UNITED STATES
NUCLEAR REGULATORY COMMISSION
ADVISORY COMMITTEE ON REACTOR SAFEGUARDS
WASHINGTON, DC 20555 - 0001

May 20, 2011

Mr. R.W. Borchardt
Executive Director for Operations
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

SUBJECT: HIGH TEMPERATURE GAS-COOLED REACTOR (HTGR) NRC RESEARCH PLAN

Dear Mr. Borchardt:

During the 583rd meeting of the Advisory Committee on Reactor Safeguards, May 12-14, 2011, we reviewed the NRC's HTGR research plan. Our Future Plant Designs Subcommittee also reviewed this matter during a meeting on April 5, 2011. During these meetings we had the benefit of discussions with representatives of the NRC staff. We also had the benefit of the documents referenced.

CONCLUSIONS AND RECOMMENDATIONS

1. Given the current state of design information, the HTGR research plan is a good step toward identifying the research needed for NRC to have an independent assessment capability.

2. As this research progresses, the staff should continue to identify the need for additional experimental data from the Department of Energy (DOE), the applicant, or NRC research.

3. The plan should be updated as data are received from the DOE, when a Next Generation Nuclear Plant (NGNP) design is selected, and if the constraints of the Energy Policy Act are relaxed.

4. It is necessary to examine the integrated NRC/DOE program to be assured that the most important issues are being effectively addressed.

BACKGROUND

In accordance with the 2005 Energy Policy Act (EPAct), Public Law 109-58, the NRC and DOE jointly developed a licensing strategy report for the NGNP, and submitted it to the Congress in August 2008. As defined in the EPAct, the prototype NGNP is conceptually a very high temperature gas-cooled reactor (VHTR) for generating electricity, and co-generating hydrogen using the process heat from the reactor. It is to be operational by September 30, 2021. The 2009 amendment of the EPAct concentrated on the public/private partnership and also addressed industrial applications other than hydrogen generation.

Under a memorandum of understanding, the DOE and NRC are pursuing complementary areas of research and have agreed to share the products of that research. Because the DOE has not yet selected a specific NGNP design, the NRC has developed an HTGR research plan that examines issues that are common to the alternative HTGR designs under consideration, i.e., either pebble bed or prismatic core designs.

The staff's priority regarding advanced reactor research is to prepare for a review of the NGNP application for a combined license. Although the review will use information from other sources (DOE, applicant, third parties, and international work), the research plan focuses on the NRC efforts. Hence, we were not able to review the bases for the staff's conclusion about the adequacy of information provided by these other sources.

The NRC has sponsored a number of phenomena identification and ranking table (PIRT) studies to: (1) prioritize its confirmatory research activities, (2) develop independent and confirmatory analytical tools for safety analysis, (3) define test data needs for the validation and verification of analytical tools and codes, and (4) provide insights for the review of applicant's safety analysis and supporting databases. Evaluations were performed for five major topical areas: (1) accident analysis and thermal-fluids including neutronics, (2) fission product transport, (3) high temperature materials, (4) graphite, and (5) process heat and hydrogen production. The results were documented in NUREG/CR-6944. A separate PIRT was conducted on TRISO-coated particle fuel for VHTR and HTGR technology and documented in NUREG/CR-6844, Volumes 1 to 3.

The NGNP licensing strategy includes a description of analytical tools that the NRC will need to develop to independently verify the NGNP design and safety performance. The NRC plans to use existing analytical tools to the extent feasible, with appropriate modifications for the NGNP application. The NRC will also use the data and tools available from the DOE funded ongoing research and development (R&D) activities, experimental data generated by the applicant and provided to the agency as part of the license submittal, data generated under cooperative domestic and international programs, and other data available in the open literature. The scope of the infrastructure development includes development of regulatory guidance; standard review plans; general design criteria; codes and standards; a reactor oversight process and inspection program; as well as NRC staff acquisition, training and qualification program development. Many of the 10 CFR Part 50 technical requirements can be applied directly, or with some modification, to NGNP. However, a number of new requirements may also be needed. The staff is preparing SECY papers on potential policy issues (e.g., containment, emergency planning, source term), and white papers are being generated for DOE under the NGNP program.

DISCUSSION

The NRC R&D plan covers seven major technical disciplines unique to HTGR:

- Plant safety analysis including thermal-fluids and accident analysis
- Nuclear analysis
- Fuel performance and fission product behavior
- High temperature materials performance
- Graphite performance
- Safety issues related to process heat applications
- Structural analysis (with particular focus on high-temperature effects)

In addition, the plan covers other technical disciplines where ongoing or planned generic R&D activities for small modular light-water reactors (LWRs) will be applicable to HTGRs, some directly, others with appropriate modifications. Therefore, little specific activity for the HTGR in these disciplines is currently in the plan. The disciplines include:

- Instrumentation and control for high-temperature applications
- Human factors and human reliability analysis
- Probabilistic risk assessment and risk-informed infrastructure development

Major themes in the NRC research plan are the assembly of experimental databases and the development of validated analysis tools to help make sound regulatory decisions on key technical issues.

The research plan states that the current trend in the NGNP conceptual designs is to focus on an outlet temperature around 750 °C to take advantage of existing code qualified material properties and performance databases. Accordingly, the scope of initial R&D activities described in the plan, primarily in the materials area, is predicated upon the choice of reactor outlet temperatures near the lower end (around 750 °C) of the outlet temperature range (the DOE high temperature material research program has started addressing temperatures up to 950 °C). Without the selection of a specific HTGR design, the planned NRC safety analysis tools will cover both the pebble-bed reactor and the prismatic core reactor designs.

While the HTGR NRC research plan appears to be a well-constructed mix of analytical tools, experimental data, and theoretical development, it is important to note that some issues are not covered in the current plan because the EPAct and the licensing strategy call for the prototype to be constructed on DOE's Idaho site. The fuel cycle (except some neutronics issues that are in the plan) and examination of security and safeguards in an integrated way will need to be addressed in the future.

There are also some areas where new or additional research and development appear to be warranted depending on the specific reactor design, such as fuel performance, water/steam ingress, long term cooling by shutdown decay heat removal, graphite dimensional changes due to irradiation and temperature characteristics, and graphite dust generation and transport. The staff should continue to identify these experimental data needs that will validate their evaluation model, provided from either the DOE, the applicant or from NRC research as appropriate.

It is difficult to assess the adequacy of the NRC research plan without considering other ongoing work. In the future, it will be necessary for us to examine the integrated NRC/DOE program to be assured that the most important issues are being effectively addressed and that the interfaces between the organizations are adequate. For example, we need to better understand if the decision to adapt LWR computer codes for HTGR modeling can meet the needs of the physics and chemistry of the more complex and more challenging aspects of the HTGR system. We also need to understand how issues associated with graphite can be addressed theoretically and experimentally and how well efforts to address new issues are being resolved through examination of new international gas reactor experience.

The plan is as well structured, as current information and legal constraints would allow. We look forward to continued interactions with the staff as the research plan is implemented and, later, as the missing elements are addressed.

Drs. Rempe, Corradini, and Powers did not participate in the Committee's deliberations regarding areas in which they have a conflict of interest.

Sincerely,

/RA/

Said Abdel-Khalik
Chairman

References:

1. High-Temperature Gas-Cooled Reactor (HTGR) NRC Research Plan (ML110310182)

2. Next Generation Nuclear Plant Licensing Strategy a Report to Congress, August 2008 (ML110620503)

3. Staff Requirements – SECY-08-0019 – Licensing and Regulatory Research Related to Advanced Nuclear Reactors, June 11, 2008 (Official Use Only - Sensitive Internal Information)

4. Staff Requirements – COMSECY-08-0018 – Report to Congress on Next Generation Nuclear Plant (NGNP) Licensing Strategy, June 16, 2008 (Official Use Only -Sensitive Internal Information)

5. Staff Requirements – SECY-11-0024 – Use of Risk Insights to Enhance the Safety Focus of Small Modular Reactor Reviews, 05/11/11 (ML111320551)

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Letter to R.W. Borchardt, EDO, NRC, from Said Abdel-Khalik, Chairman, ACRS, dated May 20, 2011

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