POLICY ISSUE
INFORMATION

April 9, 2012 SECY-12-0056

FOR: The Commissioners

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

SUBJECT: FISCAL YEAR 2011 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) 2011. 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 11th annual report to the Commission on the ITP.

NRC Inspection Manual Chapter (IMC) 0313, "Industry Trends Program," dated May 29, 2008, contains details of the ITP, including definitions of monitored indicators and program descriptions.

CONTACT: Michael F. Balazik, NRR/DIRS
301-415-2856

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 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.

The Office of Regulatory Research (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.

Outside of the normal ITP process, internal stakeholders noted an increase in the number of special inspections (SI) in calendar year (CY) 2011 as compared to CY 2009 and CY 2010. The staff reviewed SI data from 2006-2011 to evaluate whether a trend existed. The staff concluded that there was no trend over the period. Although there was an increase in the number of reactive inspections performed in calendar year (CY) 2011 compared to the number performed in CY 2009 and CY 2010, this is a reflection of fewer reactive inspections in CY 2009 and CY 2010 than in previous years. The number of reactive inspections performed in CY 2011 was comparable to the numbers from CY 2007 and CY 2008, and lower than those performed in CY 2006.

FY 2011 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 2011. 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 $1x10^{-6}$ to be a precursor.

The RES staff evaluated precursor data from FY 2001 to FY 2010 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 $1x10^{-4}$ and for precursors that occurred at pressurized-water reactors during this same period. The data period for ASP trending analysis is a rolling 10-year period.

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 $1x10^{-3}$) of leading to a reactor accident.

The one event evaluated as a potential *significant* precursor in FY 2010 involved an electrical fire at H.B. Robinson Steam Electric Plant that led to a reactor trip with a subsequent loss of reactor coolant pump seal cooling and additional complications. The potential for the event to be a significant precursor was identified after new information became available in December 2010 during followup inspection activities. The NRC staff issued a preliminary ASP analysis and transmitted it to the licensee in accordance with established procedures. This prompted the licensee to perform an additional thermal-hydraulic analysis, which resulted in changes to modeling assumptions and reduced the CCDP of the event to 4×10^{-4}, which is lower than the CCDP threshold value of a *significant* precursor.

No *significant* precursors were identified in FY 2011. However, the staff will continue to evaluate the flooding episode at Fort Calhoun Station and the earthquake at North Anna Power Station, Units 1 and 2, to identify any *significant* precursors.

<u>FY 2011 SHORT-TERM INDUSTRY PERFORMANCE</u>:

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. Based on current information, none of the indicators exceeded its prediction limit in FY 2011. Short-term FY 2011 data did not reveal any emerging trends that warranted additional analysis or significant adjustments to the nuclear reactor safety inspection or licensing programs.

<u>FY 2011 RESULTS OF BASELINE RISK INDEX FOR INITIATING EVENTS</u>:

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 based on its relative contribution to overall risk to plant safety. The greater the contribution of the event to overall risk, the higher the importance value it is assigned. 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 already have 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. The NRC staff identified one initiator, Loss of Offsite Power (LOOP), for which the 2011 occurrence rate exceeded the Tier 1 prediction limit. The seven LOOP events representing essentially three occurrences at three different multiunit sites are as follows:

- Surry Units 1 and 2, lost offsite power when a tornado damaged the switchyard on April 16, 2011.

- Browns Ferry Units 1, 2, and 3, lost offsite power when high winds and tornadoes damaged the area’s transmission lines on April 27, 2011.

- North Anna Units 1 and 2, lost offsite power during an earthquake on August 23, 2011.

These events all resulted from natural phenomena and were outside of the licensee’s control. As such, they are not indicative of degraded industry performance. In each instance, the LOOPs occurred on a particular day and depended on a single initiator. The prediction limit is determined assuming independent event occurrences. Tier 1 activities are intended to reveal degrading industry performance before any long-term adverse trends emerge. These LOOP events were accounted for in other ITP long-term performance indicators with no statistically significant adverse trends identified. Nevertheless, the staff will share information with other Office of Nuclear Reactor Regulation (NRR) staff involved in updates to Title 10 of the *Code of Federal Regulations* (10 CFR) Section 50.63 (Loss of All Alternating Current Power-Station Blackout Rule) for their consideration. No program adjustments are recommended at this time; however the staff will continue to monitor this occurrence for future program adjustments if warranted. For all other Tier 1 initiators, the FY 2011 occurrence rates are below the associated prediction limits. Figure 15 of Enclosure 3 shows that the BRIIE combined industry value in FY 2011 ($2.98x10^{-7}$ per reactor critical year) indicates above baseline industry performance and is below the established reporting threshold of $\Delta CDF = 1.0x10^{-5}$ per reactor critical year.

RESOURCES:

For ITP activities, resources are included in the FY 2012 Budget of 0.5 full-time equivalent (FTE) and $535K; and in the FY 2013 President's Budget of 0.5 FTE and $575K. These resources are to conduct ongoing ITP implementation in FY 2012 and FY 2013. Any additional resources required in the future years will be addressed during the Planning, Budgeting, and Performance Management process.

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 2011 Long-Term Industry Trend Results
2. Fiscal Year 2011 Short-Term Industry Performance
3. Summary of Baseline Risk Index for Initiating Events: Annual Graphs through Fiscal Year 2011

FISCAL YEAR 2011 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 2002–2011), as indicated by the figures below.

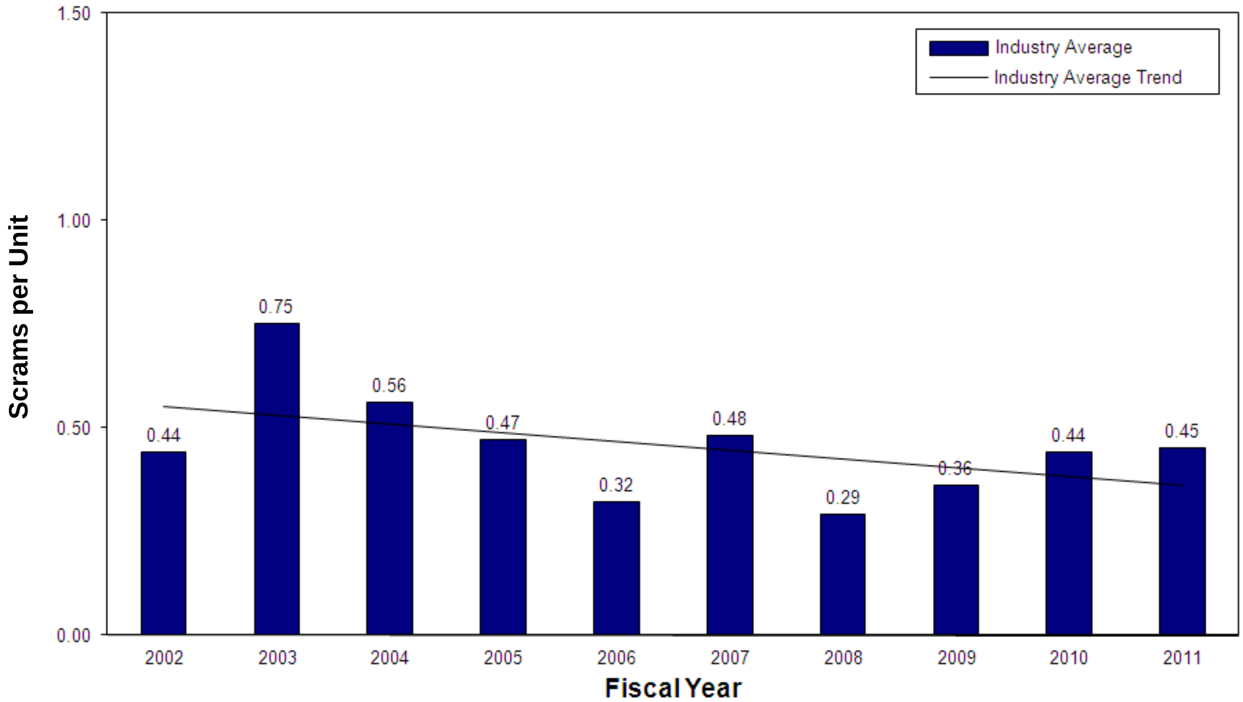


Figure 1 Automatic scrams while critical

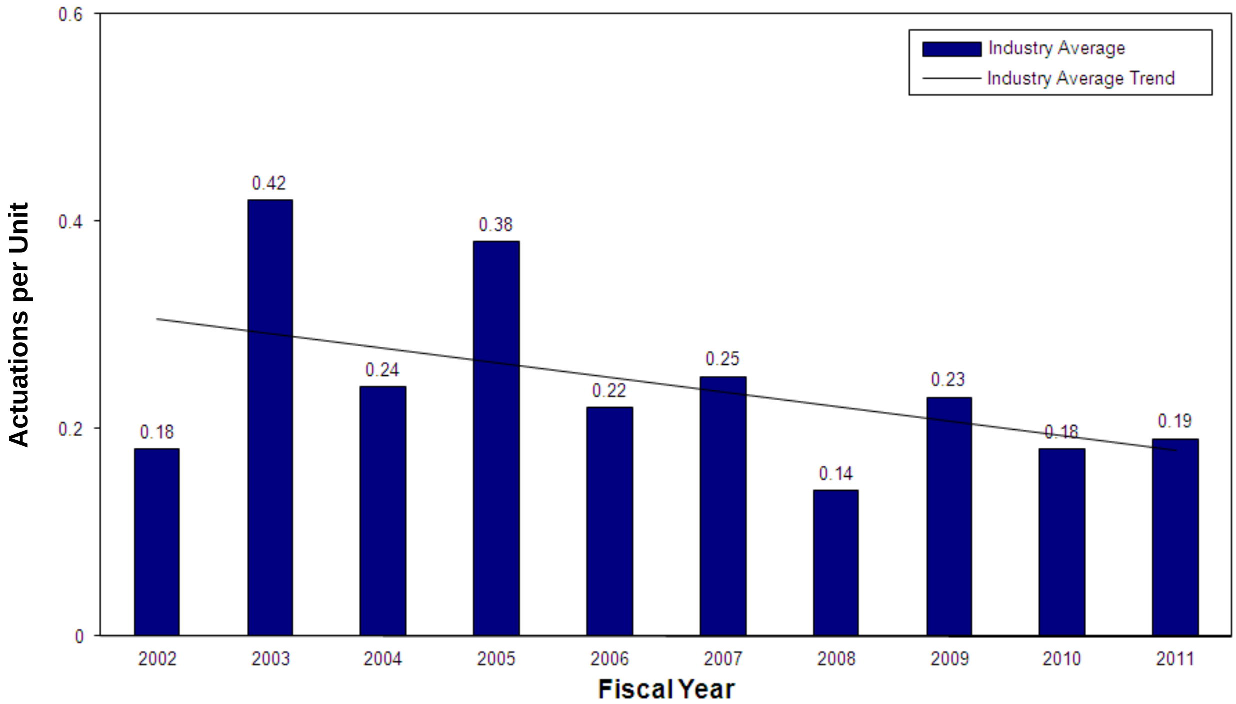


Figure 2 Safety system actuations

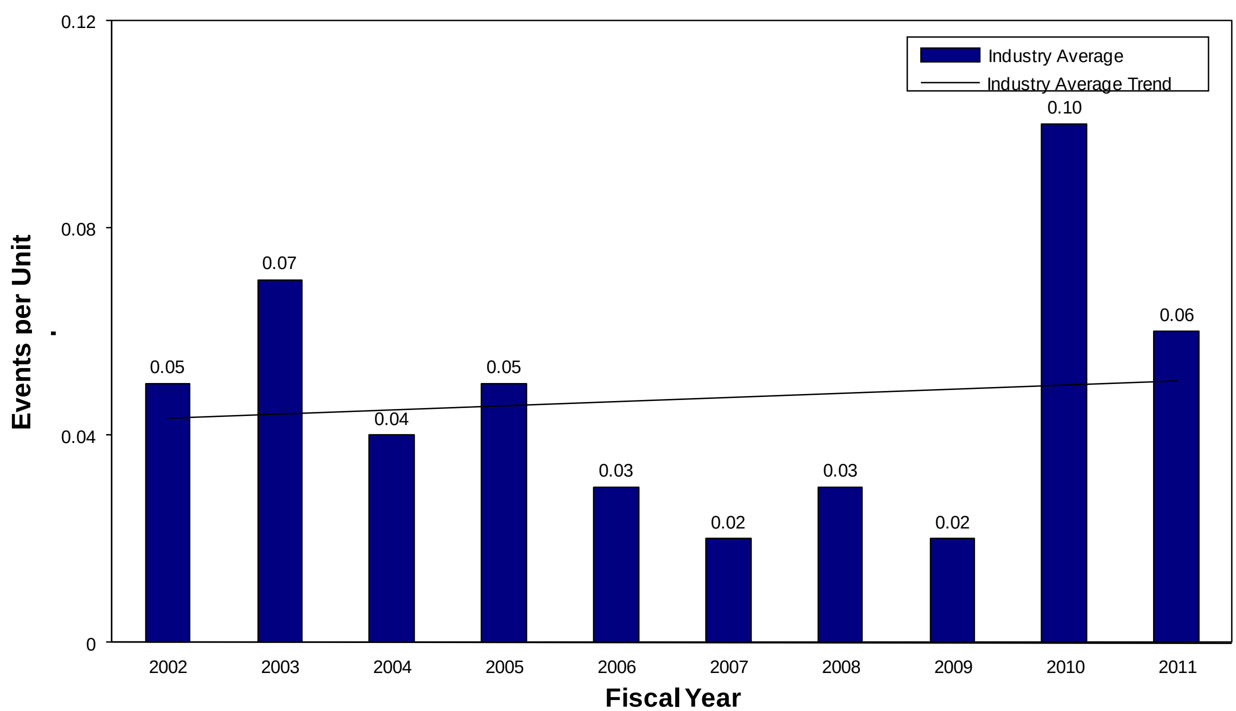


Figure 3 Significant events

While the slope of the trend line model is in the adverse direction (Figure 3), the statistical analysis of the Significant Events data indicates that the trend is not statistically significant.

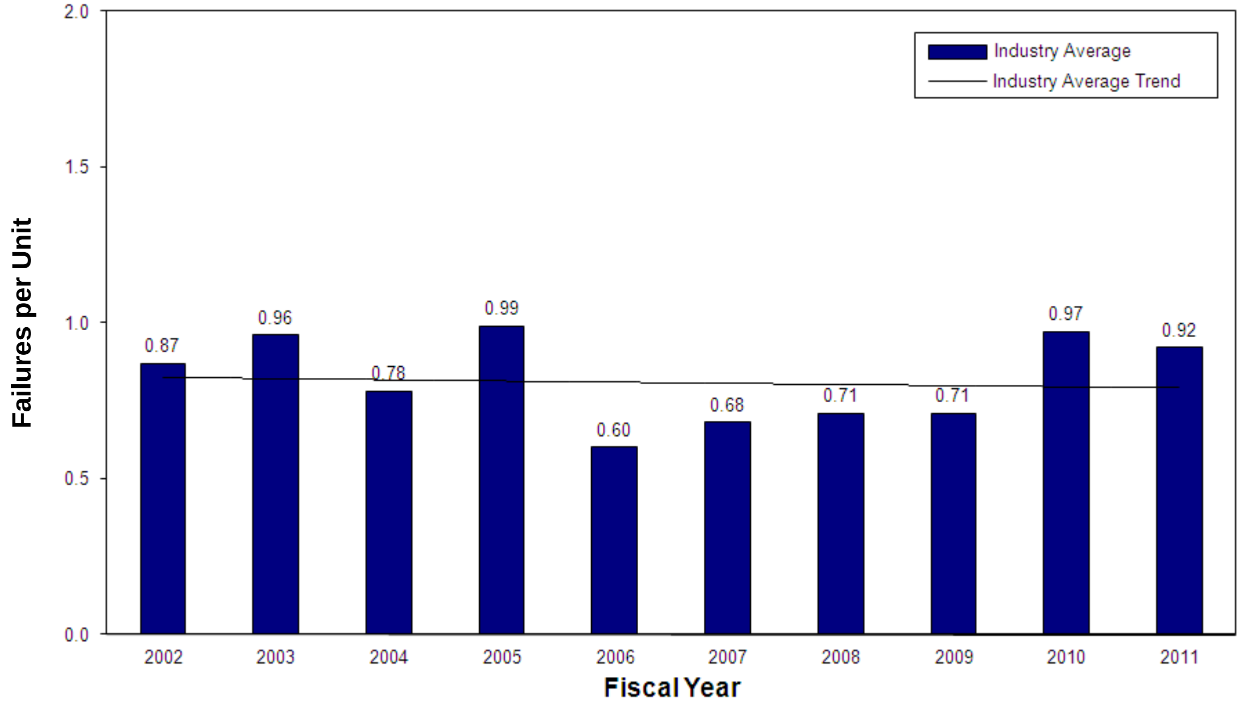


Figure 4 Safety system failures

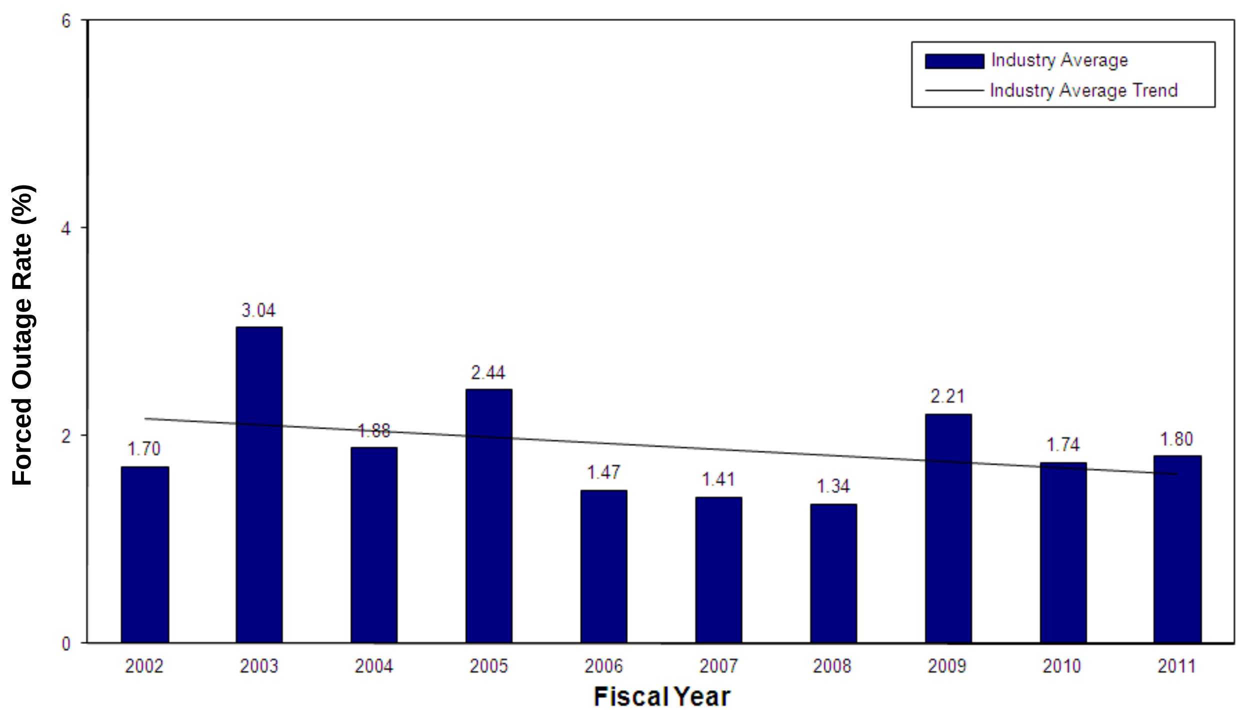


Figure 5 Forced outage rate

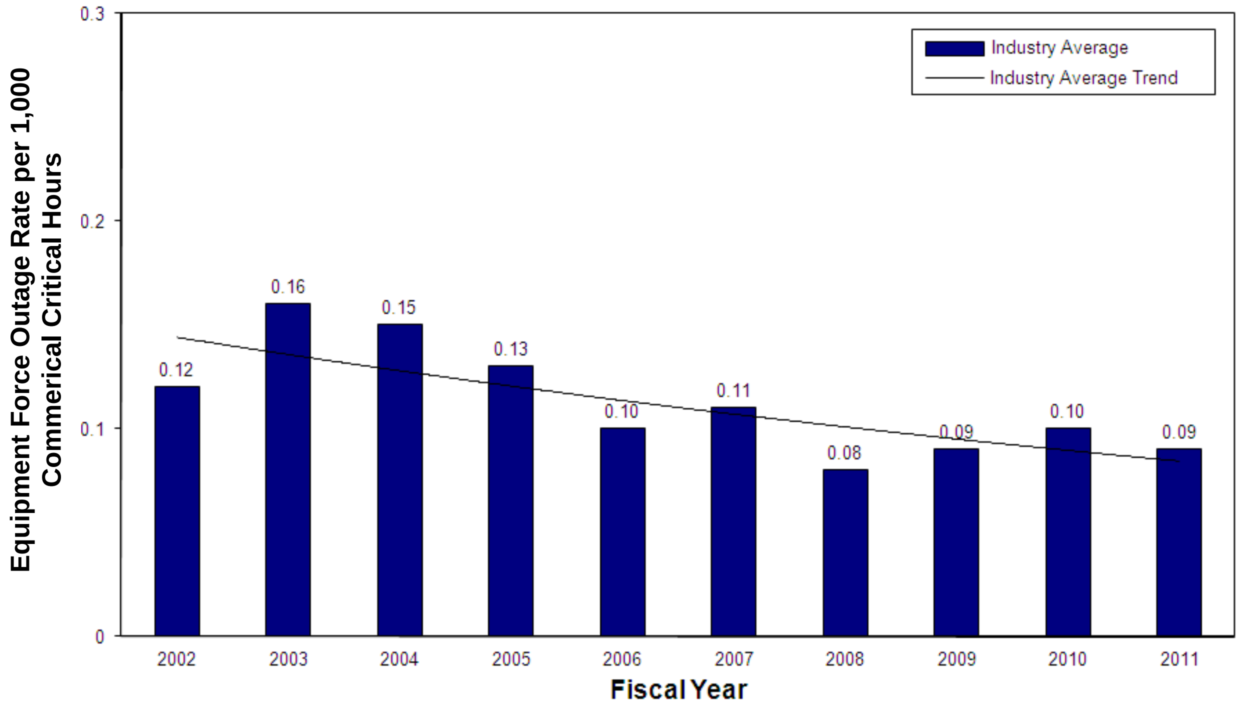


Figure 6 Equipment forced outages

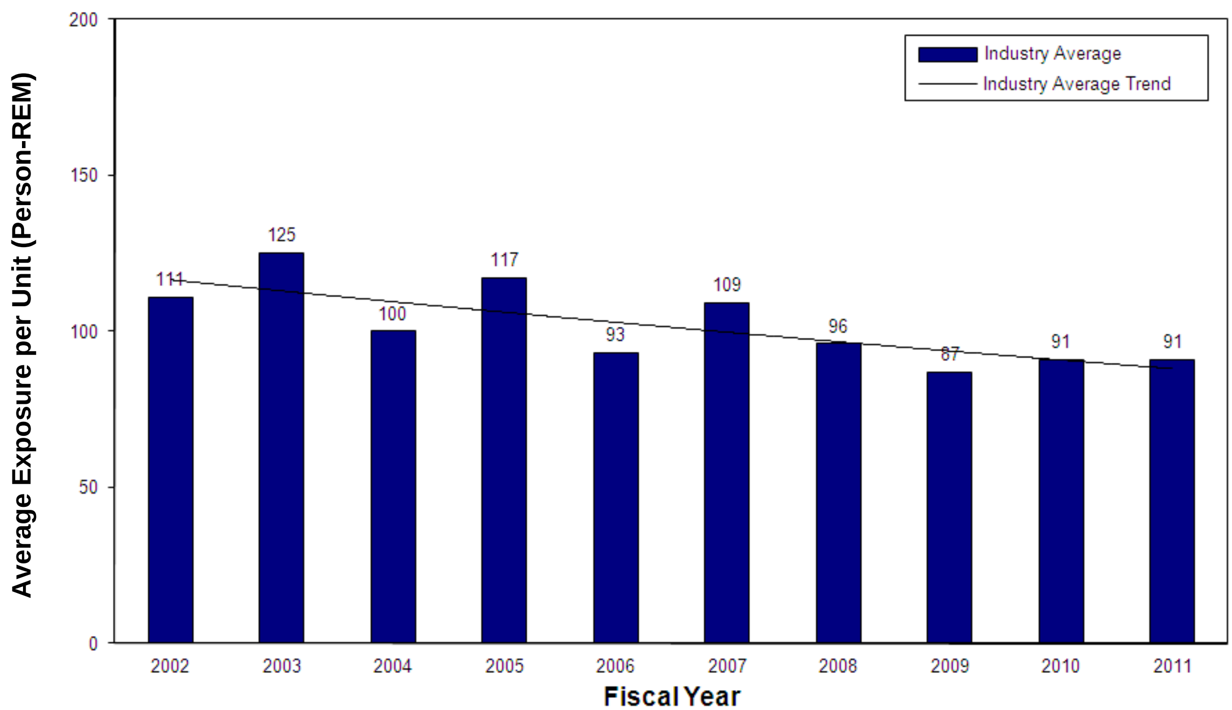


Figure 7 Collective radiation exposure

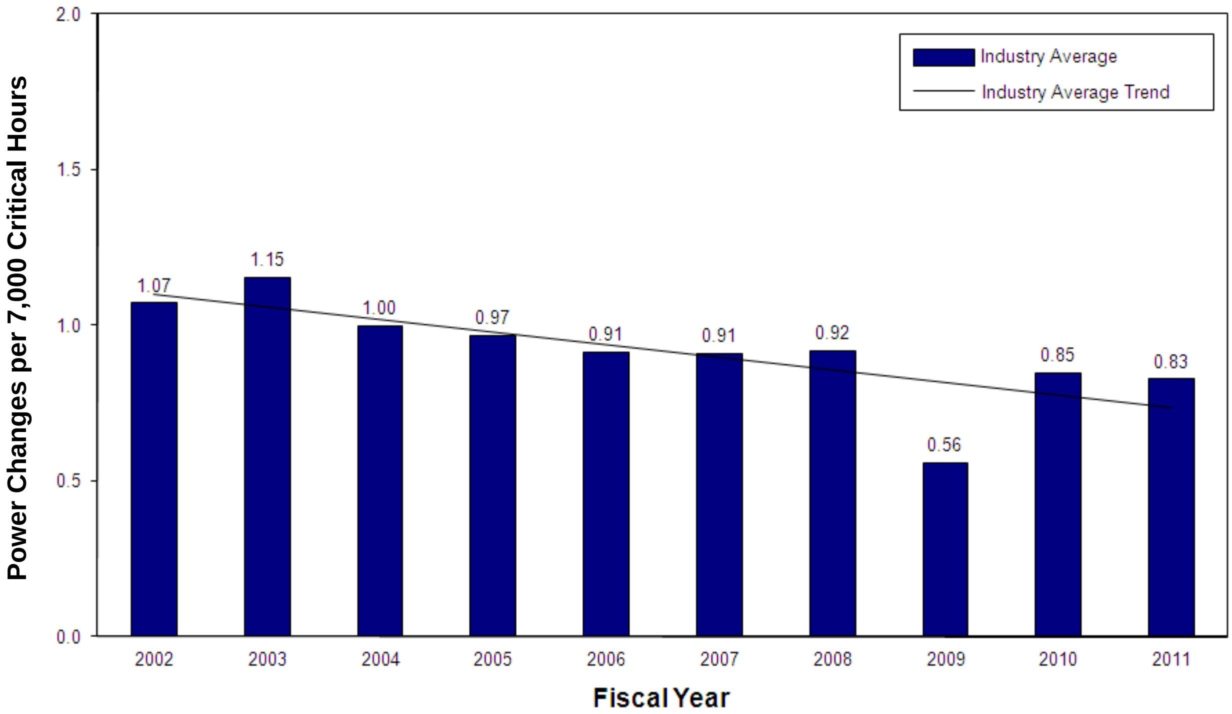


Figure 8 Unplanned power changes

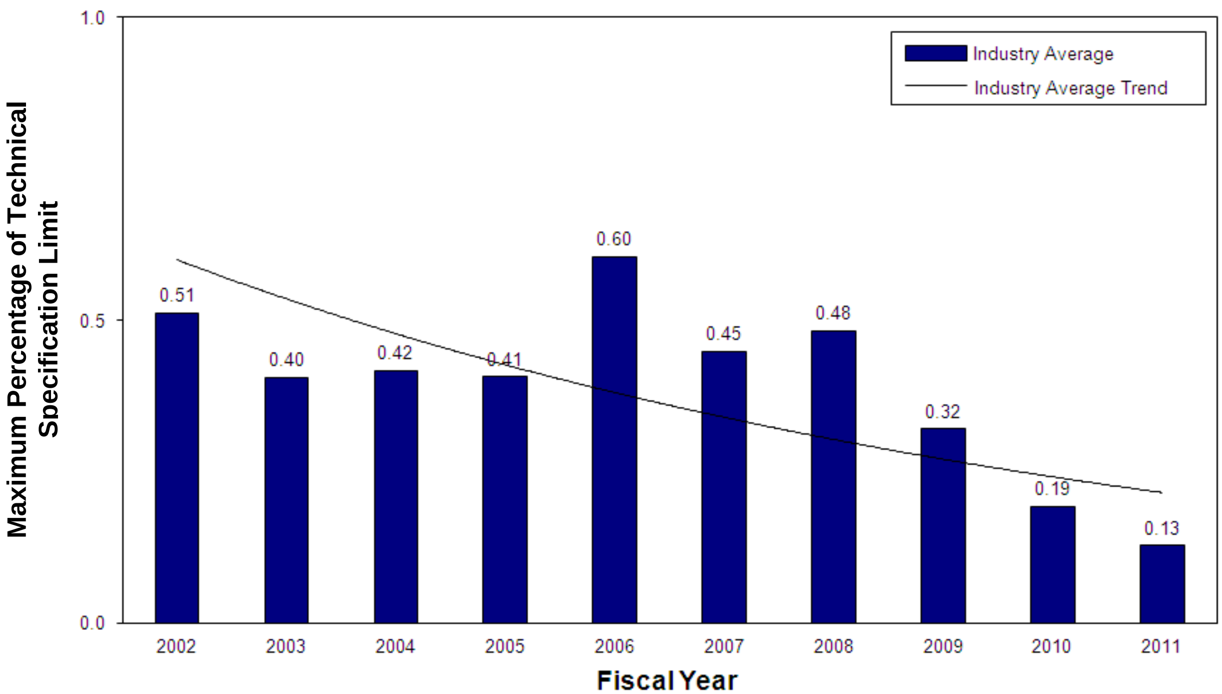


Figure 9 Reactor coolant system activity

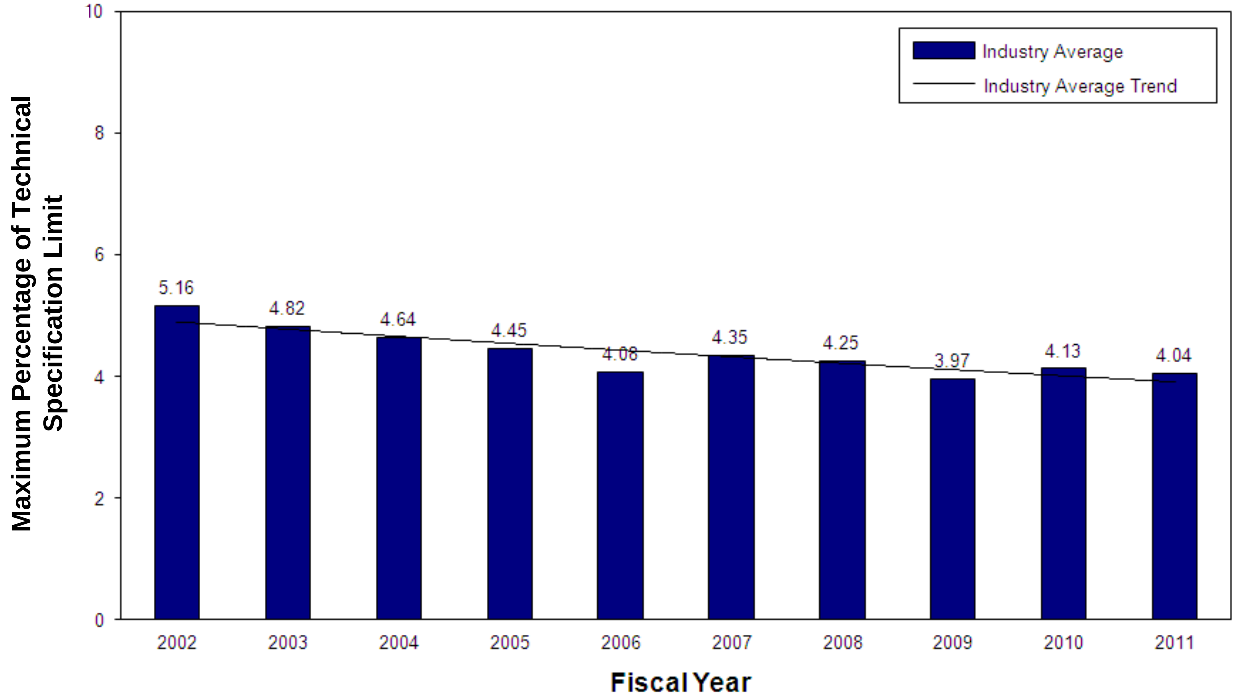


Figure 10 Reactor coolant system leakage

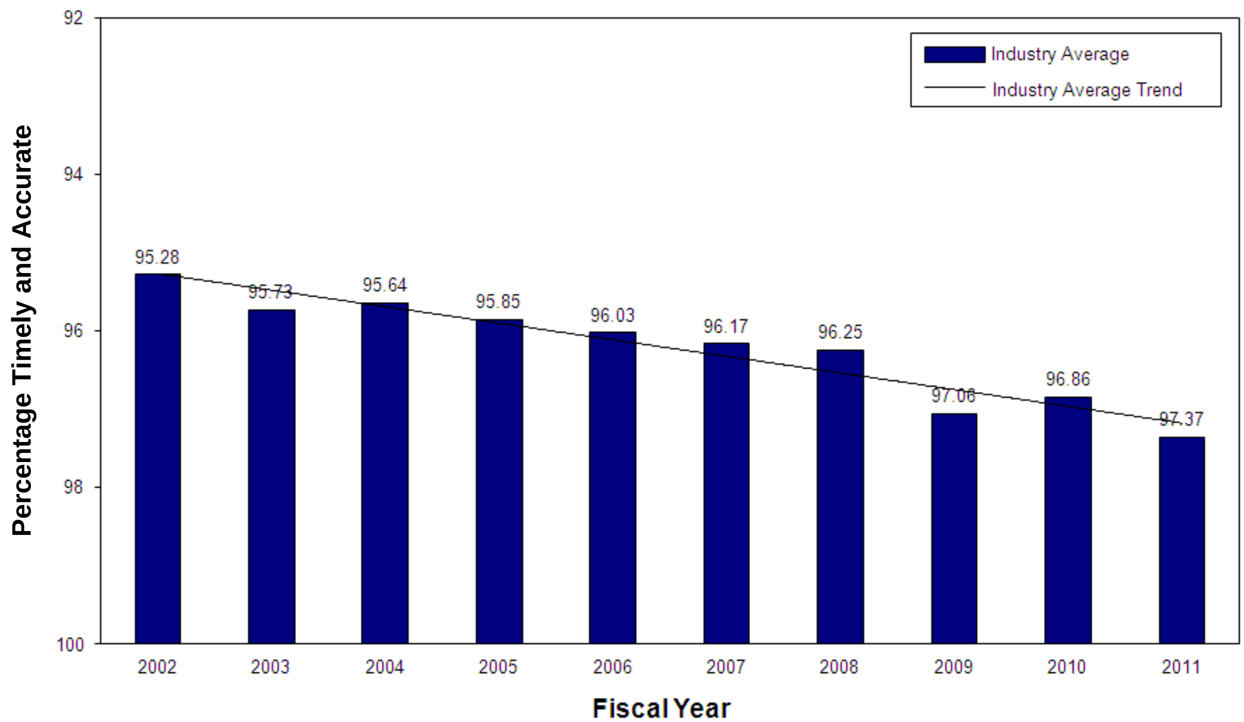


Figure 11 Drill and exercise performance

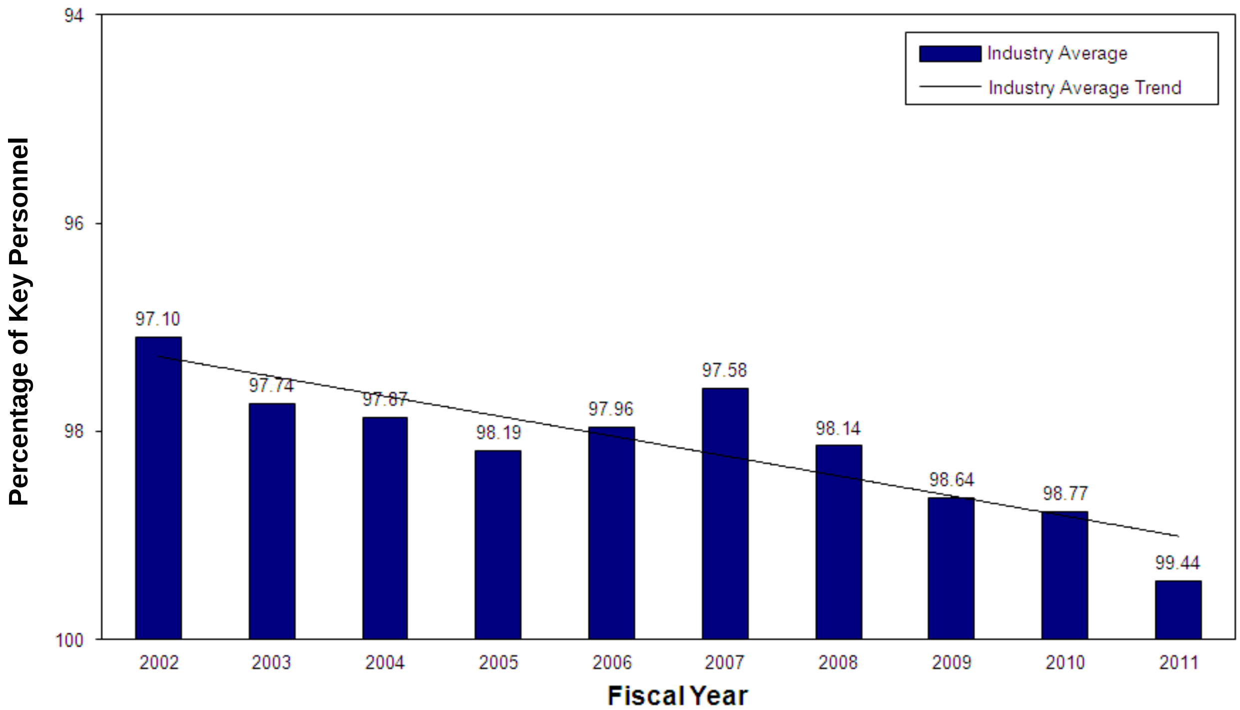


Figure 12 Emergency response organization drill participation

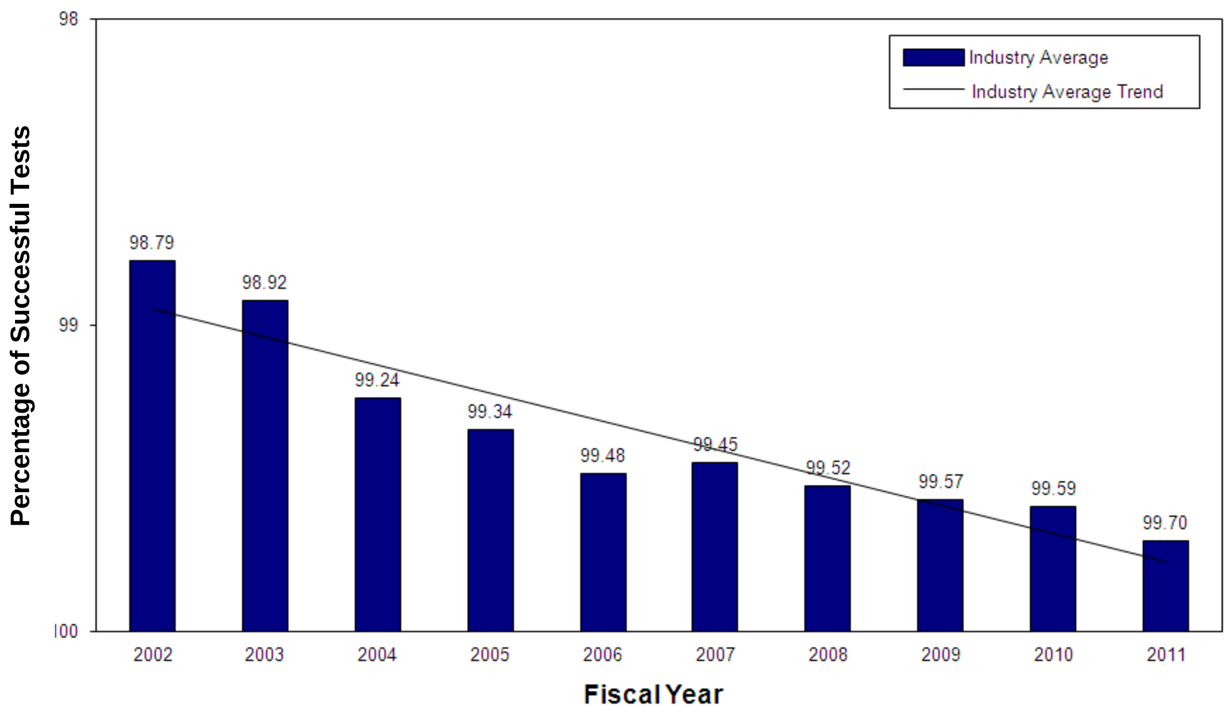


Figure 13 Alert and notification system reliability

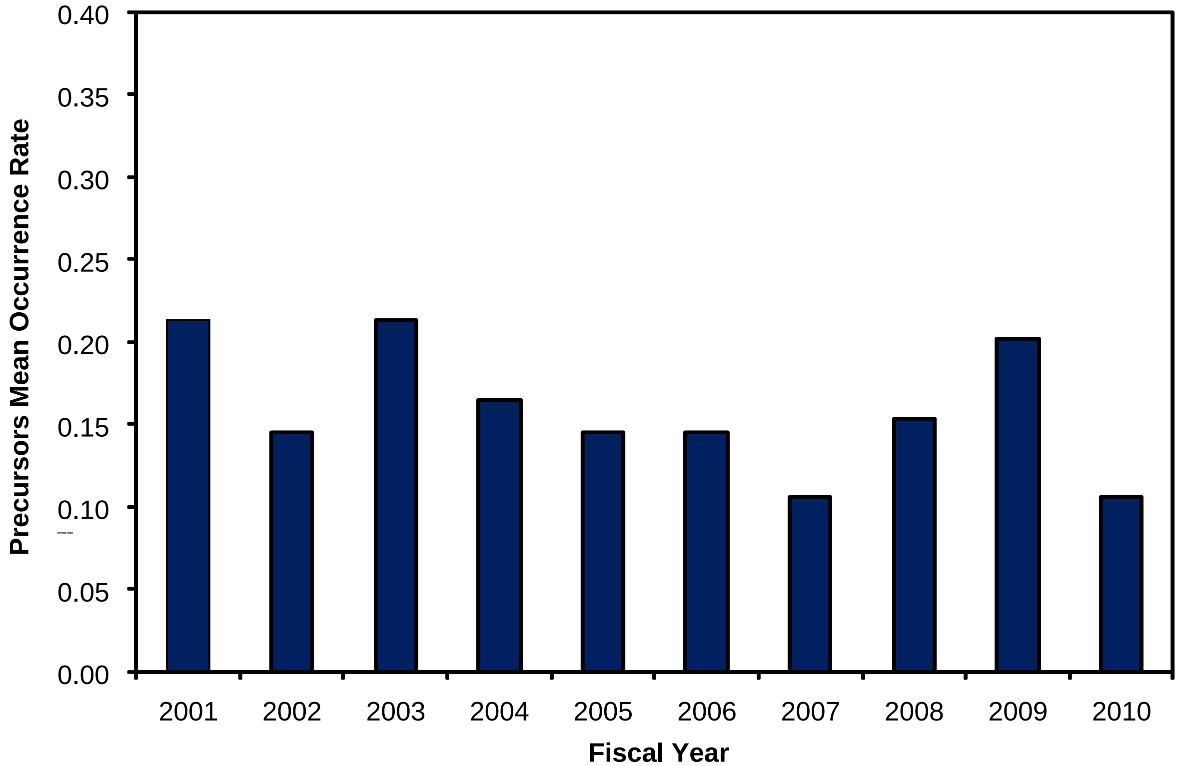
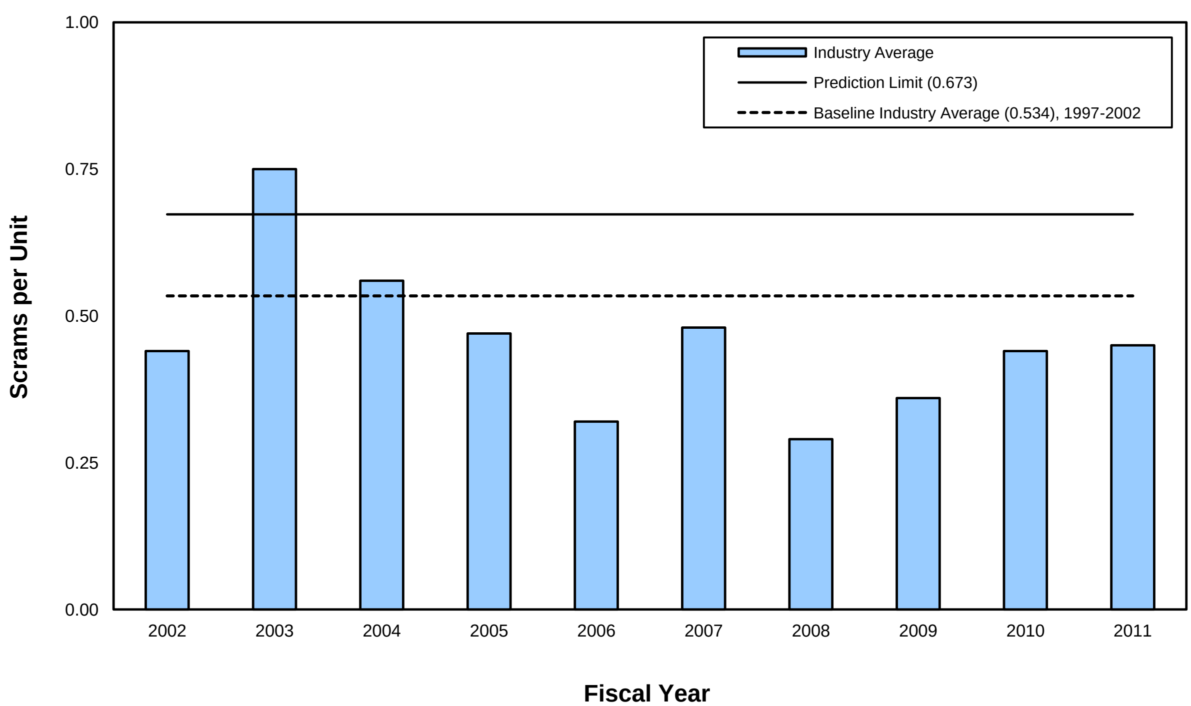


Figure 14 Accident sequence precursors

FISCAL YEAR 2011 SHORT-TERM INDUSTRY PERFORMANCE

The annual industry trend analysis compares 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.

Based on current information and using established prediction limits, the staff’s evaluation of the fiscal year (FY) 2011 Industry Trends Program PIs indicates that no PI exceeded its associated prediction limit in FY 2011, as shown in the following figures. However, the staff has not finalized the probabilistic risk analyses for several events that occurred in FY 2011. These events have the potential to be classified as Significant Events as defined by IMC 0313. The events include the earthquake that affected North Anna and the LOOPs that occurred at Browns Ferry and Surry. The Significant Events indicator may exceed its short-term prediction limit based on the finalized data associated with these events. The staff currently attributes the events to external phenomena that were beyond the licensee’s control and unrelated to safety performance. Additionally, these external events affected three multiunit sites for a total of seven reactor units, which drives the indicator value up. If the Significant Events indicator exceeds the prediction limit based on finalized data analysis, the staff will evaluate the factors contributing to the events, determine if changes to the Reactor Oversight Process are warranted, and provide an overview of its evaluation and conclusions in an addendum to this SECY paper.



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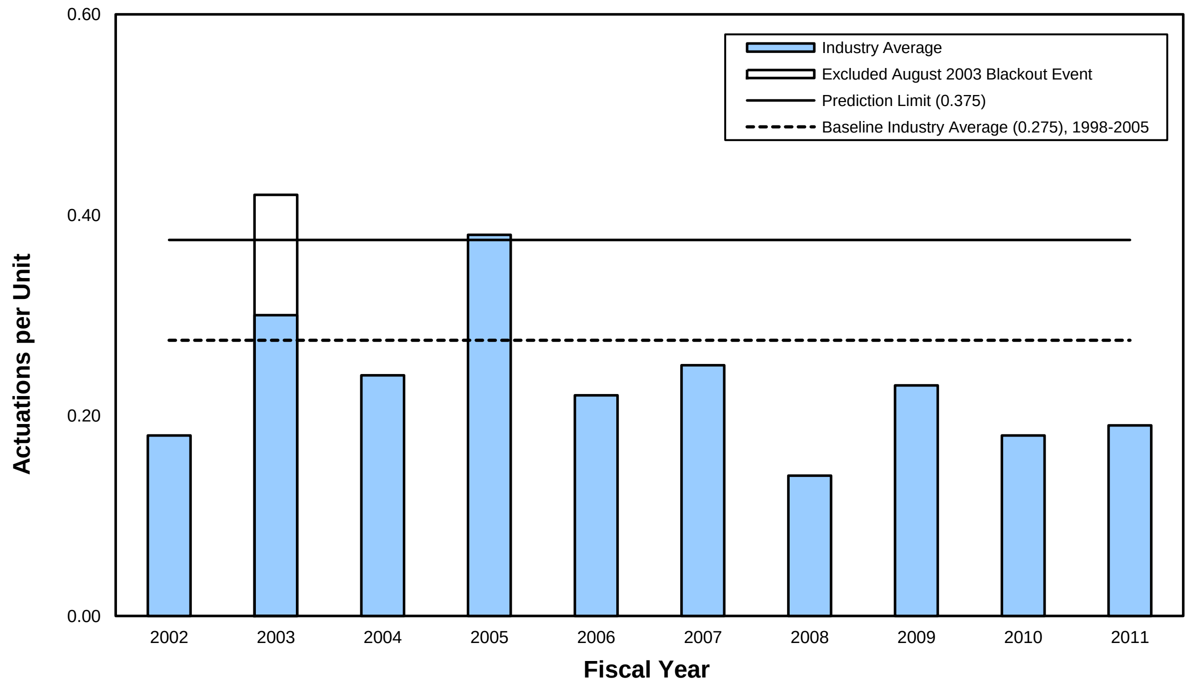

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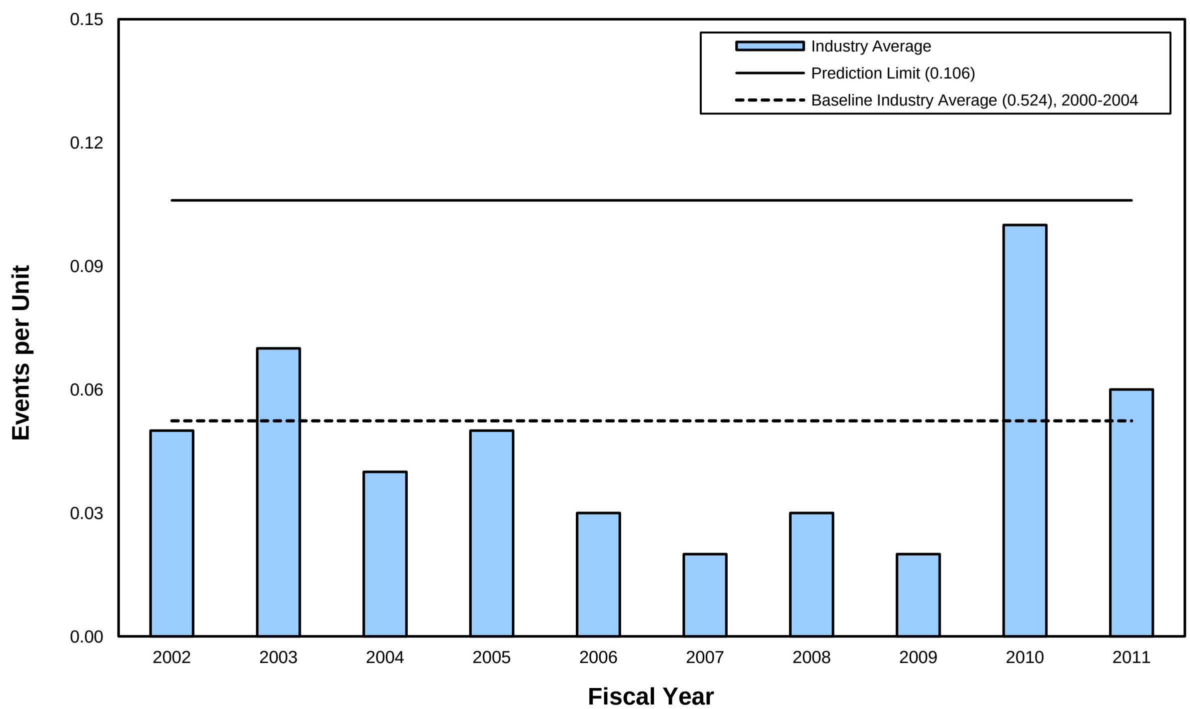


Figure 3 Significant events

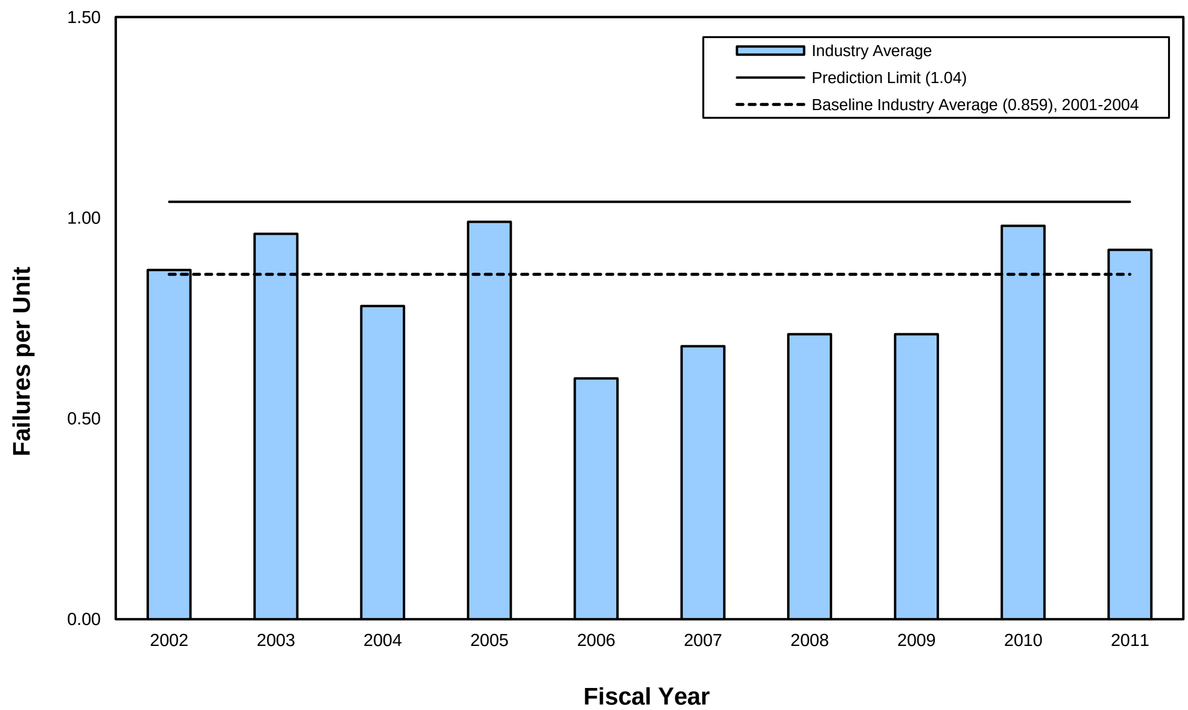


Figure 4 Safety system failures

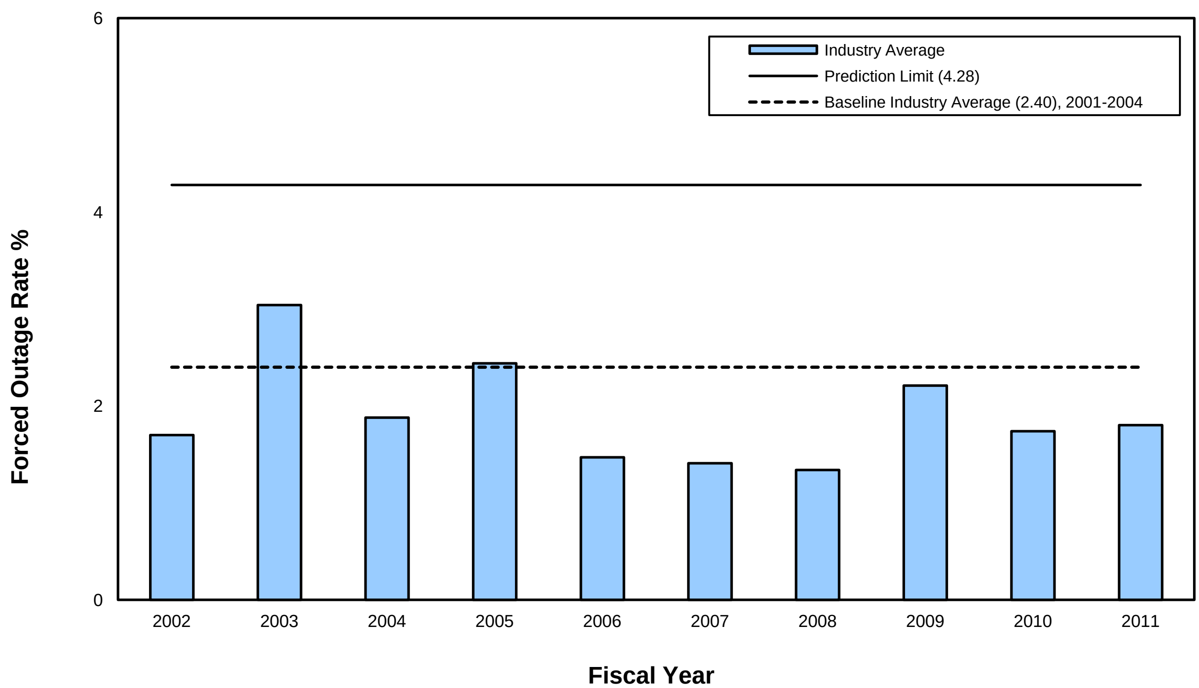


Figure 5 Forced outage rate

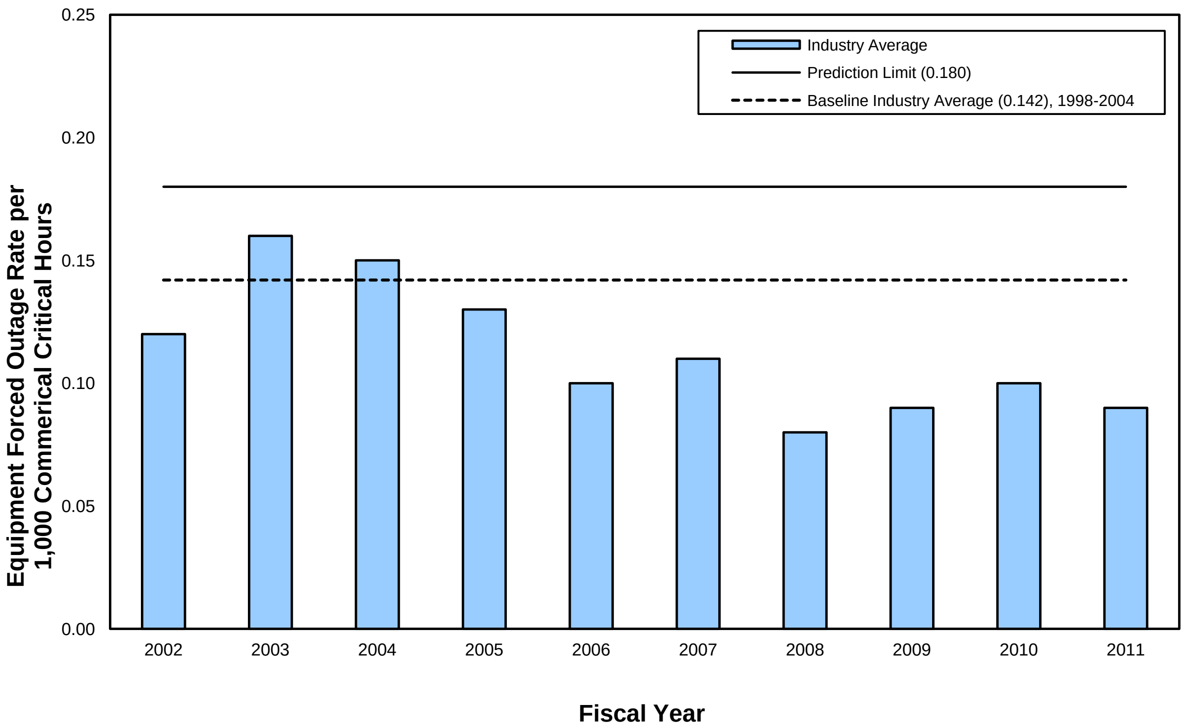
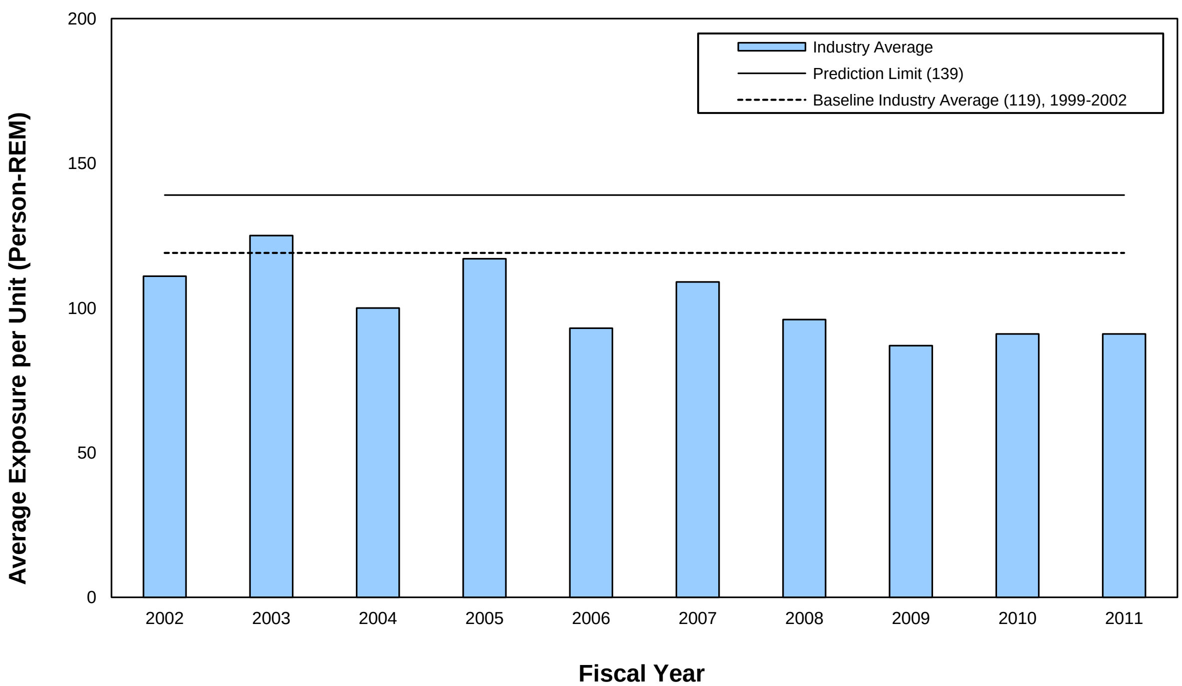


Figure 6 Equipment forced outages



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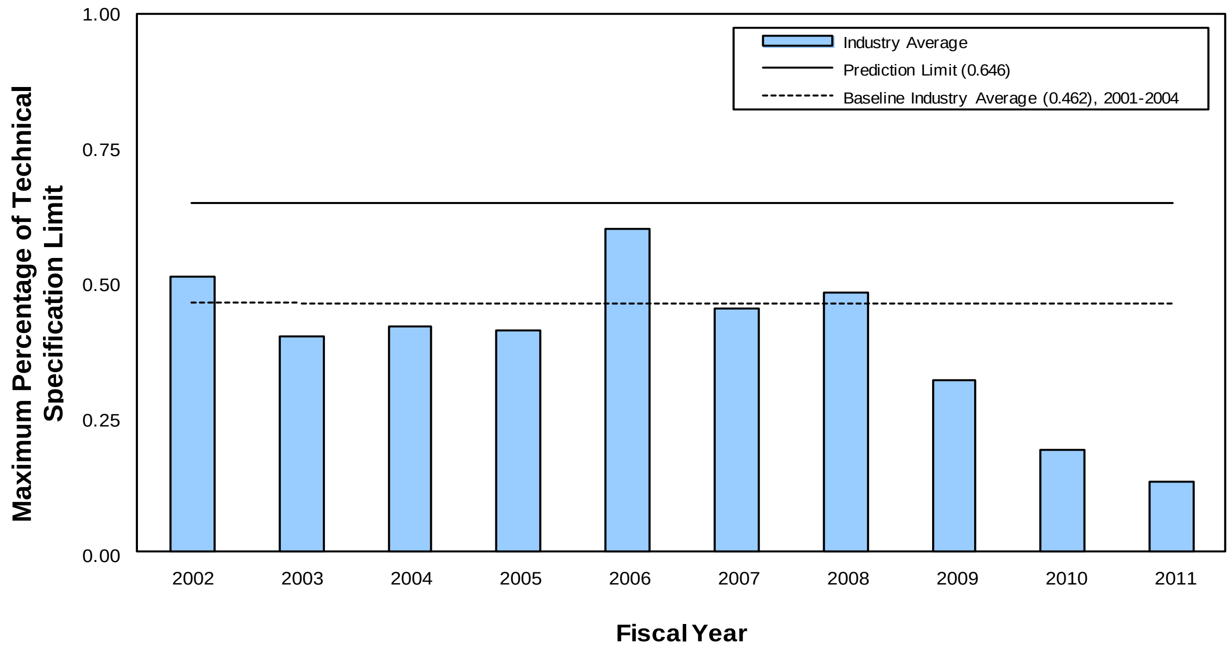

Figure 8 Unplanned power changes per 7,000 critical hours

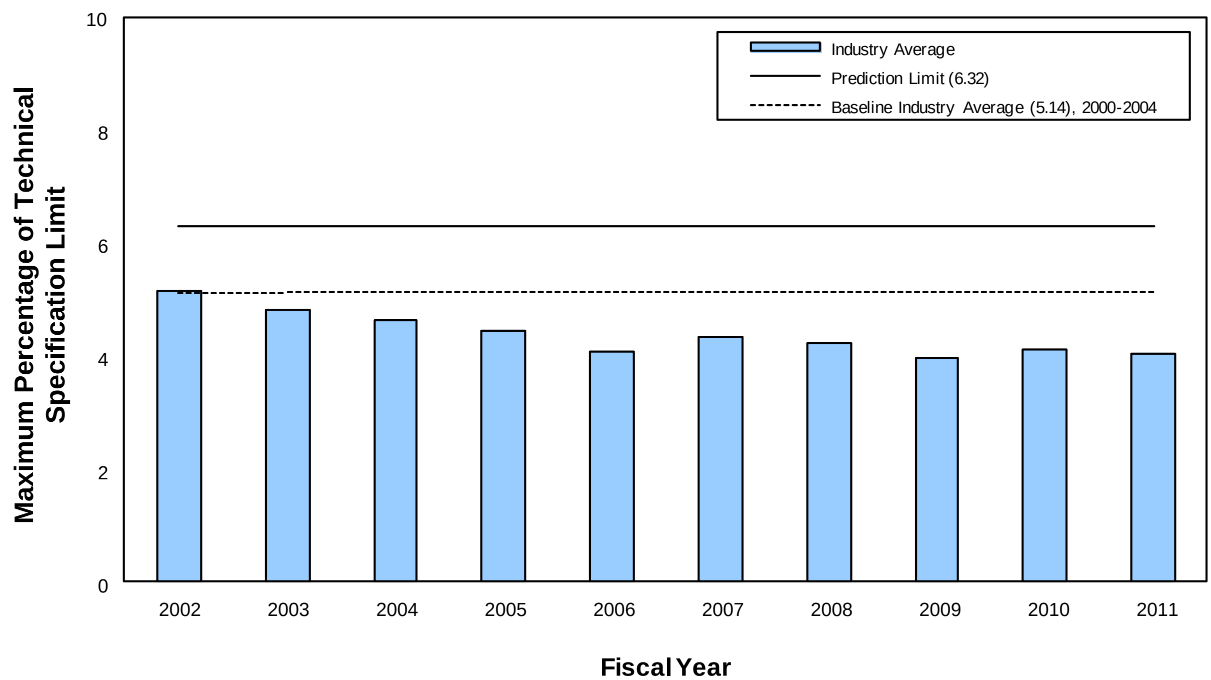

Figure 9 Reactor coolant system activity

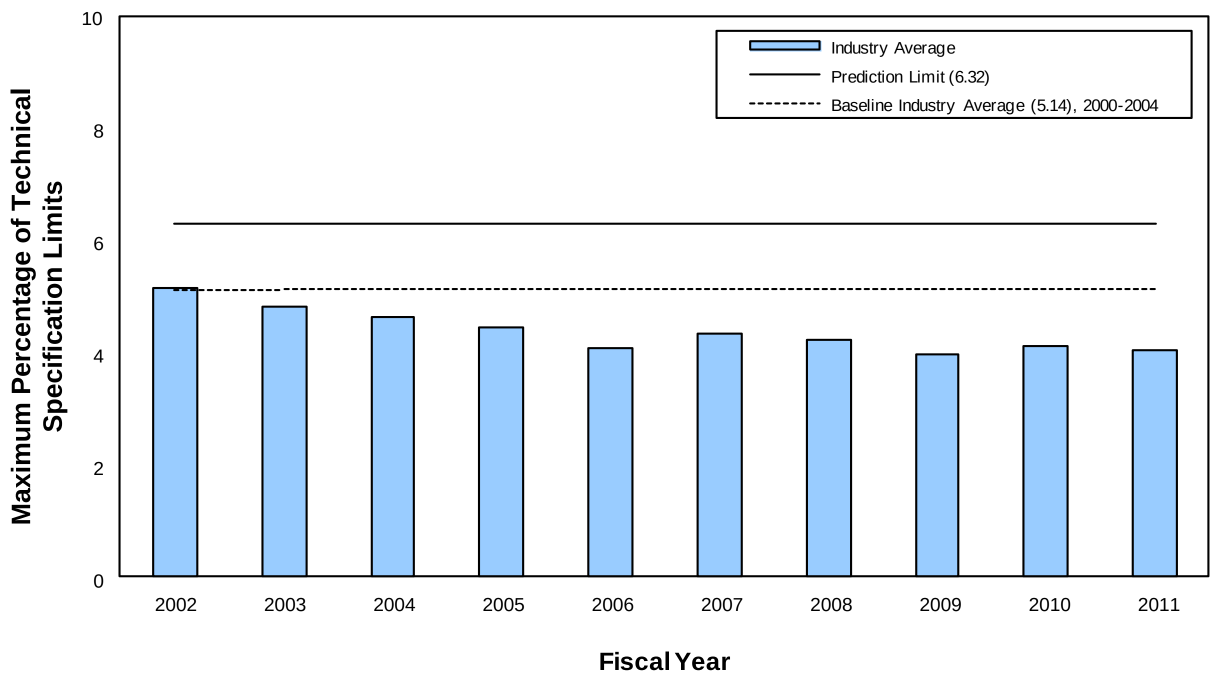

Figure 10 Reactor coolant system leakage

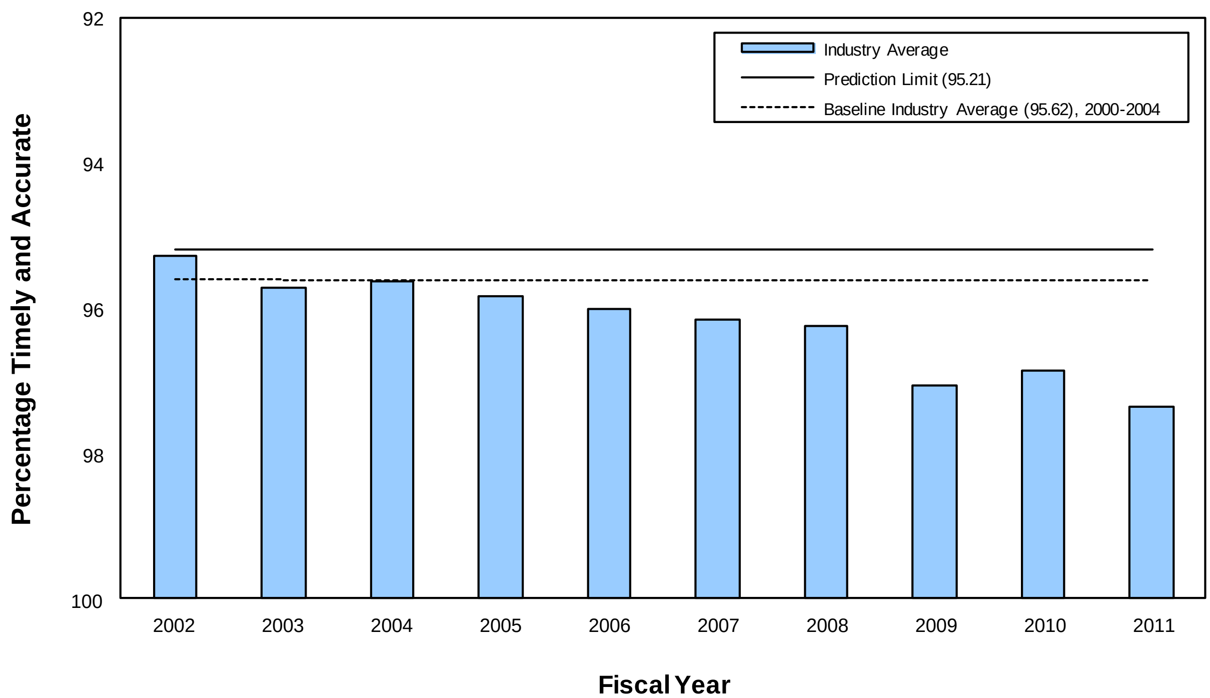

Figure 11 Drill and exercise performance

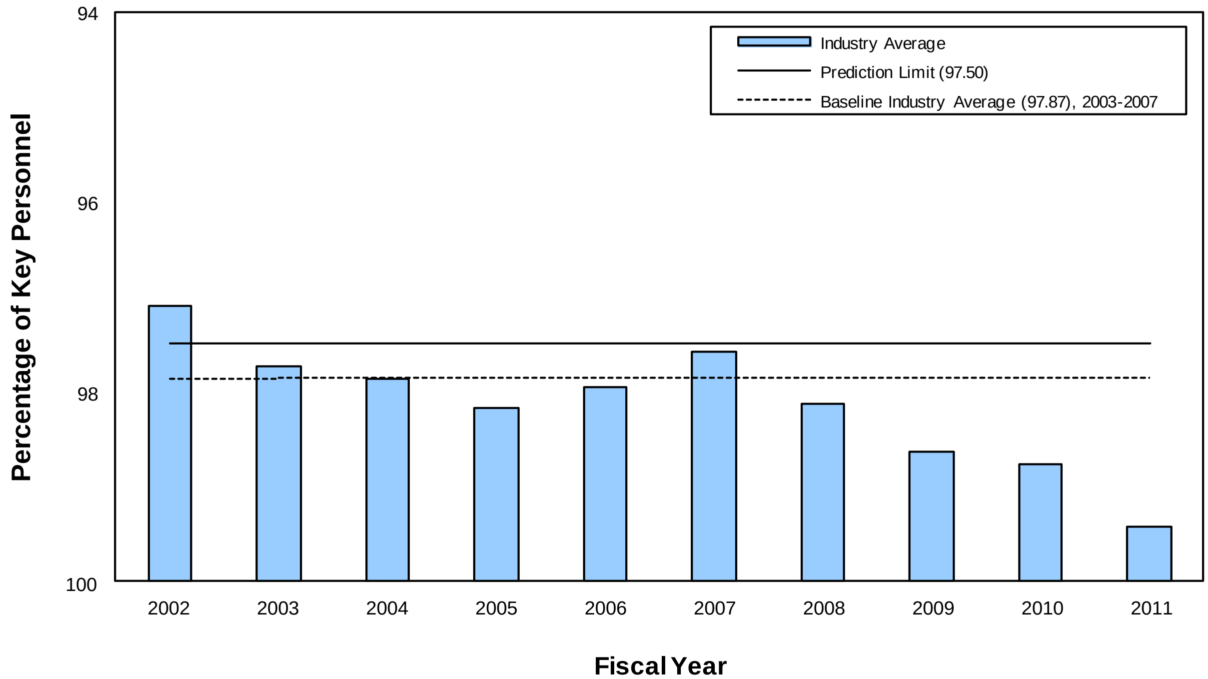

Figure 12 Emergency response organization drill participation

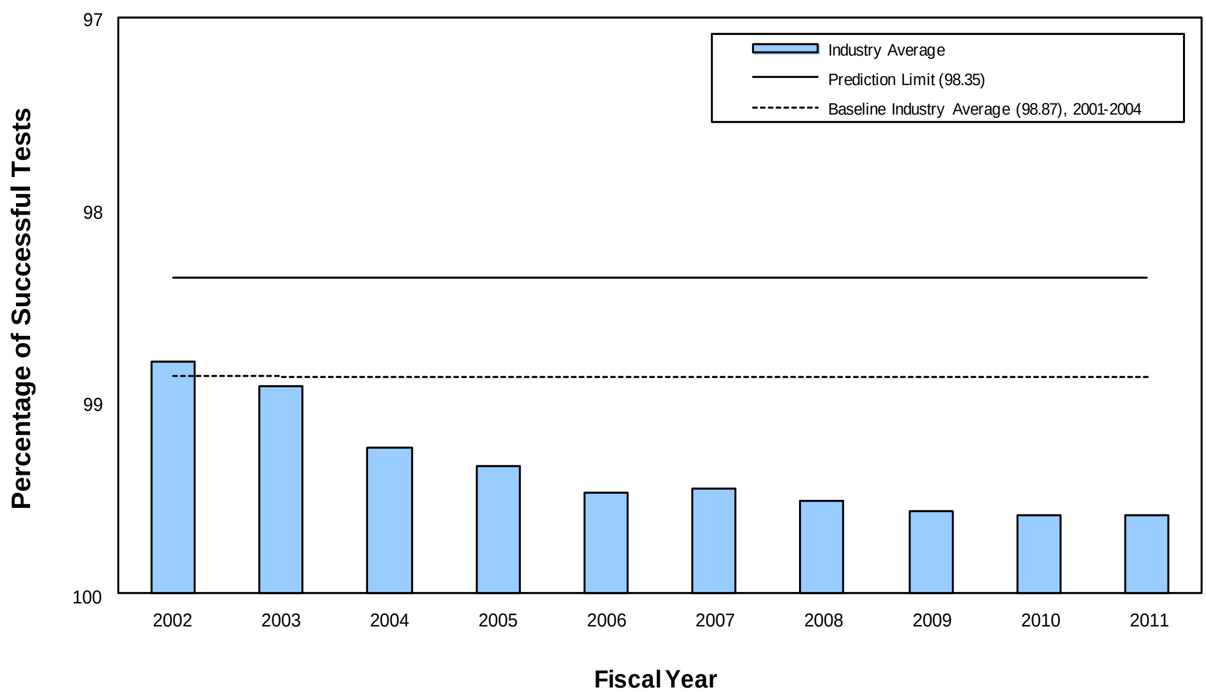

Figure 13 Alert and notification system reliability

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 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 2011

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 originally were developed to describe, roughly, calendar years 1998–2002.

The events were reviewed in early 2010. Several events in the loss of condenser heat sink and loss of main feedwater categories were reclassified to reflect more accurately the actual effect 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 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.

The NRC staff identified that for one initiator, LOOP, for which the FY 2011 occurrence rate exceeded the Tier 1 prediction limit. The seven LOOP events representing essentially three occurrences at three different multiunit sites are as follows:

- Surry Units 1 and 2, lost offsite power when a tornado damaged the switchyard on April 16, 2011.

- Browns Ferry Units 1, 2, and 3, lost offsite power when high winds and tornadoes damaged the area’s transmission lines on April 27, 2011.

- North Anna Units 1 and 2, lost offsite power during an earthquake on August 23, 2011.

These events all resulted from natural phenomena and were outside of the licensee’s control. As such, they are not indicative of degraded industry performance. In each instance, the LOOPs occurred on a particular day and depended on a single initiator. The prediction limit is determined assuming independent event occurrences. Tier 1 activities are intended to reveal degrading industry performance before any long-term adverse trends emerge. These LOOP events were accounted for in other ITP long-term performance indicators with no statistically significant adverse trends identified. Nevertheless, the staff will share information with other NRR staff involved in updates to 10 CFR 50.63 (Loss of All Alternating Current Power-Station Blackout Rule) for their consideration. No program adjustments are recommended at this time; however the staff will continue to monitor this occurrence for future program adjustments if warranted. For all other Tier 1 initiators, the FY 2011 occurrence rates are below 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 (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 FY 2011 (2.98×10^{-7} per reactor critical year) indicates a shift from the last several years of below baseline industry performance to slightly above baseline industry performance. This shift is mainly attributed to LOOP events dominating the estimated core damage frequency for both plant types. The combined industry BRIIE value is below the established reporting threshold of $\Delta CDF = 1.0 \times 10^{-5}$ per reactor critical year.

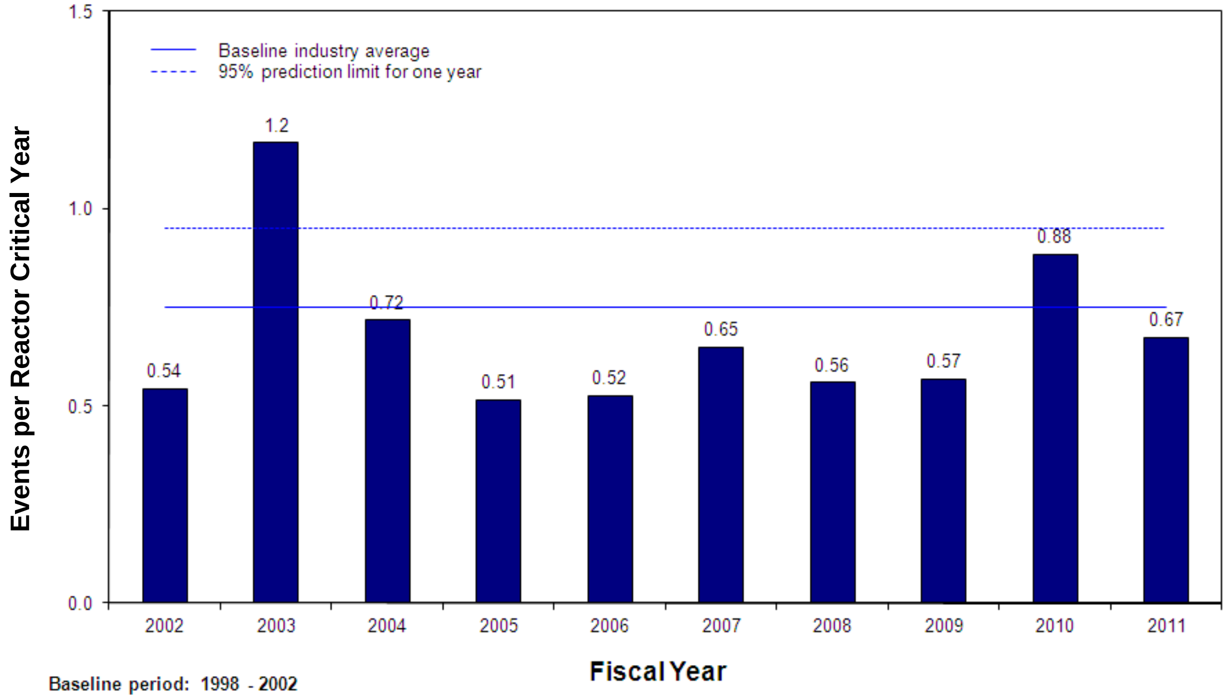

Figure 1 Pressurized-water reactor (PWR) general transients

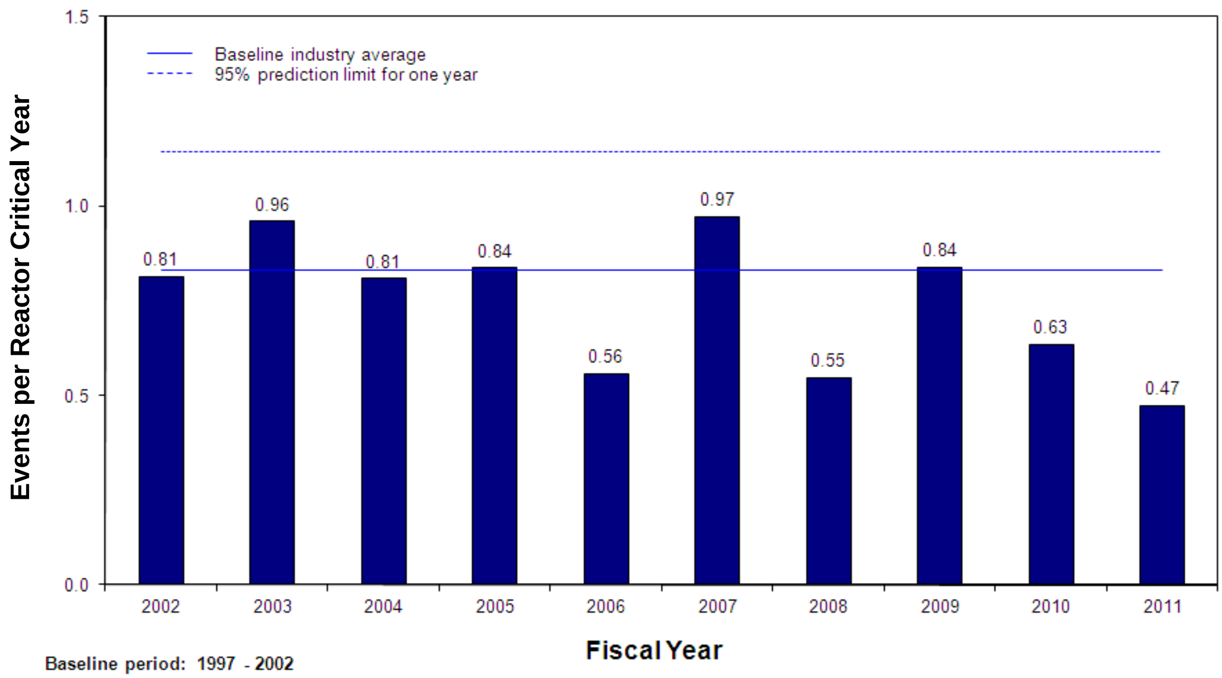

Figure 2 Boiling-water reactor (BWR) general transients

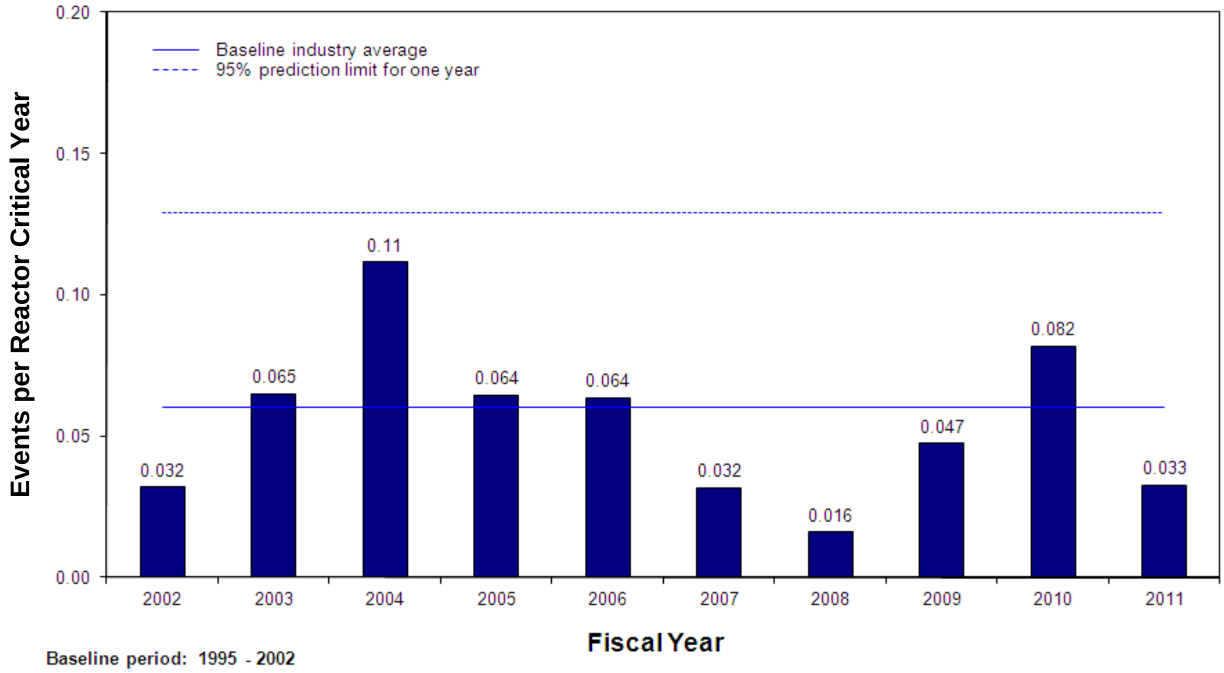

Figure 3 PWR loss of condenser heat sink

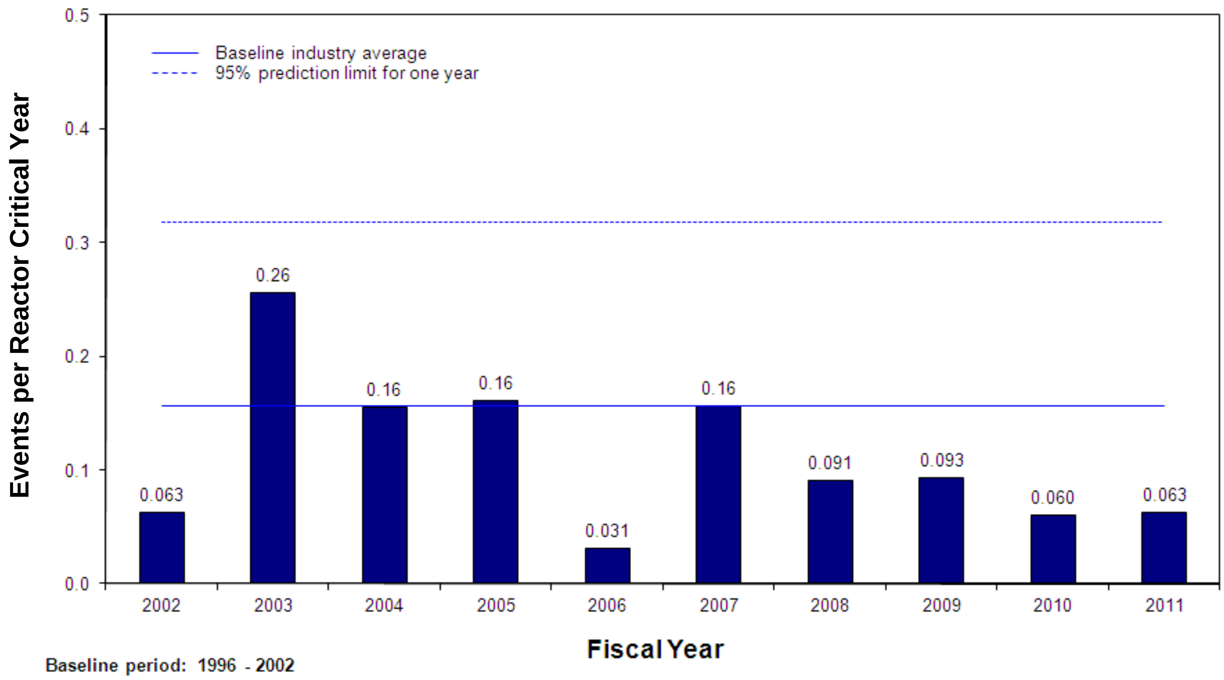

Figure 4 BWR loss of condenser heat sink

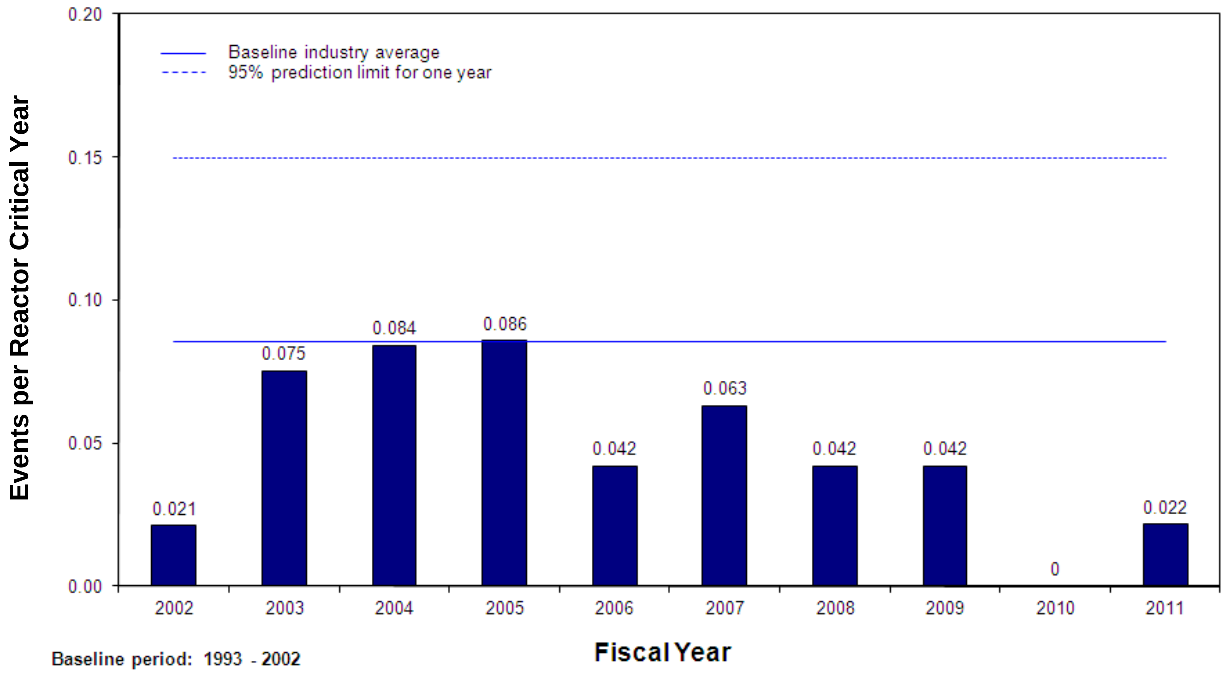

Figure 5 Loss of main feedwater

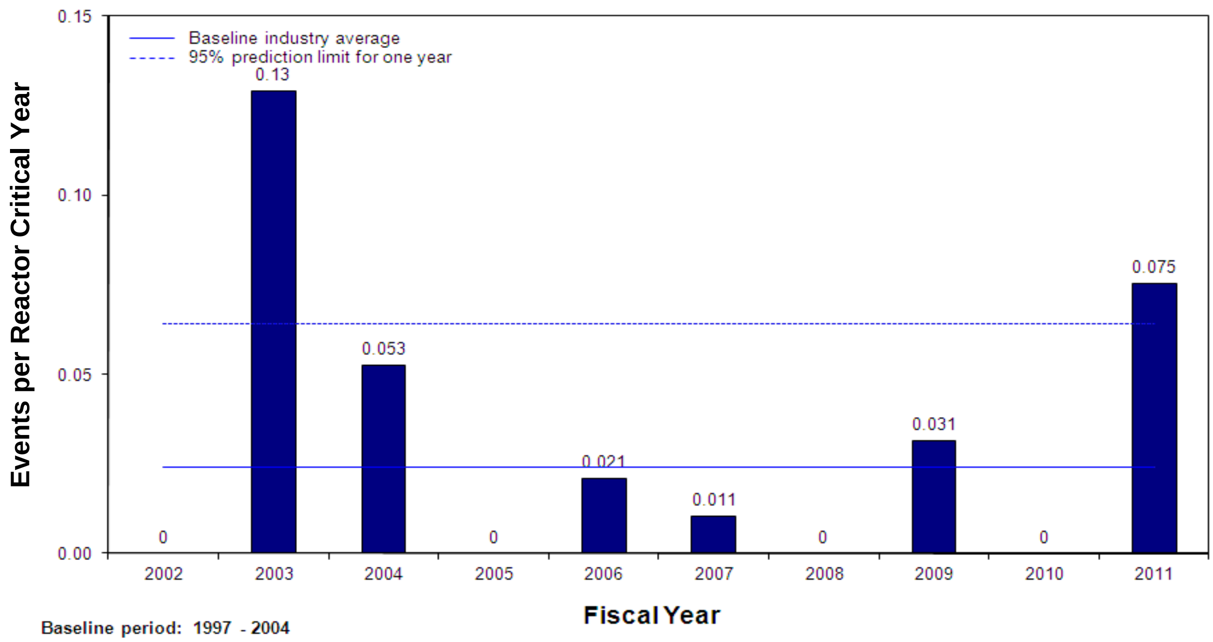

Figure 6 Loss of offsite power

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

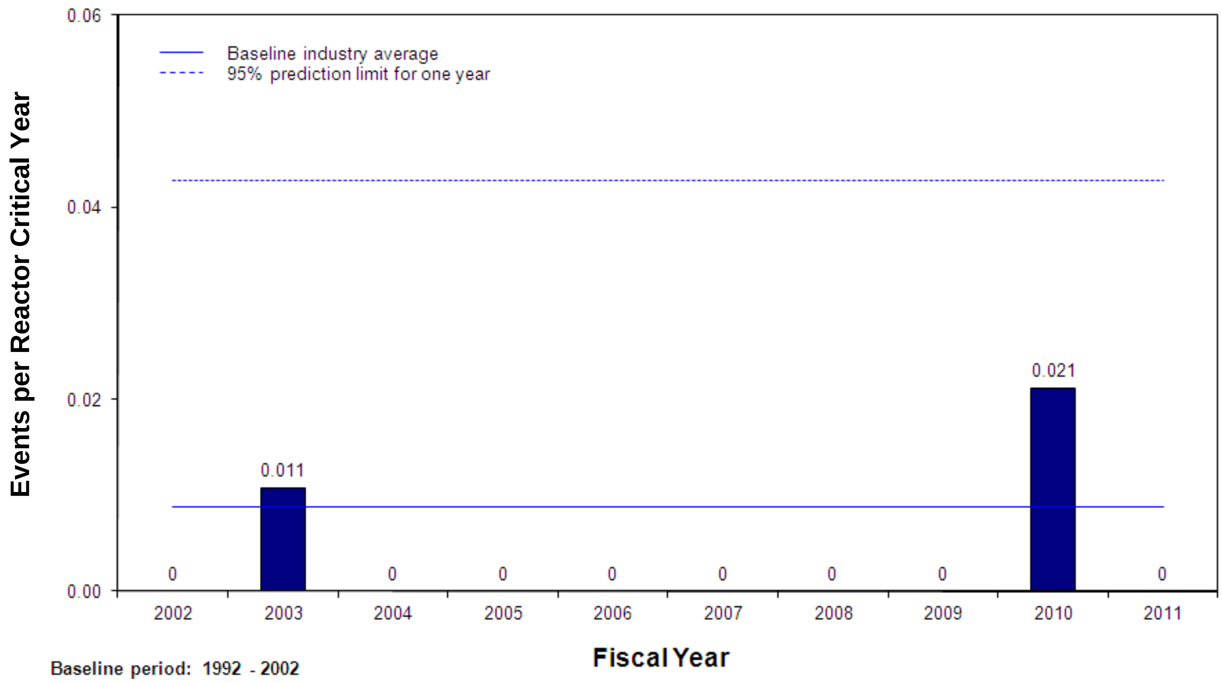

Figure 7 Loss of vital alternating current bus

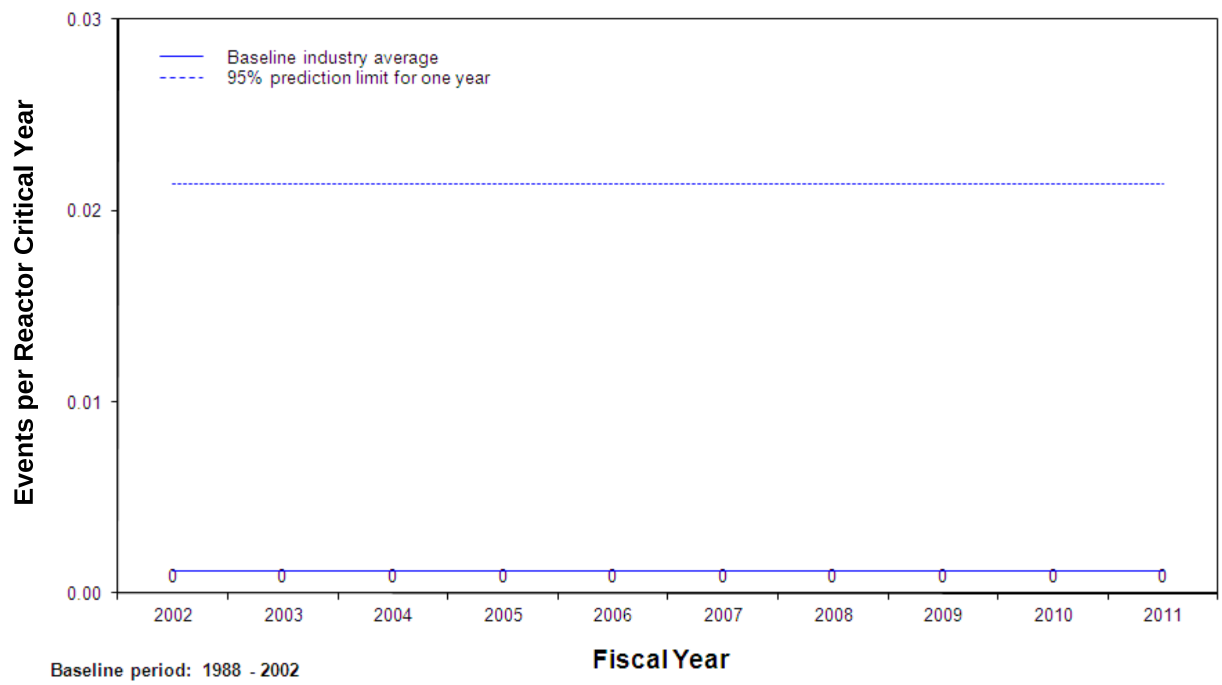

Figure 8 Loss of vital direct current bus

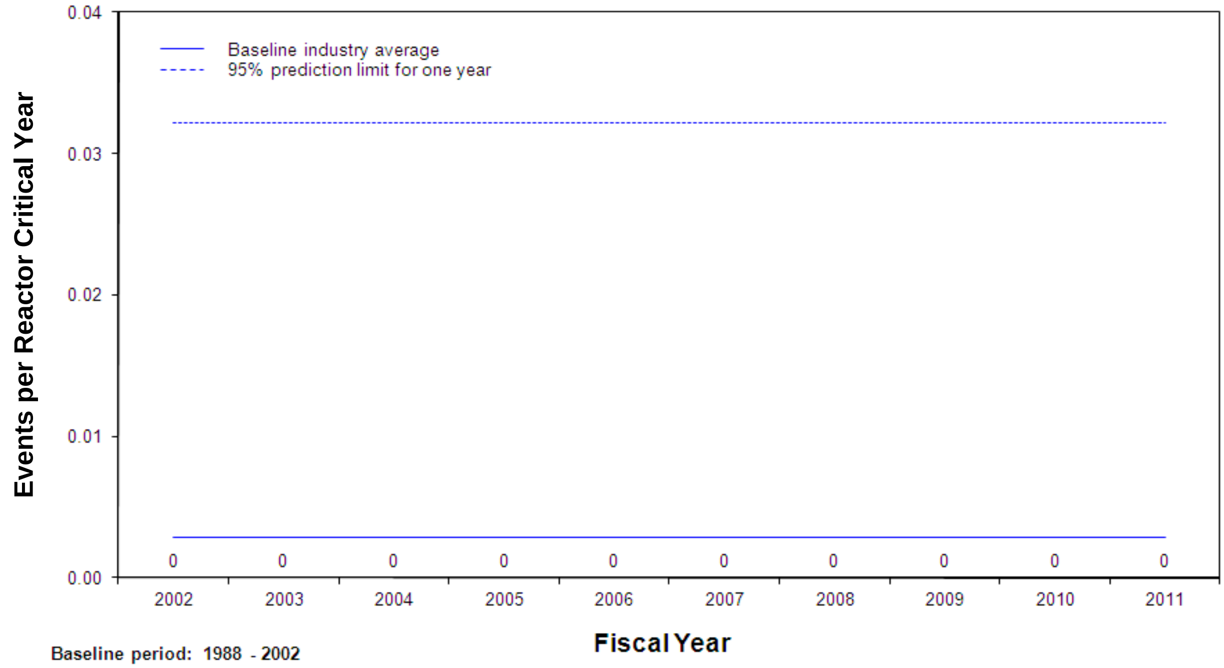

Figure 9 PWR stuck-open safety/relief valve

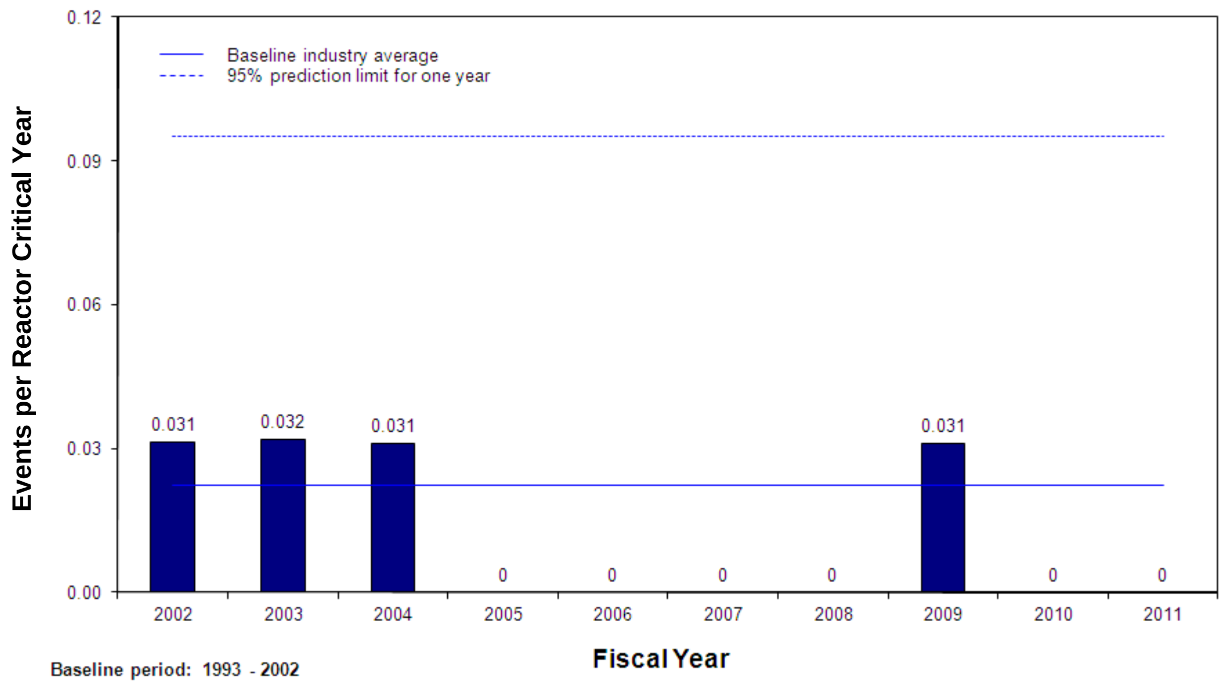

Figure 10 BWR stuck-open safety/relief valve

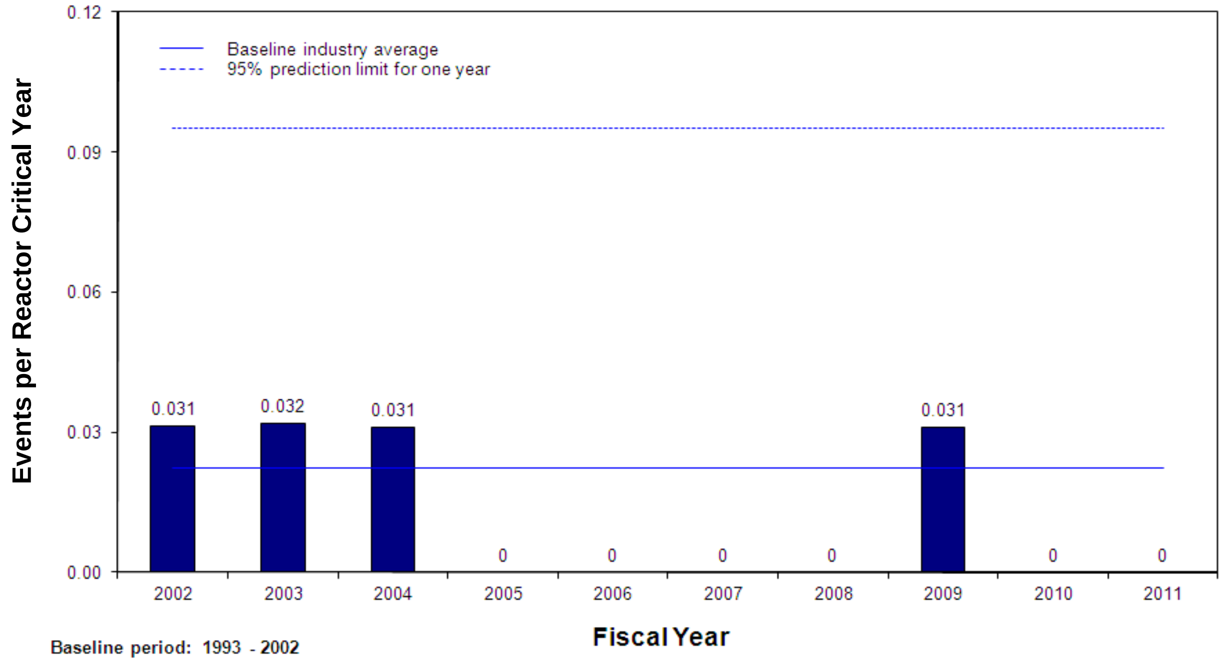

Figure 11 PWR loss of instrument air

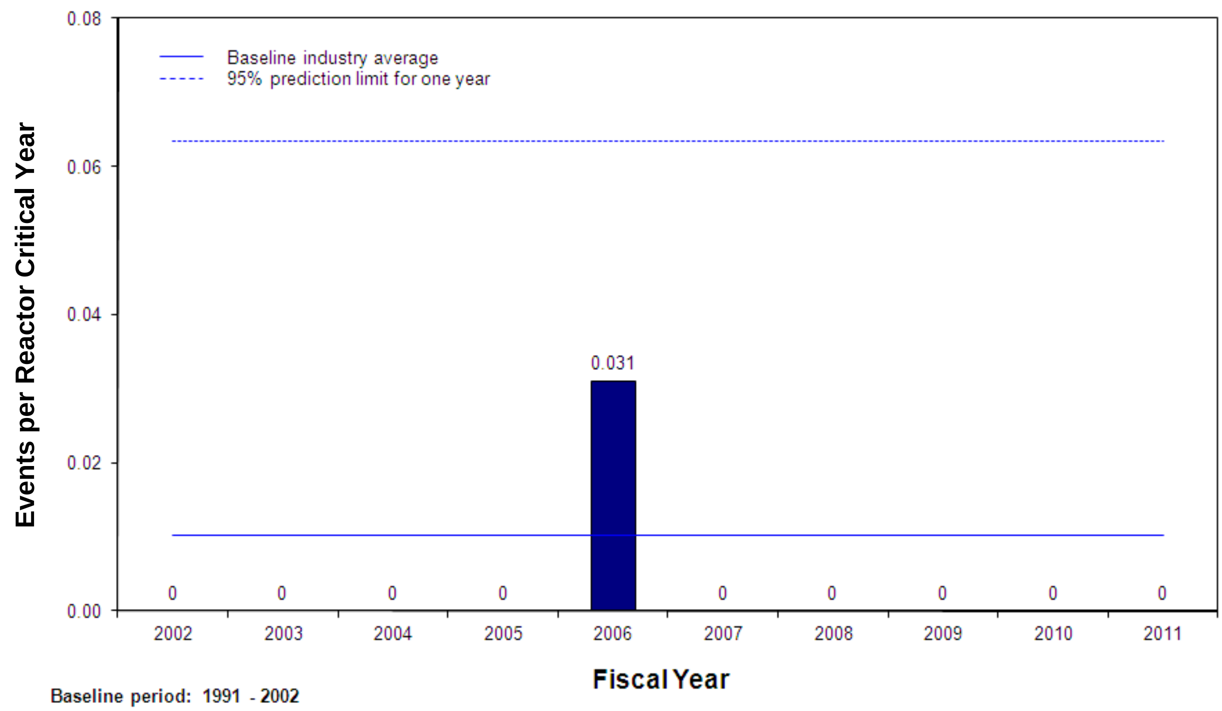

Figure 12 BWR loss of instrument air

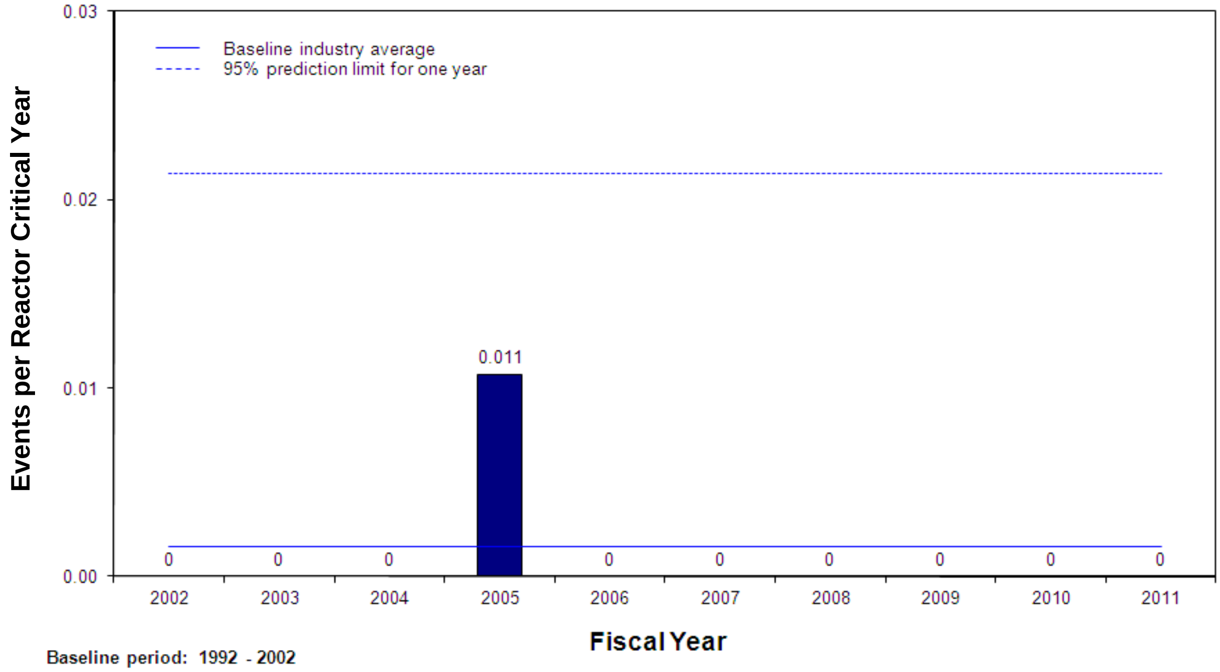

Figure 13 Very small loss-of-coolant accident

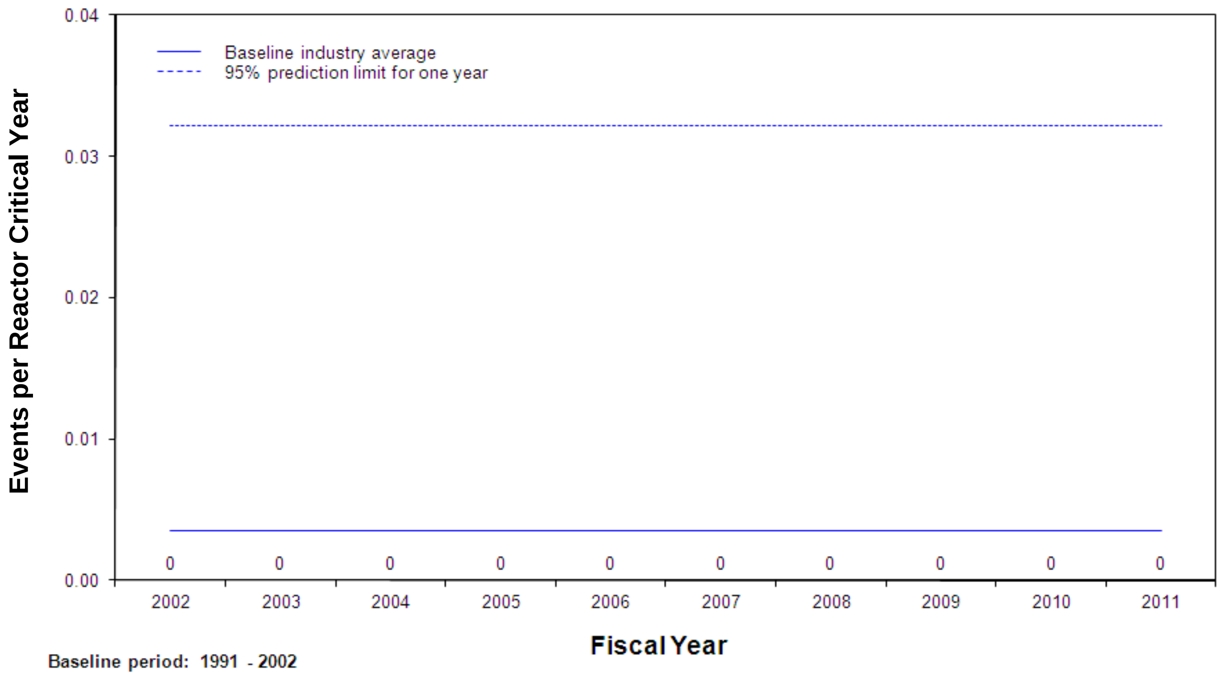

Figure 14 PWR steam generator tube rupture

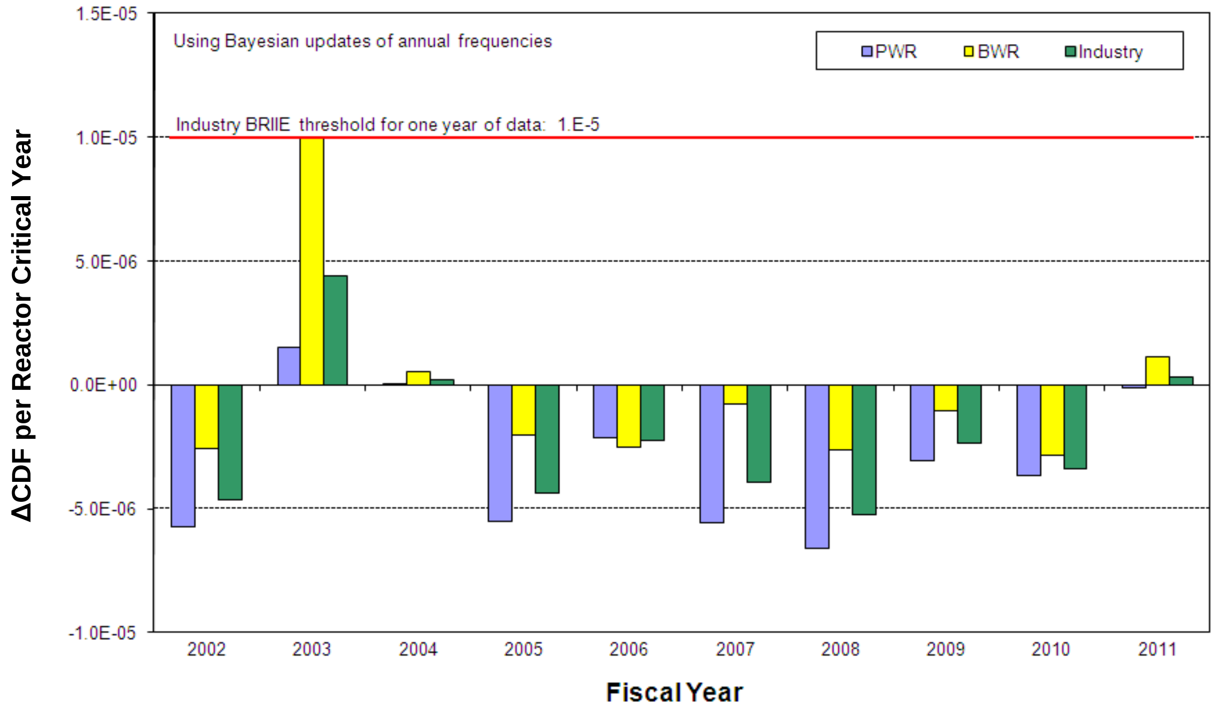

Figure 15 BRIIE Tier 2 (ΔCDF)