# POLICY ISSUE
## INFORMATION

March 16, 2010 SECY-10-0028

FOR: The Commissioners

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

SUBJECT: FISCAL YEAR 2009 RESULTS OF THE INDUSTRY TRENDS PROGRAM FOR OPERATING POWER REACTORS

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) 2009. This paper does not propose any new actions or commitments.

BACKGROUND:

The NRC staff implemented the ITP in 2001 to monitor for adverse safety performance trends based on industry-level indicators. 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. 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 ninth annual report to the Commission on the ITP.

NRC Inspection Manual Chapter 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. The staff analyzes the occurrence rate of precursors to determine if an adverse trend exists. The 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.

FY 2009 LONG-TERM INDUSTRY TRENDS:

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 2009. 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 $1\times10^{-6}$ to be a precursor.

The staff evaluated precursor data from FY 2001 to FY 2008 to identify statistically significant adverse trends. A review of the data reveals (1) a statistically significant decreasing trend for all precursors during the FY 2001–FY 2008 period (Figure 14 of Enclosure 1) and (2) a statistically significant decreasing trend for precursors with a CCDP or ΔCDP greater than or equal to $1\times10^{-4}$ 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) resulted in a step increase in the number of precursors identified compared to those identified in previous years. The data period for trending analyses ends in FY 2008 (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 (i.e., CCDP or ΔCDP greater than or equal to $1\times10^{-3}$) of leading to a reactor accident. No *significant* precursors were identified in FY 2009.

The staff reported the results of the ASP program to the Commission in SECY-09-0143, "Status of the Accident Sequence Precursor Program and the Standardized Plant Analysis Risk Models," dated September 29, 2009.

FY 2009 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 2009. Short-term FY 2009 data did not reveal any issues that warranted additional analysis or significant adjustments to the nuclear reactor safety inspection or licensing programs.

FY 2009 RESULTS OF BASELINE RISK INDEX FOR INITIATING EVENTS:

In 2008, the NRC staff implemented the Baseline Risk Index for Initiating Events (BRIIE) as part of the ITP. The BRIIE functions as follows: (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 BRIIE concept provides a two-level approach to industry performance monitoring. 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 and 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. If the BRIIE combined industry value reaches or exceeds a threshold value of $1\times10^{-5}$ per reactor critical year, the NRC informs Congress of this performance outcome along with actions that have already been taken or are planned in response, in the NRC Performance and Accountability Report.

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 2009. As shown in Enclosure 3, Figure 15, BRIIE Tier 2 (change in core damage frequency), the BRIIE combined industry value in FY 2009 ($-2.36\times10^{-6}$ per reactor critical year) indicates better than baseline industry performance and is well below the established reporting threshold of $\Delta CDF = 1.0\times10^{-5}$ per reactor critical year.

RESOURCES:

The staff of the Office of Nuclear Reactor Regulation (NRR) estimates resource needs of approximately 0.5 full-time equivalent (FTE) staff and $548,000 for ongoing ITP implementation in FY 2010, and 0.5 FTE and $525,000 in FY 2011. The resources are included in the FY 2010 budget and FY 2011 budget request as part of the 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 Standardized Plant Analysis Risk Model 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 funding and performance of RES work are completely separate from the ITP. The resources budgeted in NRR and RES are adequate for ongoing ITP implementation. Resources required in future years beyond FY 2011 would be addressed during the Planning, Budgeting, and Performance Management 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.

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Eric J. Leeds, Director
Office of Nuclear Reactor Regulation

Enclosures:
1. Fiscal Year 2009 Long-Term Industry Trends Results
2. Fiscal Year 2009 Short-Term Industry Performance
3. Fiscal Year 2009 BRIIE Results

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# FISCAL YEAR 2009 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) 2000 to FY 2009) as indicated by the following graphs.

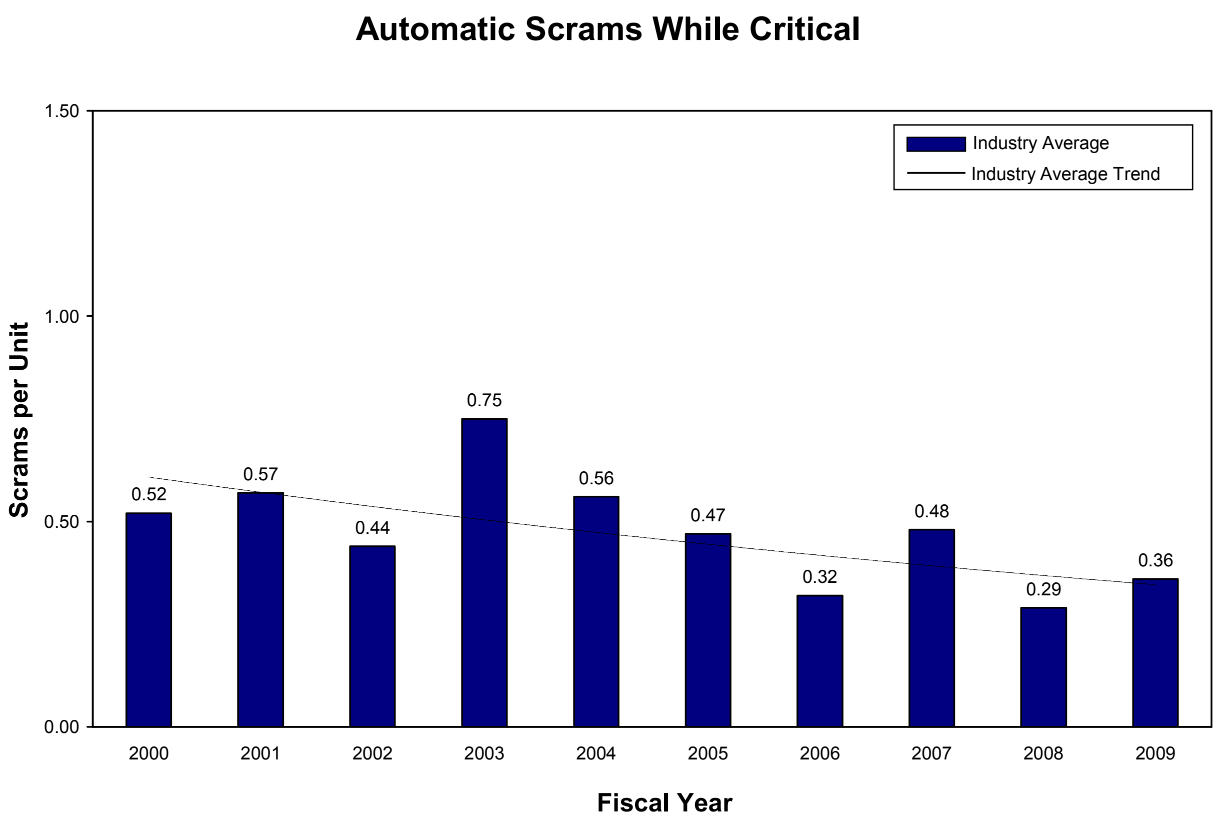



**Figure 1. Automatic Scrams While Critical**

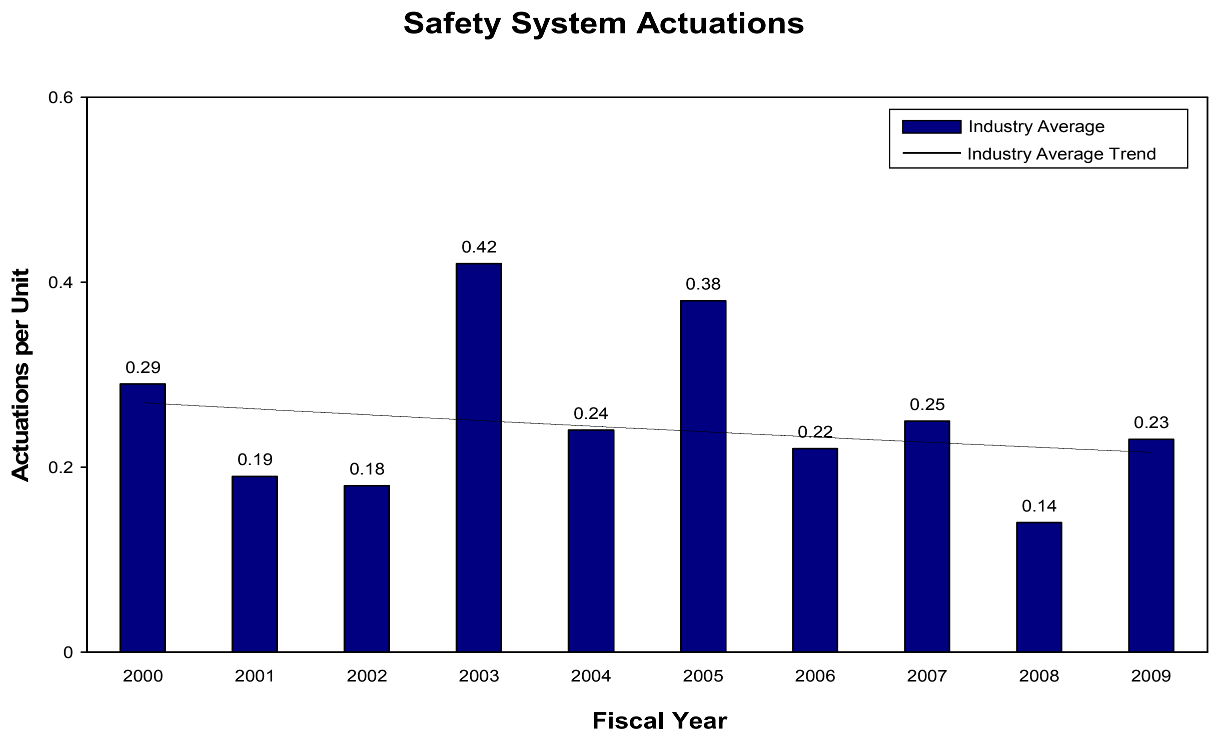



**Figure 2. Safety System Actuations**

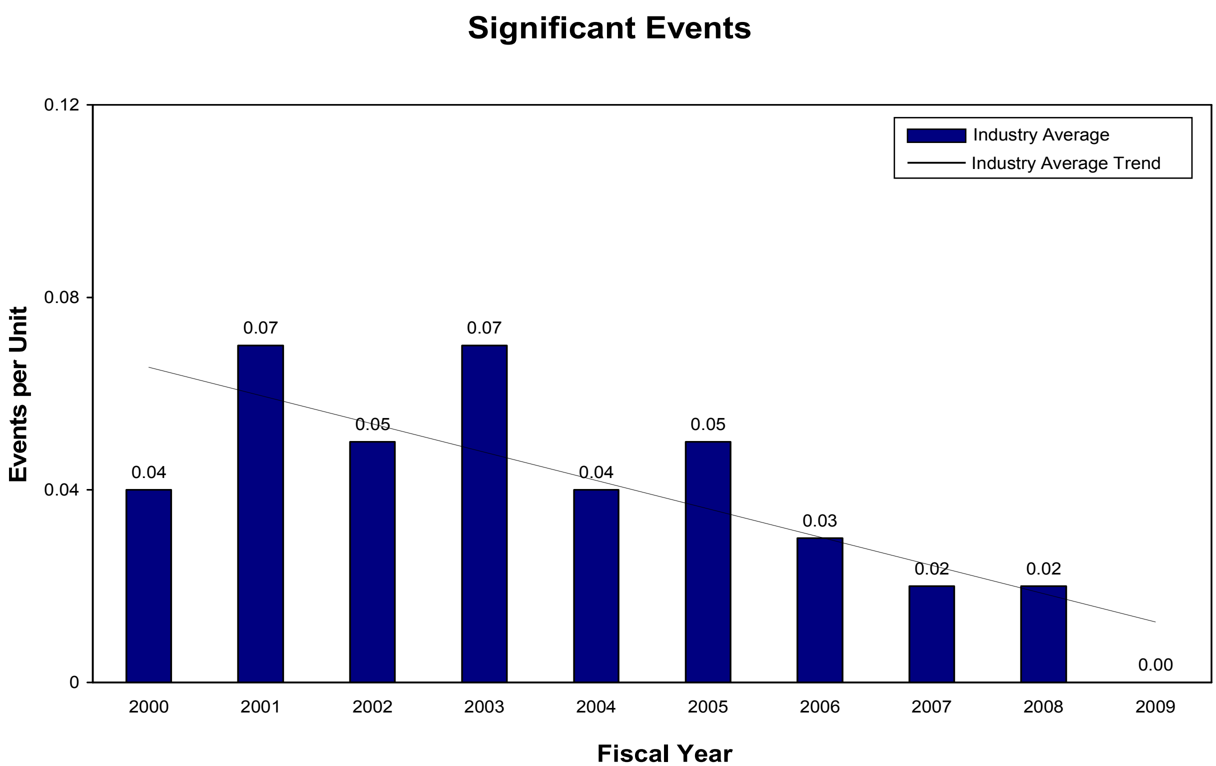



**Figure 3. Significant Events**

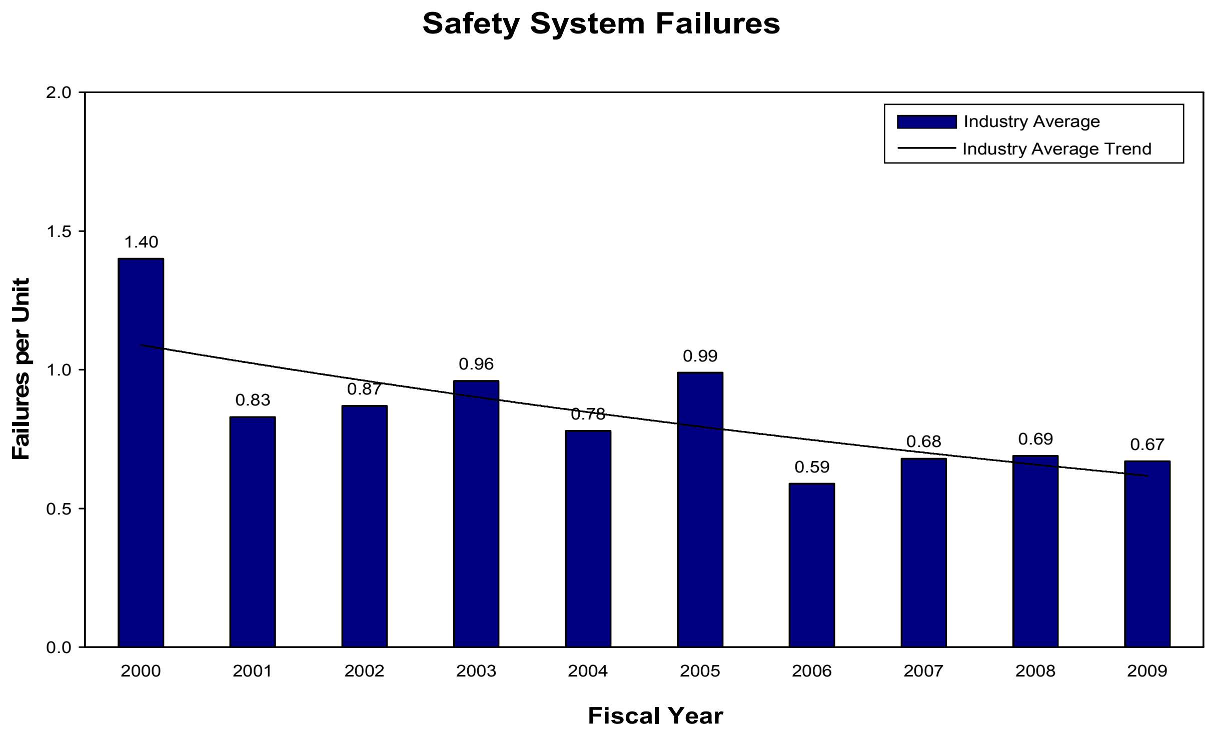



**Figure 4. Safety System Failures**

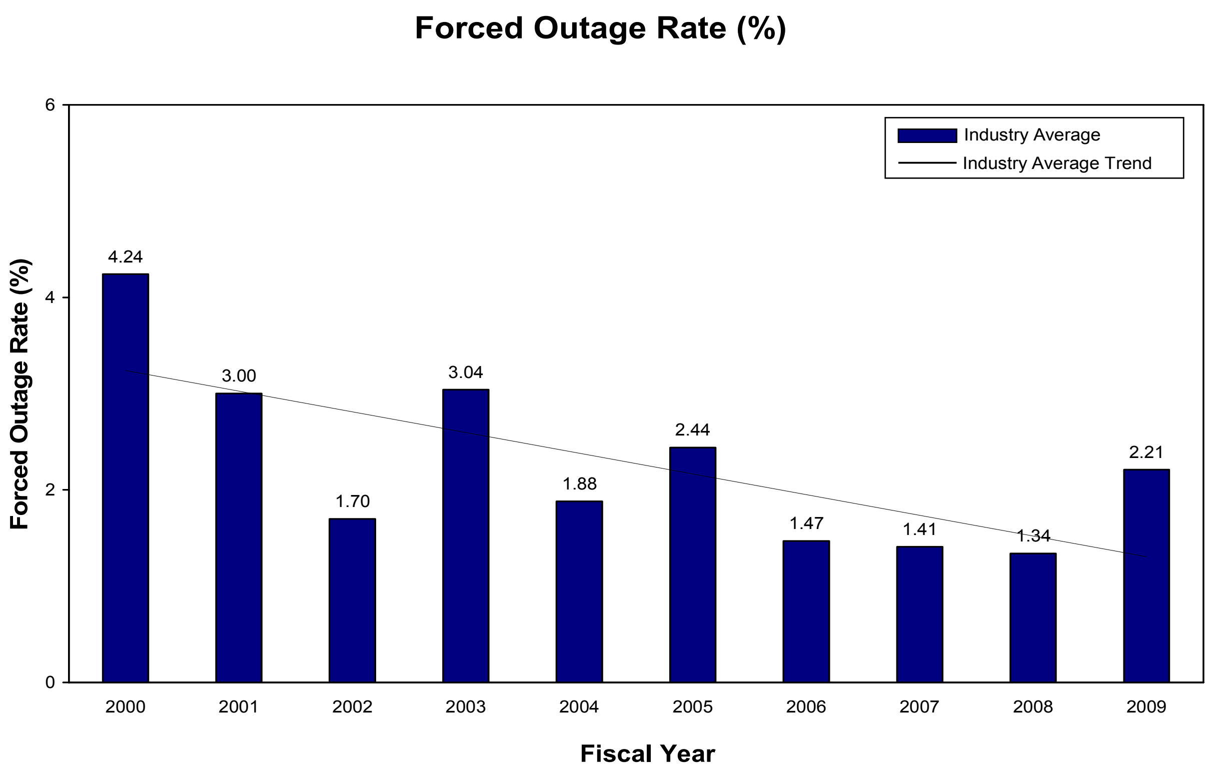



**Figure 5. Forced Outage Rate**

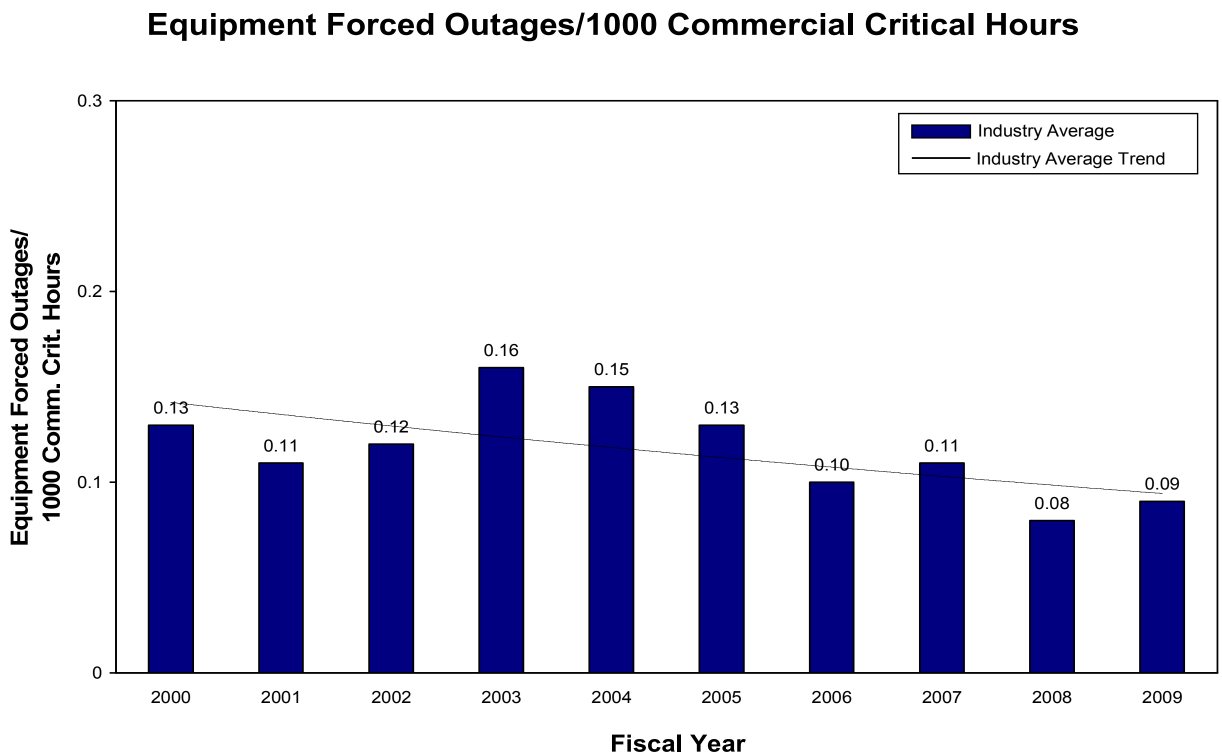



**Figure 6. Equipment Forced Outages per 1,000 Commercial Critical Hours**

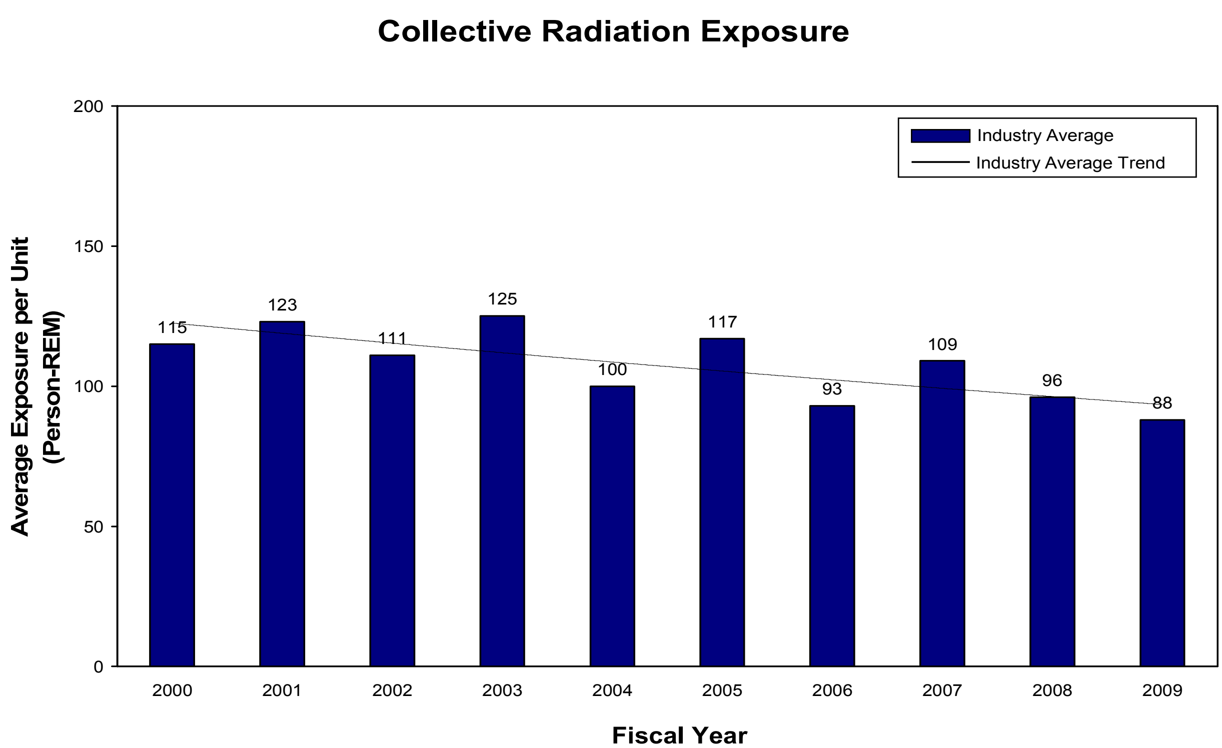



**Figure 7. Collective Radiation Exposure**

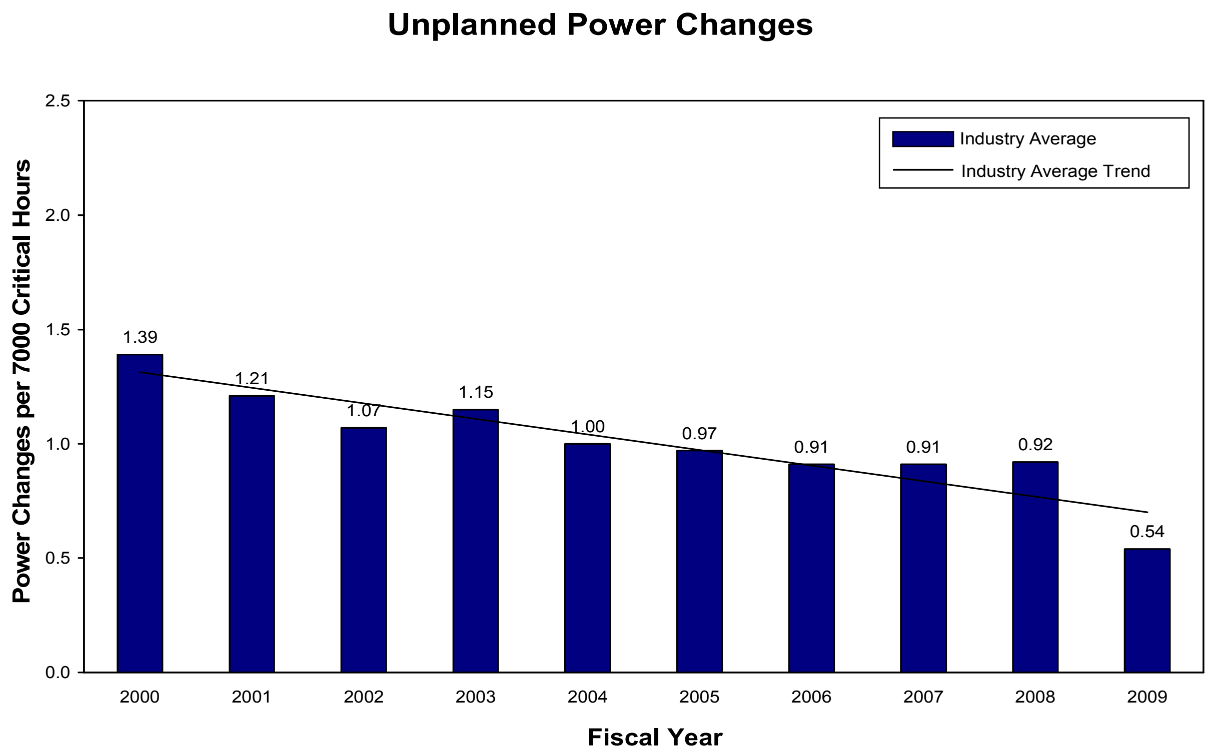



**Figure 8. Unplanned Power Changes**

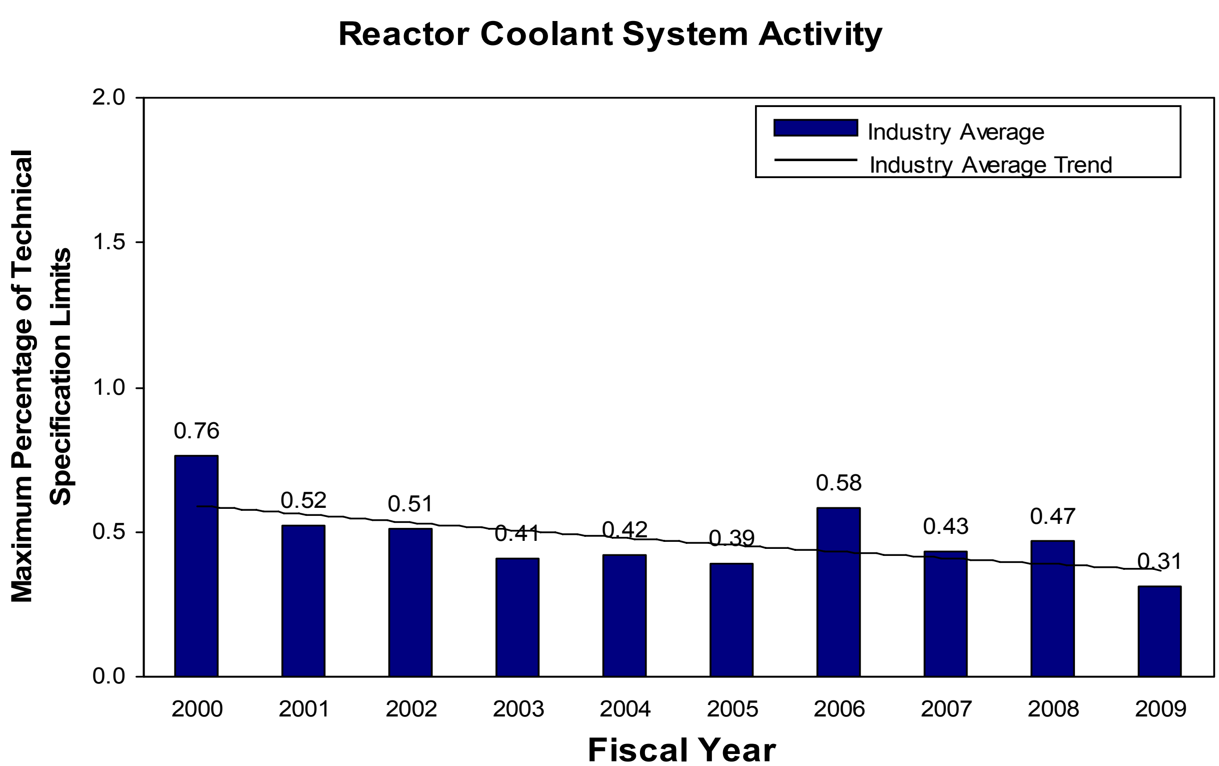



**Figure 9. Reactor Coolant System Activity**

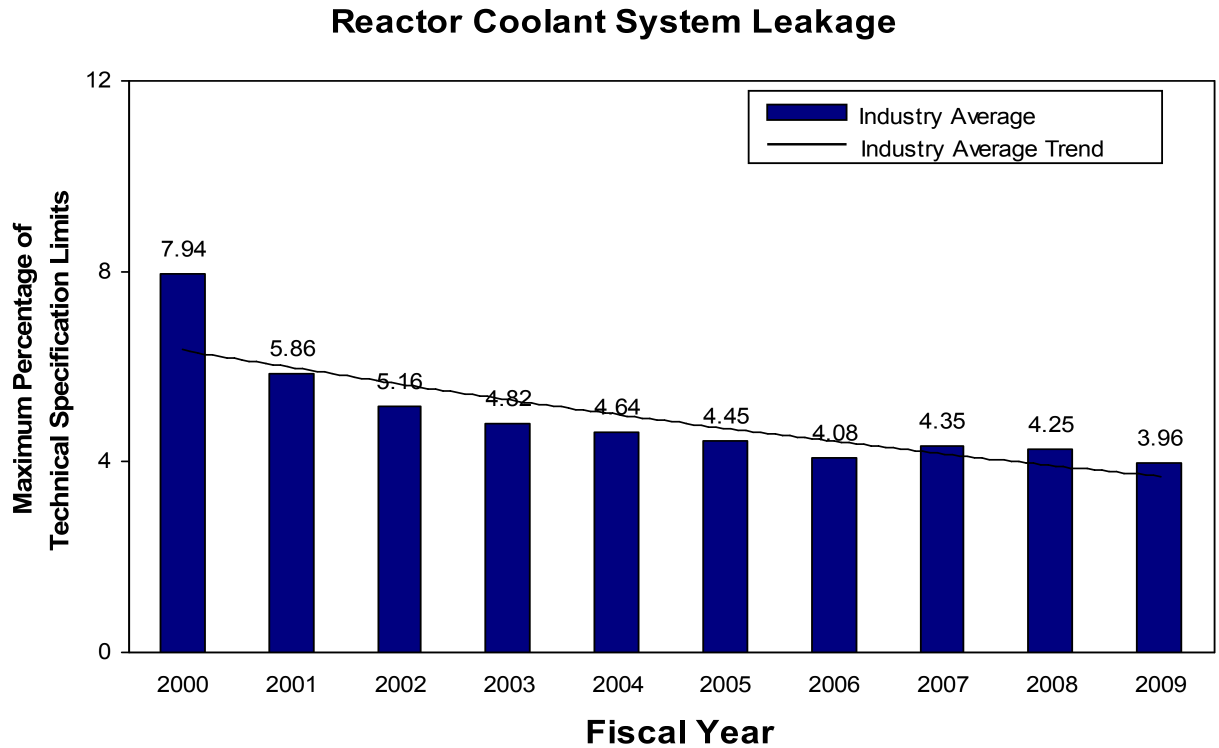



**Figure 10. Reactor Coolant System Leakage**

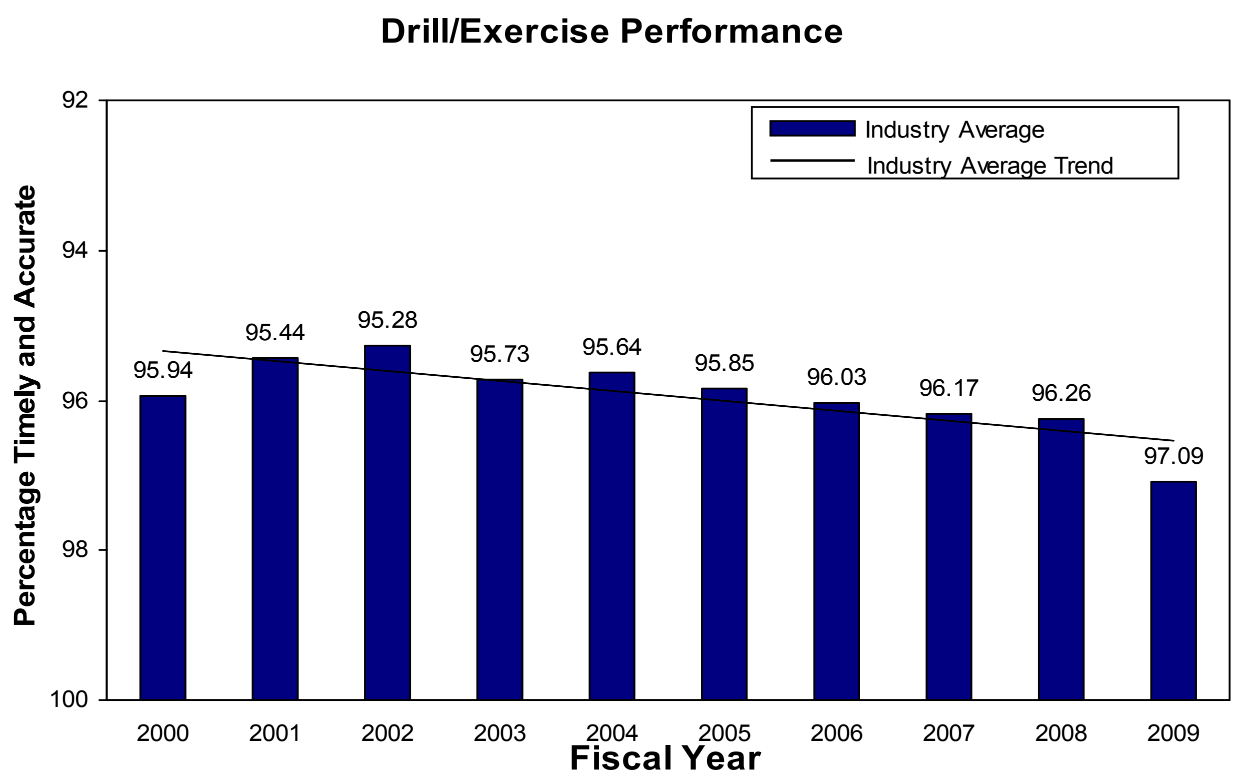



**Figure 11. Drill/Exercise Performance**

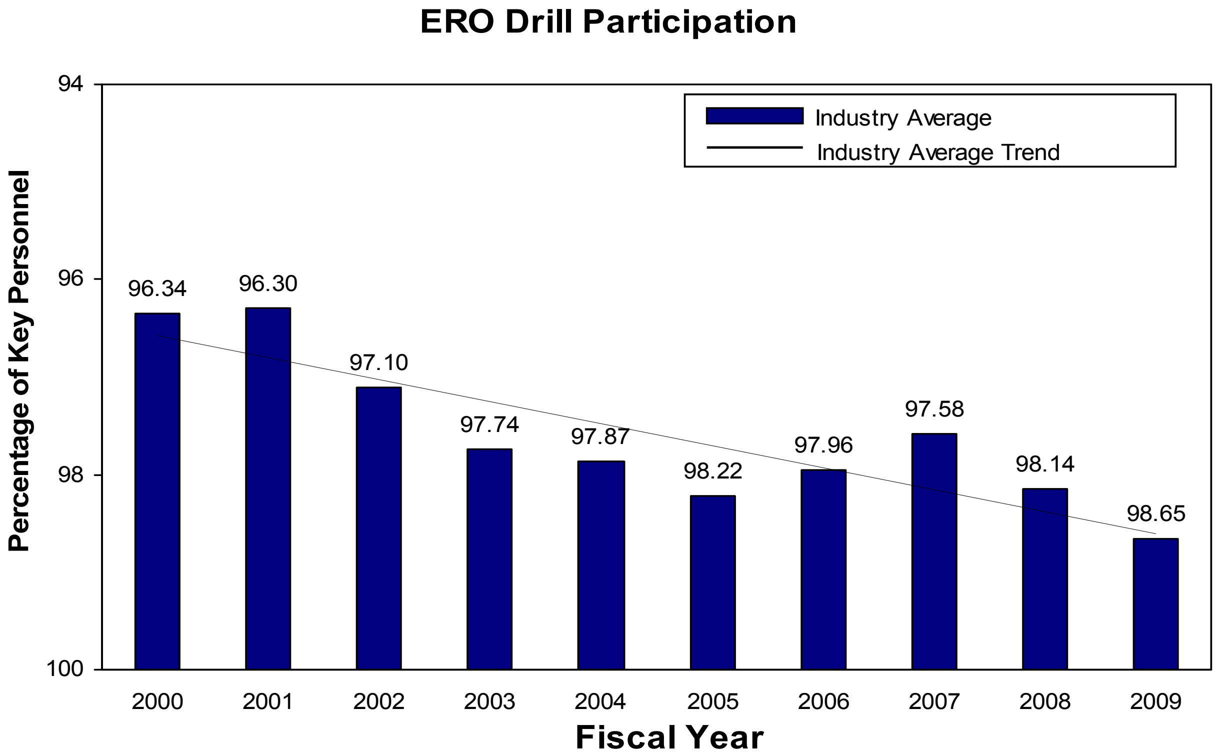



**Figure 12. Emergency Response Organization Drill Participation**

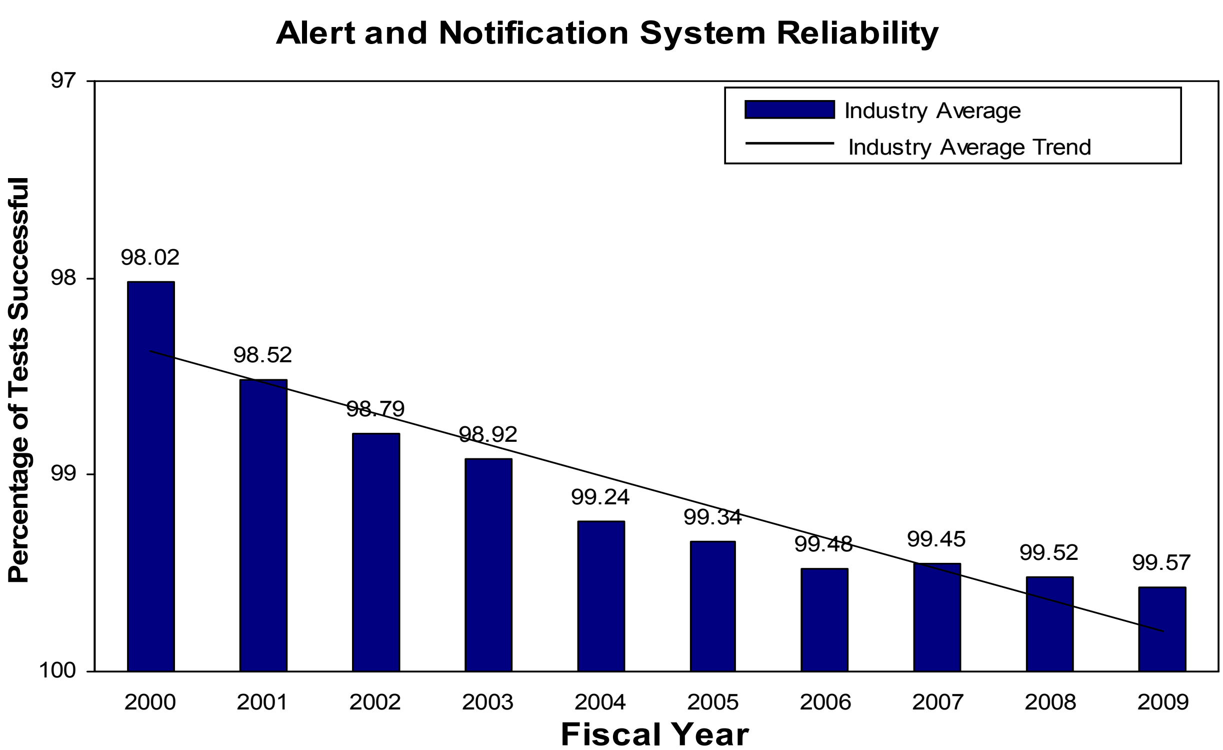



**Figure 13. Alert and Notification System Reliability**

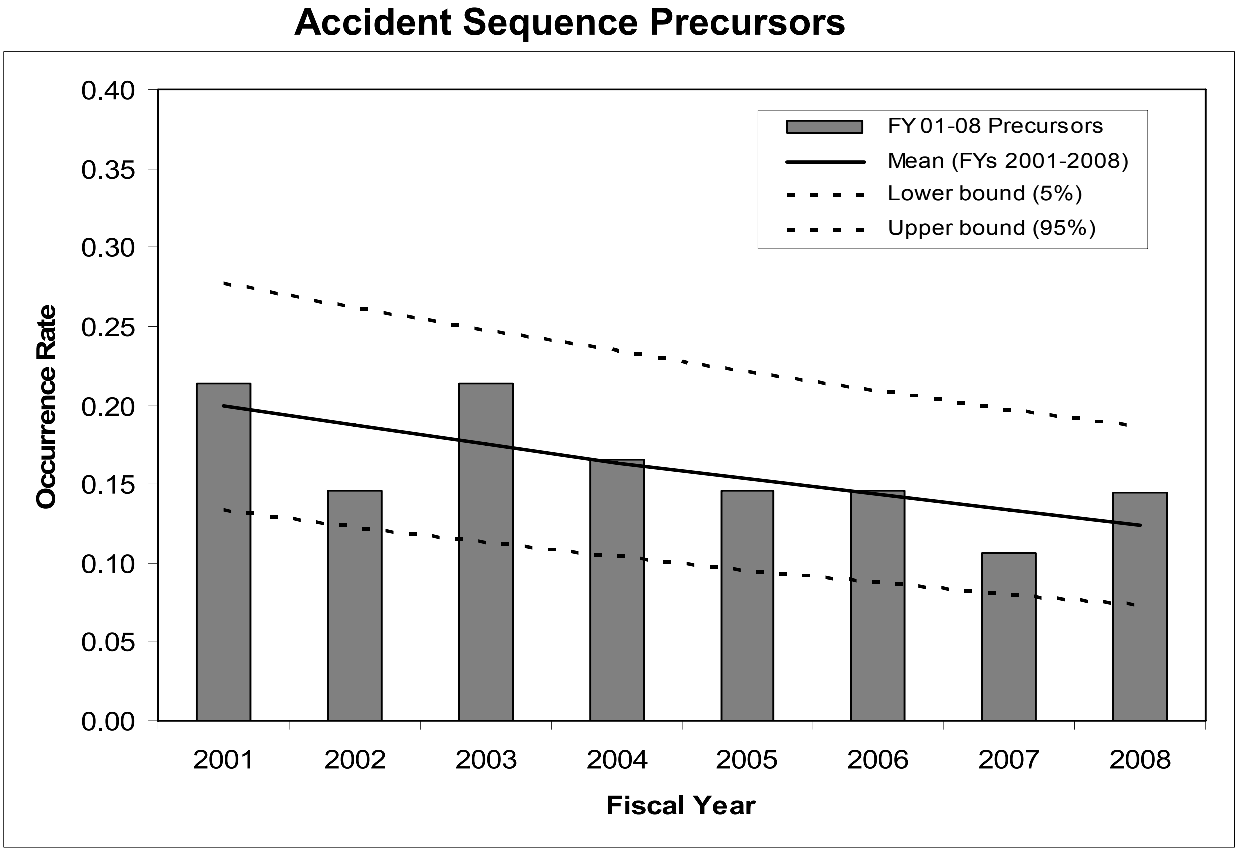


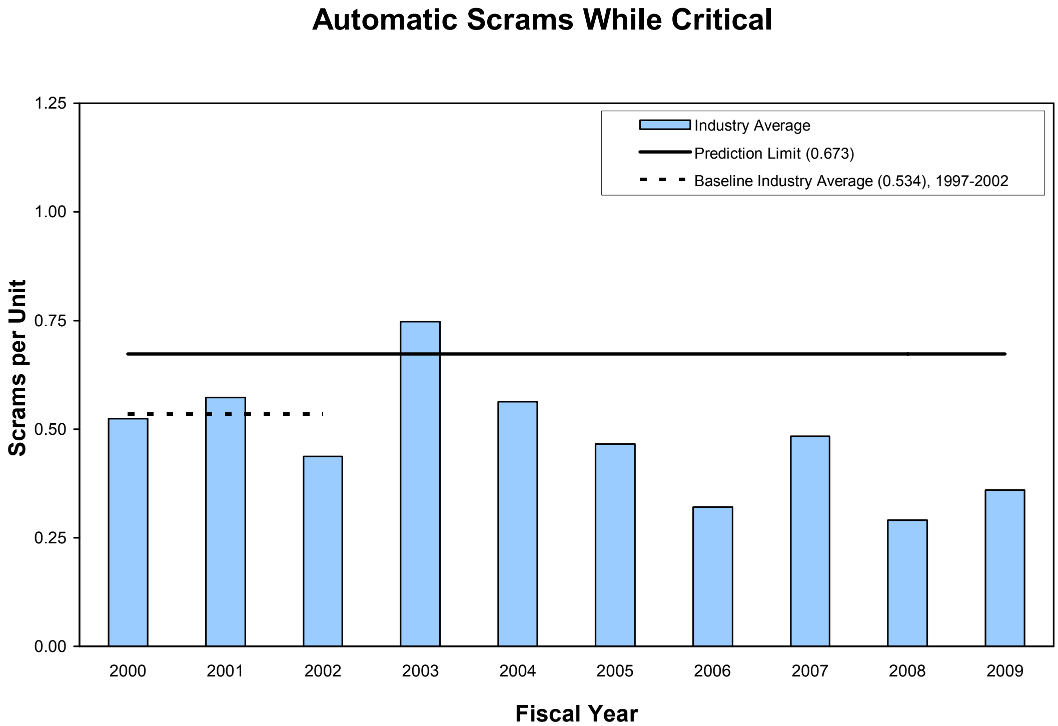

**Figure 14. Accident Sequence Precursors**

**Total precursors—occurrence rate, by fiscal year.**
The mean occurrence rate of all precursors exhibits a statistically significant decreasing trend (p-value = 0.01) for the period FY 2001–2008.

# FISCAL YEAR 2009 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 $95^{th}$ 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.

The results of the evaluation of the FY 2009 Industry Trends Program (ITP) PIs, using the established prediction limits, indicate that no PI exceeded its associated prediction limit in FY 2009, as evidenced by the following graphs of each PI with its FY 2009 data and associated prediction limit.

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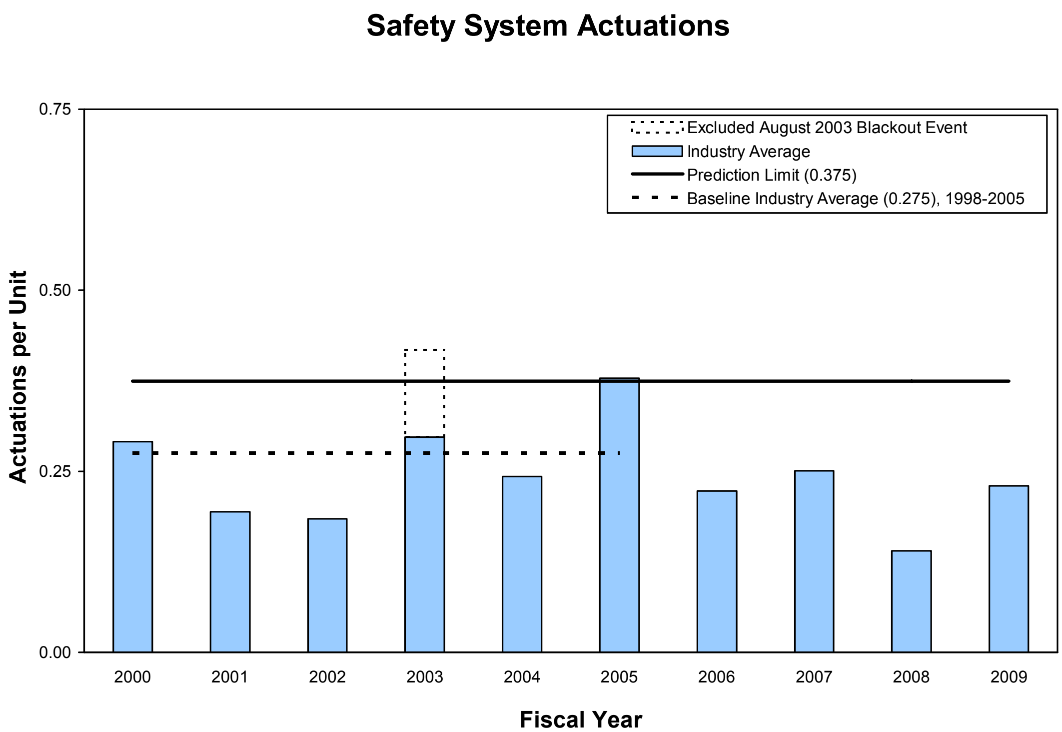


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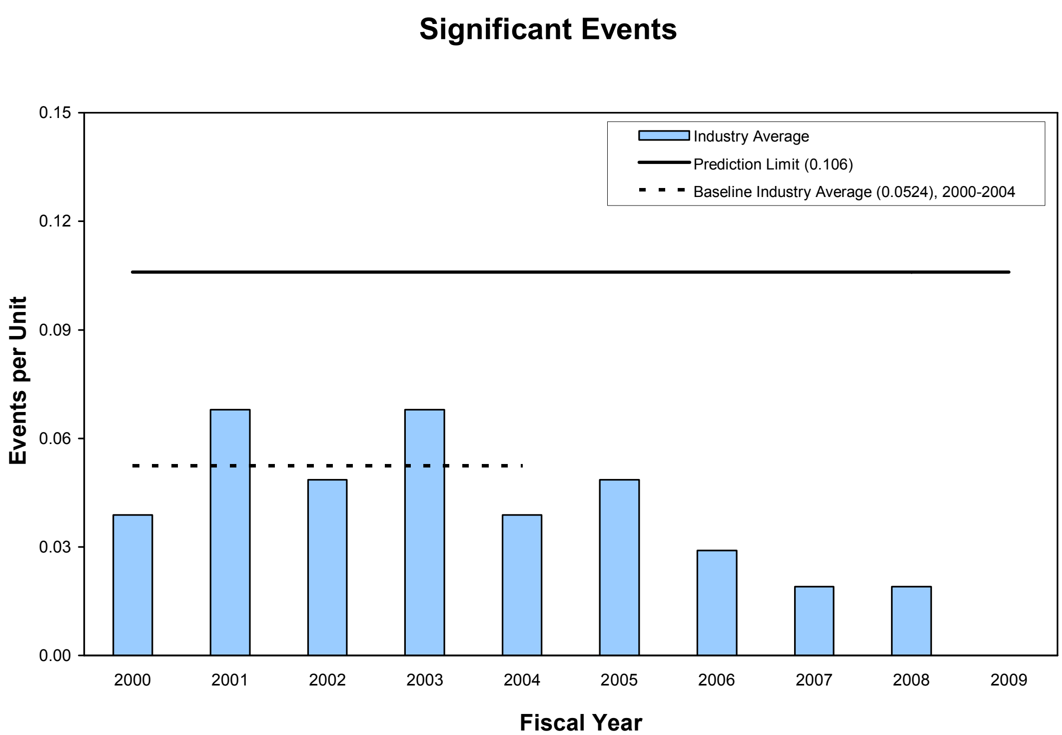
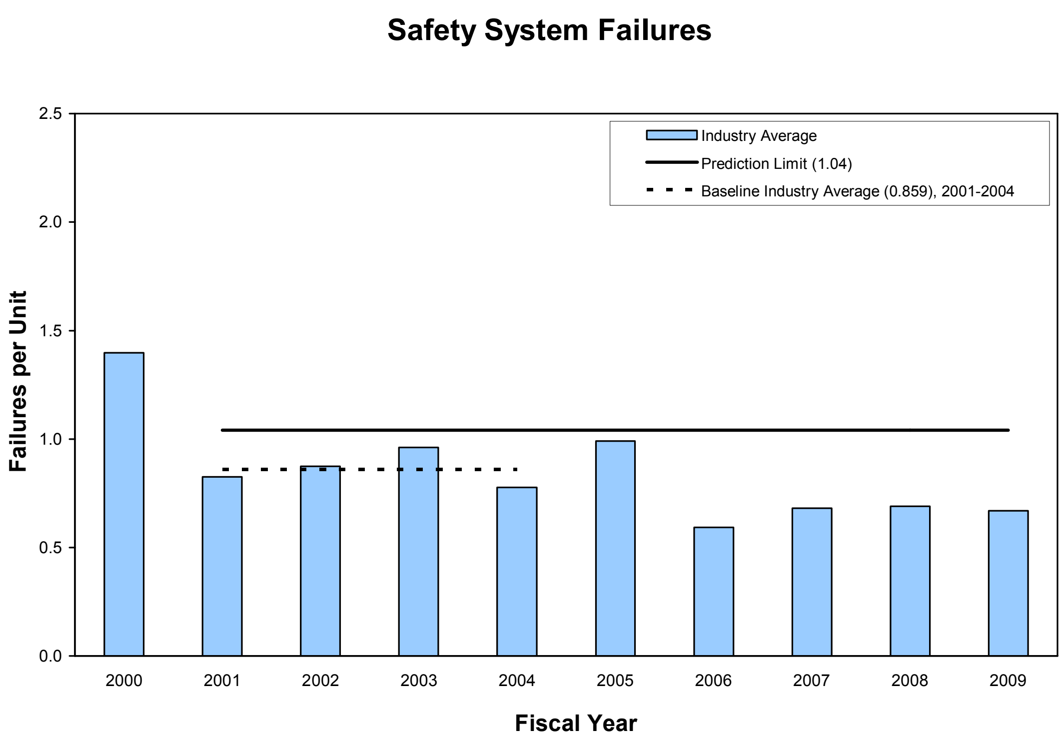



**Figure 3. Significant Events**

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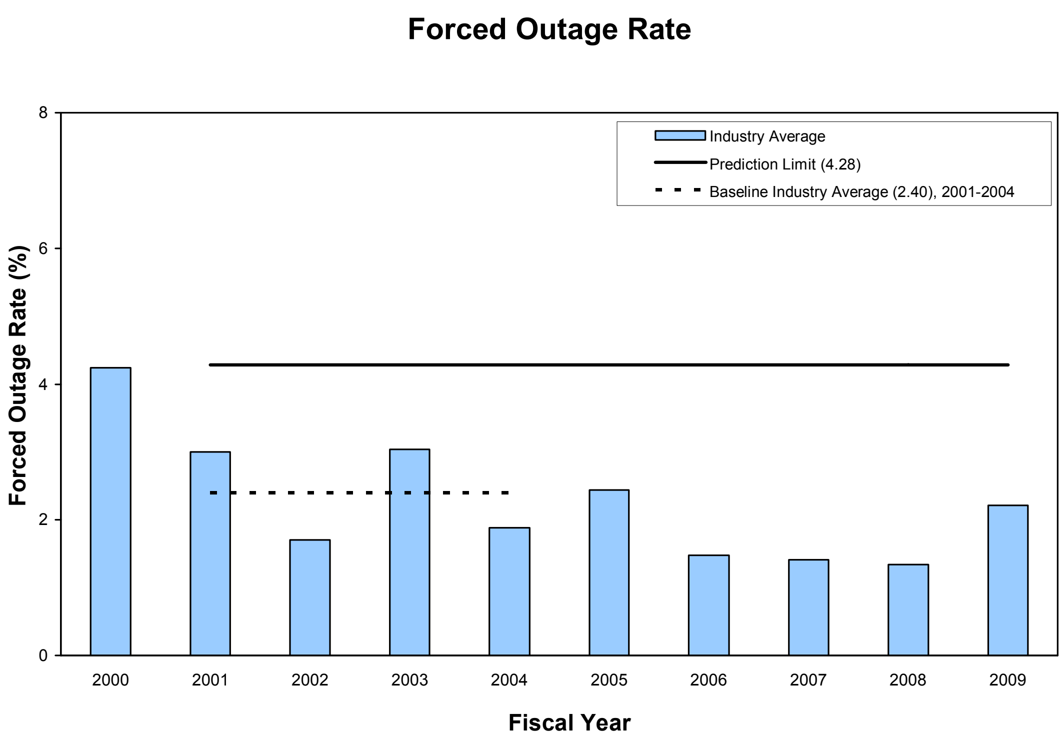


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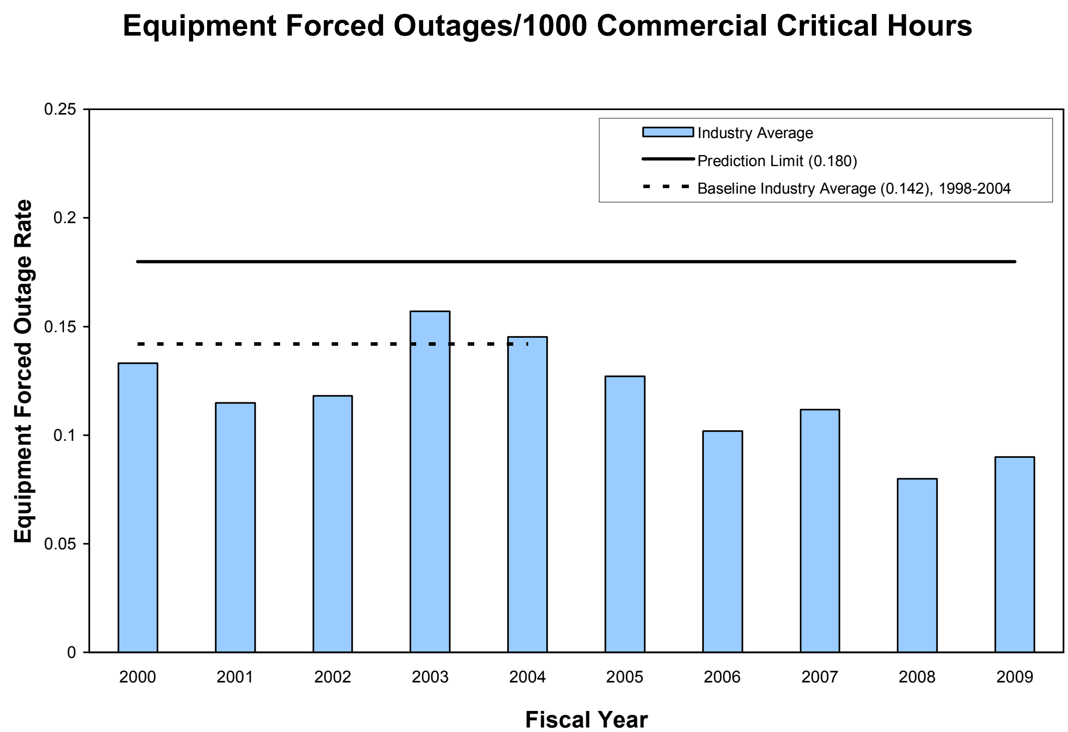


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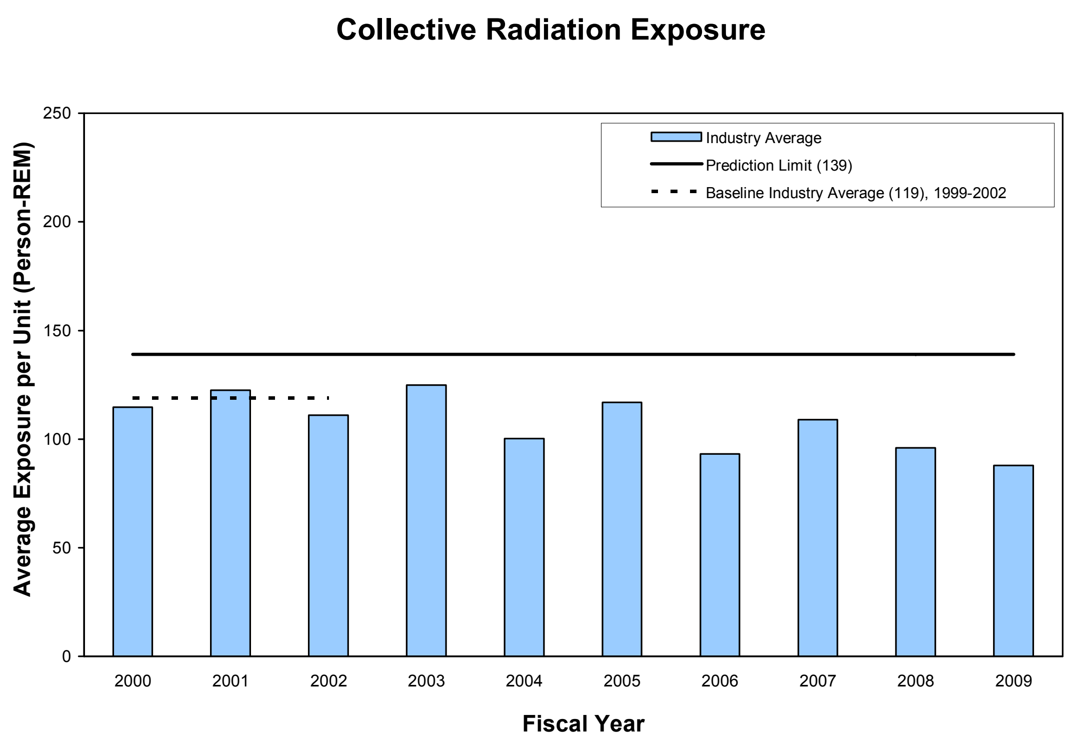


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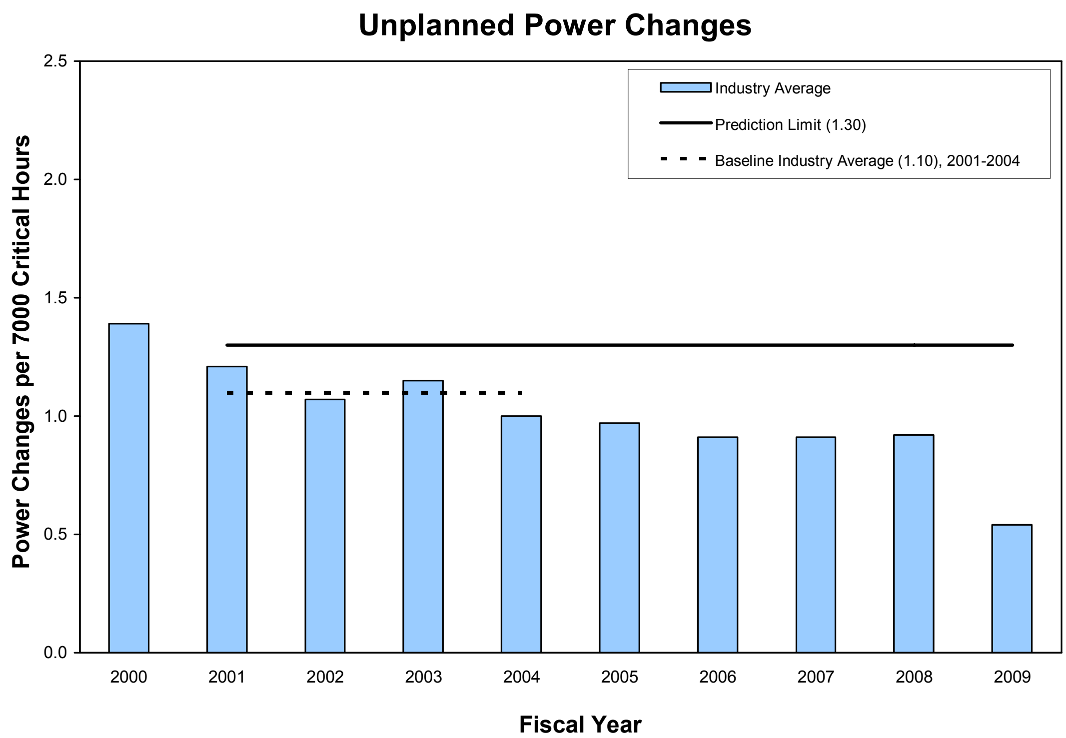
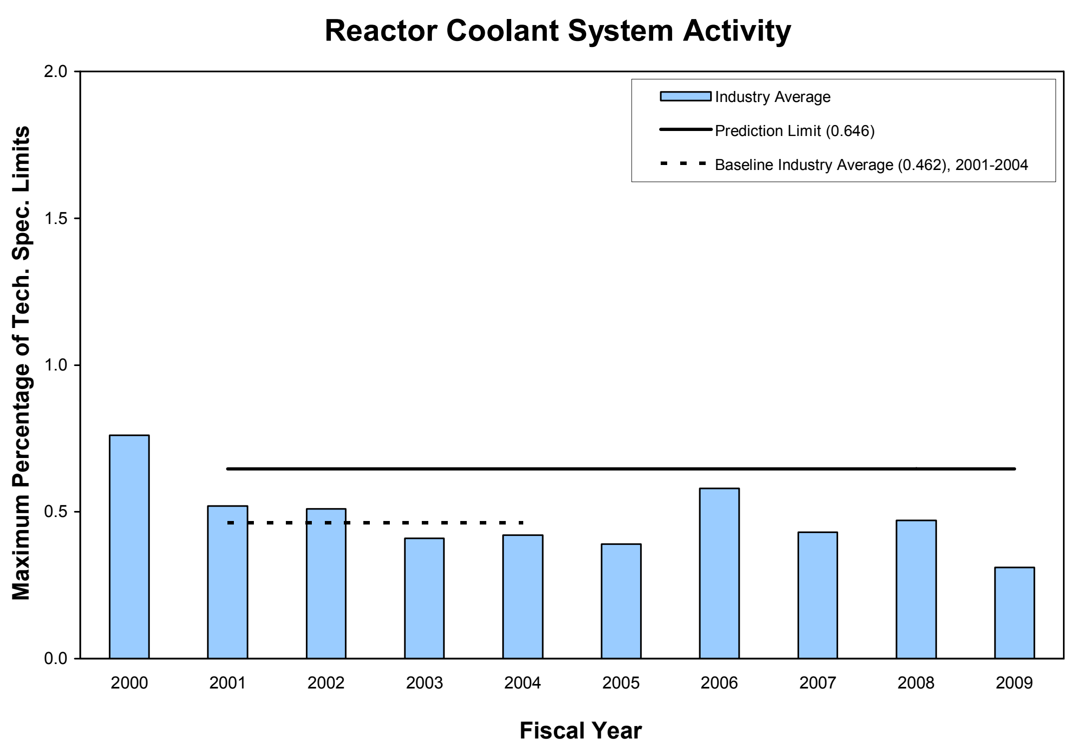



**Figure 8. Unplanned Power Changes per 7,000 Critical Hours**

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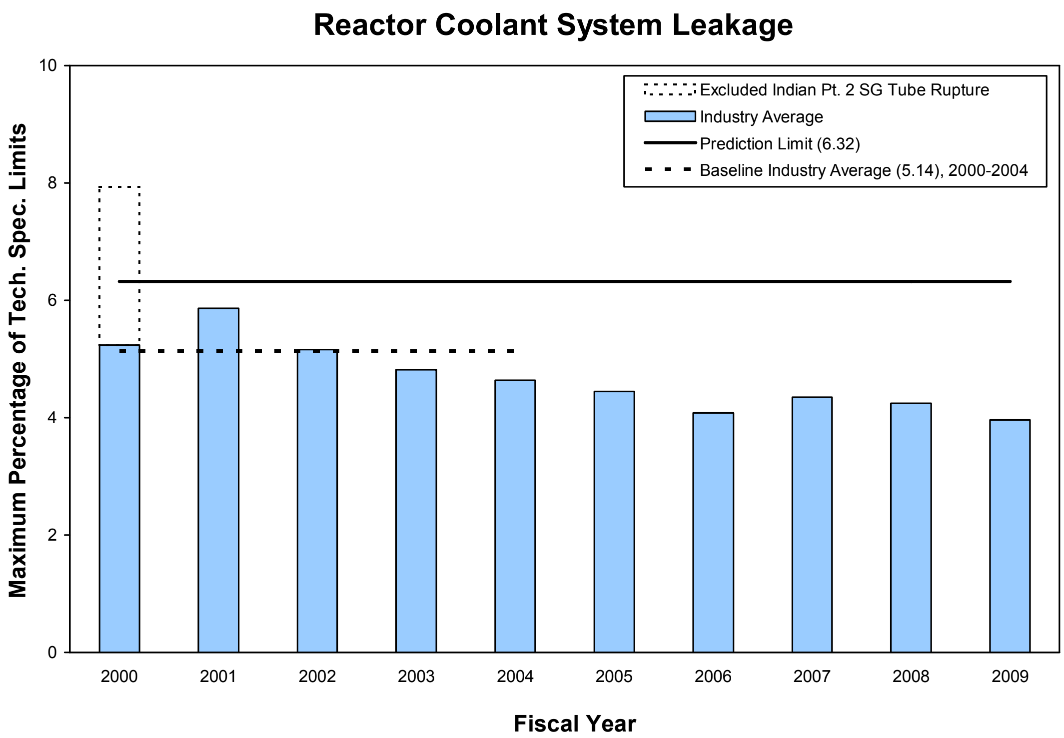


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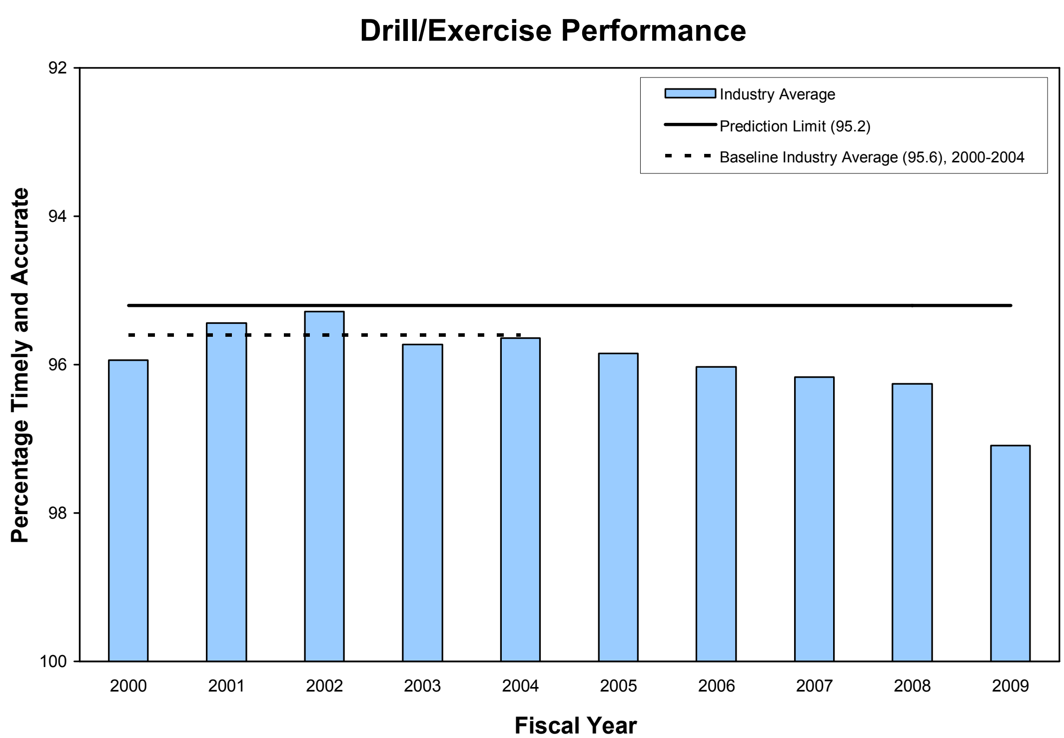


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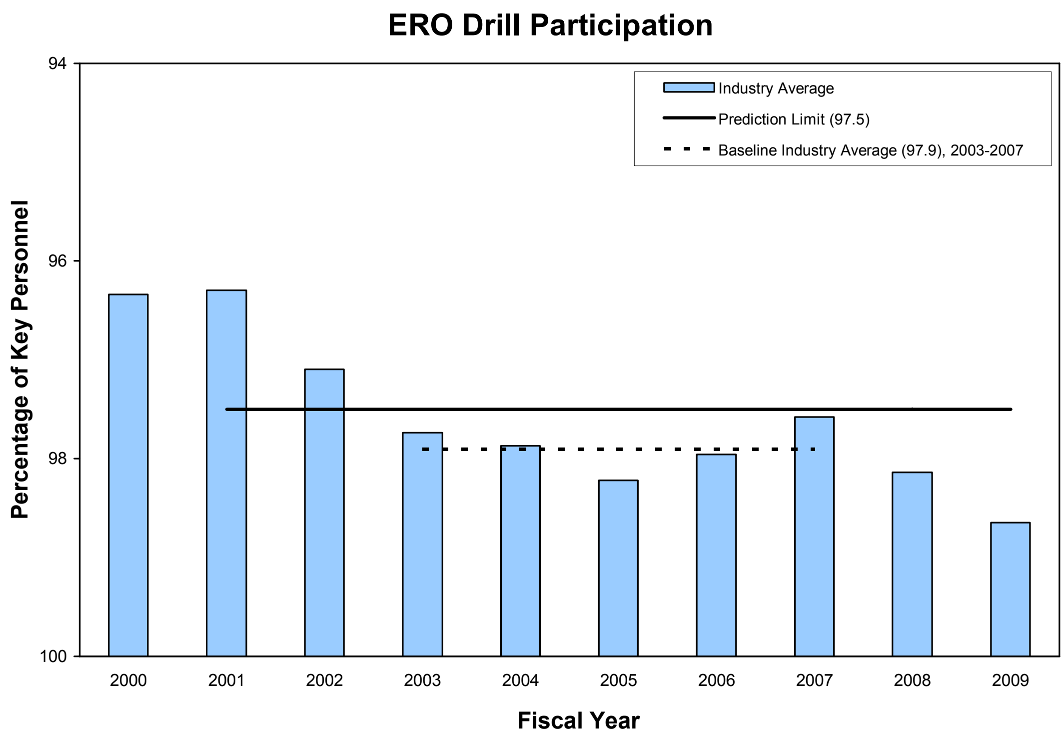


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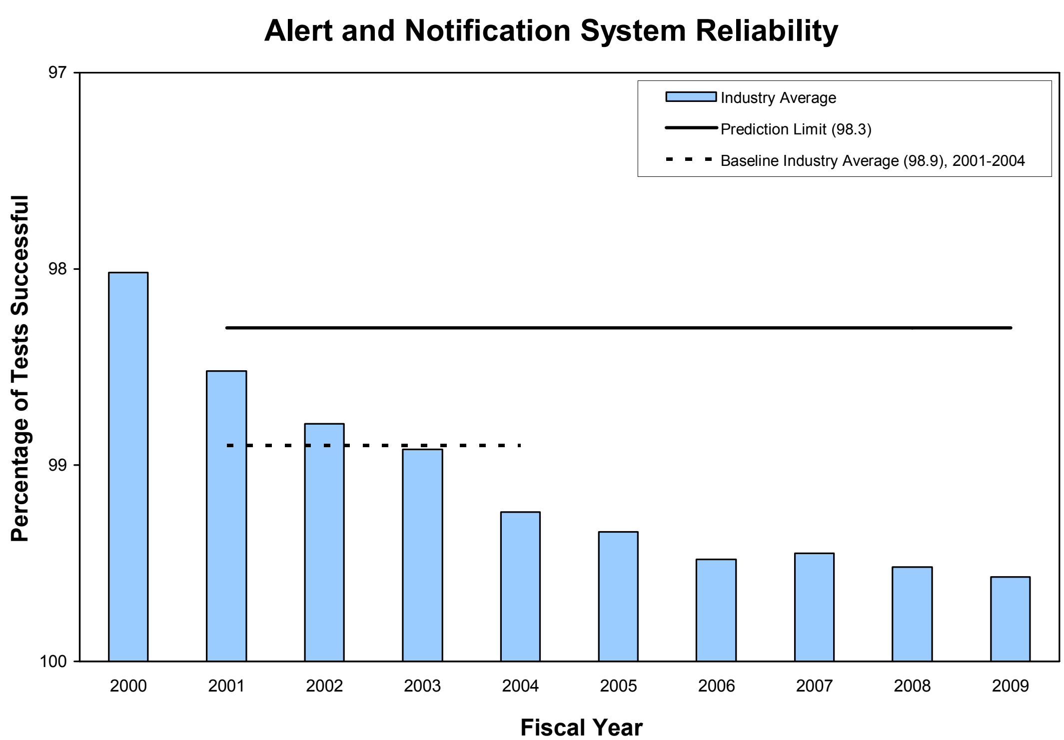


**Figure 13. Alert and Notification System Reliability**

NOTE: 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. This treatment results in a more conservative prediction limit.

# SUMMARY OF BASELINE RISK INDEX FOR INITIATING EVENTS ANNUAL GRAPHS THROUGH FISCAL YEAR 2009

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 commercial nuclear power plants. It is based on plant 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, described in NUREG/CR-6932, "Baseline Risk Index for Initiating Events (BRIIE)," issued June 2007, 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 4 of the initiators have separate data for each plant type, there are a total of 14 Tier 1 graphs.

The units for the Tier 1 IE 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. If industry data shift as time progresses, the baseline periods used to determine the prediction limits may no longer be relevant. The periods were originally developed to describe, roughly, calendar years 1998–2002. The staff intends to reevaluate the baseline values and prediction limits in the coming year and revise the values as needed to reflect changes in the data entering the BRIIE indicator.

The prediction limits depend on the expected 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 the same number of 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 2009 occurrence rates are lower than the associated Tier 1 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 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 for 2009 ($-2.36\times10^{-6}$ per reactor critical year) indicates better than baseline industry performance and is well below the established reporting threshold of $\Delta CDF = 1.0\times10^{-5}$ per reactor critical year.

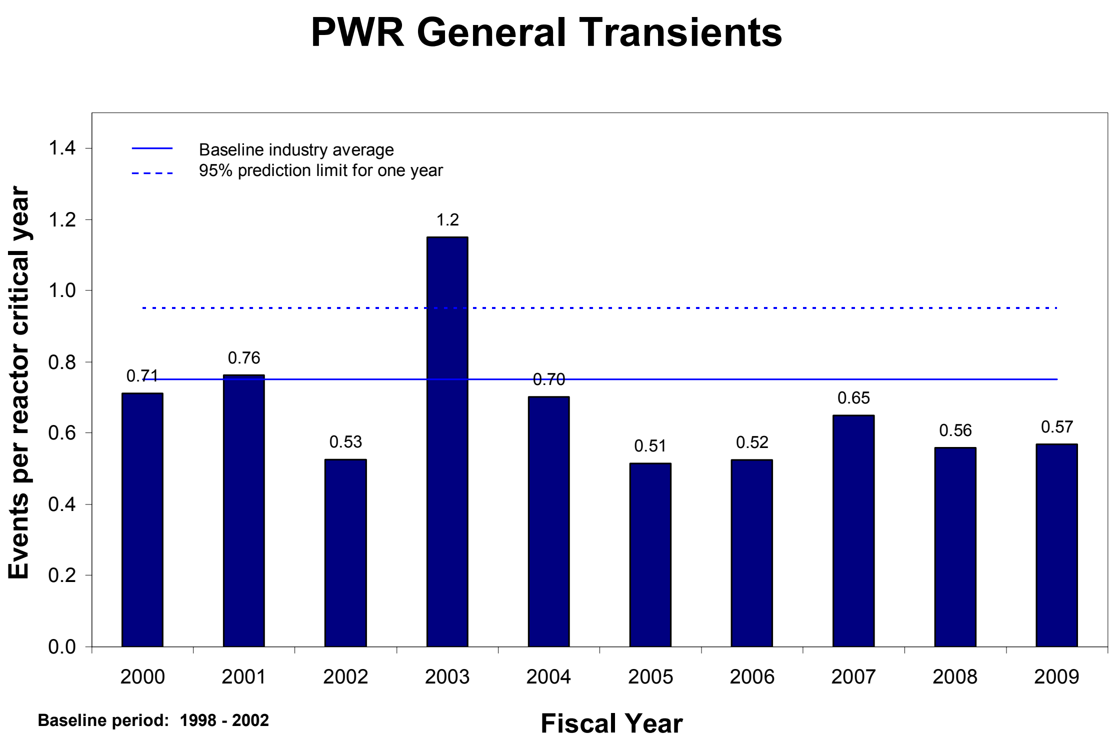


**Figure 1. Pressurized-Water Reactor (PWR) General Transients**

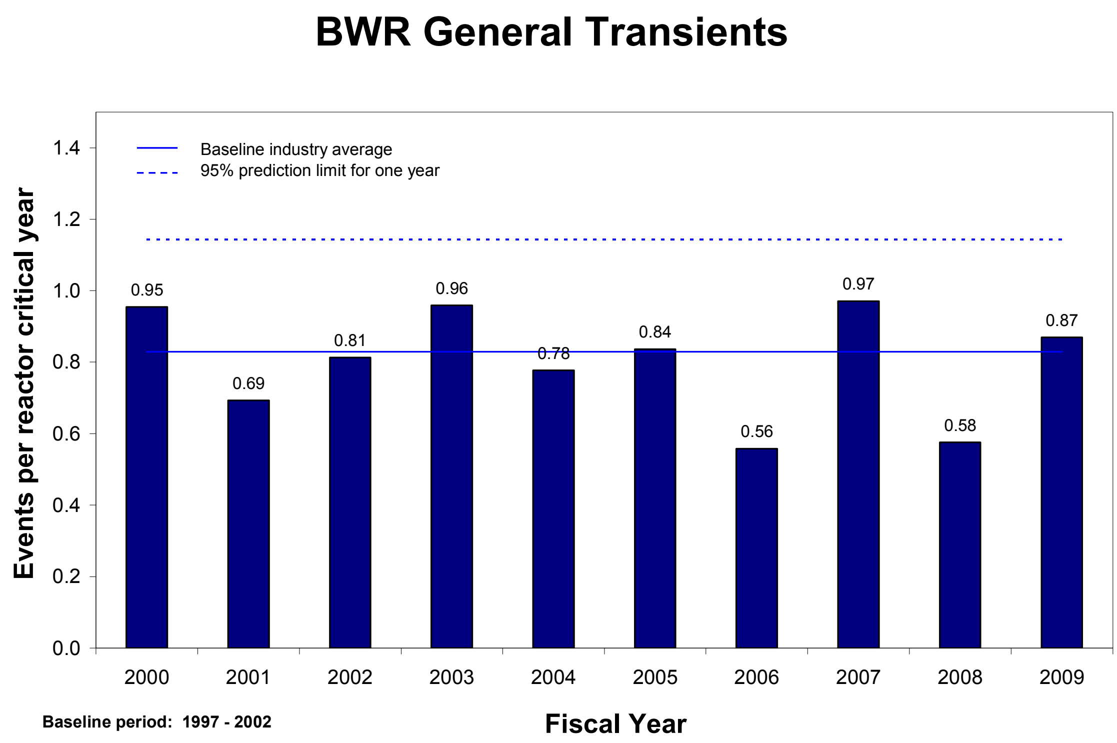


**Figure 2. Boiling-Water Reactor (BWR) General Transients**

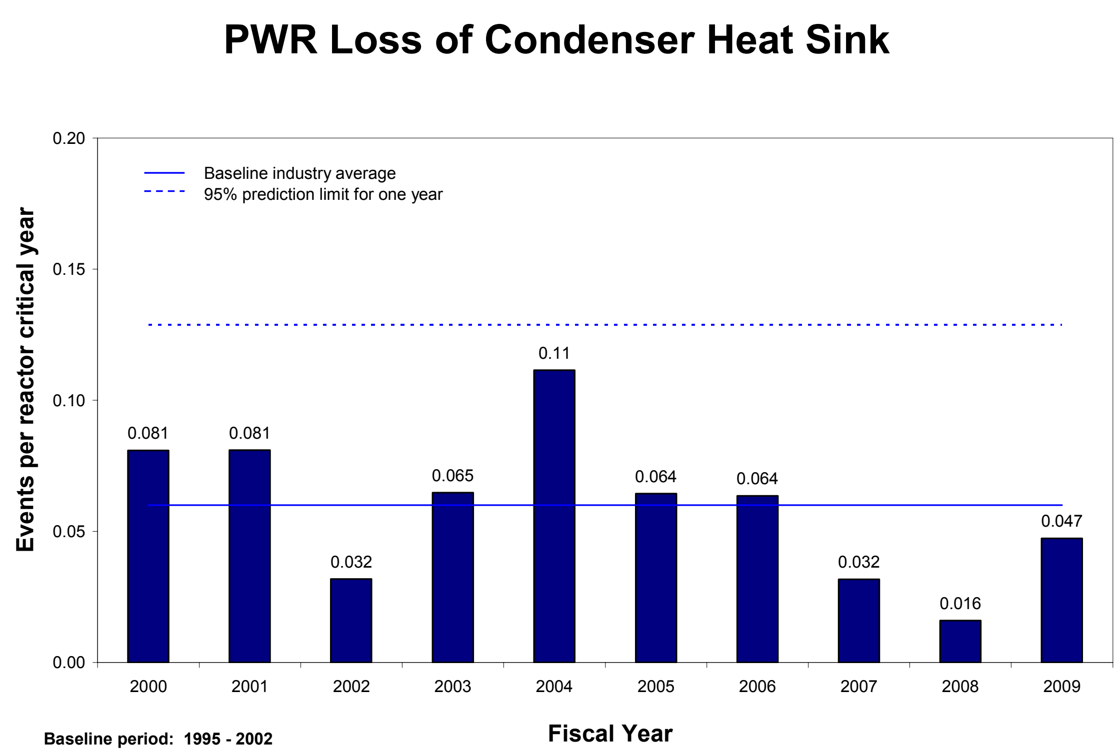


**Figure 3. PWR Loss of Condenser Heat Sink**

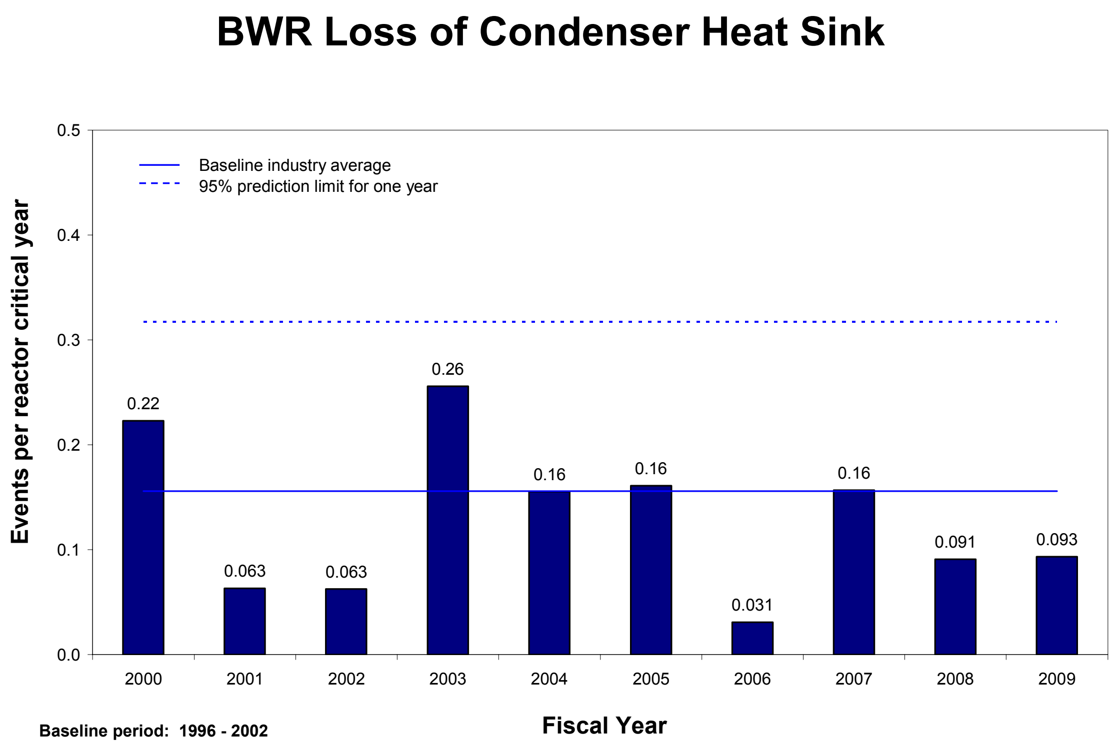


**Figure 4. BWR Loss of Condenser Heat Sink**

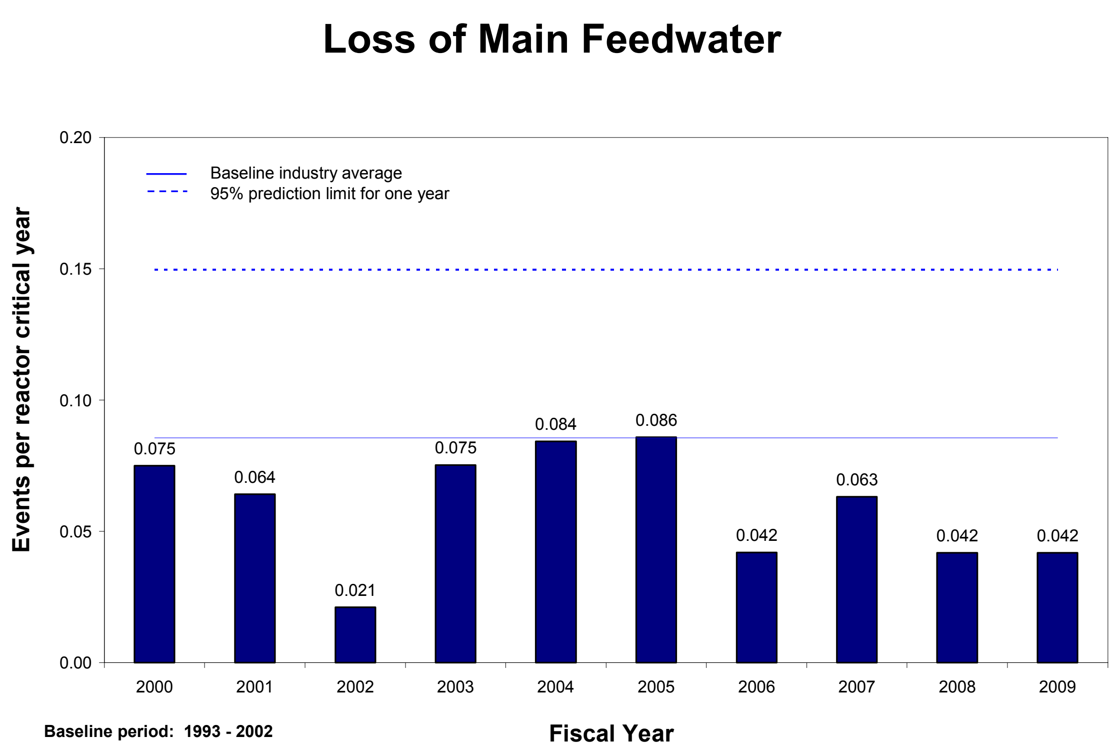


**Figure 5. Loss of Main Feedwater**

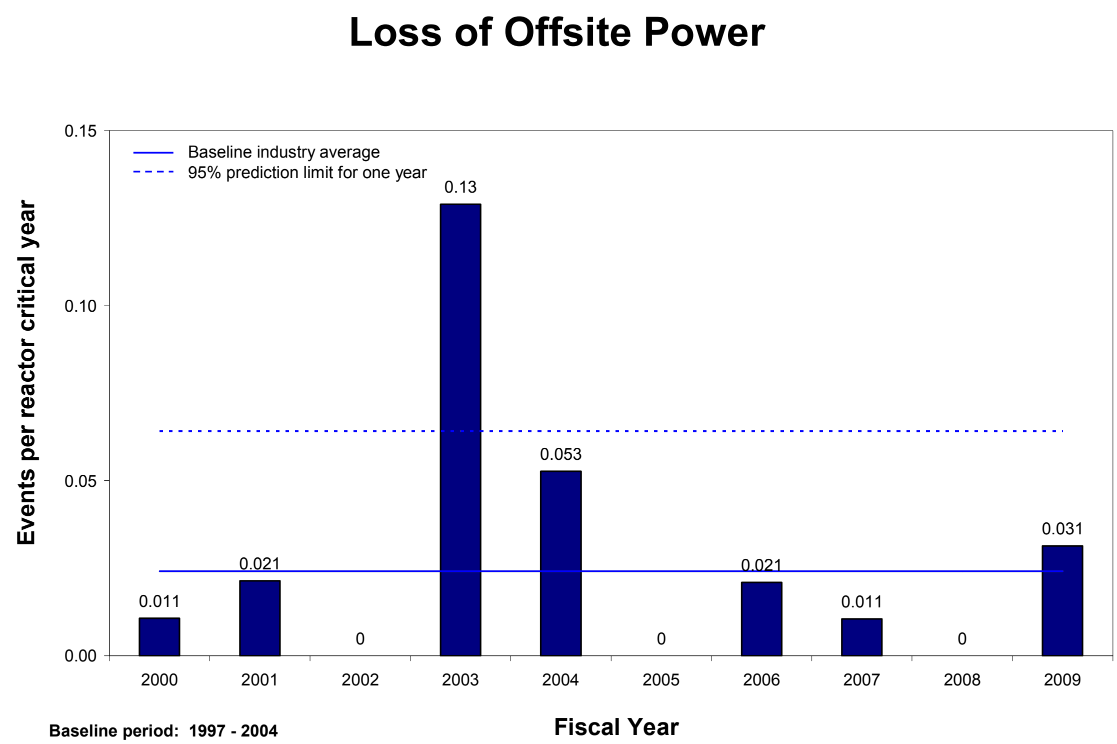


**Figure 6. Loss of Offsite Power**

NOTE: The prediction limit for loss of offsite power (LOOP) was calculated assuming that the nine LOOP events that occurred during the 2003 blackout were a single event. This treatment results in a more conservative prediction limit.

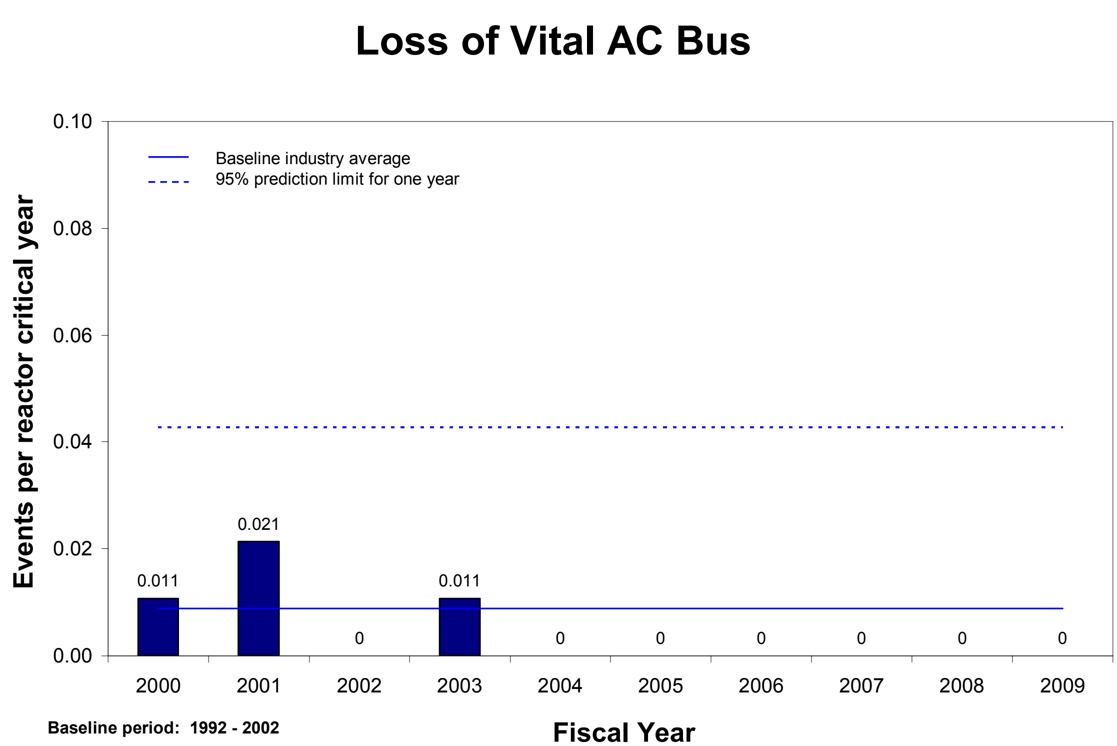


**Figure 7. Loss of Vital AC Bus**

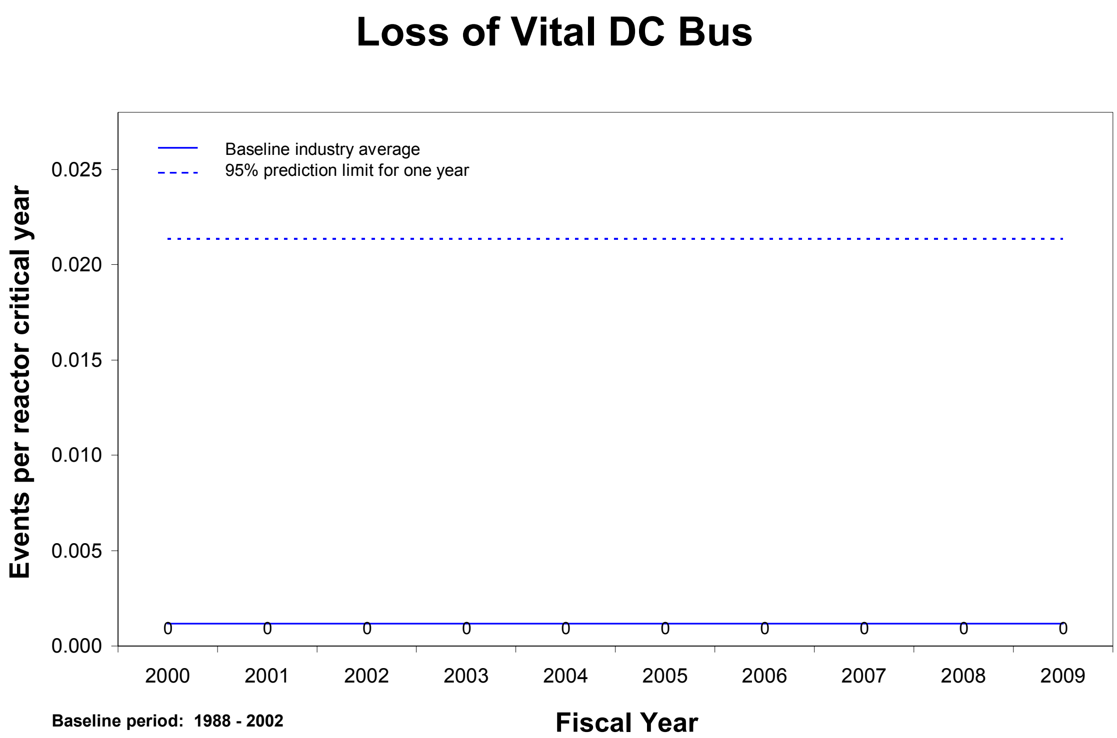


**Figure 8. Loss of Vital DC Bus**

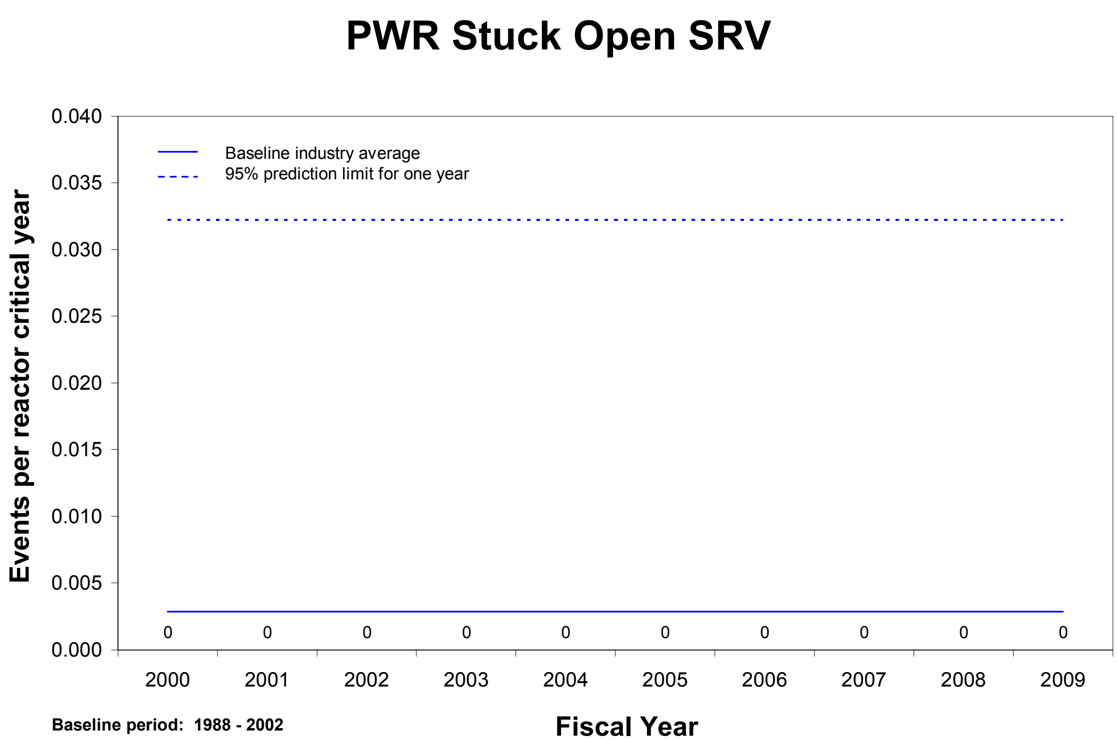


**Figure 9. PWR Stuck-Open Safety/Relief Valve**

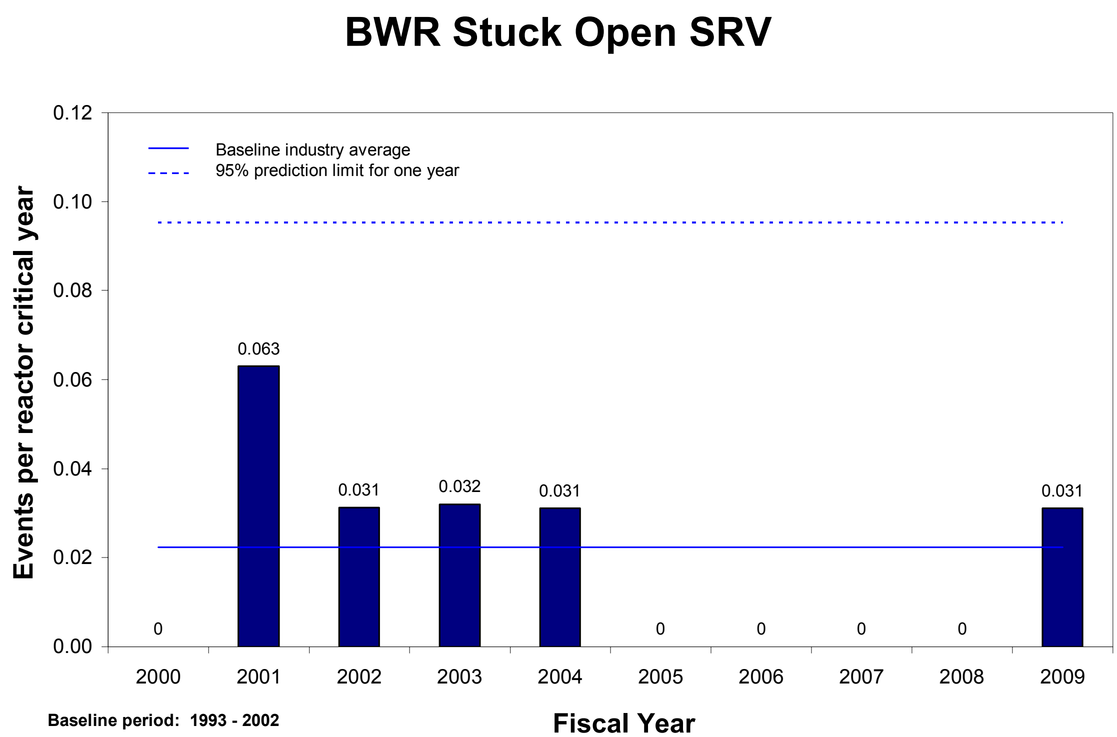


**Figure 10. BWR Stuck-Open Safety/Relief Valve**

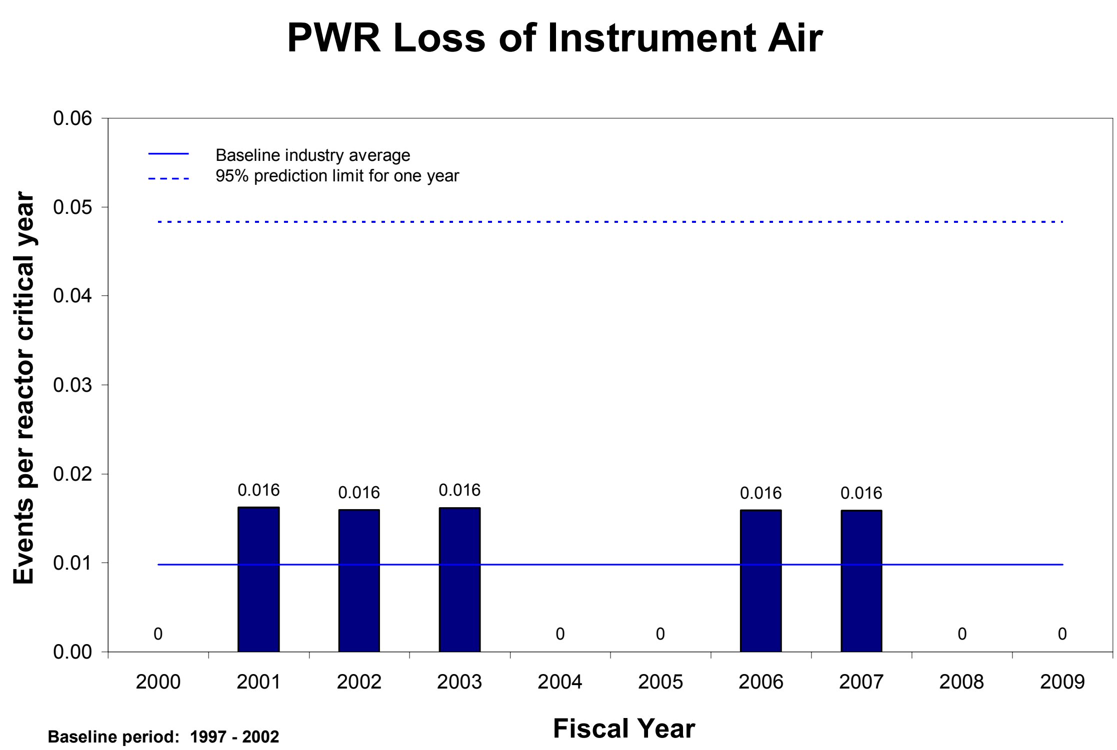


**Figure 11. PWR Loss of Instrument Air**

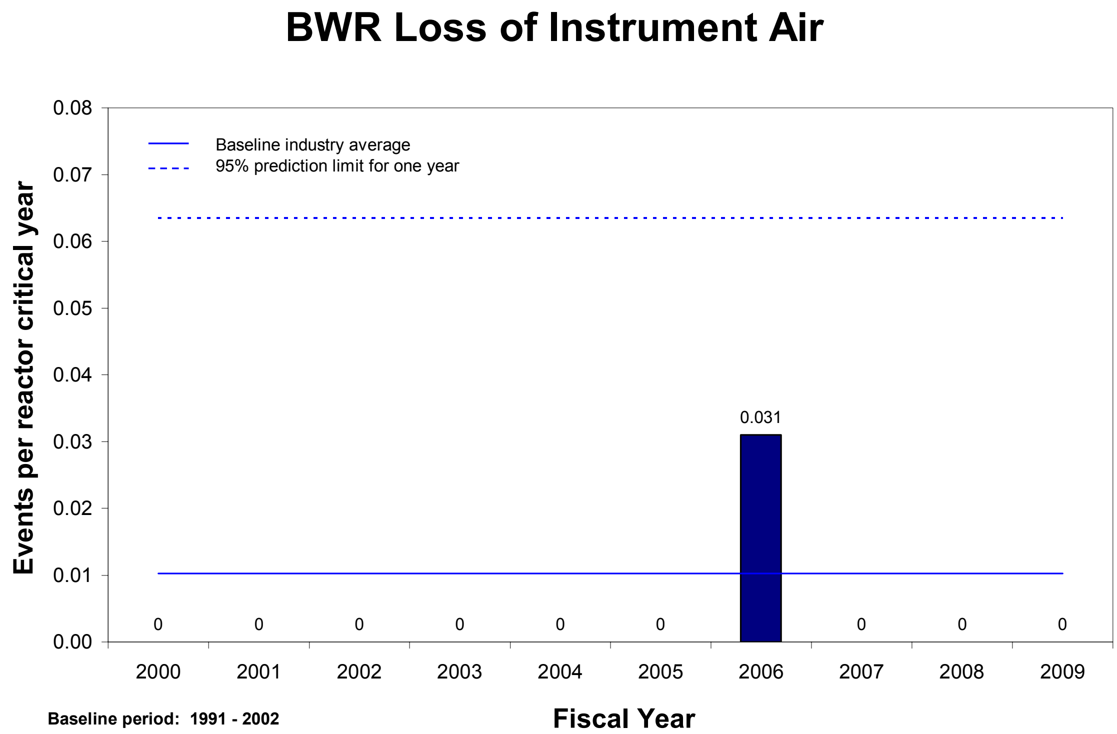


**Figure 12. BWR Loss of Instrument Air**

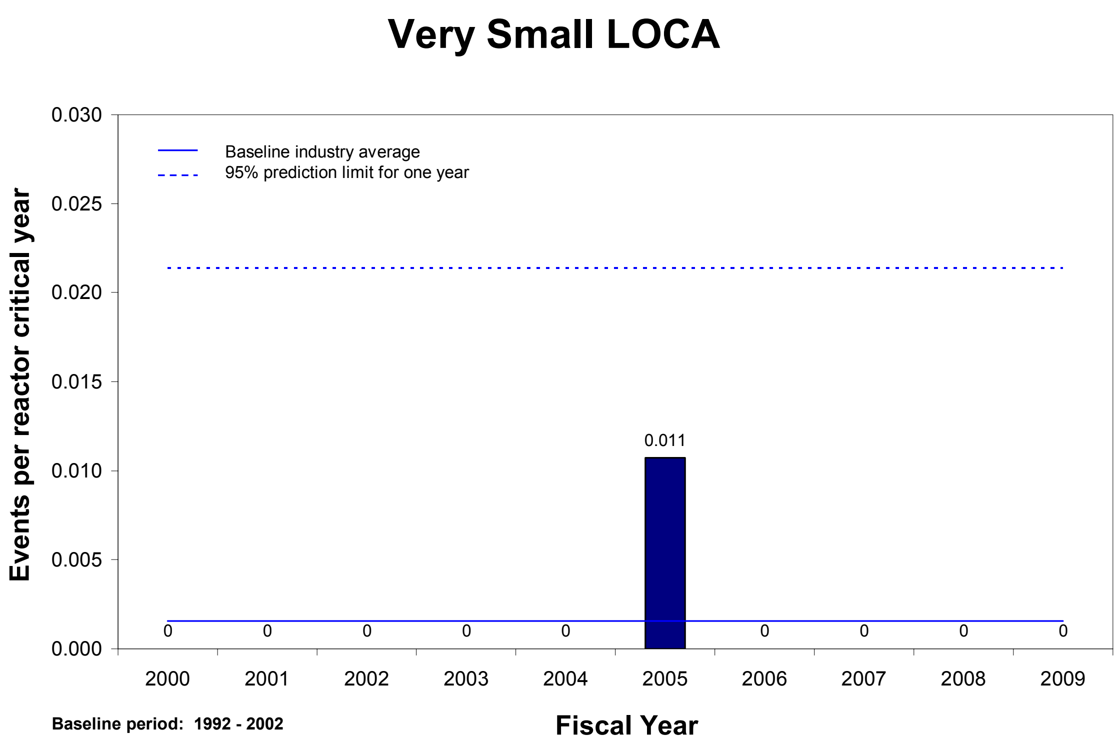


**Figure 13. Very Small Loss-of-Coolant Accident**

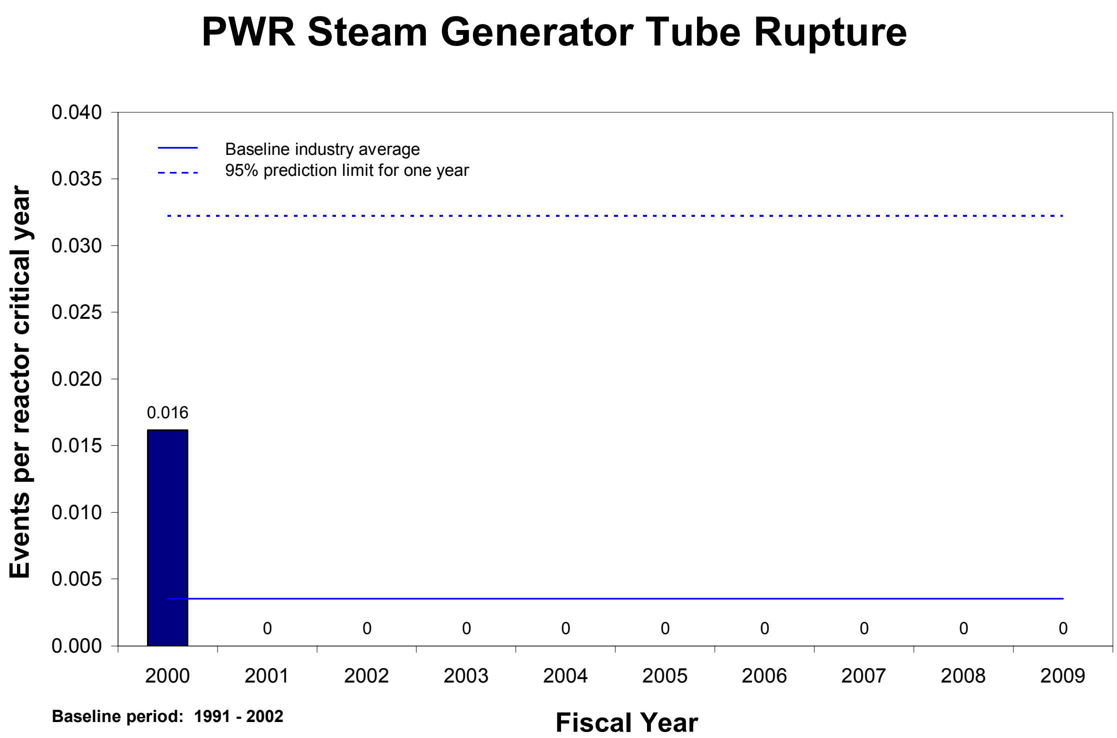


**Figure 14. PWR Steam Generator Tube Rupture**

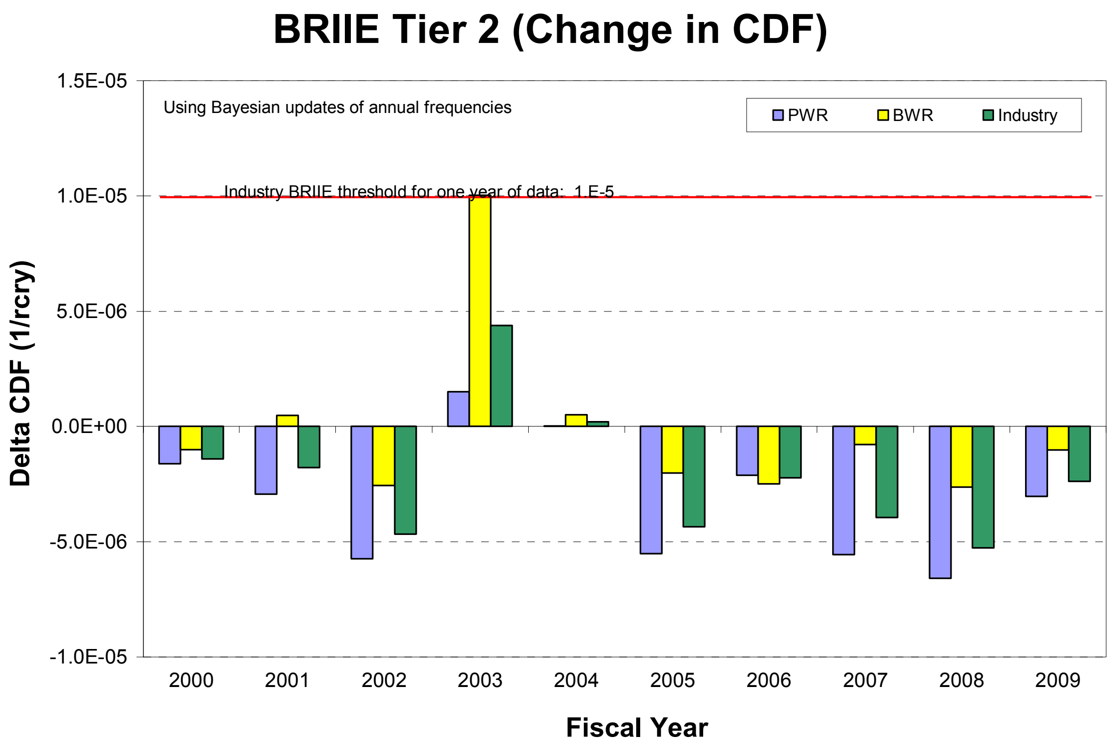


**Figure 15. BRIIE Tier 2 (Change in Core Damage Frequency)**