February 18, 2009

MEMORANDUM TO: William D. Reckley, Chief
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Advanced Reactor Program
Office of New Reactors

FROM: Thomas J. Kenyon, Senior Project Manager **/RA/**
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SUBJECT: SUMMARY OF PRE-APPLICATION MEETING WITH THE U.S. DEPARTMENT OF ENERGY TO DISCUSS THE APPROACH TO BE USED DURING THE REVIEW OF THE NEXT GENERATION NUCLEAR PLANT

On December 11, 2008, staff from the U.S. Nuclear Regulatory Commission (NRC) met with representatives from the U.S. Department of Energy (DOE) and Idaho National Laboratory (INL) to discuss the approach to be used during the review of key topic areas for the Next Generation Nuclear Plant (NGNP), including an overview of the proposed approach and a discussion of selecting licensing-basis events (LBEs). The meeting was conducted in accordance with Section 644(c) of the Energy Policy Act that states that:

> The Secretary shall seek the active participation of the Nuclear Regulatory Commission throughout the duration of the [NGNP] Project to — (1) avoid design decisions that will compromise adequate safety margins in the design of the reactor or impair the accessibility of nuclear safety-related components of the prototype reactor for inspection and maintenance…

Enclosures 1 and 2 are the meeting agenda and attendee list, respectively. DOE's slide presentation can be obtained from the Commission's Public Document Room, One White Flint North, 11555 Rockville Pike (first floor), Rockville, MD. It is also available electronically from the Public Electronic Reading Room found on the Internet at the following web address: http://www.nrc.gov/reading-rm.html. From this site, the public can gain access to the NRC's Agencywide Documents Access and Management System (ADAMS), which provides text and image files of NRC's public documents in the Publicly Available Records component of ADAMS. The ADAMS accession no. for the presentation is ML090080151.

INL began its presentation with an overview of the NGNP licensing strategy that was issued to Congress in August 2008, "Next Generation Nuclear Plant Licensing Strategy — A Report to Congress (ADAMS Accession no. ML082290020). Although the pre-application period for

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the NGNP is not scheduled to begin until 2010, INL stated that they want to begin identifying key issues now and begin developing a process framework for reaching resolution on NGNP-related issues consistent with the licensing strategy. INL was also developing the regulatory gap analysis called for in the NGNP licensing strategy. INL proposed to submit white papers for staff review during the pre-application stage as proposed resolutions to issues were developed.

INL then discussed the organization of the INL NGNP project team, which consists of INL staff, contractors from three gas-cooled reactor suppliers, owner-operators, architect-engineers, as well as contacts with the gas-cooled reactor community.

Then INL discussed their proposed approach for conducting a risk-informed, performance-based review. The NGNP licensing strategy includes recommendations for the review approach for the licensing of the NGNP prototype facility. The recommendations and technical basis supporting the NGNP licensing strategy were developed during a cooperative effort between the NRC staff and DOE. In the licensing strategy, the Secretary of Energy and the Commission jointly determined that the best option for licensing the NGNP prototype would be to use a risk-informed and performance-based technical approach that employed the use of deterministic judgment and analysis, complemented by NGNP-specific probabilistic risk assessment (PRA) information, to adapt the existing light-water reactor (LWR) technical requirements and to establish the NGNP-unique requirements that are not addressed by existing LWR requirements and guidance. This was referred to as Option 2 in the licensing strategy. Because there are three potential high-temperature gas-cooled reactor (HTGR) designs that could be selected for the NGNP, INL is initially focusing its NGNP project efforts on issues that are generically applicable to gas-cooled reactors. Issues specific to a particular design will be addressed when the actual design is selected.

INL discussed their proposed risk-informed, performance-based safety design approach, which incorporated insights from previous reviews of the Modular High-Temperature Gas-Cooled Reactor (MHTGR), the Pebble Bed Modular Reactor (PBMR), the technology neutral framework described in NUREG-1860, “Feasibility Study for a Risk-Informed and Performance-Based Regulatory Structure for Future Plant Licensing,” Volumes 1 and 2 (ADAMS Accession numbers ML062120363 and ML062120385), in December 2007, and experience with risk-informing LWR regulations. INL was conducting an iterative design approach that was adapted from a recent draft of American Nuclear Society Standard ANS-53.1. The process begins with the establishment of an initial design for further evaluation. INL indicated that this initial design is established through the use of a process that is based on design specifications and operating experience as well as uses a set of top level requirements derived from a frequency-consequence (F-C) chart.

As an example of INL’s proposed design approach, they discussed their methodology for selecting LBEs for the NGNP. INL proposed to establish top level safety criteria (TLSC) using the F-C chart shown during their presentation to identify issues early in the design development process. INL proposed that LBEs be categorized from a PRA by using the F-C curve. Cumulative risks would be evaluated as well. Design-basis accidents (DBAs) would be defined deterministically and safety analyses would be performed to confirm the top level design criteria. The PRA would be used to identify critical uncertainties, special treatment requirements, and evaluate defense-in-depth (DID) concerns. INL indicated that it believed that this would provide assurance that TLSC are met by satisfying the deterministic requirements to reduce

uncertainties in the PRA results. The staff stated that the F-C chart implied that the NRC's regulations set the criteria used in the chart, which it did not believe was the case. The F-C chart represented INL's design criteria and did not necessarily mean that the NRC would find these criteria acceptable. INL disagreed and indicated that the elements of the F-C curve are derived from the current regulations. The staff stated that the proposed approach placed more reliance on PRA than the approach recommended in the NGNP licensing strategy and that risk assessment appeared to have more influence of the design process. The staff stated that the proposed process looked more like the Option 3 approach discussed in the NGNP Licensing Strategy, which relies heavily on the use of PRA. The staff stated that it did not understand how INL was applying deterministic considerations in the safety design approach. Vulnerabilities such as aircraft impacts would need to be indentified deterministically, because the PRA does not address those types of issues. The staff further asked how INL was addressing unanticipated events.

INL indicated that the LBEs would be evaluated individually against the TLSC, and collectively to show compliance with quantitative health objectives (QHOs) of the safety goals. They stated that use of PRA would enable systematic and exhaustive enumeration of event sequences, identifying dependencies, addressing uncertainties, anchoring on realistic assumptions, and verifying plant design meets safety goal QHOs. Deterministic safety evaluation includes failure modes and effects analyses and hazard and operability reviews for identifying initiating events, success criteria development, plant response to events, mechanistic source terms, and development of accident management philosophy. Initiating event examples discussed by INL included transients involving an intact helium pressure boundary (HPB) with and without reactivity addition, HPB leaks and breaks, HPB heat exchanger failures, events with radionuclide sources outside the HPB, and internal plant hazards and external events (e.g., seismic and process hazards). HPB leak and break events present unique characteristics to safety design approach, one being the transport mechanism and release of fission products. At small break sizes, the greater blow down time allows for more decay before release. Larger break sizes increase the shear force during blow down and greater liftoff of plateout and dust material.

For analysis purposes, INL defined the plant as having up to eight reactors with a lifetime of 60 years. Anticipated operational occurrences, design-basis events (DBEs) and beyond-design-basis events would be defined in the F-C chart, with event sequence mean frequency and realistically analyzed dose at the exclusion area boundary. DBAs would be selected from DBEs to provide deterministic confirmation that safety-related structures, systems, and components (SSCs) alone can mitigate the consequences of these DBEs (or prevent high consequence beyond-design-basis accidents (BDBA) from happening). Conservative operating conditions and limiting values of parameters such as temperature, stresses, and heat loads that safety-related SSCs must meet would also be derived. Some examples of DBAs deterministically derived from DBEs from the PBMR design (i.e., assuming only safety-related SSCs work) were discussed. Finally, INL indicated that the risk-informed evaluation of DID provides for an iterative process where successive enhancement of plant capabilities and programmatic assurance are implemented to meet the TLSC, and provide for adequate prevention, mitigation, safety margins, and uncertainties. In summary, INL stated that the LBE selection approach provides for (1) a systematic search for initiating events and event sequences specific to the design; (2) clearly delineated roles of each SSC in prevention and mitigation of accidents; (3) evaluation of common cause events, multiple failures and events involving more than one reactor module in an integrated risk framework; (4) evaluation of

uncertainties; and (5) greater understanding of plant performance and margins in licensing analyses. In addition, INL indicated that deterministic methods would be used extensively in defining candidate LBEs (for DBA and BDBA selection), and that DID would be integral to the approach.

When asked how INL intended to apply this approach to establish the final design basis for the design, INL indicated that they intended to use the F-C curve only as guidance for the designer to use during early development of the reactor, but did not propose to use it for establishing the licensing basis. The staff indicated that using the PRA in this manner may be appropriate as a design tool, but that the applicant should not expect credit for this approach during the staff's licensing review.

A brief history of the development of HTGR designs was provided next. It included a discussion of the United States and European technology for modular helium reactors (Dragon, AVR, Peach Bottom Unit 1, Fort St. Vrain, and thorium high-temperature reactor) INL stated that the MHTGR represents a fundamental change in reactor design and safety philosophy. INL indicated that the NGNP will be the first HTGR that involves a risk-informed design and licensing approach. The prior NRC review of the MHTGR (canceled in 1993) was summarized in NUREG-1338, "Pre-Application Safety Evaluation Report for the Modular High-Temperature Gas-Cooled Reactor (MHTGR)," (ADAMS Accession no. ML052780519), which discussed the design of the MHTGR proposed by DOE in 1989.

In summary, the staff stated that it was not clear whether INL was proposing to follow Option 2 or Option 3 of the NGNP Licensing Strategy. The staff indicated that it appeared that INL was proposing to use an Option 3 approach (which relies more heavily on the use of PRA) for the development of the design and the licensing basis. This was not the recommended approach in the NGNP Licensing Strategy. DOE/INL were reminded that, although alternative review approaches can be proposed once the applicant is chosen to develop the NGNP, deviation from the NGNP licensing strategy could jeopardize the schedule and resource estimates in that document. The staff stated that it wanted to ensure that deterministic criteria for bounding events selection was being properly considered in accordance with the NGNP licensing strategy, and recommended INL review the licensing approach applied to the MHTGR. The staff asked that INL be clearer in how they intend to justify the acceptability of the design in the design certification application. The staff indicated that it believed that a Commission paper existed that discusses criteria for selecting bounding events. The staff indicated that it would develop a set of deterministic criteria for selecting conservative bounding events. Although the staff acknowledged that INL was discussing its process for designing the NGNP, it did not seem to be consistent with the Option 2 review approach for reviewing the facility that was described in the NGNP licensing strategy. The staff was concerned with how INL would prepare an approach for developing a licensing basis that would be consistent with the Option 2 review approach that would be needed when licensing the facility.

At the close of the meeting, INL stated that they would evaluate the staff's comments and update their approach to address them. It was agreed that additional interactions between DOE/INL and the NRC may be appropriate to discuss questions arising from the pre-applicant's analyses efforts. Potential future discussions that were identified during the meeting included discussions on resolution of comments on (1) their licensing approach; (2) LBEs events; (3) classification of SSCs; (4) containment; (5) DID; and (6) the regulatory gap analysis. The staff also indicated that it would be helpful for INL to provide design information so it did not

have to discuss issues in the abstract. Further, the staff wanted to better understand INL's research activities, and requested that it provide task-schedule information to determine 2012 budget needs.

Project No. 0748

Enclosures:
As stated

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Meeting Agenda
Meeting on Review Approach for the
Next Generation Nuclear Plant

8:30 a.m. – 3:15 p.m.
Thursday, December 11, 2008

TIME	TOPIC	LEAD
8:30 - 8:40 a.m.	Introduction and opening remarks	NRC/DOE
8:40 - 9:45 a.m.	Overview of Development and Content of the NGNP Licensing Strategy	DOE/INL
9:45 - 10:00 a.m.	Break	
10:00 - 12:00 p.m.	Proposed NGNP Risk Informed Approach Relative to the Licensing Strategy	DOE/INL
12:00 - 1:00 p.m.	Lunch	
1:00 - 1:45 p.m.	Summary of Previous Industry and NRC Interactions on the Risk-Informed Approach	DOE/INL
1:45 - 2:45 p.m.	Selection of Licensing Basis Events	DOE/INL
2:45 - 3:15 p.m.	Topics and date for next meeting	All
3:15 p.m.	Adjourn	

Enclosure 1

Meeting Attendees
Meeting on Review Approach for the
Next Generation Nuclear Plant
December 11, 2008

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