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NUENERGY INPUT TO THE NRC DESIGN INSPECTION REVIEW CHARTER

IMPROVING EFFICIENCY AND EFFECTIVENESS OF ENGINEERING INSPECTIONS

VISION: To achieve an ultimate improvement in safety, it is necessary that a valid and sufficiently detailed knowledge base for the plant safety design basis reside with the licensee, and that NRC assurance of public safety is largely implemented through inspections of this knowledge base.

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IMPROVING EFFICIENCY AND EFFECTIVENESS OF ENGINEERING INSPECTIONS

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CONTENTS

1 BACKGROUND

1.1 FORWARD

This document was prepared by Nuenergy, Inc. (Nuenergy), a recognized nuclear power industry leader in performance of independent assessments and in assisting utilities in conducting self-assessments. Our associates have significant experience as contract engineering inspectors for the US NRC, including conduct of the current Design Basis Assurance Inspections (DBAI), previous Component Design Basis Inspections (CDBI), as well as Safety System Functional Inspections (SSFIs), and other legacy design/engineering inspections.

Nuenergy's associates attended the NRC June 6, 2017 public meeting that addressed potential changes to the NRC Reactor Oversight Processes (ROP) design verification inspections. During this meeting, Nuenergy noted that any future engineering inspections must consider the declining level of knowledge of design and licensing bases that is common to both utilities and the NRC. This decline is a result of the retirement of an aging engineering workforce and the virtual halt to original design activities in the US nuclear power industry. Hence, any selected option should fulfil the following objectives:

- Maintain/Improve Plant Safety – identify latent design deficiencies.
- Maintain/Improve Quality of Design Basis; and hence, improve quality of plant future modifications by capturing knowledge discovered during these activities.
- Provide a Training Opportunity for New Engineers.

1.2 HISTORICAL PERSPECTIVE

A major related change, brought upon by the ROP and in response to the Davis Besse reactor vessel head degradation was the NRC's adoption of a component centric method (CDBI, now DBAI) to replace the previous system centric method (Safety System Design and Performance Capability Inspections [SSDPCI], SSFI, etc.). Accordingly, the utilities changed the self-assessments performed in preparation for these inspections to reflect a component centric approach. One of the drivers for this change was industry concern of a lack of efficiency in re-inspecting the same systems. This approach was thought to improve the NRC's ability to identify significant latent design deficiencies based on the risk ranked component selection and adoption of "more-than-minor" screening of findings.

1.3 PROCESSES AND OUTCOMES

1.3.1 NRC Inspections

Whether inspections are system or component centric, a **system** level review of design and licensing bases is required to learn the specific functional requirements so as to develop viable lines of inspection inquiries. Most of this effort is done during the preparation week and largely consists of learning the plant-specific licensing and design bases, which are unique for every plant, as compared to the generic bases for a specific system. In one week, an experienced engineering design professional can develop a good understanding of what makes licensing and design bases requirements unique for a single system. However, when the assigned components span two or more systems, one week is not sufficient for this detailed review of licensing and design bases of multiple systems.

The one week limit in preparation time can result in shortcuts, which place more reliance on the inspector's "hunches" and past experience. Use of "hunches" and past experiences are valuable tools for improving and targeting the lines of inquiries. However, such tools should be used only as an enhancement, and not a substitute for learning the plant-specific design and licensing bases.

This learning process continues through the duration of the entire inspection and is critical to assuring the inspectors and the licensee's time is not wasted by pursuing lines of inquiries that lie outside of plant's specific design and licensing bases.

There is no objective evidence to determine the impact on the NRC's mission due to a change from the system centric to the component centric engineering inspections. Process attributes, however, can be readily compared. A tabulated comparison between the system and component centric inspection processes attributes is provided below.

Table 1, NRC Inspection Process Comparison

Attribute	System Centric (SSFI)	Component Centric (CDBI/DBAI)
Method	Single System, Vertical Slice	Multiple Systems, Component Functional Requirements
PRA	No Formal PRA Insights Until SSDPCI	Selection Based on PRA Insights
Self-Assessment Inspection Credit	Allowed in SWSOPI	None

1.3.2 Licensee's Self-Assessments

While the major focus of NRC's inspections is maintaining or improving public safety through identification of latent design deficiencies, the licensee self-assessments have the following additional elements:

- Manage Cost.
- Improve Quality of Design Basis.
- Provide a Training Opportunity for New Engineers (also an NRC objective for inspector personnel).

An informal opinion on the effects of licensee's adoption of NRC's Inspection Procedures (IPs) for CDBIs (now DBAIs) as a means of preparation for the NRC inspections versus the previous system centric effort is tabulated below.

Table 2, Utility Self-Assessment Process Comparison		
IMPACT	**SSFI**	**CDBI/DBAI**
High Impact on Day-to-Day Activities. See Note 1.	✓	✓
Improvement of Plant Safety. See Note 2.	✓	?
Improvement in Quality of Design Basis. See Note 3.	✓	?
Meaningful Training Opportunity for New Engineers. See Note 4.	N/A	?

Notes:

1. Both methods have a high impact on plant day-to-day activities. Because component-centric inspections typically involve more system interfaces when multiple and diverse components are sampled, this often requires additional support from several licensee system engineers and other plant staff than is required for system centric inspections. In addition, as described above for NRC preparation activities, the licensee's component centric self-assessments increase inspection overhead and associated costs. However, like the NRC inspections, there is no objective evidence to determine the impact on safety improvement due to a change from system centric to component centric engineering self-assessments.
2. SSFIs focused on a single system allowed for targeted and more productive outcomes. In the current CDBI/DBAI self-assessment efforts, the industry adopted a prescriptive assessment style (typically check lists similar to those used for modifications). This approach can restrict the proactive and exploratory nature of the inspection and can create artificial blinders and silos during discovery, which is contrary to the primary mission of the self-assessment.
3. The time period during which the SSFIs were performed coincided with industry efforts to capture the plant specific Design Basis Documents (DBD). Hence, the results of the SSFIs contributed to development, verification, and improvement of the DBDs. Currently, the engineering information revealed during the self-assessments or inspections is not being captured, unless a discrepancy is identified. In addition, the legacy system and topical DBDs are no longer being maintained as user-friendly controlled documents.
4. There was not a significant change in the utility labor force during the time period when the SSFIs were performed; hence, the effect cannot be evaluated. The current check list approach to the self-assessment does not lend itself to acquiring a deeper understanding of the design and licensing basis.

1.4 STAFFING CHALLENGES

1.4.1 NRC Labor Force

A tabulated comparison of the NRC's labor force experience during the implementation of SSFIs vs. CDBI/DBAI is provided below.

Table 3, NRC Labor Force Comparison	
SSFI	**CDBI/DBAI**
Majority: Highly experienced with prior nuclear submarine, shipyard, or nuclear utility expertise	• Progressively declining level of broad institutional experience. • Some new team leaders have a limited experience outside of the NRC.

1.4.2 Licensee Labor Force

A tabulated comparison of the licensee's labor force experience during the implementation of SSFIs vs. CDBI/DBAI is provided below.

Table 4, Licensee's Labor Force Comparison	
SSFI	**CDBI/DBAI**
Majority: Highly experienced with detailed knowledge of plant design including startup.	• Progressively declining level of broad experience. • Higher turnover rates of new hires.

1.5 COMMON NRC AND LICENSEE CDBI/DBAI CHALLENGES

The adoption of the component centric engineering inspection methodology combined with the changes in demographic labor force created the following common set of challenges:

- Focus on individual components (at expense of):
  - Identification of system-level issues.
  - Systematic review of engineering programs done as an organic inspection/assessment vs. a dedicated single program focused approach.
  - Systematic identification of latent design deficiencies.
- Acquiring credit for repetitive inspections of components:
  - As noted at the June 6, 2017 meeting [Enclosure 2, p. 26 of the July 26, 2017 NRC letter], "The design bases of most risk significant components have been interrogated through many inspections…"
  - However, there are typically significant differences in the various designs of certain high risk systems (e.g., emergency feedwater, service water, UHS, electrical systems, et al) among all operating plants.
    - ✓ This is evident in the many different design configurations and vintages for systems designed by the various NSSS vendors and A/Es,
    - ✓ As a result of these numerous combinations, each plant exhibits – to varying degrees – unique design bases, configurations, and design margins for a given safety system function.
- Thus, the findings as well as the favorable conclusions resulting from a component-based inspection at a given plant might not be applicable or sufficiently representative of the unique safety system configurations at other plants. Potential for "near miss" findings that could impact other plants:
  - When a finding below the "Green" threshold is captured in a condition report at a given plant, there is currently no systematic and efficient method of assuring that a similar, but latent, condition at another plant could exceed the "Green" threshold, because of differences in design bases, configuration or operating conditions.
  - This knowledge transfer from one plant to others is currently limited to findings that meet or exceed the "Green" threshold. Condition reports below this threshold that are initiated during NRC inspections are listed by number but typically not described otherwise. Without screening and evaluating these low significance condition reports for applicability at other plants (where conditions and their evaluation might be different), this could result in masking of precursor conditions.
- Declining experience leads to misdirected emphasis on non-safety related, or non risk-significant component functions.

2 PROPOSED WAY FORWARD

2.1 FUTURE NRC ENGINEERING INSPECTIONS

2.1.1 Objectives

- Maintain and improve plant safety – identify existing latent design deficiencies, if any
- NRC engineering inspections set **THE** template for the licensee's self‑assessments.
- The inspections can be valuable for licensees, provided the expended resources in addition to maintaining and improvement in plant safety:
  - Improve understanding and/or quality of design basis.
  - Provide a training opportunity for new engineers.
- Opportunities for regulatory credit for self-assessments is critical for success.

2.1.2 Proposed Method of Implementation

2.1.2.1 Risk Informed SSFI

The NRC should go "back to the future" and adopt a system-centric approach to the engineering inspections. Building up on the last NRC's system-centric Safety System Design and Performance Capability Inspections (SSDPCI), this new engineering inspection would reflect the latest plant-specific Probabilistic Risk Assessment (PRA) advances and would use the PRA not just for the system selection, but for the selection of components while evaluating both system level and component level functions.

This inspection should also address the following PRA insights:

- Natural phenomena.
- Loss of system function.
- High-Energy Line Break (HELB)/Medium-Energy Line Break (MELB) and internal flooding.
- Accident sequence precursors.

Like the DBAI, the selection criteria will take into account recent system and component modifications.

Additionally, a "problem-child" approach should also be employed in the selection process. For example, consider the following criteria for assigning a lower priority to candidate systems:

- The system has a high RAW value, but it's design and licensing basis are well documented.
- The system has a substantial and well documented margin and few operational challenges.
- By contrast, a safety-related or even a risk-significant system with a lower RAW value that exhibits operational challenges and low design margins could be a higher priority SSFI candidate.

The benefits of this approach include:

- Systematic identification of latent design deficiencies.
- Inherent assessment of the adequacy of modifications and 10CFR50.59 screenings/evaluations.
- Inherent assessment of the adequacy of critical engineering programs.
- Inherent assessment of the adequacy of related inservice inspection activities.
- Inherent assessment of the adequacy of related maintenance activities.

2.1.2.2 Self-Assessment Credit

The NRC should encourage licensee self-assessments. To achieve an ultimate improvement in safety, it is necessary that a valid and sufficiently detailed knowledge base for the plant safety design basis reside with the licensee, and that NRC assurance of public safety is largely implemented through inspections of this knowledge base.

Toward this end, the NRC should develop a new Inspection Procedure (IP) for the oversight of the licensee's self-assessment process. This procedure should incorporate the appropriate elements of IP 40501 that was used for the self-assessment credit for the Service Water System Operational Inspections (SWSOPI).

Should the NRC adopt this approach, the licensee would:

- Develop a detailed Safety System Functional Assessment (SSFA) plan to reasonably assure the consistency, correctness, and completeness of the SSFA process and submit this plan and the supporting documents (P&IDs, one lines, schematics, calculations, DBD, specifications, etc.) to the NRC.
- Coordinate with the NRC the schedule of the SSFA self-assessment.

The NRC's in-process inspection of the licensee's self-assessment should include:

- Inspection of the adequacy of the licensee's self-assessment plan.
- Inspection of a sample of the licensee's selected components/functions.
- Inspection of a sample of the components/functions not selected by the licensee.

Upon the licensee's completion of the self-assessment the NRC would review the licensee's final self-assessment report versus the NRC's findings (gap analysis).

2.2 FUTURE LICENSEE ENGINEERING SELF-ASSESSMENTS

2.2.1 Objectives

The licensee self-assessment objectives parallel the NRC's objective of maintaining plant safety plus the following:

- Improve the quality of the design basis.
- Provide a training opportunity for new engineers.

2.2.2 Proposed Method of Implementation

2.2.2.1 Risk Informed SSFA

Should the NRC adopt the new risk informed SSFI, with or without the self-assessment credit, the licensee would develop a self-assessment module that will includes:

- Identification of the purpose and effective conduct of the self-assessment
- Documentation of SSFA scope selection
- Documentation of SSFA system boundaries
- Documentation of SSFA major components or subsystems and reference to design/licensing bases
- Documentation of functional and performance requirements
- Documentation of results
- Documentation of conclusions
- Documents reviewed

Additionally, promote independence of the assessment; to address the declining knowledge of the labor force; and to provide a training opportunity for new engineers, the self-assessment should include oversight and support by independent industry experts.

2.2.2.2 Lessons Learned from Current Self-Assessments

The two following elements should be considered for the future self-assessment improvements:

- Emphasize a function driven approach for assessing the components and systems under review.
- Capture and transfer the knowledge identified or revealed during the self-assessment process into the existing plant data bases to improve the quality of future modifications, operability determinations, and associated engineering products.

2.3 MEETING NRC EFFICIENCY OBJECTIVE

Nuenergy believes that the proposed function-driven approach will allow meeting the NRC's efficiency objective by simultaneously addressing the following NRC inspection into a single inspection activity:

- IP 71111.07, "Heat Sink Performance" – will be addressed when the service water system is selected
- IP 71111.08, "Inservice Inspection Activities"
- IP 71111.12, "Maintenance Effectiveness,"
- IP 71111.17T, "Evaluations of Changes, Tests, and Experiments"
- IP 71111.18, "Plant Modifications,"
- IP 71111.21M, "Design Bases Assurance Inspection (Team)"
- IP 71111.21N, "Design Bases Assurance Inspection (Program)"

Nuenergy has no first-hand experience with implementation of IPs IP 71111.05T, "Fire Protection (Triennial)" or IP 71111.05XT, "Fire Protection-NFPA 805 (Triennial)."