POLICY ISSUE
NOTATION VOTE

October 22, 2007 SECY-07-0184

FOR: The Commissioners

FROM: Luis A. Reyes
Executive Director for Operations

SUBJECT: INDUSTRY TRENDS PROGRAM FOR OPERATING POWER REACTORS - BASELINE RISK INDEX FOR INITIATING EVENTS

PURPOSE:

To request Commission approval to implement the Baseline Risk Index for Initiating Events (BRIIE), a new performance indicator for the Nuclear Regulatory Commission's (NRC) Industry Trends Program (ITP).

SUMMARY:

The staff proposes to implement the BRIIE, a new performance indicator in the ITP. NRC staff developed the BRIIE indicator to provide a risk-based index which will serve to assess overall industry performance with regard to the frequency of selected initiating events. The BRIIE will monitor a number of risk-significant initiating events, assign an importance measure to each event according to the relative contribution of the event to industry core damage frequency, and calculate an integrated, industry-level, risk-based indicator for the initiating events cornerstone. Once implemented, the staff will include BRIIE results in the annual Commission paper on the ITP results.

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BACKGROUND:

Since the ITP was initiated, the staff has looked to incorporate risk information into the ITP. In SECY-01-0111, "Development of an Industry Trends Program for Operating Power Reactors," the staff stated that they were working to develop a more objective, predictable approach to establishing risk-informed thresholds used to assess trends in indicators and to determine the appropriate agency response. In the staff requirements memorandum related to SECY-01-0111, dated August 2, 2001, the Commission directed the staff to develop risk-informed thresholds for the industry-level indicators "as soon as practicable."

In SECY-02-0058, "Results of the Industry Trends Program for Operating Power Reactors and Status of Ongoing Development," dated April 1, 2002, the staff reported on the development of additional risk-informed indicators for the initiating events cornerstone, consisting of multiple indicators of initiating events for both pressurized water reactors (PWRs) and boiling water reactors (BWRs). This effort involved updating the data that were most recently published in NUREG/CR-5750, "Rates of Initiating Events at U.S. Nuclear Power Plants: 1987–1995."

At this point, the staff determined that a single indicator, which combines the initiating events, would be more effective than having numerous indicators for each type of initiating event. During Fiscal Year (FY) 2002, the staff built on the prior work by developing an overall industry-level indicator. This overall indicator of initiating events, initially called the Industry Initiating Events Performance Indicator (IIEPI), consisted of an index of the most risk-significant industry initiating events. This set of events is defined in NUREG-1753, "Risk-Based Performance Indicators: Results of Phase 1 Development," as those events that contribute more than one percent to industry core damage frequency and that have occurred at least once between 1987 and 1995.

The electric grid blackout event of 2003 temporarily redirected staff attention and suspended development work. Work resumed in FY 2006. The result of the staff's efforts was the development of: (1) an index for BWRs that monitors nine risk-significant initiating events; and (2) a similar index for PWRs that monitors 10 events (the additional event category is steam generator tube rupture). The index weighs each initiating event according to its relative contribution to industry core damage frequency. The indicator was renamed BRIIE, the baseline risk index for initiating events.

The BRIIE development effort has benefited from stakeholder interaction which included: (1) a request for public review of a draft version of the BRIIE and the resolutions of comments received through the public review process; (2) a detailed presentation to the Advisory Committee on Reactor Safeguards on May 7, 2003, on the draft BRIIE methods and results with additional comments and suggestions for final development of the BRIIE; and (3) a public workshop on the draft BRIIE methodology held at NRC Headquarters on July 30, 2003. That interaction also resulted in stakeholder feedback concerning the draft BRIIE.

In addition, the BRIIE benefited from work leading up to implementation of the Mitigating System Performance Index in 2006. The MSPI included a significant effort to address issues related to the quality of licensee probabilistic risk assessment models and the NRC's Standardized Plant Analysis Risk (SPAR) models. That work led to a comprehensive program to upgrade the SPAR models based on cut-set-level comparisons with licensee risk models. This helped to improve the Birnbaum importance measures (a measure of the risk of each initiating event) used in the BRIIE and ensured that they are adequate for this application.

DISCUSSION:

The NRC staff implemented the ITP in 2001 and uses the ITP industry-level indicators to monitor for adverse trends in industry performance. Should adverse trends arise, further staff evaluation of the likely causes would follow, and if appropriate, changes to the NRC regulatory framework could be made.

The BRIIE concept uses a three-step process to enhance the ITP:

Step 1 - Identify appropriate risk-significant categories of initiating events;

Step 2 - Trend and establish performance-based prediction limits for these individual event categories (Tier 1 performance monitoring); and

Step 3 - Calculate an integrated, risk-informed indicator by assigning a risk importance factor to each initiating event category according to its relative contribution to industry core damage frequency (CDF) in order to calculate a change in CDF (ΔCDF) from a baseline CDF (Tier 2 performance monitoring).

A summary description of the BRIIE is provided in the enclosure. A detailed description and the technical basis for the BRIIE is in NUREG/CR-6932 (INLEXT-06-11950), “Baseline Risk Index for Initiating Events (BRIIE),” published in June 2007. The BRIIE has now been developed to the point that it is ready to be incorporated into the ITP. Data collection for the BRIIE has been ongoing as part of the development effort.

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. The threshold for reporting BRIIE results to Congress as part of the adverse industry trends metric has been set at a value of $1x10^{-5}$ per reactor critical year and it is associated only with the ΔCDF BRIIE calculations for industry-wide results. This threshold value was arrived at from considerations of the NRC safety goals, RG 1.174, and consistency with the ROP and Accident Sequence Precursor (ASP) programs. As an industry-wide indicator, the BRIIE is not an input to the Reactor Oversight Process (ROP) Action Matrix, and will not directly affect NRC oversight of individual plants.

NRC Inspection Manual Chapter 0313, “Industry Trends Program,” contains ITP details, including program descriptions and definitions of the indicators. BRIIE will be included in this Inspection Manual Chapter.

As part of BRIIE implementation, the staff has also developed a communication plan to inform NRC internal and external stakeholders of the use of BRIIE as a new, industry-wide indicator.

The staff will use available NRC communication tools such as Congressional Reports (NUREG-1100 and NUREG-1542), Commission Papers, Public Meetings/Workshops, the Regulatory Information Conference, and the NRC Web site. These will ensure that the following key messages are clearly communicated:

- The NRC's highest priority is protection of public health, safety, and the environment.
- The BRIIE is intended to enhance and complement the ITP, not as a replacement for the ITP.
- The NRC staff has undertaken efforts that will enhance the accuracy, effectiveness, and efficiency of the ITP and the process to evaluate nuclear industry safety performance.
- The BRIIE indicator of nuclear industry safety performance provides a mechanism for determining the risk significance of changes in industry performance at both the individual initiating event level and at the integrated cornerstone of safety level.
- The BRIIE concept consists of a two-tier process. The first tier provides short-term trending information and an action point for NRC engagement. The second tier provides a risk perspective of industry performance as a change from a baseline CDF value.

The communication plan includes a matrix that identifies: (1) the internal and external stakeholders; (2) the information needs of the various stakeholders; (3) the way the information will be communicated to the stakeholders; (4) the date and frequency at which the information will be communicated; and (5) the person(s)/groups responsible for communicating the information to the stakeholders. This communication plan is currently available on the NRC internal Web page at http://www.internal.nrc.gov/communications/plans/active-plans.html.

COMMITMENTS:

Upon Commission approval, the staff will incorporate the BRIIE into NRC Inspection Manual Chapter 0313 and will formally use BRIIE results as an ITP indicator, starting with the annual Commission paper on the FY 2007 ITP results (to be issued in early 2008).

RESOURCES:

The data needed for BRIIE calculation are already being collected as part of the ITP. No new data collection is necessary. In FY 2008, for the Office of Nuclear Reactor Regulation, $450,000 and 0.5 full-time equivalents (FTE) are needed to support ITP and BRIIE implementation. Currently, $325,000 and 0.5 FTE are budgeted. The remaining $125,000 needed for contractor support of the ITP will be reallocated from lower priority work in the ROP. For FY 2009, approximately $475,000 for contractor support and 0.5 FTE are needed and are included in the FY 2009 budget request. The NRC Office of Nuclear Regulatory Research (RES) provides indirect support to the ITP in the areas of operating experience data, and models developed and budgeted under other RES programs such as the SPAR Program and the Reactor Operating Experience Data Collection and Analysis Program.

COORDINATION:

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

/RA/

Luis A. Reyes
Executive Director
for Operations

Enclosure:
Baseline Risk Index for Initiating Events

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Baseline Risk Index for Initiating Events

The staff has developed the Baseline Risk Index for Initiating Events (BRIIE), a performance indicator that provides a mechanism for determining the risk significance of changes in industry performance, at both the individual initiating event level and at the integrated cornerstone of safety level.

A. BRIIE Derivation

A three-step process is used to derive the BRIIE:

Step 1 - Identify appropriate risk-significant categories of initiating events;

Step 2 - Trend and establish performance-based prediction limits for these individual event categories (Tier 1 performance monitoring); and

Step 3 - Calculate an integrated, risk-informed indicator by assigning a risk importance factor to each initiating event category according to its relative contribution to industry core damage frequency (CDF) in order to calculate a change in CDF (ΔCDF) from a baseline CDF (Tier 2 performance monitoring).

Step 1 - Identification of Risk-Significant Initiating Events

The list of risk-significant initiating event types consists of 10 initiating event categories applicable to pressurized-water reactors (PWRs) and 9 applicable to boiling-water reactors (BWRs) as listed below in Table 1:

Table 1 - Risk-significant initiating event categories covered by the BRIIE

Pressurized Water Reactors (PWRs)	Boiling Water Reactors (BWRs)
1. Loss of offsite power (LOOP)	1. Loss of offsite power (LOOP)
2. Loss of vital AC bus (LOAC)	2. Loss of vital AC bus (LOAC)
3. Loss of vital DC bus (LODC)	3. Loss of vital DC bus (LODC)
4. Loss of main feedwater (LOMFW)	4. Loss of main feedwater (LOMFW)
5. Very small loss of coolant accident (VSLOCA)	5. Very small loss of coolant accident (VSLOCA)
6. PWR general transient (TRAN)	6. BWR general transient (TRAN)
7. PWR loss of condenser heat sink (LOCHS)	7. BWR loss of condenser heat sink (LOCHS)
8. PWR stuck open safety/relief valve (SORV)	8. BWR stuck open safety/relief valve (SORV)
9. PWR loss of instrument air (LOIA)	9. BWR loss of instrument air (LOIA)
10. Steam generator tube rupture (SGTR)	

In general, these risk-significant initiating event types cover approximately 60 percent of the internal event core damage risk (excluding internal flooding) from the operating commercial nuclear power plants in the United States. Also, these initiating events do not overlap.

Step 2 - Performance Monitoring of Risk-Significant Initiating Event Categories
(Tier 1 Performance Monitoring)

Tier 1 performance monitoring activity consists of trending risk-significant initiating event categories and monitoring yearly industry performance against prediction limits. To accomplish this, the staff established up-to-date baseline frequencies for each of the risk-significant initiating event categories, and then determined performance-based prediction limits using these baseline frequencies and estimated yearly industry-total critical-reactor years of operation. The process is similar to the "prediction limit" process described in Appendix B of NRC Inspection Manual Chapter (IMC) 0313 for the ITP indicators. An example is presented in Figure 1 for one of the initiating events - PWR General Transients.

These Tier 1 activities are intended to help NRC identify degrading industry performance as an adjunct to the plant-specific performance assessment performed as part of the Reactor Oversight Process (ROP). Potential NRC responses if one or more of the prediction limits are reached or exceeded are outlined in Section E of this enclosure. Also, example scenarios are presented in Section E for illustrative purposes. Tier 1 activities and results are not reported to Congress but are used by NRC as a diagnostic tool to identify degrading industry performance before the emergence of any long-term adverse trends.

The Tier 1 results will be placed on the NRC Web site for access by interested stakeholders.

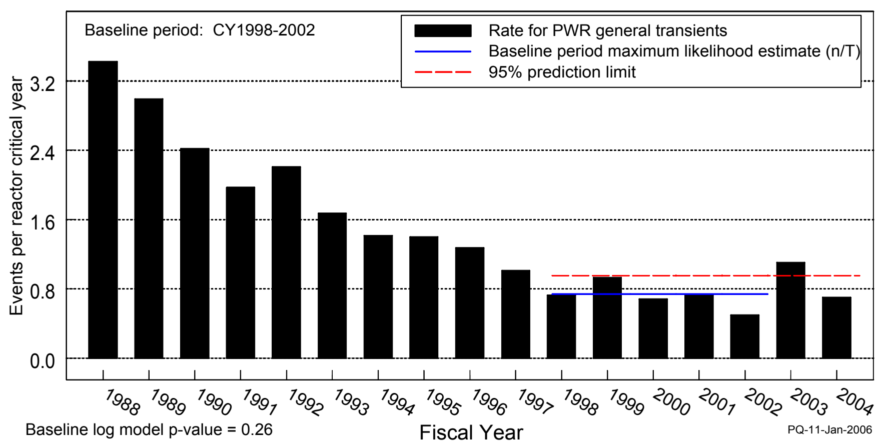

Figure 1 - Rate for PWR General Transients

Step 3 - Risk-Informed Monitoring of Initiating Events Cornerstone of Safety
(Tier 2 Performance Monitoring)

Tier 2 performance monitoring provides an evaluation of the risk significance of changes in industry initiating event category performance in an integrated, risk-informed performance indicator -- the Risk significance is evaluated in terms of ΔCDF. This indicator combines operating experience for risk-significant initiating event categories with information associated with internal event, CDF-based importance. Although Tier 2 does not provide strict trending information, it does provide an annual risk perspective of industry performance as a deviation from a baseline value and the proximity of the deviation from a set threshold.

Using BRIIE, the staff is able to appropriately combine frequent and infrequent initiating event category frequencies with different risk measures (i.e., Birnbaum importance measures). The main use of the BRIIE is to combine individual initiating event category performance changes into an integrated, risk-informed indicator at the Initiating Events Cornerstone of Safety level. The BRIIE solves several deficiencies in the present ITP: (1) no systematic and defined method for determining whether individual initiating event category performance changes or adverse trends are risk significant, (2) no systematic and defined method for integrating individual initiating event category performance changes into an overall risk result at the Cornerstone of Safety level, and (3) untimely risk-informed industry trend results. The staff proposes to use the results of the BRIIE in the ITP, along with the other qualified indicators, when reporting the number of adverse trends to Congress.

B. BRIIE Calculation

The quantification method used for formulating the related changes in CDF (ΔCDF) is given by the following:

$$BRIIE = \sum_{i=1}^{m} \overline{B_i} \left(\lambda_{ic}^{*} - \lambda_{ib} \right) \qquad \text{Equation (1)}$$

where

$\overline{B}_i$ = industry-average Birnbaum for initiating event *i*

λ_{ic}^{*} = common industry current frequency for initiating event *i*

λ_{ib} = baseline frequency for initiating event *i*

m = number of initiating events covered in BRIIE

BWRs and PWRs have different core damage frequencies, which depend to some extent on different initiating event types. The risk weights for various initiating events also are different for the two types of reactors. Therefore, BRIIE results are provided for each reactor type and the two BRIIE results are also combined into a single index that provides an indication of overall industry performance.

The BRIIE formulation in Equation (1), above, uses PWR- or BWR-average Birnbaum importance measures and combines the industry-wide data to generate the “common industry current frequency” for each initiating event category.

In order to ensure that the BRIIE indicator reflects current industry performance, industry performance for components and initiating events will be reviewed and baseline CDF will be recalculated periodically. The industry-average Birnbaum importance measure for each initiating event category also will be recalculated periodically.

C. Reporting Thresholds

BRIIE results, although representing industry-wide results, are presented as average results per plant. The PWR-wide impact is (PWR BRIIE result per PWR) $\times$ (total number of PWRs). Similarly, the BWR-wide impact is (BWR BRIIE result per BWR)$\times$ (total number of BWRs).

These industry-wide impacts were considered in establishing reporting thresholds for the BRIIE, together with the following information:

1. Uncertainty in the BRIIEs and the 95 and 99 percentiles from simulations

2. Distribution of the Birnbaum importance measures for each initiating event category and understanding of the groups of plants that have large values for each category

3. Major contributors (i.e., dominant initiating event categories) to the BRIIEs

4. Sensitivity of BRIIEs to initiating event categories, especially those with lower frequencies

5. Other factors, such as the NRC safety goal policy and Regulatory Guide 1.174

An expert panel was convened in July 2006 with the objective of reviewing the BRIIE and establishing a threshold value for reporting to Congress. The panel reached the following conclusions:

1. The two-tier process for BRIIE provides an accurate and full picture of industry performance. The two-tier process provides trending information and an action level for NRC engagement if the 95 percent prediction limit of Tier 1 is reached, as detailed in Appendix B of NRC Inspection Manual Chapter 0313. Tier 2 provides an annual risk perspective of industry performance as a deviation from a baseline value.

2. The presentation for BRIIE should be in a bar graph that provides three separate annual values: one bar providing industry-wide results, one bar for BWR results, and the third bar for PWRs. All three bars for each year will be presented on one graph. This presentation provides more information than simply aggregating industry-wide results into one number or presenting BWRs and PWRs individually.

3. The BRIIE should be in the form of ΔCDF. The absolute CDF form will be calculated and be available, if requested, as a communication tool to provide additional insights to interested stakeholders. The ΔCDF form of BRIIE is preferred because the absolute CDF form of BRIIE would result in different CDF values for BWRs and PWRs. The ΔCDF form shows the change from the baseline for both types of reactors and hence is more understandable. Infrequently occurring initiating events such as Loss of Service Water, Loss of Component Cooling Water, Small Loss of Coolant Accident, and others would not be included in the calculation of BRIIE. These events, if they occur, would be inspected as part of the ROP.

4. The threshold for reporting BRIIE results to Congress should be set at $1x10^{-5}$ per reactor critical year (rcry). It should be associated only with the ΔCDF BRIIE calculations for industry-wide results. This threshold value was arrived at from considerations of the NRC safety goals, RG 1.174, and consistency with the ROP and Accident Sequence Precursor (ASP) programs. The threshold was derived from coherency with current agency metrics and the surrogates for the safety goals discussed in RG 1.174. Two scenarios were discussed. The first was that a single event at $1x10^{-3}$ /rcry ΔCDF (e.g., the current ASP indicator threshold for reporting significant events to Congress) would make the aggregate industry performance about equal to $1x10^{-5}$ /rcry ΔCDF ($1x10^{-3}$ divided by 100 plants). Also, if 10 percent of plants had a problem at about $1x10^{-4}$ /rcry ΔCDF, then this would also make industry performance about equal to $1x10^{-5}$ /rcry ΔCDF. The 10 percent number was chosen to provide a distinction between an industry problem in contrast to issues with individual plants.

D. BRIIE Historical Performance

Figure 2 provides representative industry BRIIE results for 1988 through 2005 and illustrates how this indicator successfully provided the desired information. As already stated, the baseline CDF value will be recalculated periodically to reflect ongoing industry performance. Since the BRIIE indicator shows a change from a baseline CDF value, negative BRIIE values indicate an improvement compared to the baseline CDF.

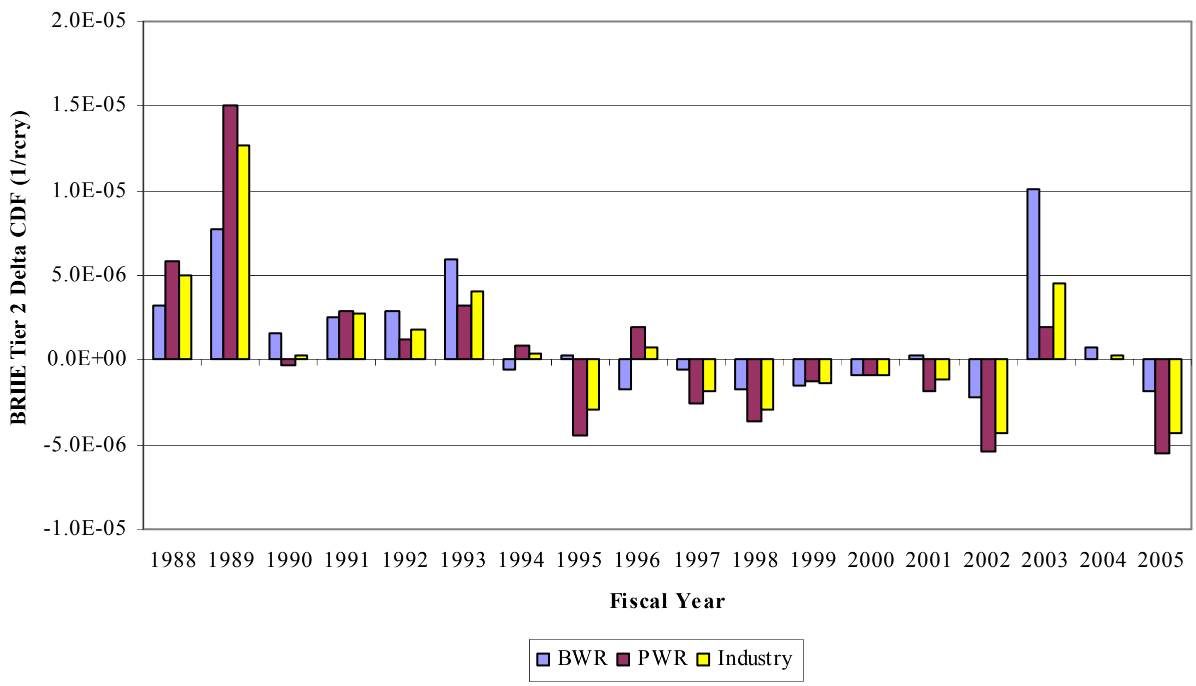

Figure 2 - Baseline Risk Index for Initiating Events 1988 – 2005

E. Potential Regulatory Responses to BRIIE Results

In this section we present two examples to show how the enhanced ITP might treat initiating event performance changes.

As a first example, consider if we observe four events in one year that are classified as very small break LOCAs (VSLOCA), and each event occurred at a different plant. A VSLOCA as an initiating event is rare. The 95 percent prediction limit (used in the Tier 1 analysis) is two events. Therefore, we have exceeded the 95 percent prediction limit. Because the number of actual events exceeds the prediction limit, this initiating event is a candidate for further investigation.

Because VSLOCAs do not occur very often, NRC would examine and review each event in more detail after it occurred. The ROP would review each event for performance deficiencies and the ITP would look at these events to see if there were similarities among the events and to provide any lessons learned from this evaluation. These lessons would be communicated to the industry via an appropriate generic communication. Further regulatory action would probably not be necessary because NRC investigated each event in detail. If all of these events had occurred at PWRs, the resulting PWR ΔCDF-BRIIE would be significantly below the $1x10^{-5}$ ΔCDF threshold. The plant-type average Birnbaum importance measure for the PWR VSLOCA is the smallest (least important) of the Birnbaum importance measures. This means that a much higher count of events would have to occur before the average PWR would exceed its BRIIE threshold or to have any significant impact in the composite industry ΔCDF BRIIE value. Therefore, since neither the PWR nor industry BRIIE reporting threshold is exceeded, NRC would not make a report to Congress. However, the staff would analyze and take appropriate action in response to these events.

Since the threshold for reporting to Congress is associated with the ΔCDF BRIIE calculations for industry-wide results, the same NRC response would apply if the PWR ΔCDF BRIIE value would exceed the $1x10^{-5}$ threshold but the industry average ΔCDF BRIIE value does not.

In a second example we assume that there is a marked increase in the number of BWR loss of DC (LODC) events, resulting in seven LODC events for the year. This exceeds the 95 percent prediction limit for Tier 1, which is three events for all plants. As such, this initiating event is a candidate for further investigation and NRC engagement. NRC would examine and review each event in more detail to see if there were similarities among the events and to provide any lessons learned from the evaluation. These lessons would be communicated to the industry via an appropriate generic communication. Further regulatory action would be taken as necessary based on the results of a detailed NRC investigation of each event.

However, unlike in the previous case, both the BWR ΔCDF BRIIE and the industry ΔCDF BRIIE would exceed $1x10^{-5}$ for this hypothetical case and NRC would report this result to Congress as part of the adverse industry trends metric along with actions that have already been taken or are planned in response to these events.