September 15, 2010

CCN 222027
NRC Project #0748

U.S. Nuclear Regulatory Commission
Document Control Desk
Washington, D.C. 20555-0001

SUBJECT: Contract No. DE-AC07-05ID14517 – Next Generation Nuclear Plant Project Licensing White Paper – Next Generation Nuclear Plant Project Defense-in-Depth Approach – Response to Nuclear Regulatory Commission Request for Additional Information Letter No. 001 – NRC Project #0748

Consistent with the actions identified in "NGNP *Licensing Strategy – Report to Congress*," dated August 2008, the purpose of this letter is to submit the subject Next Generation Nuclear Plant (NGNP) Project response to Nuclear Regulatory Commission (NRC) Request for Additional Information (RAI) Letter No. 001 (Reference 1) for U.S. NRC review as part of the early licensing phase of the project. These RAIs were developed by the NRC staff following review of the NGNP white paper *Defense in Depth Approach* which was submitted to the NRC on December 9, 2009, (Reference 2). Defense-in-depth is a safety philosophy in which multiple lines of defense and conservative design and evaluation methods are applied to assure the safety of the public. The NGNP will be a licensed commercial high temperature gas-cooled reactor (HTGR) plant capable of producing electricity and/or high temperature process heat for a variety of energy intensive industries.

The NRC licensing process encourages early interactions to identify and resolve policy, regulatory, and key technical issues related to the proposed facility. Conducting effective interactions with the NRC is a critical part of the NGNP licensing strategy because the early resolution of issues can significantly impact the preparation of an acceptable license application, the subsequent application review schedule, and the ultimate deployment of the NGNP. This white paper and the NGNP response to the NRC's RAIs (Attachment 1) represent the first in a series of submittals that will address priority licensing topics related to establishing HTGR regulatory requirements using the process outlined in the Report to Congress.

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Following completion of NRC Staff review of NGNP white papers, and pending resolution of associated follow-on questions or requests for additional information, the NGNP Project requests that NRC provide feedback and documentation of its review in a format that will facilitate resolution of key design, safety, and licensing issues associated with the topic of defense in depth that can be used as a firm basis for the preparation of future HTGR license application(s).

If you have any questions, please contact me at (208) 526-6063 or Jim Kinsey, Director, NGNP Regulatory Affairs at (208) 569-6751.

Sincerely,

G. A. Gibbs

Greg Gibbs, Project Director
Next Generation Nuclear Plant Project

MH:CN

Attachment:
1. NGNP Response to NRC RAI Letter No. 001

References:
(a) Idaho National Laboratory, Next Generation Nuclear Plant Project Licensing White Paper – *Next Generation Nuclear Plant Project Defense-in-Depth Approach* - NRC Project #0748 (ML 093480191), December 9, 2009.
(b) USNRC, Next Generation Nuclear Plant (NGNP) – *Request for Additional Information Letter No. 001 Regarding Defense in Depth*, NRC Project #0748 (ML102020580), July 26, 2010.

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Attachment

NGNP Response to NRC RAI Letter No. 1

NRC Request for Additional Information Letter No. 001, July 26, 2010
Next Generation Nuclear Plant Pre-Application Activities
Department of Energy - Idaho National Laboratory
NRC Project No. 0748

SRP Section: ARP DD - Defense in Depth
Application Section: INL/EXT-09-17139 Section 3.1.1

RAI - ARP DD-2

The footnote on page 19 in section 3.1.1 states that "It is expected that intermediate design performance or reliability metrics will be used to establish the special treatment requirements." Clarify what is meant by this statement. What are "intermediate design performance or reliability metrics?" Why are intermediate metrics adequate for definition of special treatment, as opposed to final design parameters?

Response:

The term intermediate design performance or reliability metrics refer not to the stage in the design cycle but to system and/or component design parameters that act to maintain the plant within the license basis. Reliability metrics are directed towards the frequency of events while system design performance metrics are directed towards the consequences of events.

The example described in the footnote is from the ASME Section XI Reliability and Integrity Management (RIM) program, in which the target reliability metric (for welds within the helium pressure boundary) would be set to keep the frequency of design basis breaks within the Design Basis Event (DBE) region. Similarly, for Beyond Design Basis Event (BDBE) breaks (e.g., large breaks), the target metric would be to keep the frequency in the BDBE region. Similarly, system design level capability requirements would be set to ensure that the consequences of events remain within their respective DBE and BDBE regions.

Final design parameters would include reliability and capability requirements for those SSCs that are classified as safety-related or non-safety-related with special treatment. The final design parameters will be established during the design process and will be documented in the Final Safety Analysis Report (FSAR) that forms the basis for the plant license.

SRP Section: ARP DD - Defense in Depth
Application Section: INL/EXT-09-17139 Section 3.3.1.4

RAI - ARP DD-3

In section 3.3.1.4, the statement that there is a "low level of excess reactivity and on-line refueling capability for the PBMR based NGNP design" only addresses a single design concept. Provide a discussion of reactivity accidents for prismatic designs.

Response:

The prismatic design minimizes excess reactivity at the beginning of cycle by including lumped burnable poison into the fresh fuel element design. Both the prismatic and pebble bed designs have similar excess reactivity requirements for load following and xenon override. Peak excess reactivity in a prismatic design typically occurs at the middle of the cycle when a large fraction of the lumped burnable poison has been burned. Peak excess reactivity in the prismatic design is about twice that of the pebble bed design, but it is nonetheless also quite low. Excess reactivity for both designs is controlled by between 1 and 4 control rod groups. Both designs have reactor protection systems capable of responding to reactivity events such as control rod withdrawal events.

RAI - ARP DD-4

In section 3.3.1.4, justify the claim that there are no significant reactivity addition accidents, given the presence of steam generators.

Response:

Reactivity addition associated with steam generators is not fundamentally different than the control rod withdrawal events already addressed by HTGR designs. Water ingress from a steam generator tube break causes only a modest reactivity addition of a few tenths of a percent Δk which causes an increase in reactor power up to the reactor trip set point after several seconds at which time the control rods are tripped. The rate of reactivity addition from a steam generator tube break can be more rapid than a control rod group withdrawal by a factor of ten, but the consequences on core power and on temperature are similar. The large heat capacity and thermal margins of the core result in a negligible increase in fuel temperatures (~50°C) due to reactivity addition associated with postulated steam generator tube leaks or breaks. Further protection system actions can isolate the steam generator and trip the circulator which further restricts the reactivity addition to the core.

SRP Section: ARP DD - Defense in Depth
Application Section: 3.2.2

RAI - ARP DD-5

In section 3.2.2, explain how siting is considered plant capability defense-in-depth.

Response:

As described in Section 3.2.2, plant siting acts within the multiple lines of defense (e.g., barriers) for both limiting public exposures and protecting the plant from external hazards. Plant siting is considered within plant capability defense-in-depth due to its relationship to emergency planning. This recognition of plant siting as an element of defense-in-depth is described in SECY-97-020, *Results of Evaluation of Emergency Planning for Evolutionary and Advanced Reactors.* This SECY described the nexus between defense-in-depth and emergency planning, emphasizing the importance of siting.

> "Evolutionary and passive advanced LWRs have lower calculated probabilities of accidents than current plant designs. However, beyond design basis accidents are still possible, although very unlikely. Use of the consequence rationale is closely related to the 'defense-in-depth' safety philosophy which provides multiple layers of defense so that if one layer of defense fails, another is available to protect the public." In its Safety Goal Policy Statement, 51 FR 30028, August 21, 1986, the Commission stated that: "A defense-in-depth approach has been mandated in order to prevent accidents from happening and to mitigate their consequences. Siting in less populated areas is emphasized. Furthermore, emergency response capabilities are mandated to provide additional defense-in-depth protection to the surrounding populations."

At the time SECY-97-020 was published, the NRC had just recently revised the 10 CFR Part 100 siting factors to address realistic source terms [61 FR 65157, December 11, 1996]. In this rulemaking, which decoupled siting from dose analyses, the NRC stated:

> "The relocation of source term and dose calculations to Part 50 represent (sic) a partial decoupling of siting from accident source term and dose calculations. The siting criteria are envisioned to be utilized together with standardized plant designs whose features will be certified in a separate design certification rulemaking procedure. Each of the standardized designs will specify an atmospheric dilution factor that would be required to be met, in order to meet the dose criteria at the exclusion area boundary. For a given standardized design, a site having relatively poor dispersion characteristics would require a larger exclusion area distance than one having good dispersion characteristics. Additional design features would be discouraged in a standardized design to compensate for otherwise poor site conditions.
>
> Although individual plant tradeoffs will be discouraged for a given standardized design, a different standardized design could require a different atmospheric dilution factor. For custom plants that do not involve a standardized design, the source term and dose criteria will continue to provide assurance that the site is acceptable for the proposed design."

Current NRC regulations in 10 CFR §50.34(a)(1)(ii)(D) require that:

> "The applicant shall perform an evaluation and analysis of the postulated fission product release, using the expected demonstrable containment leak rate and any fission product cleanup systems intended to mitigate the consequences of the accidents, together with applicable site characteristics, including site meteorology, to evaluate the offsite radiological consequences. Site characteristics must comply with part 100 of this chapter."

Additionally, Regulatory Guide 4.7, *General Site Suitability Criteria for Nuclear Power Stations*, (Revision 2, April 1998) notes:

> "Locating reactors away from densely populated centers is part of the NRC's defense-in-depth philosophy and facilitates emergency planning and preparedness as well as reducing potential doses and property damage in the event of a severe accident."

In summary, plant siting is to be evaluated in conjunction with plant design, and acts within the multiple lines of defense for both limiting public exposures and protecting the plant from external hazards, and is an element of emergency planning, which, in itself, is an essential component of the defense-in-depth strategy.

SRP Section: ARP DD - Defense in Depth
Application Section: Programmatic DID

RAI - ARP DD-6

Basic LWR strategies for managing catastrophic events call for covering the core with water. This action serves to terminate melt progression and reduce fission product releases. In modern HTGR designs, the corresponding challenge would be to terminate and mitigate a postulated severe graphite oxidation event involving massive and sustained air ingress. (For the MHTGR design, the Commission called out such events in the Staff Requirements Memorandum for SECY-93-092; see top of page 2).

Describe how programmatic DiD would establish and evaluate appropriate strategies for managing the progression and consequences of postulated severe air ingress events with massive graphite oxidation.

Response:

Section 3.2.3 of the white paper discusses examples of programs within the *Programmatic Defense-in-Depth* element of the NGNP approach. Table 3-2 lists a number of programs that would act to prevent and/or mitigate events. Programmatic elements include such strategies as maintenance and monitoring of SSCs, operator training, emergency planning, emergency operating procedures and their implementation, and the establishment and implementation of accident management guidelines. As stated in section 3.2.3, these strategies will need to be developed in the context of the NGNP approach to the use of PRA, the selection of Licensing Basis Events (LBEs), the safety classification of Structures, Systems, and Components (SSCs), and the derivation of special treatment requirements for SSCs. More information regarding use of these strategies for specific LBEs that have been selected following an agreed upon process will be available later in the design effort as the elements of this context are developed in detail.

SRP Section: ARP DD - Defense in Depth
Application Section: NGNP Licensing Strategy

RAI - ARP DD-7

Provide a discussion of how the proposed DID approach is consistent with the NGNP Licensing Strategy Report plan for a risk-informed and performance-based licensing approach, using deterministic engineering judgment and analysis, complemented by design-specific PRA information.

Response:

Advanced reactor designs are expected to provide enhanced margins of safety and/or use simplified, inherent, passive, or other innovative means to accomplish their safety and security functions. The NGNP's proposed framework for DID includes the three major elements discussed below.

Plant Capability Defense in Depth

As noted in the DID white paper, "Plant Capability Defense-in-Depth" reflects the decisions made by the designer to incorporate DID into the functional capability of the physical plant. This element of DID includes the use of deterministic evaluations.

The NGNP design will utilize simplified safety systems, plant features that minimize the potential for severe accidents, and a DID philosophy to maintain multiple barriers against radiation release. For example, HTGR safety design is based on containment of radionuclide releases at the source (i.e., the TRISO coated fuel particle). Other preventive and mitigative design features work in an integrated fashion with the coated particle fuel to deal with the consequences of accidents and to provide successive and multiple physical barriers to the release of radioactive material.

As a second example, NGNP design features will include the use of passive means to prevent and mitigate transients and design basis accidents. Conventional engineering design and analysis techniques will be used to make design selections to satisfy these requirements, and existing HTGR experience will be utilized by the design process. The transient and accident prevention measures will result from deterministic engineering judgment backed by analysis of uncertainties that supports the adequacy of the design.

Programmatic Defense in Depth

As stated in the DID white paper, "Programmatic Defense-in-Depth" reflects the programmatic actions for designing, constructing, operating, testing, maintaining, and inspecting the plant so that there is a greater degree of assurance that the DID factored into the plant capabilities during the design stage is maintained throughout the life of the plant. As with Plant Capability DID, this element includes the use of deterministic evaluations.

Given the importance of TRISO fuel to contain the release of fission products, proof of this capability will required by the NGNP fuel qualification program. In addition, the plant is designed and operated such that a large margin to particle fuel damage is maintained during all anticipated operational occurrences, design basis events, and beyond design basis events.

Testing and maintenance programs will provide assurance that SSC safety functions will perform as designed.

Prior to obtaining SSC performance test data, uncertainties would be covered by engineering judgment.

Risk-Informed Evaluation

Risk-informed evaluation of DID is the structured use of information provided by the PRA to: identify the roles of SSCs in the prevention and mitigation of accidents, identify and evaluate uncertainties in the PRA results, devise deterministic approaches to address these uncertainties, and guide and provide risk insights to support deterministic judgments on the adequacy and sufficiency of DID.

The NGNP design process will use systematic top-down approach to meeting regulatory/end user requirements. A design specific PRA will be used to illustrate conformance of plant response and an indication that the plant response meets the top level regulatory criteria. In addition, NGNP design features will be evaluated for their risk significance in determining safety classification.

Once SSC performance data is available, it would be used in the analysis to provide assurance that the SSC safety functions are accomplished. Assurance that SSCs will perform as expected and modeled in the design specific PRA is provided by test and qualification.

In summary, the DID process described above is an integrated approach that uses a blend of deterministic and probabilistic elements that is consistent with the recommended strategy discussed in Section 2.1.1 on Page 9 of the NGNP Licensing Strategy Report (Report to Congress – August 2008).