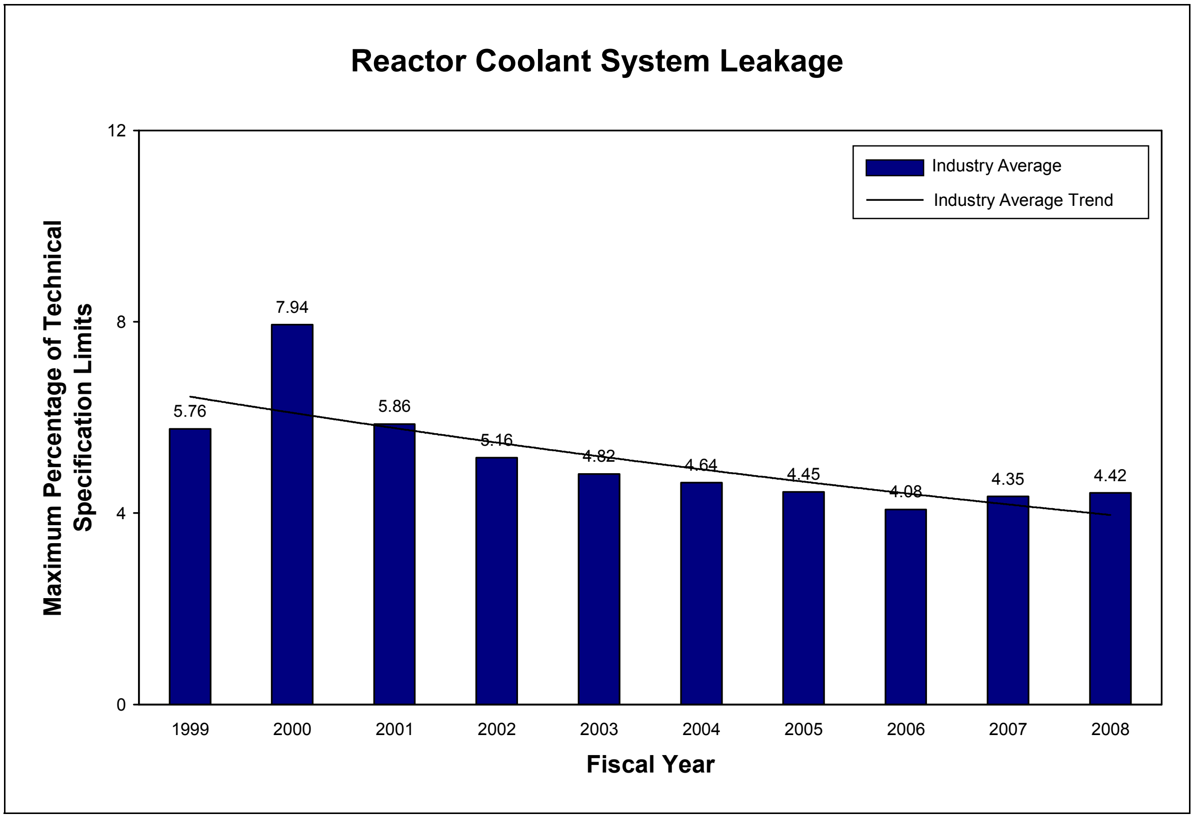


Figure 10. Reactor Coolant System Leakage

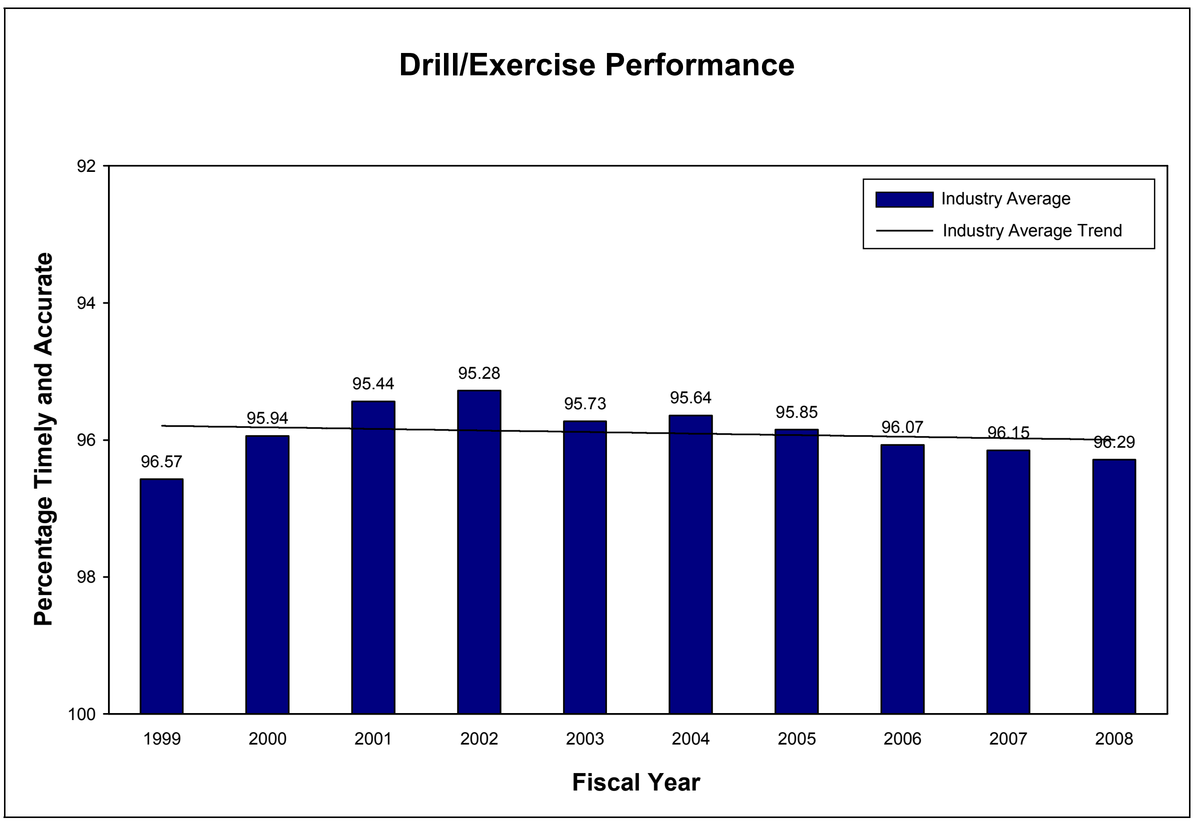


Figure 11. Drill/Exercise Performance

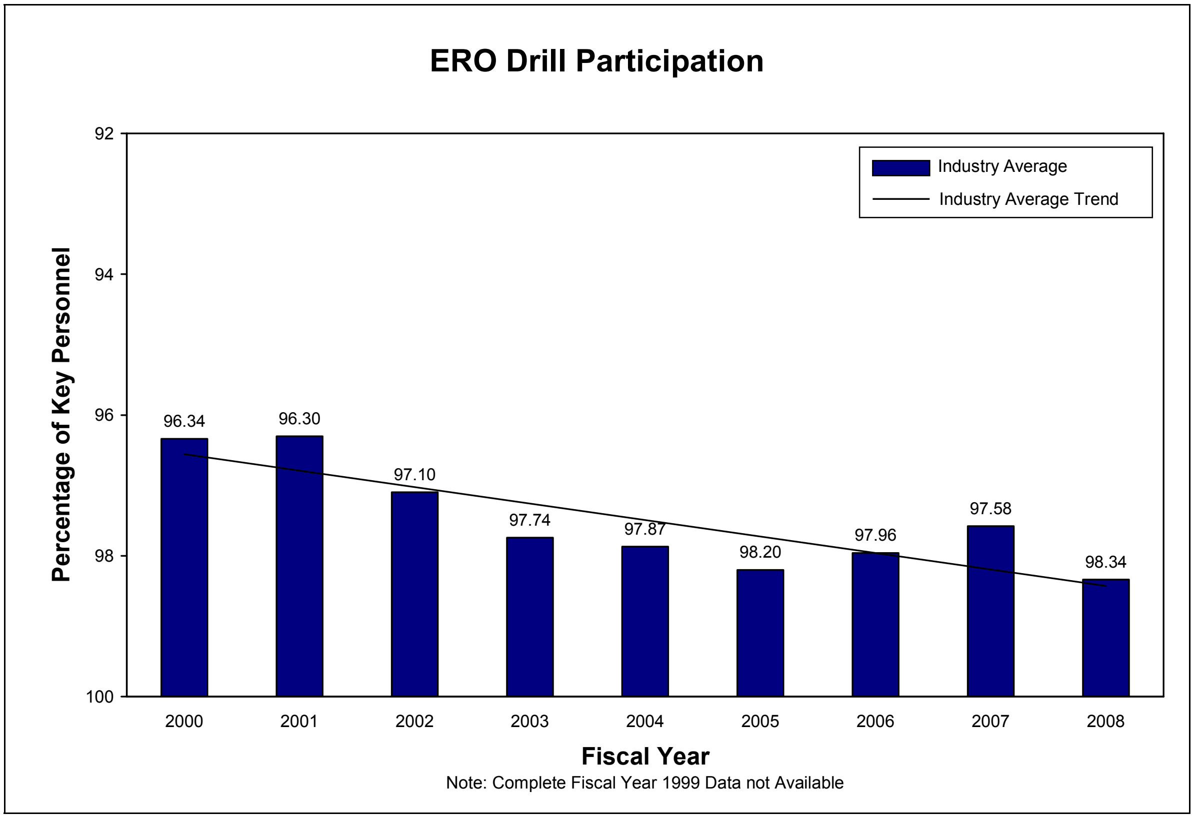


Figure 12. Emergency Response Organization Drill Participation

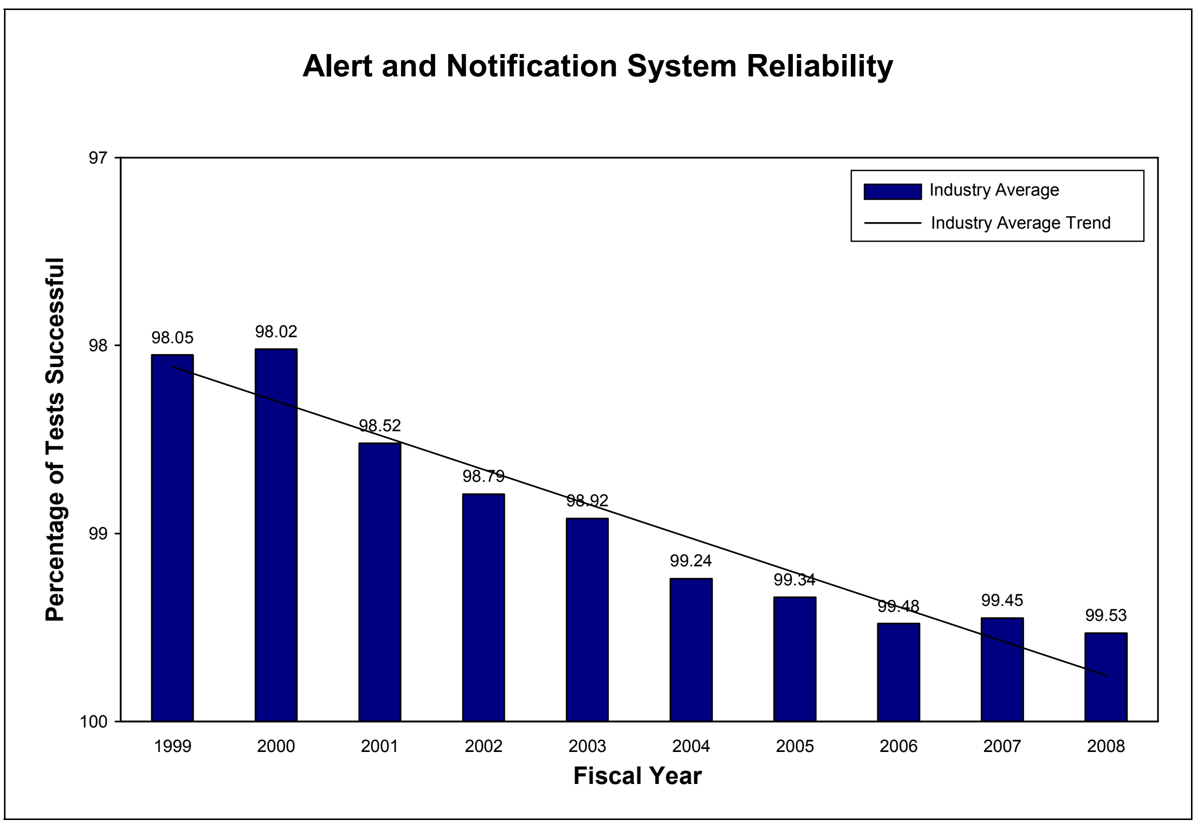


Figure 13. Alert and Notification System Reliability

Accident Sequence Precursors

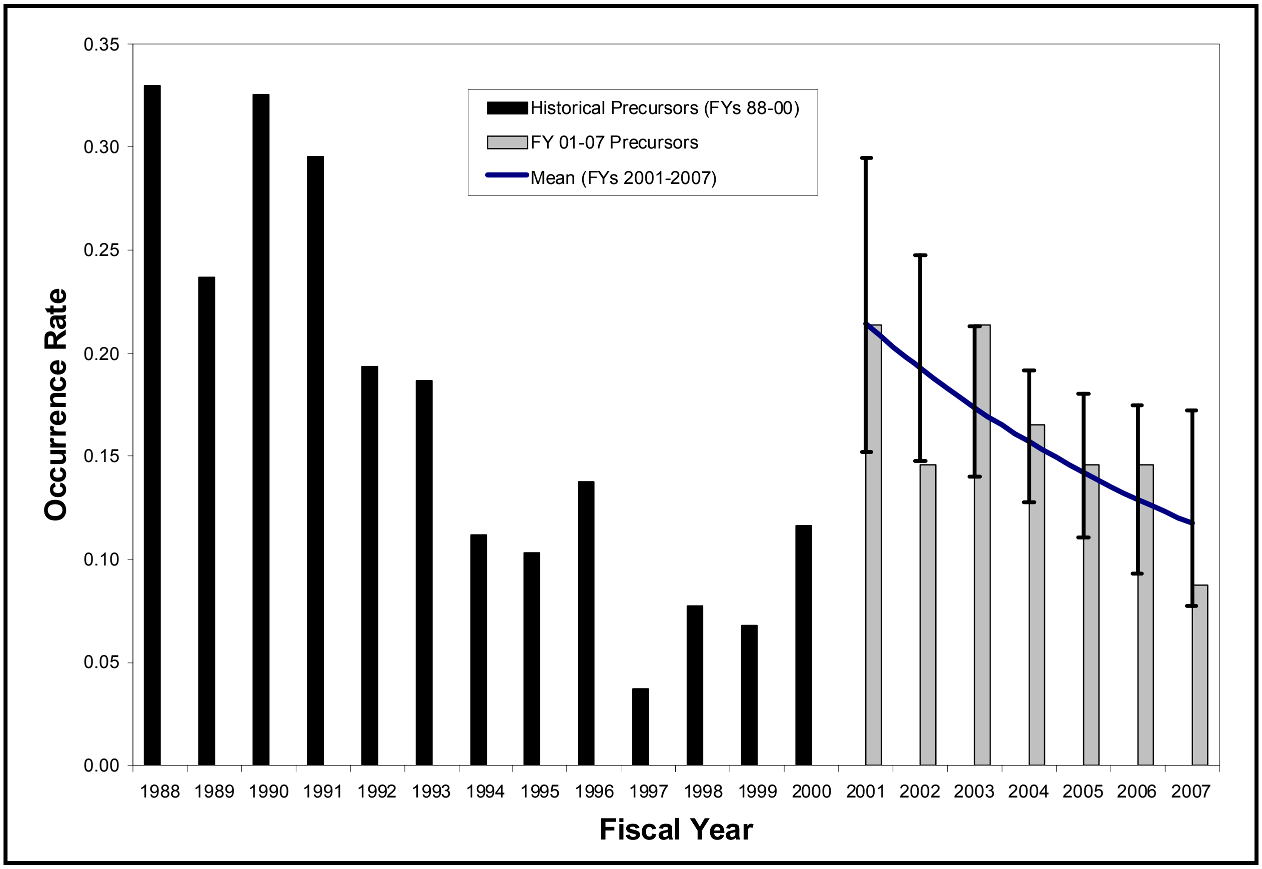
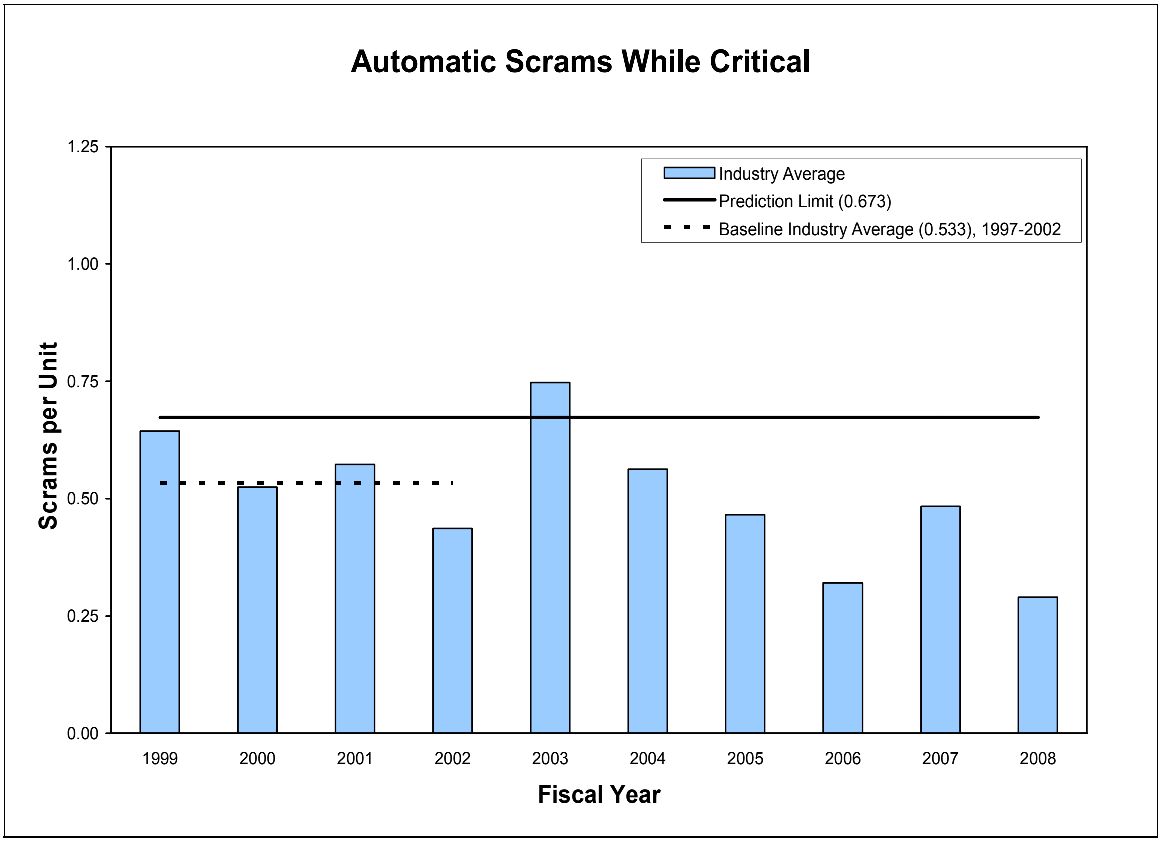


Figure 14. Accident Sequence Precursors

Total precursors—occurrence rate, by fiscal year. Data for FY 1988–FY 2000 are shown for historical perspective. A statistically significant decreasing trend (p-value=0.03) is detected for the FY 2001–FY 2007 period.

FISCAL YEAR 2008 SHORT-TERM INDUSTRY PERFORMANCE

The annual industry trend analysis compares the data for the most recent year with established short-term "prediction limits." The prediction limits are 95th percentiles of predictive distributions for the data. The predictive distributions are statistical probability distributions that describe expected future performance. They are derived from performance during "baseline" periods for each performance indicator (PI). Baseline periods are periods for each PI during which the data can be regarded as fairly constant and indicative of "current" performance. Therefore, for each PI, a series of trend analyses was performed to identify, if possible, a baseline period in which no statistically significant trend exists. In the Industry Trends Program (ITP) methodology, the minimum baseline period is at least 4 years, ending in the year with the most recent data (initially fiscal year (FY) 2002). If the most recent 4-year period satisfies the criteria, then the most recent 5-year period is considered. Successively longer periods are selected, as long as the statistical models fit and the test for trends shows little evidence of a trend. In the current methodology, whenever a new baseline period is sought, the period selected is the one that shows the least evidence of a trend. The results of the evaluation of the FY 2008 ITP PIs, using the established prediction limits, indicate that no PI exceeded its associated prediction limit in FY 2008, as evidenced by graphs of each PI with its FY 2008 data and associated prediction limit provided in the following pages.



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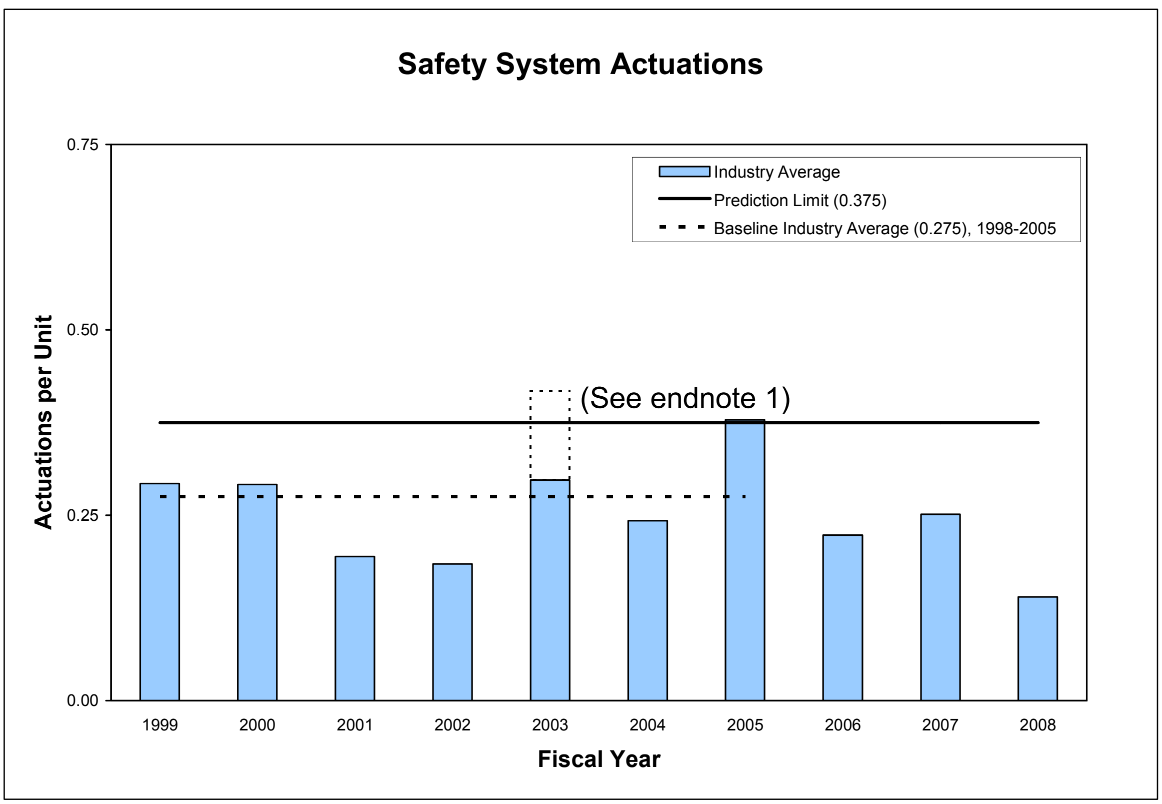

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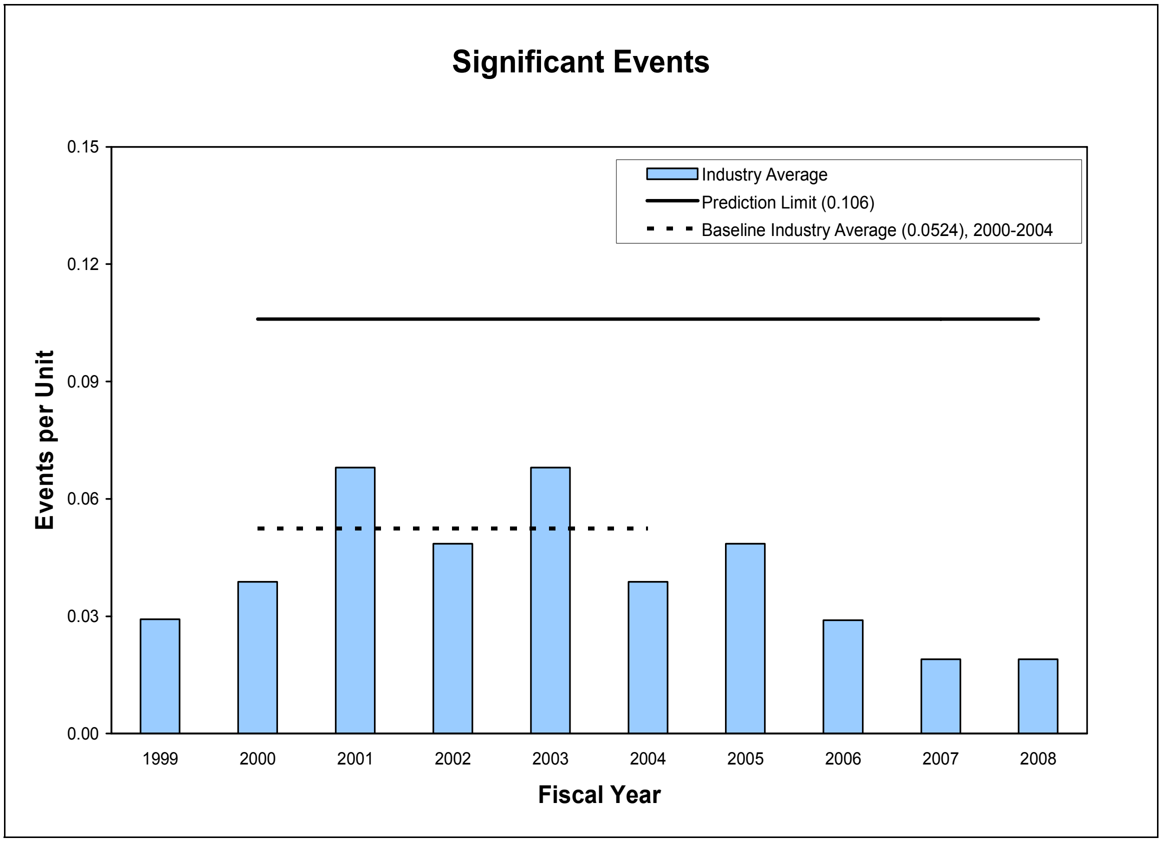
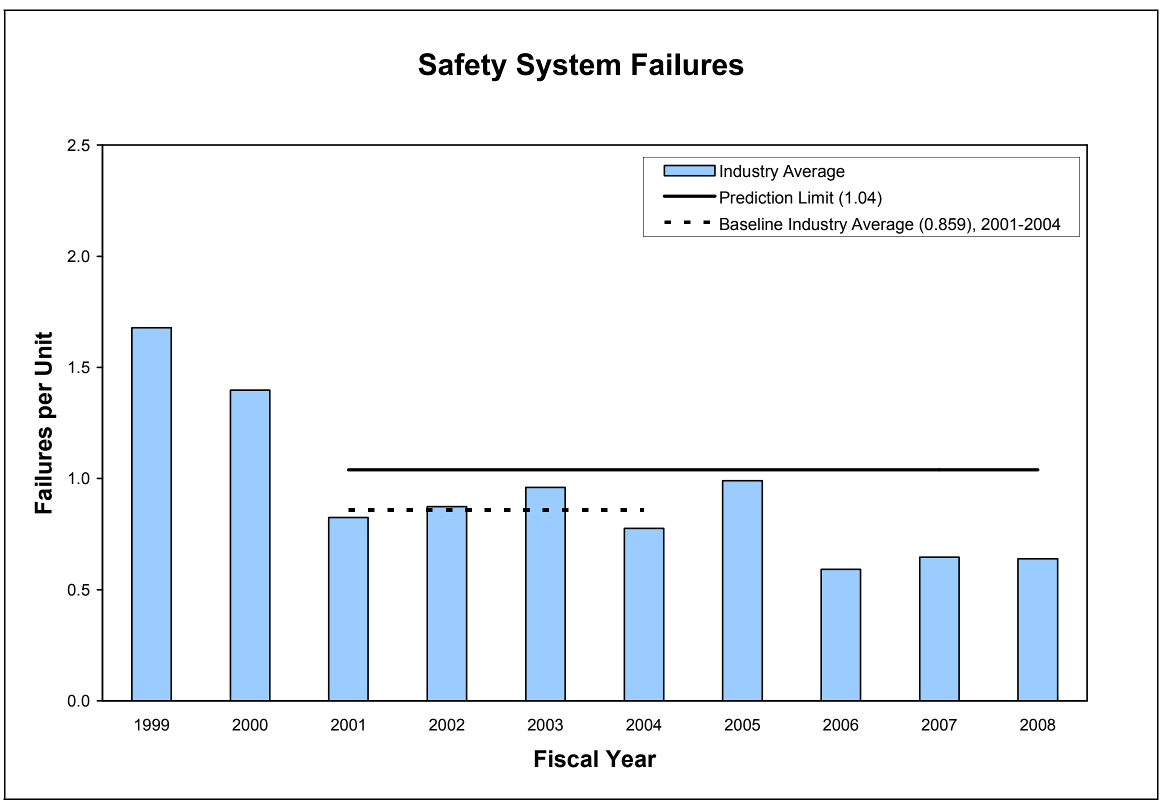


Figure 3. Significant Events



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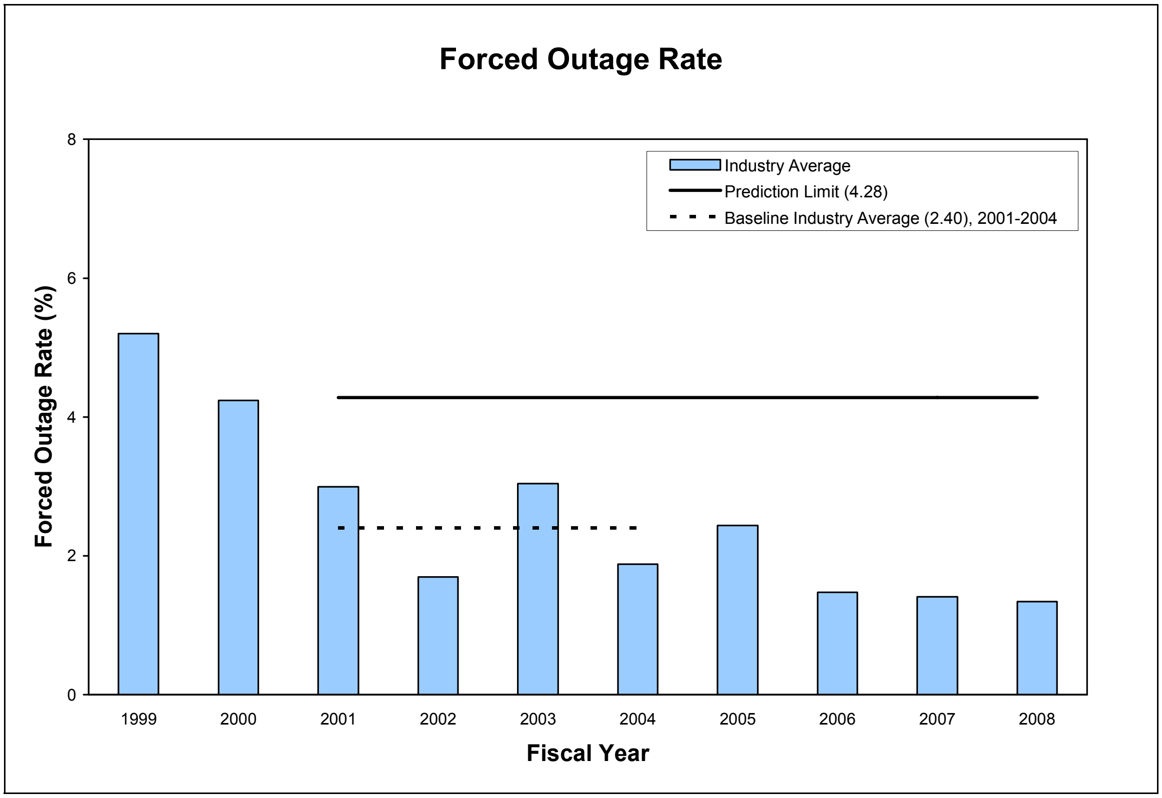

Figure 5. Forced Outage Rate

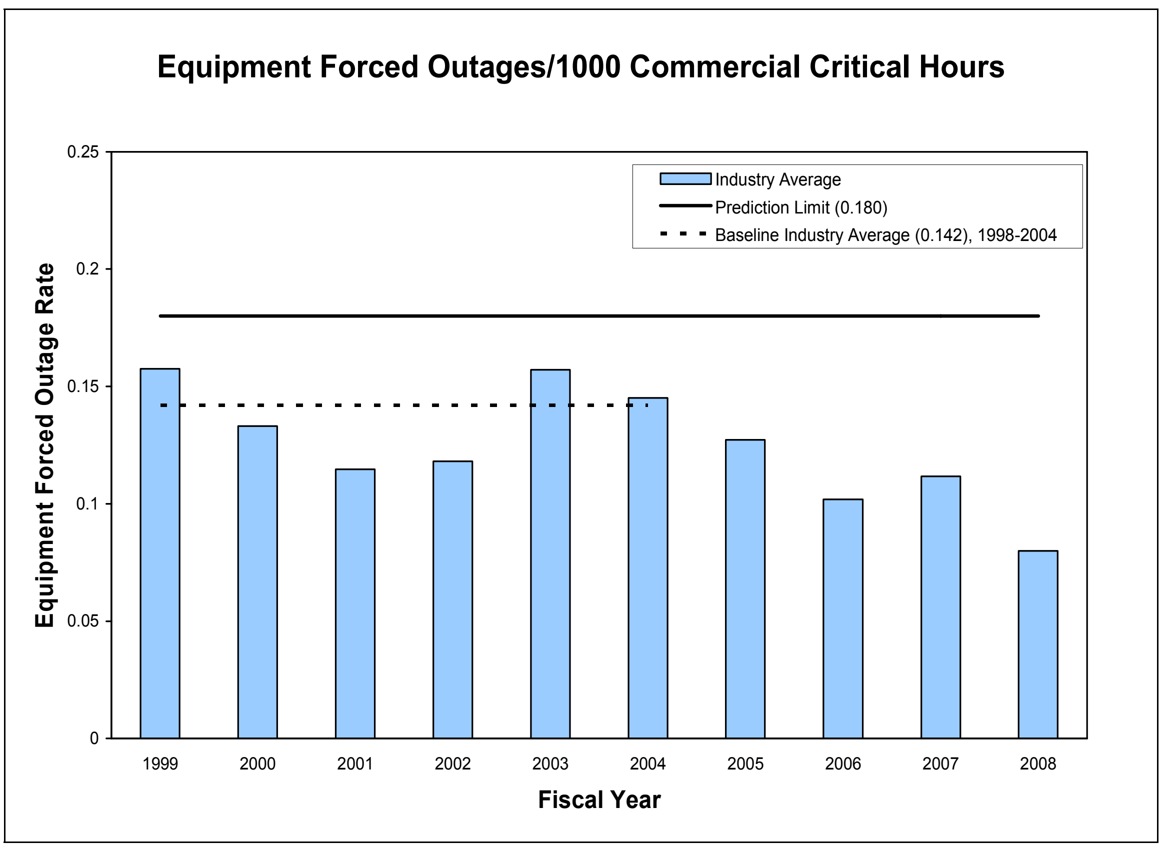

Figure 6. Equipment Forced Outages per 1000 Commercial Critical Hours

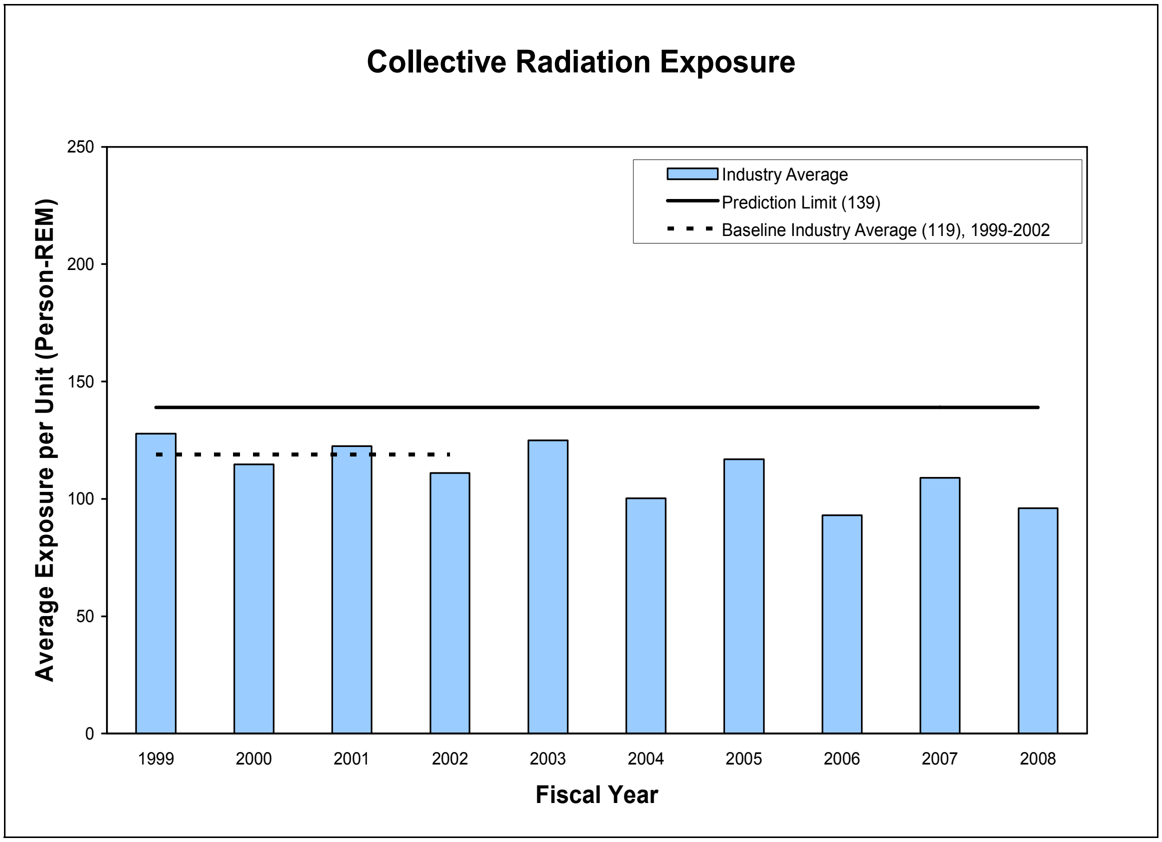

Figure 7. Collective Radiation Exposure

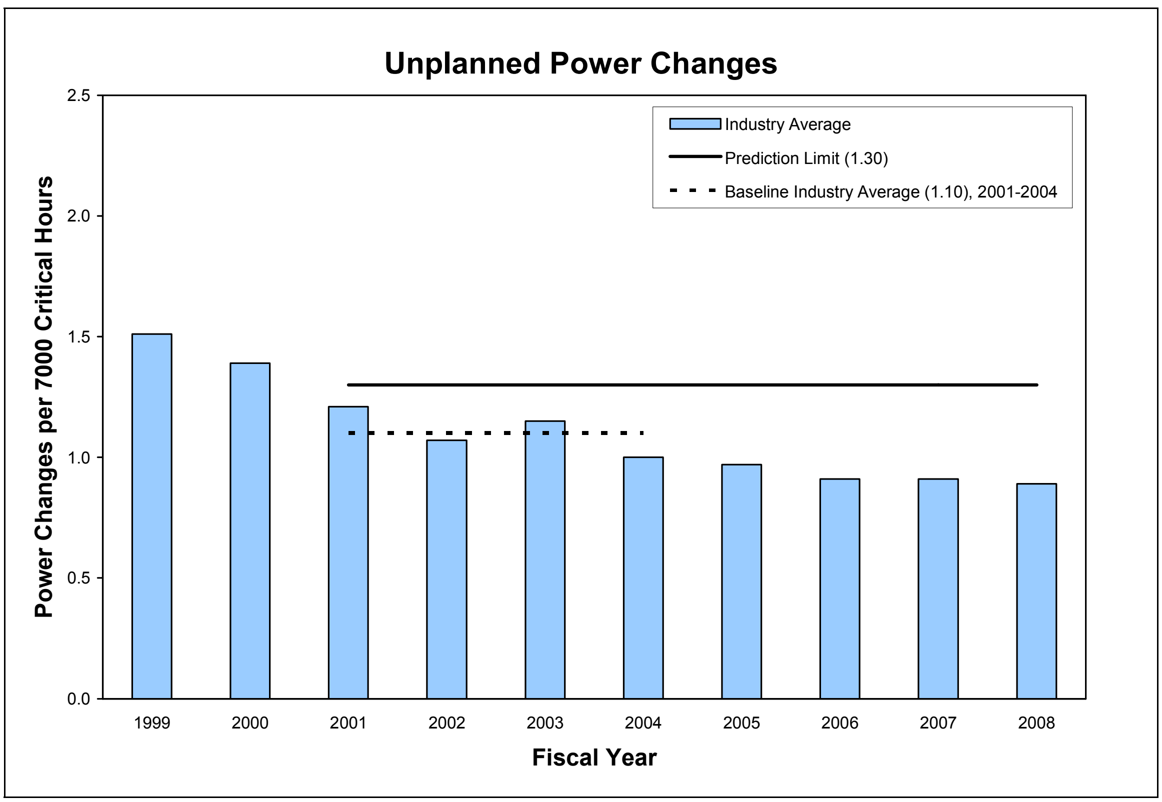

Figure 8. Unplanned Power Changes per 7000 Critical Hours

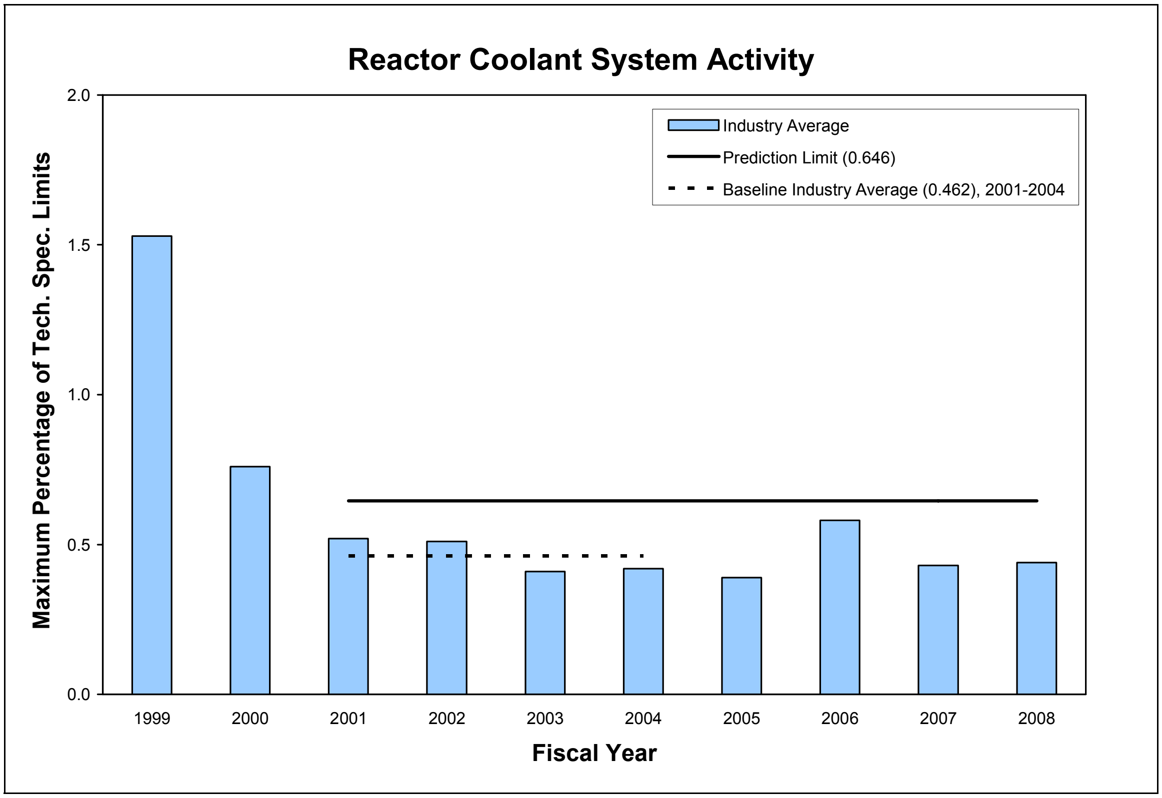

Figure 9. Reactor Coolant System Activity

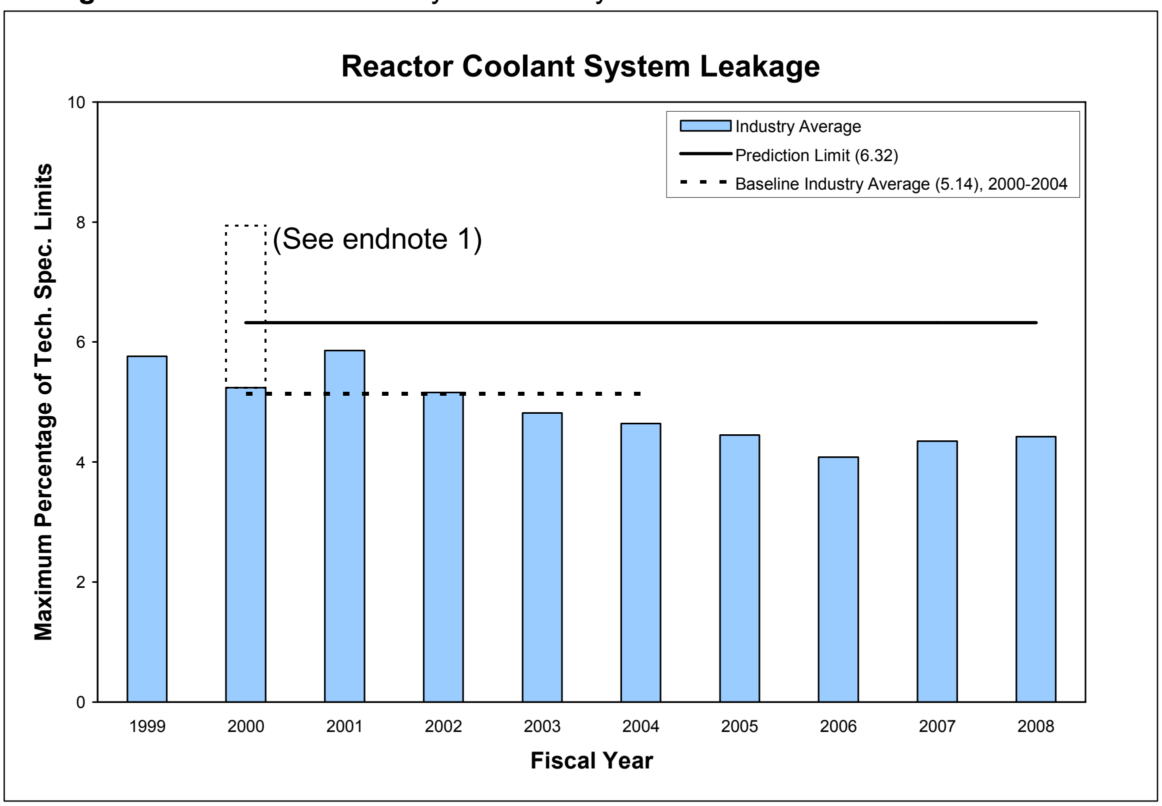

Figure 10. Reactor Coolant System Leakage

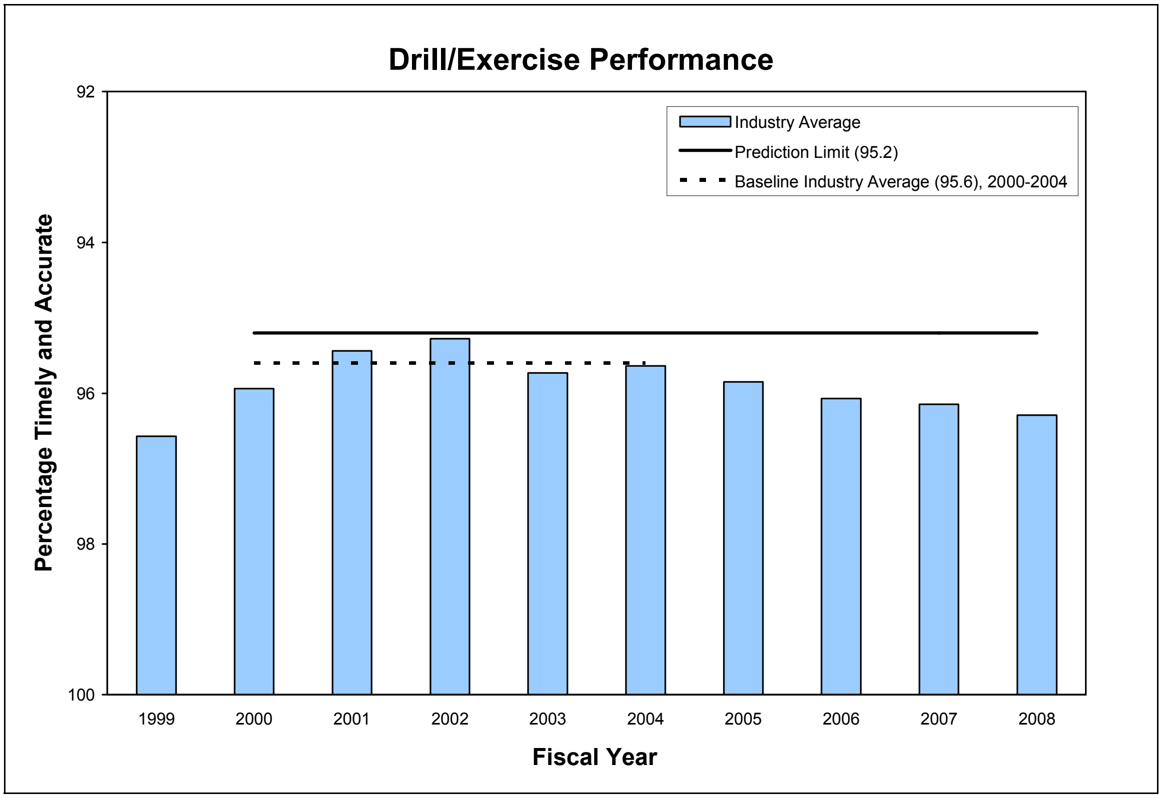

Figure 11. Drill/Exercise Performance

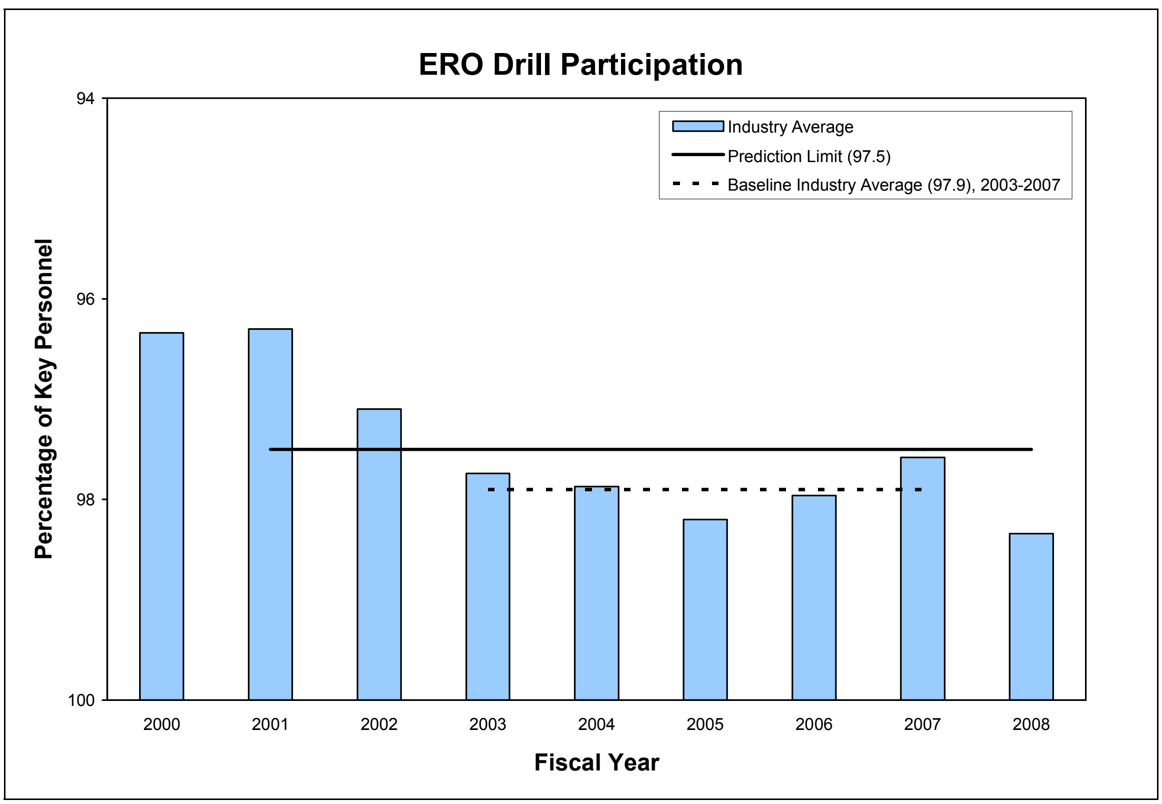

Figure 12. Emergency Response Organization Drill Participation

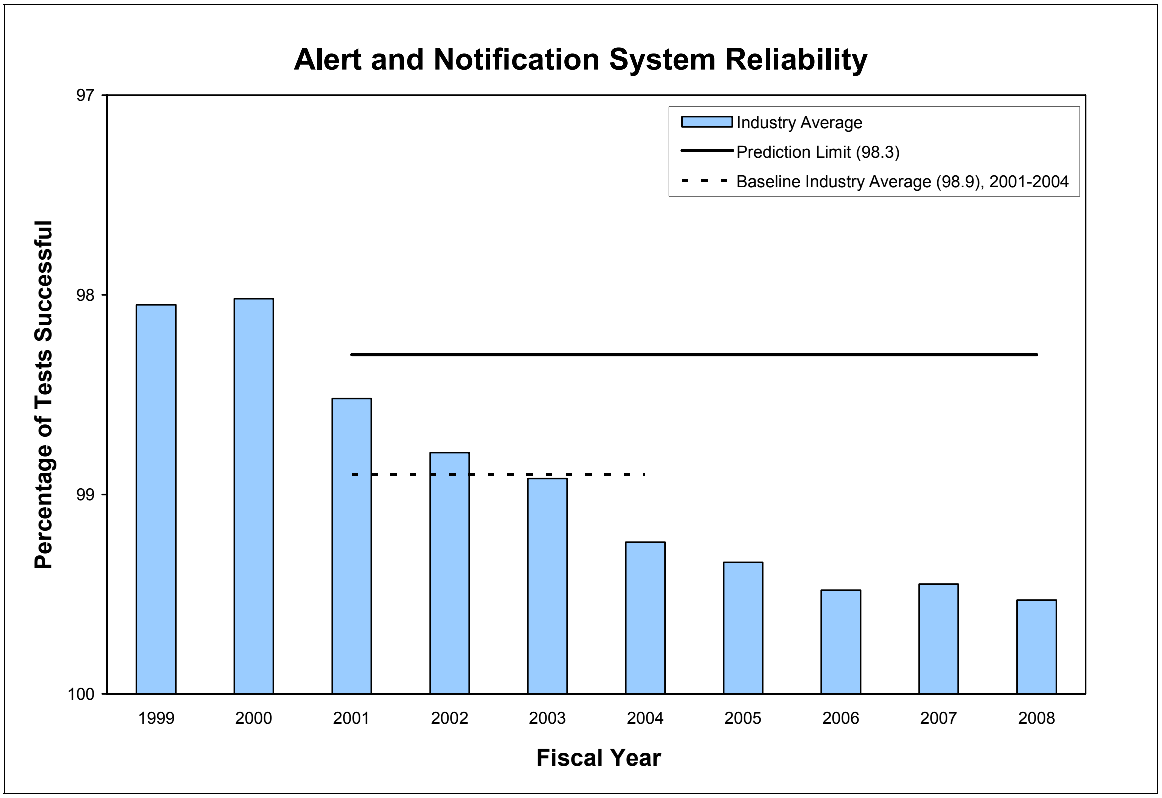

Figure 13. Alert and Notification System Reliability

NOTE 1: The 2003 blackout event in the safety system actuations graph (Figure 2) and the 2000 Indian Point 2 steam generator tube rupture event in the reactor coolant system leakage graph (Figure 10) were not included in the short-term data for the purpose of determining prediction limits. They were excluded from the development of the prediction limit models because they are considered outlier events that overly influenced the statistical analysis of the industry-wide data. Removing these events resulted in less restrictive prediction limits.

FISCAL YEAR 2008 BRIIE RESULTS

The Baseline Risk Index for Initiating Events (BRIIE) addresses the Initiating Event (IE) Cornerstone in the U.S. Nuclear Regulatory Commission's (NRC's) Reactor Oversight Program (ROP) for monitoring boiling water reactor and pressurized water reactor commercial nuclear power plants (NPP). It is based on NPP performance for the following 10 initiators:

Initiator	Acronym	Applicable Plants
General transient	TRAN	Both plant types, separately
Loss of condenser heat sink	LOCHS	Both plant types, separately
Loss of main feedwater	LOMFW	Both plant types
Loss of offsite power	LOOP	Both plant types
Loss of vital AC bus	LOAC	Both plant types
Loss of vital DC bus	LODC	Both plant types
Stuck open SRV	SORV	Both plant types, separately
Loss of instrument air	LOIA	Both plant types, separately
Very small LOCA	VSLOCA	Both plant types
Steam generator tube rupture	SGTR	Pressurized water reactors only

The BRIIE program, as described in NRC Inspection Manual Chapter 0313, "Industry Trends Program," and in NUREG /CR-6932, "Baseline Risk Index for Initiating Events (BRIIE)," consists of two levels, or tiers. The first considers individual IEs and evaluates performance based on statistical prediction limits. This evaluation is for ongoing monitoring and early detection of possible industry-level deficiencies. A second tier is a risk-based, integrated measure, evaluated for each plant type. Since four of the initiators have separate data for each plant type, there are a total of fourteen Tier 1 graphs.

The units for the Tier 1 initiating event frequency graphs are event counts for a fiscal year, divided by the industry critical time for the year. The Tier 1 graphs also show the average frequency for an established "baseline period," and 95 percent prediction limits for a future year if occurrences continue at the same rate as in the baseline period.

The prediction limits depend on the expected number of critical years of reactor operation in the upcoming year as well as on the baseline occurrence rate for each indicator. A rate can exceed a limit by having more events than expected, or by having events and less critical time than expected. In recent years, U.S. nuclear power plant availability has been approximately 90 percent at the industry level. This figure enters into the calculations determining the bounds on the number of events that might be expected. For all of the initiators, the 2008 occurrence rates are lower than the associated prediction limits.

The Tier 2, integrated index includes, for each plant type, the relative contribution of each initiator to the risk of core damage, based on the events that occurred in each fiscal year. The event frequencies are converted to core damage frequency estimates by multiplying by Birnbaum risk coefficients. These coefficients are industry averages of the contribution to core damage from each initiator as reflected in the industry standardized plant analysis risk (SPAR) models.

The BRIIE Tier 2 plot, Figure 15, shows annual differences in estimated industry core damage frequency compared with the established baseline levels of these quantities. The combined industry BRIIE value in FY 2008 (-5.2×10^{-6} per reactor critical year) is well below the established threshold of 1×10^{-5} per reactor critical year.

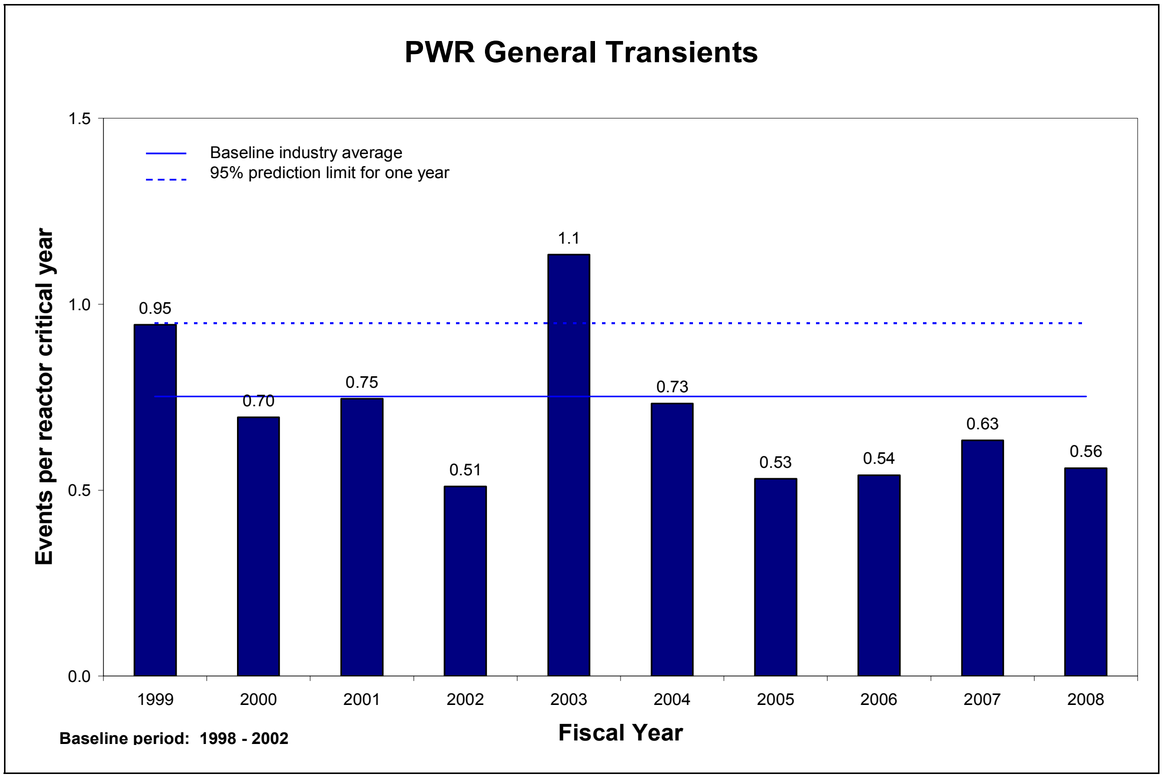

Figure 1. PWR General Transients

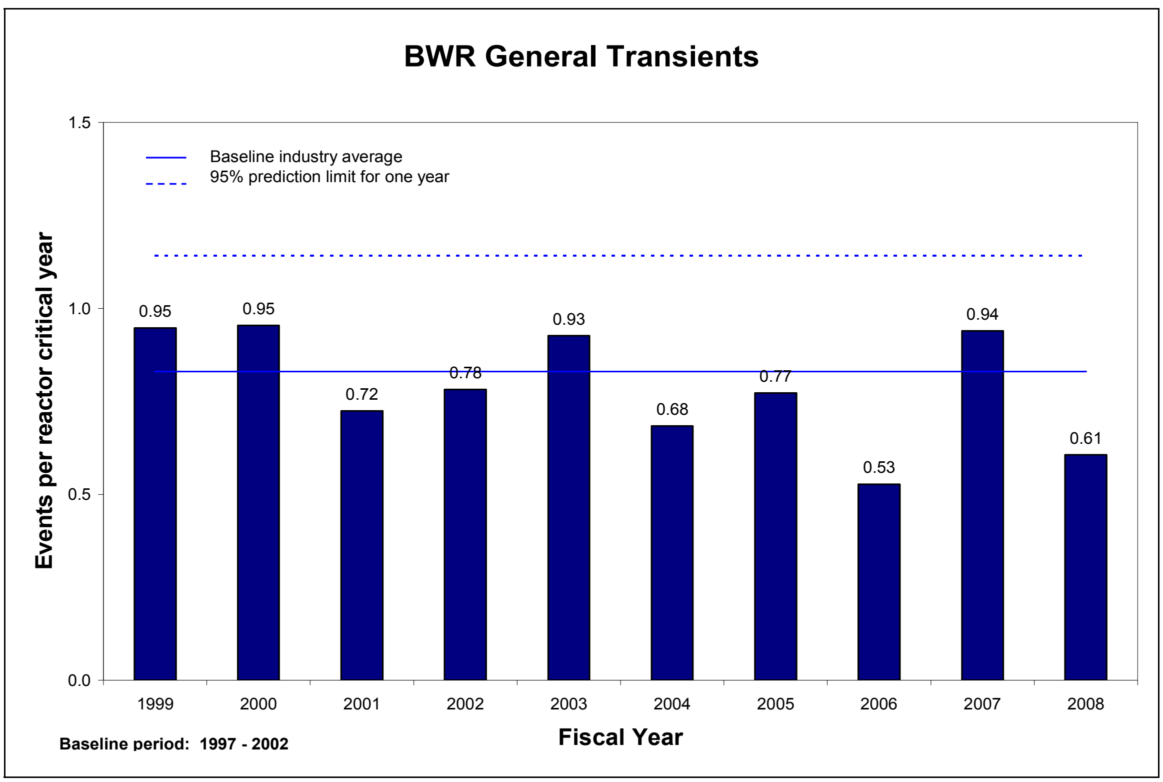

Figure 2. BWR General Transients

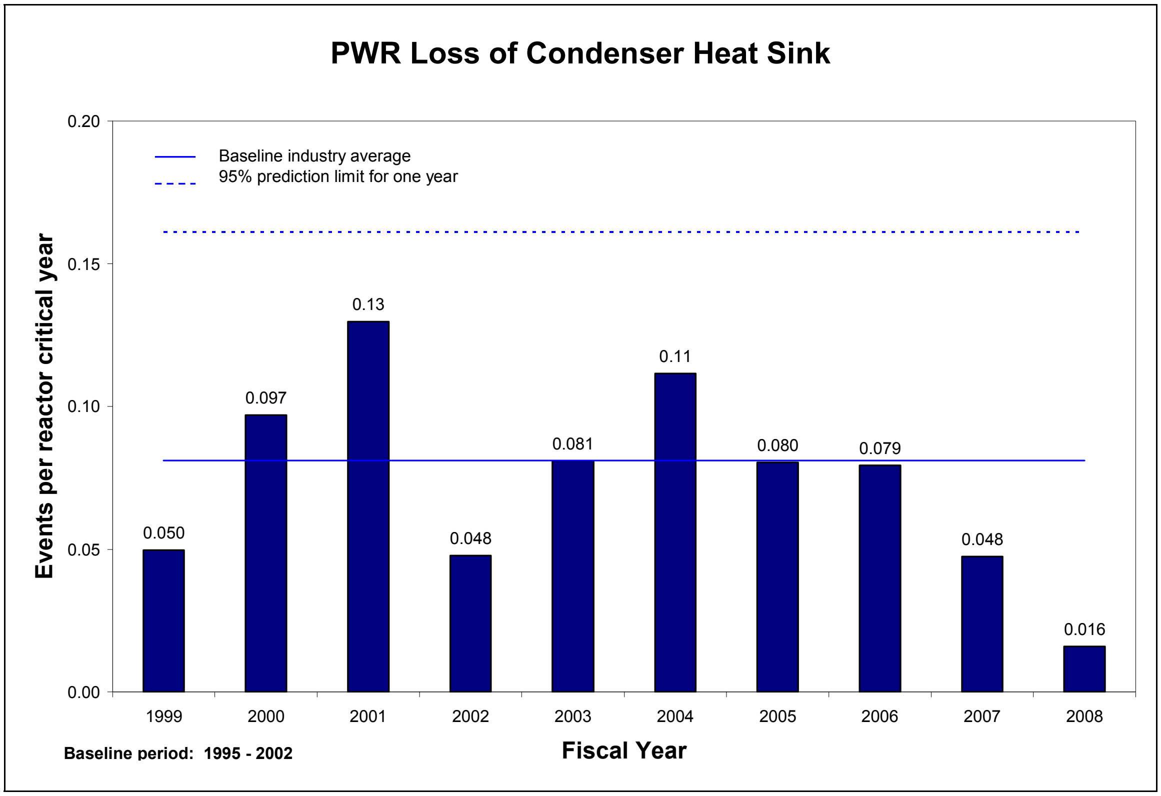

Figure 3. PWR Loss of Condenser Heat Sink

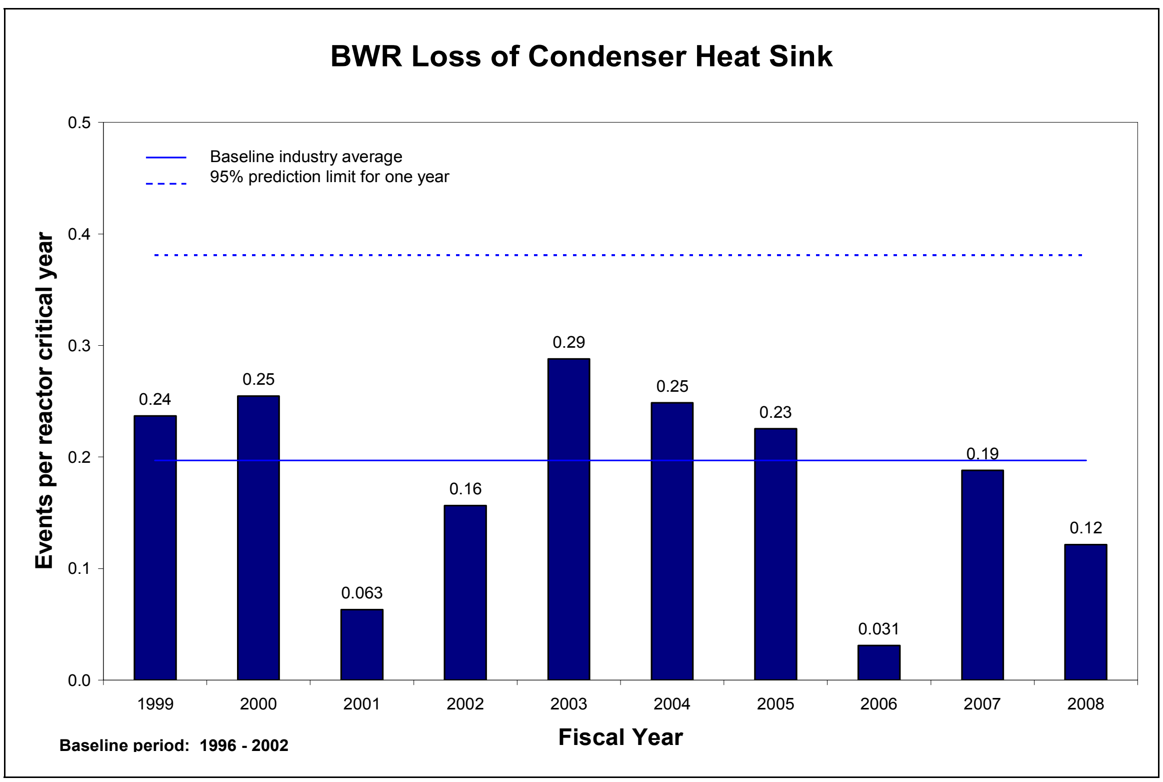

Figure 4. BWR Loss of Condenser Heat Sink

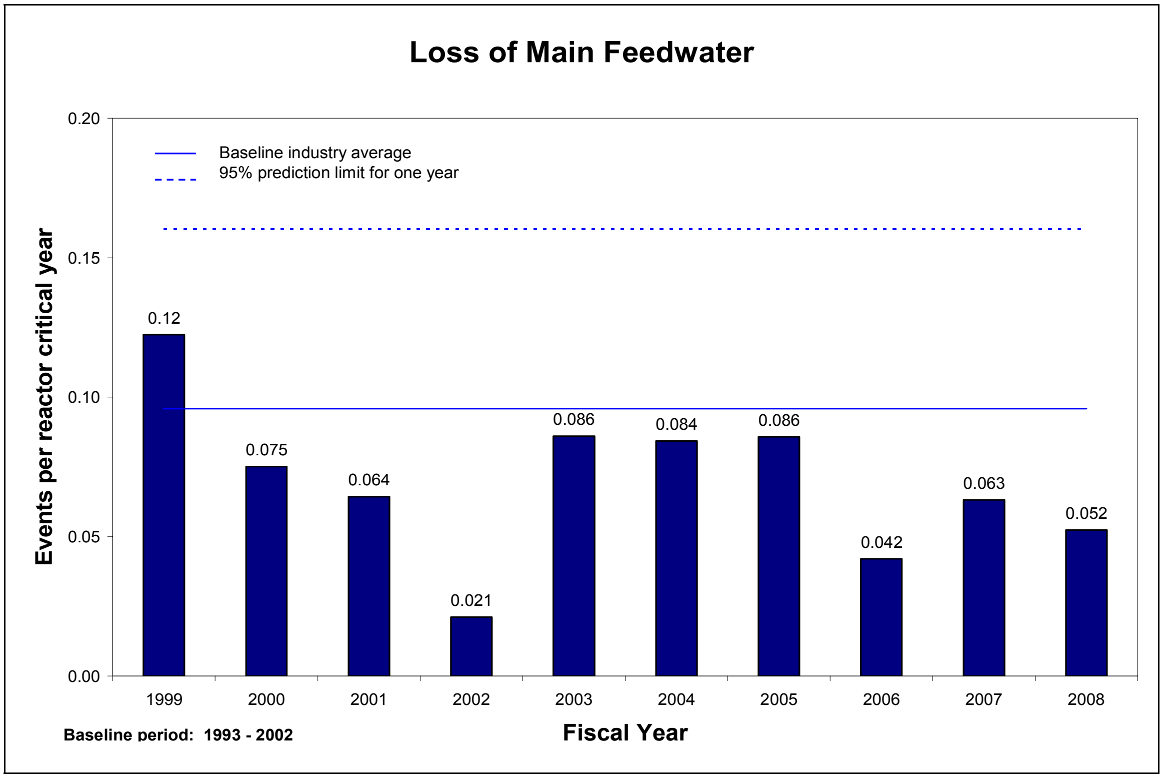

Figure 5. Loss of Main Feedwater

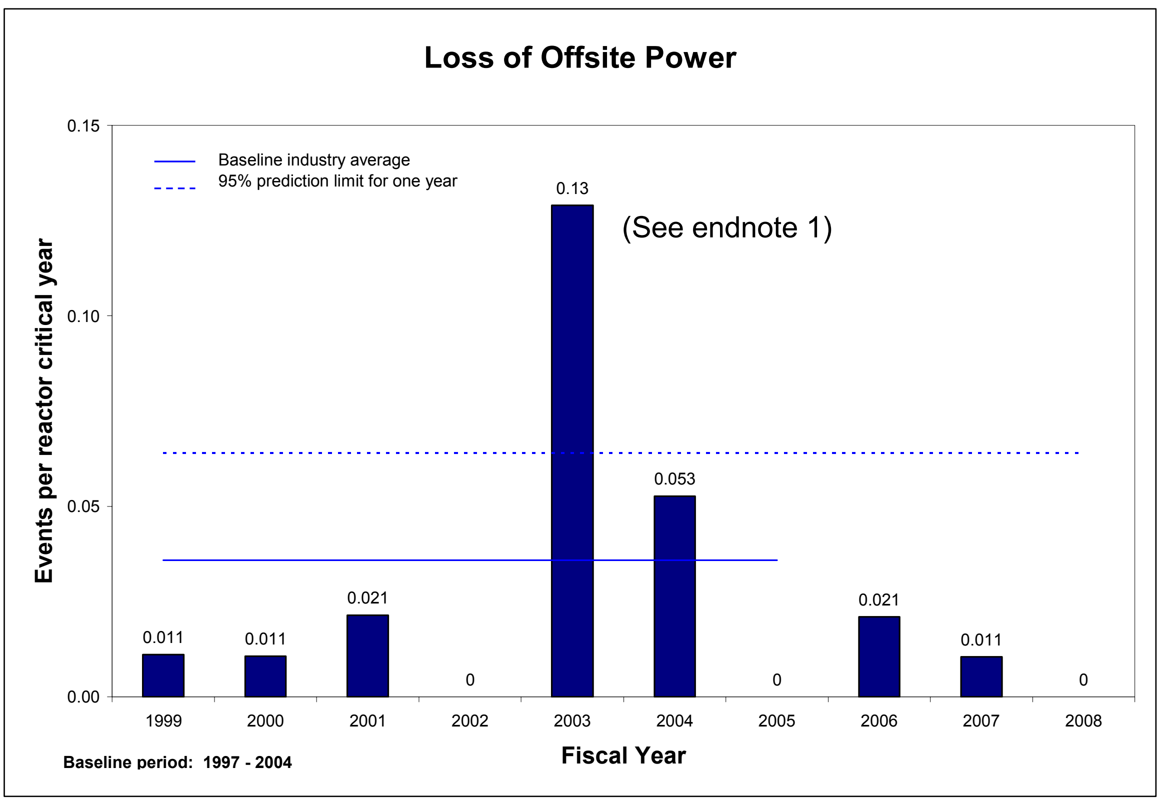

Figure 6. Loss of Offsite Power

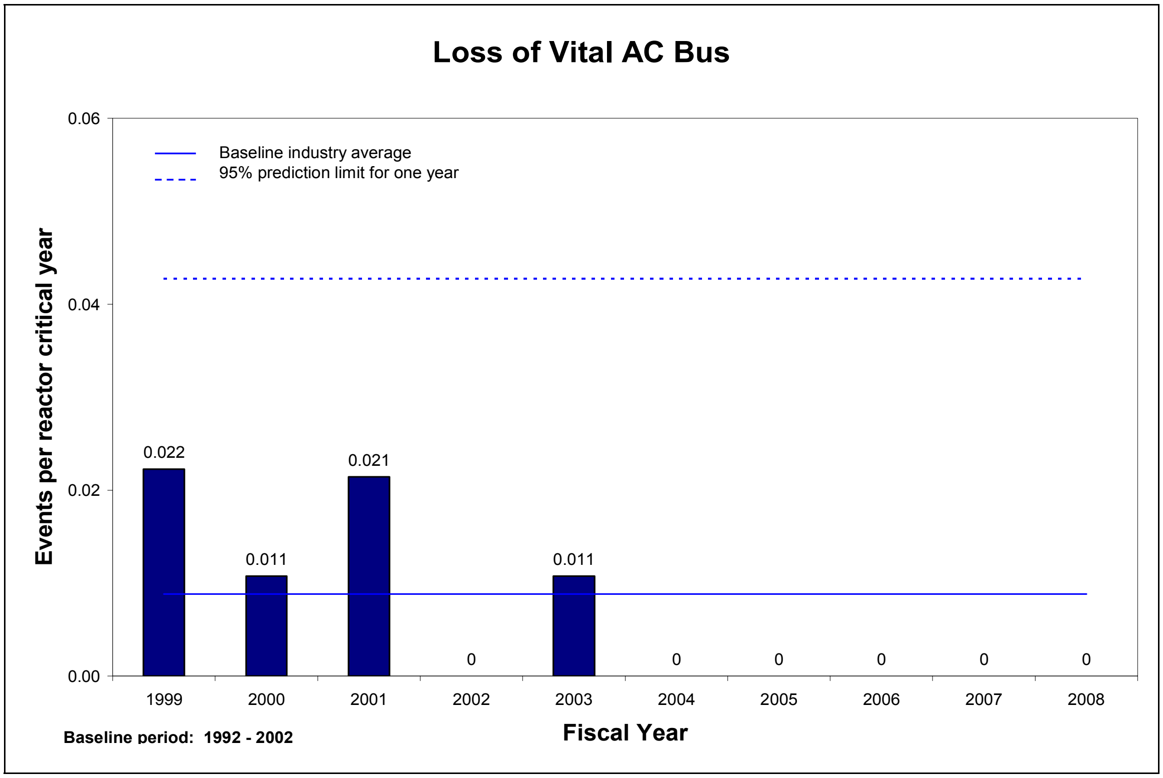

Figure 7. Loss of Vital AC Bus

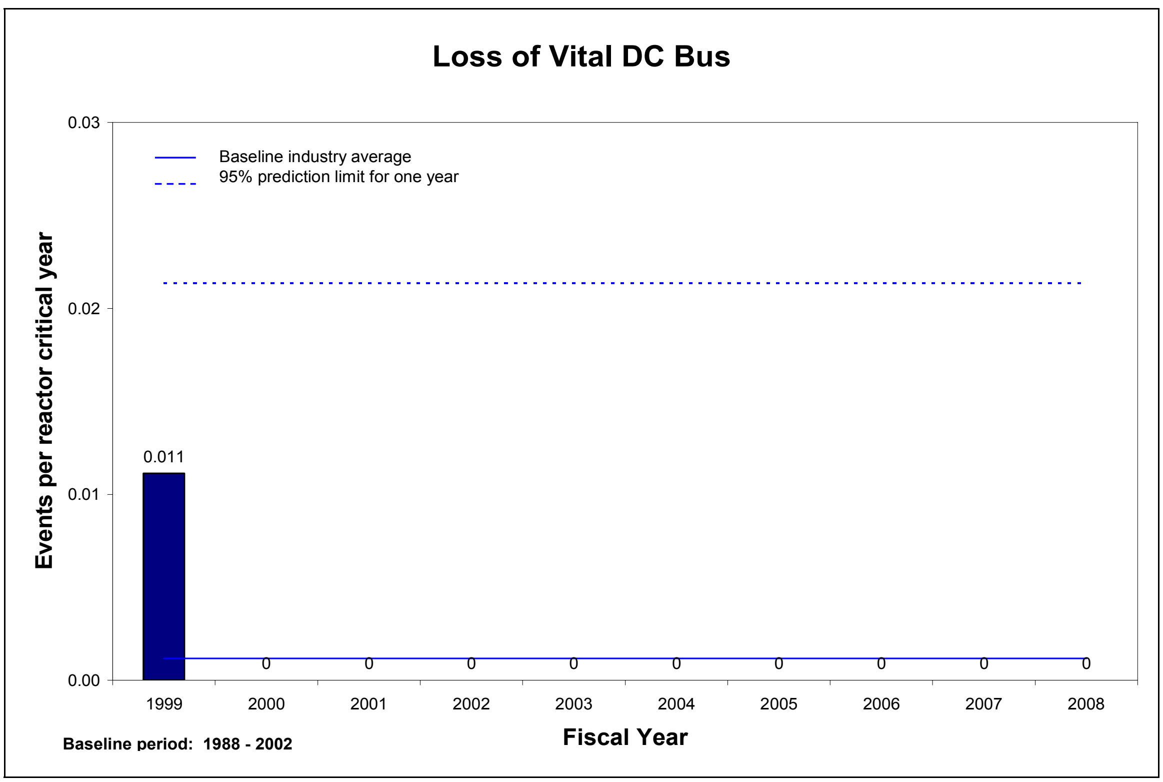

Figure 8. Loss of Vital DC Bus

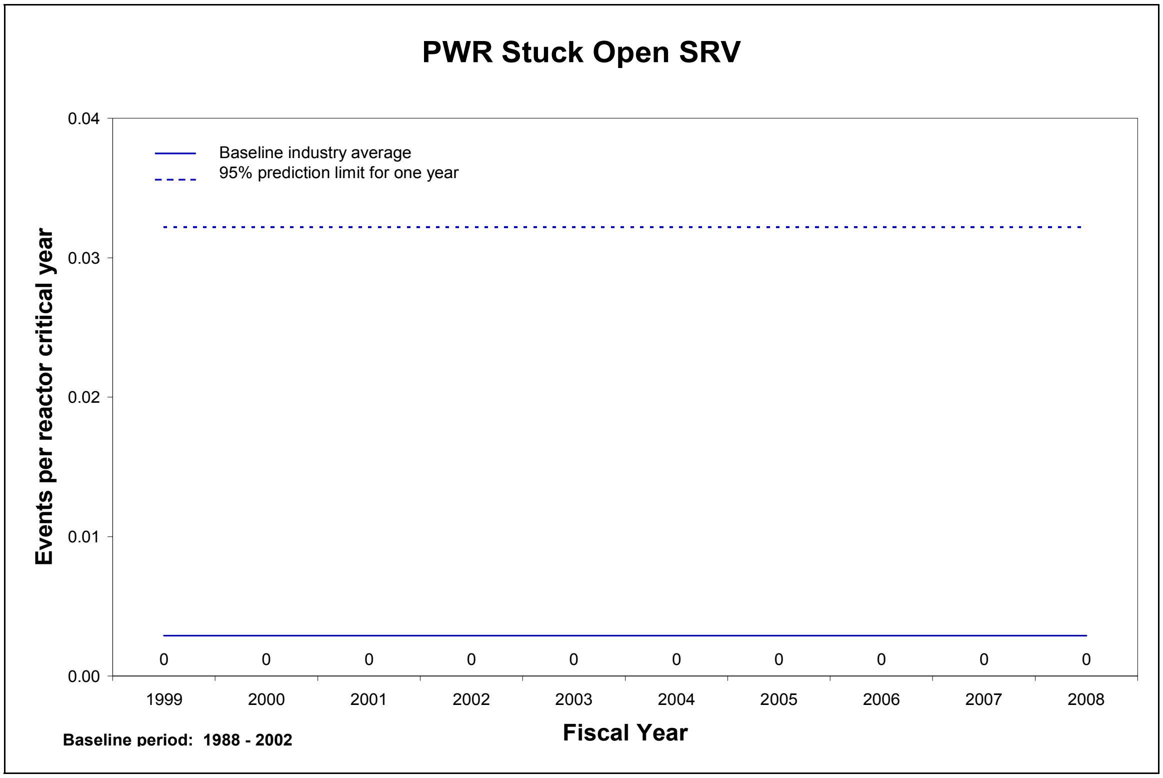

Figure 9. PWR Stuck Open SRV

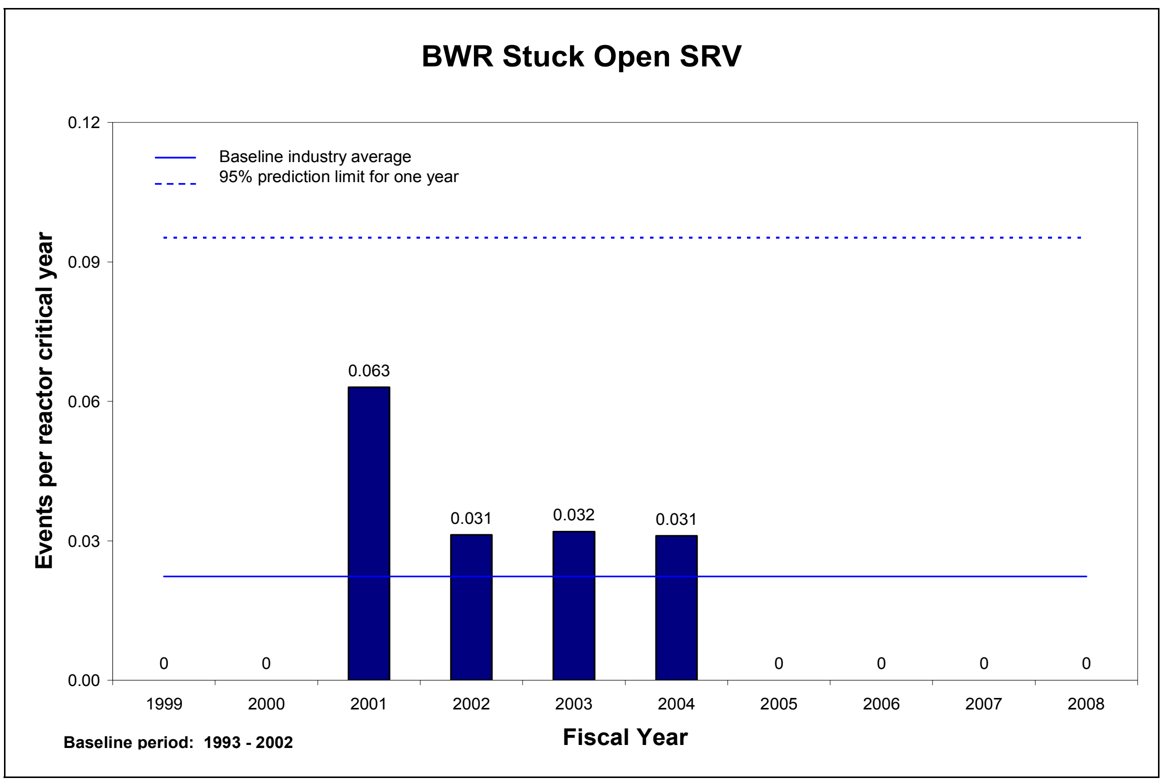

Figure 10. BWR Stuck Open SRV

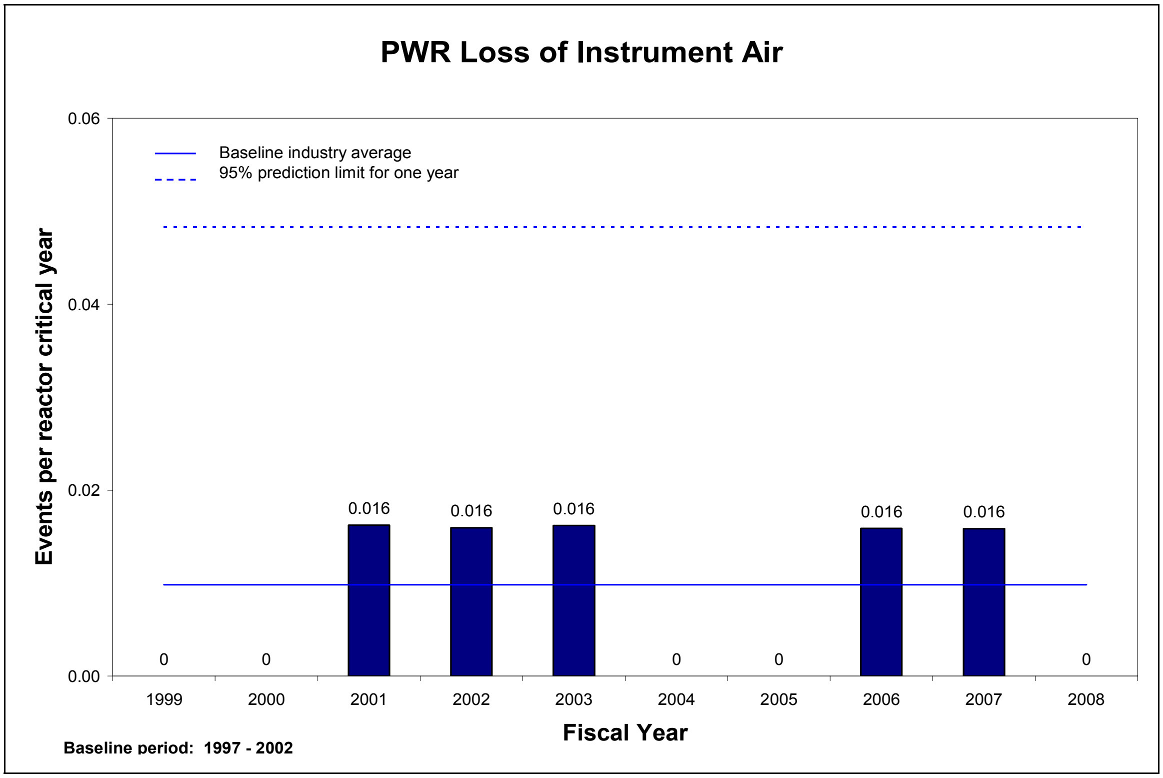

Figure 11. PWR Loss of Instrument Air

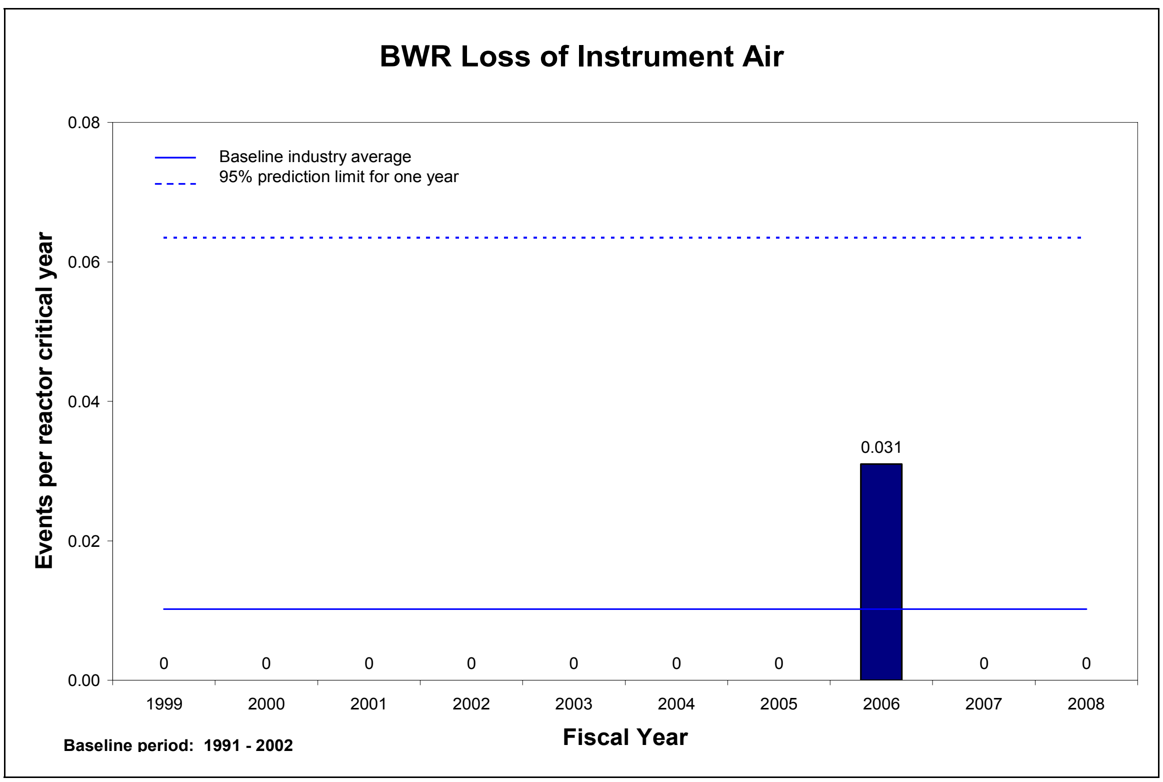

Figure 12. BWR Loss of Instrument Air

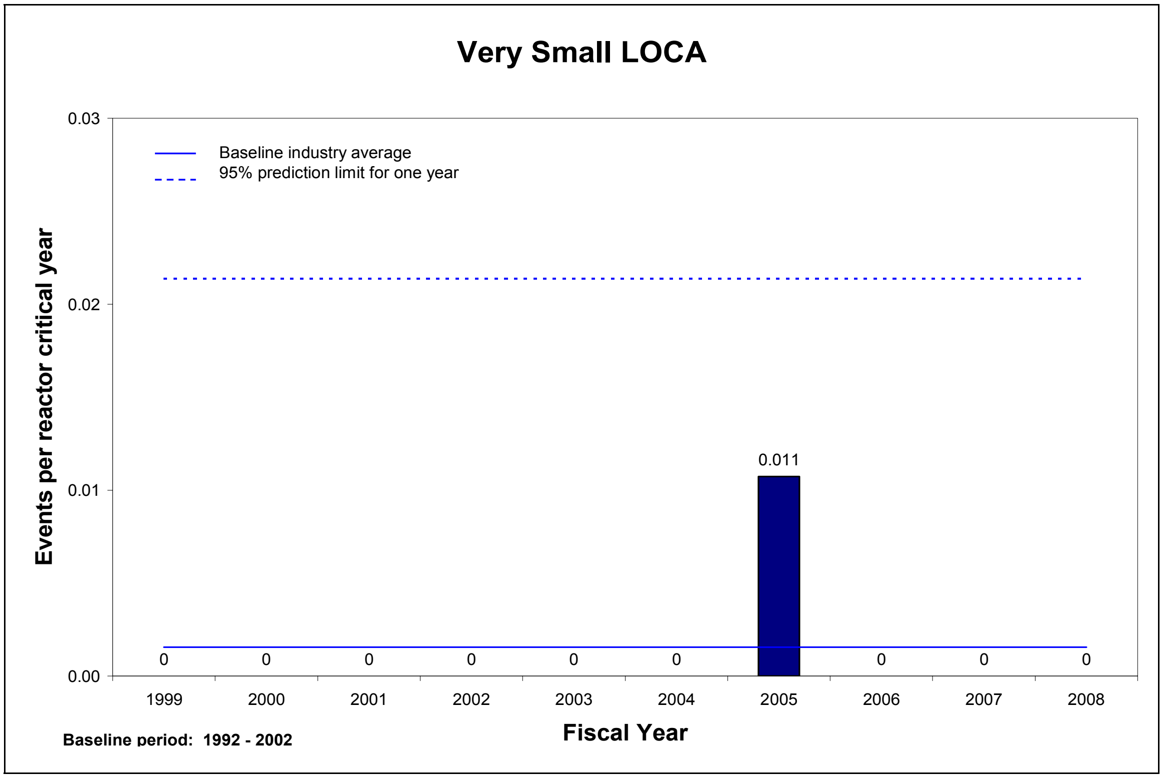

Figure 13. Very Small LOCA

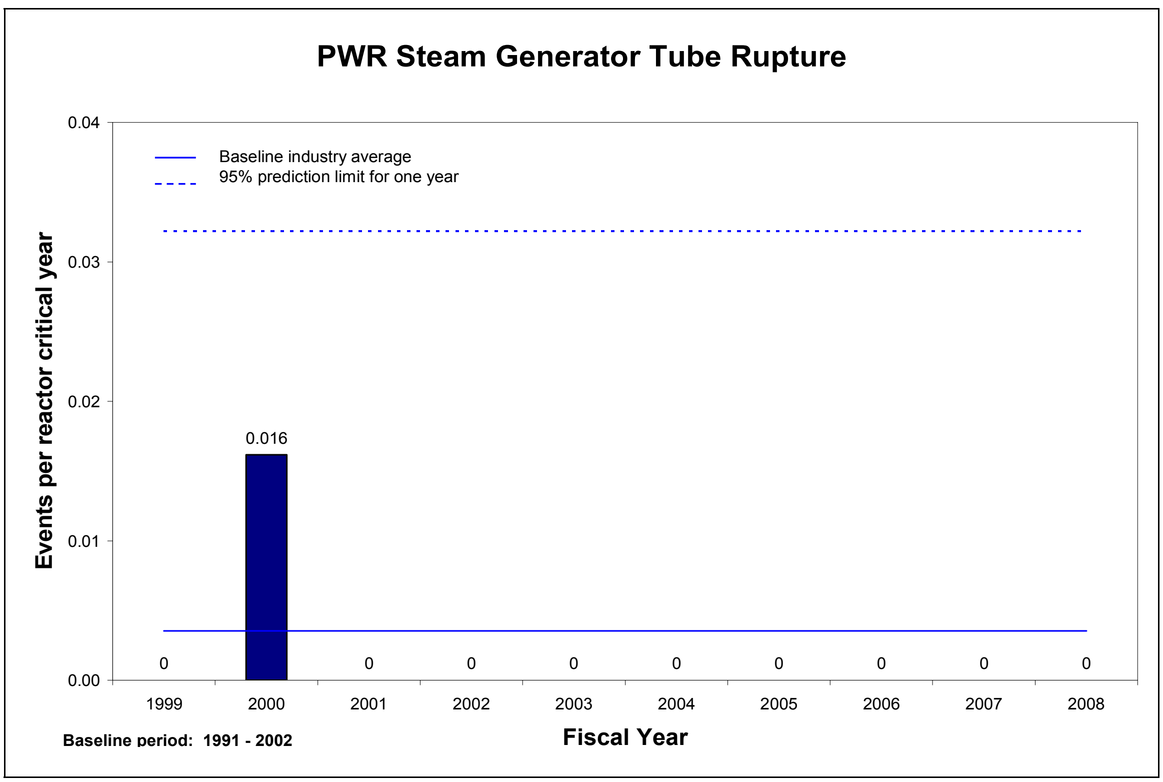

Figure 14. PWR Steam Generator Tube Rupture

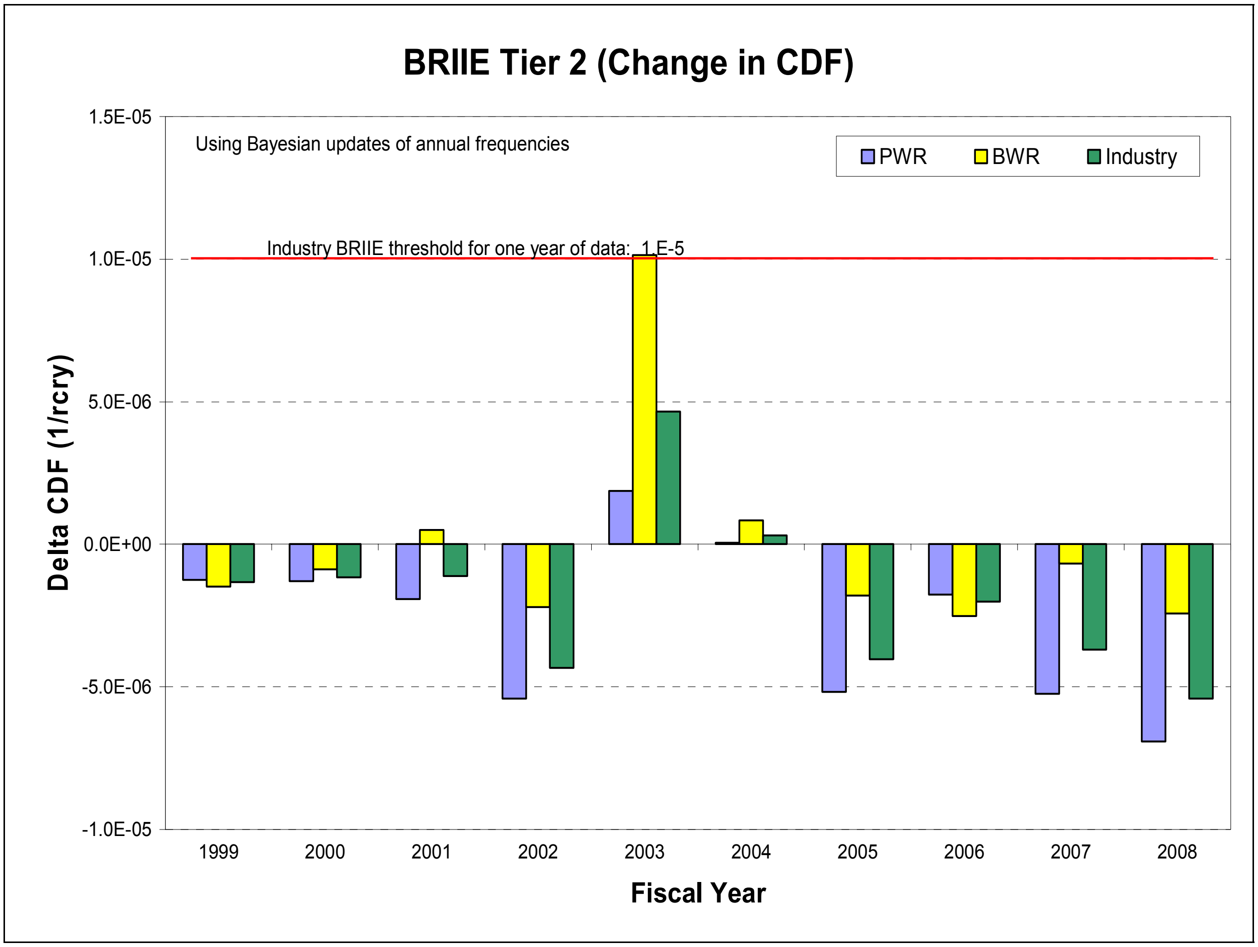

Figure 15. BRIIE Tier 2 (Change in Core Damage Frequency)

NOTE 1: The prediction limit for the Loss of Offsite Power (LOOP) graph, shown in Figure 6, was calculated assuming the 9 LOOP events that occurred during the 2003 blackout event were a single event. This treatment results in a more conservative prediction limit.