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STATUS REPORT ON PREPARATION OF AN IAEA DOCUMENT ON GOOD PRACTICES FOR QUALIFICATION OF RESEARCH REACTOR FUELS*

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PRESENTATION OUTLINE

- Background
- Goal and Guiding Principles of Fuel Development
- Structure of the Good Practices Document
- Definition Of Qualification
- Information Supplied By Fuel Developer
- Generic Approach To Fuel Development and Qualification
- Actual Qualification Practices and Specific Examples
- Conclusion

BACKGROUND

THE PROBLEM:

- A number of research reactor fuel development and qualification programs are currently underway around the world
- But, there is no common understanding of what “fuel qualification” means
  - What information should a reactor operator or regulator expect to be provided for a new fuel?
  - How might such information be obtained?
  - Who decides that a fuel is qualified?

THE SOLUTION:

- Under the auspices of the IAEA, a document is being prepared that:
  - Defines fuel “qualification”
  - Describes what information must be provided before a fuel can be considered qualified
  - Describes a process for qualifying a fuel in terms of a set of internationally recognized good practices
  - Indicates the roles of the major entities/organizations involved

BACKGROUND (Cont'd)

- This Good Practices Document (GPD) is being prepared by a group of consultants representing a broad cross section of international fuel development experts, including
  - Fuel developers (FD)
  - Fuel manufacturers (FM)
- Final draft is expected to be presented to IAEA in mid-December
- Publication is expected in 2008

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GUIDING PRINCIPLES OF FUEL DEVELOPMENT

- **The GPD is <u>not</u> a safety standard or a safety guide!**

- However, the good practices described promote development of a fuel that will operate safely under the specified operating conditions

- The guiding principles of fuel development are that, under normal operating and anticipated incident conditions:
  - A heat transfer path is maintained between the fuel meat and the cladding
  - The fuel element must maintain its integrity to prevent release of fission products to the coolant
  - Fuel meat swelling must remain stable beyond the highest operationally achievable burnup

STRUCTURE OF THE GOOD PRACTICES DOCUMENT

DEFINITION OF QUALIFICATION

Qualification is a process carried out by a

- Fuel Developer to provide sufficient information about a new fuel type or about a new use for an existing fuel type for a regulatory body to license that fuel type for use under a set of bounding geometric configurations and irradiation conditions
- Fuel Manufacturer to demonstrate to a regulatory body and a customer that Fuel Elements and Fuel Assemblies of the new fuel type can be reliably and consistently manufactured to the required specifications.
- Regulatory Body to approve use of the fuel in at least one research reactor or for use in a generic class of research reactors
- A Reactor Operating Organization (customer) to specify Manufacturer qualification requirements and to determine if the Manufacturer is qualified

INFORMATION SUPPLIED BY FUEL DEVELOPER

- **Basic Fuel Properties**
  - Fuel chemical and phase composition
  - Density
  - Heat capacity
  - Thermal expansion coefficient
  - Method used to produce fuel powder for dispersion fuels
  - Particle size distribution (for dispersion fuels)
  - Fuel foil properties (for monolithic fuel)

- **As-Manufactured Fuel Meat and Fuel Element Properties**
  - Volume and constituent volume fractions
  - Heat capacity
  - Thermal conductivity
  - Thermal expansion coefficient
  - Exothermic energy release
  - Mechanical properties

INFORMATION SUPPLIED BY FUEL DEVELOPER (Cont'd)

- **Fuel Meat and Fuel Element Irradiation Properties**
  - Fission density distribution
  - Fuel element and fuel meat swelling
  - Fuel meat and fuel particle microstructures
  - Mechanical integrity
  - Blister threshold temperature
  - Cladding corrosion behavior
  - Fission product release

- **Fuel Assembly Properties**
  - Hydraulic and mechanical properties
  - Irradiation behavior

GENERIC APPROACH TO FUEL DEVELOPMENT AND QUALIFICATION

- A generic approach to developing a <u>new</u> fuel is described
  - Consistent and integrated approached based on
    - *the experience of organizations previously involved in LEU fuel development*
    - *international best practices*
  - The process described focuses on
    - *the tasks to be accomplished*
    - *the logical sequence of events*
  - The GPD neither describes the tasks in detail nor prescribes the way in which the tasks should be accomplished
- A phased approach is recommended
  - Phase 1. Research and development leading to choice of fuel type
  - Phase 2. Fuel performance qualification
  - Phase 3. Manufacturer qualification

GENERIC APPROACH TO FUEL DEVELOPMENT AND QUALIFICATION (Cont'd)

- **Phase 1: Research and Development**
  - Fuel conceptual design
  - Fuel manufacturing development
  - Out-of-pile testing
  - Irradiation testing and post-irradiation examination
  - Decision point (continue R&D or move to Phase 2)
- **Phase 2: Fuel Performance Qualification**
  - Detailed design
  - Technical specification
  - Prototype manufacturing assessment and development
  - Prototypic fuel element and fuel assembly manufacturing
  - Qualification test planning
  - Prototype full-size fuel assembly irradiation testing, including post-irradiation examinations
  - Fuel qualification report
  - Fuel licensing

GENERIC APPROACH TO FUEL DEVELOPMENT AND QUALIFICATION (Cont'd)

- **Phase 3. Manufacturer qualification**
  - Subcomponent manufacturing qualification
  - Full-size fuel element and assembly manufacturing qualification
  - Requalification (if needed)

- **Qualification of previously qualified fuel for use**
  - In fuel element/fuel assembly of substantially different design
  - Beyond the existing qualification limits in terms of
    - *fission rate (heat flux)*
    - *fuel meat temperature*
    - *U-235 burnup*

- Determination that a fuel is qualified is made by
  - The regulatory body – with respect to fuel performance qualification
  - The reactor operating organization (customer) – with respect to manufacturing qualification

SPECIFIC IMPLEMENTATIONS OF THE FUEL DEVELOPMENT AND QUALIFICATION PROCESS

- Two generically equivalent approaches are in common use
  - Approach used in Argentina, Canada, France, Republic of Korea, and United States
  - Approach used in Russia

- Examples
  - U_3Si_2-Al dispersion fuel through an international collaboration during the 1980s led by the US RERTR program
  - U_3Si_2-Al dispersion fuel by the French CEA for the enhanced conditions required for use in the OSIRIS reactor and in the new Jules Horowitz reactor
  - U_3Si-Al dispersion fuel in Canada for use in AECL's NRU and Maple-type research reactors
  - High-density TRIGA® fuel by GA in the USA
  - High-density UO_2-Al dispersion fuel (IRT-4M) fuel assemblies in Russia for use in several reactors outside Russia

CONCLUSION

- A draft document on 'GOOD PRACTICES FOR QUALIFICATION OF RESEARCH REACTOR FUELS' is nearing completion
  - Expect to present the final draft to the IAEA in mid-December 2007
  - Expect publication by IAEA in 2008

- This GPD will
  - Recommend good practices to any organization undertaking a fuel development program in the future
  - Bring research reactor fuel manufacturers, fuel users, and regulatory bodies up to date on the information expected to be available to support licensing of newly developed fuels for conversion of research reactors from the use of HEU fuels to the use of LEU fuels and for use in new reactors