Core Management and Fuel Handling for Research Reactors

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Introduction

- Core configuration is regularly changed during research reactor lifetime.

- These changes must be accommodated in a core management programme to ensure compliance with design intents and Operational Limits and Conditions (OLCs) as derived from the reactor safety analysis.

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Introduction

- Due to their safety significance, fuel handling activities must be subjected to operational constraints and strict administrative conditions which are usually established in the limiting conditions for safe operation as a part of OLCs.

- Activities of fuel handling should be performed in such a way that avoids mishandling of fuel which may lead to inadvertent criticality, overheating, mechanical damages or other kind of fuel failures.

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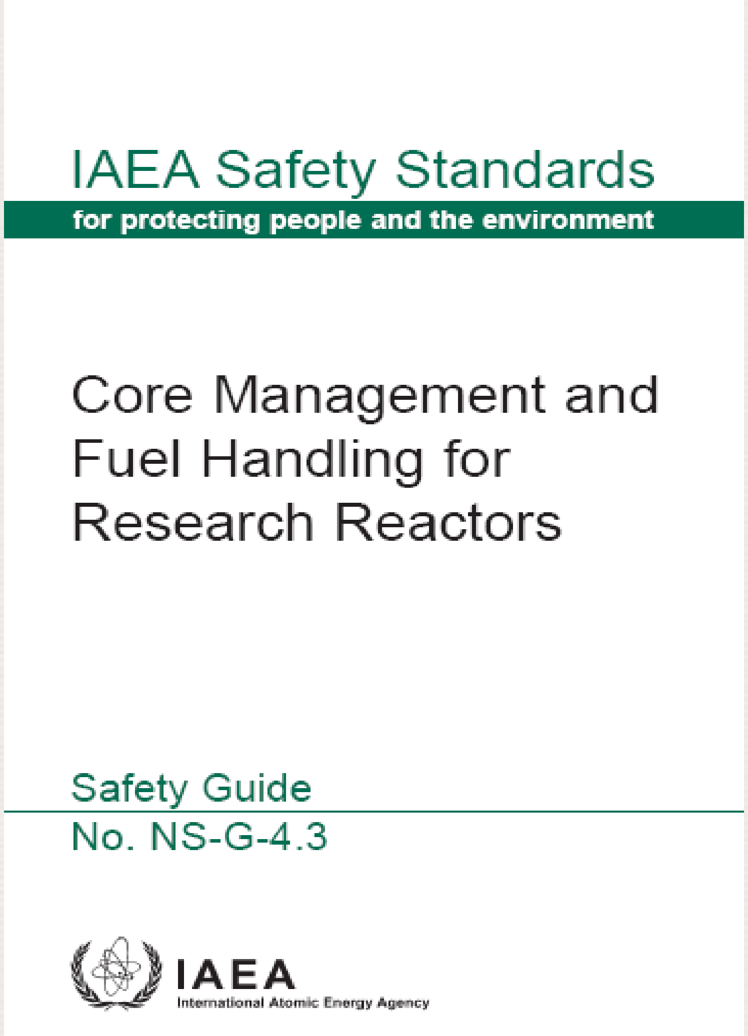
NS-G-4.3: Core Management and Fuel Handling for Research Reactors

- NS-G-4.3 addresses activities of core management and fuel handling that should be performed to allow optimum reactor operation and utilization without compromising safety of the fuel and reactor.



Core calculations

- The main objective is to determine the physical parameters of a proposed configuration and ensure compliance with the OLCs and the needs of utilization programme.

- The calculations should be:

  - *Performed for the steady state conditions and the anticipated operational occurrences using validated and verified methods and computer codes;*
  - *Verified by measurements before further operation with the proposed configuration.*

- Comparison between the measurements and calculations is essential for further improvements to the calculation methods and tools.

Core calculations

- Fuel loading pattern and burn-up values;
- Control rod reactivity worth (shutdown margin, excess reactivity, shadow effect and effect on neutron detectors);
- Shutdown capability of the second shutdown system, if applicable;
- Reactivity worth of experiment and their effects on flux spatial distribution and neutron detectors;
- Detailed power distribution across the core and the power peak factor.

Core calculations

- Thermal-hydraulic analysis should also be performed, covering all the operation modes (forced and natural circulation cooling conditions).

- This analysis should demonstrate that the reactor can be operated with adequate safety margins against the thermal-hydraulic critical phenomena (e.g. ONB, DNB, and flow redistribution).

- This analysis should be the basis for the determination of the Safety System Settings of the proposed core configuration.

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Core operation and monitoring

Approved operating procedures should be available for:

- Core configuration change;
- Reactor start-up, operation, and shutting down;
- Determination of excess reactivity, shutdown margin, reactivity worth of experiments;
- Determination of the reactor thermal power;
- Determination and adjustment of safety system settings;
- Handling of fuel elements and core components;
- Performance of routine checks of reactor operation and status of systems and components.

Core operation and monitoring

Parameters to be monitored during operation include:

- Reactor thermal power;
- Reactivity, as a function of the control rod positions;
- Control rods drop time, moderator or reflector dump time;
- Pressure difference across the reactor core, coolant flow rate, coolant temperature at the core inlet and outlet, and the reactor water level;
- Margins to the thermal-hydraulic critical phenomena (derived);
- Fuel temperature (may be derived);
- Radioactivity content in the primary coolant;
- Physical and chemical parameters of the coolant and moderator.

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Refueling programme

- The refueling programme determines the details of the core configurations throughout the reactor lifetime and a schedule for movement of the fuel elements and core components.

- It should be developed in the design stage and be subjected to review based on the experience acquired from reactor operation and on the changes in the utilization programme.

- The refueling strategy should provide for maximum flexibility for reactor utilization and an optimum use of the fuel without jeopardizing safety.

Refueling process

- Should be performed using dedicated operation tools and according to approved procedures;
- During execution of the refueling operation:
  - *All the instrumentation required to monitor the safety parameters and the reactor protection system should be operational;*
  - *Intermediate core configurations should be less reactive than the most reactive one of the OLCs;*
  - *Fuel elements identifications and correct positioning in the core including orientation should be checked.*
- Checks , testing, and measurements should be performed to verify that the core has been correctly configured.

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Fuel handling

- Mishandling of fresh fuel elements may lead to:
  - *Inadvertent criticality;*
  - *Physical damages to the cladding that could affect the behaviour of the fuel in the core or result in a release of radioactive material into the reactor coolant.*

- Mishandling of irradiated fuel may lead to:
  - *Inadvertent criticality;*
  - *Overheating;*
  - *Degradation of cladding material that may lead to release of fission products into the storage media;*
  - *Radiation exposure.*

Fuel handling

- Fresh fuel elements should be inspected before their loading into the reactor core (dimensional checks, visual inspection, etc.);

- Fresh fuel elements which have been stored for a long time period should be re-inspected prior to their loading into the reactor core;

- Surveillance programme should be in place to ensure retention of the effectiveness of the physical measures and procedures that ensure the sub-criticality of the fuel storage and the fuel integrity.

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Fuel handling

- Storage areas should be maintained under appropriate environmental conditions (humidity, temperature, etc.) and effective security measures should be in place.

- Adequate storage places should be available to ensure that complete core unloading could be performed at any time during the reactor lifetime.

- Handling of irradiated fuel should be covered by the operational radiation protection programme (adequate shielding, radiation monitors, access control, ventilation).

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IAEA activities on core management and fuel handling

- IAEA programme on safety of research reactors includes assistance to Member States to ensure safety of core management, including core conversion from HEU to LEU, and fuel handling.

- In addition to the development of Safety Standards and guidance documents, the activities include conduct of safety review / expert missions, meetings, training workshops Coordinated Research Projects.

Concluding remarks

- The needs for a flexible core operation and for an effective use of the fuel for optimum utilization of the reactor should not compromise its safety.

- Specific precautions need to be taken in performing fuel handling activities to ensure that the fuel integrity and sub-criticality are maintained.

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Thank you for your attention!