POLICY ISSUE
(Information)

March 28, 2011 SECY-11-0044

FOR: The Commissioners

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

SUBJECT: FISCAL YEAR 2010 RESULTS OF THE INDUSTRY TRENDS PROGRAM FOR OPERATING POWER REACTORS

PURPOSE:

The purpose of this paper is to inform the Commission of the results of the U.S. Nuclear Regulatory Commission's (NRC's) Industry Trends Program (ITP) for fiscal year (FY) 2010. This paper does not propose any new actions or commitments.

BACKGROUND:

The NRC staff implemented the ITP in 2001 to monitor for adverse trends in safety performance based on industry-level indicators. After the NRC assesses adverse trends for safety significance, it responds as necessary to any identified safety issues, including adjustments to the inspection and licensing programs. 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 tenth annual report to the Commission on the ITP.

NRC Inspection Manual Chapter 0313, "Industry Trends Program," dated May 29, 2008,

CONTACT: Kevin M Roche, NRR/DIRS
(301) 415-3106

contains details of the ITP, including definitions of monitored indicators and program descriptions.

DISCUSSION:

Using the ITP, the staff monitors industry safety performance to identify and address adverse industry trends. The indicators are comprehensive and are based on the best available data. An adverse trend exists if the slope of the regression line fitted to the long-term indicator data has 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 complements the Reactor Oversight Process (ROP); the ITP monitors industry-level performance, whereas the ROP provides oversight of individual plant conditions and events.

FY 2010 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 2010. The graphs in Enclosure 1 show the long-term ITP indicator trends and the ASP data. The ASP Program considers an event with a conditional core damage probability (CCDP) or an increase in core damage probability (ΔCDP) greater than or equal to 1×10^{-6} to be a precursor.

The Office of Nuclear Regulatory Research (RES) staff evaluated precursor data from FY 2001 to FY 2009 and identified no statistically significant trends for the occurrence rate of all precursors during that period (Figure 14 of Enclosure 1). Additionally, the staff identified statistically significant decreasing trends for precursors with a CCDP or ΔCDP greater than or equal to 1×10^{-4} and for precursors that occurred at pressurized-water reactors during this same period. The data period for ASP trending analysis will become a rolling 10-year period when the FY 2010 analyses are completed.

The ASP Program also provides the basis for the safety performance measure of zero *significant* accident sequence precursors of a nuclear reactor accident. This is one measure that is associated with the safety goal that the NRC established in its 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 1×10^{-3}) of leading to a reactor accident.

On March 28, 2010, an event occurred at H.B. Robinson Steam Electric Plant involving electrical equipment fires, a reactor trip, a subsequent safety injection actuation, and an Alert emergency declaration. Based on information provided in Inspection Report

05000261/2010009, "H.B. Robinson Steam Electric Plant—Augmented Inspection Team Report," dated July 2, 2010 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML101830101), the NRC staff initially performed an ASP screening analysis and determined that the event was not a potential *significant* precursor. Subsequently, the staff reported in SECY-10-0125, "Status of the Accident Sequence Precursor Program and the Standardized Plant Analysis Risk Models," dated September 29, 2010 (ADAMS Accession No. ML102100313), that no *significant* precursors had been identified in FY 2010. However, RES staff received new information in December 2010 that could lead to the event being a potential *significant* precursor. The ASP analysis is currently ongoing. If the final ASP analysis results in a *significant* precursor, the NRC will report this event in next year's Abnormal Occurrence Report and in the FY 2011 Performance and Accountability Report to Congress.

FY 2010 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 2010; however, the number of significant events (SEs) did increase. These events were unrelated and appear to have no common theme. Furthermore, the number of SEs is inflated because yellow inspection findings were identified for each reactor unit at two three-unit sites, essentially tripling the number of SEs for those sites because SEs are counted on a per-unit basis. Short-term FY 2010 data did not reveal any emerging trends that warranted additional analysis or significant adjustments to the nuclear reactor safety inspection or licensing programs. The NRC Staff and Industry have noted issues related to human performance and training. The ITP has captured those issues that have manifested themselves as significant events or one of the other ITP performance indicators; never the less, no statistically significant increase has been noted.

FY 2010 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 (1) tracks several types of events that could potentially start ("initiate") a challenge to a plant's safety systems, (2) 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) 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 10 for pressurized-water reactors. The number of times that each event occurs is compared to a predetermined number of occurrences for that event. If the predetermined number is exceeded, one can infer the 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 event 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 it. 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 $1x10^{-5}$ 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 2010. Figure 15 of Enclosure 3 shows that the BRIIE combined industry value in FY 2010 ($-3.39x10^{-6}$ per reactor critical year) indicates better than baseline industry performance and is well below the established reporting threshold of $\Delta CDF = 1.0x10^{-5}$ 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 $510,000 for ongoing ITP implementation in FY 2011, and 0.5 FTE and $535,000 in FY 2012. The resources are included in the FY 2011 budget and FY 2012 budget request as part of the ROP in Subprogram: Reactor Oversight; Planned Activity: Reactor Performance Assessment.

RES provides indirect support to the ITP in the areas of operating experience data and models that are developed and budgeted under other RES programs such as the Standardized Plant Analysis Risk Model Development 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 2012 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.

/RA/

Eric J. Leeds, Director
Office of Nuclear Reactor Regulation

Enclosures:
1. Fiscal Year 2010 Long-Term Industry Trend Results
2. Fiscal Year 2010 Short-Term Industry Performance
3. Summary of Baseline Risk Index for Initiating Events: Annual Graphs through Fiscal Year 2010

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ADAMS Accession Number: ML110320544 *concurred via email

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NAME	KRoche	RFranovich	KAzariah-Kribbs	JThorp	HLe
DATE	02/05/11	02/15/11	02/08/11	02/14/11	02/17/11
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FISCAL YEAR 2010 LONG-TERM INDUSTRY TREND RESULTS

The staff of the U.S. Nuclear Regulatory Commission did not observe any statistically significant adverse trends in the Industry Trends Program performance indicator data from the most recent 10 years (fiscal years 2001–2010), as indicated by the figures below.

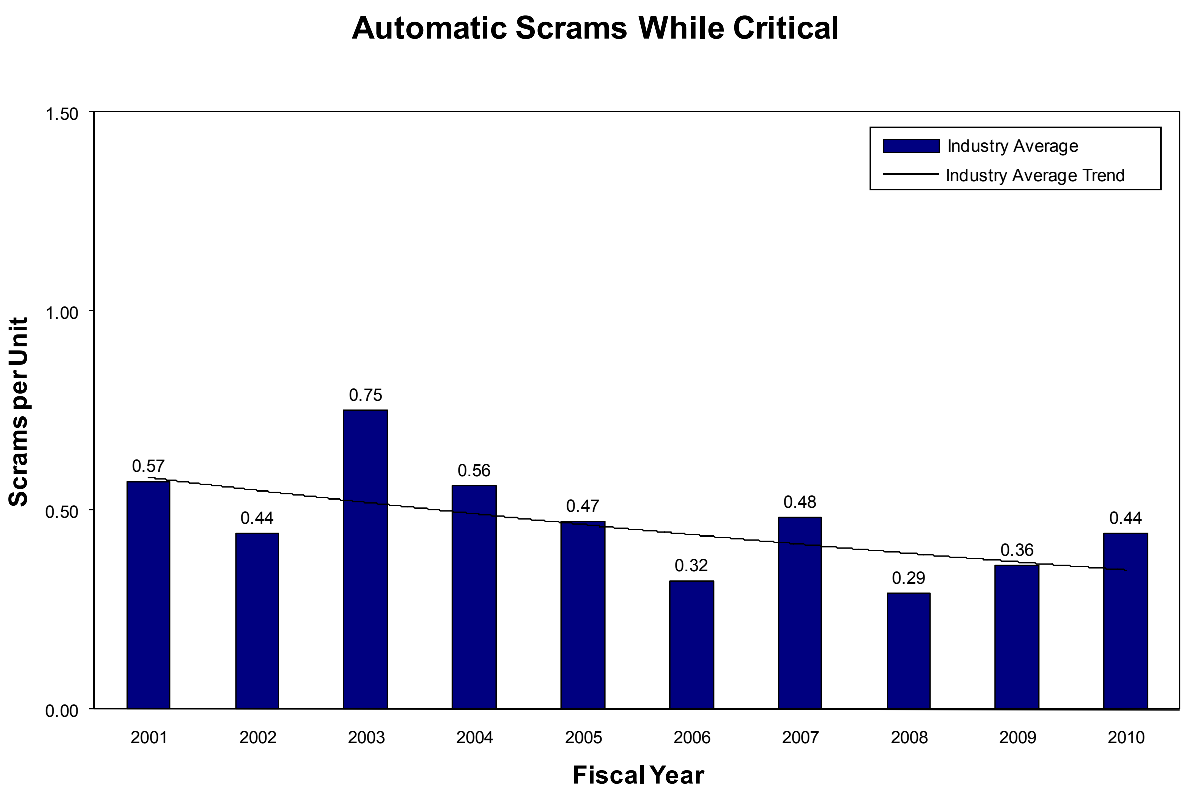


Figure 1 Automatic scrams while critical

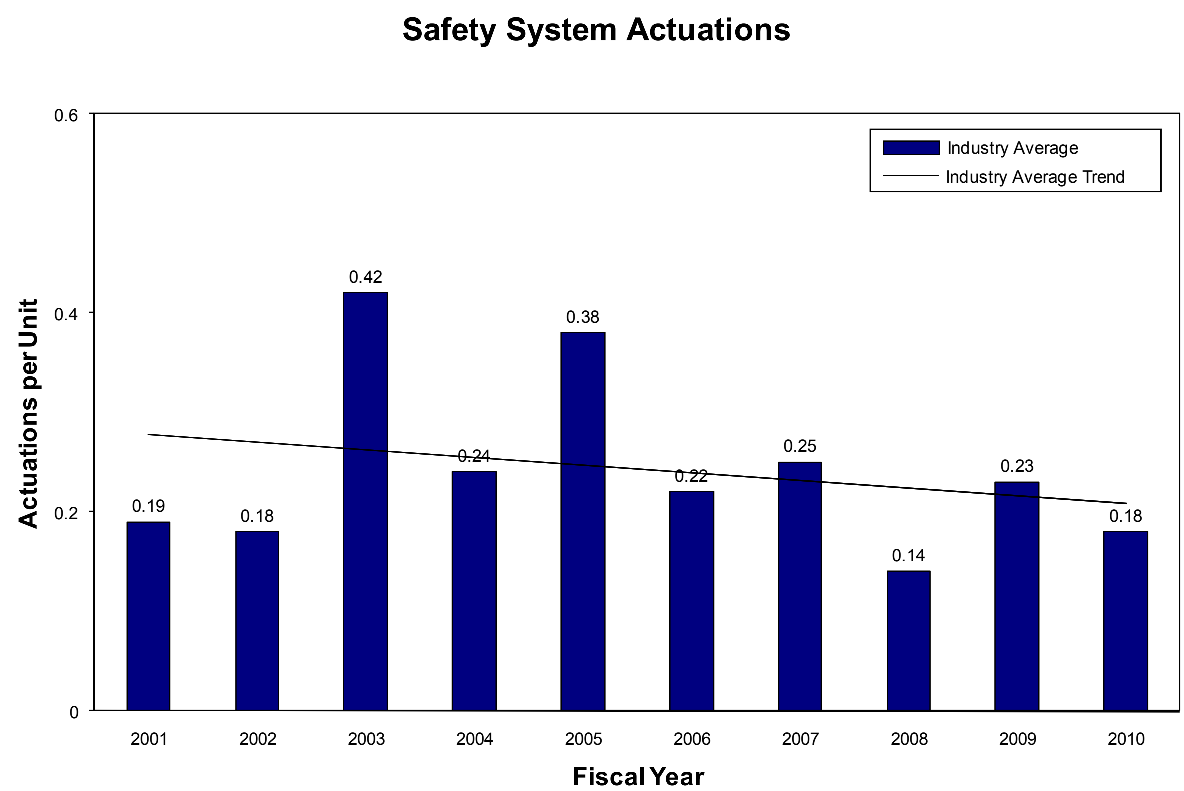


Figure 2 Safety system actuations

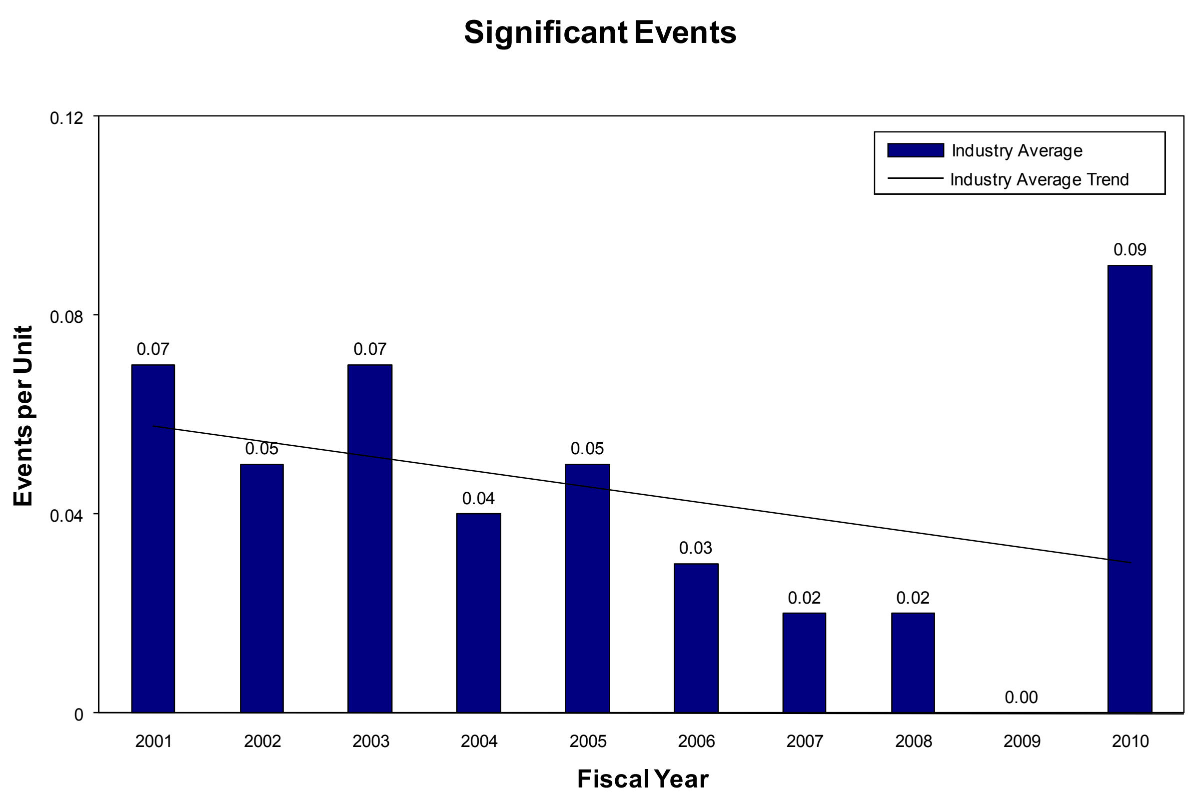


Figure 3 Significant events

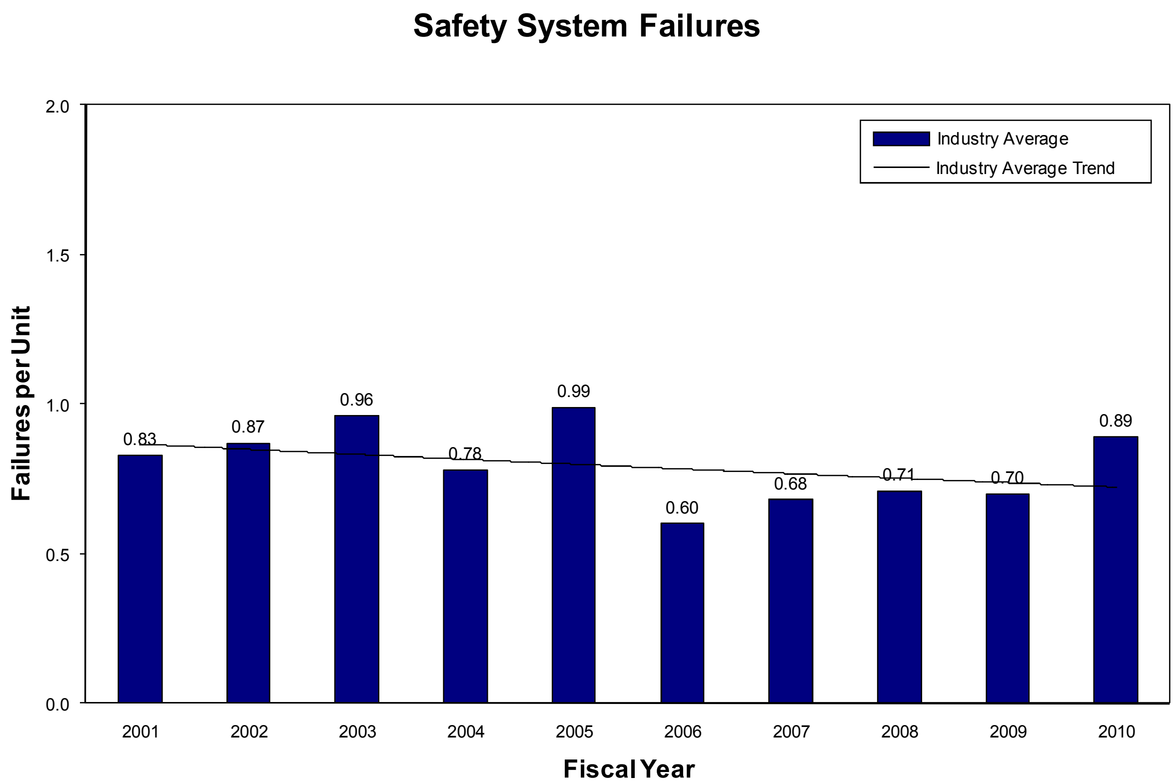


Figure 4 Safety system failures

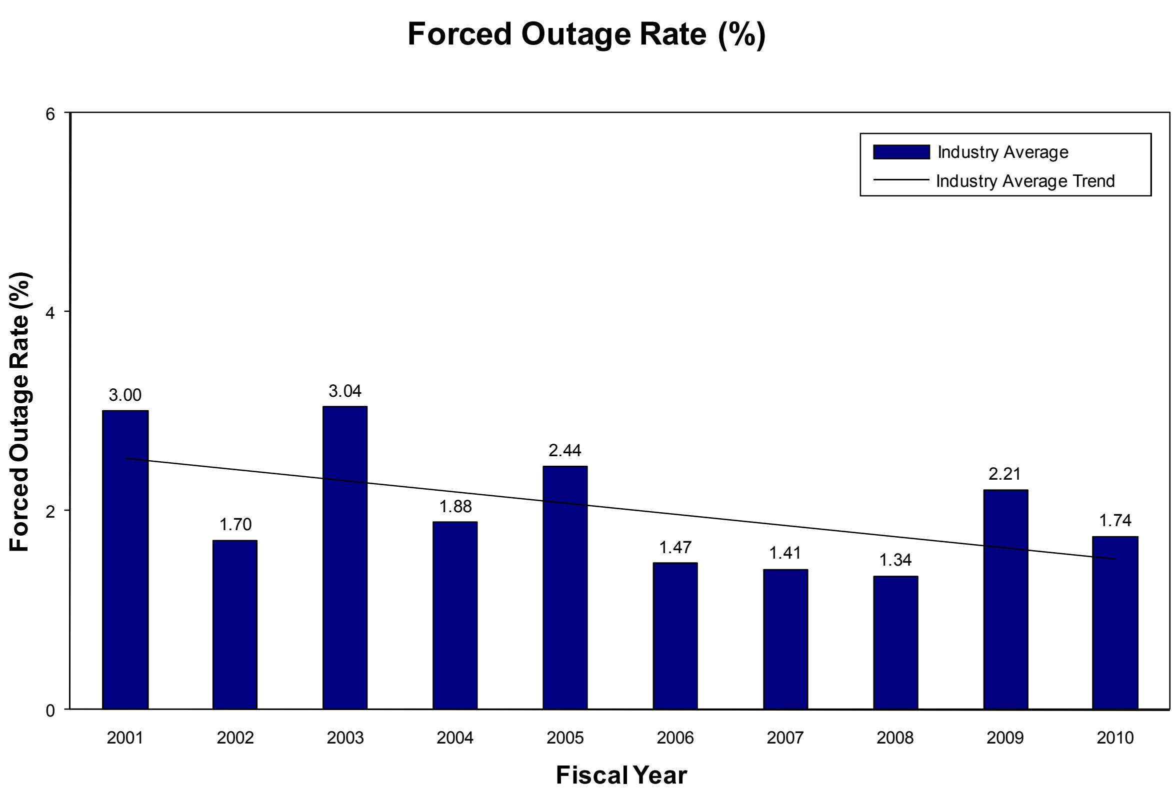


Figure 5 Forced outage rate

Equipment Forced Outages/1000 Commercial Critical Hours

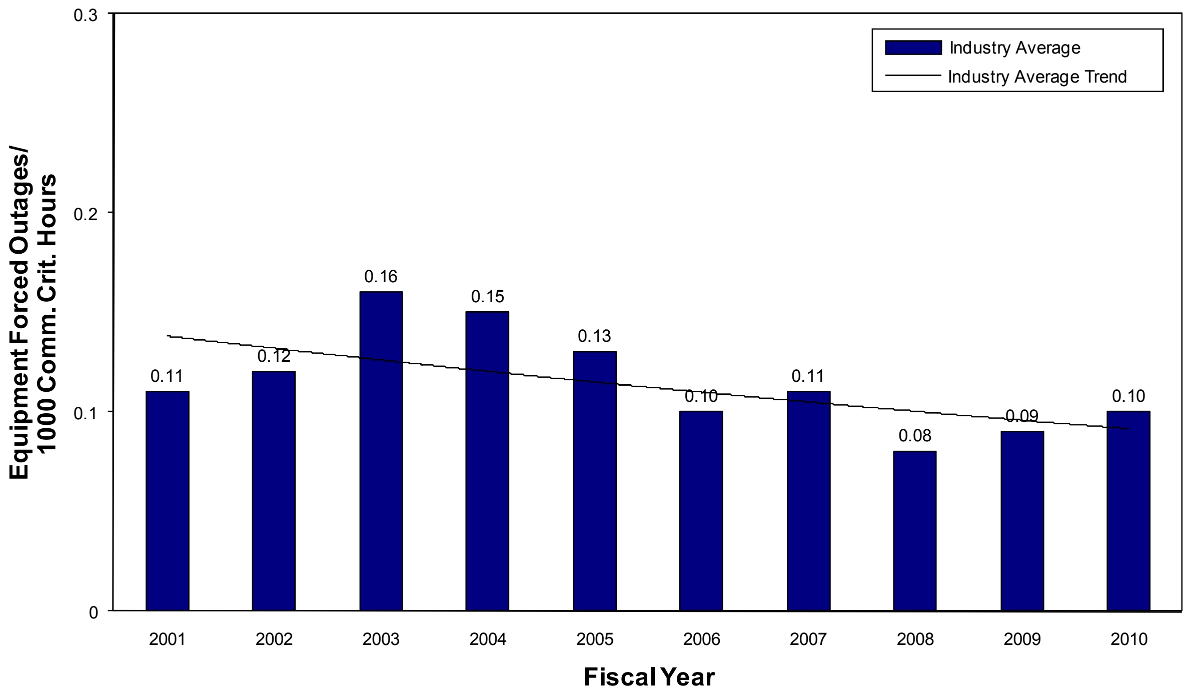


Figure 6 Equipment forced outages per 1,000 commercial critical hours

Collective Radiation Exposure

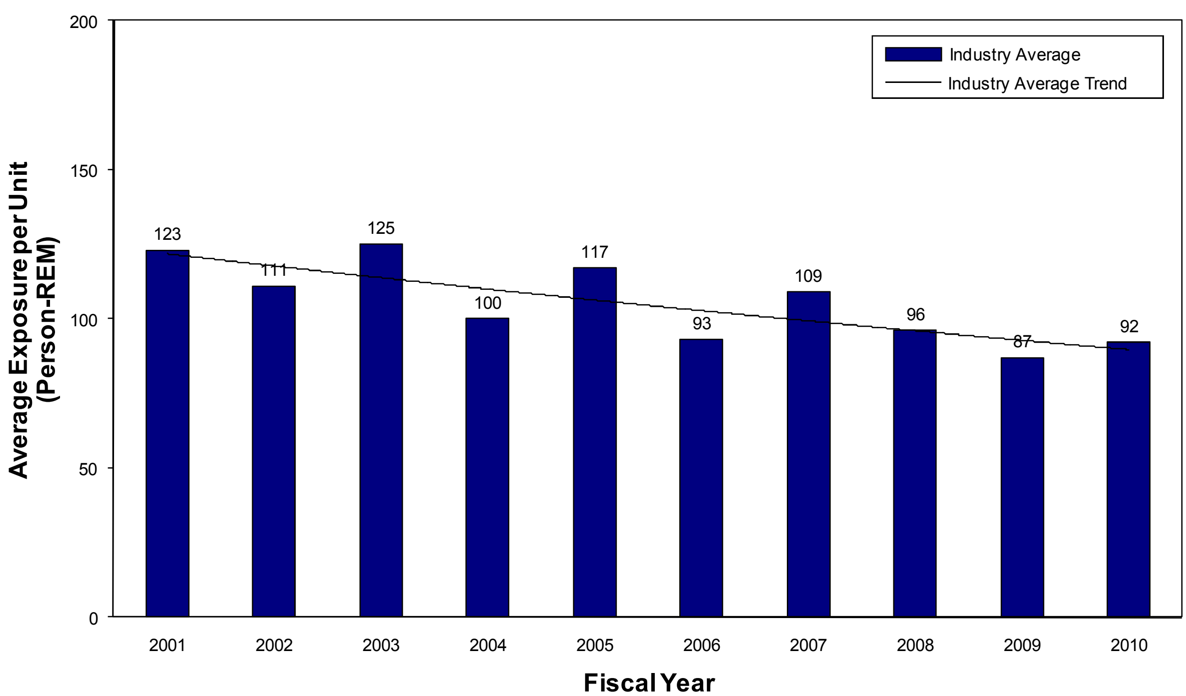


Figure 7 Collective radiation exposure

Unplanned Power Changes

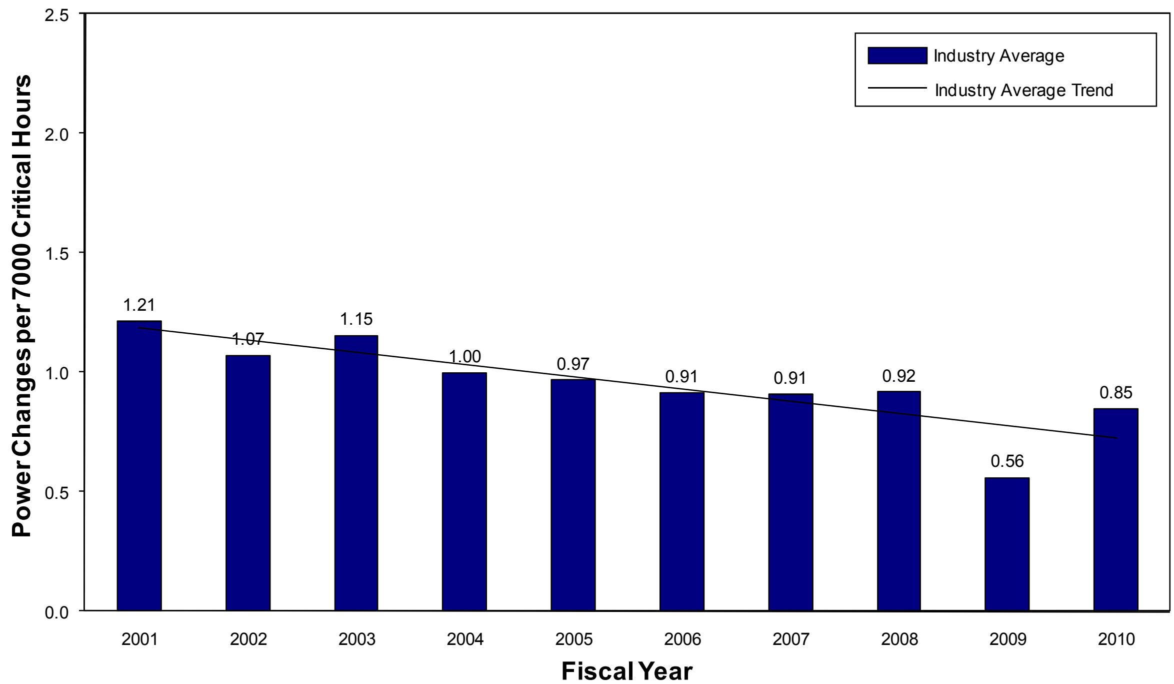


Figure 8 Unplanned power changes

Reactor Coolant System Activity

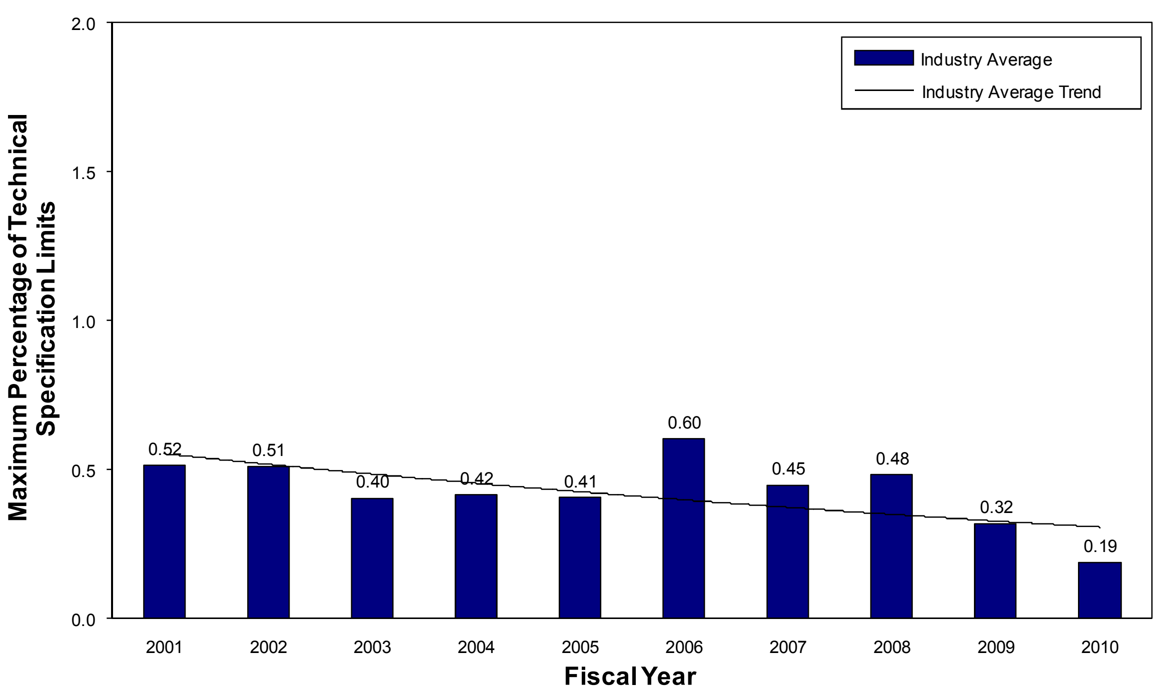


Figure 9 Reactor coolant system activity

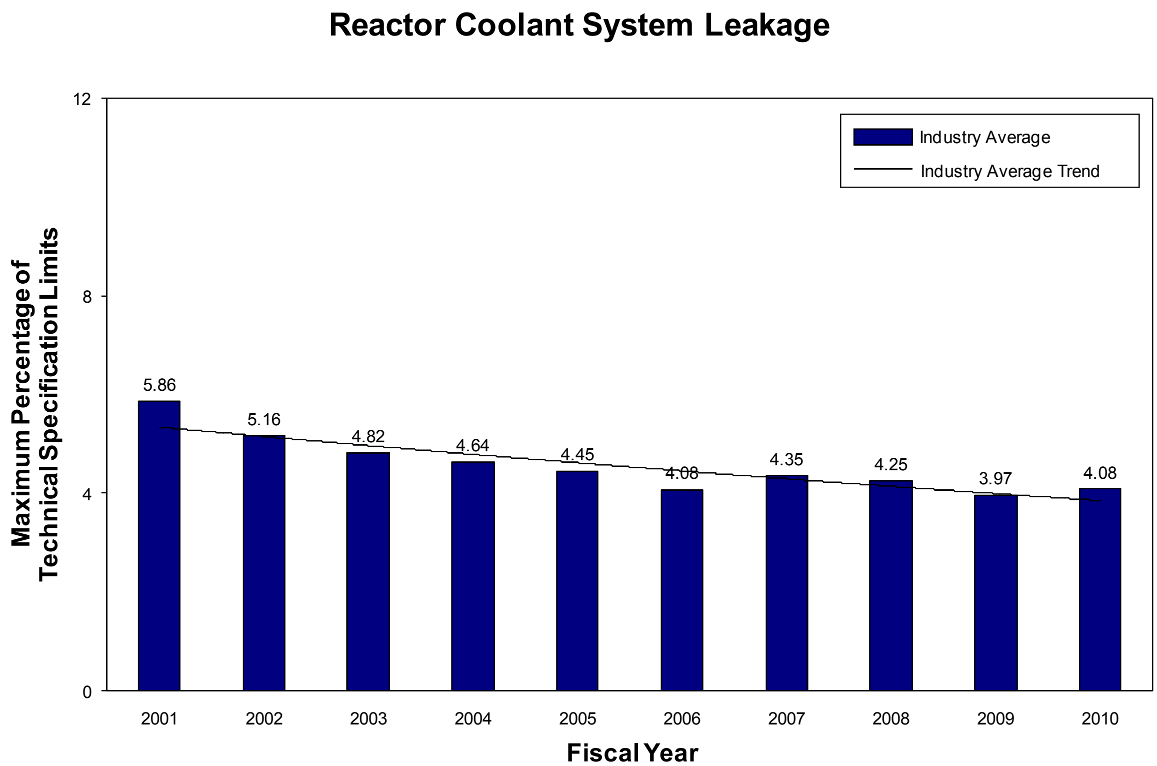


Figure 10 Reactor coolant system leakage

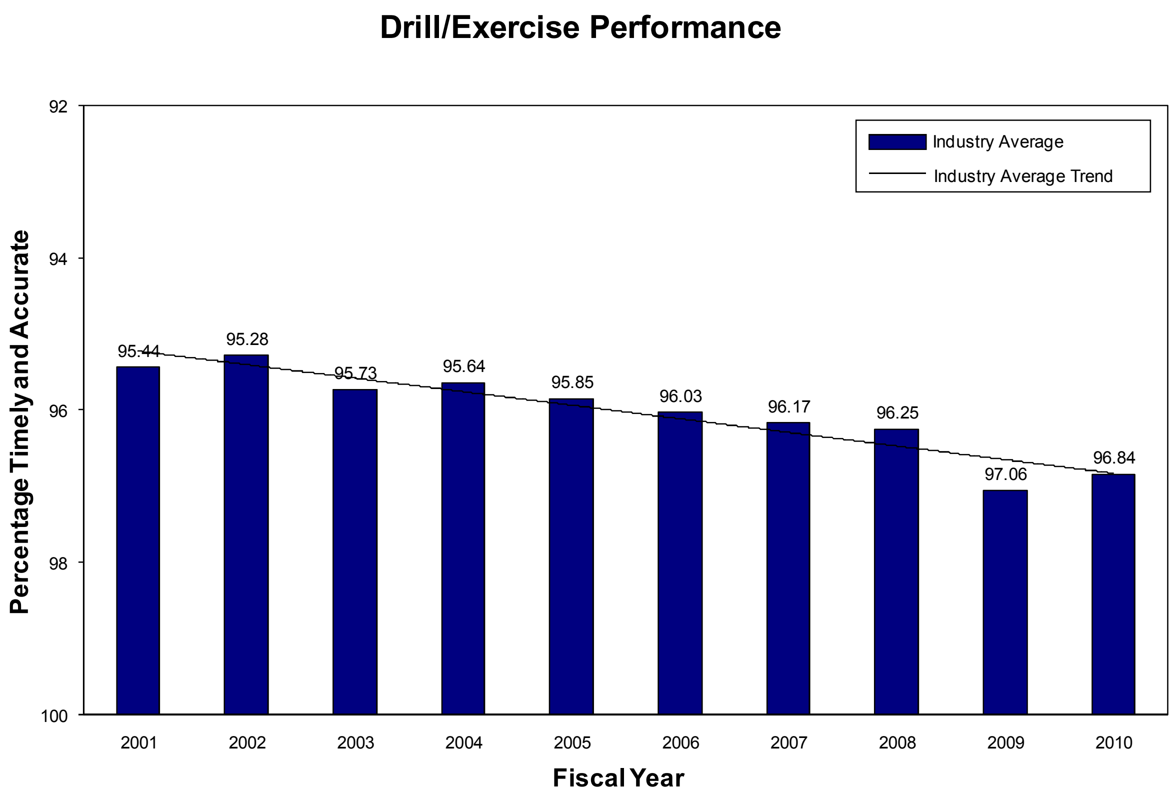


Figure 11 Drill/exercise performance

ERO Drill Participation

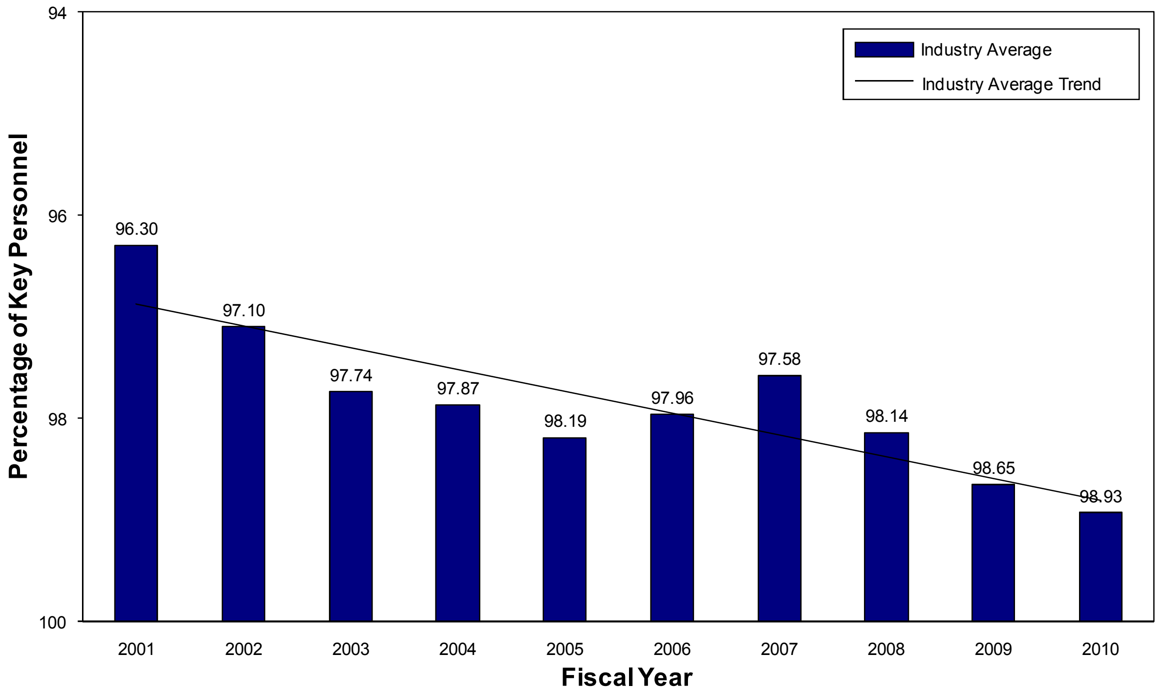


Figure 12 Emergency response organization drill participation

Alert and Notification System Reliability

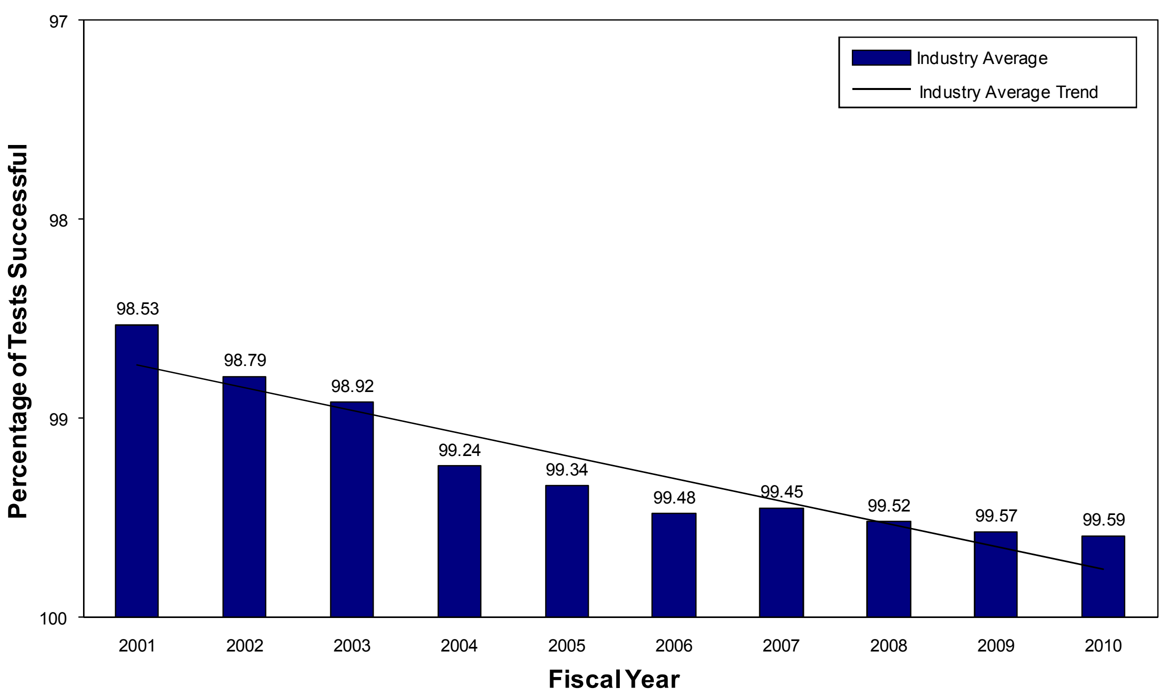


Figure 13 Alert and notification system reliability

Accident Sequence Precursors

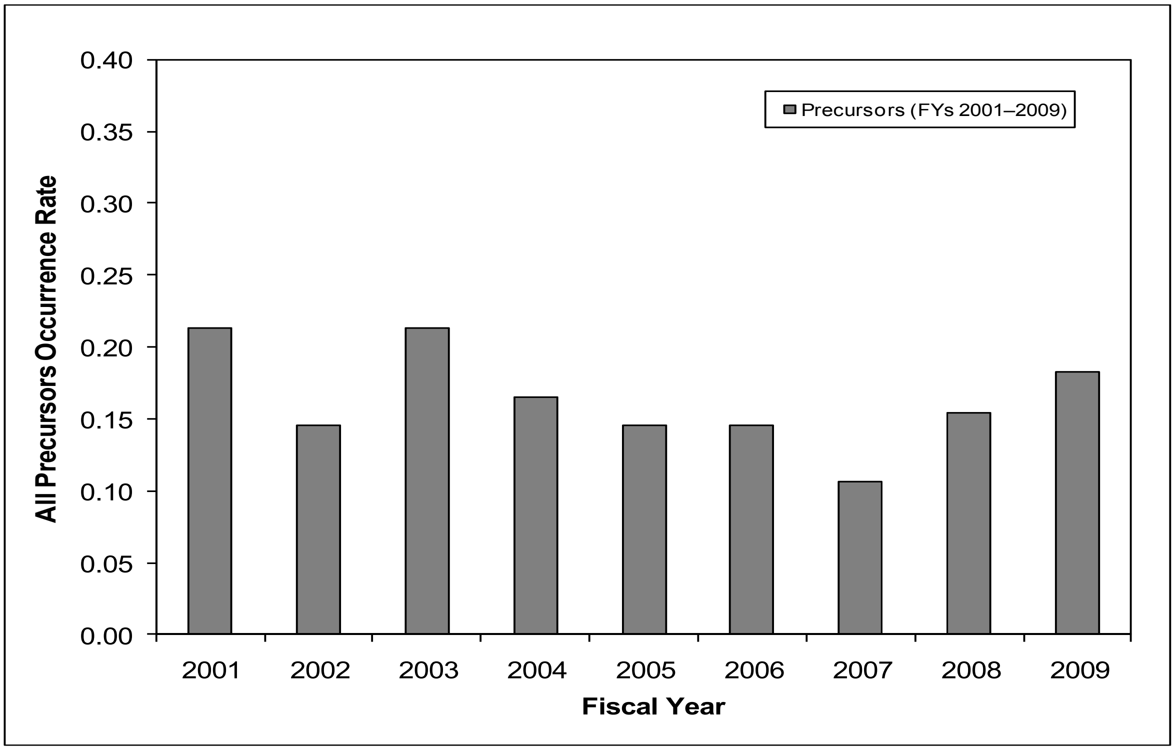
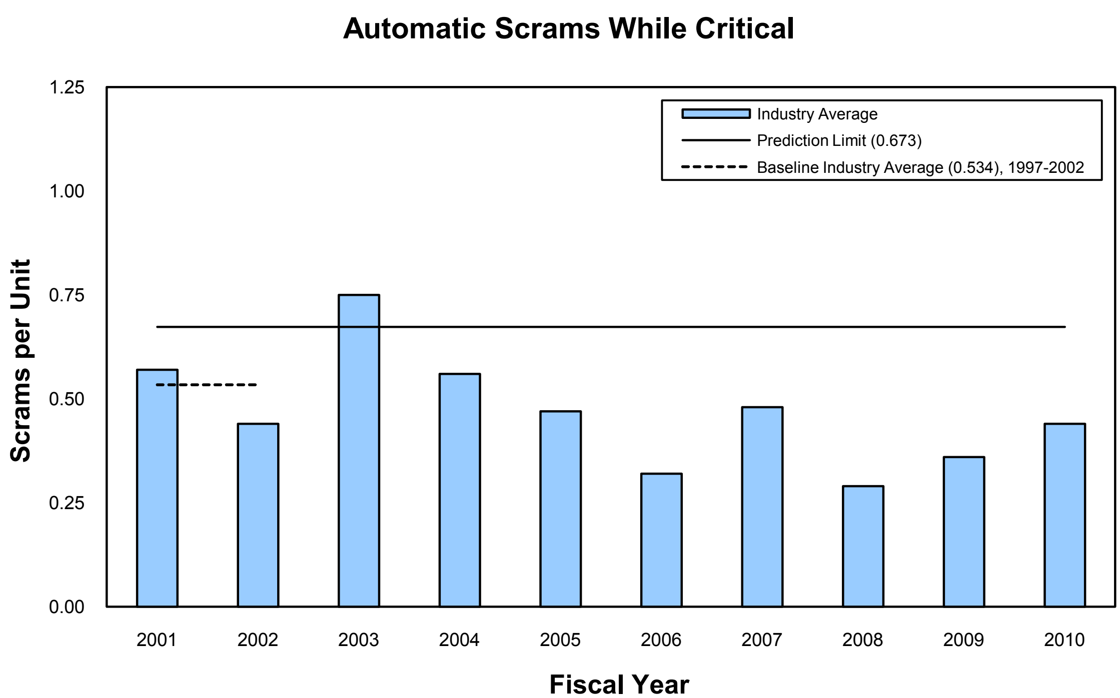


Figure 14 Accident sequence precursors

FISCAL YEAR 2010 SHORT-TERM INDUSTRY PERFORMANCE

The annual industry trend analysis compares the data for the most recent year to 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.

The results of the evaluation of the fiscal year (FY) 2010 Industry Trends Program PIs, using the established prediction limits, indicate that no PI exceeded its associated prediction limit in FY 2010, as shown in the following figures for each PI with its FY 2010 data and associated prediction limit.



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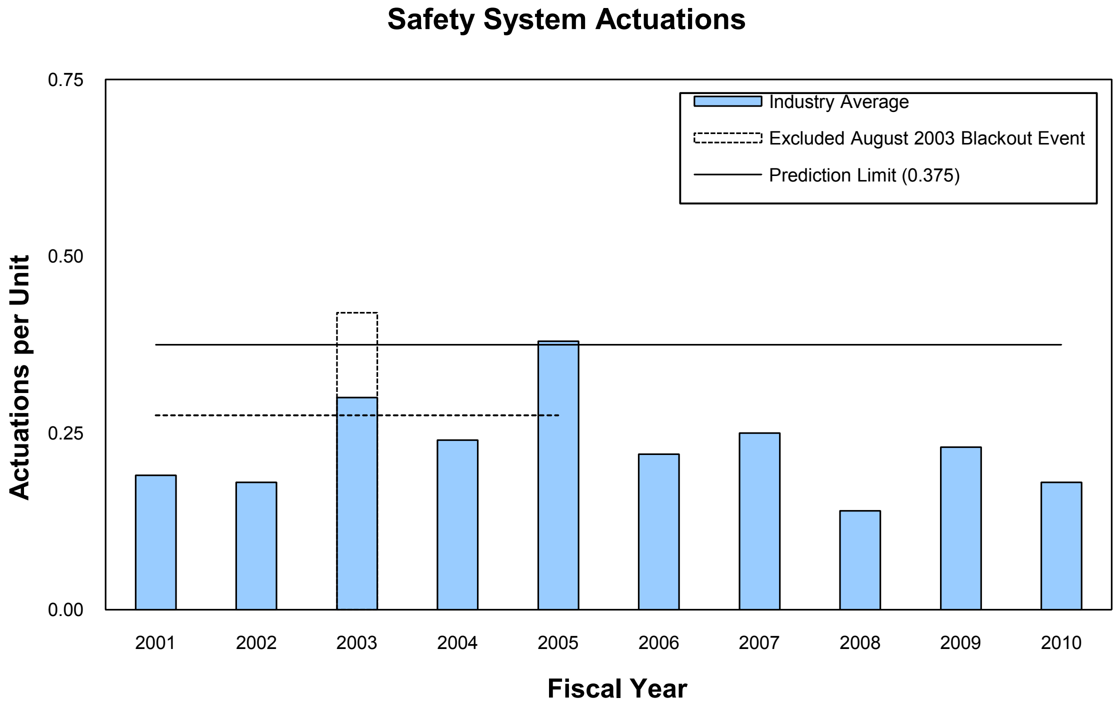

Figure 2 Safety system actuations

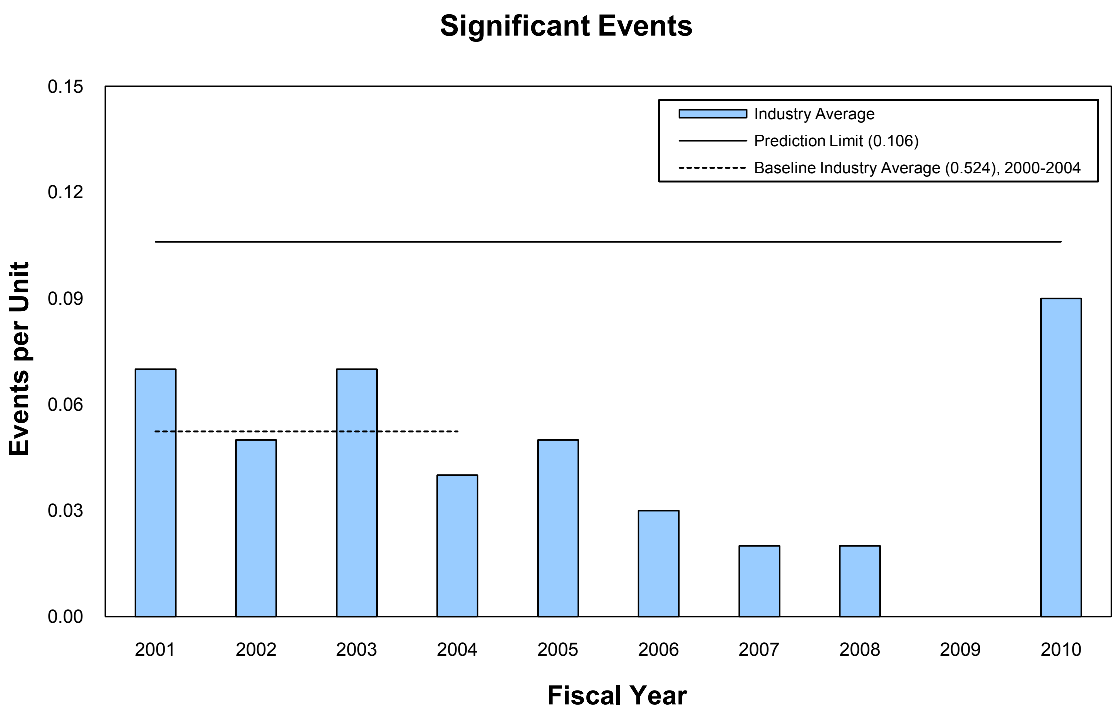

Figure 3 Significant events

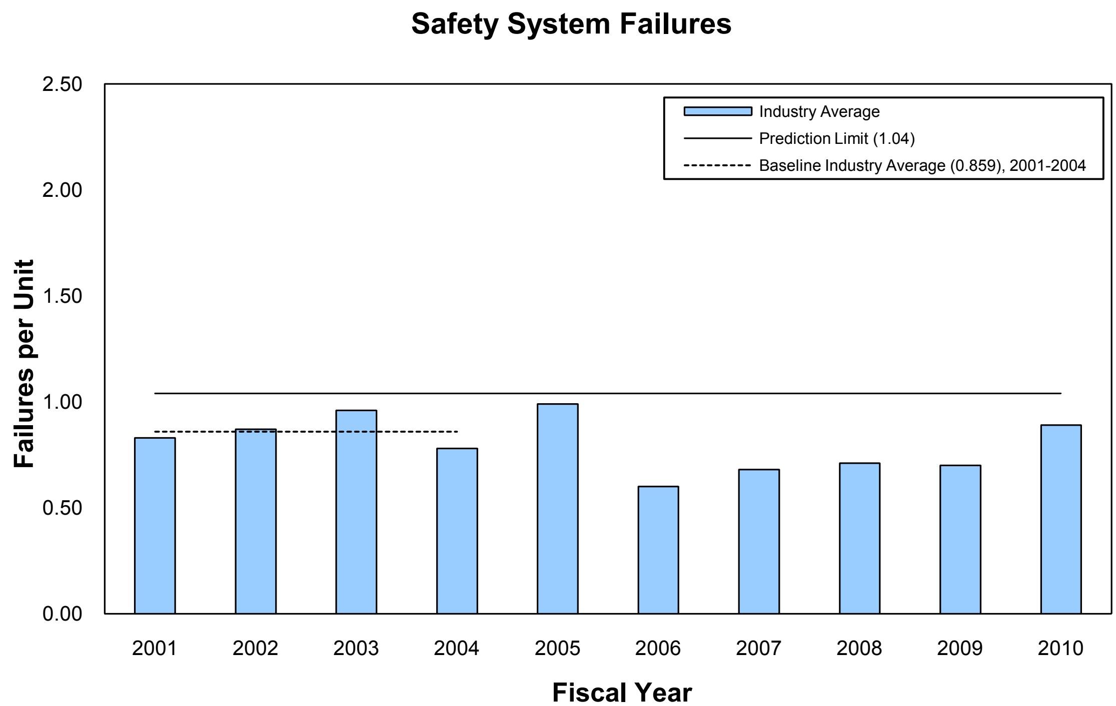

Figure 4 Safety system failures

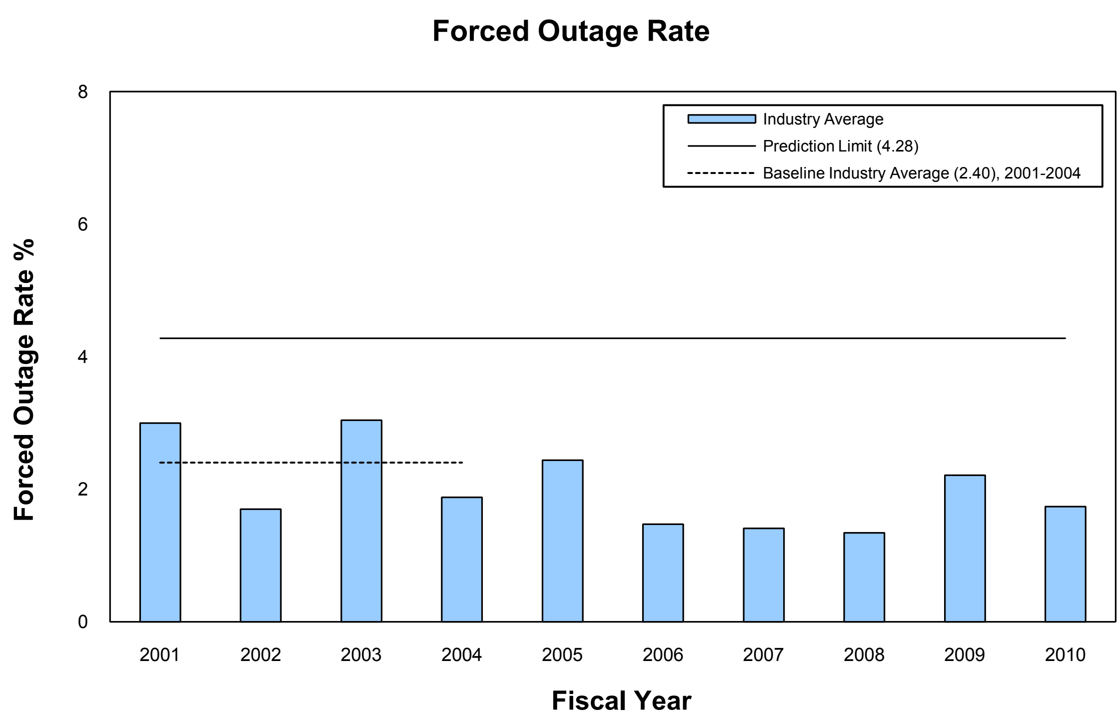

Figure 5 Forced outage rate

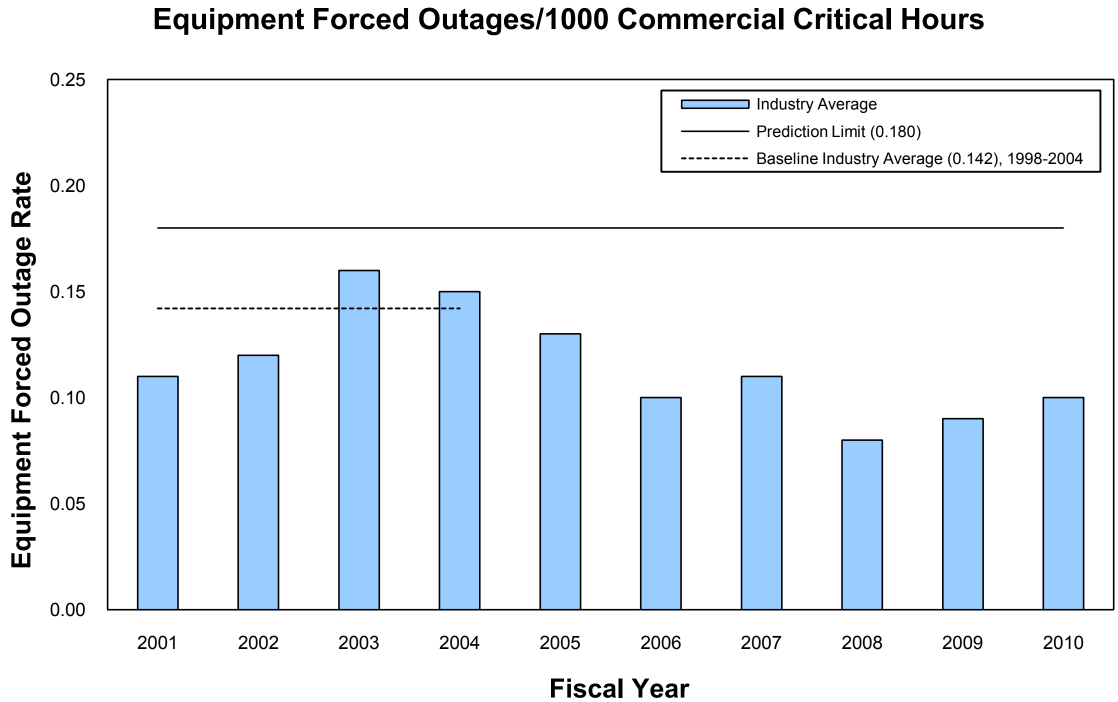

Figure 6 Forced outage rate of equipment per 1,000 commercial critical hours

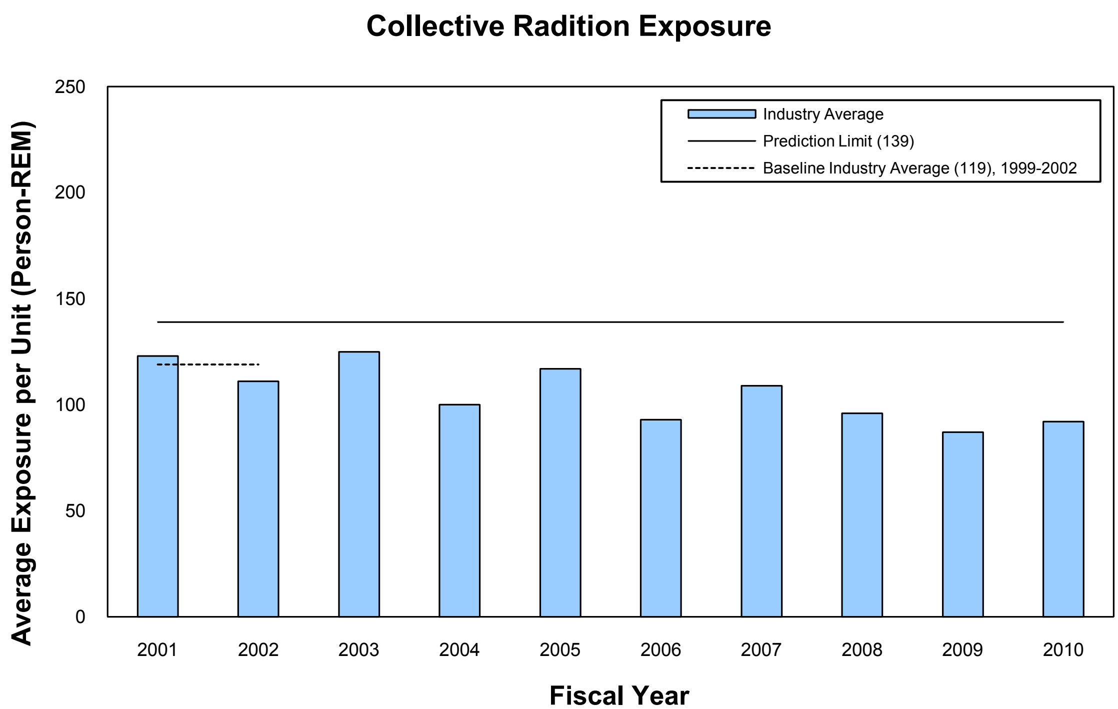

Figure 7 Collective radiation exposure

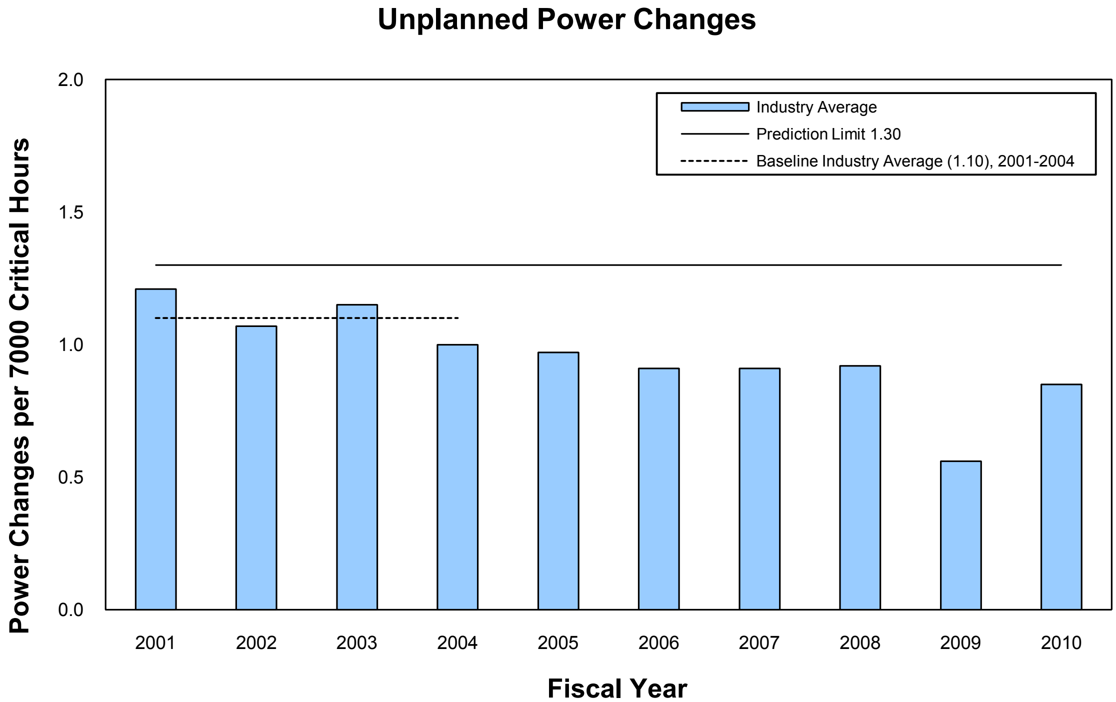

Figure 8 Unplanned power changes per 7,000 critical hours

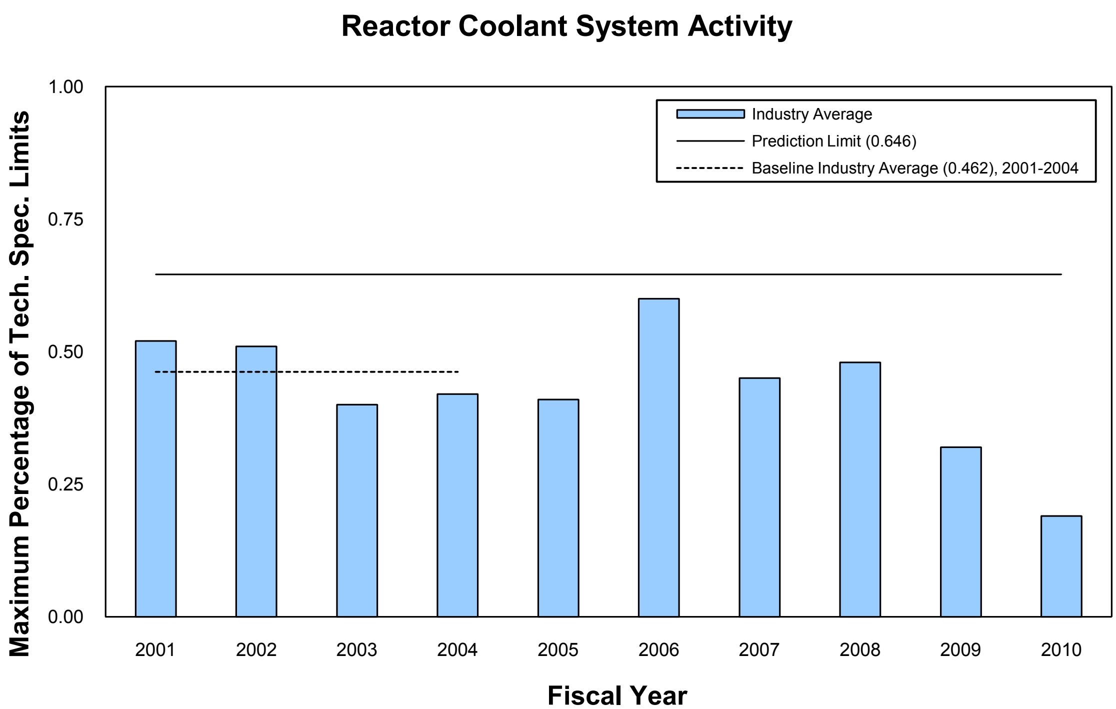

Figure 9 Reactor coolant system activity

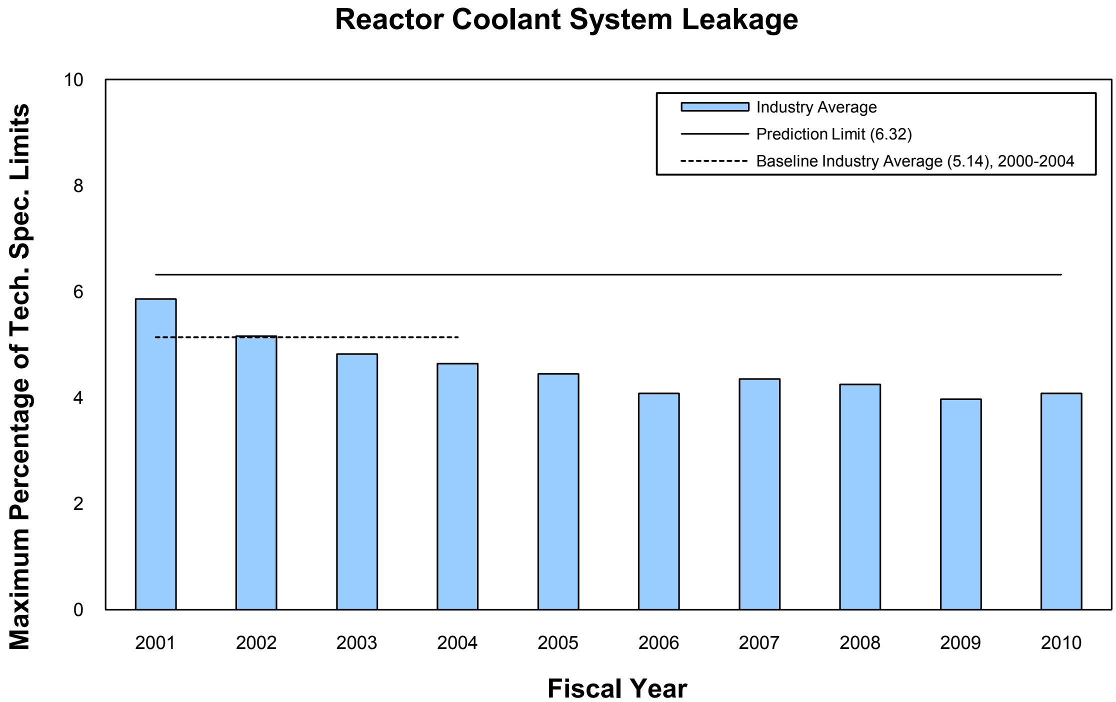

Figure 10 Reactor coolant system leakage

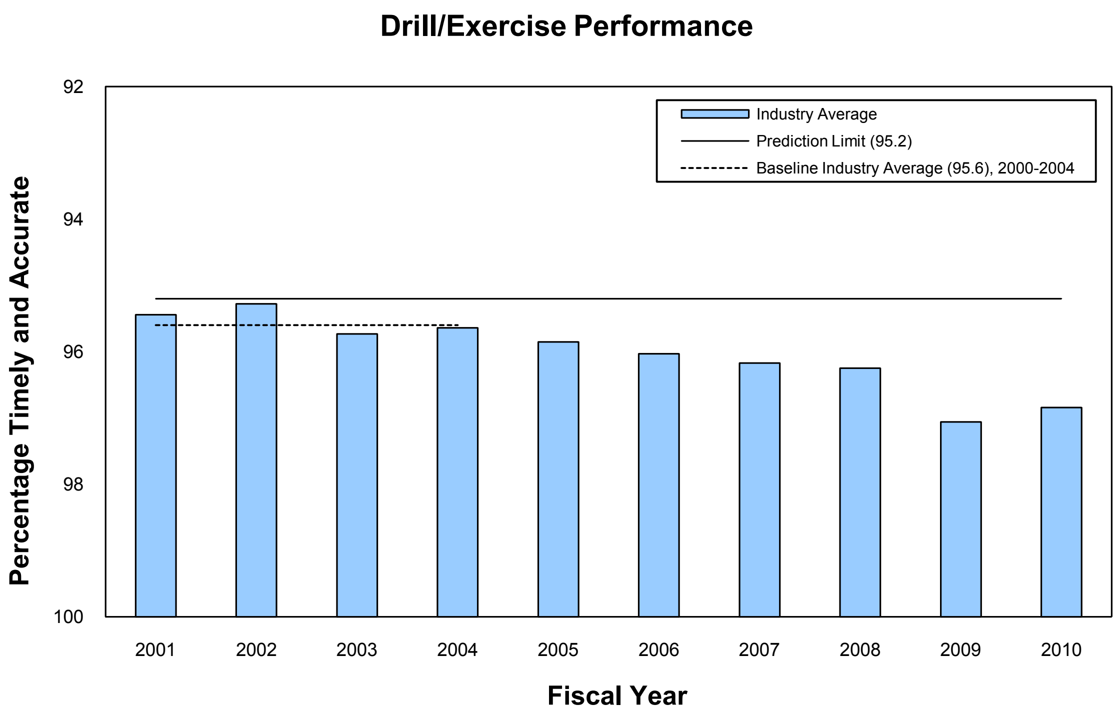

Figure 11 Drill/exercise performance

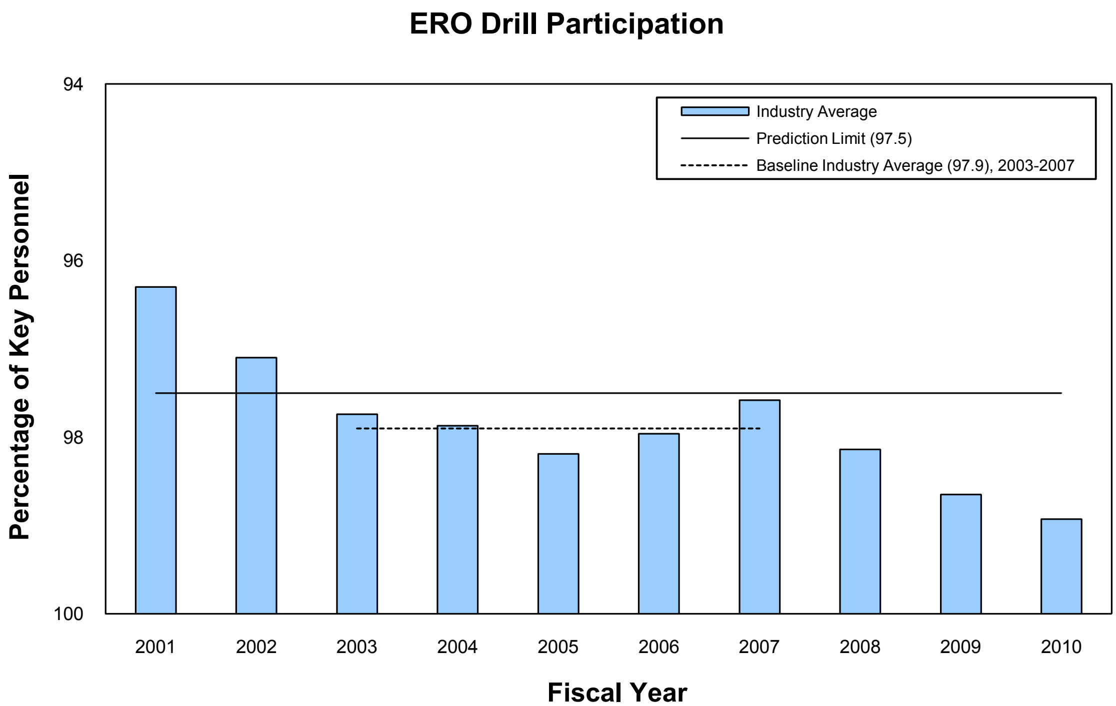

Figure 12 Emergency response organization drill participation

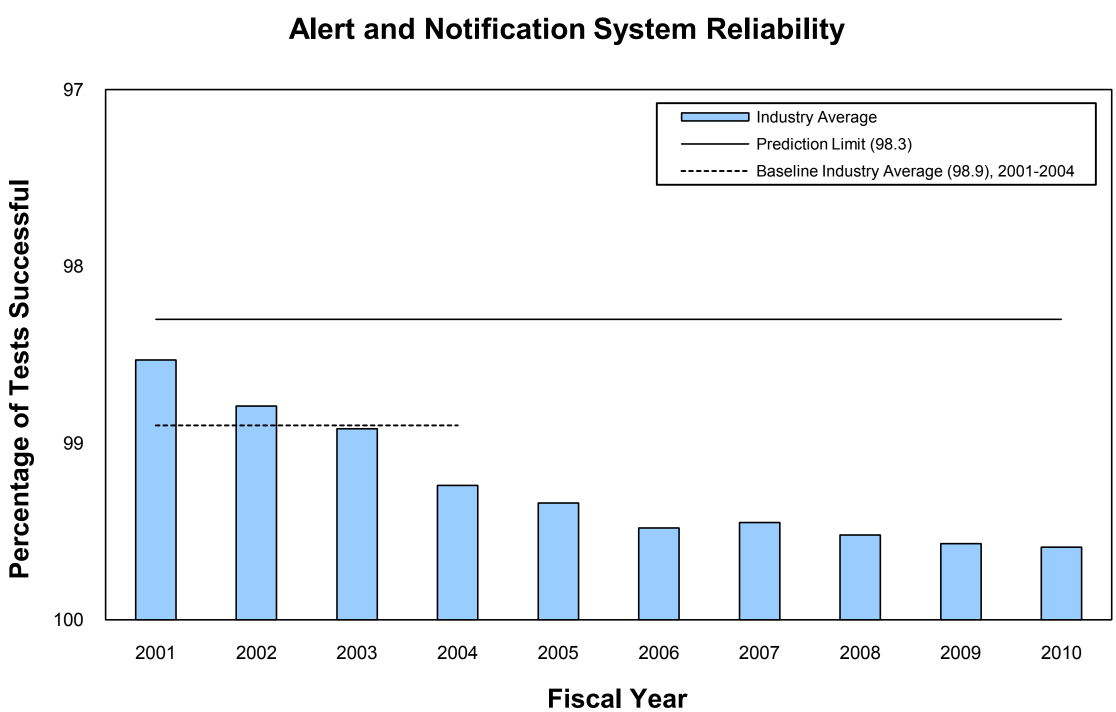

Figure 13 Alert and notification system reliability

Note that the 2003 blackout event in the safety system actuations graph (Figure 2) and the 2000 steam generator tube rupture event at Indian Point Nuclear Generating Unit 2 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 2010

The Baseline Risk Index for Initiating Events (BRIIE) addresses the initiating event (IE) cornerstone in the U.S. Nuclear Regulatory Commission's Reactor Oversight Process for monitoring commercial nuclear power plants. It is based on plant performance for the 10 initiator events listed in the table below.

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 alternating current bus	LOAC	Both plant types
Loss of vital direct current bus	LODC	Both plant types
Stuck-open safety/relief valve	SORV	Both plant types, separately
Loss of instrument air	LOIA	Both plant types, separately
Very small loss-of-coolant accident	VSLOCA	Both plant types
Steam generator tube rupture	SGTR	Pressurized-water reactors (PWRs) 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 tier considers individual IEs and evaluates performance based on statistical prediction limits. This evaluation is for the ongoing monitoring and early detection of possible industry-level deficiencies. A second tier is a risk-based integrated measure evaluated for each plant type. Because four 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.

In early 2010, the events were reviewed, and several events in the loss of condenser heat sink and loss of main feedwater categories were reclassified to more accurately reflect the actual impact on the plant. After the data were reclassified, the existing baseline periods were checked to see if any trends were present that would make the periods no longer appropriate for describing the ongoing data. Because such trends were not found, the baseline periods were not changed. However, new prediction limits were identified for these categories with reduced data that are more appropriate for the way ongoing events are now classified and that allow the Tier 1 BRIIE assessment to remain realistic and not overly conservative.

The prediction limits depend on the expected critical years of reactor operation in the upcoming year and 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 that determine the bounds on the number of events that might be expected.

For all of the initiators, the 2010 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 (CDF) 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.

Figure 15 shows annual differences in estimated industry CDF compared to the established baseline levels of these quantities. The combined industry BRIIE value for 2010 (-3.39×10^{-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.

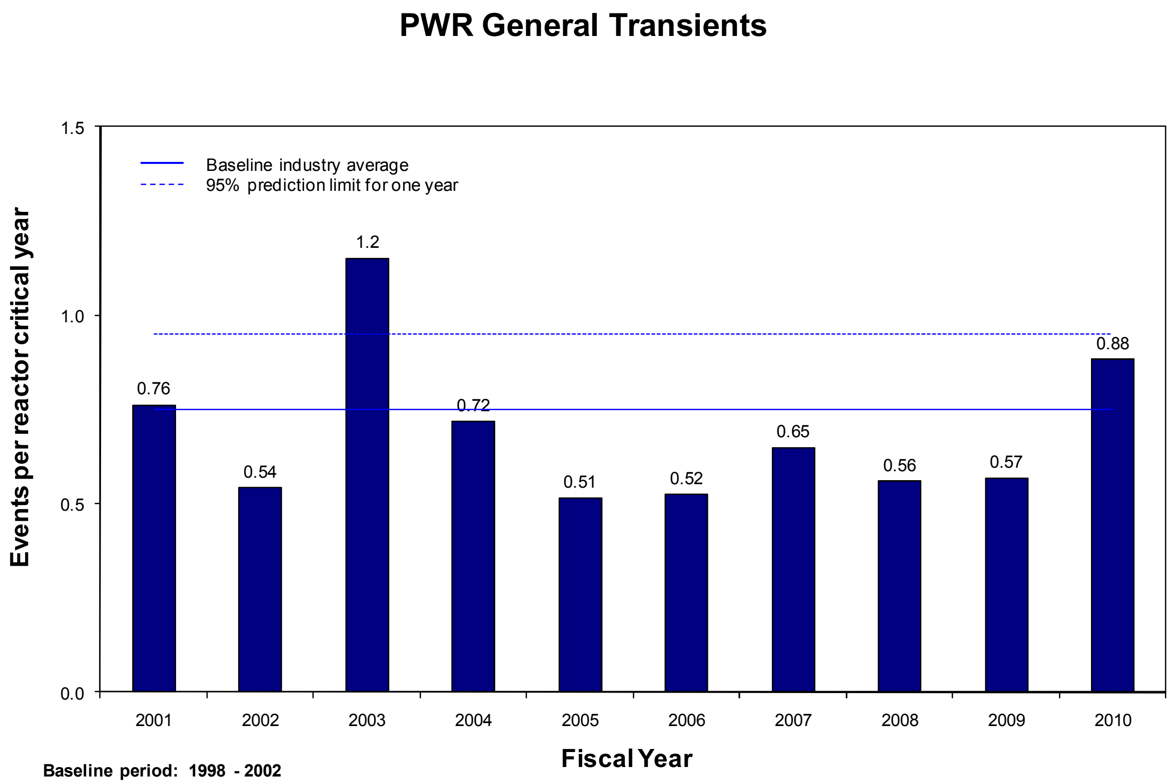

Figure 1 Pressurized-water reactor (PWR) general transients

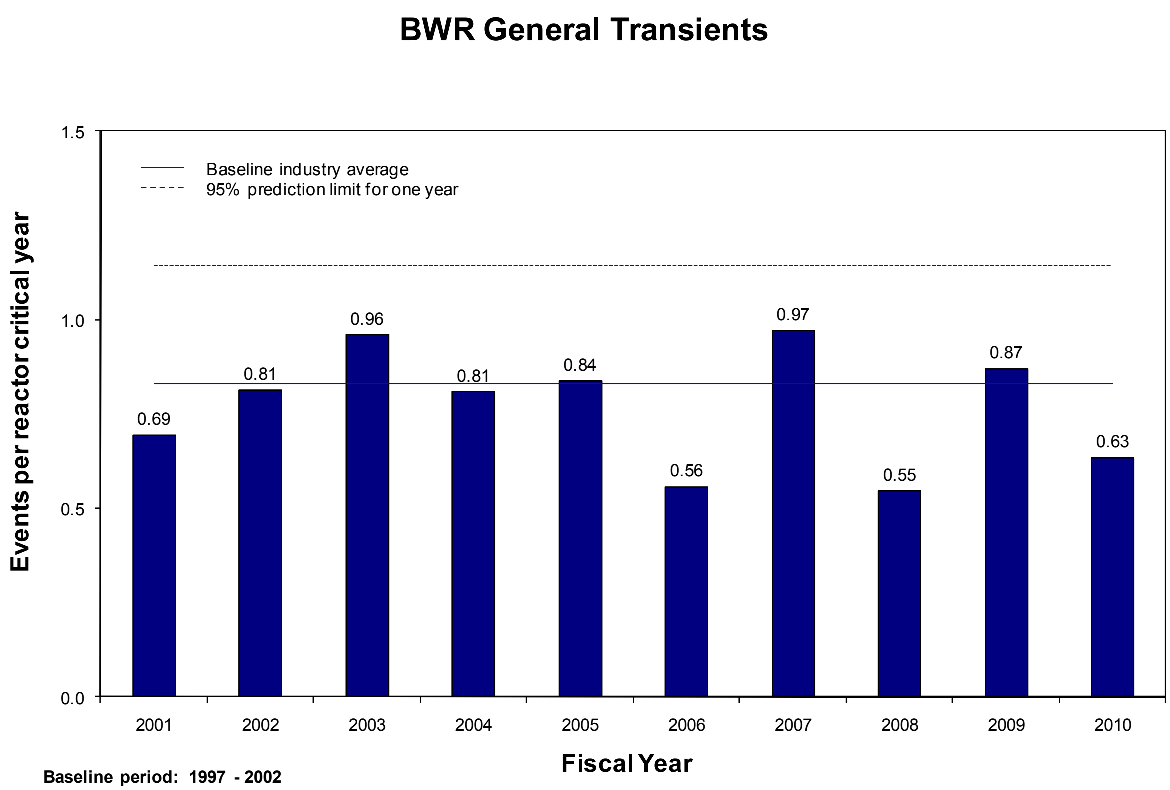

Figure 2 Boiling-water reactor (BWR) general transients

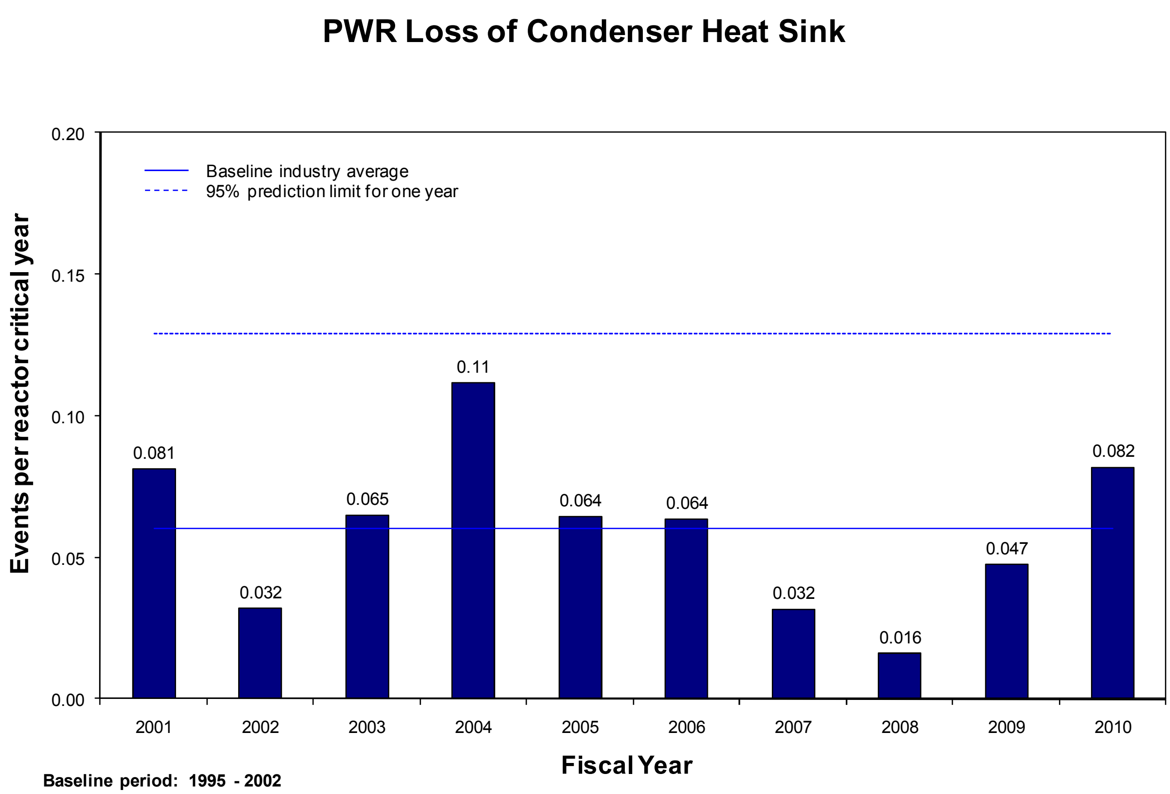

Figure 3 PWR loss of condenser heat sink

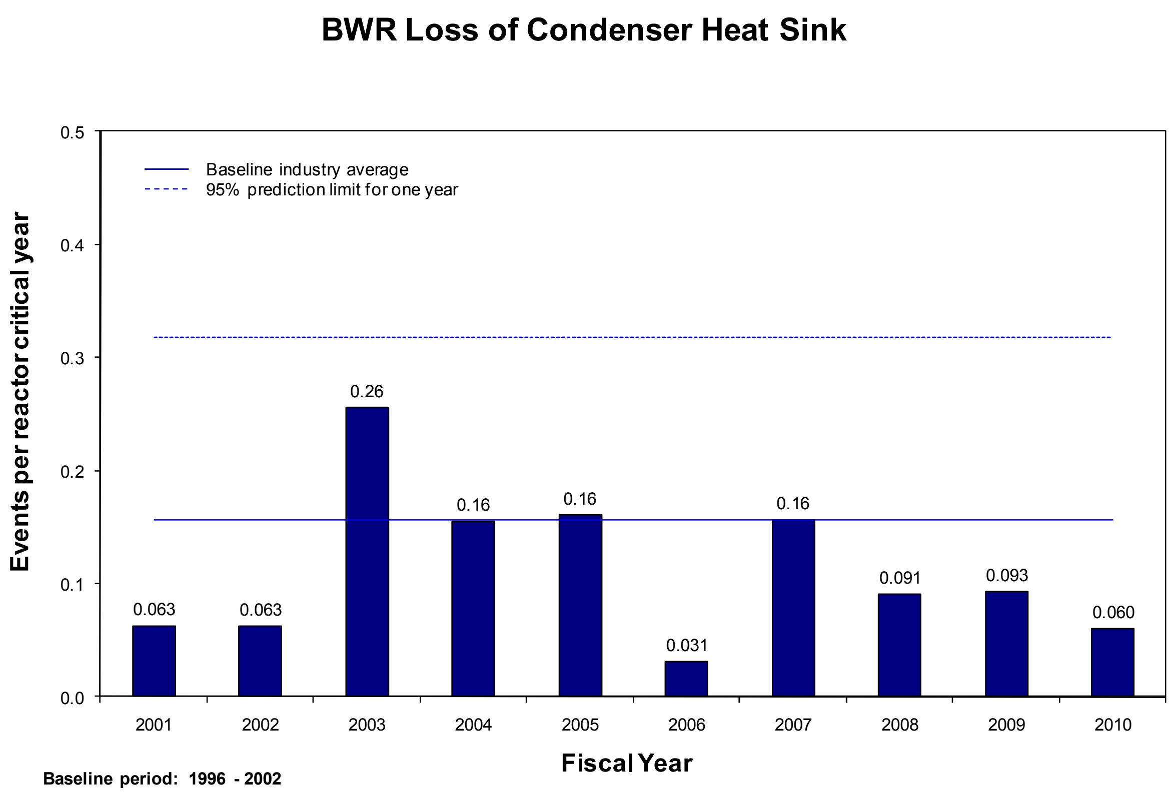

Figure 4 BWR loss of condenser heat sink

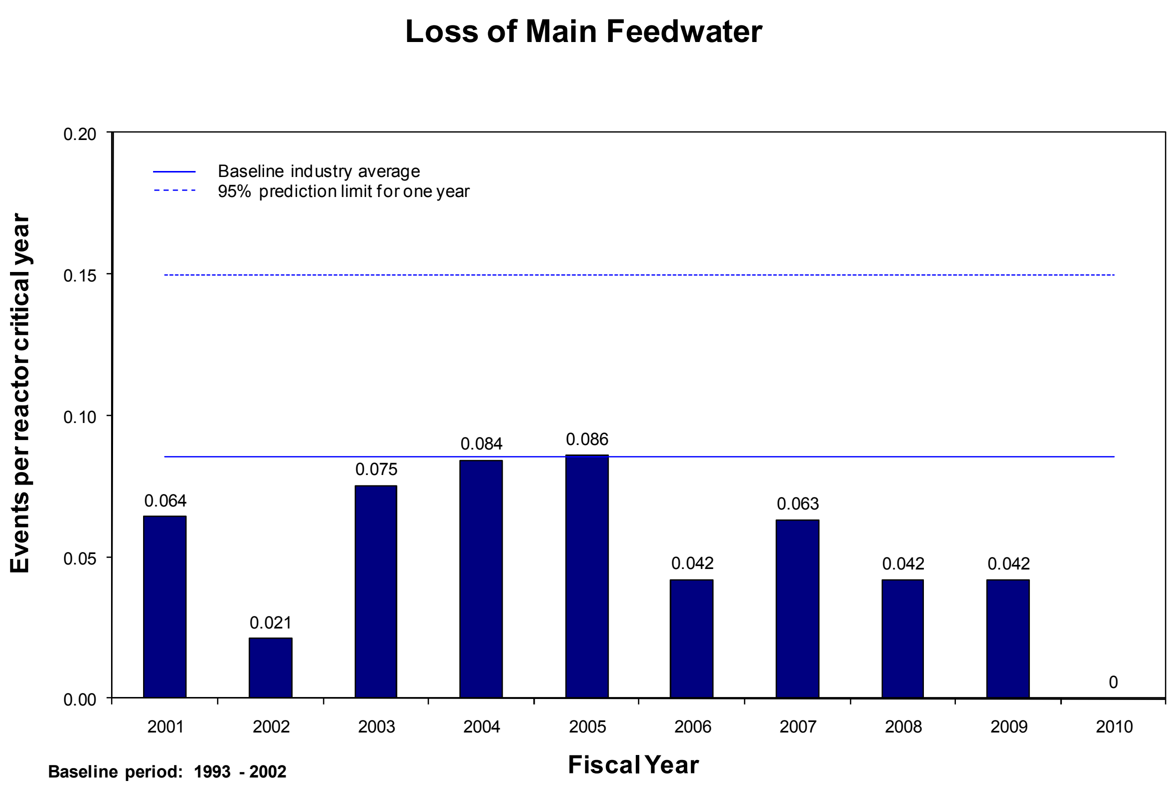

Figure 5 Loss of main feedwater

Loss of Offsite Power

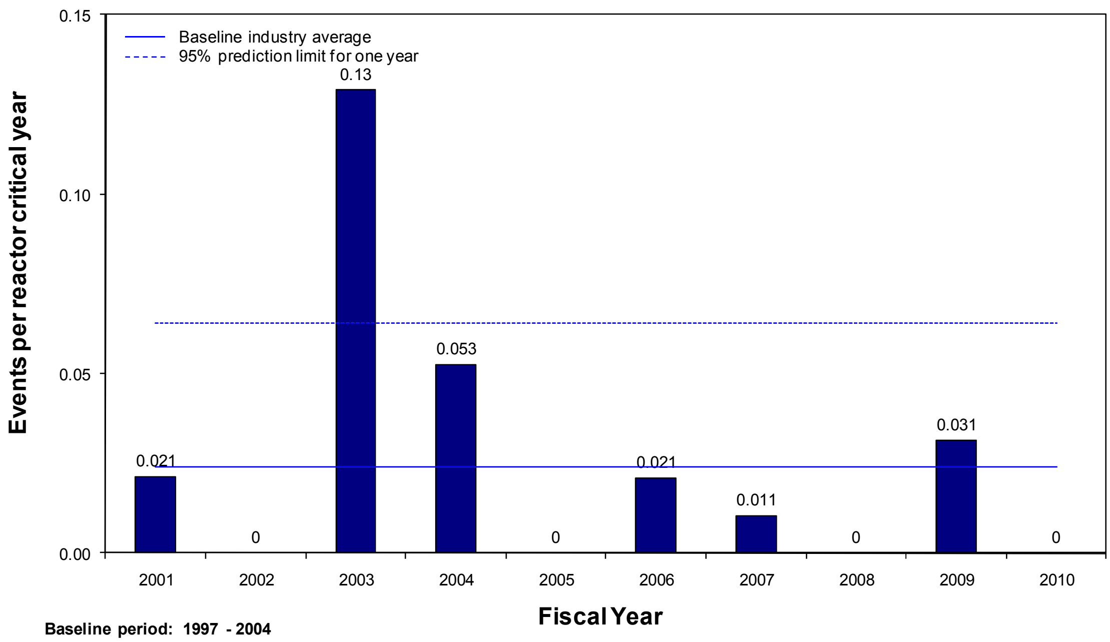

Figure 6 Loss of offsite power

Note that the prediction limit for loss of offsite power was calculated under the assumption that the nine such events that occurred during the 2003 blackout were a single event. This treatment results in a more conservative prediction limit.

Loss of Vital AC Bus

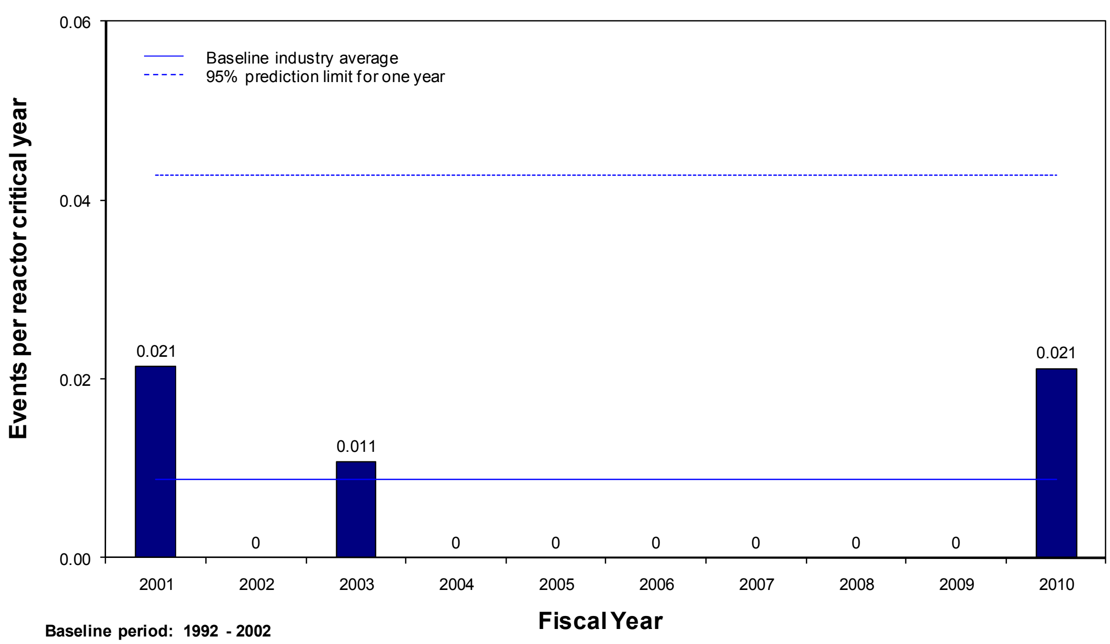

Figure 7 Loss of vital alternating current bus

Loss of Vital DC Bus

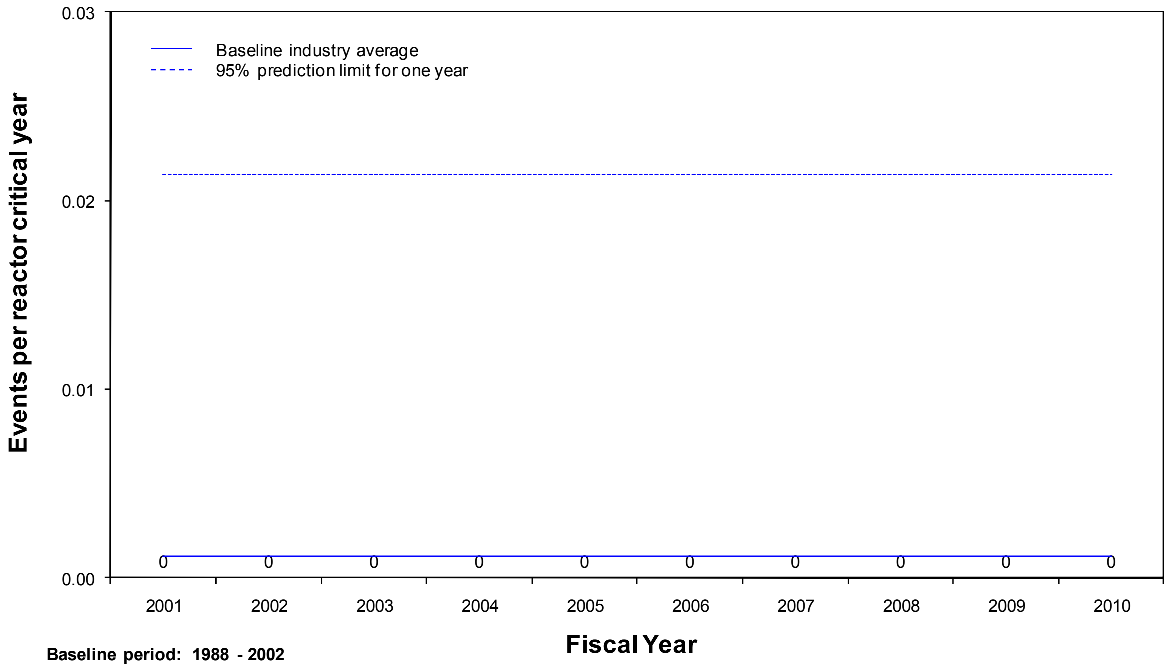

Figure 8 Loss of vital direct current bus

PWR Stuck Open SRV

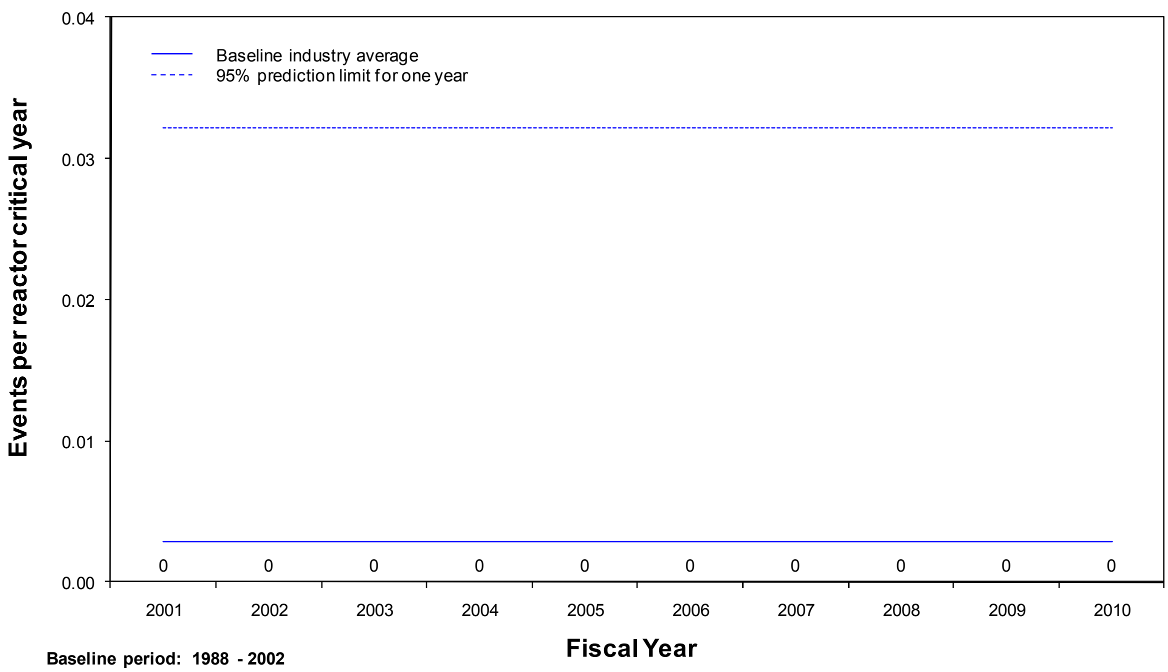

Figure 9 PWR stuck-open safety/relief valve

BWR Stuck Open SRV

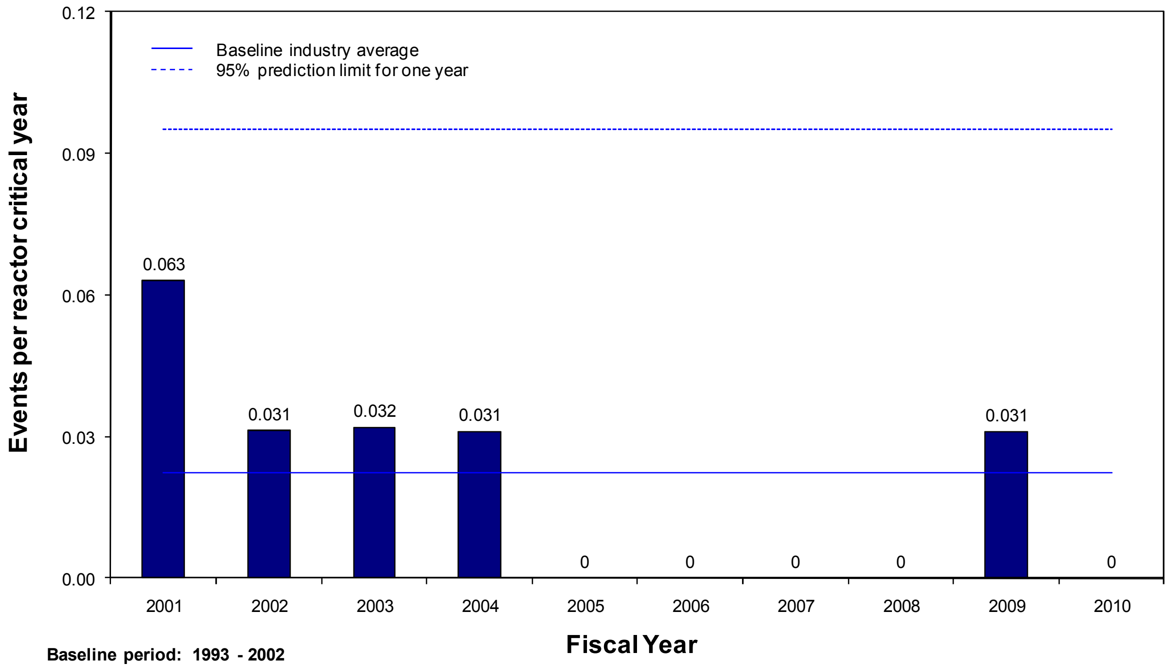

Figure 10 BWR stuck-open safety/relief valve

PWR Loss of Instrument Air

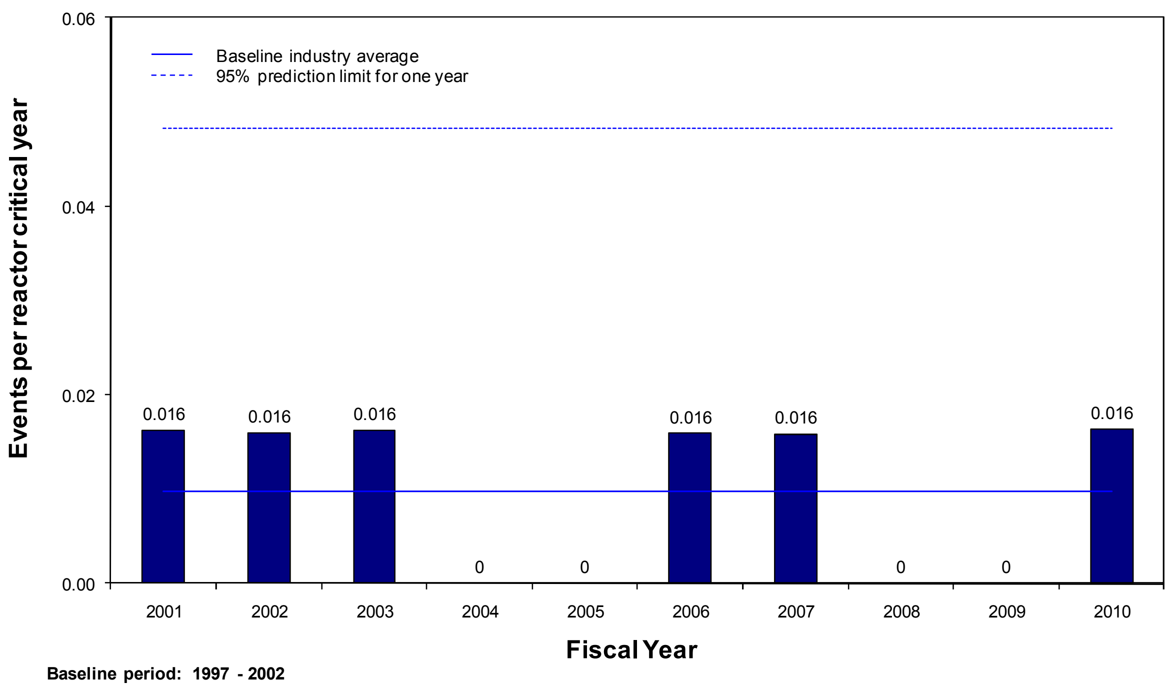

Figure 11 PWR loss of instrument air

BWR Loss of Instrument Air

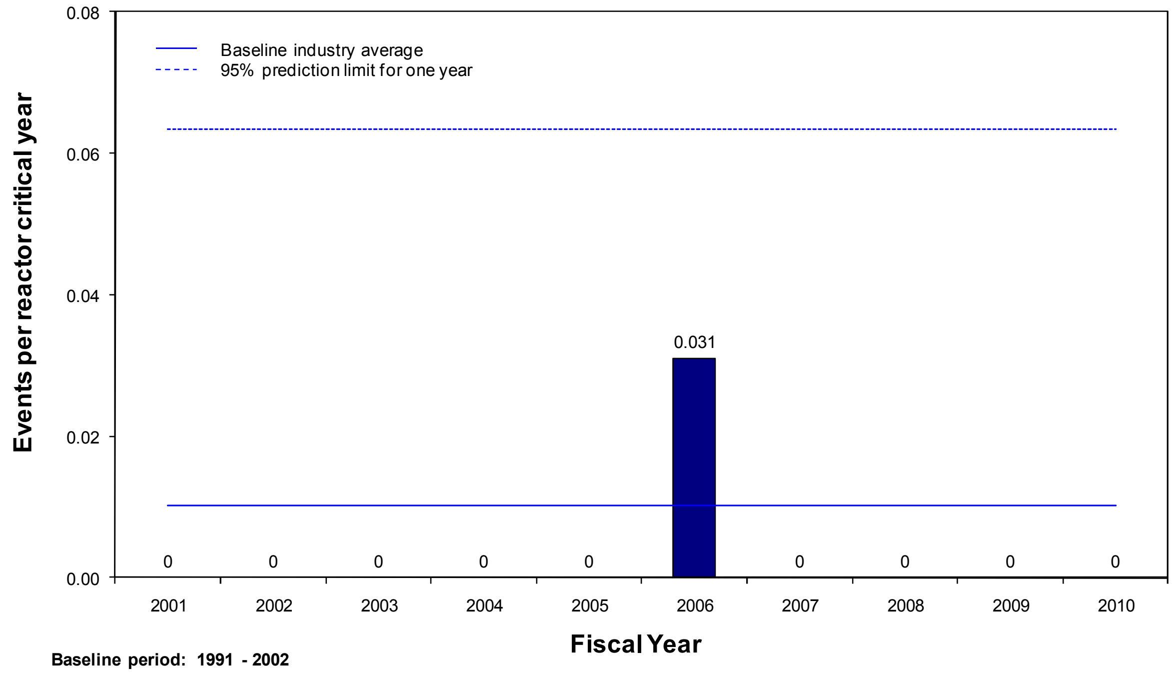

Figure 12 BWR loss of instrument air

Very Small LOCA

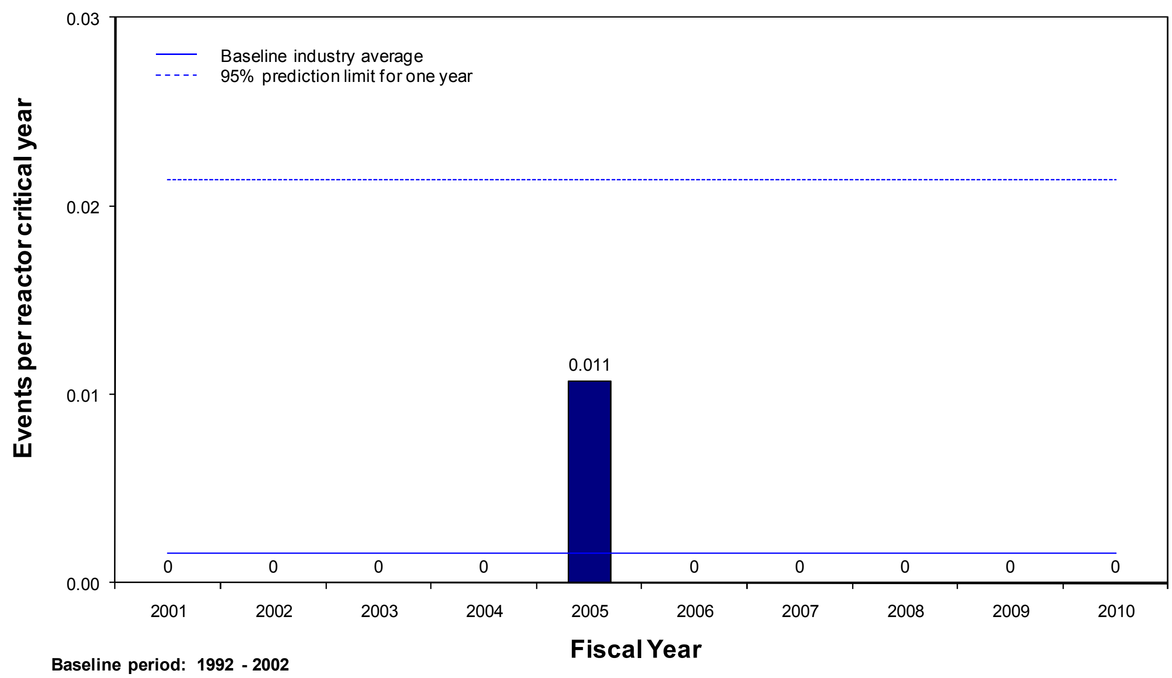

Figure 13 Very small loss-of-coolant accident

PWR Steam Generator Tube Rupture

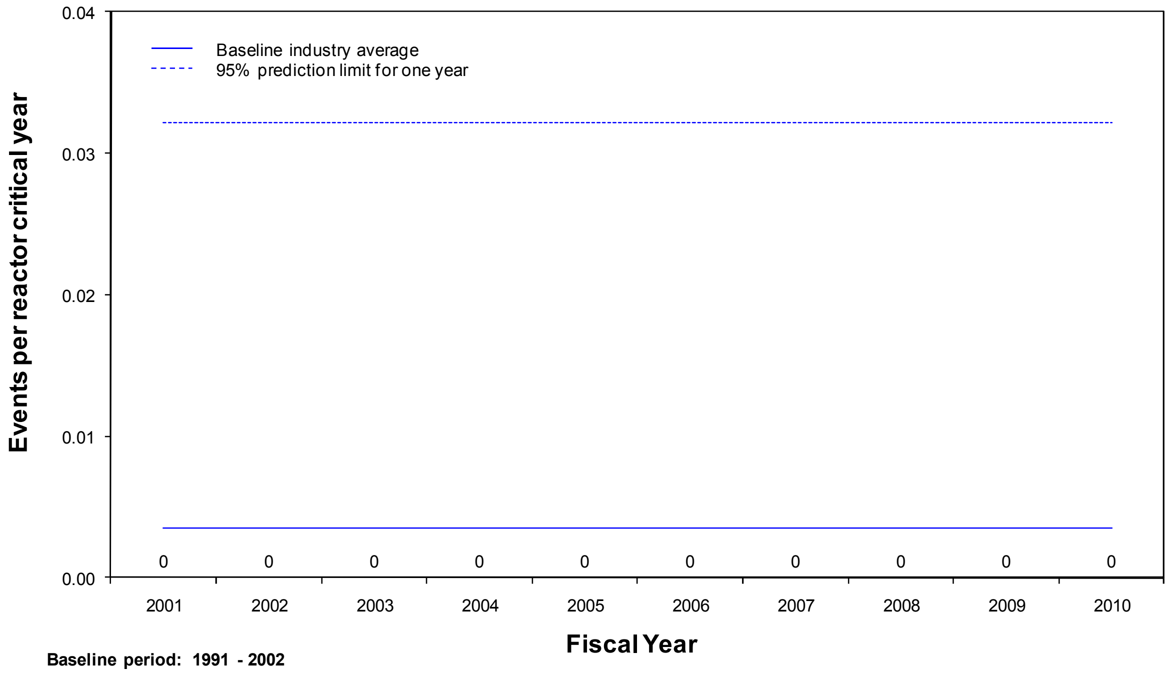

Figure 14 PWR steam generator tube rupture

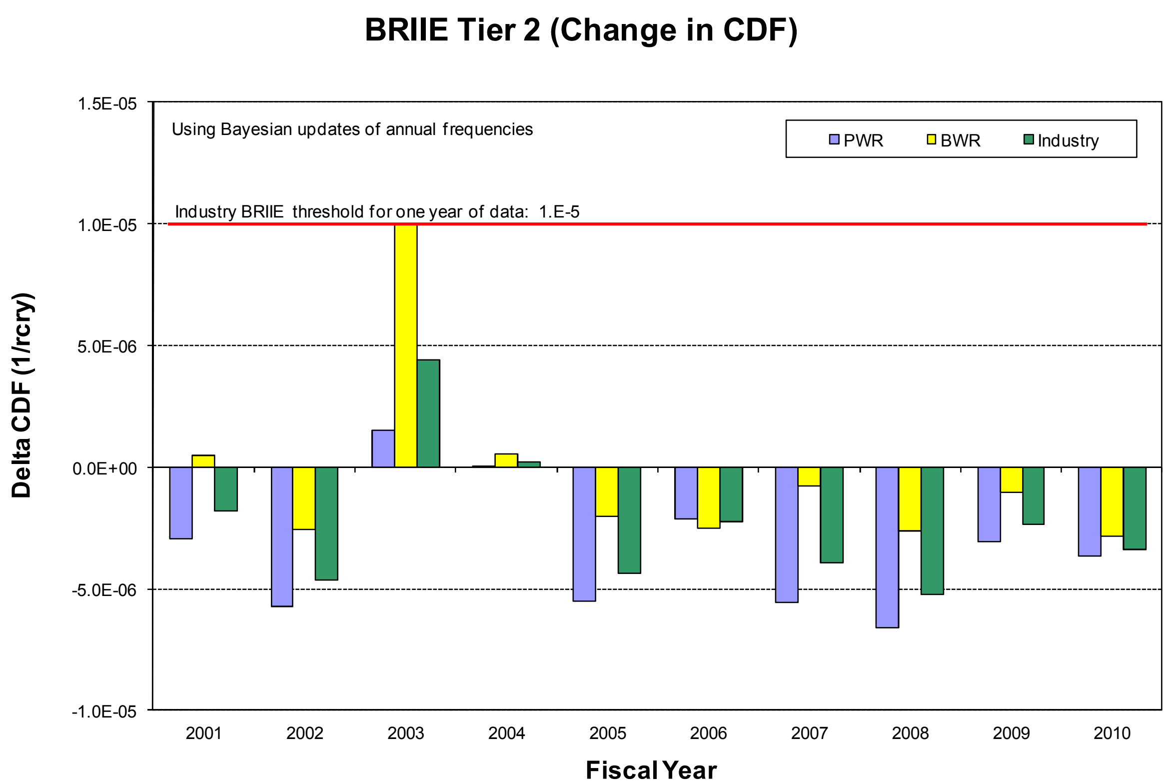

Figure 15 BRIIE Tier 2 (change in CDF)