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ANL-AFCI-188

Interim Progress Report on Safety and Licensing Strategy Support for the ABR Prototype

Nuclear Engineering Division

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May 31, 2007

WBS 1.4.3
Work Package PAN07ABCD05

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Introduction and Background

Argonne National Laboratory is providing support to the U.S. Department of Energy in the Global Nuclear Energy Partnership (GNEP) in certification of an advanced, sodium-cooled fast reactor. The reactor is to be constructed as a prototype for future commercial power reactors that will produce electricity while consuming actinides recovered from light water reactor spent fuel. This prototype reactor has been called the ABR, or Advanced Burner Reactor.

As part of its activities, Argonne is providing technical services to assist definition of a safety and licensing strategy for the ABR prototype, and to further implementation of the strategy. In FY06, an organizational meeting was held for DOE and its laboratory contractors to discuss licensing alternatives and review previous licensing experience for the Fast Flux Test Facility (FFTF) and the Clinch River Breeder Reactor Plant (CRBRP). Near the end of FY06, a report summarizing the discussions and conclusions was written. One of the top-level conclusions recorded in the report was a recommendation to follow a licensing strategy that included the U.S. Nuclear Regulatory Commission (NRC) as the regulatory review and licensing authority.

In FY07, activities at Argonne to support safety and licensing progress have continued. Because the ABR prototype designer and constructor are not yet determined, formal licensing interactions with NRC must currently be limited to consideration of conceptual design bases and the technological readiness of the sodium fast reactor industry to proceed. To address these issues, an introductory meeting between NRC and DOE was held at which the status of current regulatory requirements was reviewed by NRC, and the status of the GNEP/ABR project was summarized by DOE. Selected reviews of the history of sodium fast reactor projects in the U.S. and the current status of technology were summarized at this meeting by DOE laboratory staff. As a result of these discussions, it was recognized that the program would benefit from further technical interactions between NRC and DOE laboratory technical staff. To that end, a series of technical information meetings were planned in which knowledgeable DOE laboratory researchers could communicate up-to-date technology status reports to NRC staff. This series of information exchange meetings is covered by Wrok Package PAN07ABTD03, Knowledge Management. Two of these meetings have been held, and additional topics will be covered in future meetings.

A regulatory crosscut planning meeting is scheduled for June 6-7 at Sandia National Laboratory.

Information Exchange Meetings with NRC

An initial information exchange meeting between NRC and DOE and its laboratory staff was held at DOE-Germantown on December 12, 2006. Discussions at this meeting revealed the desirability for a continuing series of meetings to provide NRC with information on the status of the sodium fast reactor technology, with coverage of performance characteristics for actinide consumption. A list of technical topics to be covered in further meetings was prepared by Argonne and forwarded to NRC and DOE for review. NRC subsequently provided comments and additional topics for consideration. The revised list of topics is provided in Appendix A.

The second and third meetings, covered by Work Package PAN07ABTD03 – Knowledge Management, have been held at NRC-White Flint with presentations by Argonne research staff. These presentations were video-taped by NRC for future reference. Non-sensitive presentations from all meetings are being made available to registered personnel on a worldwide web site at Argonne.

December 12, 2006 Meeting at DOE-Germantown

In this initial meeting, DOE presented an overview of the GNEP program, and identified policy, resource, and infrastructure issues and challenges from the project sponsor's perspective. NRC presented information on potential regulatory approaches and also addressed issues associated with integrated safety analysis, management measures, and quality assurance requirements. DOE laboratory staff presented information on previous sodium fast reactor experience and lessons learned, use of probabilistic risk assessment (PRA) in new facility design, status of materials technology, and ABR prototype driver fuel qualification status.

Discussions of sodium fast reactor technology status in this meeting identified the desirability for further information exchange meetings, prompting preparation of the list of topical areas in Appendix A and the scheduling of presentations by DOE laboratory staff to NRC.

March 21 and May 3, 2007, Meetings at NRC-White Flint

In the March 21 meeting, Argonne research staff presented introductory information on sodium fast reactor technology (Topic 1a in Appendix A) to NRC staff. The presentation began with an introduction to liquid-metal-cooled reactor (LMR) technology and continued with a summary of U.S. LMR experience, including the EBR-I and EBR-II research facilities at Argonne-Idaho, and the Fast Flux Test Facility (FFTF) at Hanford. Other significant, but not constructed projects included the Clinch River Breeder Reactor Plant, the Rockwell International SAFR design, and the General Electric PRISM design. The design, performance, operational, and safety issues associated with these projects were reviewed, with emphasis on aspects that are relevant to the ABR prototype. Information and experience from the legacy U.S. LMR research and development program were reviewed.

In the May 3 meeting, Argonne research staff presented technical information on the technology of sodium as a reactor coolant (Topic 1b in Appendix A) and on sodium fast reactor physics performance (Topic 2a in Appendix A).

In the sodium coolant presentation, the thermophysical, transport, and chemical properties of sodium were reviewed and compared with water. The relationship of sodium properties to reactor and plant design features was described with emphasis on safety-related performance characteristics. Important contrasts with light water reactor performance and safety design features were highlighted.

In the fast reactor physics presentation, the neutronics performance characteristics of a fast spectrum reactor were reviewed, with consideration of fuel loadings for actinide burning. The presentation covered relevant operational and safety reactor physics issues, including traditional safety concerns regarding important reactivity feedbacks such as fuel Doppler and coolant voiding.

Future Meetings

Additional meetings are planned for FY2007 to address remaining topics listed in Appendix A. The next informational meeting with NRC is tentatively scheduled for June 21, 2007, with an agenda to cover topics under item 6, Safety Issues #1.

Regulatory Crosscut Planning

A regulatory crosscut planning meeting is scheduled for June 6-7 at Sandia National Laboratory. The purpose of this meeting is to identify activities necessary to support licensing of GNEP facilities, and to schedule execution of activities in the near and longer terms.

Appendix A

Proposed DOE/NRC GNEP Closed Fuel Cycle Topical Seminar Areas
February 5 NRC Mark-Up (Bold type)

1. Overview and Sodium Technology Background
   a. Introduction to LMR Technology; LMR experience, designs, performance, operational issues, safety issues, US and international, status. US R&D program and experience.
   b. Sodium technology, chemistry, thermal-hydraulic performance, corrosion of steel, oxidation

2. Physics and Thermal-Hydraulics Performance
   a. Fast reactor physics performance; breeding, burning, mass loadings/inventory, coolant void worth, and reactivity coefficients
   b. Fast reactor thermal-hydraulic performance; temperatures, heat fluxes, forced convection, natural circulation, etc.

3. Fuel Performance Experience
   a. Fuel performance - general; metal and oxide
   b. Fuel irradiation experience and results; EBR-II, FFTF
   c. TREAT testing results for metal and oxide fuel
   d. Fabrication & standards history/current capabilities

4. Structures, Systems, and Components #1
   a. Major sodium component technology; pumps, heat exchangers, vessels, refueling systems design and performance, etc.
   b. Structural materials for SFR technology and their performance
   c. I&C, fire protection, sodium leak detection, etc.
   d. Prior and current operating experience (availability?)

5. Structures, Systems, and Components #2
   a. Control and protection systems designs and performance
   b. Containment systems designs and performance
   c. Seismic isolation systems and reactor applications
   d. **Prior and current operating experience (availability?)**

6. Safety Issues #1
   a. Safety issues; DBA, BDBA, severe accident historically (coolant void, recriticality, FCI), passive safety
   b. Safety analysis past results (FFTF, CRBRP, **SAFR, PRISM**)
   c. Safety analysis methods; reactor, structural, coolant aerosols, containment

7. Safety Issues #2

a. Licensing issues in FFTF, CRBRP, SAFR, PRISM. International experience in perspective, high profile issues in Phenix, SuperPhenix, MONJU, BN-350, EBR-1, FERMI explained and lessons learned.
b. Inherent passive safety characteristics of sodium fast reactor systems (wrt loss of flow without scram, etc.). Inherent reactivity shutdown, natural circulation decay heat removal
c. Safety testing results, EBR-II SHRT, FFTF ULOF (GEMS); TREAT

8. **Codes, Modeling, Analyses**
   a. **Computer Codes Used for Transient and Accident Analyses of LMRs**
   b. **Mechanistic Source Term Modeling for LMRs**
   c. **General – status of other codes, modeling, analyses; need for updating or new applications; access to data and codes, etc.**

9. **Licensing Strategy/Framework**
   a. **DOE – Applicant/Licensee**
      - **Relationship**
      - **Responsibilities**
      - **Contractual Requirements**
   b. **Applicability of DOE Orders**
   c. **NRC Regulatory Requirements**
      - **Technical Requirements**
      - **Material, SSC Specifications**
      - **Safety Program**
      - **QA Program**
      - **Fuel Technical Criteria and Qualification**
   d. **Recycle/Fabrication/Reactor Operations/Safety/Quality Interactions**

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