



# NRC Research Needs: High-Temperature Gas-Cooled Reactor Fuel

May 21, 2002

**Stuart D. Rubin**  
**Office of Nuclear Regulatory Research**  
**U.S. Nuclear Regulatory Commission**

# Outline

- HTGR Research Goals
- HTGR Safety Research Plan Development
- Safety/Regulatory vs Development/Qualification Research
- Scope of HTGR Fuel Research
- Objectives for HTGR Fuel Testing Research
- Potential Regulatory Applications

# HTGR Research Goals

- Establish a technical basis for regulatory decision-making
- Understand and address uncertainties
- Gain insights into safety margins and failure points
- Increase public confidence in NRC regulatory decisions

# Safety Research Plan Development

## Research Plan Inputs and Insights:

- NRC Workshop on HTGR Safety and Research Issues
- IAEA Technical Documents
- Technical Exchange Visits to Germany, Japan, China, RSA, UK
- PBMR Pre-Application Review
- MHTGR Pre-Application Review
- OECD/CSNI Workshop on Safety Issues and Research Needs
- ACRS Workshop on HTGR Safety Issues
- DOE-Sponsored HTGR Training Course

# NRC Workshop: Selected Issues

- Q/A used for earlier fuel performance and qualification test programs
- Completeness of earlier fuel performance tests (conditions, margins)
- Prompt supercritical reactivity pulse accident fuel behavior and limits
- Chemical attack accident fuel performance and limits
- Design and licensing-basis events for the new HTGR plant designs
- Fission product release data for mechanistic source term calculation
- Effects of accelerated versus real-time irradiation testing
- Conservatism of traditional time-temperature accident test profiles
- Key fabrication process variables/values for fuel quality/performance
- Product characteristics and statistical methods for fuel fabrication QA
- Availability and reliability of fuel performance models and methods
- Availability of required test data for fuel performance models
- Ability to predict maximum local fuel operating/accident temperatures

# Safety/Regulatory vs. Development/Qualification Research

NRC Research is **Not** to Develop or Qualify Fuel:

- NOT to demonstrate adequate performance of the coated fuel particle (in compacts or pebbles) for *licensing basis conditions*
- NOT to identify margins to failure for fuel for *licensing basis conditions*
- NOT to provide the data to qualify the fuel manufacturing specification as adequate to produce fuel which meets in-reactor performance requirements
- NOT for fuel types other than potential US near-term commercial plant deployment (PBMR or GT-MHR)

# Safety/Regulatory vs. Development/Qualification Research

## NRC Research **Is** For Safety Evaluation/Regulation

- Explore limits (i.e., margins) of coated fuel particle performance and fission product retention capability
- Independently assess applicant claims of fuel performance and fission product release
- Develop information to judge acceptability of applicant's fuel qualification test plans, methods and results
- Develop independent tools to predict fuel fission product release and particle failure for licensing basis conditions

# Scope of HTGR Fuel Research

- Fuel irradiation and accident condition testing
- Fuel analytical model and methods
- Fuel fabrication
- Fuel technical expertise and information

# Objectives for Fuel Irradiation and Accident Condition Testing

- Explore the Limits/Margins of Fuel Performance and Fission Product Retention Capability
- Evaluate the Acceptability of Applicant's Fuel Qualification Testing
- Develop independent methods to predict coated fuel particle failure and fuel fission product release

# Explore the Limits/Margins of Fuel Performance and Fission Product Retention Capability

## Irradiation Conditions **Beyond** the Licensing Basis:

- Max irradiation temperature
- Max burn up
- Max fast fluence
- Max power level

## Accident Conditions **Beyond** the Licensing Basis:

- Max accident temperature
- Max supercritical reactivity pulse
- Severe chemical attack

# Evaluate Applicant Fuel Qualification Testing Acceptability

- Accelerated vs real time irradiation testing
- Temperature changes and power changes
- Accident condition heat up testing method: ramp and hold vs transient simulation
- Fuel testing knowledge and experience

# **Develop Independent Methods to Predict Coated Fuel Particle Failure and Fission Product Release**

Experimental data for:

- Coated fuel particle failure models
- Coated fuel particle material properties
- Fission product transport models for intact and failed particles and graphite matrix

# Potential Regulatory Applications

- Fuel fabrication technical specifications
- Fuel fabrication inspection procedures
- Fuel safety limits and limiting conditions for operation
- On-line fuel condition monitoring evaluations
- Fuel safety evaluations