Use of Risk Insights to Enhance Safety Focus of Small Modular Reactor Reviews

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Use of Risk Insights to Enhance Safety Focus of Small Modular Reactor Reviews

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Abstract *– The U.S. Nuclear Regulatory Commission staff is considering a more integrated, graded approach to the review of small modular reactor (SMR) pre-application activities and design applications. The concept is to improve the efficiency and effectiveness of the reviews by focusing on safety significant structures, systems, and components (SSCs). The unique design features associated with SMRs and knowledge gained reviewing other passive reactor designs present opportunities to risk-inform the SMR design certification process to a greater extent than previously employed. The review process can be modified for SMR applications by considering the aggregate of regulatory controls pertaining to SSCs as part of the review and determining those regulatory controls which may supplement or replace, as appropriate, part of the technical or engineering analysis and evaluation. Risk insights acquired from staff reviews of passive LWR designs (i.e. AP1000, ESBWR) can also be incorporated into the review process. Further, risk insights associated with integral pressurized water reactor (iPWR) design features (i.e. underground facilities impact on turbine missiles review) can be incorporated into the review process. Thus, the staff can use a graded approach to the SMR design certification process.*

I. INTRODUCTION

The U.S NRC staff has developed a more risk-informed and more integrated review framework for pre-application and application review activities pertaining to iPWR designs in response to guidance from the Commission.[1] The proposed iPWR review framework is consistent with current regulatory requirements and Commission policy statements and builds on the staff's current application review process. In addition, the framework retains the current processes the staff uses to determine both safety class (i.e., safety-related or non-safety-related) and risk-significance. The framework is more risk-informed in that it provides a graded approach for the review of structures, systems, and components (SSCs) with the most detailed, in-depth review (analogous to the current review process) conducted for SSCs determined to be both safety-related and risk-significant, and a progressively less detailed review applied to SSCs determined to be non-safety-related or not risk-significant. The framework enhances the efficiency of the SSC review process by improving the integration of performance-based program requirements into the SSC review process. This integration is possible for most SSCs because of the correlation between certain review acceptance criteria (i.e., those criteria which are performance-oriented) and certain program requirements (i.e., those which are performance-based). The staff anticipates that implementation of the proposed iPWR review framework could result in efficiencies that would be incorporated into future budgets and application schedules. The framework is discussed in more detail in a paper the staff sent to the Commission.[2]

II. Background

As discussed by the staff in a paper describing key policy and technical issues[3], and in other communications with the Commission, nuclear reactor vendors are developing SMR designs using several technologies. Potential applicants have notified the NRC that they may submit applications as early as fiscal year (FY) 2012

The Commission directed the staff to more fully integrate the use of risk insights into pre-application activities and the review of applications and, consistent with regulatory requirements and Commission policy statements, to align the review focus and resources to risk-significant SSCs and other aspects of the design that

contribute most to safety in order to enhance the efficiency of the review process. The Commission directed the staff to develop a design-specific, risk-informed review plan for each iPWR to address pre-application and application review activities. Over the longer term, the Commission directed the staff to develop a new risk-informed regulatory structure, building on insights from iPWR reviews, next generation nuclear plant (NGNP) review activities, and a feasibility study conducted by the staff several years ago[4].

III. Risk-Informed Framework for the Licensing Review of iPWRs

III. A. Overview

The staff intends this review framework to be consistent with current regulatory requirements and Commission policy statements. It will provide guidance to the staff on the review of risk-significant SSCs and other aspects of the design that contribute most to safety in order to enhance the efficiency of the review process. This review framework builds on the current review process to result in a more risk-informed and integrated process for the review of iPWR designs. The processes described in the framework could result in more efficient reviews.

The review framework addresses the level of detail in the staff's review of selected acceptance criteria, as defined in the staff's review guidance. It should be noted that this initiative does not change any regulatory requirements or Commission policy and makes no change to the current processes the staff uses to determine both safety class (i.e., safety-related or non-safety-related) and risk-significance of SSCs. The framework incorporates a more risk-informed approach to the staff's review by considering both the safety-importance and risk-significance of each SSC to help determine the appropriate level of review for each SSC. In this regard, the framework is similar to the requirements of a recent regulation on the risk-informed categorization and treatment of SSCs.[5] The determination of risk-significance is discussed in the next section of this paper.

It should be noted the risk-significance determinations use not only risk insights from probabilistic risk assessments but also rely on deterministic approaches and defense-in-depth concepts. The framework provides a graded approach in which the staff would conduct the most detailed, in-depth review (analogous to the current review process) for SSCs determined to be both safety-related and risk-significant, and a progressively less detailed review would be applied to SSCs determined to be non-safety-related or not risk-significant. SSCs determined to be neither safety-related nor risk-significant would receive the least detailed review under this framework.

The review framework derives from the current review process, to include current reviewer guidance and SSC-specific acceptance criteria contained in the standard review plan (SRP) for light water reactor safety reviews[6], but it enhances the efficiency of the SSC review process by improving the integration of performance-based program requirements into the SSC review process. This integration is possible because of the correlation between certain acceptance criteria (i.e., those criteria which are performance-oriented) and certain program requirements (i.e., those which are performance-based). For most SSCs, specific acceptance criteria contained in the SRP may be characterized as either design-related criteria or performance-oriented criteria. The design-related criteria address SSC functions and adequacy of the design. The performance-oriented criteria address aspects of performance (e.g., the capability, availability, reliability, or maintainability) of the SSC. In addition to the SRP specific acceptance criteria, most SSCs are subject to programmatic requirements (e.g., technical specifications, availability controls for SSCs subject to the regulatory treatment of non-safety systems, the maintenance rule, reliability assurance program, initial test program) which also address aspects of performance. It is observed that, for most SSCs, a number of the performance-based measures identified in the programmatic requirements correlate with the performance-oriented acceptance criteria identified in the respective SRP sections. The staff's review of SSCs, under both the current review process and the proposed review framework, involves review against all of the SSC-specific acceptance criteria (i.e., both design-related and performance-oriented acceptance criteria), and, additionally, the applicable programmatic requirements. It should be noted that the proposed review framework makes no change to the current review process regarding review against the SSC-specific design-related acceptance criteria. However, the proposed review framework revises the current review process by providing for integration of the review of the performance-oriented acceptance criteria and the programmatic requirements.

The review framework, for review areas in which a correlation exists between specific performance-oriented acceptance criteria and performance-based program requirements, provides for identifying those program requirements as part of the SSC review. The framework would use tests or inspections to either augment or replace, as appropriate, technical analysis and evaluation techniques that the staff currently applies. For SSCs determined to be both safety-related and risk-significant, the review would be detailed and in-depth (analogous to current review process), including independent technical analysis and evaluation, and the identification of correlated

program requirements would augment the review. For SSCs determined to be non-safety-related and/or not risk-significant, the framework relies increasingly on specific elements (e.g., tests or inspections) of programmatic requirements to satisfy performance-oriented acceptance criteria for such SSCs. For example, the requisite monitoring and analyses of an SSC's performance that are associated with its inclusion within an applicant's reliability assurance program (RAP)[7] and maintenance rule program may be sufficient to satisfy performance-oriented acceptance criteria pertaining to the reliability, availability, and maintainability of the SSC.

III. B. Risk-Informed Review Approach

The review framework incorporates a more risk-informed approach by considering both the safety importance and risk significance of SSCs to determine the appropriate level of review (i.e., the framework uses a graded review approach). The staff determines whether an SSC is safety related, risk significant, or both as a prerequisite to implementing the review framework through current evaluation and decision processes.

The process for determining risk-significance of SSCs consists of four steps. The first step is to collect and examine design/plant-specific information that can facilitate risk-significant determinations. The second step is to identify plant systems and associated functions that are modeled (explicitly or implicitly) or included in the following analyses and programs:

- the design/plant-specific risk assessments and severe accident evaluations that cover the full spectrum of potential events and the range of plant operating modes considered in SRP Section 19.0;
- the list of risk-significant SSCs included in the RAP.

The third step is to categorize each of the system functions identified in step two as risk-significant if it has been included in the RAP. System functions that are not included in RAP onsidered low risk-significant candidates. The fourth, and final, step is to ensure that the identified systems/system functions and associated risk-significance are reasonably reflective of the current design/plant-specific information (e.g., plant design, risk models) and that the information is updated, as needed, throughout the review process. The staff anticipates that during the review of a new design the design/plant-specific information used to identify the systems/system functions and associated risk significance may change as review of the PRA and RAP evolve.

Figure 1 illustrates the framework for this review process. For a particular SSC, the level of review is derived from both the SSC's safety importance (i.e., safety related or nonsafety related) and risk significance (i.e., risk significant or not risk significant). Four review levels (labeled as A1, A2, B1, and B2 in Figure 1) correlate to the safety importance and risk significance of the SSC under review.

III. C. Implementation Example

Provided here is an example of how the framework would be implemented for an iPWR design review and how the review would differ from what is currently done. The system chosen, station service water, is assumed to be a nonsafety related system that is risk significant. As such, it would receive a B1 level review in accordance with the framework flowchart. For this system, SRP section 9.2.1 identifies several acceptance criteria that are design-related and several that are performance oriented. One of the design-related acceptance criteria refers to the requirements in General Design Criteria[8] (GDC) 2 for protection against natural phenomena. This acceptance criterion would require technical analysis and evaluation to verify that, for example, the system adequately addresses seismic design standards. This review is the same as would be done under the current process. Another example of a design-related acceptance criterion is GDC 4 for environmental and dynamic effects. In contrast, the acceptance criteria related to GDC 45 (inspection) and GDC 46 (testing) may be satisfied by specific performance-based activities (e.g., testing or monitoring) within programmatic requirements (e.g., combination of, initial plant testing and RAP. No credit for these activities is given in the current process, however, in the new framework, the reviewer may be able to gain efficiency by relying on these performance-based activities as an alternative to detailed technical analysis and evaluation.

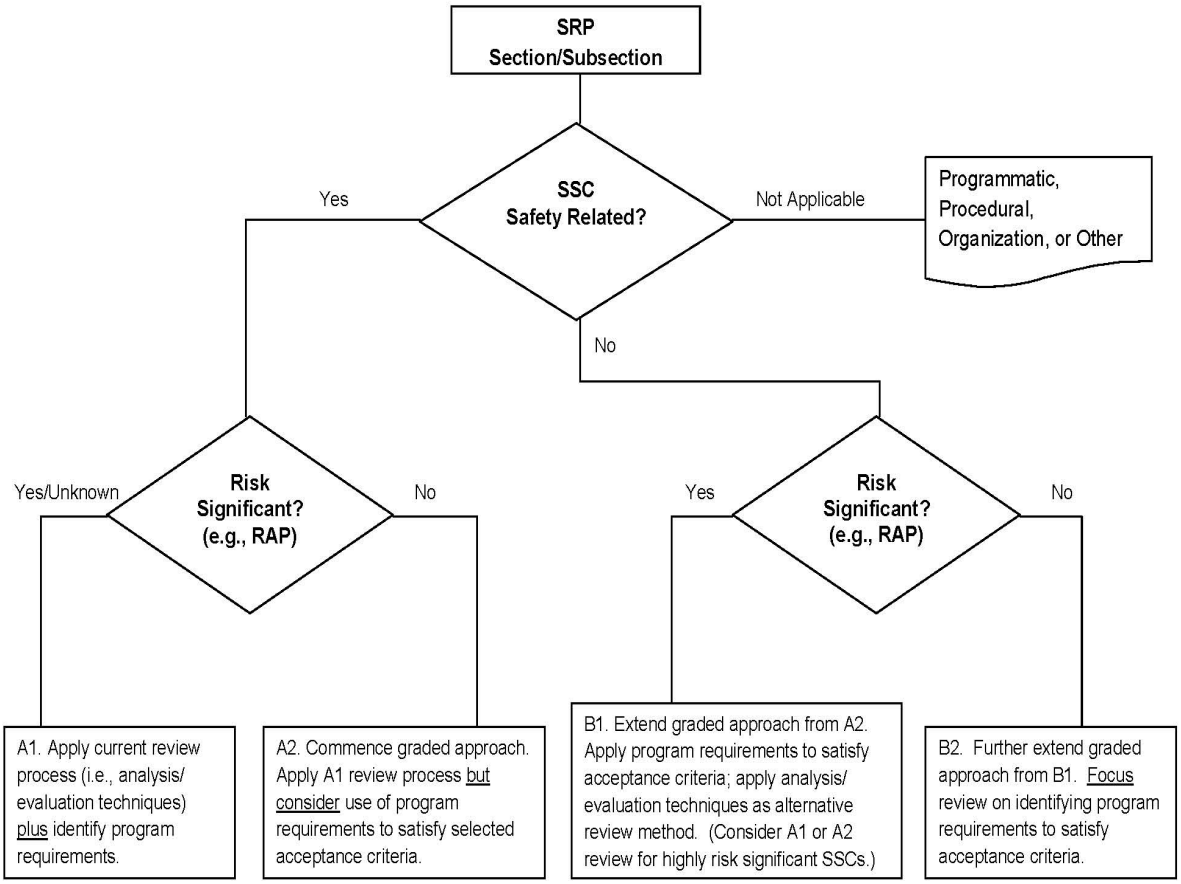

Fig. 1. Risk-informed integrated review framework (iPWRs)

IV. CONCLUSIONS

This review framework builds on the current review process at the U.S. NRC to result in a more risk-informed and integrated process for the review of iPWR designs. The processes described in the framework could result in more efficient reviews.

REFERENCES

1. U.S. Nuclear Regulatory Commission, (2010, August 31). SRM-COMGBJ-10-004/COMGEA-10-0001, Use of Risk Insights to Enhance Safety Focus of Small Modular Reactor Reviews. Washington, DC, USA.

2. U.S. Nuclear Regulatory Commission,. (2011, February 18). SECY-11-0024, Use of Risk Insights to Enhance the Safety Focus of Small Modular Reactor Reviews. Washington, DC, USA

3. U.S. Nuclear Regulatory Commission, (2010, March 28). Potential Policy, Licensing, and Key Technical Issues for Small Modular Nuclear Reactor Designs. Washington, DC, USA.

4. U.S. Nuclear Regulatory Commission, (2007, December). NUREG-1860, Feasibility Study for a Risk-Informed and Performance-Based Regulatory Structure for Future Plant Licensing. Washington, DC, USA.

5. U.S. Code of Federal Regulations (2004, November 22). Title 10, Part 50.69, Risk-informed categorization and treatment of structures, systems and components for nuclear power reactors.

6. U.S. Nuclear Regulatory Commission, (2007, March). NUREG-0800, Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants: LWR Edition. Washington, DC, USA.

7. U.S. Nuclear Regulatory Commission,. (2009, October 22). DC/COL-ISG-018, Interim Staff Guidance on NUREG-0800 Standard Review Plan Section 17.4, 'Reliability Assurance Program'. Washington, DC, USA.

8. U.S. Code of Federal Regulations (2007, August 28). Title 10, Appendix A to Part 50--General Design Criteria for Nuclear Power Plants, Washington, DC, USA.