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Safety Review of Light-Water Reactor Construction Permit Applications

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Safety Review of Light-Water Power-Reactor Construction Permit Applications

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General Comment

NewClear Day offers a discussion of the review guidance discussed in the Draft Interim Staff Guidance document as well as some important review guidance not discussed. NewClear Day proposes an alternative I&C regulatory framework that would better support new plant reviews. Finally, NewClear Day offers a proposed outline for a PSAR discussion of I&C systems.

Attachments

NewClear Day Comments on DNRL-ISG-2022-XX

NewClear Day Inc.

Comments on DNRL-ISG-2022-XX, Safety Review of Light-Water Power-Reactor Construction Permit Applications - Draft Interim Staff Guidance

The U.S. Nuclear Regulatory Commission (NRC) has solicited public comment on a draft interim staff guidance (ISG), ‘‘Safety Review of Light-Water Power-Reactor Construction Permit Applications.’’ The stated purpose of this ISG is to clarify existing guidance and to assist the NRC staff in determining whether an application to construct a light water reactor (LWR) facility meets the minimum requirements to issue a construction permit (CP).

Relevant Instrumentation and Control Guidance

The draft ISG has an appendix that provides clarifications to the existing review guidance in NUREG–0800 Standard Review Plan (SRP), which addresses instrumentation and control (I&C) systems.[1] The first part of the discussion for I&C systems is related to an organizing framework for the I&C review. It states:

> In its development of design-specific review standard (DSRS) guidance (Reference 25)[2] for the NuScale small modular reactor design, the NRC incorporated some of the lessons learned from its review of large LWR designs. The guidance emphasizes fundamental instrumentation and control (I&C) design principles of independence, redundancy, predictability and repeatability, and diversity and defense in depth. The guidance in SRP Chapter 7, “Instrumentation and Controls,” is system focused and does not take advantage of such a unifying framework. The DSRS guidance aims to address all the significant aspects of the I&C design in a unified manner through this framework to minimize the repetition of the requirements in a system-focused approach. The structure of the DSRS guidance reflects an integrated I&C design using digital technology; introduces the use of an integrated hazards analysis approach to the I&C reviews; consolidates the various methods discussed in SRP Chapter 7; and provides a consistent, comprehensive, and systematic way to address the potential hazards associated with the I&C systems in a unified framework. Lastly, the guidance encompasses all relevant branch technical positions discussed in SRP Chapter 7 and clarifies the interface between the I&C area and other disciplines, such as equipment qualification, human factors engineering, quality assurance, and reactor systems.

The second part of the discussion for I&C systems is related to review criteria for the I&C review. It states:

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1 See https://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr0800/ch7/index.html

2 See https://www.nrc.gov/docs/ML1535/ML15355A295.html

In evaluating a CP application, the NRC staff should focus on the following elements of the I&C design:

- an overall I&C architecture that demonstrates adherence to the fundamental I&C design principles
- plant safety functions allocated to each of the safety-related I&C systems
- proposed communications between safety-related and non-safety-related I&C systems
- regulations that the applicant intends to comply with for the I&C design
- regulations that the applicant intends to take exemption from or deems not applicable to its design
- topical reports incorporated by reference in the application

The discussion on the organizing framework for the I&C review is ambiguous. It seems to suggest that the NuScale DSRS is the preferred review format; however, no discussion is provided on how to adapt or adopt the DSRS for a particular new plant design. It would be better to more fully the develop how an alternative to the SRP Chapter 7 could be adopted.

The discussion on the review criteria for the I&C review is appropriately defined; however, a chosen PSAR format for the I&C systems should clearly address the first three bullets. The NuScale DSRS structure does not reflect these review objectives since key information on these topics is relegated to appendices.

NewClear Day offers the following discussion of the review guidance discussed in the Draft Interim Staff Guidance document as well as some important review guidance not discussed. NewClear Day proposes an alternative I&C regulatory framework that would better support new plant reviews. Finally, NewClear Day offers a proposed outline for a PSAR discussion of I&C systems.

Perspectives on SRP Chapter 7

The SRP Chapter 7 organization for presentation of I&C systems information reflects the historical designs of I&C systems with information added to address the introduction of digital technology and evolution of dynamic regulatory topics. It is not an effective format to describe modern integrated I&C systems (most notably the integrated aspect of the I&C systems and cyber security). It does not reflect all relevant regulatory topics of interest (notably cyber security is omitted) or key new plant design concepts for the defense-in-depth (D-in-D) framework. The SRP Chapter 7 organization is also not up to date with the ongoing evolution of graded approaches to system classification or treatment of beyond-design-basis-event mitigation topics.

The Advisory Committee on Reactor Safeguards (ACRS) commented during reviews of large LWR design certifications that the SRP Chapter 7 format had a compliance mentality that did not effectively address what I&C systems do, why they do what they do, and why they are safe. The ACRS feedback led to improvements for small modular reactor (SMR) Design Certification Application (DCA) reviews.[3]

Adoption of the SRP Chapter 7 model requires small initial investment of project time or resources; however, experience has shown that managing the safety I&C reviews for modern

[3] ACRS Letter to NRC dated December 18, 2012, “Draft Design Specific Review Standard for mPower iPWR Chapter 7 Instrumentation and Control Systems”, U.S. Nuclear Regulatory Commission (See https://www.nrc.gov/docs/ML1234/ML12346A353.pdf)

highly integrated digital I&C systems, using the SRP Chapter 7 model, results in longer reviews with higher review costs.

Perspectives on DSRS Chapter 7

The successful use of DSRS Chapter 7 on the NuScale DCA review illustrates NRC willingness to adapt better review methods to improve efficiency and effectiveness and accommodate technology changes. It was effective for the review of a passive plant design using integrated digital I&C systems in a risk-based classification system. It enabled the NRC staff to maintain focus on significant aspects of the I&C design in a unified manner throughout the review. It avoided inefficiencies experienced with the large LWR design certification reviews by tailoring the review guidance to the specific SMR technology. It reinforced the flexibility to consider and accept alternative approaches, when justified, to provide adequate safety. IEEE Standards for digital system and software development were within a graded quality assurance framework for safety systems, based on the system classification.

DSRS Chapter 7 did not address ongoing evolution of beyond-design-basis-event mitigation topics due to the timing of the associated 10 Code of Federal Regulations (CFR) 50.155 rulemaking for mitigation of beyond-design-basis events.

Adoption of the DSRS Chapter 7 model requires minimal upfront investment of project time and resources to adapt the NuScale DSRS Chapter 7 to a different reactor technology, since the I&C review guidance is reactor agnostic. The NuScale experience illustrates the potential savings in review time and costs for managing the safety I&C reviews for modern highly integrated digital I&C systems using the DSRS Chapter 7 model.

Perspectives on I&C Design Review Guide

NRC issued a new I&C review guidance in March 2021, titled “Design Review Guide (DRG): Instrumentation and Controls for Non-Light-Water Reactor (Non-LWR) Reviews.” [4] NRC considers the DRG as a proactive way to modernize the I&C safety review by providing guidance for technology-inclusive, risk-informed, and performance-based reviews. It anticipates that new advanced reactor designs will continue to use modern digital I&C technology developed to state-of the-art standards. To that end, the DRG provides guidance to evaluate, where appropriate, whether I&C systems and components are designed in accordance with the relevant domestic and/or international standards and via proven engineering design practices and processes. The DRG suggests an I&C system review framework in DRG Figure X-1.

The DRG review priorities are established in a comparable manner as in DSRS Chapter 7 for I&C architectures and safety-significant systems. The DRG adds an improvement by clarifying that the review of other I&C systems should focus on hazards that could impair the performance of safety-significant systems. The DRG review priorities are DRG Figure X-2.

[4] U.S. Nuclear Regulatory Commission, “Design Review Guide (DRG): Instrumentation and Controls for Non-Light-Water Reactor (Non-LWR) Reviews,” February 26, 2021. (See https://www.nrc.gov/docs/ML2101/ML21011A140.pdf)

The DRG proposal was well received by the ACRS and noted it had a more universal applicability for I&C system reviews than the limitation to non-LWR reviews, since it was applicable to the I&C systems review for any type of reactor.[5]

The DRG proposal provides an opportunity to achieve a measure of international harmonization with respect to International Atomic Energy Agency (IAEA) safety guidance and International Electrotechnical Commission (IEC) standards for nuclear power plant safety systems. The DRG framework aligns with new plant design philosophy for plant safety based on lines of defense and use of international standards for I&C systems.

Alternative I&C Regulatory Framework

The fundamental regulatory challenge posed by modern I&C designs is not one related to technology or design, but the challenge is the effective communication and explanation of the integration such that it can be clearly and easily understood. An alternative I&C regulatory framework is proposed that organizes the key regulatory topics for I&C system reviews that is more accessible and understandable. The alternative I&C regulatory framework is illustrated in Figure 1.

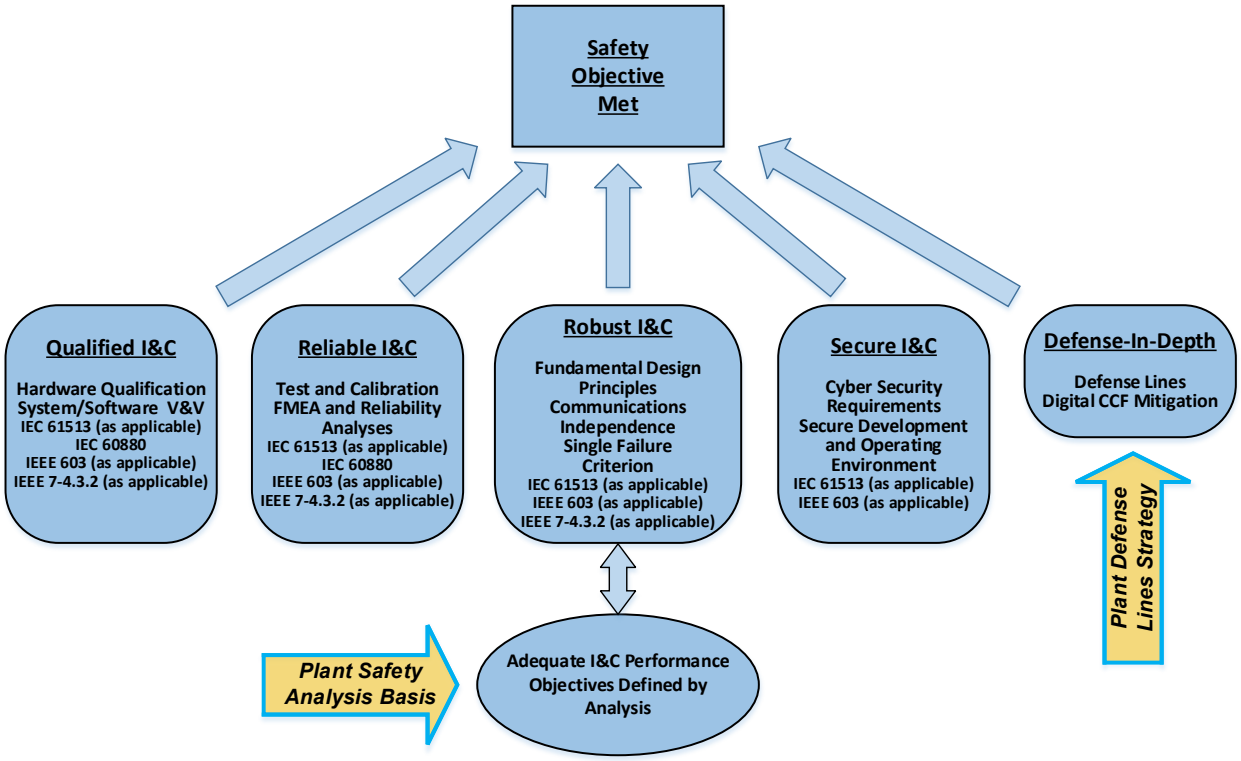

Figure 1: Alternative I&C Regulatory Framework

[5] ACRS Letter to NRC dated December 16, 2020, "Design Review Guide: Instrumentation and Controls for Non-Light-Water Reactor Reviews," U.S. Nuclear Regulatory Commission (See https://www.nrc.gov/docs/ML2034/ML20349E838.pdf)

The alternative I&C regulatory framework separates the D-in-D framework from the DRG placement as an element of robustness to provide a more prominent focus on a key part of the new plant design concepts. It also adds in a secure I&C element to reflect the overall importance to this topic to any digital I&C system design.

The alternative framework can be linked to IEEE Std 603 [6] and IEEE Std 7-4.3.2 [7] because of their historical use in the NRC review process. The alternative framework also can be linked to common international standards IEC 61513 [8] and IEC 60880 [9] because of their use in the broader international nuclear sector for I&C system technical requirements. This framework is consistent with both the DSRS and DRG for the common elements.

Suggested Outline for I&C Systems PSAR Content

The I&C systems used in new NPPs can be comprised of a system of systems. System architecture issues have complicated digital I&C reviews in several international regulatory forums. The overall I&C architecture provides a framework to systematically develop, present, and understand the I&C design bases in the necessary context (i.e., the plant-level). This framework must be established and understood before reviewers attempt to understand the I&C design at the system/technology level.

A suggested outline for the I&C systems PSAR content is provided to best explain the features of the I&C system of system architecture and the individual I&C system:

I. I&C Systems of Systems Introduction and Overview
   - A. Relationship to Plant Level Lines of Defense
   - B. I&C System Classification
   - C. Regulatory Requirements and Industry Standards

II. I&C Systems of Systems
   - A. Overall Architecture
   - B. System and Component Network Connections
   - C. Enterprise Network and Firewall

III. Individual I&C Systems
   - A. System Architecture
   - B. System Design Bases and Associated Safety Functions
   - C. Fundamental Design Principles in the System Design
     - i. Qualified I&C (e.g., hardware qualification and system/software validation)
     - ii. Reliable I&C (e.g., single-failure criterion, failure modes and effects analysis, and testing capabilities)
     - iii. Robust I&C (e.g., separation, independence, fail-safe design, and diversity)

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6 Institute of Electrical and Electronics Engineers, IEEE Std 603-1991, “IEEE Standard Criteria for Safety Systems for Nuclear Power Generating Stations”

7 Institute of Electrical and Electronics Engineers, IEEE Std 7-4.3.2-2003, “IEEE Standard Criteria for Digital Computers in Safety Systems of Nuclear Power Generating Stations”

8 International Electrotechnical Commission, IEC 61513:2011, “Nuclear Power Plants – Instrumentation and Control Important to Safety – General Requirements for Systems”

9 International Electrotechnical Commission, IEC 60880:2006, “Nuclear Power Plants – Instrumentation and Control Systems Important to Safety – Software Aspects for Computer-Based Systems Performing Category A Functions”

        iv. Secure I&C (e.g., system secure operating environment features)
        v. D-in-D (e.g., treatment of Defense Line 3 common cause failures)
    D. Operator Interface
    E. Compliance Alignment

IV. Digital I&C System Development Processes

    A. Defense-in-Depth and Architecture Design
    B. I&C System Life Cycle
    C. Cyber Security Life Cycle
    D. Compliance Alignment

V. Main Control Room

    A. Main Control Room Use
    B. Main Control Room Layout

VI. Secondary Control Room

    A. Control Transfer Function
    B. Secondary Control Room Use
    C. Secondary Control Room Layout

This outline effectively communicates how the I&C systems are integrated into the overall plant D-in-D framework, how the applicable regulatory requirements are met for each defense line, and how the I&C system are integrated with the support system and structures.