POLICY ISSUE
INFORMATION

April 8, 2013 SECY-13-0038

FOR: The Commissioners

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

SUBJECT: FISCAL YEAR 2012 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) 2012. This paper does not address any new commitments or resource implications.

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 12th 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.

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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 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 results from the ASP program as one of the agency's safety goal performance measures reported in the NRC Performance and Accountability Report.

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 short-term prediction limits are determined from a predictive distribution derived using information from an established baseline period. These prediction limits are reevaluated each year.

The ITP complements the Reactor Oversight Process (ROP). The ITP monitors industry-level performance, whereas the ROP provides oversight to individual plant conditions and events.

The Office of Nuclear 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 separate from the ITP.

FY 2012 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 2012 (i.e., until September 30, 2012). The graphs in Enclosure 1 show the long-term ITP indicator trends and the ASP data. The staff removed the trendlines from the graphs in Enclosure 1 that did not have a statistically significant trend. The staff evaluated both linear and exponential trendlines for each set of data, and used the trendline showing the highest degree of statistical significance.

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 RES staff evaluated precursor data from FY 2002 through FY 2011 and identified no statistically significant trends for the occurrence rate of all precursors during that period (Figure 14 of Enclosure 1). Additional information can be found in Section 4.1 of Enclosure 1 of SECY-12-0133, "Status of the Accident Sequence Precursor Program and the Standardized Plant Analysis Risk Models," dated October 4, 2012 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML12220A608).

The ASP Program also provides the basis for the safety performance measure of zero *significant* 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.

Since the issuance of SECY-12-0056, “Fiscal Year 2011 Results of the Industry Trends Program for Operating Power Reactors,” on April 9, 2012, the RES staff completed the ASP analysis for FY 2011 and identified seven events as significant events (i.e., CCDP or ΔCDP greater than or equal to 1×10^{-5}). These seven events were related to natural phenomena occurring at Surry, Units 1 and 2; Browns Ferry, Units 1, 2 and 3; and North Anna, Units 1 and 2. None of these events were a *significant* precursor. Figure 3 of Enclosure 1 has been revised to incorporate these significant events.

The RES staff completed preliminary analyses and identified no *significant* precursors in FY 2012. However, the staff identified one event as a potential *significant* precursor, a reactor trip and loss of offsite power that occurred on January 13, 2012, at Wolf Creek because of a switchyard breaker failure. Based on preliminary analysis, RES staff does not anticipate that this event will constitute a *significant* precursor. The RES staff will complete its evaluation of FY 2012 precursors to obtain final results. The staff will update the FY 2012 precursor data and will report any changes to the ITP analysis in a memorandum to the Commission after receiving the final ASP results from RES.

<u>FY 2012 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. None of the indicators exceeded its prediction limit in FY 2012. Short-term FY 2012 data did not reveal any emerging trends that warranted additional analysis or significant adjustments to the nuclear reactor safety inspection or licensing programs.

In SECY-12-0056, the staff identified the potential for a high number of significant events for FY 2011. On February 4, 2013, the staff issued a memorandum to the Commission (ADAMS Accession No. ML12347A034) reporting that this indicator was exceeded. The staff noted that the significant events prediction limit was exceeded because of natural phenomena occurring at three multi-unit sites (Surry, Browns Ferry, and North Anna) and concluded that these events do not represent degradation in overall industry safety performance mainly because the reliability and avilability of safety systems, along with operator response, minimized the overall risk significance of each event. As indicated in the memorandum, the staff in the Operating Experience Branch of the Office of Nuclear Reactor Regulation performed an independent evaluation of significant reactor events for calendar year (CY) 2006 through CY 2012, using modified criteria, to examine the underlying causes of the events and recommend potential changes to agency programs. The modified criteria used to determine a significant event for this study were: an Augmented Inspection Team was chartered, a Yellow or Red inspection finding was issued under the ROP, or a CCDP of 1×10^{-5} or higher was calculated by the ASP program. The study revealed that the number of events meeting at least one of these criteria has increased since 2009. In addition, the number of these events involving an initiator and subsequent complications has increased since 2010. The staff found that nonsafety-related system failures and corrective action program weaknesses contributed to most of those significant events involving an initiator and complications. The staff's insights are being considered as part of the ongoing ROP enhancement effort discussed in the "Reactor Oversight Process Self-Assessment for Calendar Year 2012," SECY paper.

FY 2012 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 initiate a challenge to a plant's safety systems, (2) assigns a value to each initiating event (IE) 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 IEs that have an effect on plant safety occur in nuclear power plants (NPP) during the year. Nine IE categories are monitored for boiling-water reactors (BWRs) and 10 for pressurized-water reactors (PWRs). The number of times that each event occurs is compared to a predetermined number of occurrences for that event. The predetermined number of occurrences is calculated from a predictive distribution derived using information from an established baseline period, and it is reevaluated on a annual basis. 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 1×10^{-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 includes Tier 1 and Tier 2 BRIIE results. None of the IEs tracked in Tier 1 exceeded its prediction limit in FY 2012. On Tier 2, Figure 15 of Enclosure 3 shows that the combined industry BRIIE value for FY 2012 (-9.17×10^{-7} per reactor critical year) indicates better than baseline industry performance. The combined industry BRIIE value is below the established reporting threshold of $\Delta CDF = 1.0\times10^{-5}$ per reactor critical year.

In addition to the BRIIE value for FY 2012, the staff also updated the BRIIE value for FY 2011 to account for a loss of vital direct current bus event that occurred at Palisades on September 25,

2011. The corrected BRIIE value for FY 2011 is 1.56×10^{-6}, which remains below the threshold of $\Delta CDF = 1.0 \times 10^{-5}$ per reactor critical year.

CONCLUSION:

As discussed in this paper, for FY 2012, the staff identified no statistically significant adverse trends in industry safety performance. Specifically, no ITP indicator exceeded its prediction limit, and the BRIIE value remained below the threshold for a report to Congress.

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 2012 Long-Term Industry Trend Results
2. Fiscal Year 2012 Short-Term Industry Performance
3. Summary of Baseline Risk Index for Initiating Events: Annual Graphs through Fiscal Year 2012

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ADAMS Accession Number: ML13091A103 *concurred via email

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FISCAL YEAR 2012 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 2003–2012), as indicated by the figures below.

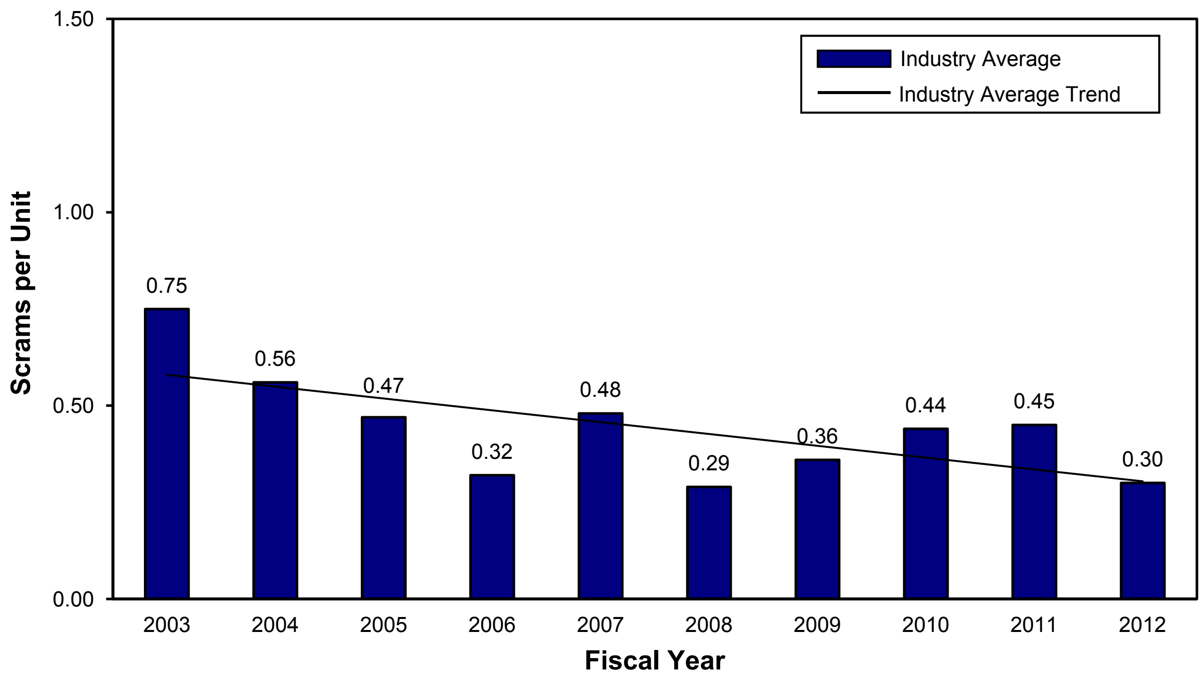


Figure 1. Automatic scrams while critical

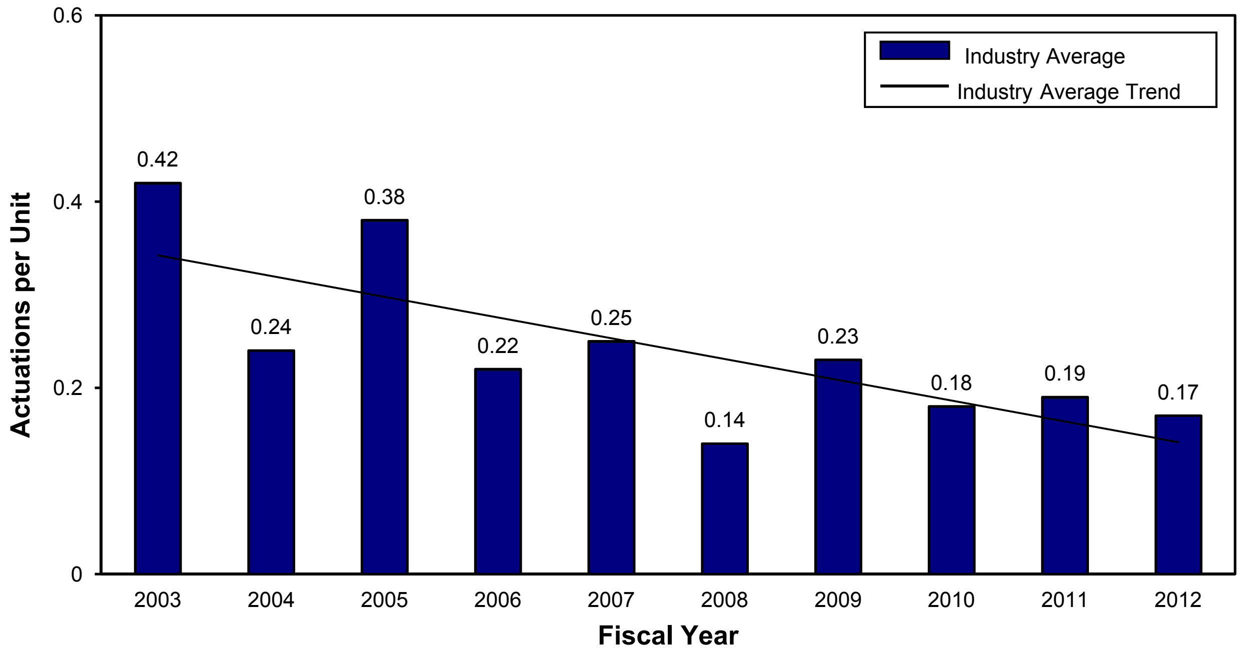


Figure 2. Safety system actuations

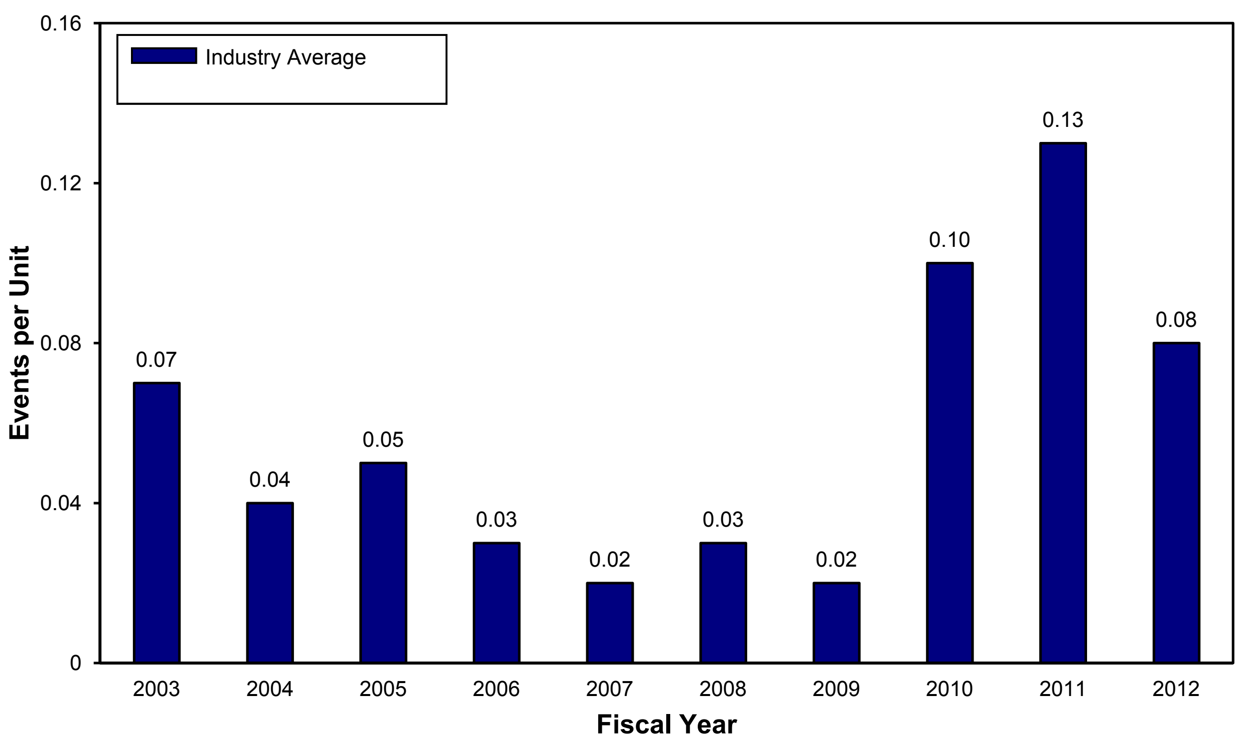


Figure 3. Significant events

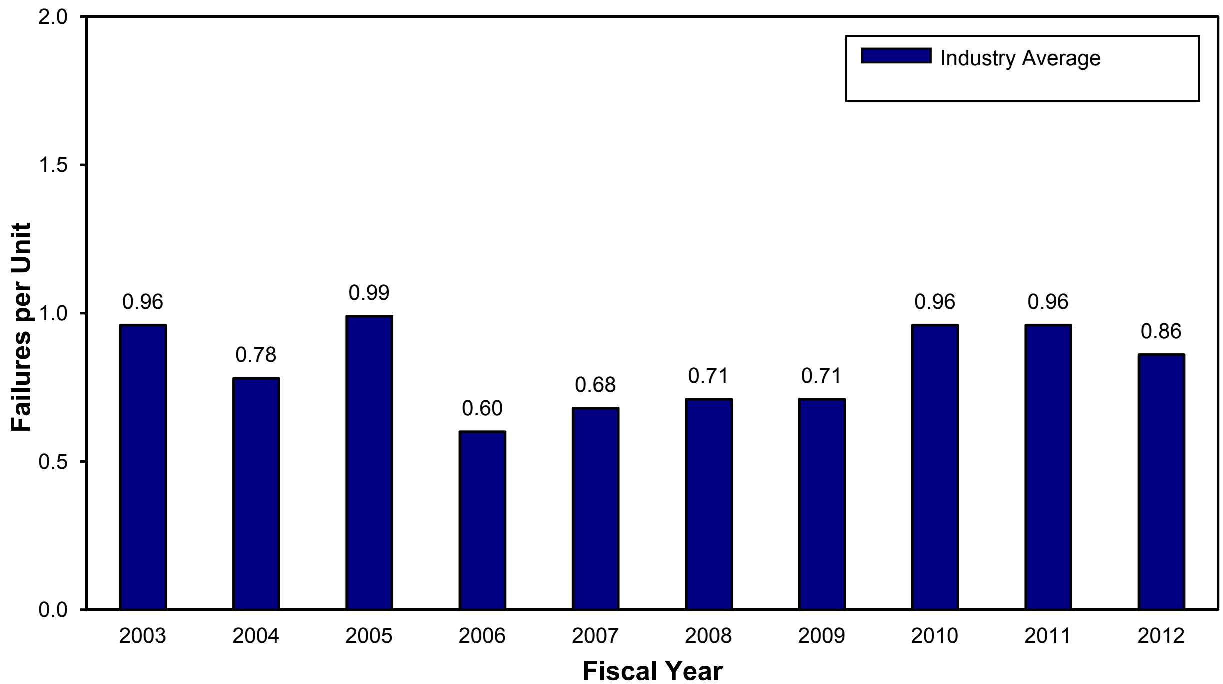


Figure 4. Safety system failures

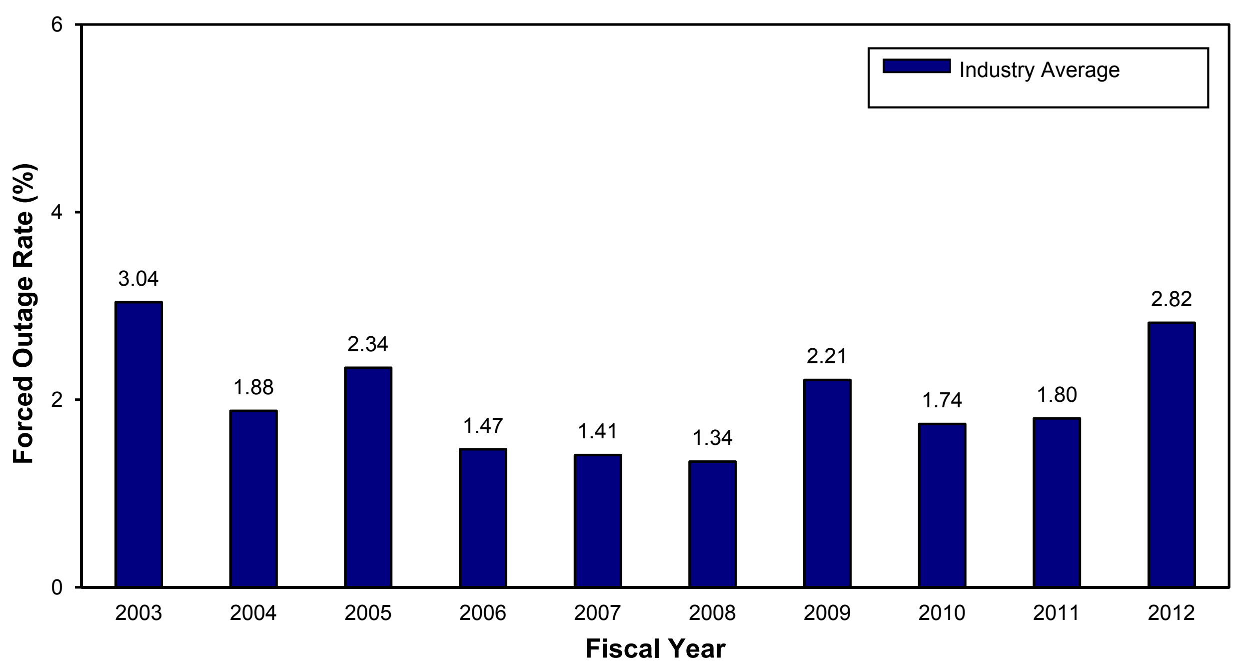


Figure 5. Forced outage rate

As discussed in this paper, Figures 3-5 do not display a trendline because these graphs do not have a statistically significant trend.

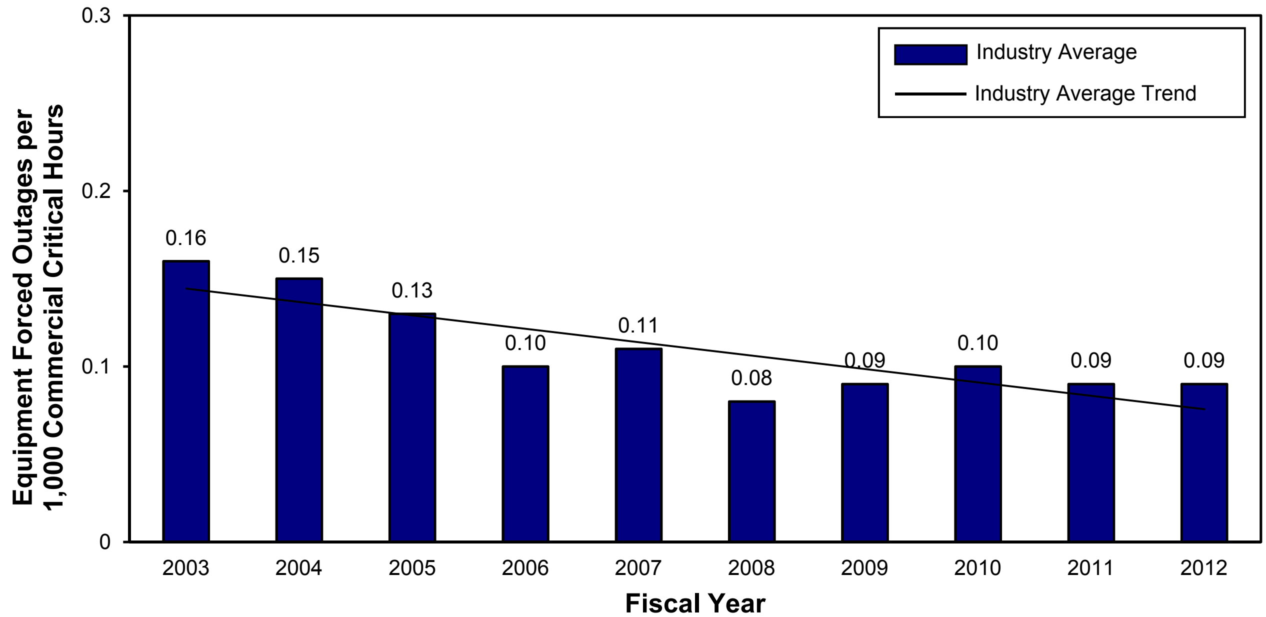


Figure 6. Equipment forced outages

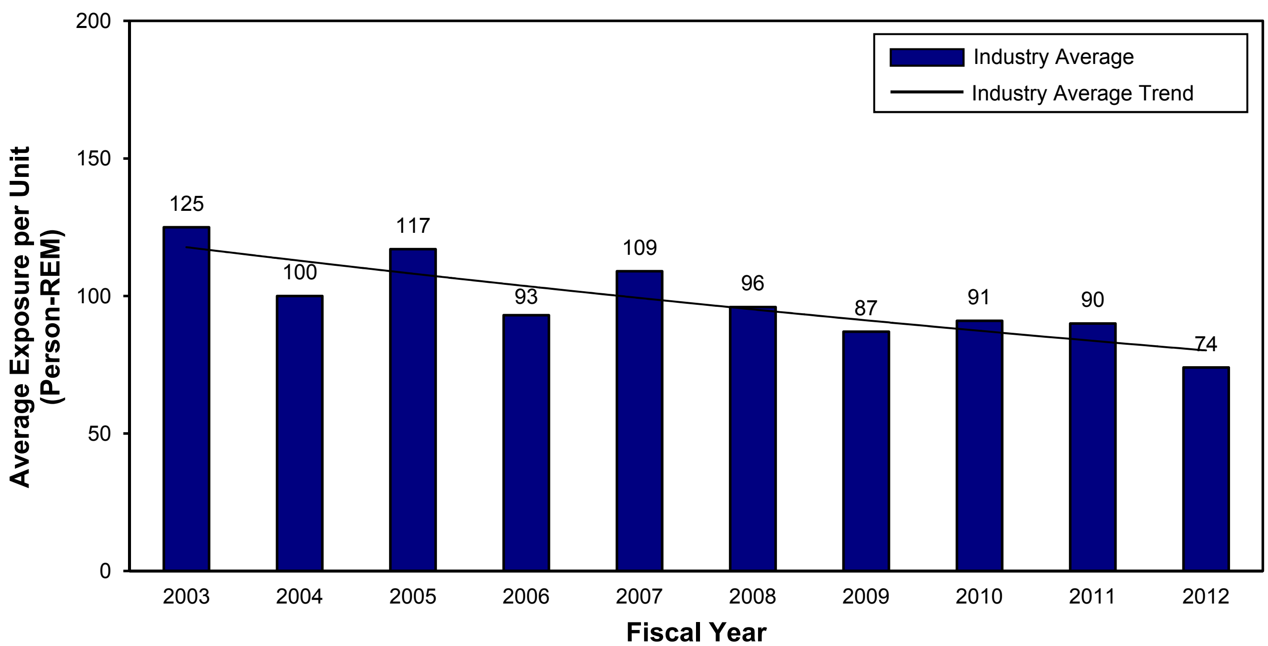


Figure 7. Collective radiation exposure

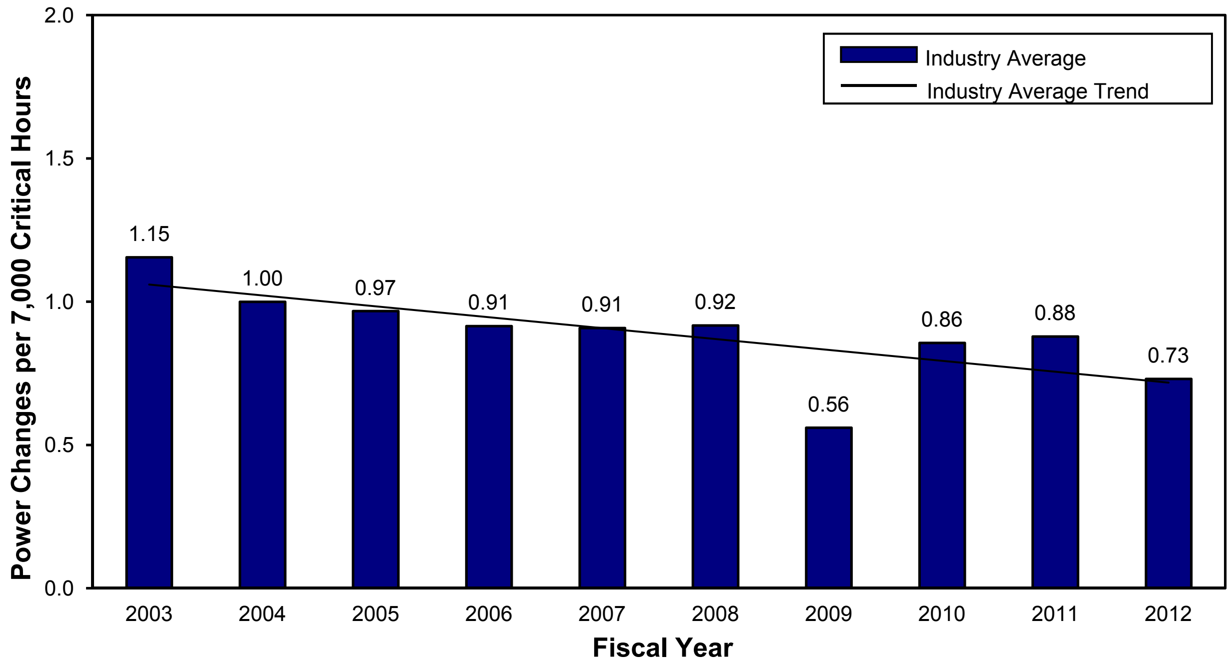


Figure 8. Unplanned power changes

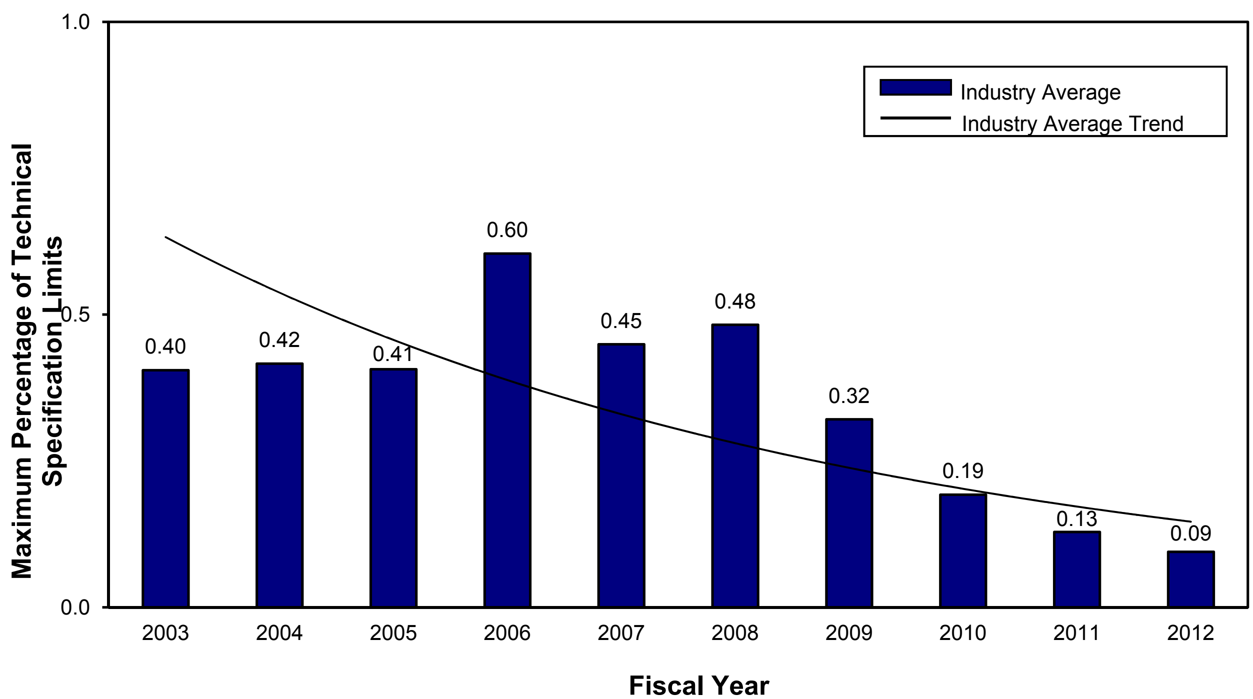


Figure 9. Reactor coolant system activity

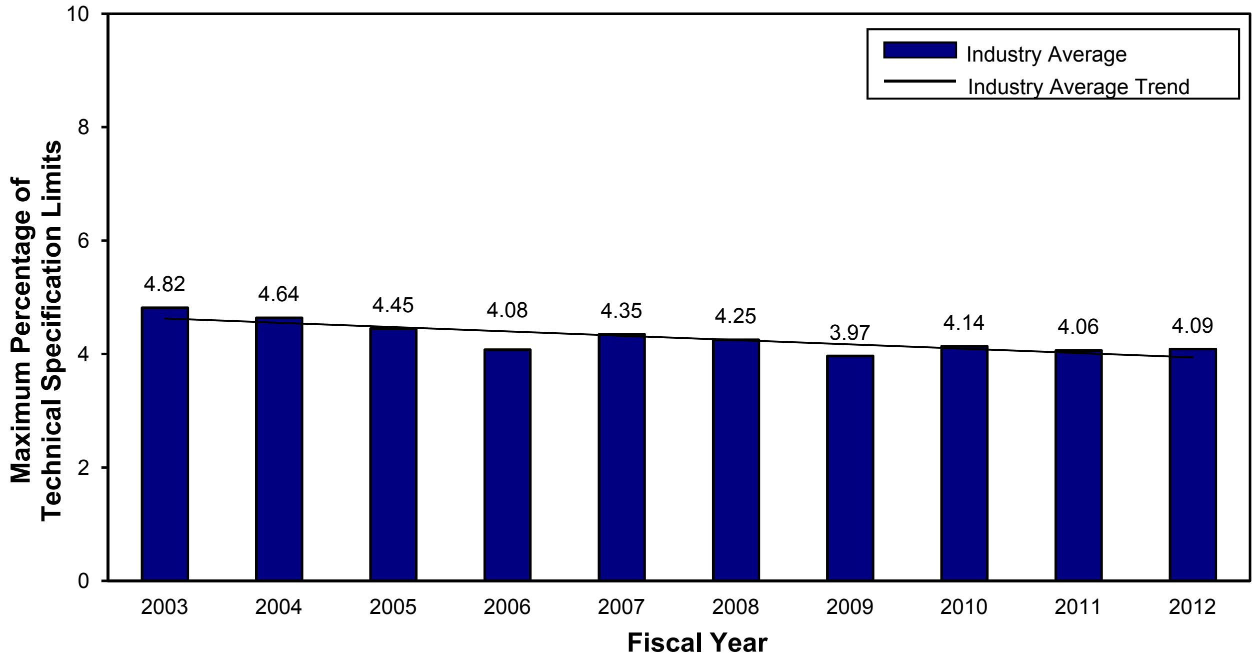


Figure 10. Reactor coolant system leakage

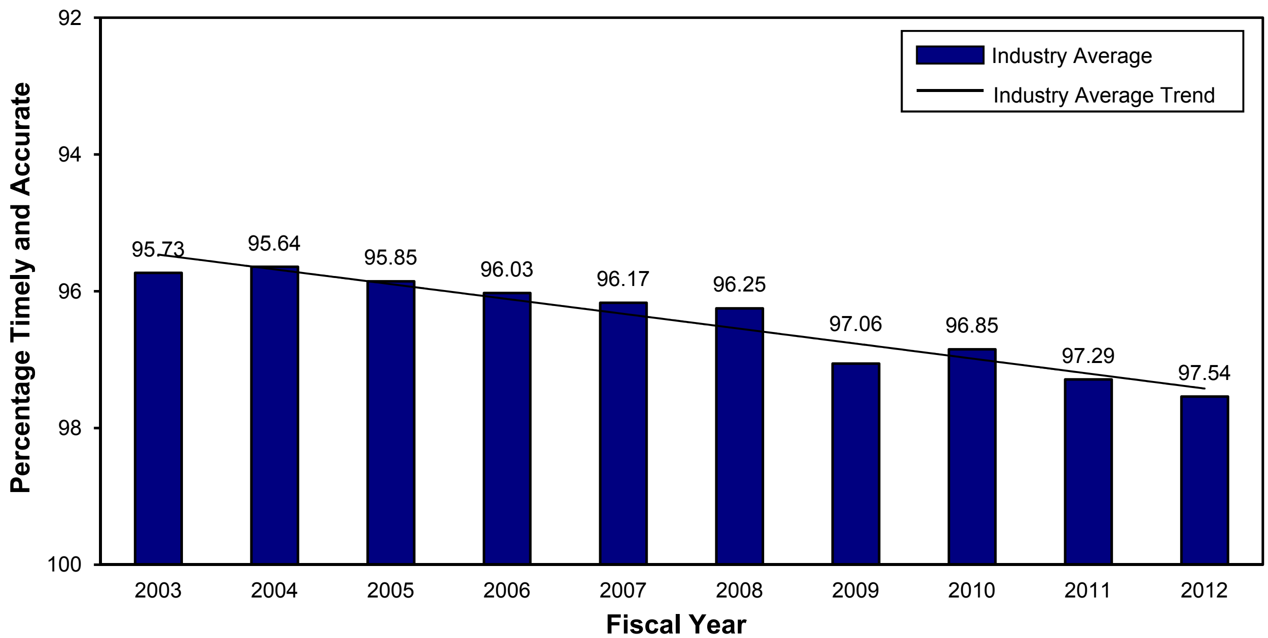


Figure 11. Drill and exercise performance

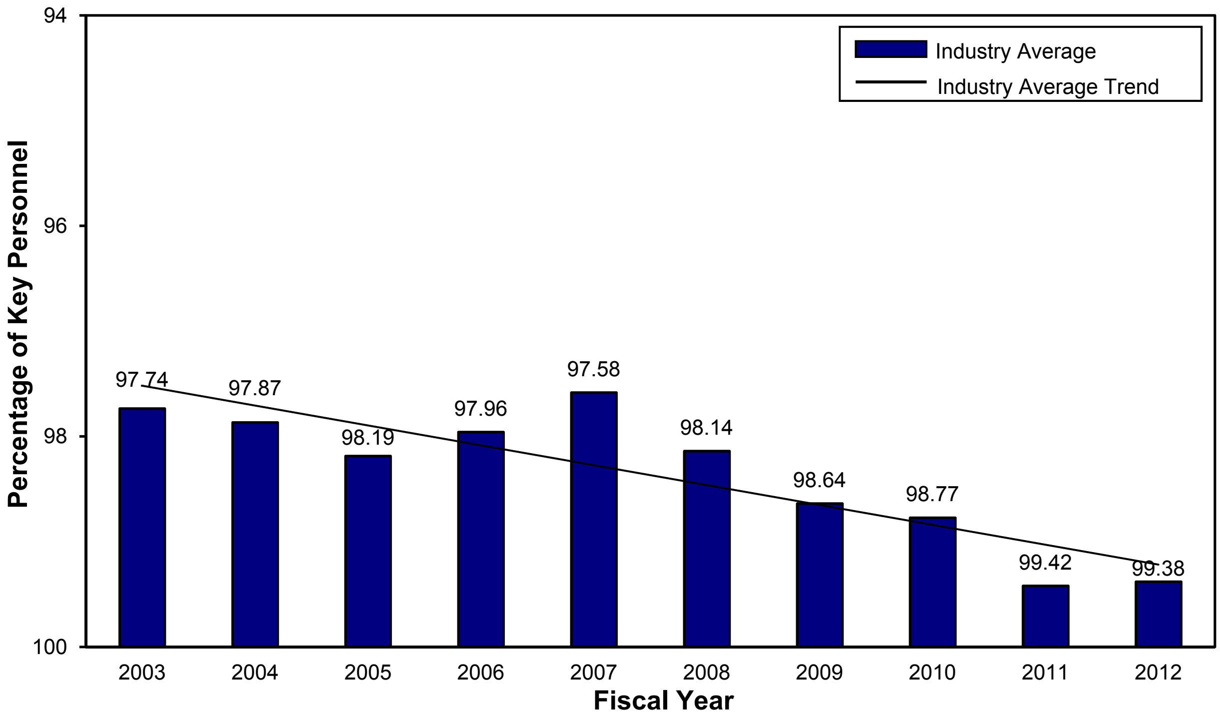


Figure 12. Emergency response organization drill participation

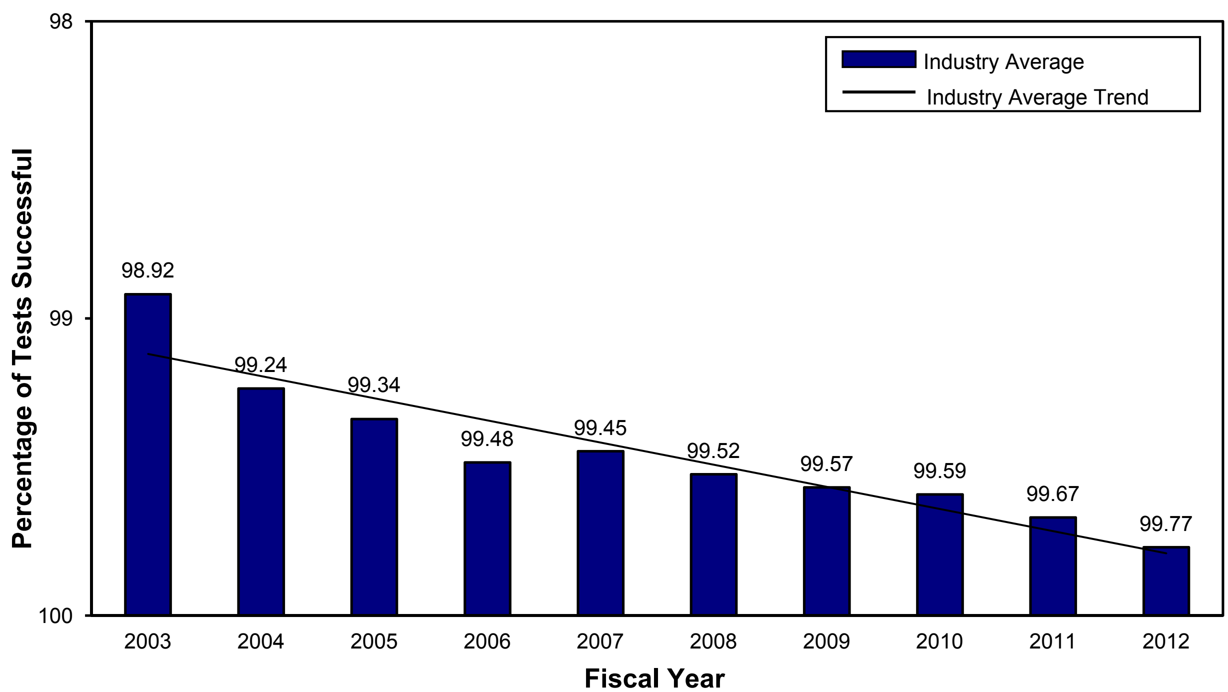


Figure 13. Alert and notification system reliability

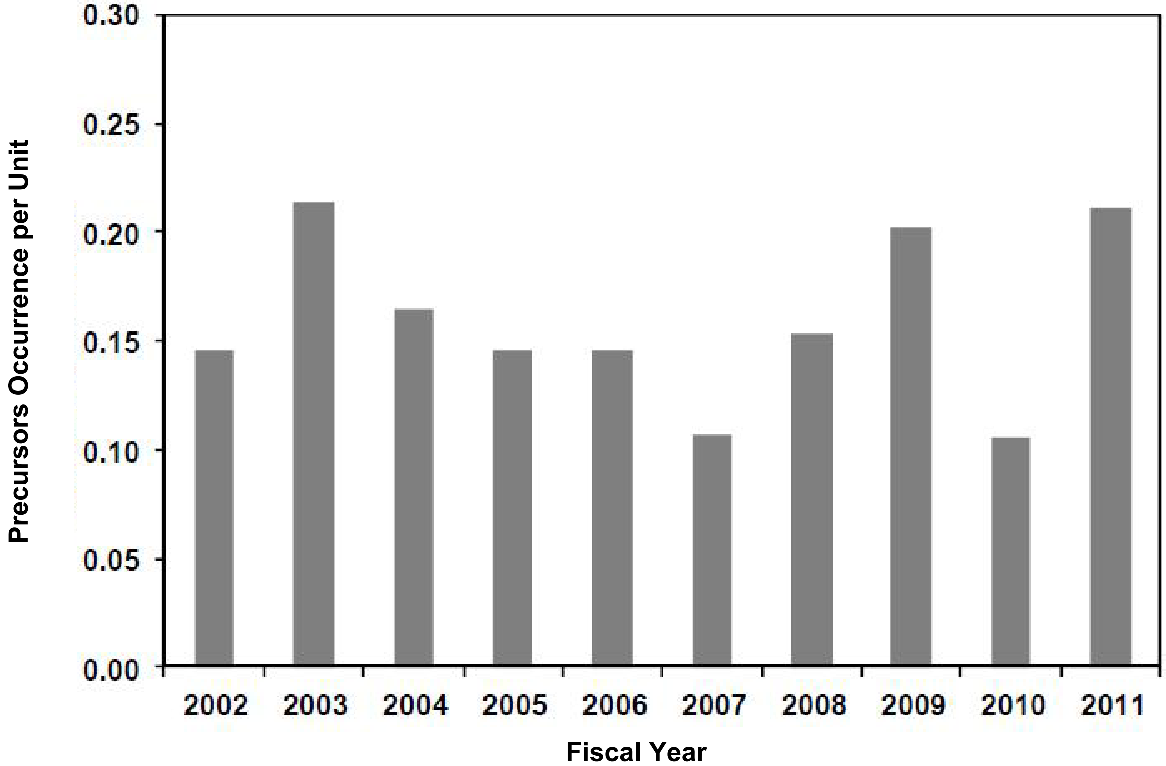


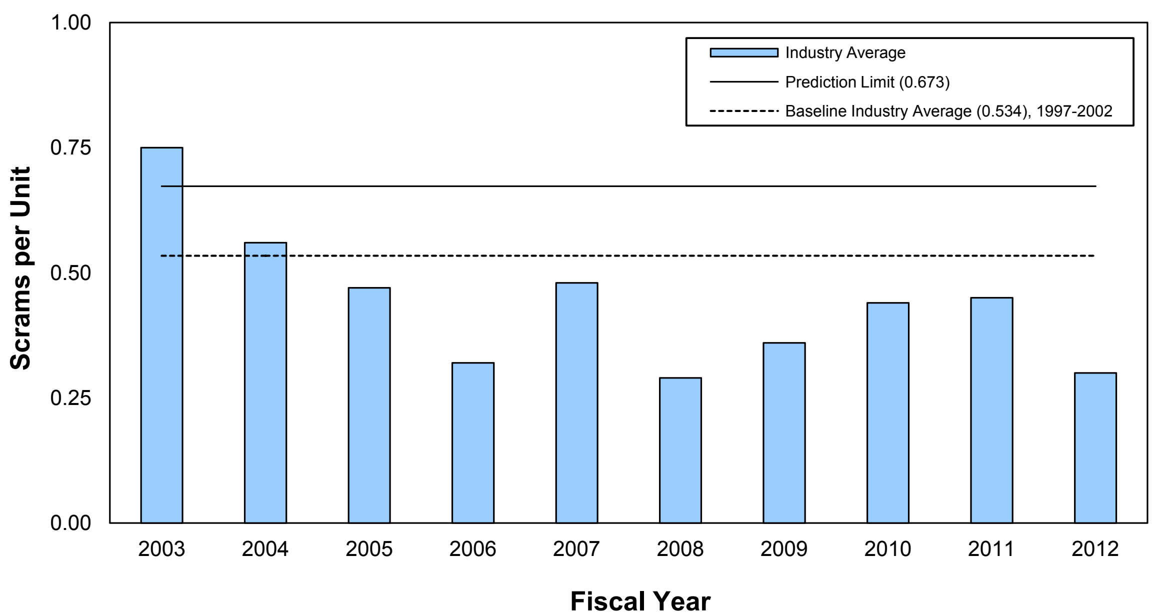
Figure 14. Accident sequence precursors

FISCAL YEAR 2012 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.

The results of the evaluation of the fiscal year (FY) 2012 Industry Trends Program PIs, using the established prediction limits, indicate that no PI exceeded its associated prediction limit in FY 2012, as shown in the following figures for each PI with its FY 2012 data and associated prediction limit.

In SECY-12-0056, “Fiscal Year 2011 Results of the Industry Trends Program for Operating Power Reactors,” the staff identified the potential for a high number of significant events for FY 2011. After completing the accident sequence precursor (ASP) evaluation for seven FY 2011 events and including this data, the significant events indicator exceeded its prediction limit. On February 4, 2013, the staff issued a memorandum to the Commission (Agencywide Documents Access and Management System Accession No. ML12347A034) reporting that this indicator was exceeded. The staff noted that the significant events prediction limit was exceeded because of natural phenomena occurring at three multi-unit sites (Surry, Browns Ferry, and North Anna) and concluded that these events do not represent degradation in overall industry safety performance.



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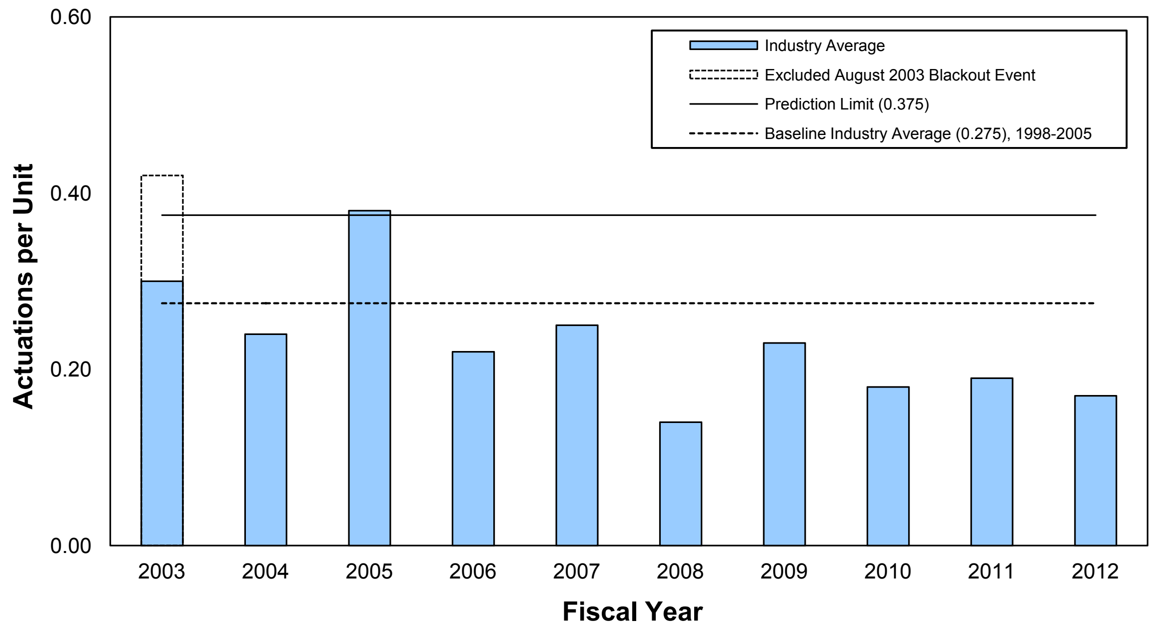


Figure 2. Safety system actuations

Note that the 2003 blackout event was not included in the short-term data for determining prediction limits in Figure 2. It was excluded from the development of the prediction limit models because they are considered outlier events that overly influenced the statistical analysis of the industrywide data. This treatment results in a more conservative prediction limit.

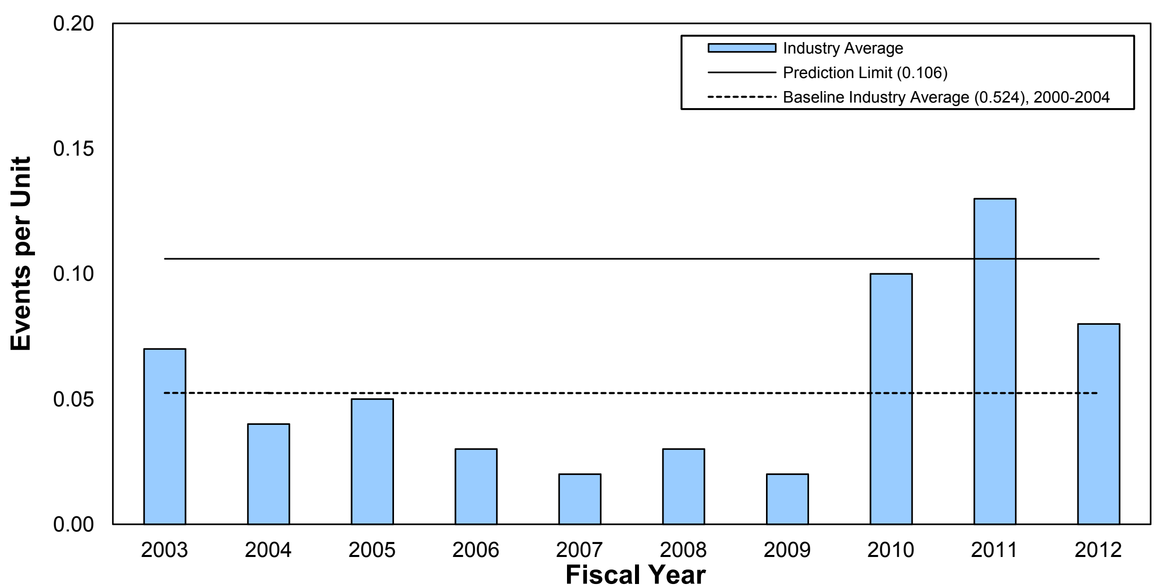


Figure 3. Significant events

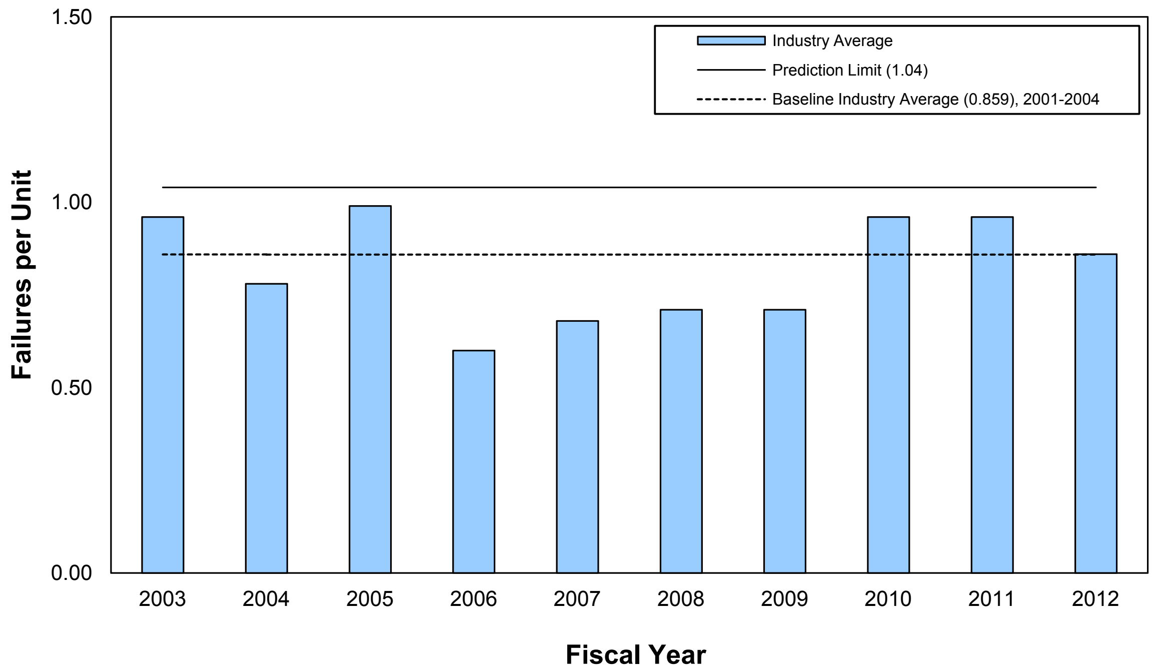


Figure 4. Safety system failures

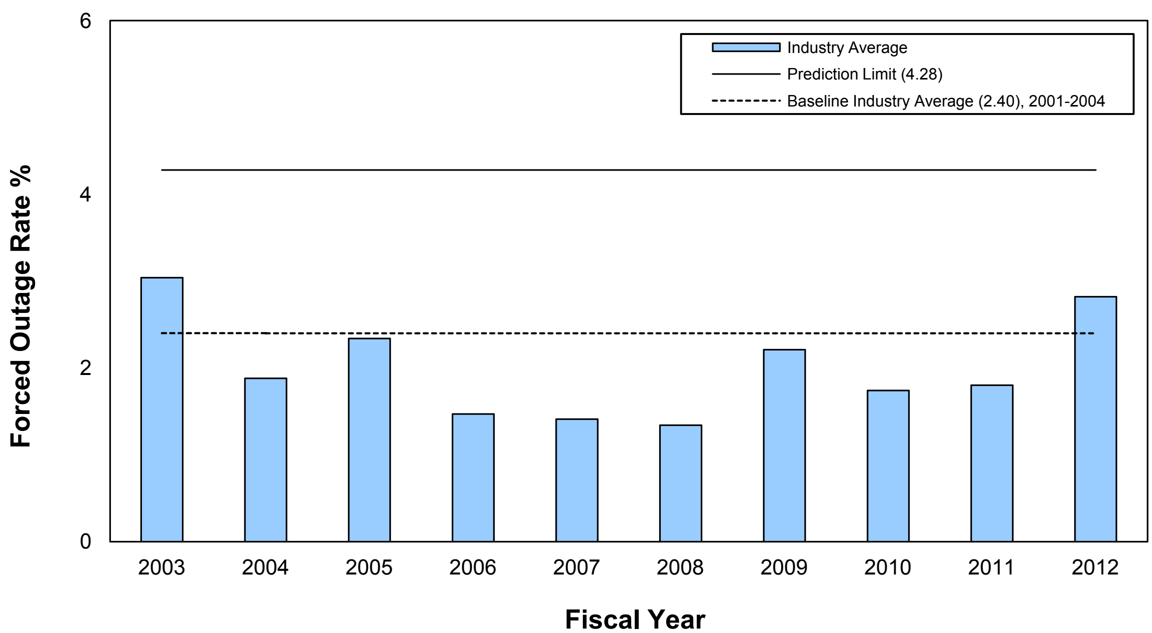


Figure 5. Forced outage rate

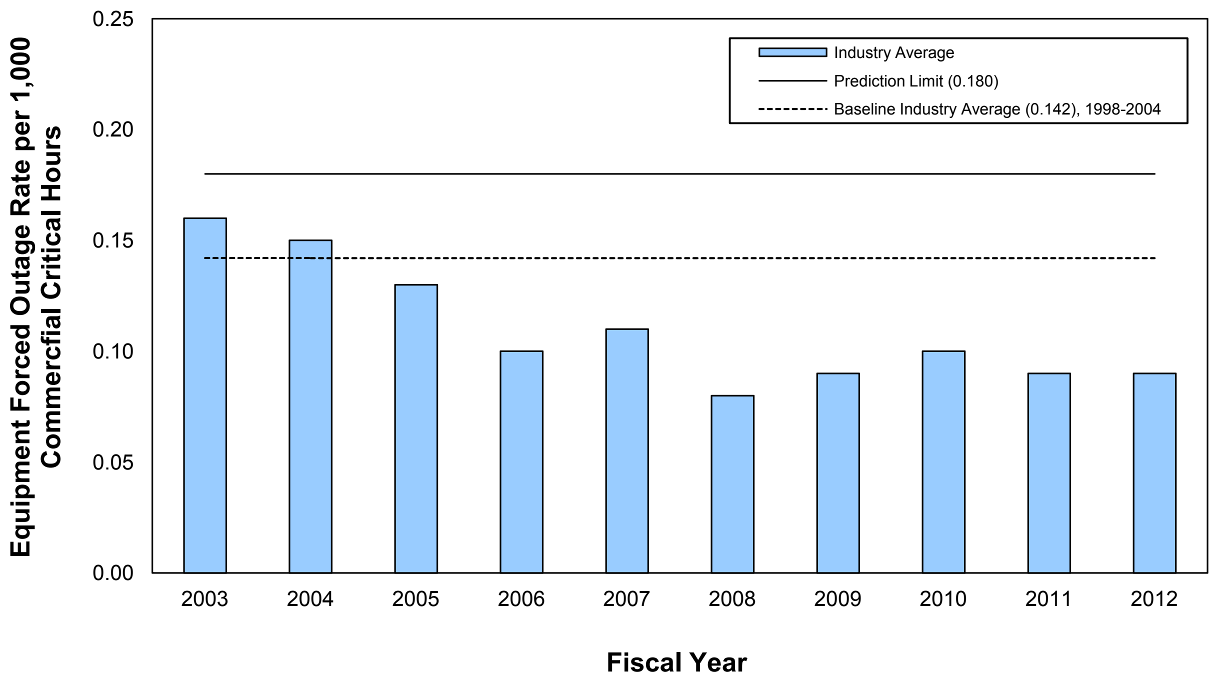


Figure 6. Equipment forced outages

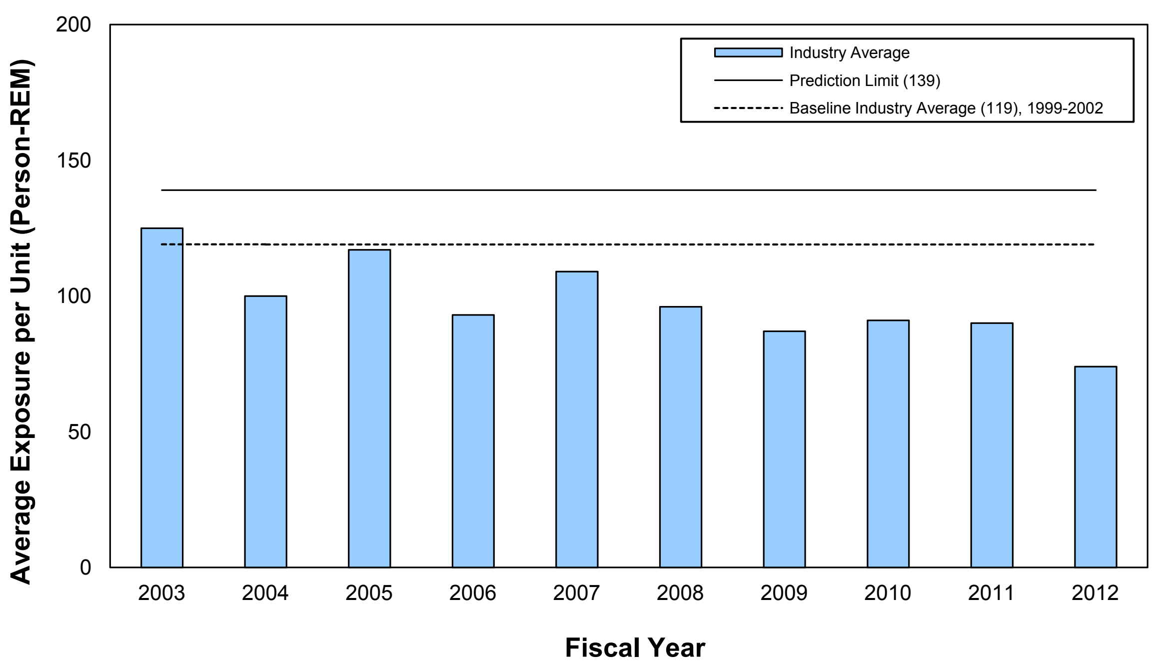


Figure 7. Collective radiation exposure

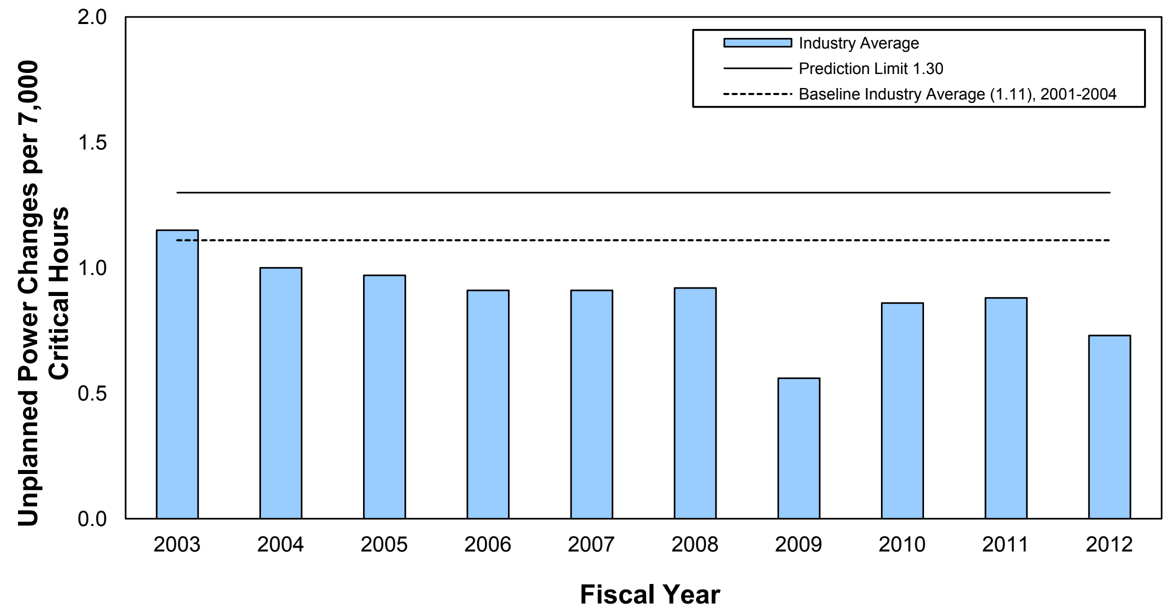


Figure 8. Unplanned power changes per 7,000 critical hours

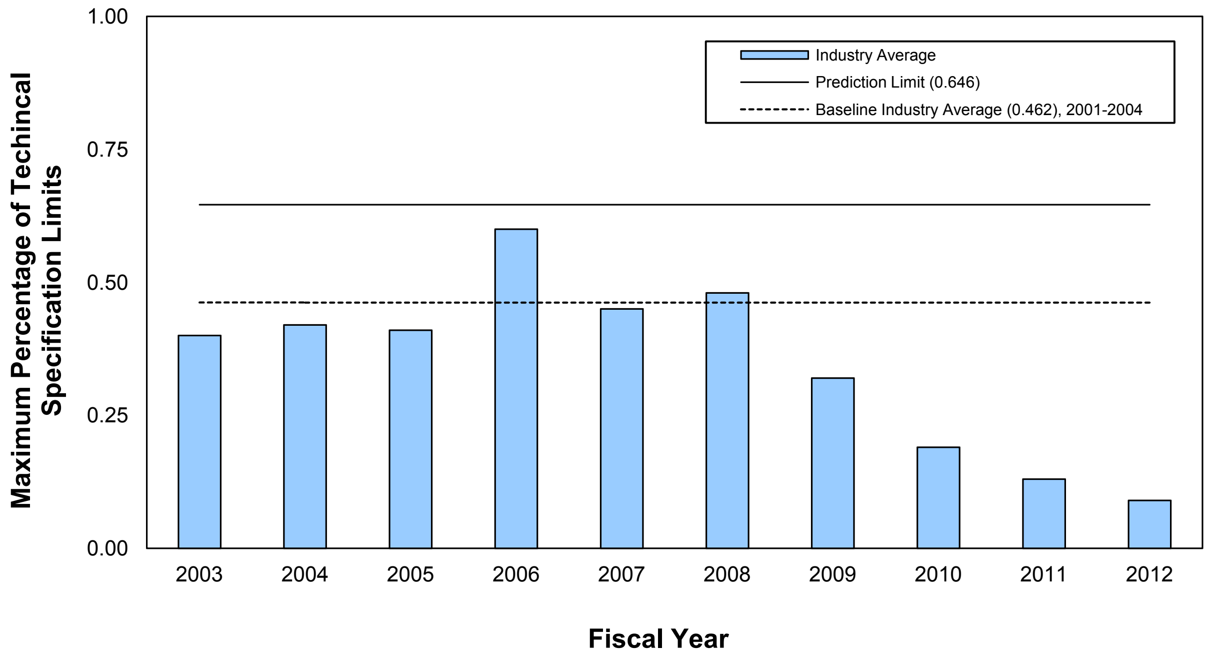


Figure 9. Reactor coolant system activity

Note that Figures 8 and 9 are different from the figures included in SECY-12-0056. The graphs were not portrayed correctly in SECY-12-0056 and are corrected in this paper; however, revision of these graphs does not change the conclusions presented in SECY-12-0056.

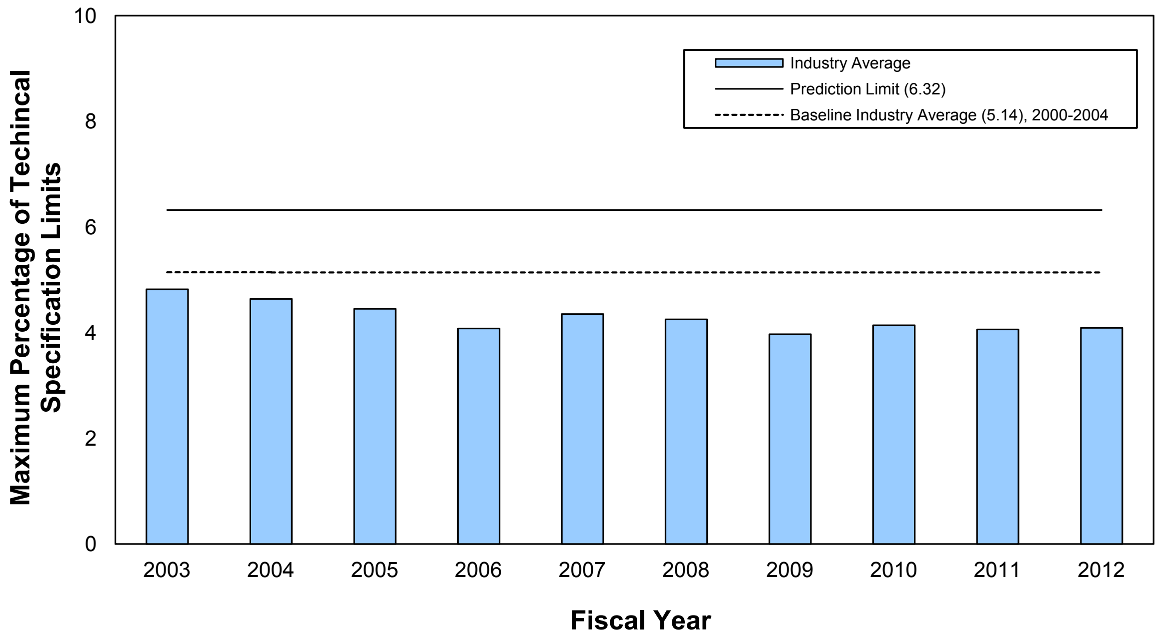


Figure 10. Reactor coolant system leakage

Note that the 2000 steam generator tube rupture event at Indian Point Nuclear Generating Unit 2 was not included in the short-term data for determining prediction limits in Figure 10. It was excluded from the development of the prediction limit models because they are considered outlier events that overly influenced the statistical analysis of the industrywide data. This treatment results in a more conservative prediction limit.

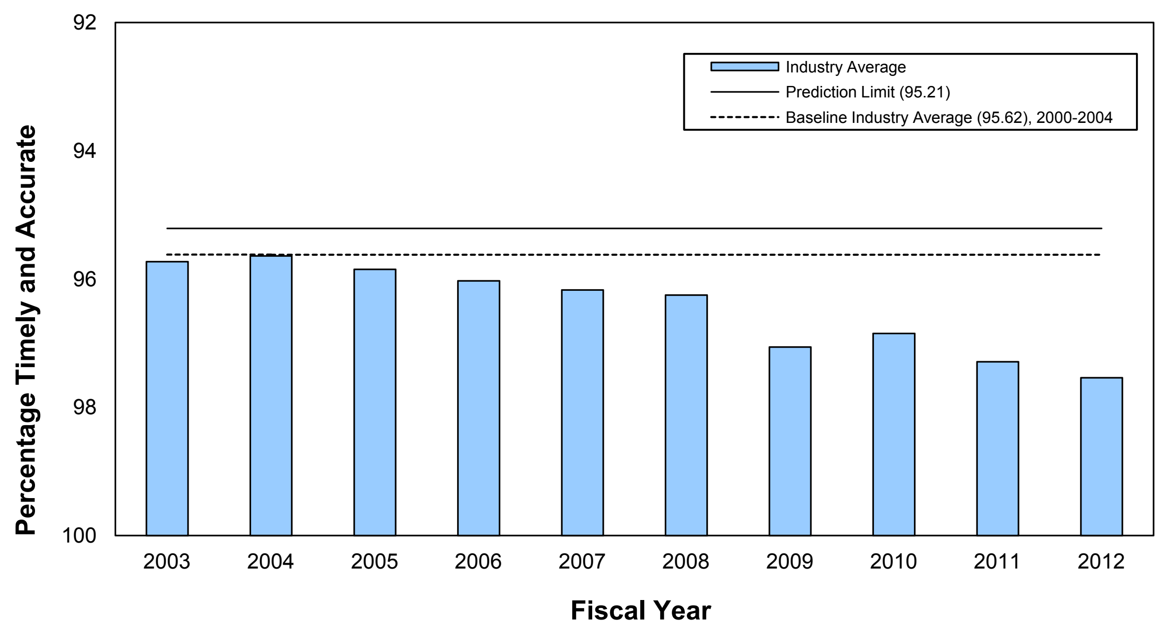


Figure 11. Drill and exercise performance

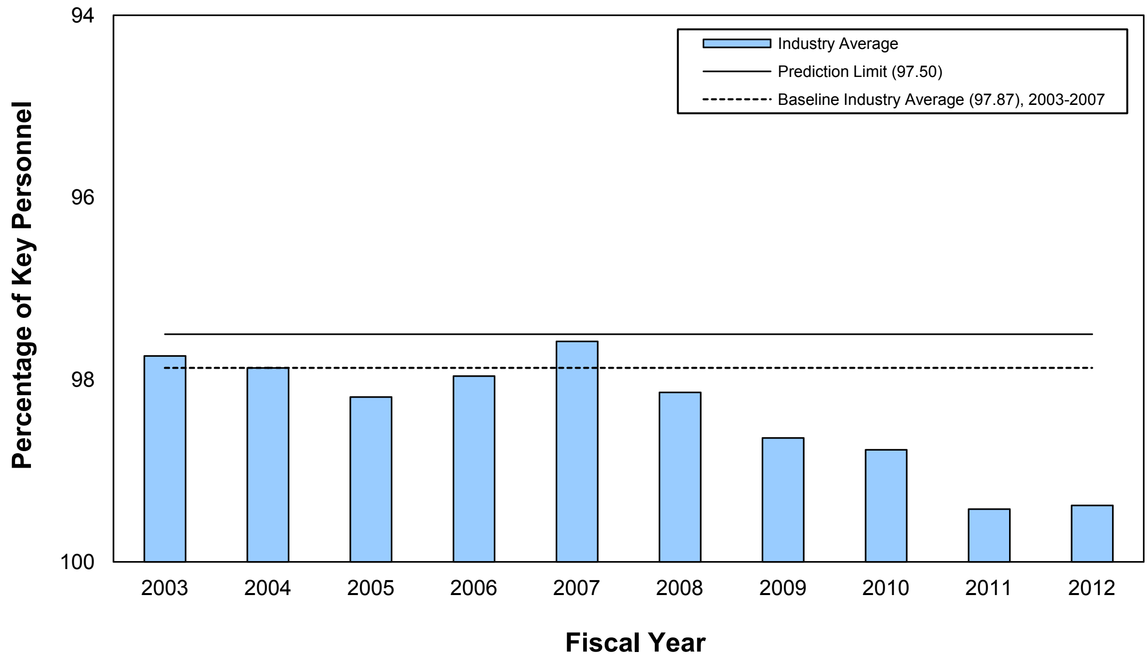


Figure 12. Emergency response organization drill participation

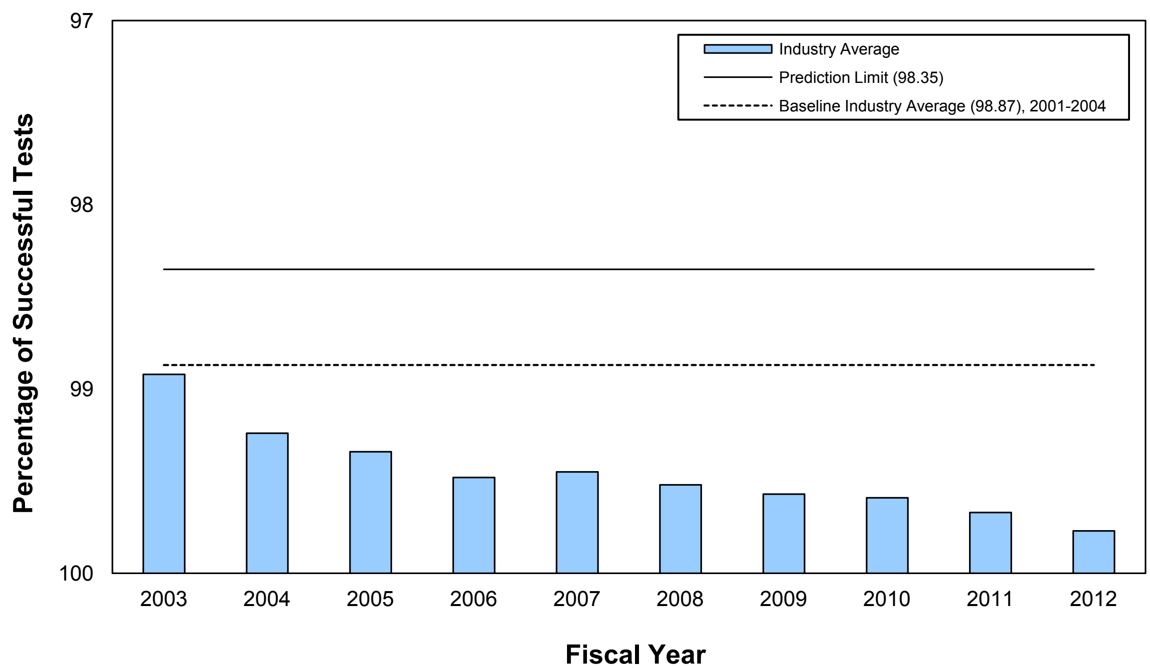


Figure 13. Alert and notification system reliability

SUMMARY OF BASELINE RISK INDEX FOR INITIATING EVENTS: ANNUAL GRAPHS THROUGH FISCAL YEAR 2012

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 Process (ROP) 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 or 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 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.

None of the fiscal year (FY) 2012 occurrence rates exceeded their 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 2012 (-9.17×10^{-7} per reactor critical year) indicates better than baseline industry performance. The combined industry BRIIE value is below the established reporting threshold of $\Delta CDF = 1.0\times10^{-5}$ per reactor critical year.

In addition to the BRIIE value for FY 2012, the staff also updated the BRIIE value for FY 2011. Figure 8 was corrected to account for a loss of vital direct current bus event that occurred at Palisades on September 25, 2011. The staff did not include this event in the BRIIE analysis for SECY-12-0056, "Fiscal Year 2011 Results of the Industry Trends Program for Operating Power Reactors," because the licensee event report (LER) was submitted during FY 2012 (Agencywide Documents Access and Management System Accession No. ML113260522). The staff identified this event as applicable to FY 2011 during its analysis of FY 2012 BRIIE data. The corrected BRIIE value for FY 2011 is 1.56×10^{-6}, as reflected in Figure 15, which remains below the threshold of $\Delta CDF = 1.0\times10^{-5}$ per reactor critical year.

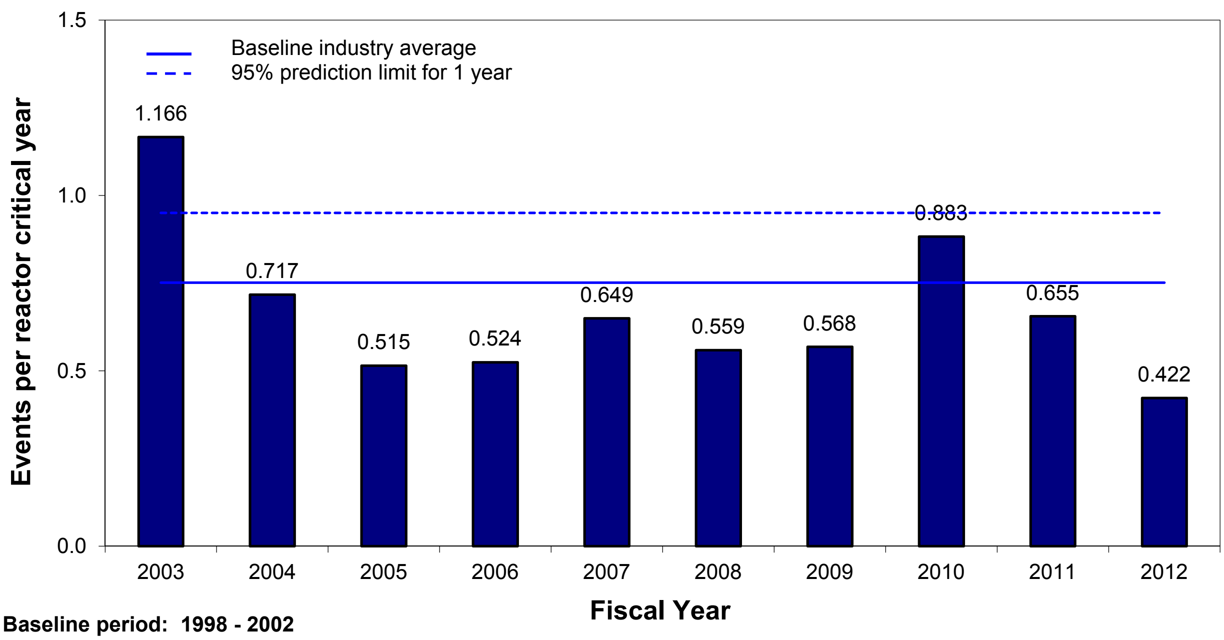
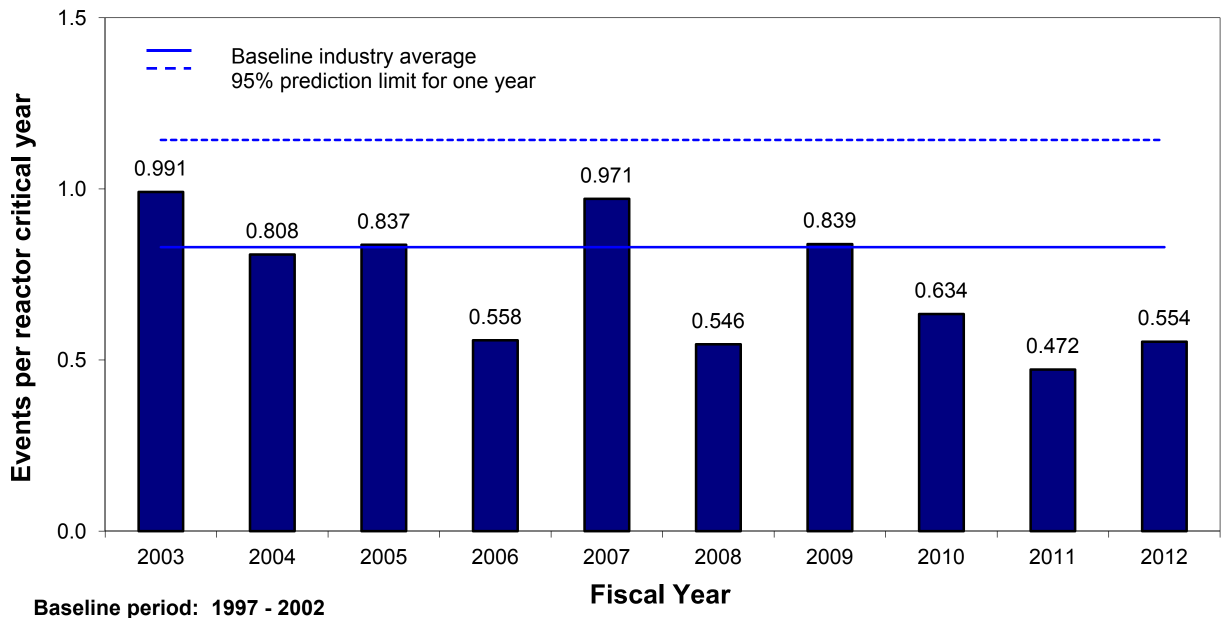
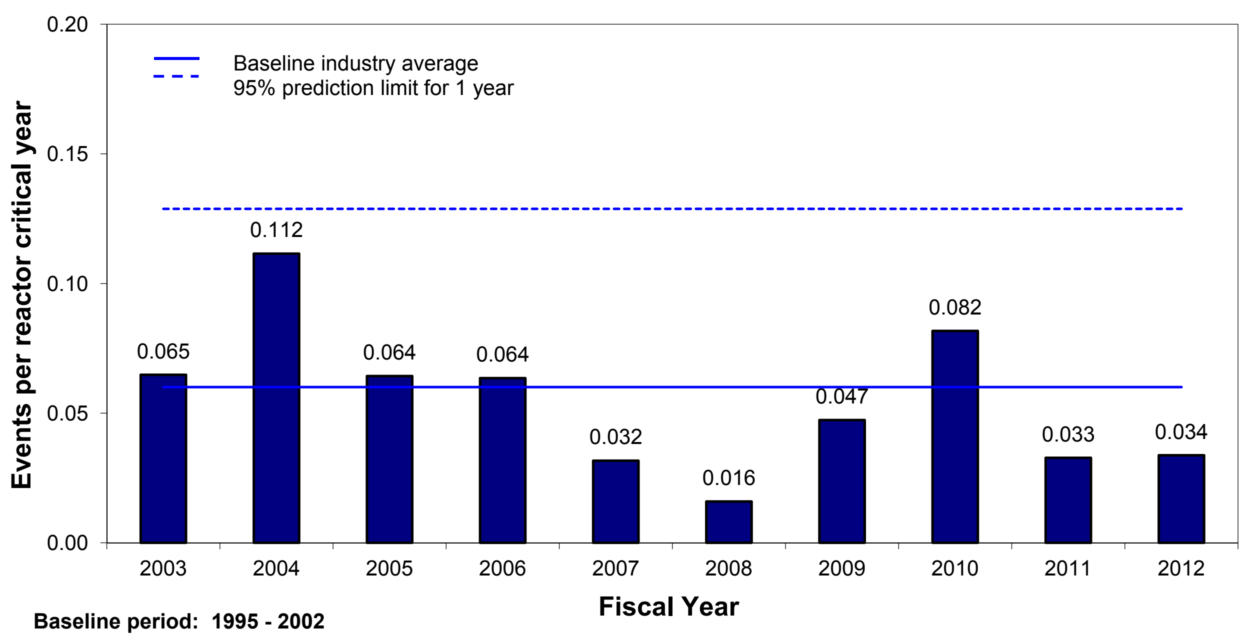


Figure 1. Pressurized-water reactor (PWR) general transients



Baseline period: 1997 - 2002

Figure 2. Boiling-water reactor (BWR) general transients



Baseline period: 1995 - 2002

Figure 3. PWR loss of condenser heat sink

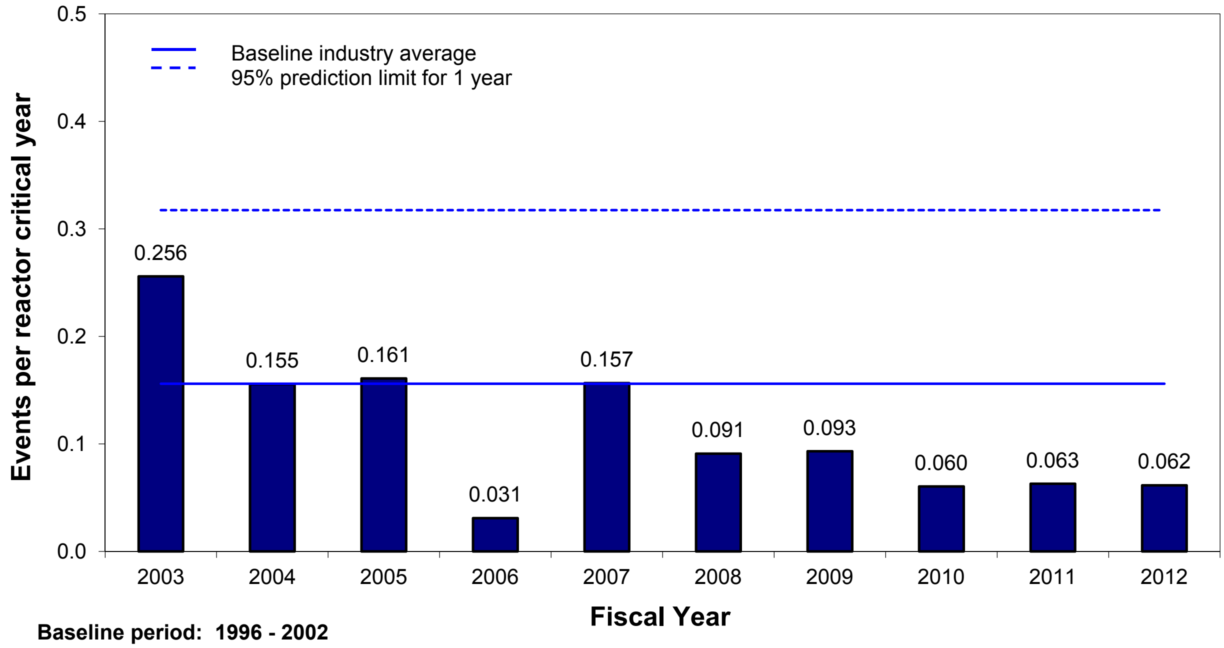


Figure 4. BWR loss of condenser heat sink

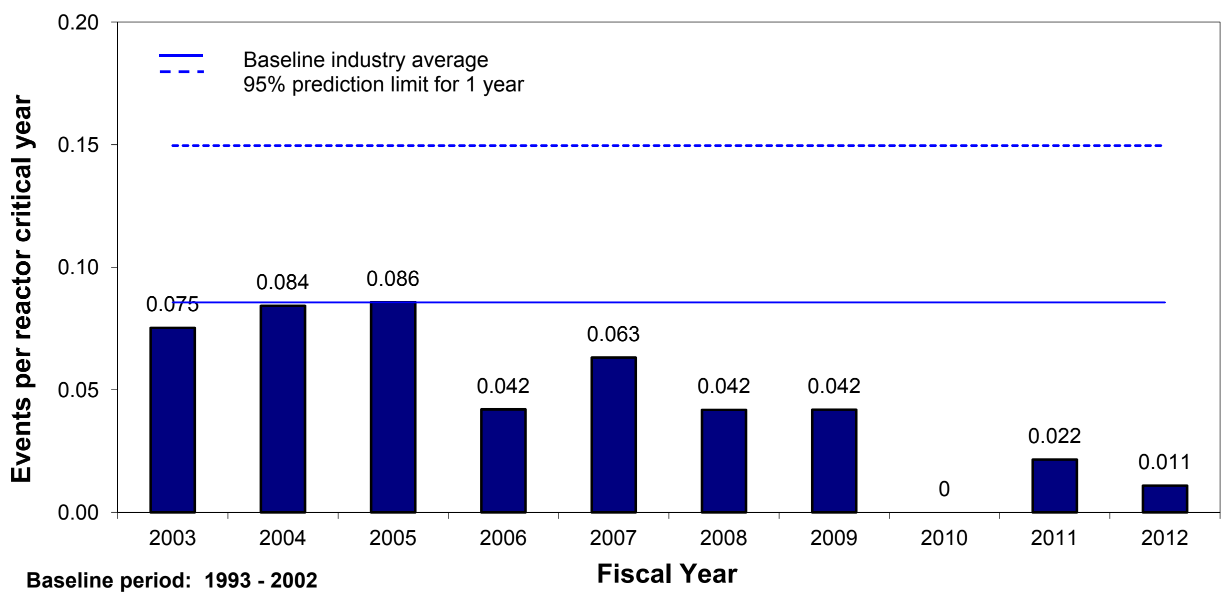


Figure 5. Loss of main feedwater

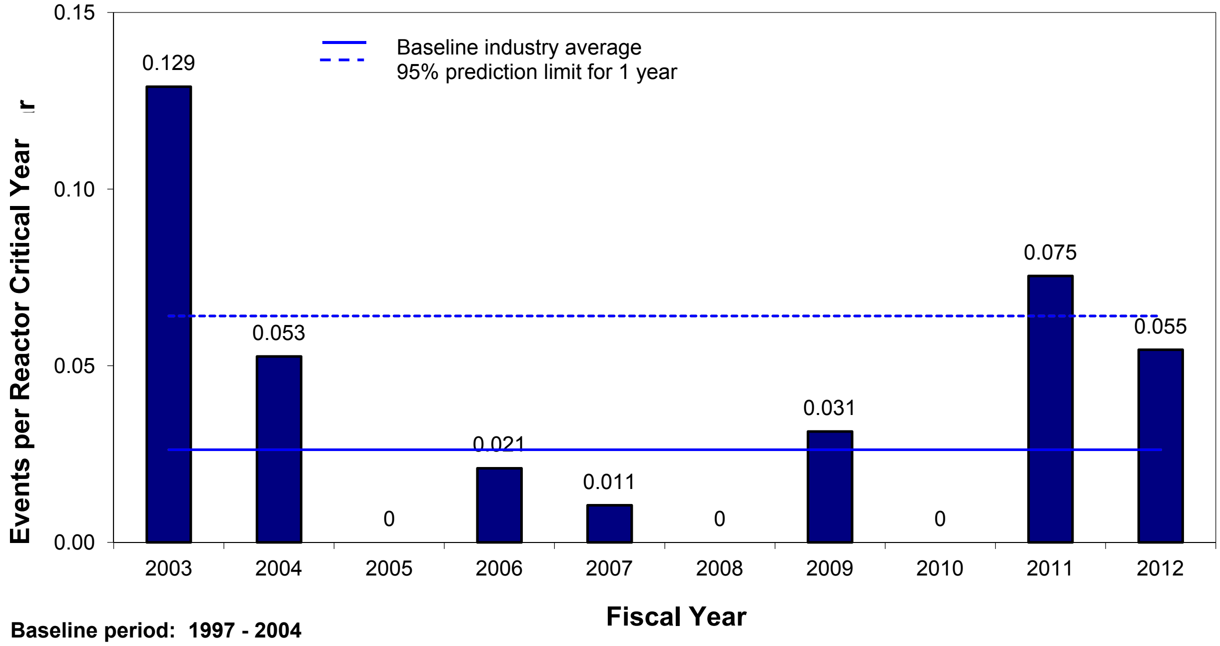


Figure 6. Loss of offsite power

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.

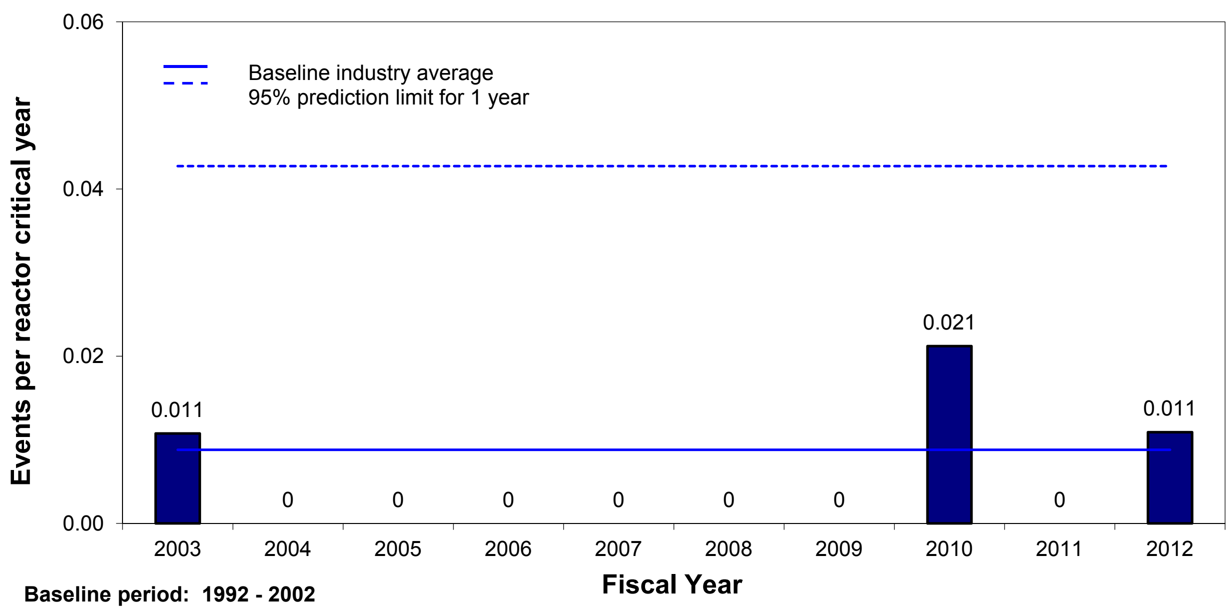


Figure 7. Loss of vital alternating current bus

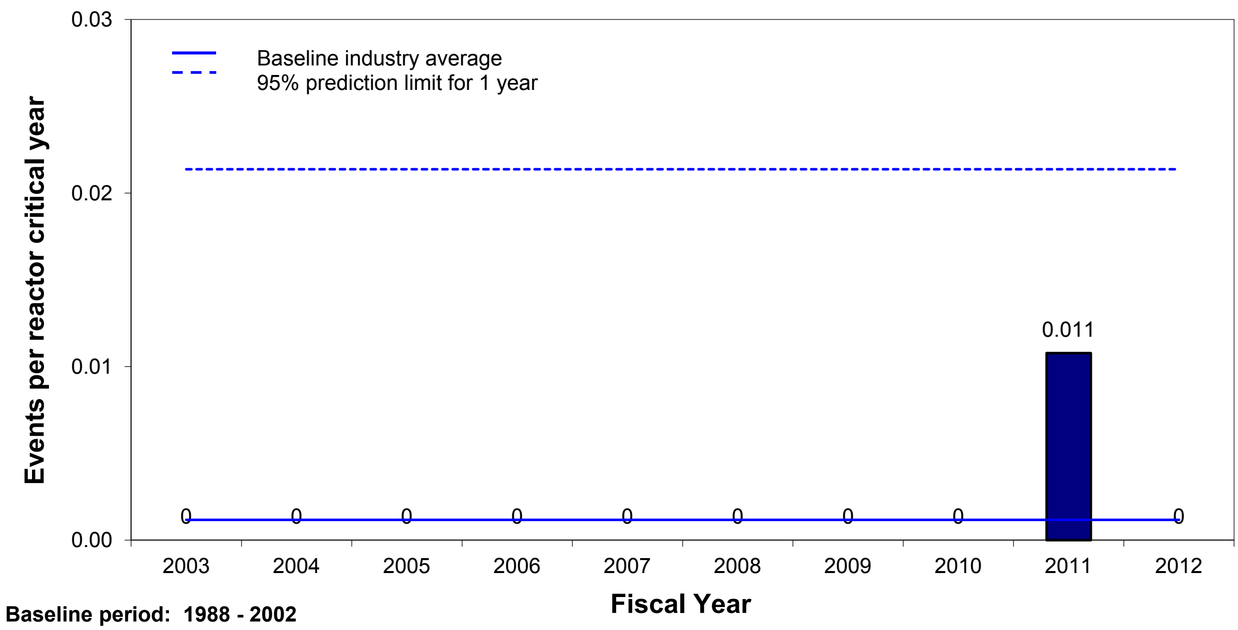


Figure 8. Loss of vital direct current bus

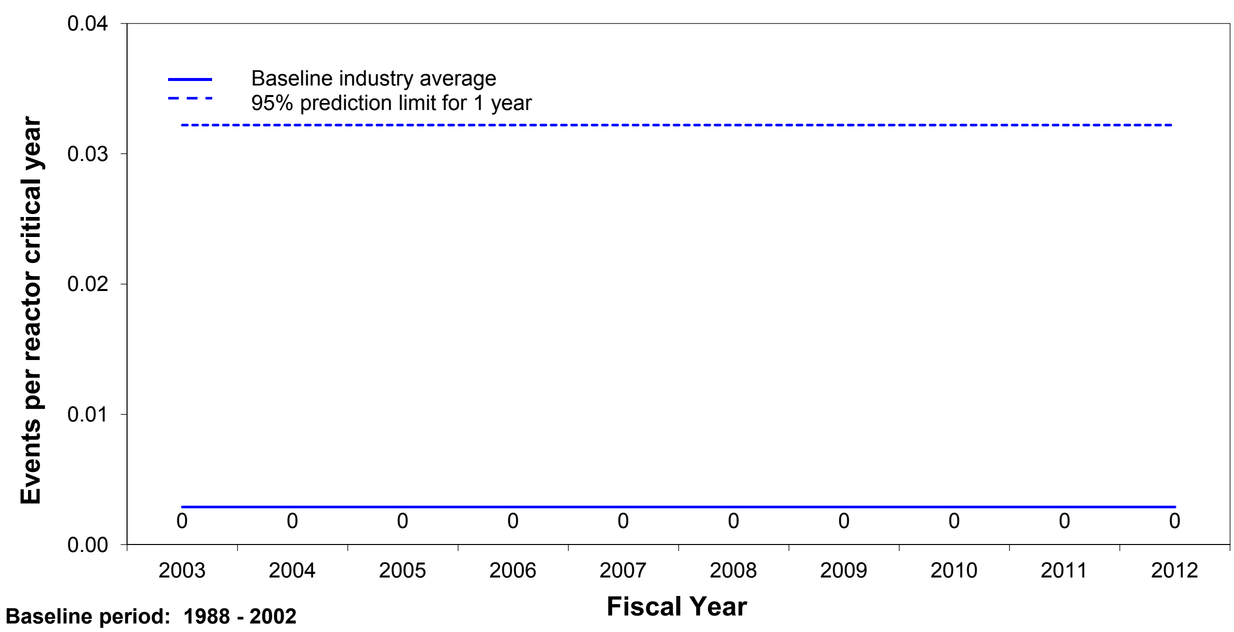


Figure 9. PWR stuck-open safety or relief valve

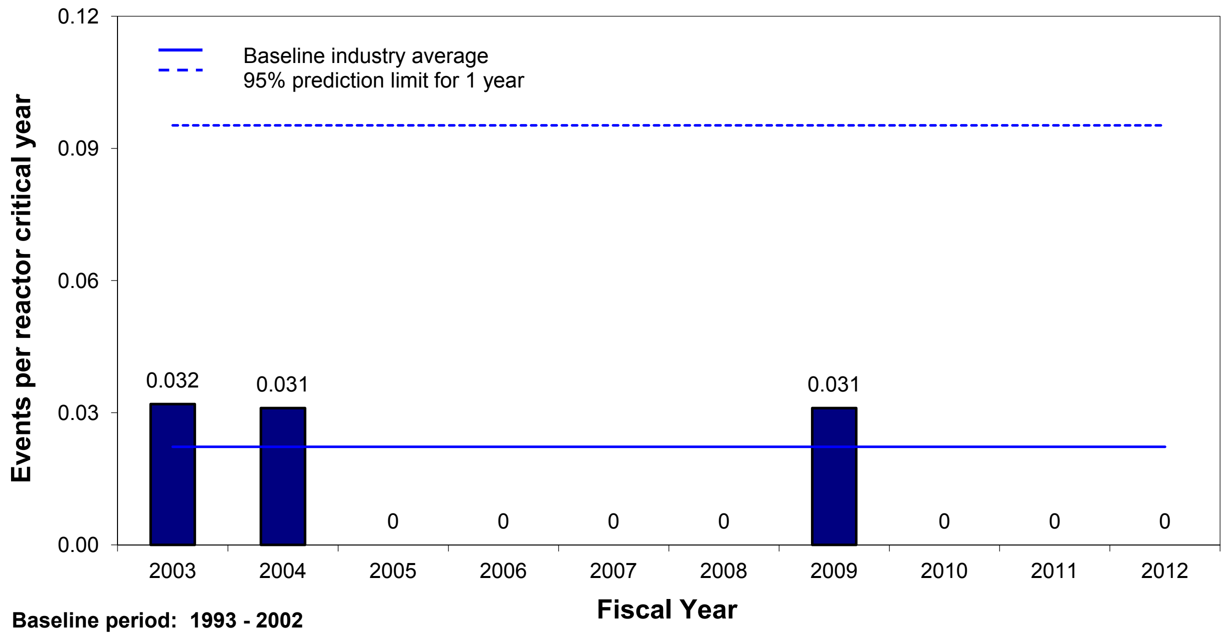


Figure 10. BWR stuck-open safety or relief valve

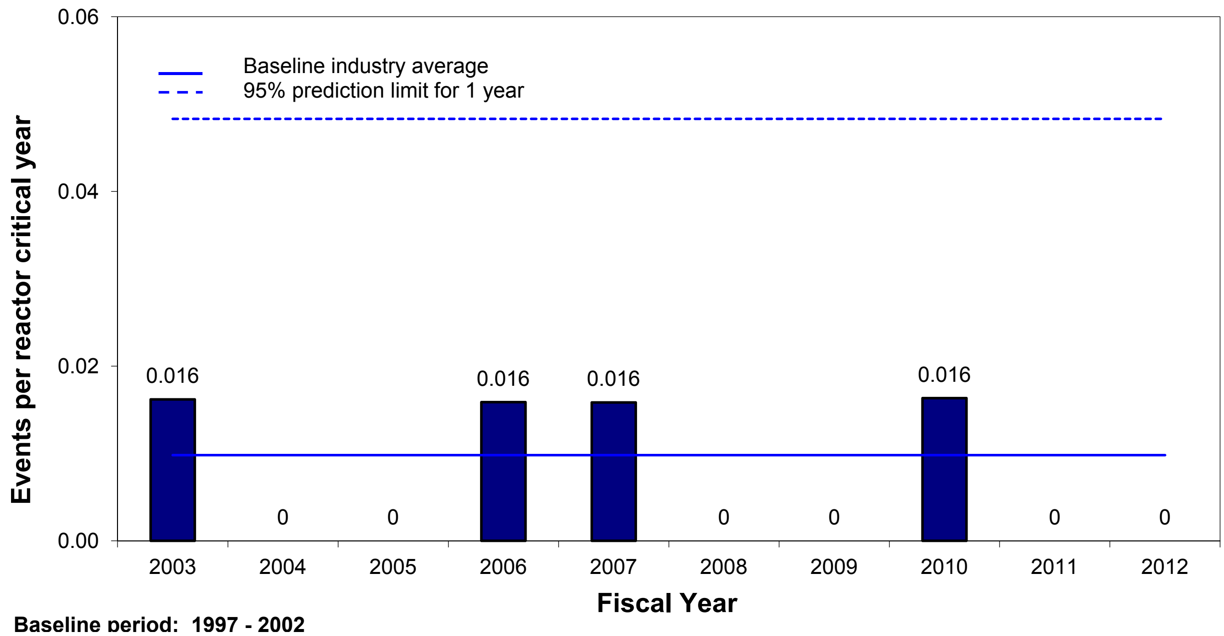


Figure 11. PWR loss of instrument air

Note that Figure 11 is different from the figure included in SECY-12-0056. The graph was not portrayed correctly in SECY-12-0056 and is corrected in this paper; however, revision of this graph does not change the conclusions presented in SECY-12-0056.

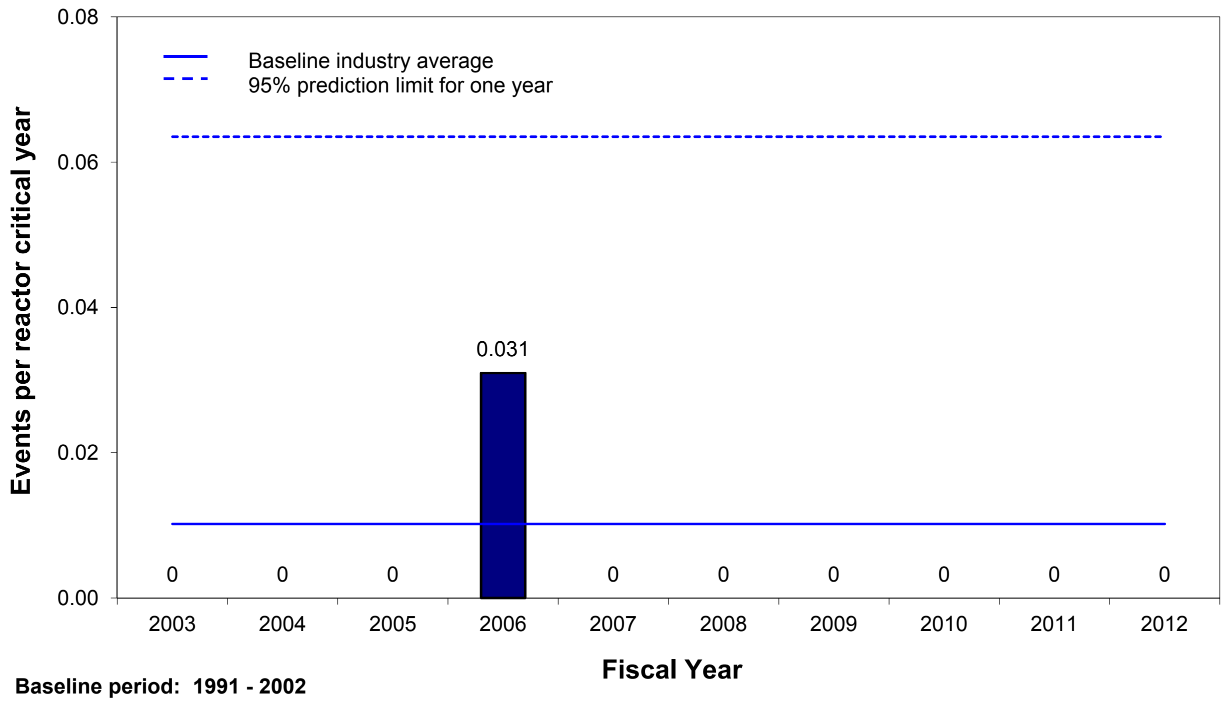


Figure 12. BWR loss of instrument air

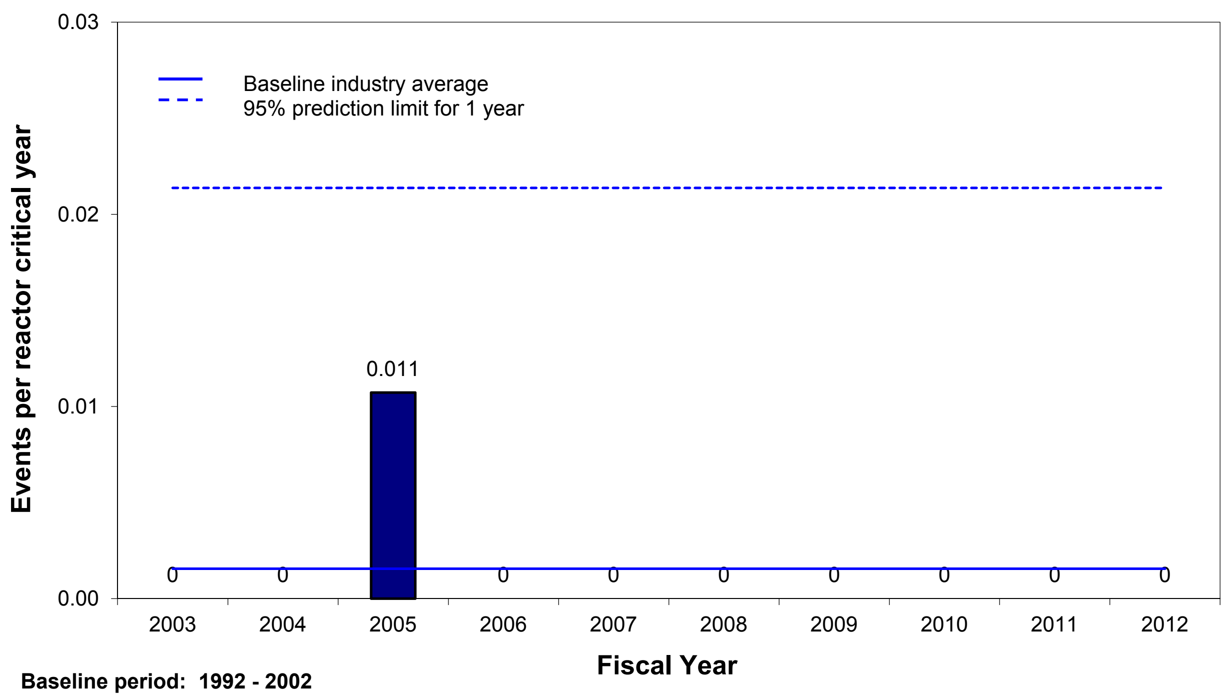


Figure 13. Very small loss-of-coolant accident

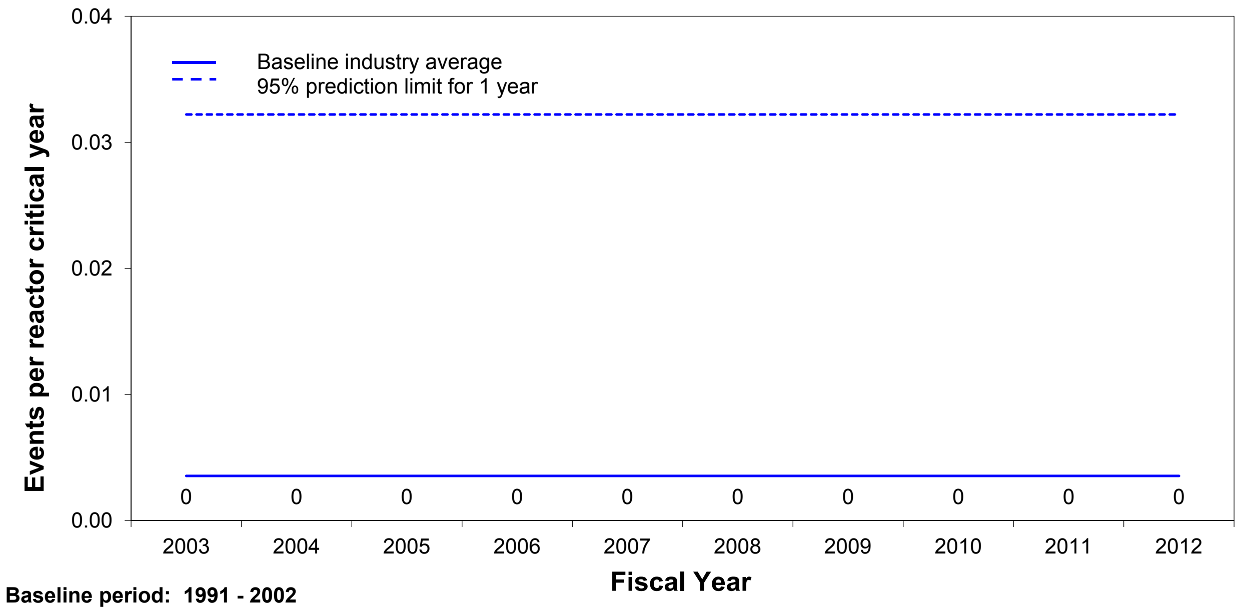


Figure 14. PWR steam generator tube rupture

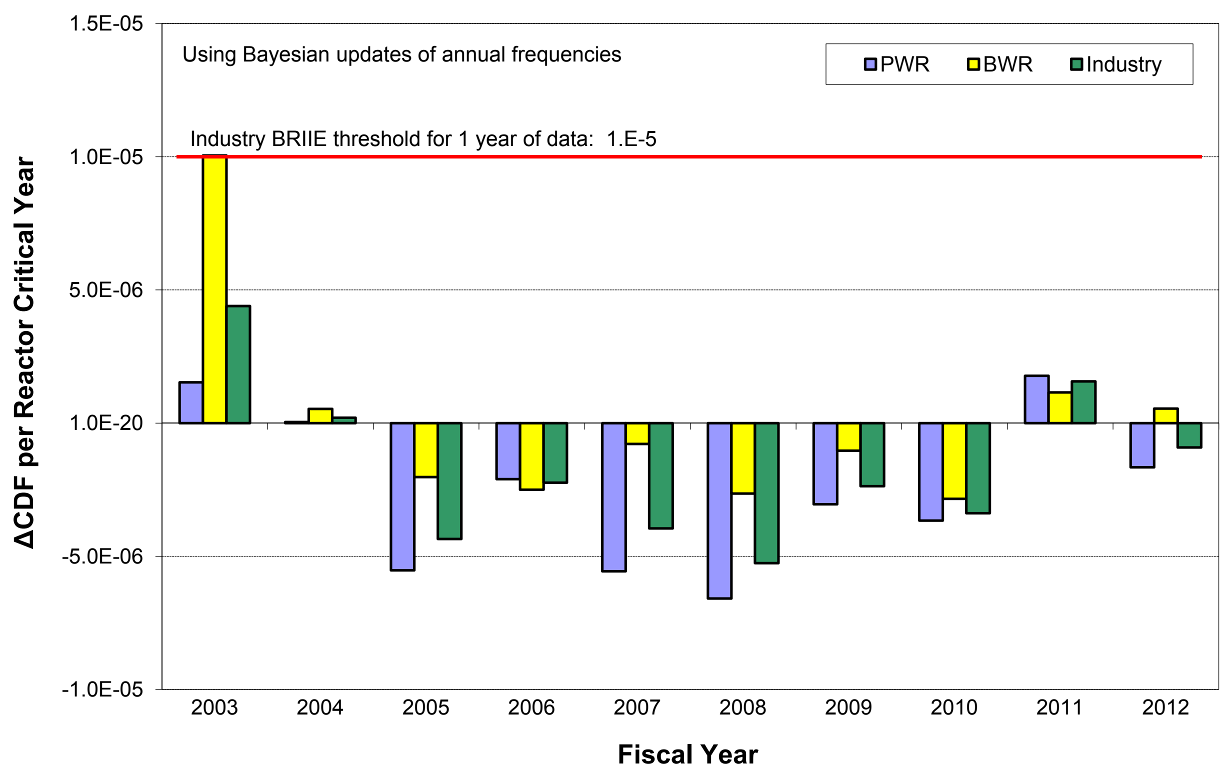


Figure 15. BRIIE Tier 2 (ΔCDF)