Modular HTGR Safety Analysis and Licensing Challenges

Challenges to Establishing an Acceptable HTGR Licensing Basis

- Deciding the technical approach and criteria for concluding that modular HTGRs meet the Commission's expectations for advanced reactors that they provide for enhanced margins of safety.to accomplish their safety functions.

- Deciding the technical approach and criteria for concluding that the integrated risk posed by the multiple reactor modules of an HTGR modular plant at a site in meeting the Commissions safety goals.

- Developing an acceptable approach for utilizing risk information and deterministic information in establishing the plant licensing basis.

    - Utilizing event probabilities, including uncertainties and engineering judgement in selecting events to be included in the licensing basis

    - Establishing safety margin and defense-in-depth requirements to adequately accommodate uncertainties and unknowns for non-LWR plant designs which have limited operational experience, but utilize inherent characteristics and passive SSCs to reliably achieve safety functions.

    - Establishing a risk-informed approach to equipment classification where calculated dose consequences may be very low for even the most limiting design basis events and beyond the design basis events.

    - Establishing functional performance requirements for radiological barriers (e.g., whether a vented confinement would be acceptable vs a traditional low leakage containment building).

    - Establishing methodology and quality standards for the plant PRA to ensure its acceptability as a reference for establishing the licensing basis

- Establishing an acceptable basis for potential (longer-term) changes to emergency planning requirements for plants that are proposed to be built on green field sites

- Ensuring that the expectations and standards for security and physical protection are adequately integrated with the expectations and standards for safety

Challenges to Establishing an Acceptable Technical Basis for the Plant Safety Analysis

- Nuclear, thermal-hydraulic and accident analysis computer codes to be used in the safety analysis (e.g, models, experimental data, applications) will need to be verified and validated.

- Fuel performance analysis computer codes for use in the safety analysis (e.g, models, experimental data, applications) will need to be verified and validated.

- An acceptable fuel qualification test program, together with adequate and continuing controls that ensure the safety performance of the fuel supplied over the life of the plant will need to be established.

- An acceptable basis from operating experience, experimental data and analysis methods for predicting the performance and behavior of reactor metallic components and graphite structures within the HTGR pressure boundary system operating environment will need to be established.

- An adequate data base, models and methods to use and acceptably quantify fission product transport and release for calculating the accident source term on a mechanistic basis will need to be established.

- The technical basis for licensing a highly automated multi-modular plant with significantly reduced control room staffing and significantly reduced plant staffing (compared to LWRs) will need to be established.

- Selected fuel cycle, transportation and waste issues that stem from the PBMR fuel form and, material accounting and control issues that stem from the PBMR's continuous on-line refueling, will need to be resolved.

<u>Challenges to Reviewing a HTGR (e.g., PBMR) Application</u>

- Significant safety research will be required to develop the technical tools, data and expertise need to support an effective and efficient independent NRC safety review of an HTGR application.

  – PRA models and data
  – Human performance analysis
  – Advanced Instrumentation and Controls
  – Thermal-Hydraulic and Systems Analysis
  – Accident and Severe Accident Analysis
  – Fuel Performance Analysis including Fuel Fabrication
  – Materials Performance Analysis
  – Structural Analysis
  – Fission Product Transport, Source Term and Consequence Analysis

- There are no HTGR-specific regulatory guides or HTGR-specific standard review plans. Additionally, the NRC technical staff has limited knowledge and expertise in the design, safety approach and technology of HTGRs. This will result in additional NRC challenges in conducting an HTGR safety review. Technical reviewer knowledge and capabilities will need to be developed across a range of technical review areas.
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- The PBMR Pty plans to reference in the PBMR design, selected international codes and standards as well as selected US professional society code cases that have not been reviewed and endorsed by the NRC. NRC review resources will be needed to assess the acceptability of these references.

- Current LWR (e.g., Part 50) requirements either do not apply or do not address significant HTGR design features and use of new technologies. Deterministic technical and safety requirements will need to be established to address these features and technologies.

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