NRC AND ACRS TECHNICAL ISSUES RELATING TO CLINCH RIVER BREEDER REACTOR (CRBR)

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Introduction

The Nuclear Regulatory Commission has not accepted Subsection NH of Section III of the ASME Code "Class 1 Components in Elevated Temperature Service." Further, the Advisory Committee on Reactor Safeguards (ACRS) reviewed similar elevated temperature structural design criteria proposed for the Clinch River Breeder Reactor (CRBR) and generated a list of technical issues and safety concerns that they believed still needed to be resolved. DOE agreed to fund R & D efforts to answer their concerns to the satisfaction of the U.S. NRC and ACRS prior to requesting an Operating License for CRBR. The structural design criteria being used at that time was fundamentally similar to the current criteria in Subsection NH of Section III of the ASME Code. It is clear that these safety issues need to be resolved from a regulatory perspective in order to assure that the technology needed to support the licensing of NGNP and Gen IV will be in place to support Design Efforts in a timely manner.

Overview of Regulatory Safety Issues

Assurances must be provided that the structural criteria used for Very High Temperature Reactors (VHTR) provide adequate safety margins against cracking of safety related components. The following basic technical questions have been raised:

1. Recognizing that creep strains concentrate in grain boundaries, how do limits on strains in the equivalent homogeneous material prevent excessive grain boundary strains, and grain boundary cracking?

2. Since elevated temperature material properties are measured in uniaxial test specimens, how do we account for the lower ductility and creep rupture strength under biaxial conditions?

3. How can we reliably predict and prevent long term creep cracking behavior?

4. Since base metal, weld material, and the heat affected zone (HAZ) of weldments have different creep properties, how are we accounting for the resulting strain concentration effects at the weldments?

5. How are we accounting for long-term environmental and irradiation effects?

6. Since Linear Elastic Fracture Mechanics (LEFM) and Elastic Plastic Fracture Mechanics (EPFM) are not applicable in the creep regime, how is very high temperature crack growth being analyzed?

7. How is the aging effect on material at Very High Temperatures being taken into account from a safety point-of-view?

8. Have “lessons learned” from elevated temperature vessel failures in the commercial and industrial world been considered in the design criteria?

9. Is inspection technology available for measuring creep swelling, creep rupture damage and creep cracking?

10. Are flow tolerance technologies available for very high temperature safety related reactor components or do they need to be developed?

11. Have the effects of material imperfections been considered in the safety analyses?

12. Safety which depends entirely on the “black box” finite element cyclic creep analyses is not sufficiently reliable for licensing purposes. An independent simplified method of verifying the cyclic creep response is needed to provide the necessary assurance of reliability.