POLICY ISSUE
(Information)

April 8, 2015 SECY-15-0061

FOR: The Commissioners

FROM: William M. Dean, Director
Office of Nuclear Reactor Regulation

SUBJECT: FISCAL YEAR 2014 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) 2014, and updated results from the FY 2013 ITP review. In summary, the staff did not identify any statistically significant adverse trends in industry safety performance in 2014. For the updated FY 2013 results, the staff did identify a statistically significant adverse trend for the Significant Events indicator, but it was no longer evident following the 2014 review. This paper does not address any new commitments or resource implications.

BACKGROUND:

The staff established the ITP in 2001 to monitor trends in licensee safety performance using industry-level indicators. Should the staff identify any adverse trends, further analysis would be conducted to determine causal factors, and adjustments to the NRC inspection program may result. Another 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 reviews the results of the ITP and any actions taken or planned as

CONTACT: Andrew Waugh, NRR/DIRS
301-415-5601

a result during the annual Agency Action Review Meeting. The NRC reports the findings of this review to the Commission during the subsequent Commission meeting. NRC Inspection Manual Chapter (IMC) 0313, "Industry Trends Program," dated May 29, 2008 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML080860540), contains details of the ITP including definitions of monitored indicators and program descriptions.

Using the ITP, the staff monitors industry-wide safety performance to identify and address any statistically significant adverse trends. A statistically significant adverse trend exists if the slope of the regression line fitted to the long-term indicator data has a positive value and the fit of the regression line is statistically relevant.

The Significant Events and Accident Sequence Precursors ITP indicators use data from the Accident Sequence Precursor (ASP) Program. The Significant Events indicator uses precursors with a conditional core damage probability (CCDP) or an increase in core damage probability (ΔCDP) greater than or equal to 1×10^{-5} as one of its inputs. The Accident Sequence Precursors indicator is based on precursors with a CCDP or ΔCDP greater than or equal to 1×10^{-6}. Due to the time needed to perform the complex risk analysis required for identifying precursors, these two indicators lag behind other ITP indicators.

In addition to the above 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 an established baseline period during which data can be regarded as fairly constant.

The ITP complements the Reactor Oversight Process (ROP). Specifically, the ITP monitors and responds to industry-wide performance, whereas the ROP provides oversight of individual reactor sites commensurate with their safety performance.

The Office of Nuclear Regulatory Research (RES) provides indirect support to the ITP by analyzing operating experience data and providing analytical tools, 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.

In 2008, the NRC staff established 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 offers a two-level approach to industry performance monitoring. The first level (referred to as Tier 1 performance monitoring) tracks IEs that occur during the year. Nine IE 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. The predetermined number of occurrences is calculated using information from an established baseline period. If the predetermined number is exceeded, the staff assesses whether there is a possible degradation in overall 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 (i.e., Tier 2 performance monitoring) addresses the risk to plant safety and core damage that each IE contributes. Each event is assigned an importance value based on its relative contribution to overall risk of plant safety. The greater the contribution of the event to overall risk, the higher the importance value assigned. Using statistical methods, the importance values are combined with the number of times the events occur during the year to calculate a value 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 have already been taken or are planned in response, in the annual NRC Performance and Accountability Report.

DISCUSSION:

Results of FY 2014 Long-Term Industry Trends

For the FY 2014 ITP results, the staff did not identify any statistically significant adverse trends in industry-wide safety performance. The graphs in Enclosure 1 show the long-term ITP indicator trends. Six indicators showed statistically significant improving trends. Trend lines are provided for those indicators with a statistically significant trend. The staff evaluated both linear and exponential trend lines for each set of data and used the trend line showing the highest degree of statistical significance.

Updated Results of FY 2013 Long-Term Industry Trends

In SECY-14-0042, "Fiscal Year 2013 Results of the Industry Trends Program for Operating Power Reactors," the staff identified five precursors that could potentially meet the criteria for significant events. The staff noted that a statistically significant adverse trend for the Significant Events indicator would exist if the final ASP results for all five of these precursor events meet the significant events criteria.

Upon completing the final ASP analysis, all five precursor events did meet the significant events criteria which yielded a statistically significant adverse trend for the significant event indicator during the FY 2004 to 2013 timeframe (included as Figure 15 of Enclosure 1). Based on currently available data, this statistically significant adverse trend did not continue into FY 2014. The staff had already been analyzing the increase in significant events that began in FY 2010 as part of the industry trends, operating experience, and RES programs. A Bulletin and several Information Notices were issued based on staff's review of these significant events. The review revealed that the causes of most of these events were related to issues with electrical distribution systems. Because of the ASP result, the staff has initiated an in-depth electrical distribution system and component reliability study to glean insights from precursors associated with issues in plant electrical systems. Other broad issues, such as those initiated by natural phenomena, are already being considered using normal agency processes. Any safety concern involving an individual plant was addressed already in a timely manner and no changes to oversight or licensing were identified as a result.

Results of FY 2014 Short-Term Industry Performance

As described above, 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 their prediction limits in FY 2014. Short-term FY 2014 data did not reveal any emerging trends that warranted additional analysis or significant adjustments to the nuclear reactor safety inspection or licensing programs.

Results of FY 2014 Baseline Risk Index for Initiating Events

Enclosure 3 includes the Tier 1 and Tier 2 BRIIE results. None of the IEs tracked in Tier 1 exceeded their prediction limits in FY 2014. For Tier 2, Figure 15 of Enclosure 3 shows that the combined industry BRIIE value for FY 2014, -2.53×10^{-6} per reactor critical year, is negative, which shows that industry performance was in fact better than baseline. The combined industry BRIIE value is below the established reporting threshold of $\Delta CDF = 1.0\times10^{-5}$ per reactor critical year.

Status of Commitments from Program Review

On June 13, 2013, the Commission issued a staff requirements memorandum (SRM) in response to the May 29, 2013, "Briefing on the Results of the Agency Action Review Meeting (AARM)." In this SRM the Commission directed the staff to review the ITP as follows:

> *As part of the Reactor Oversight Process (ROP) Self-Assessment for calendar year (CY) 2013, the staff should review implementation of the Industry Trends Program over its history for lessons learned and inform the Commission of any program enhancements and/or resource reductions that may be warranted.*

After completing the review of the ITP in 2013, the staff made the following commitments in SECY-14-0042:

- Consider using the public radiation safety cornerstone ROP performance indicator (i.e., radiological effluence occurrence) in the ITP

- Consider using the security cornerstone ROP performance indicator (i.e., protected area security equipment performance index) in the ITP

- Evaluate the possibility of supplementing or replacing ITP indicators with ROP performance indicators (PIs) where applicable

- Evaluate performance data for new reactors in the ITP, as applicable

The staff continues to evaluate the efficacy of replacing the current ITP indicators with ROP PIs. PIs were established to provide a broad sample of data to assess licensee performance in the risk-significant areas of each cornerstone. Shifting the ITP focus to an evaluation of trends in PIs could provide a complementary approach on an industry-wide basis to what the ROP provides on a plant-by-plant basis. The advantages of replacing the current ITP indicators with ROP PIs are as follows:

- A more holistic view of industry safety performance would be achieved because all cornerstones of the ROP would be evaluated

- The significant resource burden (i.e., contract support) related to data collection and analysis would be greatly reduced

- The ITP would be more understandable by using the ROP PIs because they are more commonly used and widely disseminated

Currently, 6 of the 14 ITP indicators are based upon ROP PIs and several of the other indicators have an ROP PI that is very similar in nature, such as the “automatic scrams while critical” ITP indicator and the “unplanned scrams” ROP PI.

The staff plans to solicit internal and external feedback regarding the potential for unintended consequences to making the change to ITP indicators based on ROP PIs, determine the necessary program revisions to enact this change, and seek to put those changes in place in time for the FY 2015 ITP assessment period.

Finally, as a part of the ongoing ROP enhancement effort, the staff continues to examine the overall efficacy of this program. Specifically, the staff is evaluating the relative benefits and costs of the ITP given that it has not informed any substantive changes to the ROP since its inception, and similar insights could potentially be gained by leveraging other NRC programs.

CONCLUSION:

The results of the FY 2014 ITP did not indicate any statistically significant adverse trends in industry safety performance. Also, no ITP indicator exceeded its prediction limit, and the BRIIE value remained below the threshold for a report to Congress.

The updated results for FY 2013 ITP caused a statistically significant adverse trend for the Significant Events indicator. The trend was evaluated and no changes to oversight or licensing were identified.

RESOURCES:

The resources for ITP activities are included in the FY 2015 Current Estimate (CE) and the FY 2016 Congressional Budget Justification (CBJ). The total resources that are included in the FY 2015 CE are 0.5 full-time equivalent (FTE) and $595K; and in the FY 2016 CBJ of 0.5 FTE and $595K. No additional resources beyond those already budgeted will be required for the ITP. Resources beyond FY 2017 will be addressed during the Planning, Budgeting, and Performance Management process.

COORDINATION:

The Office of the Chief Financial Officer has reviewed this paper for resource implications and has no objections. The Office of the General Counsel has reviewed this paper and has no legal objection.

Sincerely,

/RA by Jennifer Uhle for/

William M. Dean, Director
Office of Nuclear Reactor Regulation

Enclosures:
1. Fiscal Year 2014 Long-Term Industry Trend Results
2. Fiscal Year 2014 Short-Term Industry Performance
3. Summary of Baseline Risk Index for Initiating Events: Annual Graphs through Fiscal Year 2014

FISCAL YEAR 2014 LONG-TERM INDUSTRY TREND RESULTS

The staff of the U.S. Nuclear Regulatory Commission did not identify any statistically significant adverse trends in the industry trends program performance indicator data from the most recent 10 years (fiscal years 2005–2014), as shown by the figures below.

Upon receiving finalized FY 2013 data the staff identified a statistically significant adverse trend for the significant event indicator during the FY 2004 to 2013 timeframe as shown in Figure 15.

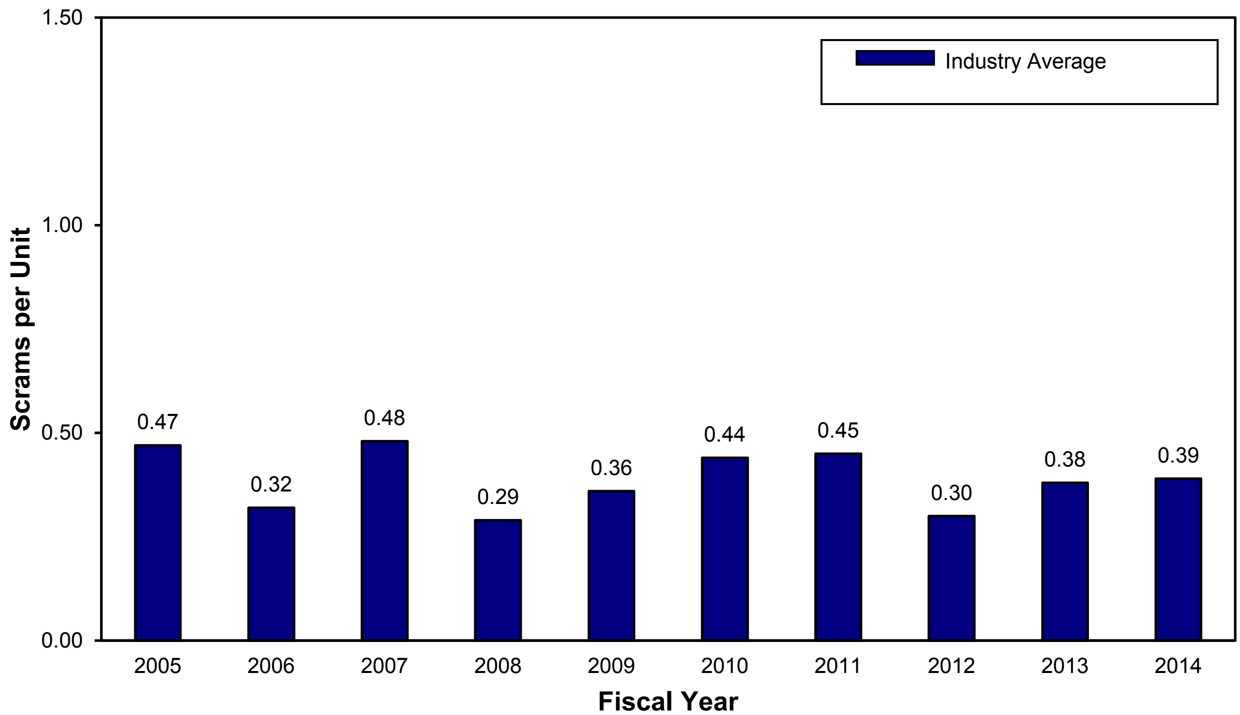

Figure 1. Automatic scrams while critical

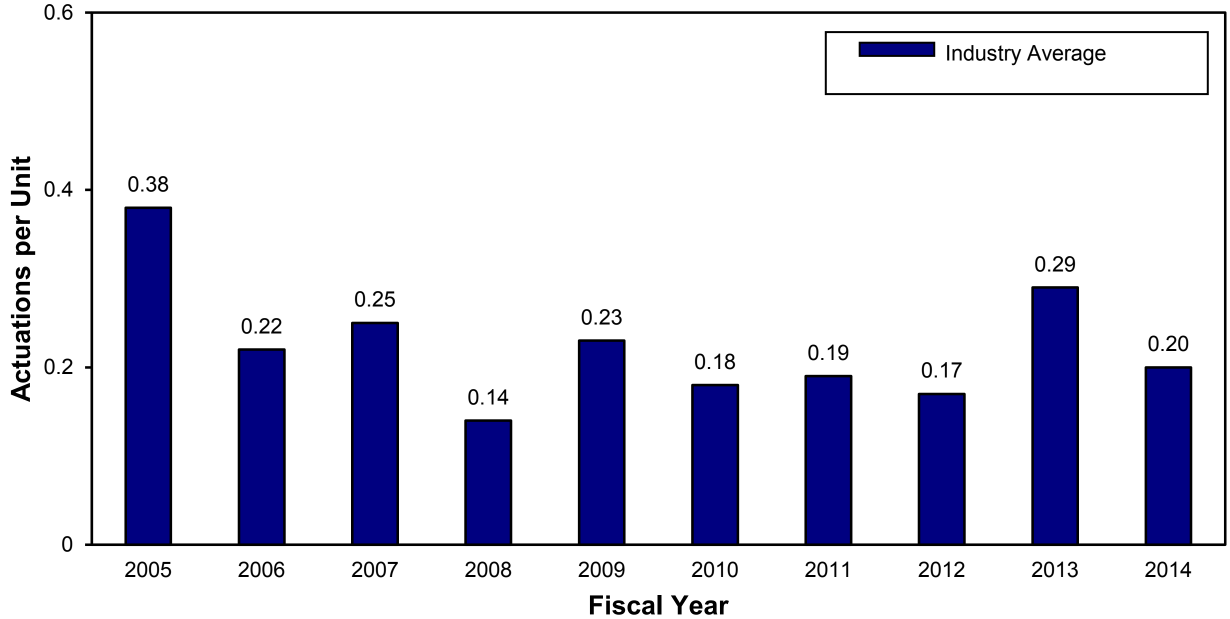

Figure 2. Safety-system actuations

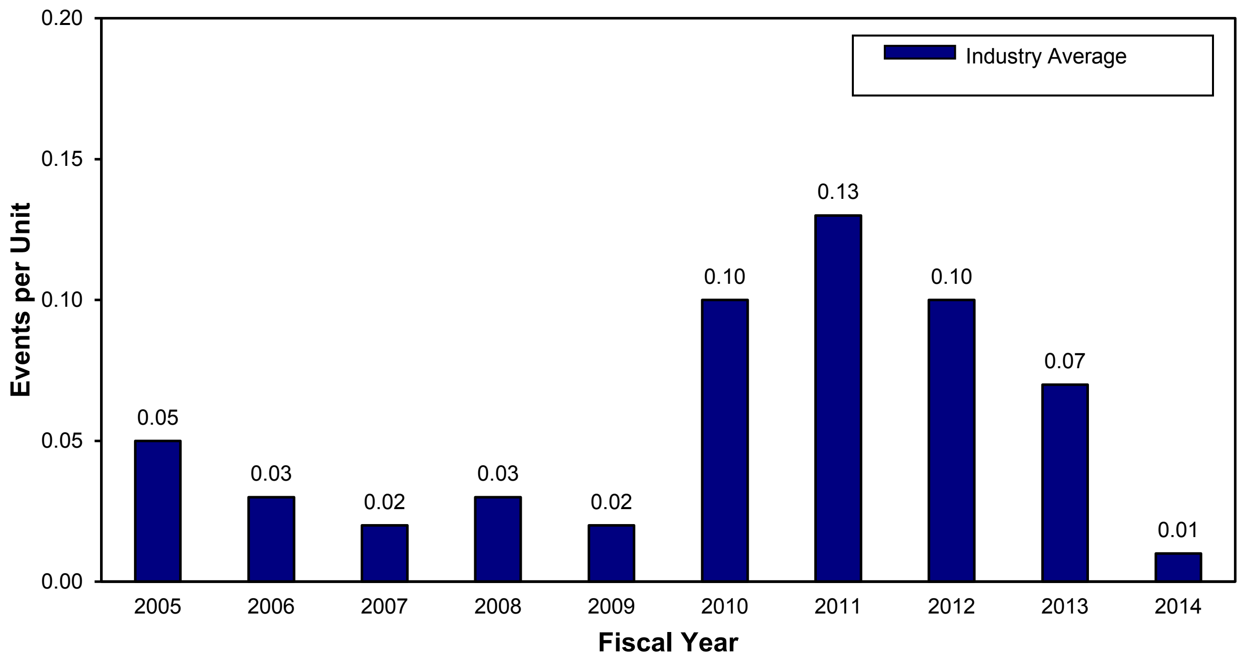

Figure 3. Significant events (FY 2014 inputs are not yet complete)

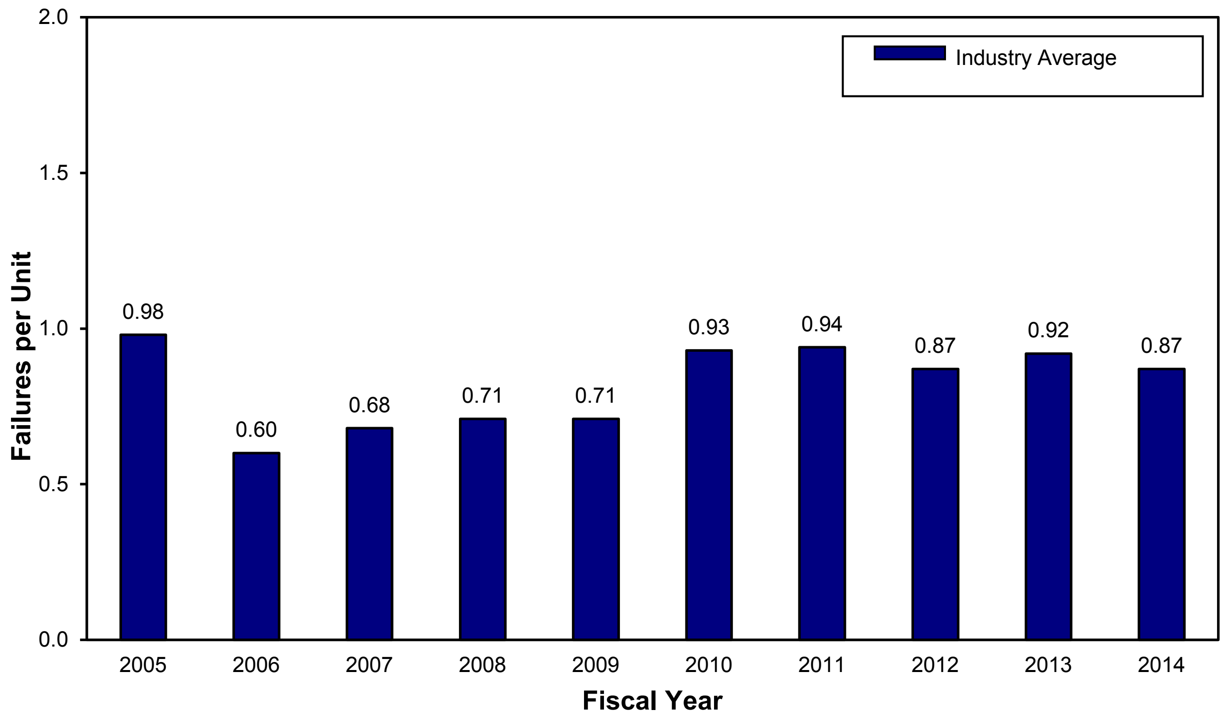

Figure 4. Safety-system failures

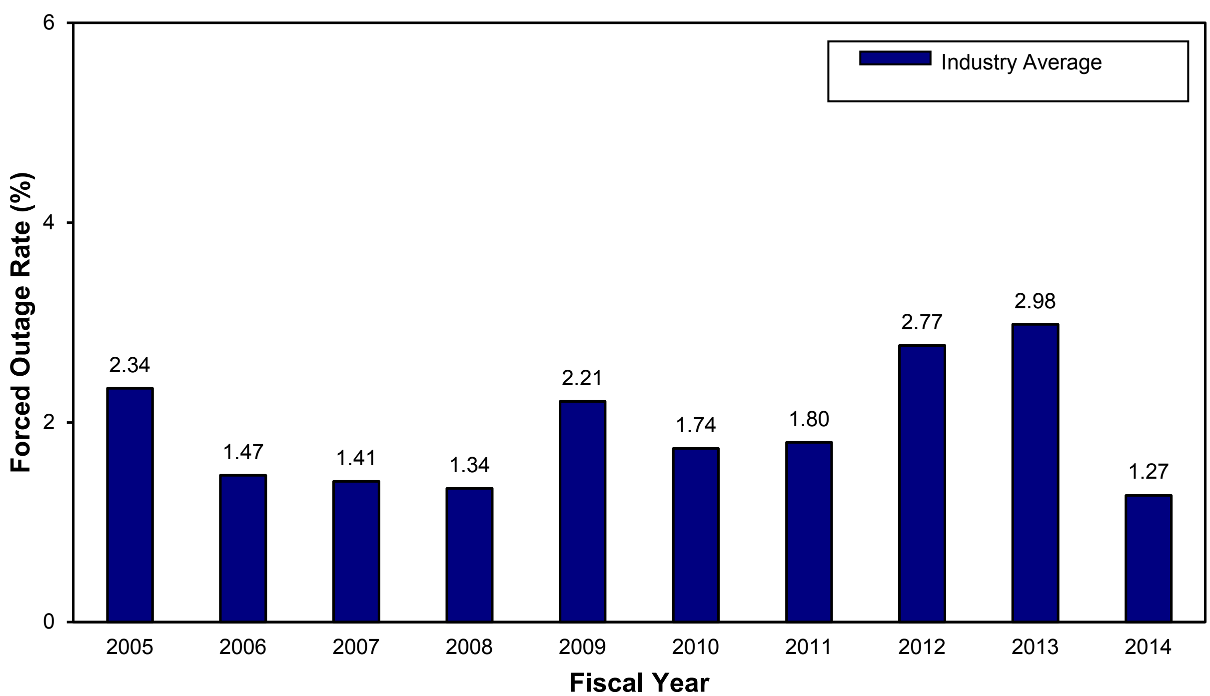

Figure 5. Forced outage rate

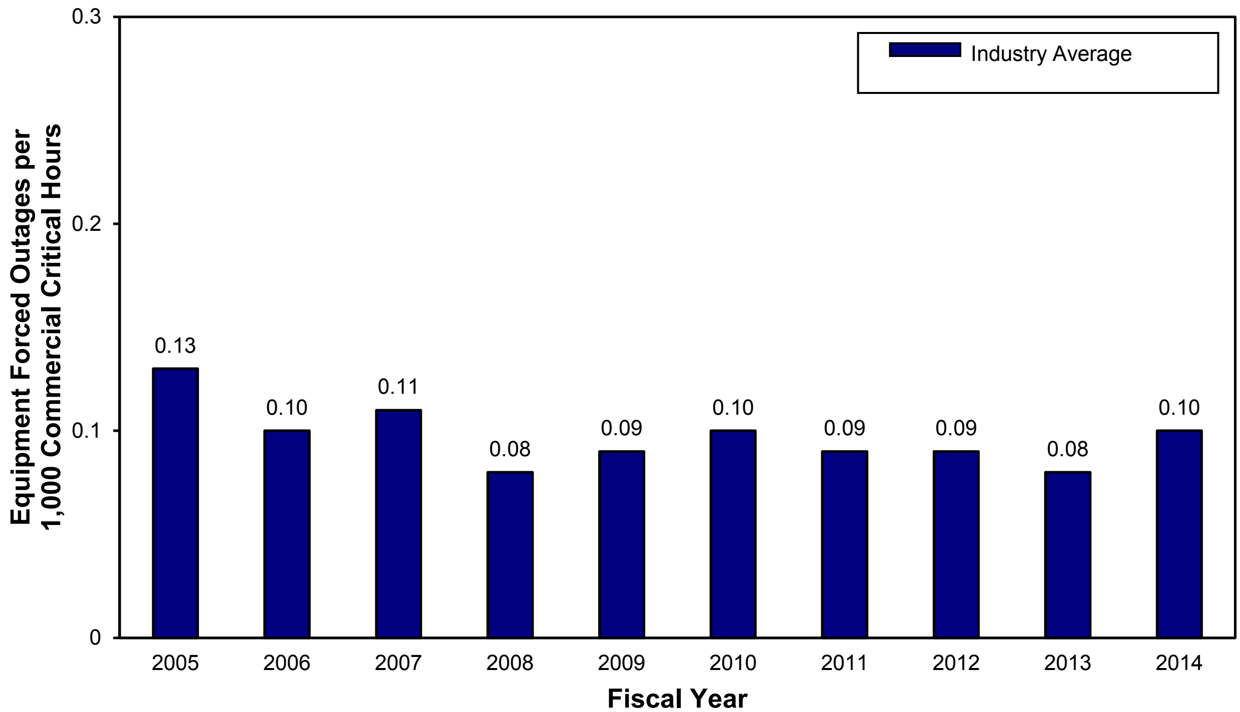

Figure 6. Equipment forced outages

As discussed in this paper, Figures 1 through 6 do not display a trend line because these graphs do not have a statistically significant trend.

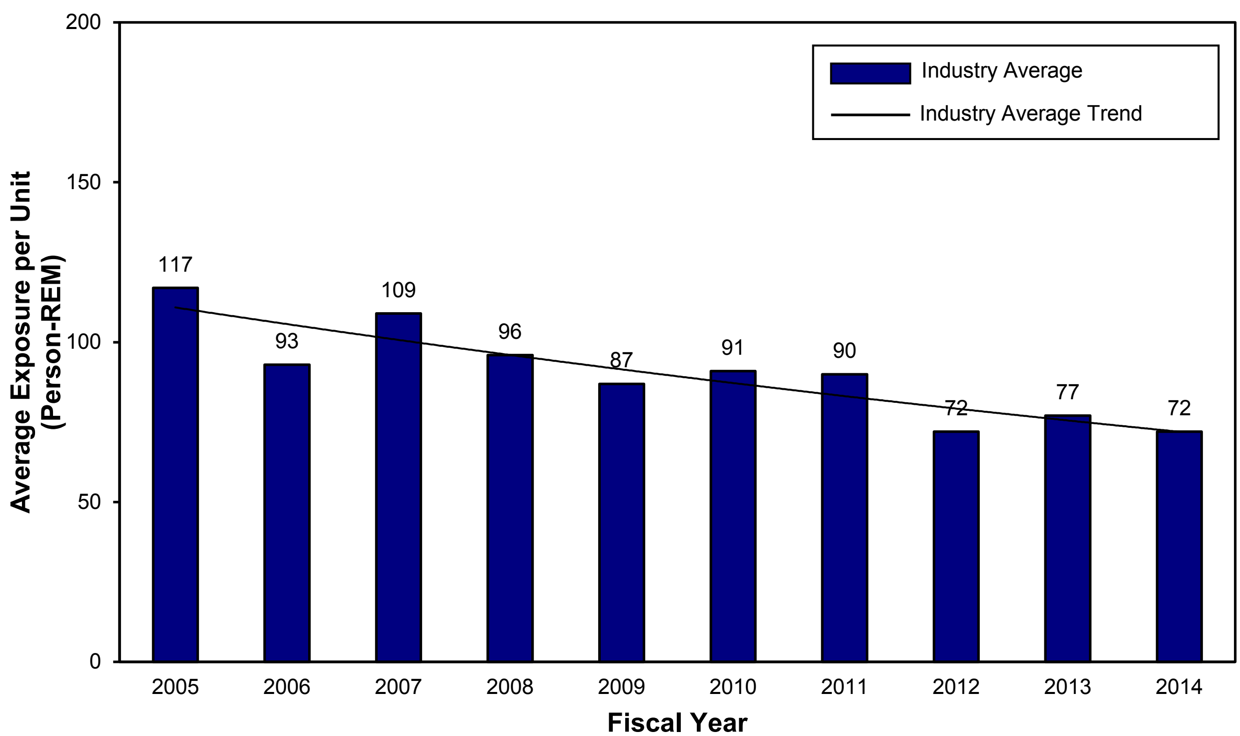

Figure 7. Collective radiation exposure

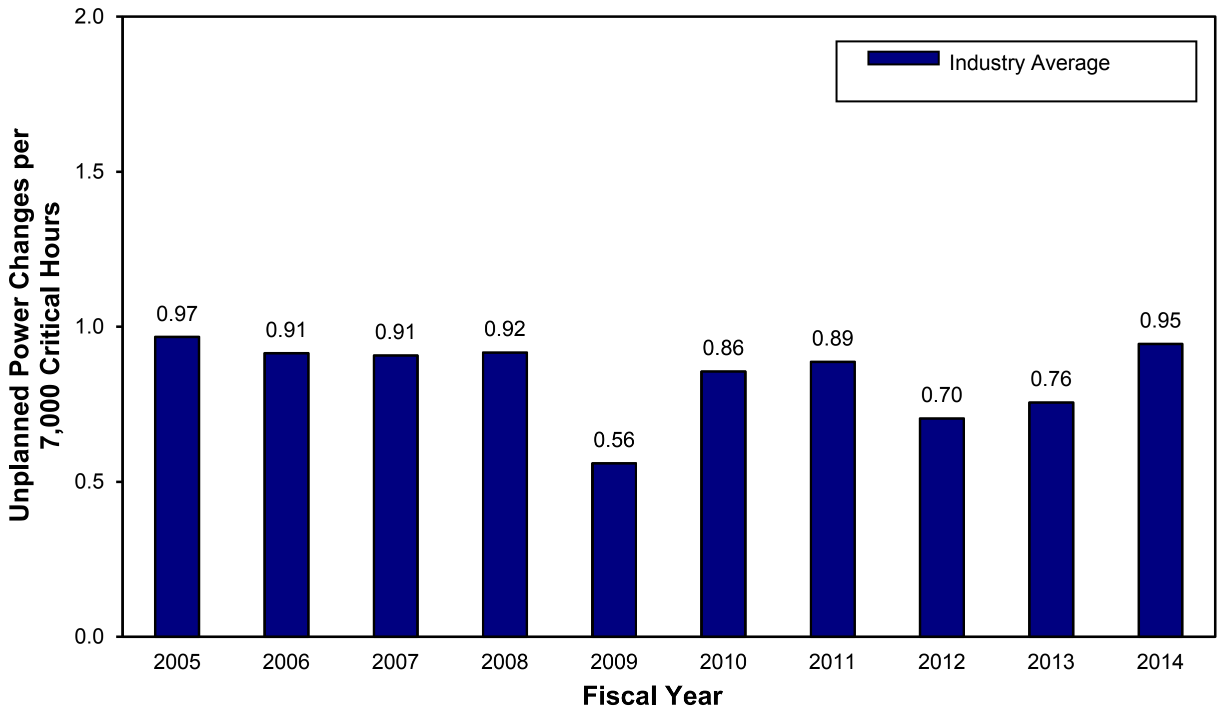

Figure 8. Unplanned power changes

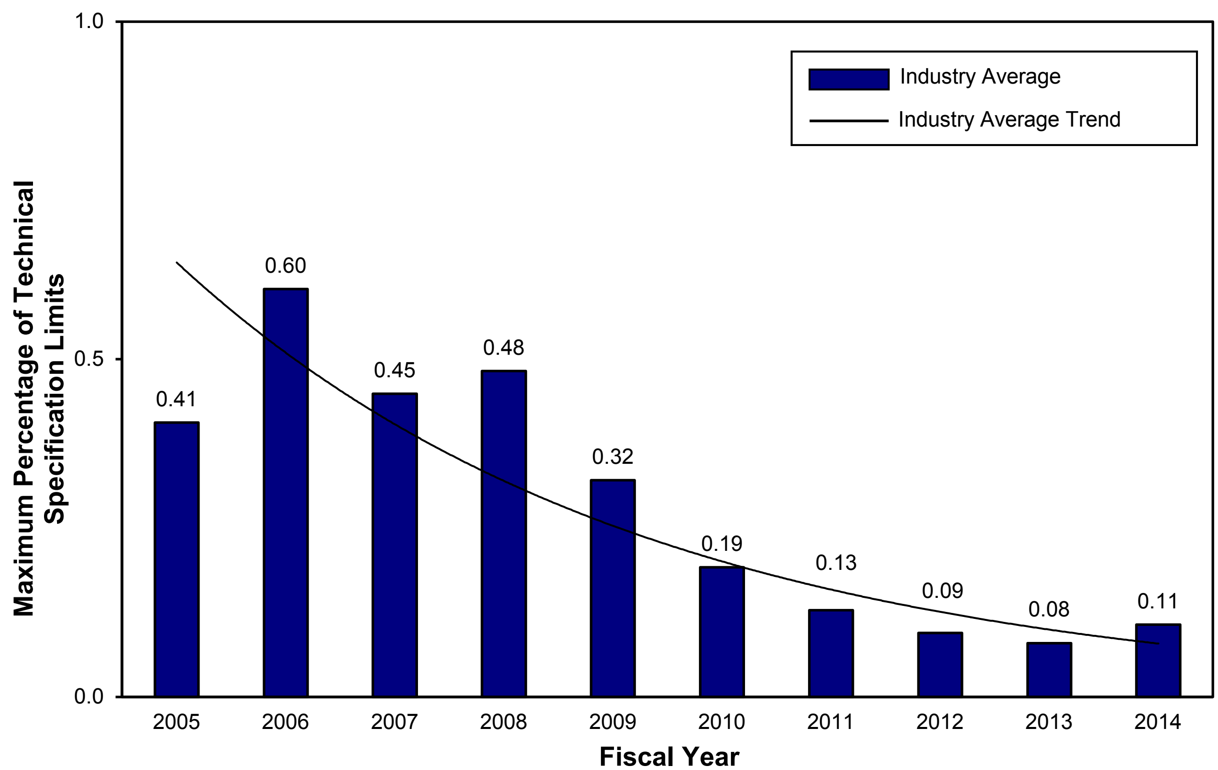

Figure 9. Reactor coolant system activity

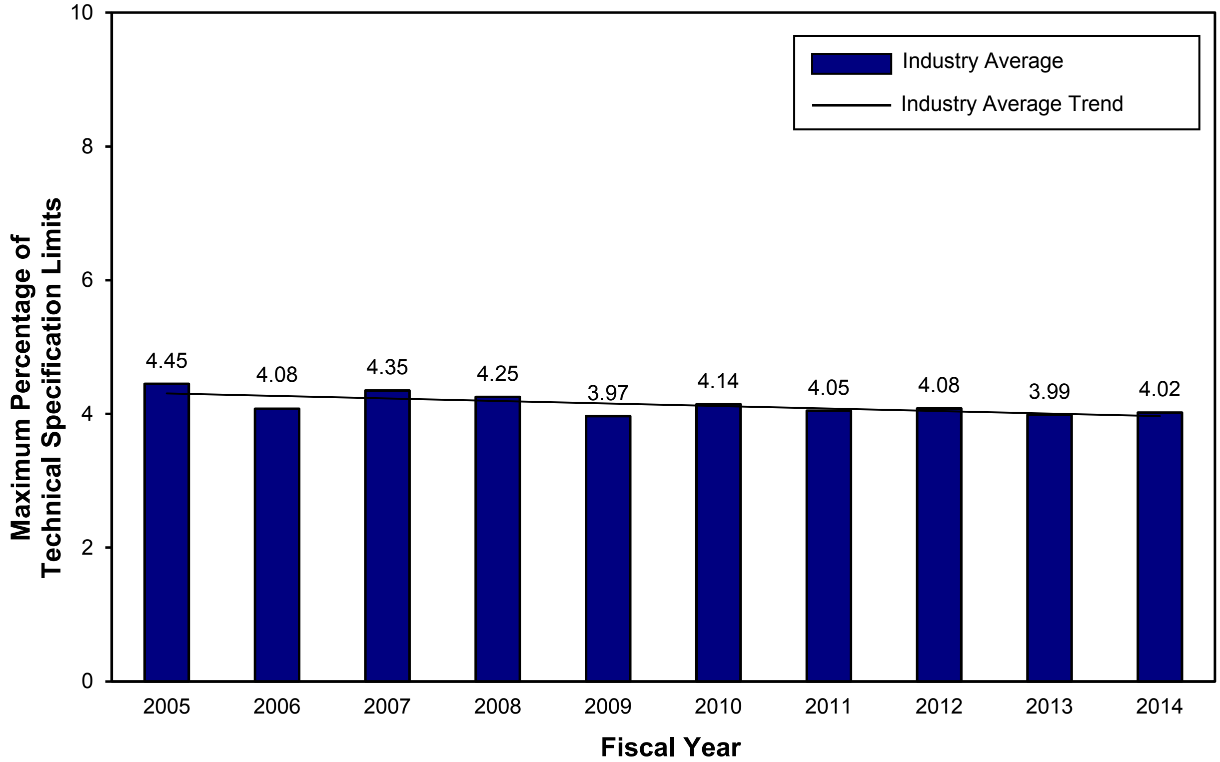

Figure 10. Reactor coolant system leakage

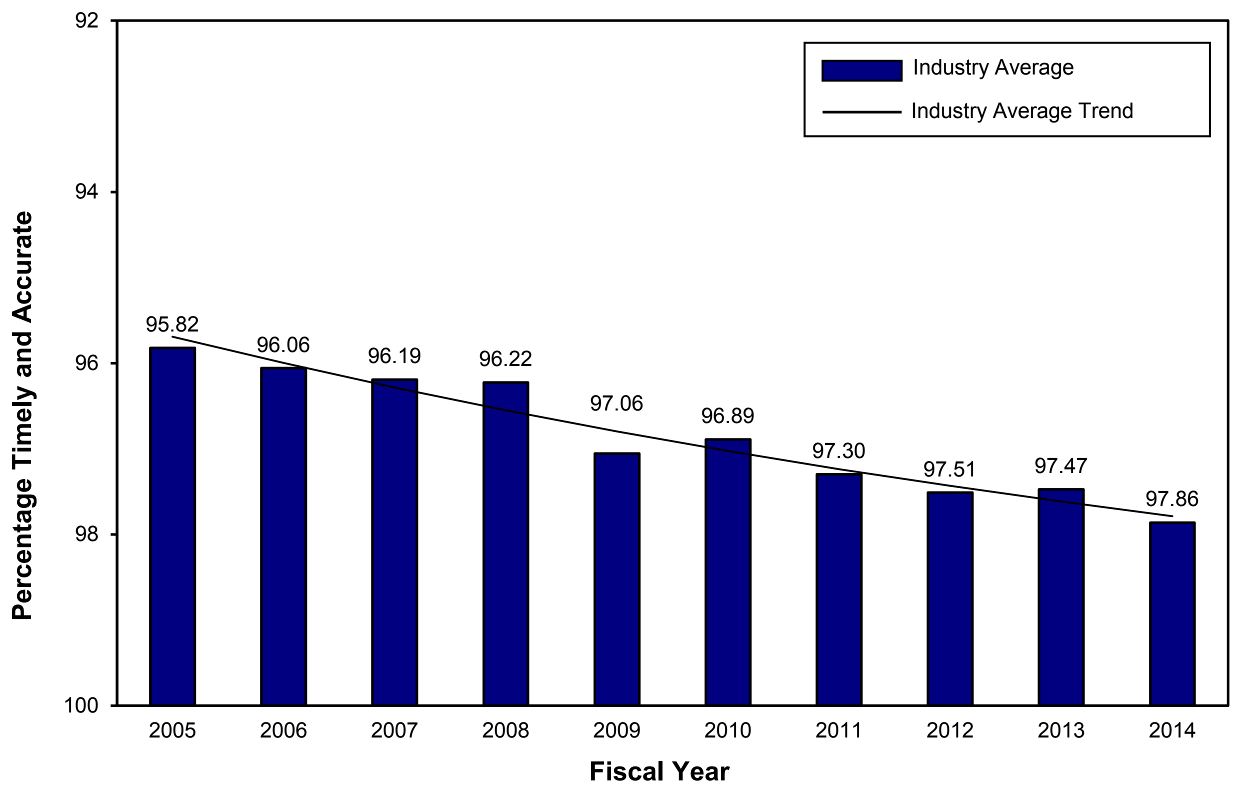

Figure 11. Drill and exercise performance

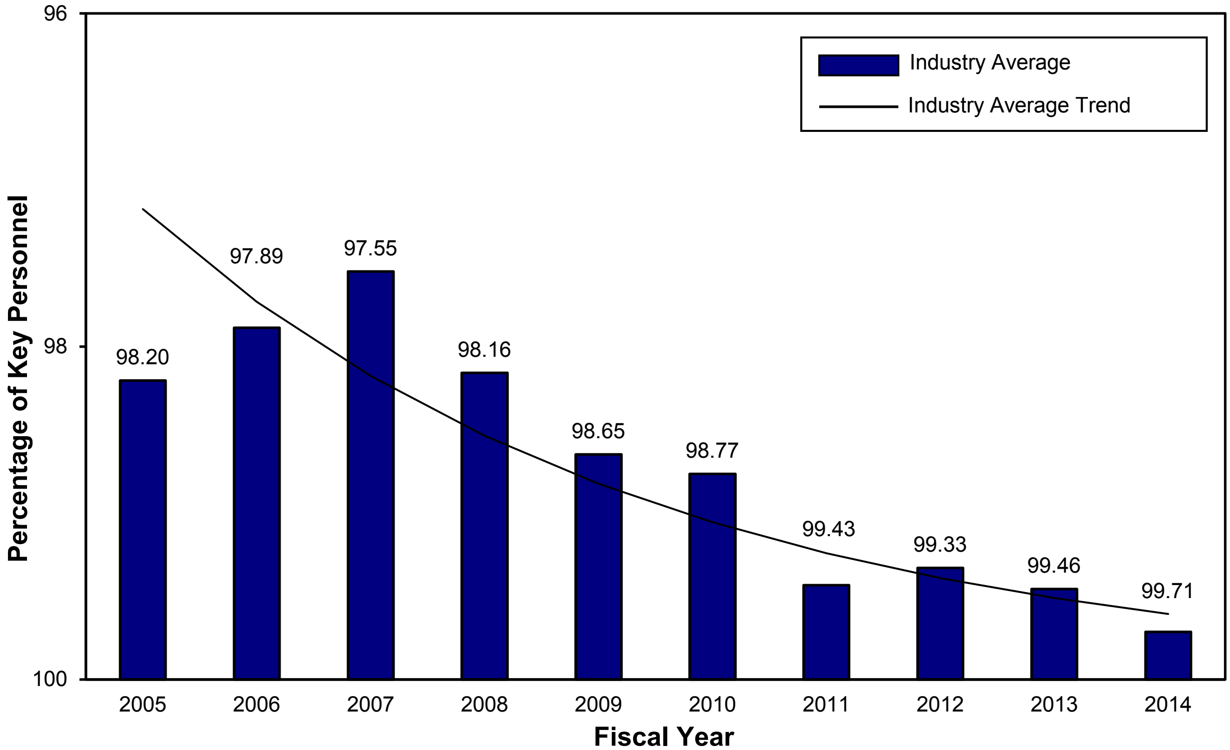

Figure 12. Emergency response organization drill participation

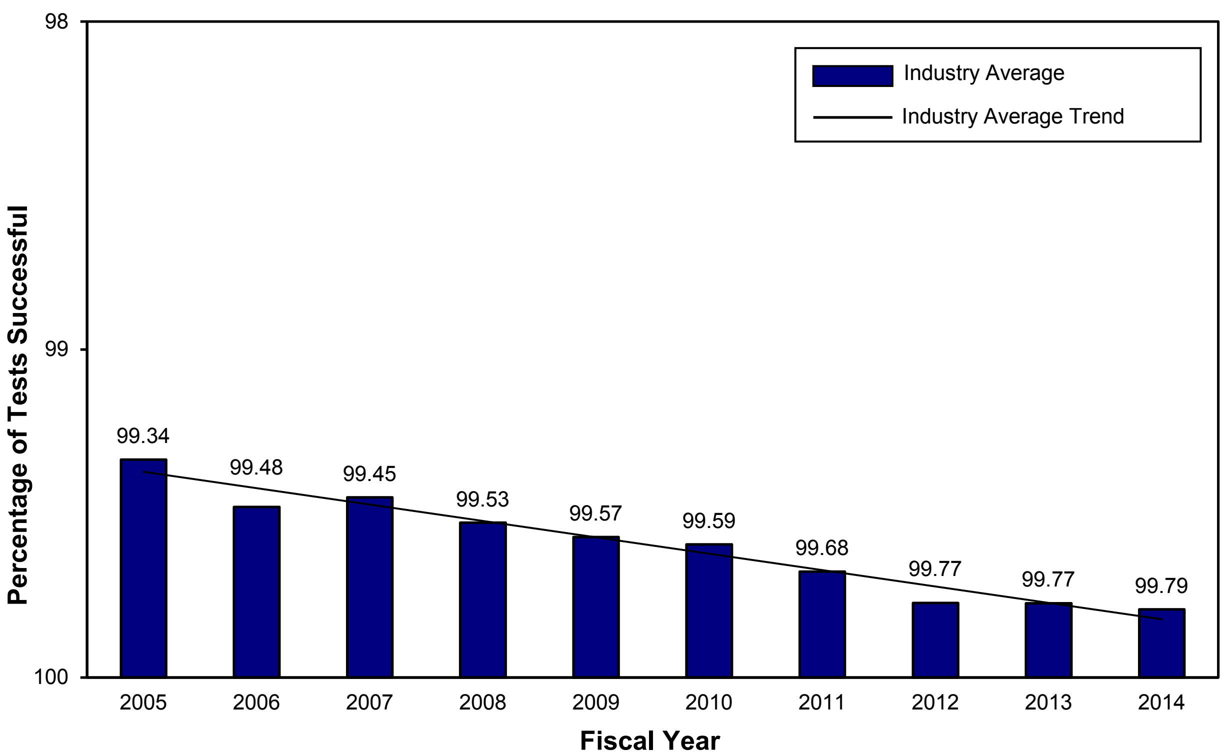

Figure 13. Alert and notification system reliability

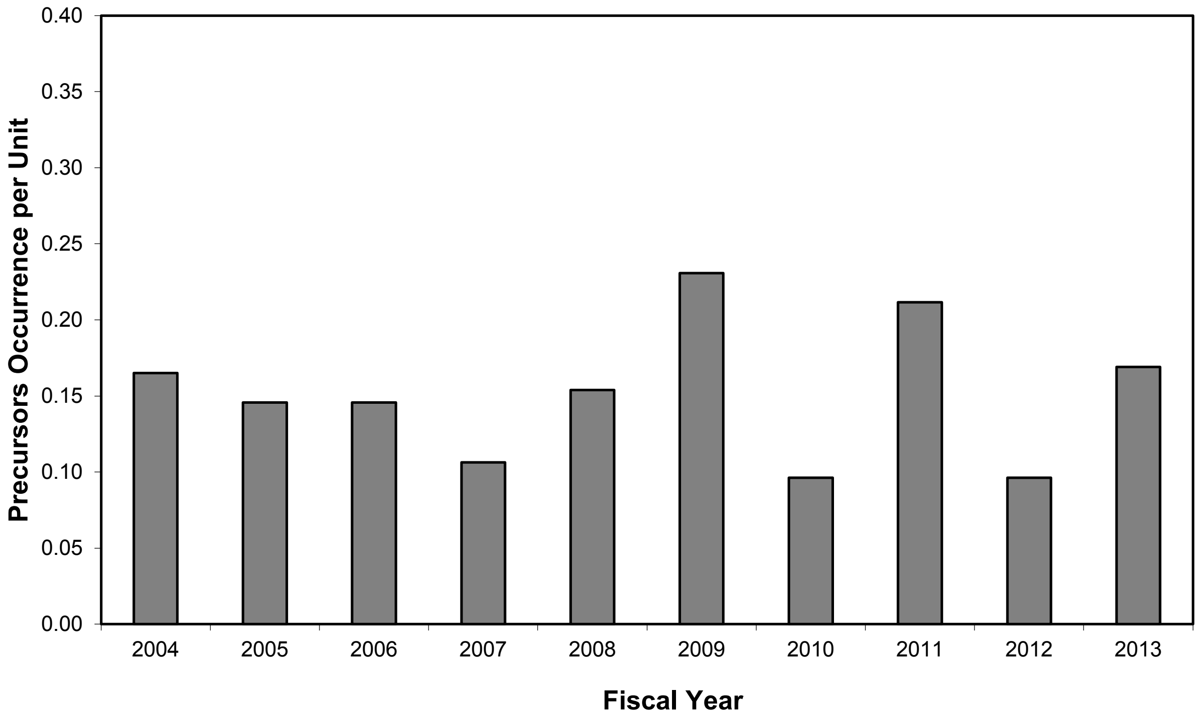

Figure 14. Accident sequence precursors (FY 2004-2013)

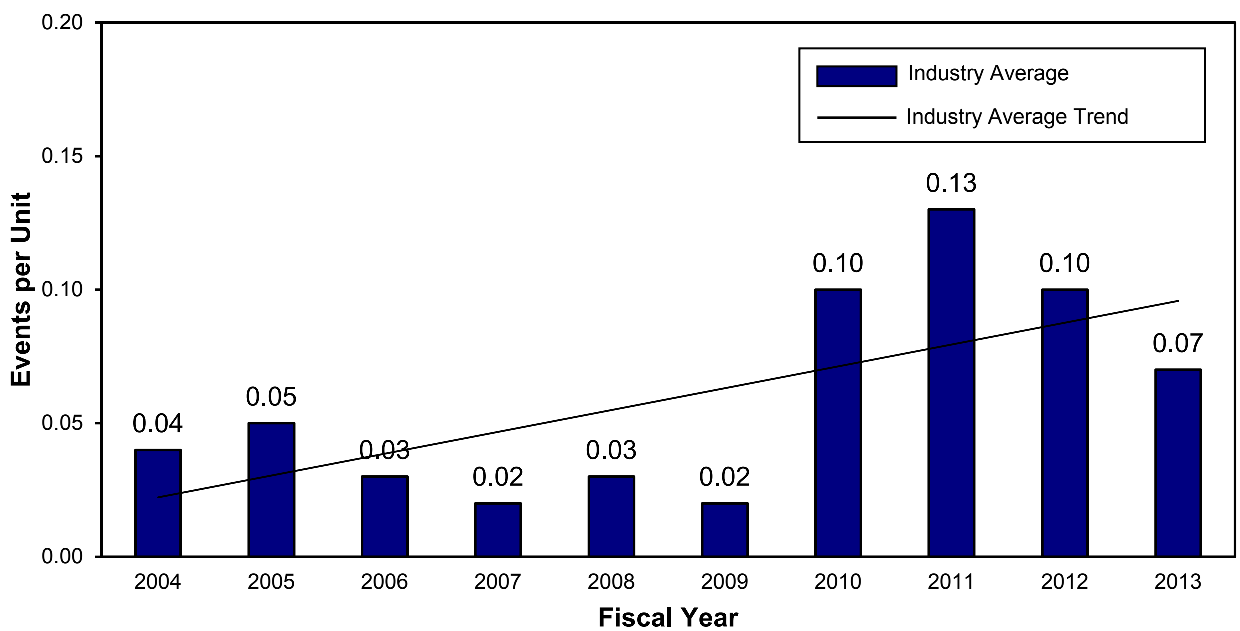

Figure 15. Updated Significant events 2004-2013

FISCAL YEAR 2014 SHORT-TERM INDUSTRY PERFORMANCE

The annual industry trend analysis compares data for the most recent year with established short-term “prediction limits.” The prediction limits are 95th percentiles of predictive distributions for the data. The predictive distributions are statistical probability distributions that describe expected future performance. They are derived from performance during “baseline” periods for each indicator. Baseline periods are periods for each indicator during which the data can be regarded as fairly constant and indicative of “current” performance.

The results of the evaluation for fiscal year (FY) 2014 Industry Trends Program indicators, using the established prediction limits, show that no indicator exceeded its associated prediction limit in FY 2014, as shown in the following figures for each indicator with its FY 2014 data and associated prediction limit.

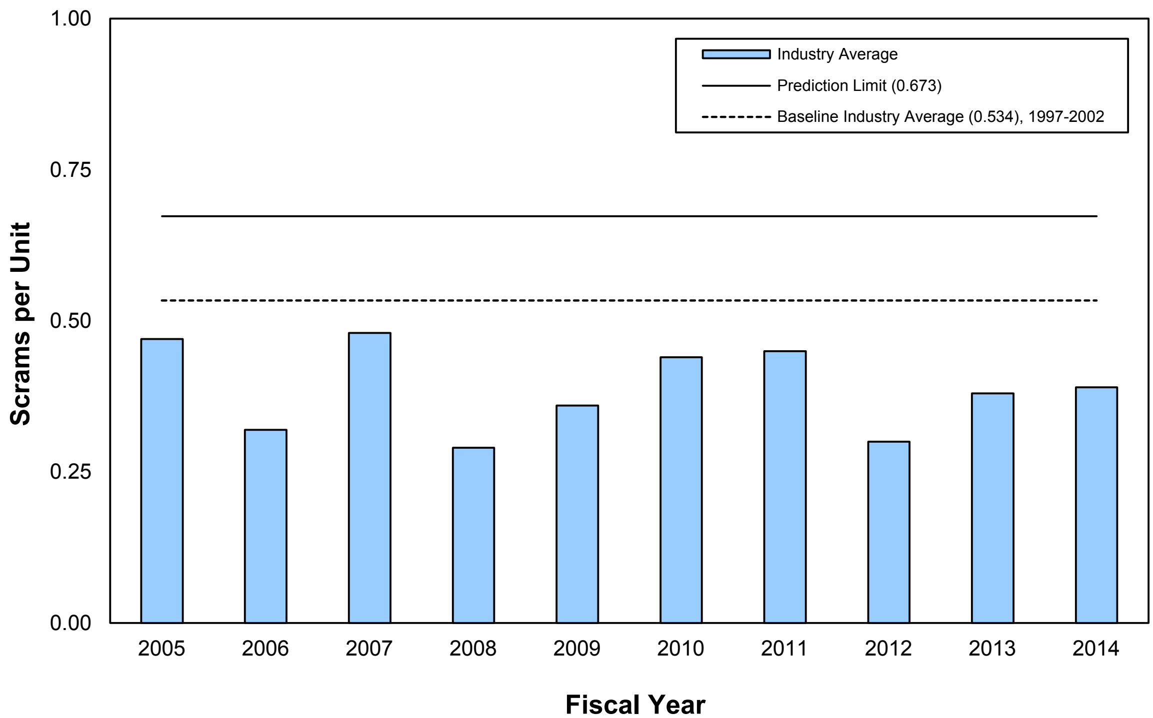

Figure 1. Automatic scrams while critical

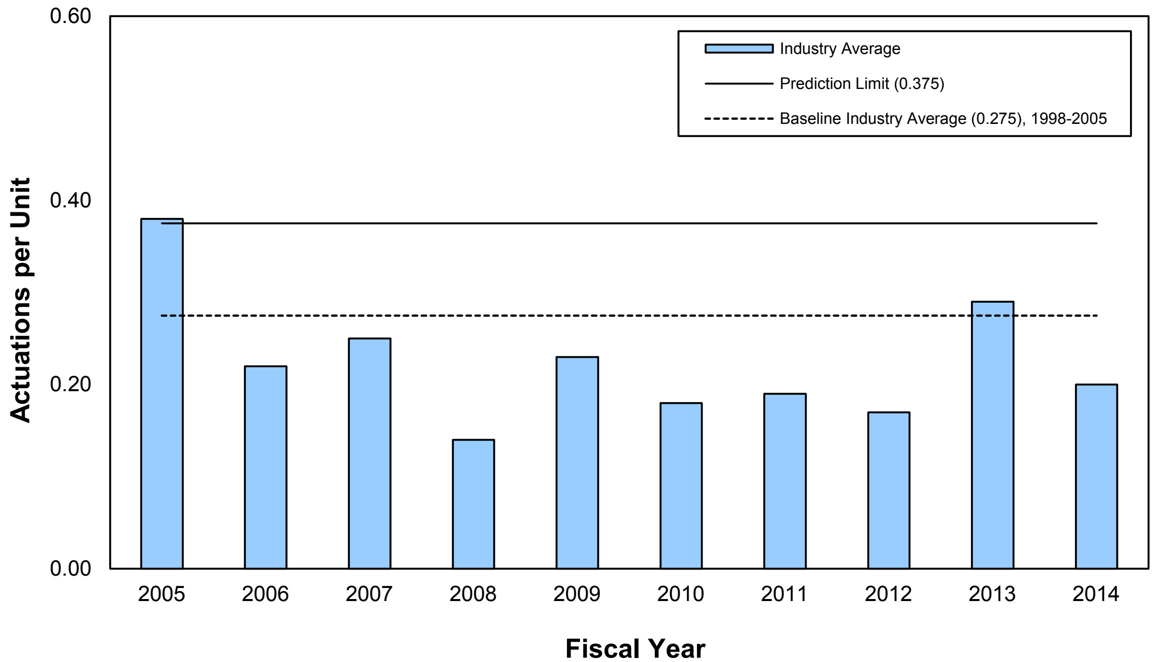

Figure 2. Safety-system actuations

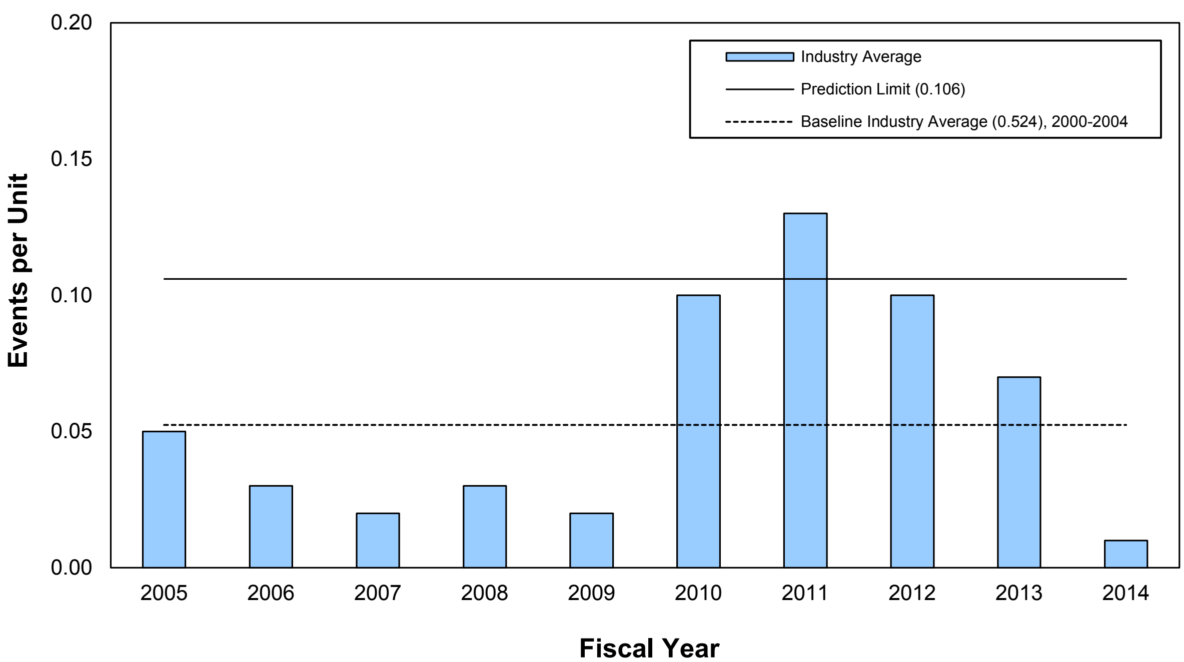

Figure 3. Significant events (FY 2014 inputs are not yet complete)

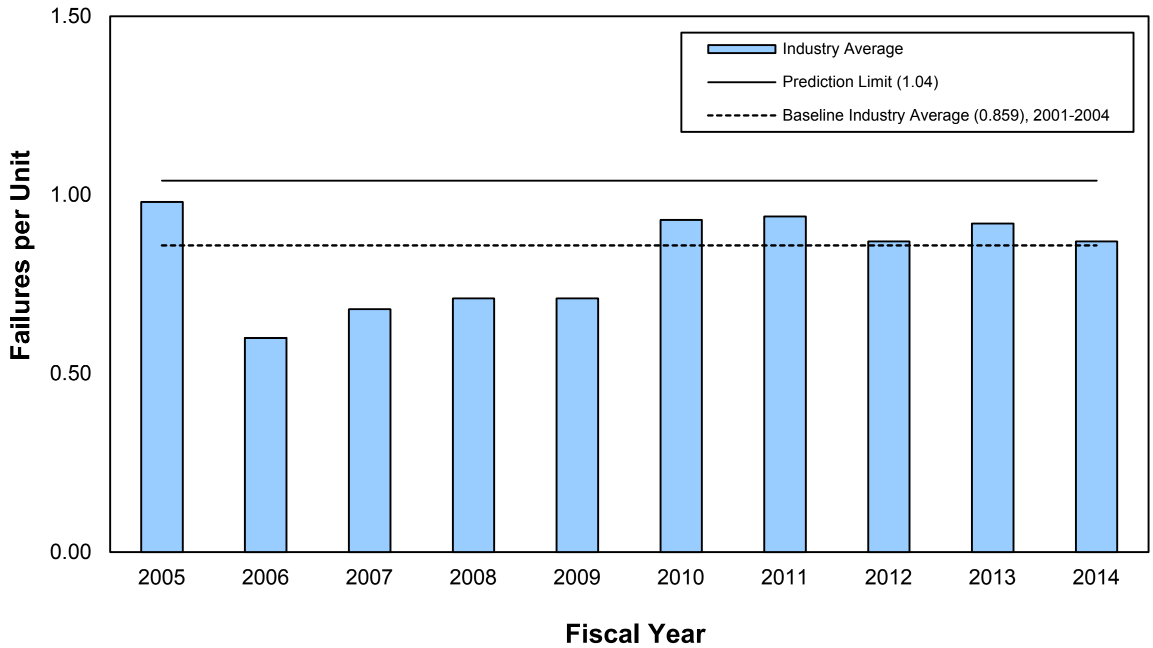

Figure 4. Safety-system failures

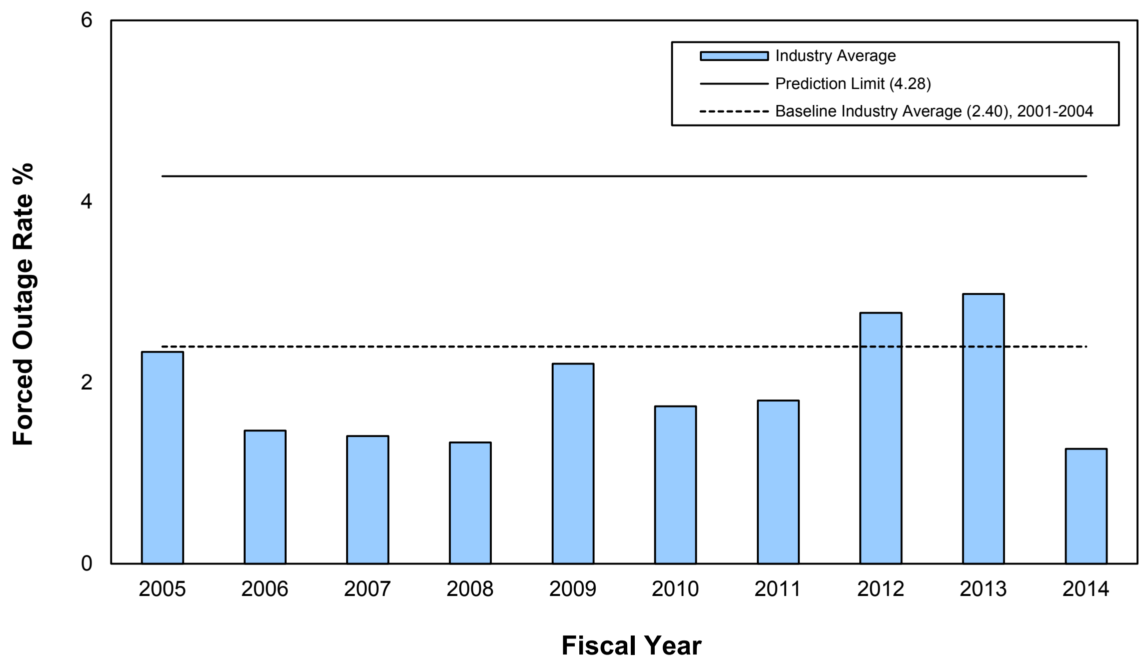

Figure 5. Forced outage rate

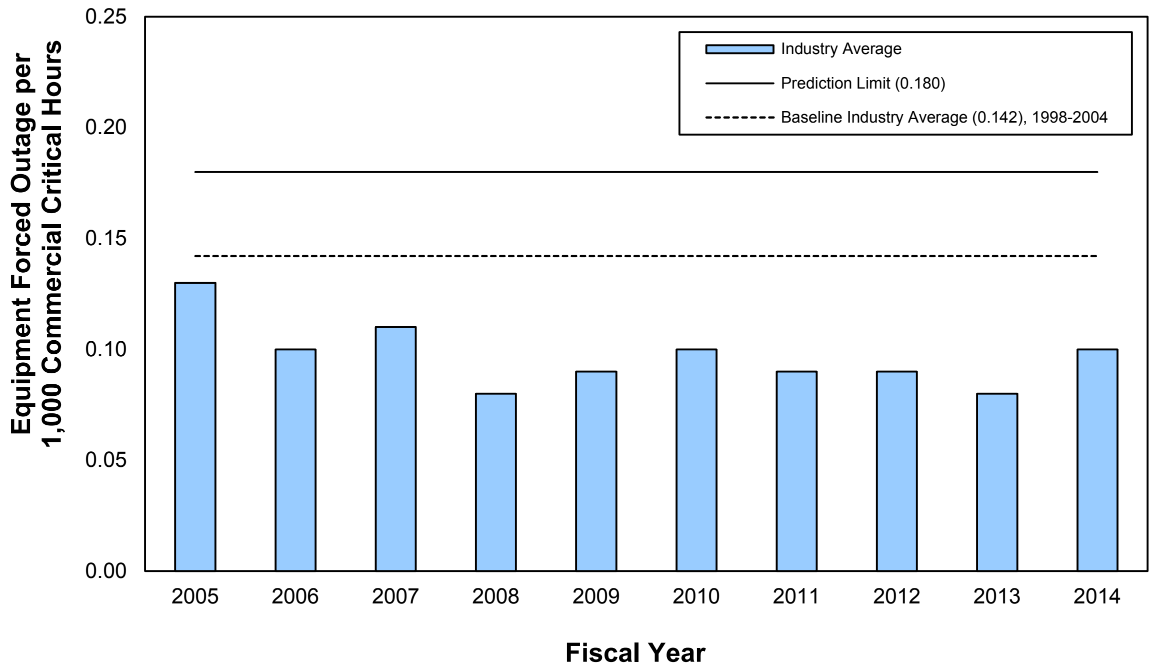

Figure 6. Equipment forced outages

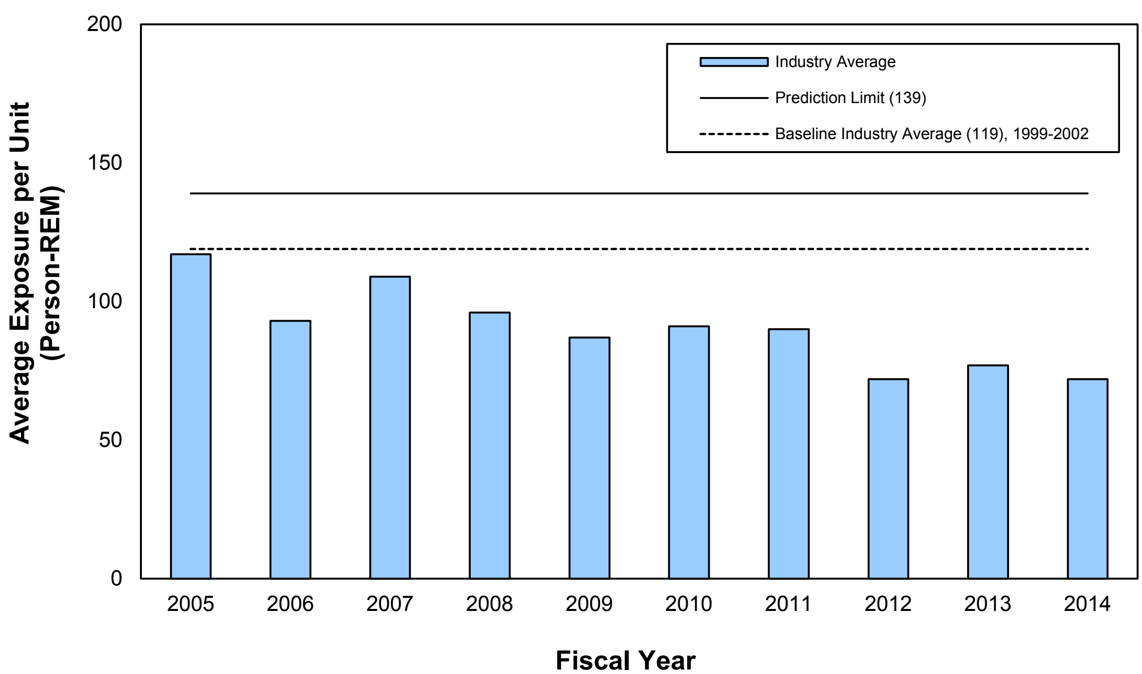

Figure 7. Collective radiation exposure

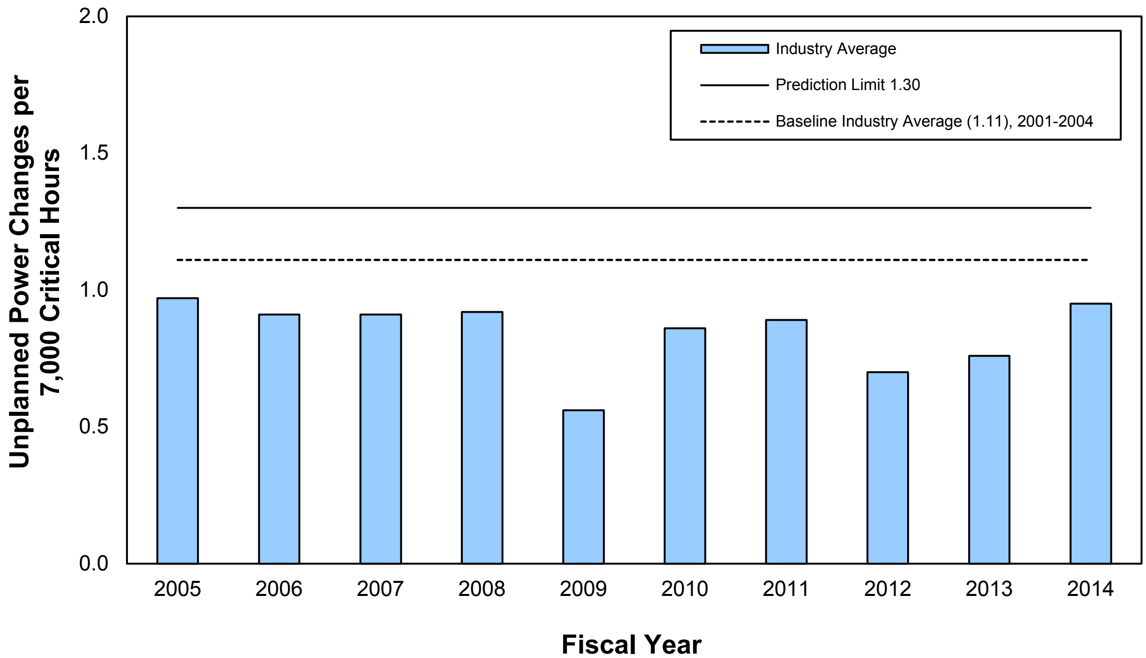

Figure 8. Unplanned power changes per 7,000 critical hours

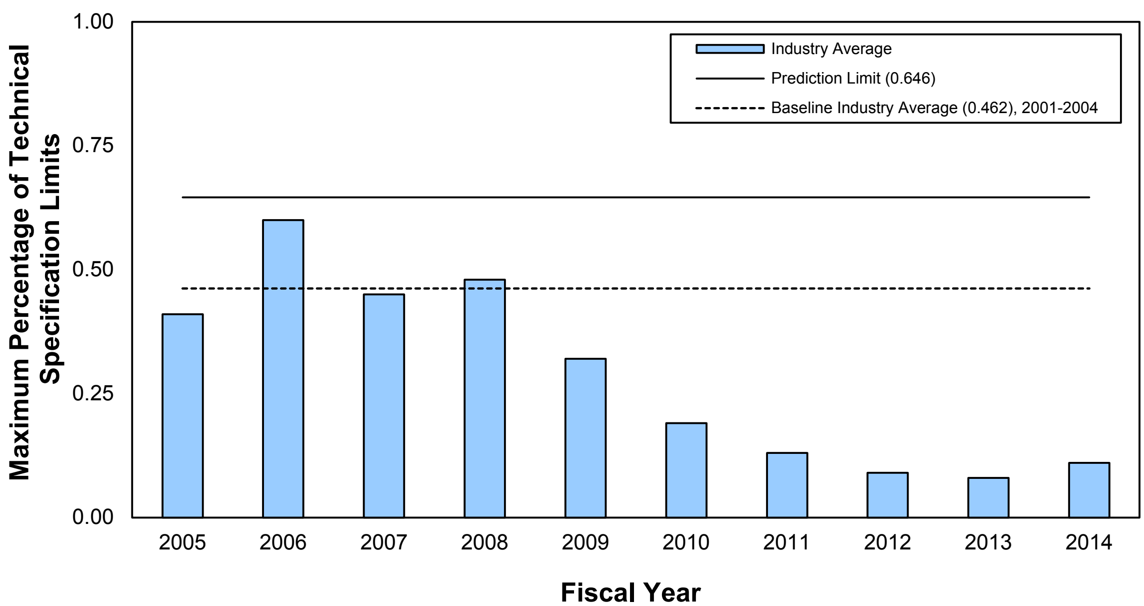

Figure 9. Reactor coolant system activity

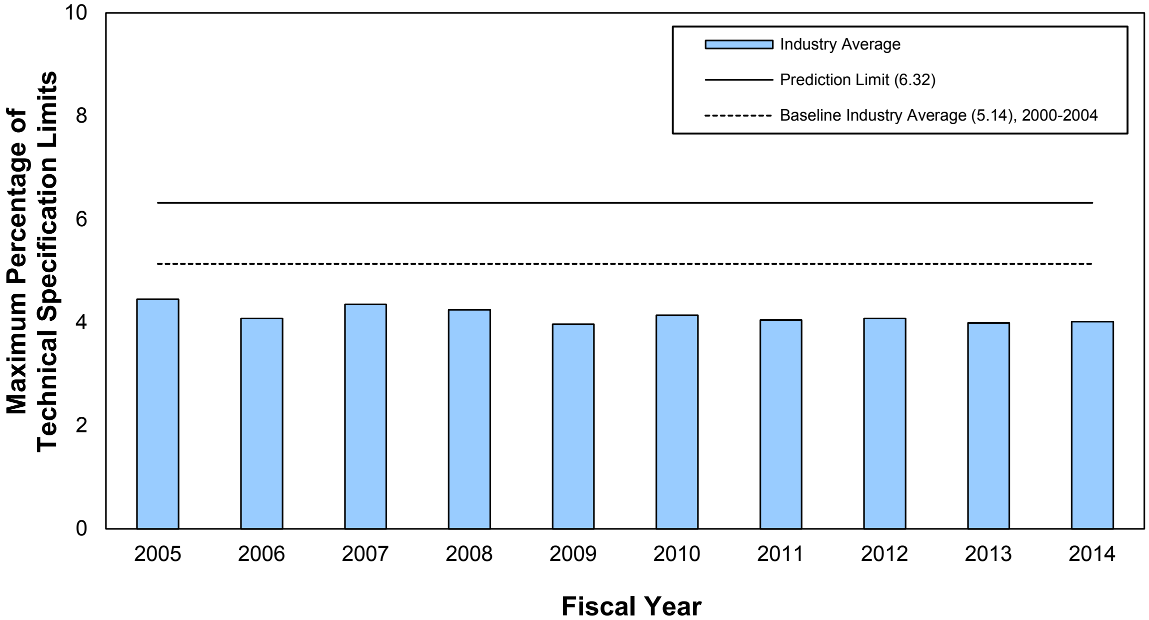

Figure 10. Reactor coolant system leakage

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

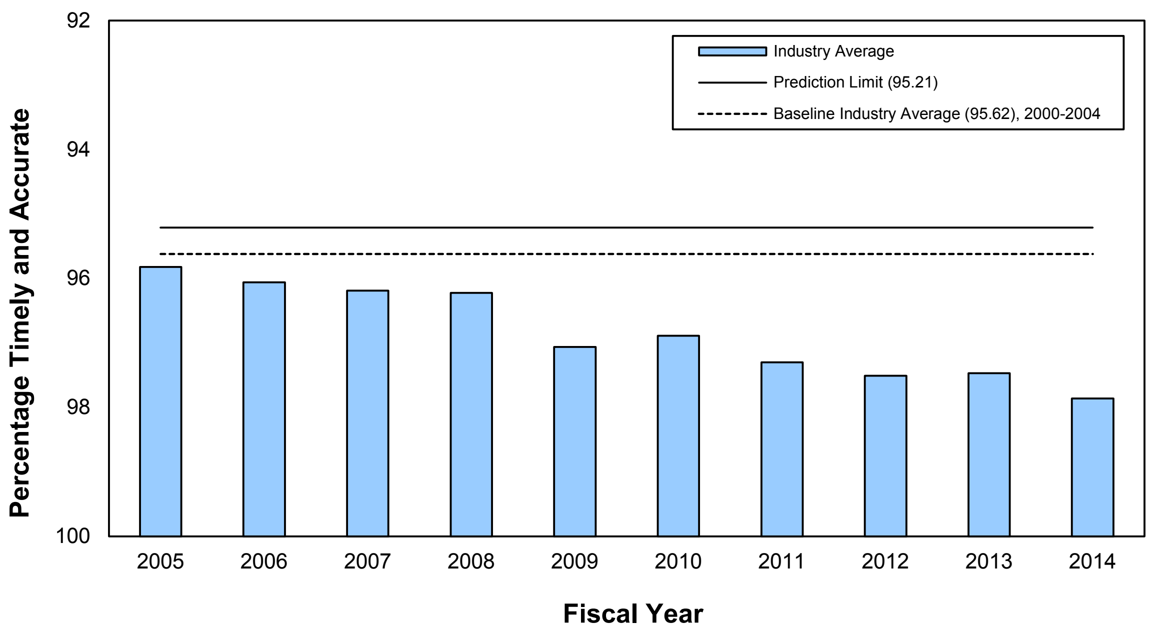

Figure 11. Drill and exercise performance

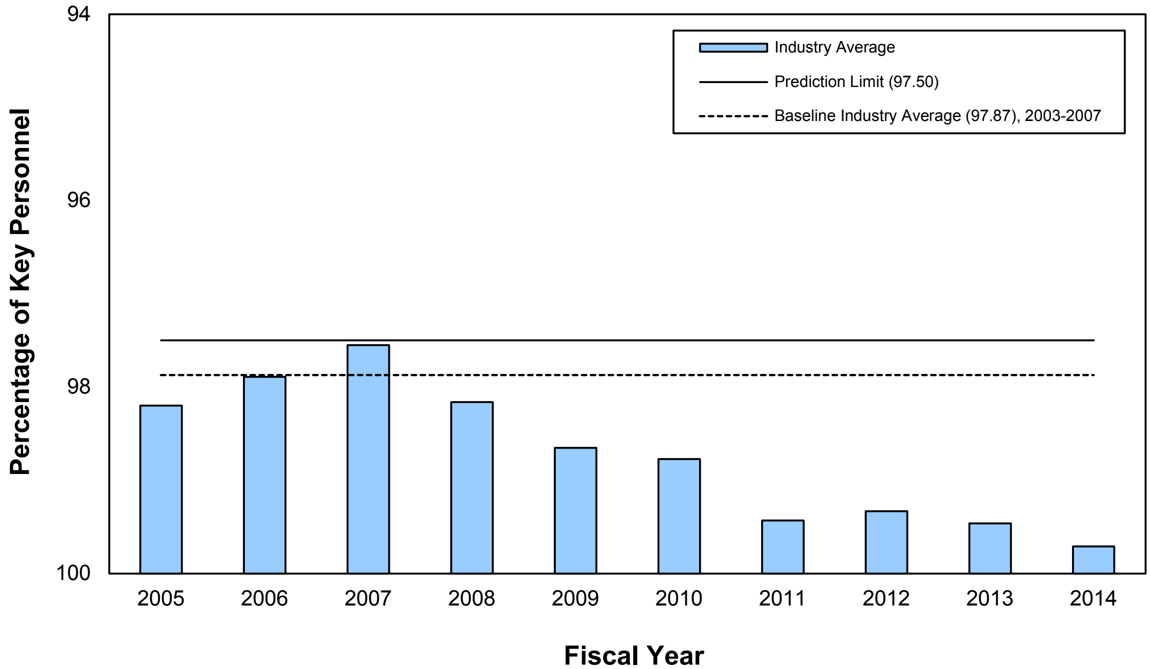

Figure 12. Emergency response organization drill participation

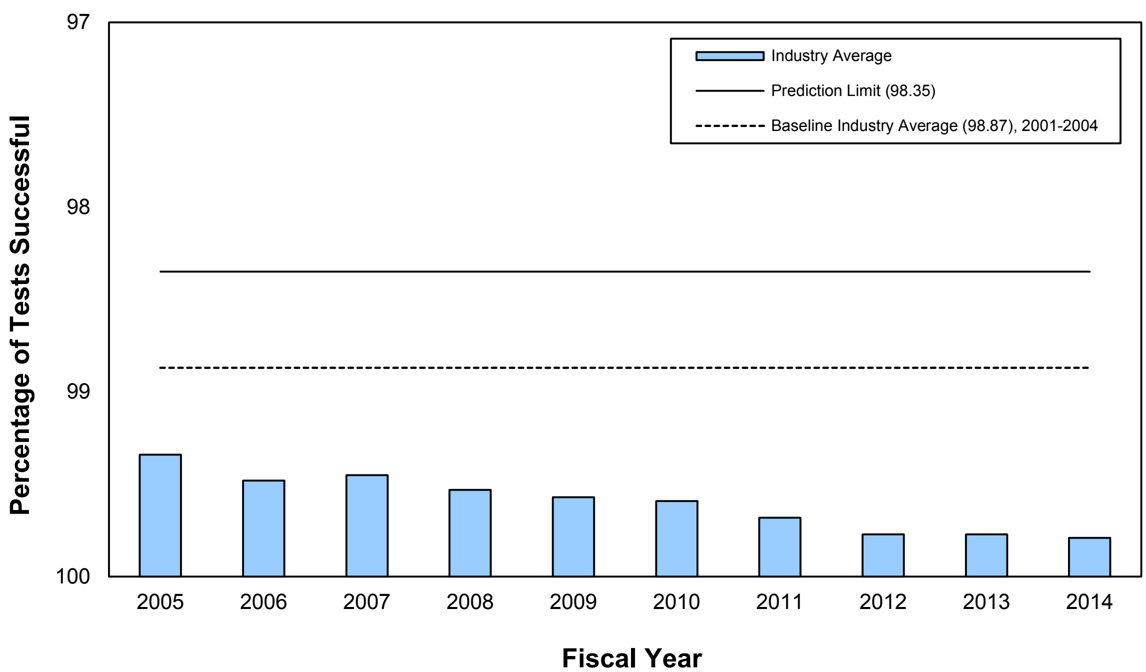

Figure 13. Alert and notification system reliability

SUMMARY OF BASELINE RISK INDEX FOR INITIATING EVENTS: ANNUAL GRAPHS THROUGH FISCAL YEAR 2014

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 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 might 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 about 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) 2014 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 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 2014 (-2.53×10^{-6} per reactor critical year) shows 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.

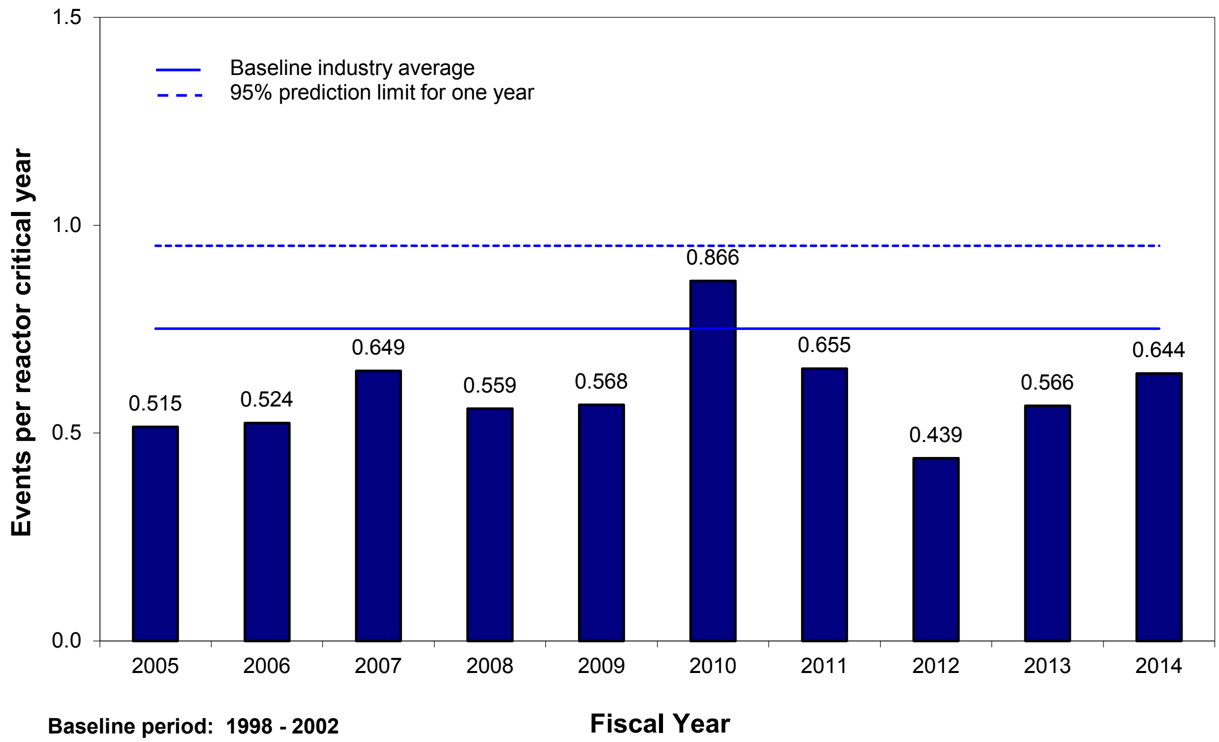

Figure 1. Pressurized-water reactor (PWR) general transients

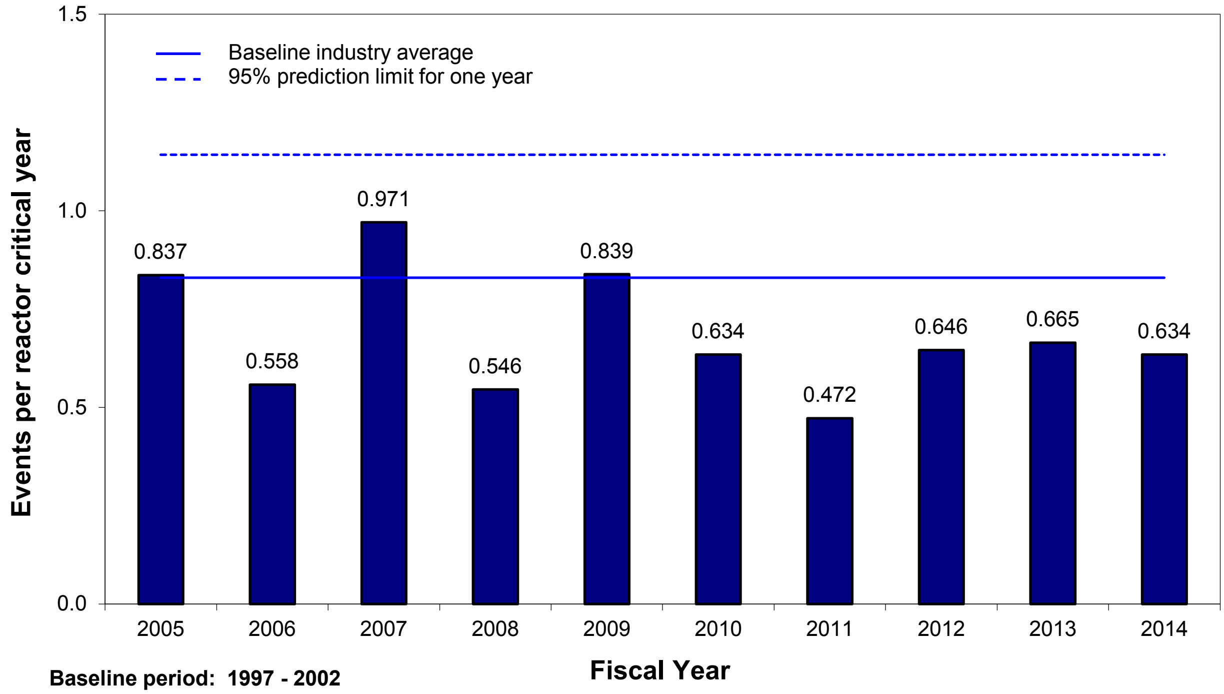

Figure 2. Boiling-water reactor (BWR) general transients

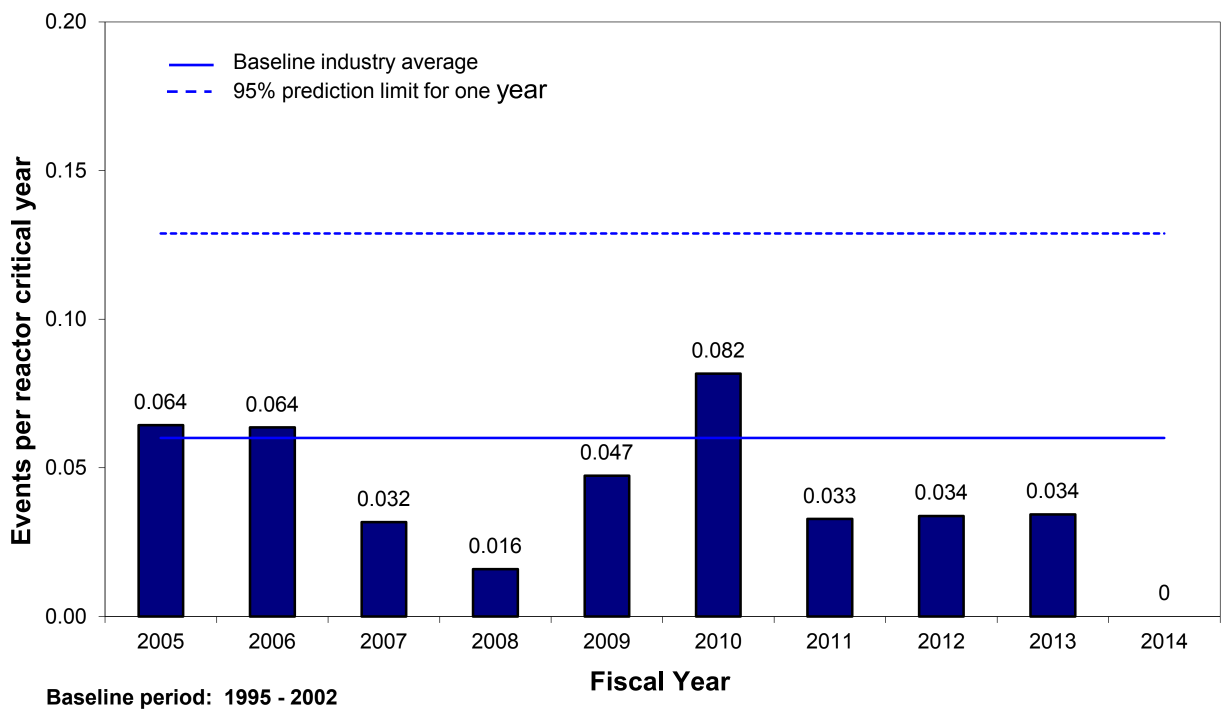

Figure 3. PWR loss of condenser heat sink

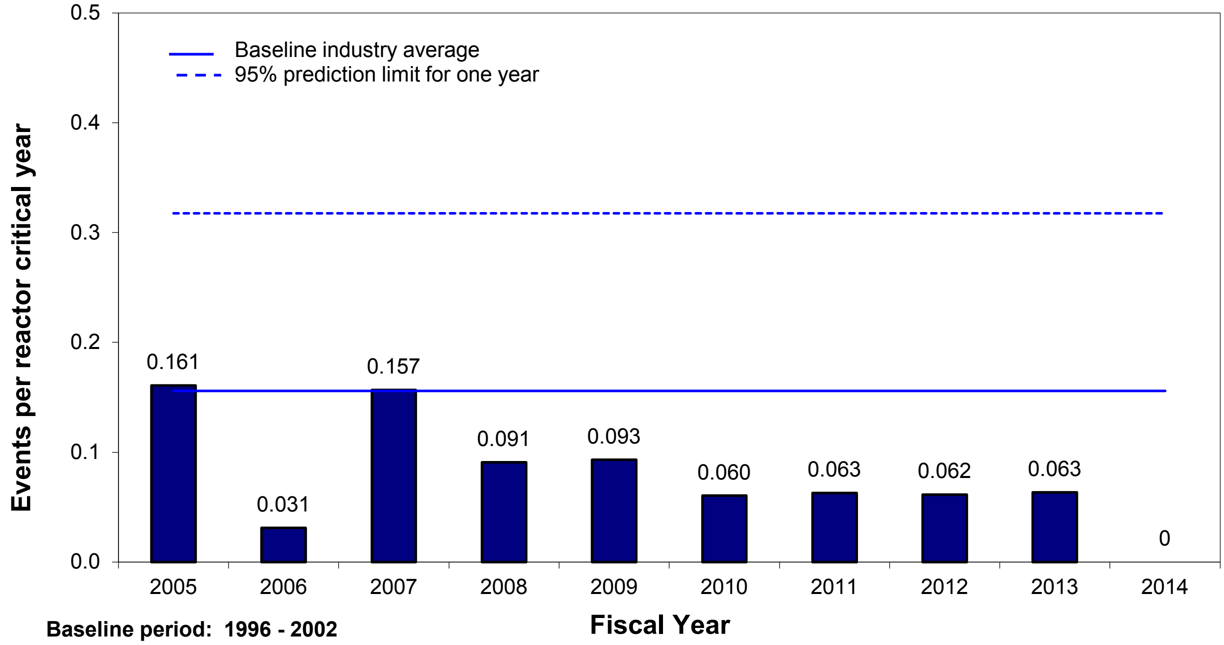

Figure 4. BWR loss of condenser heat sink

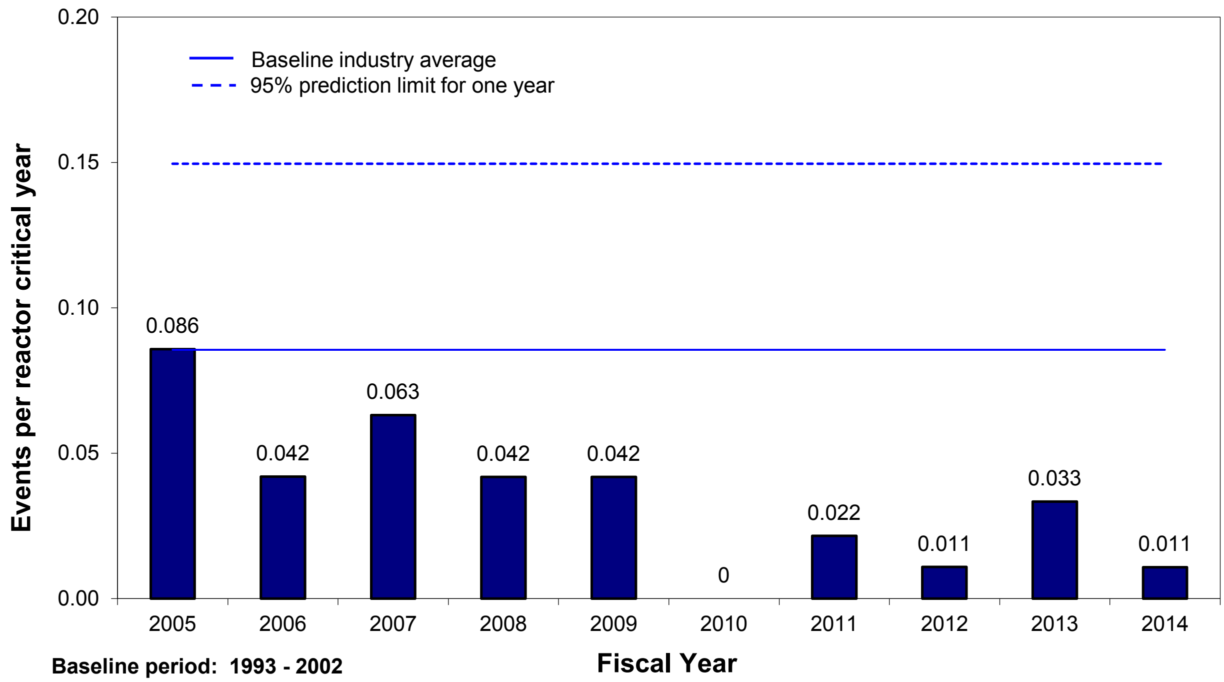

Figure 5. Loss of main feedwater

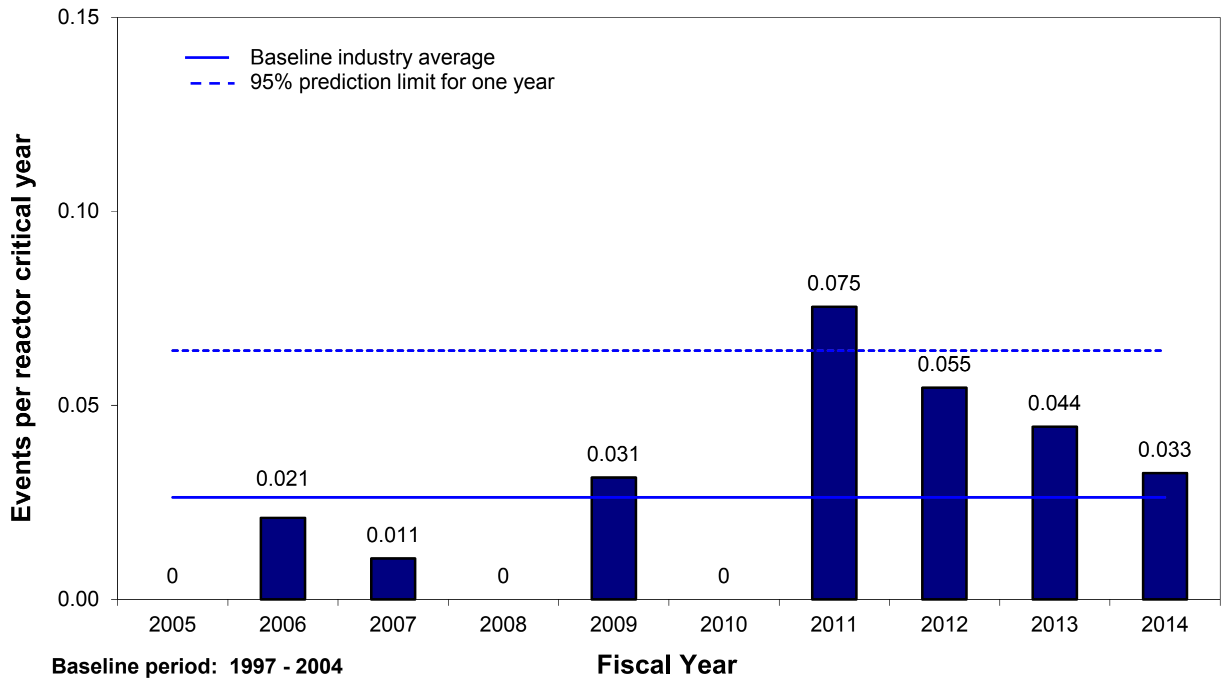

Figure 6. Loss of offsite power

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.

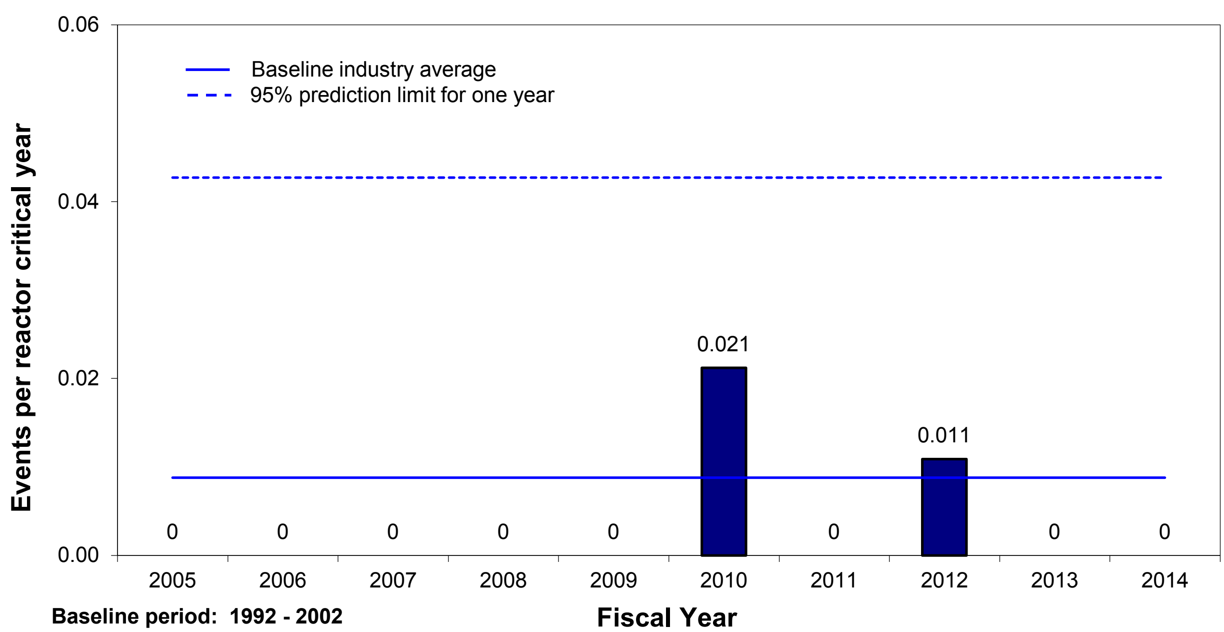

Figure 7. Loss of vital alternating-current bus

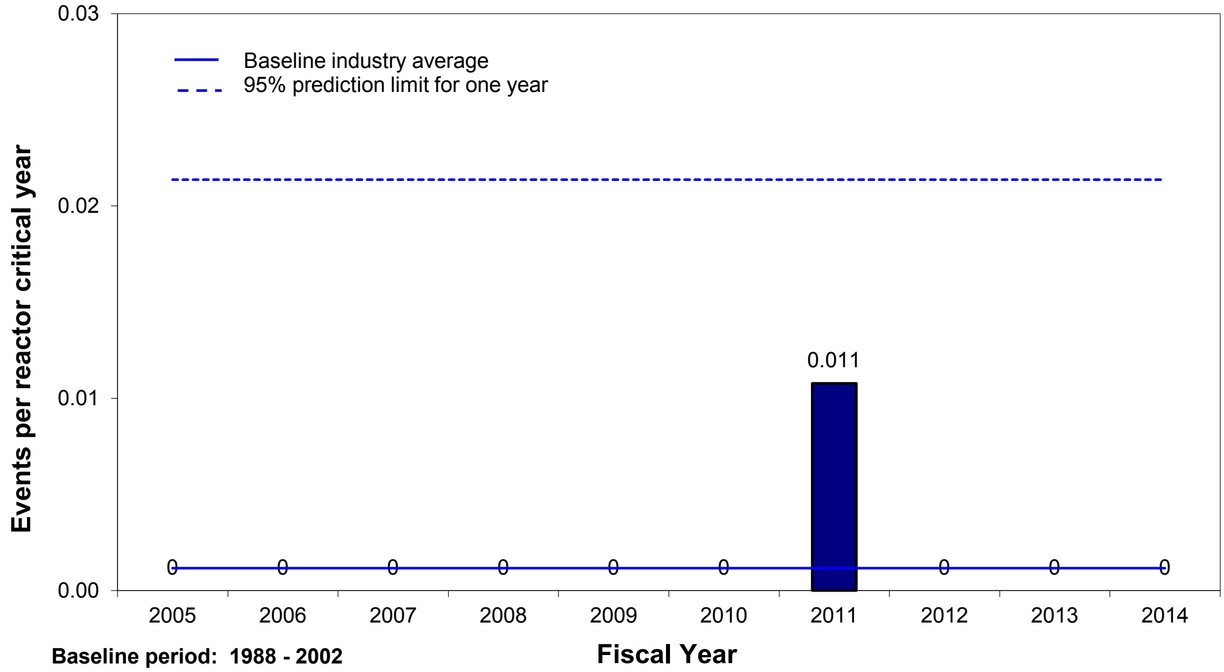

Figure 8. Loss of vital direct-current bus

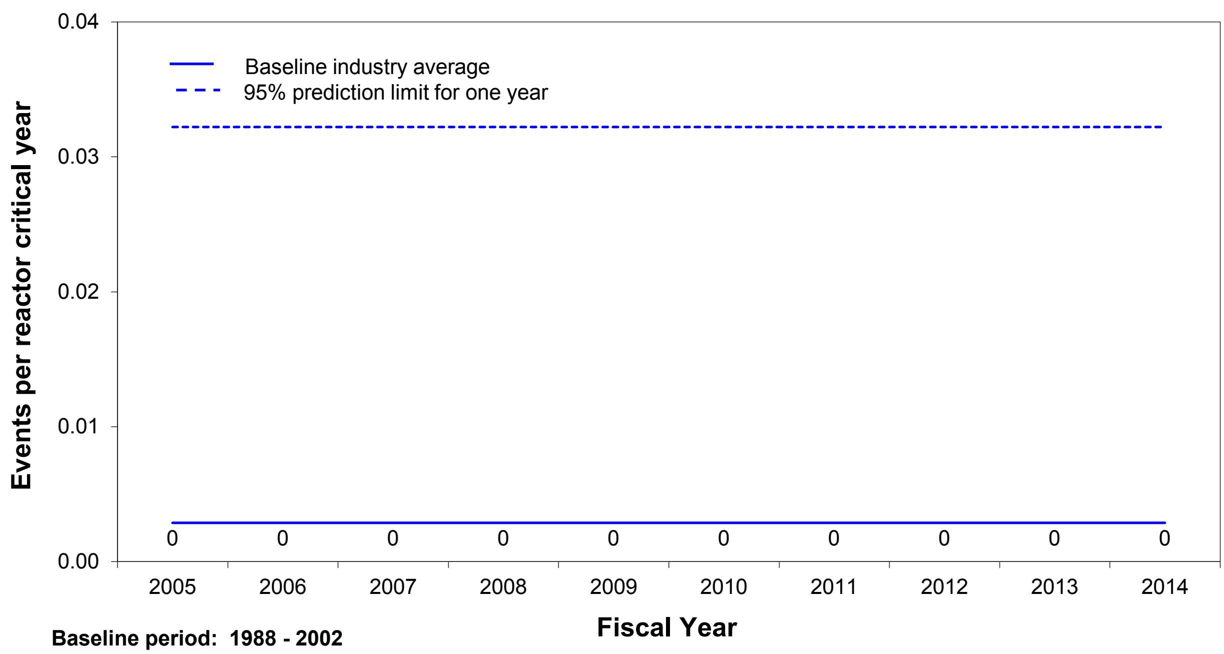

Figure 9. PWR stuck-open safety or relief valve

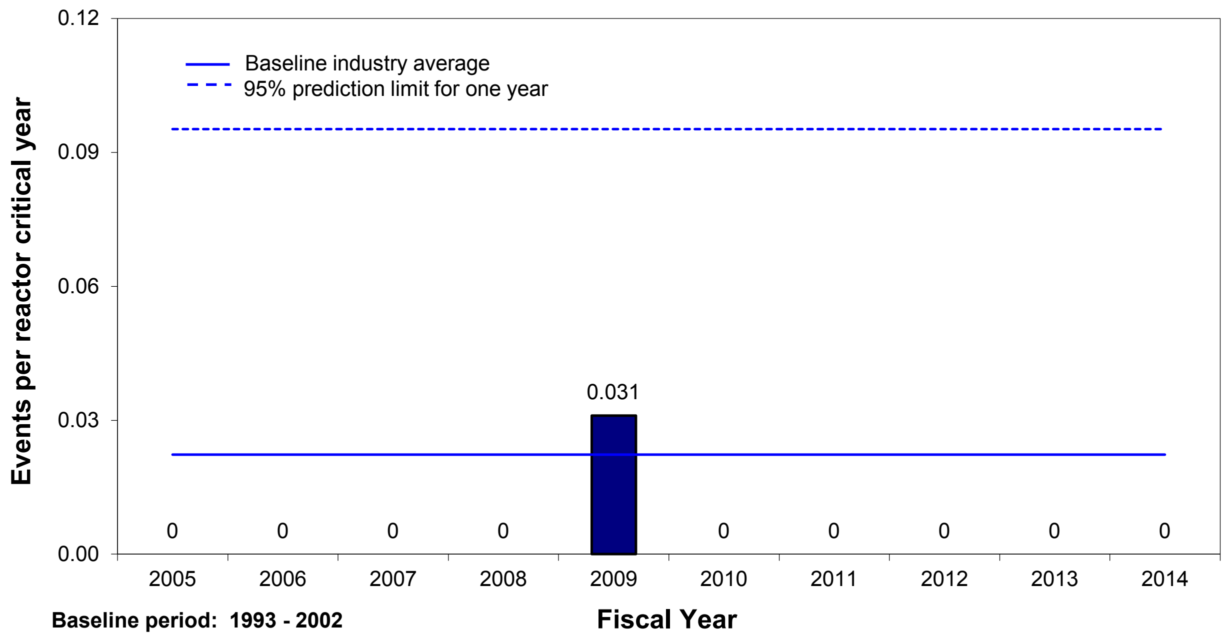

Figure 10. BWR stuck-open safety or relief valve

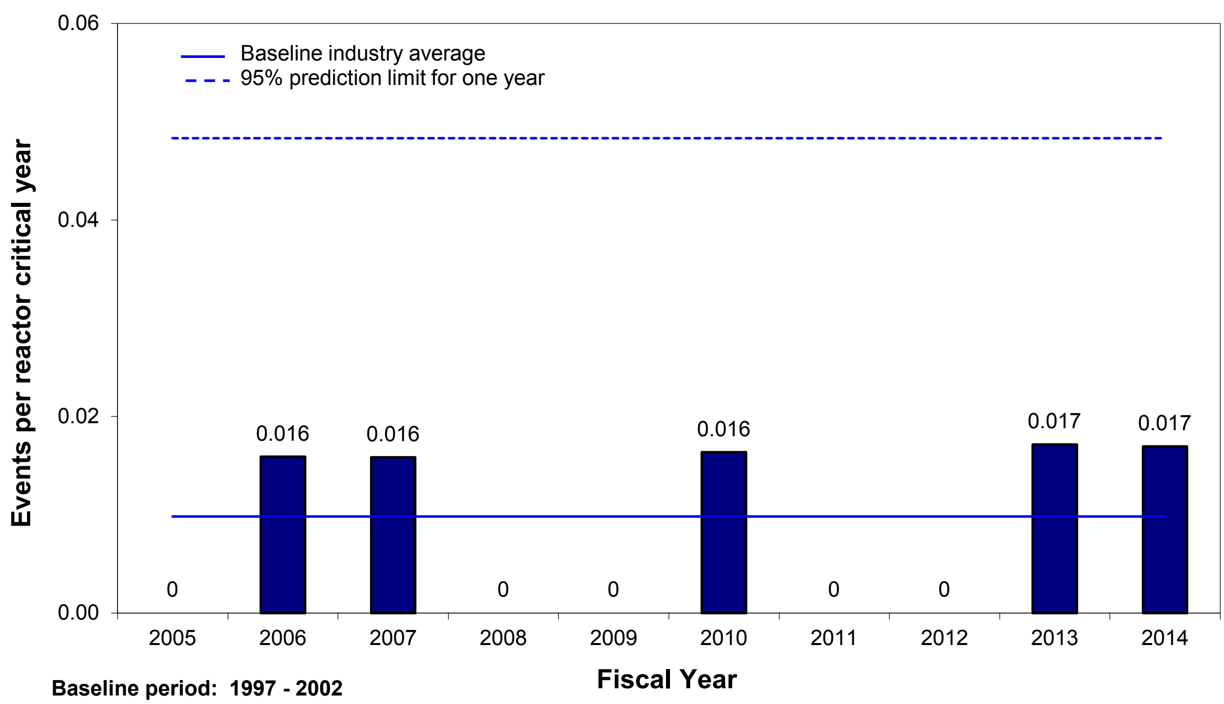

Figure 11. PWR loss of instrument air

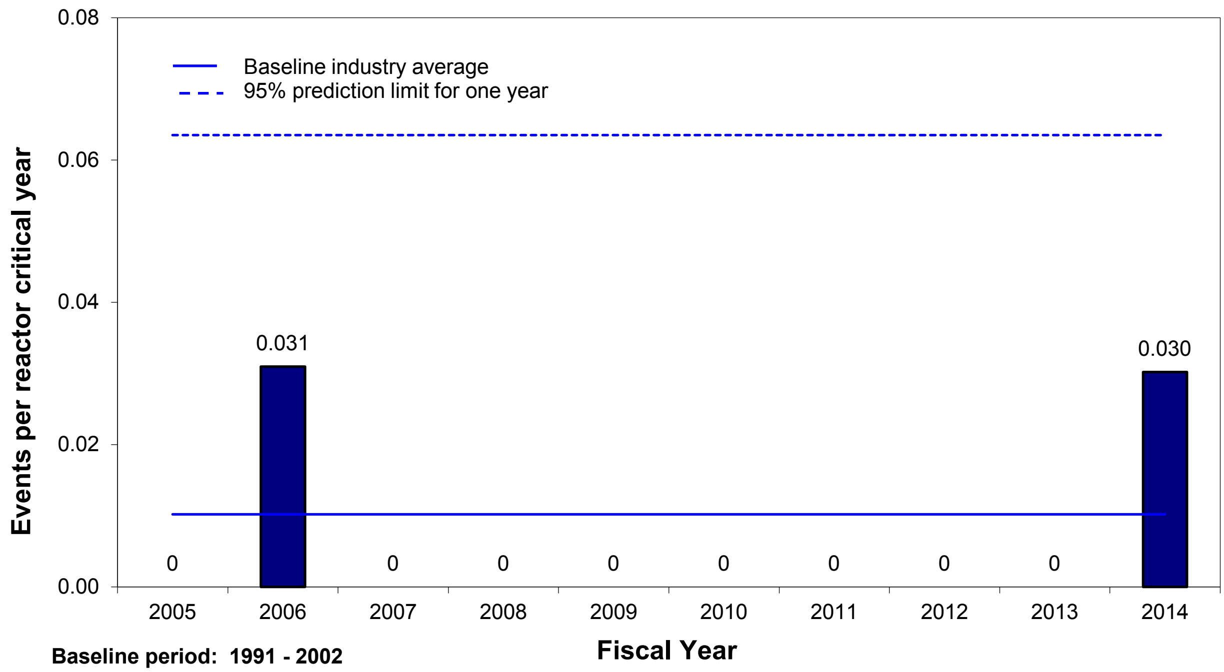

Figure 12. BWR loss of instrument air

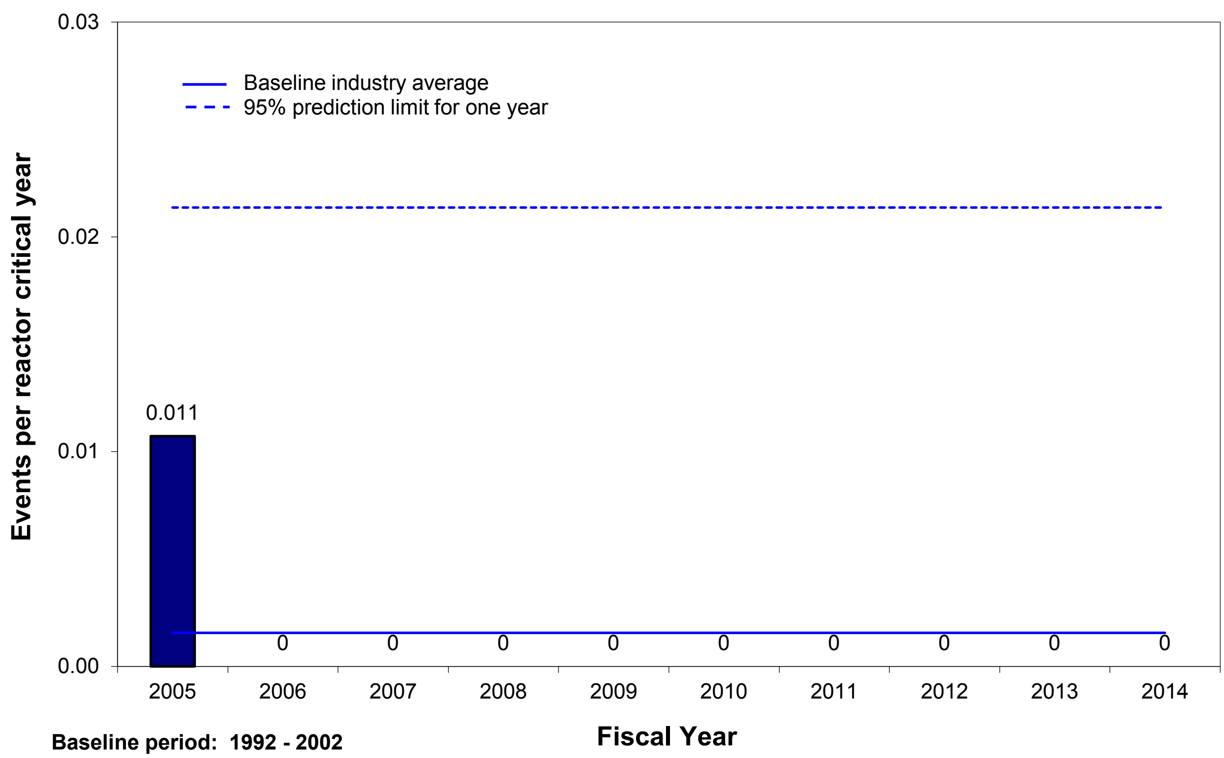

Figure 13. Very small loss-of-coolant accident

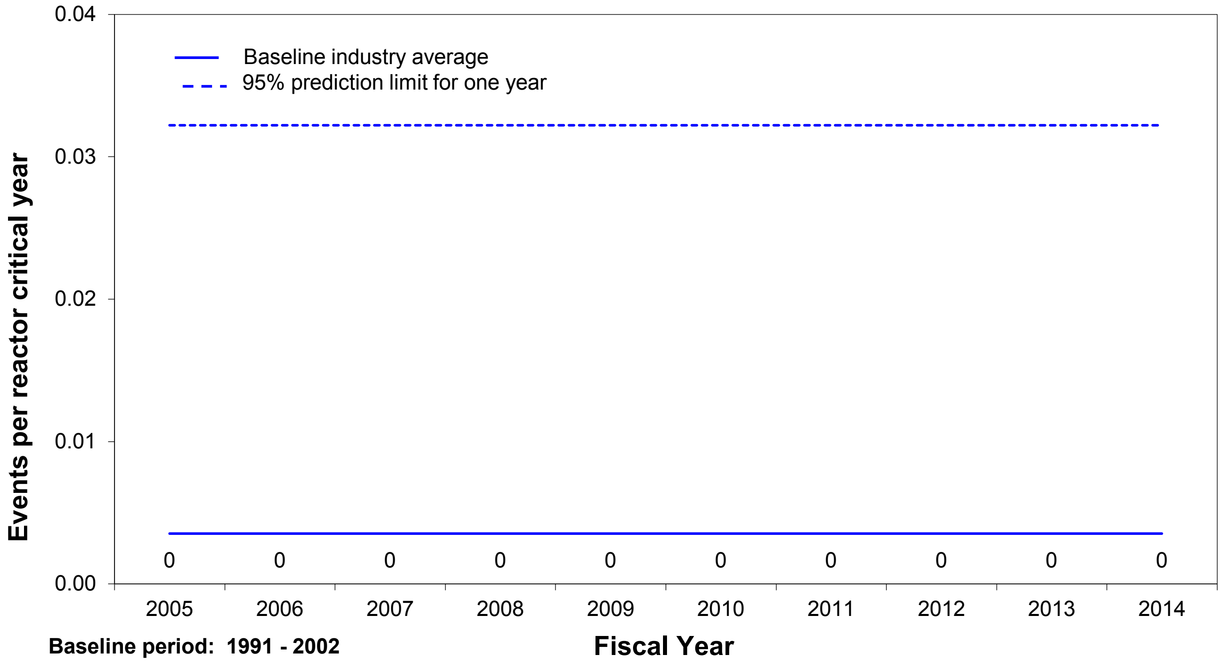

Figure 14. PWR steam generator tube rupture

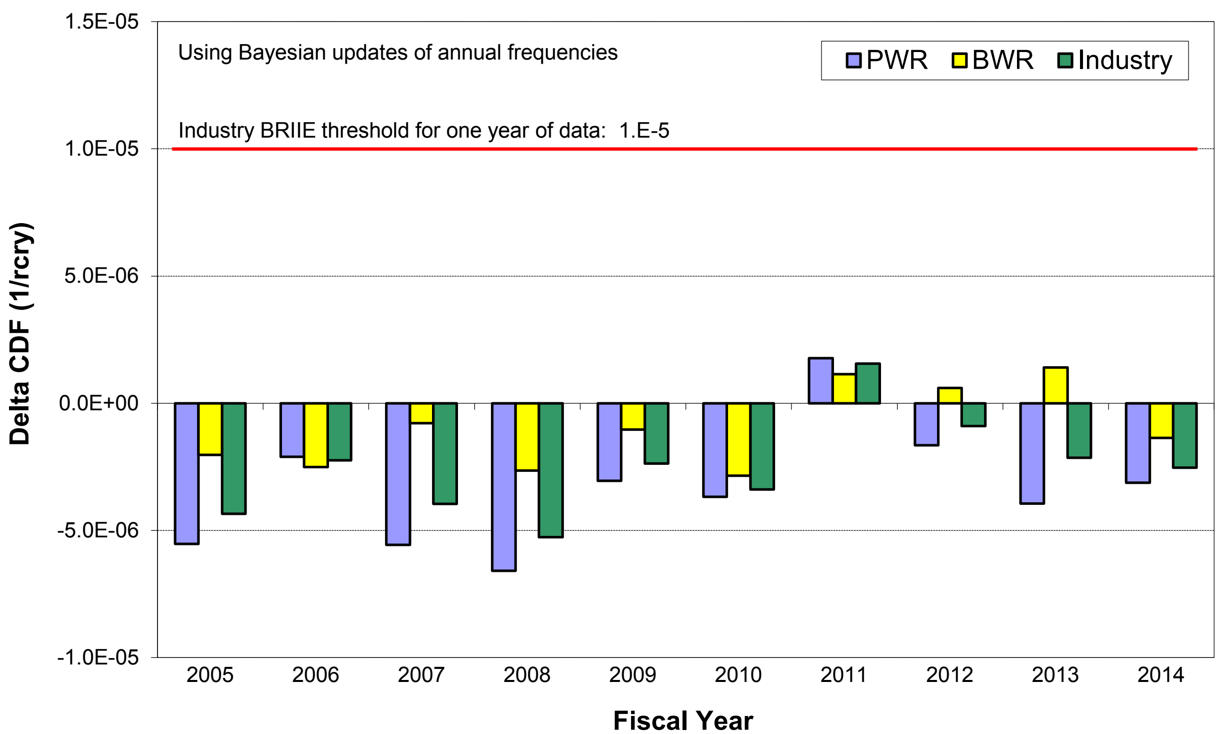

Figure 15. BRIIE Tier 2 (ΔCDF)