Safety of Research Reactor Experiments

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Introduction

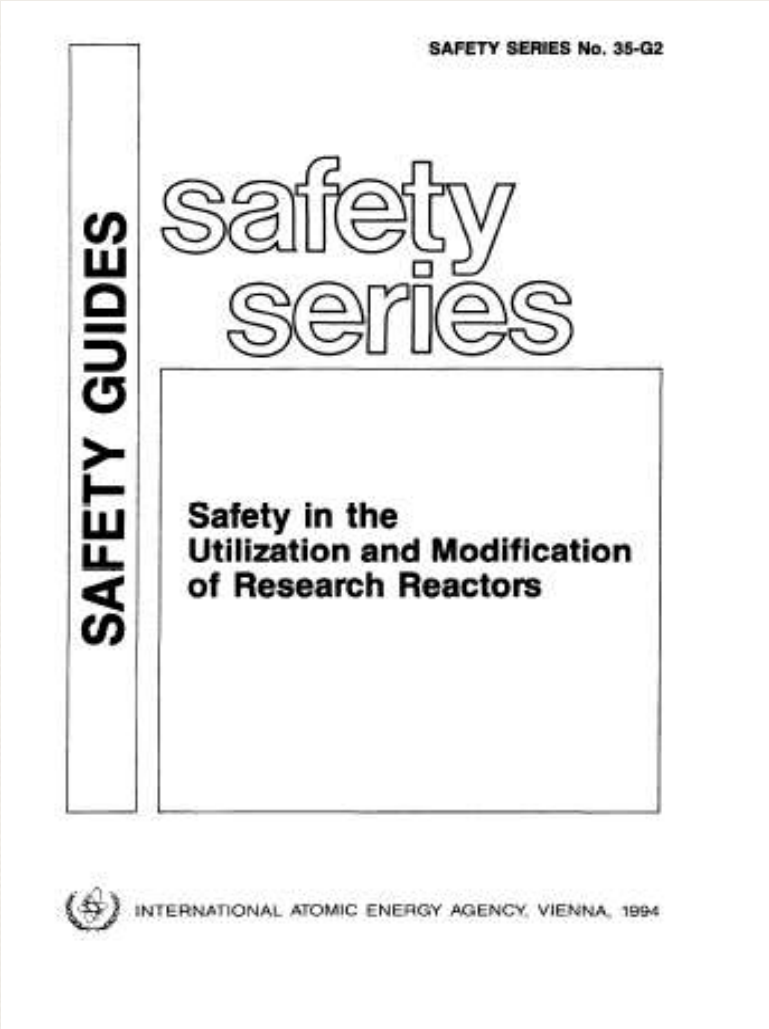
- Several incidents have occurred (resulted in radiation exposure to workers and contamination of surfaces and equipment) due to:
  - *Inadequate design or improper use of beam tubes;*
  - *Unsuitable samples or inadequate procedures.*
- The feedback from the IAEA safety review missions showed the need for improving the safety of experiments and experimental devices:
  - *Categorization of experiments according to their safety significance;*
  - *Routes of approval according to the safety significance;*
  - *Procedures for safety analysis, installation and formal commissioning programmes for experiments with major safety significance.*

IAEA publications on research reactor utilization

- NS-R-4 establishes safety requirements for the utilization and modification of research reactors, including:
  - Design provisions for utilization and modification;
  - Safety requirements during operation for the research reactors: Utilization and modification.

IAEA publications on research reactor utilization: SS 35-G2 (1994)

- Provides guidance on the safety categorization of modification and utilization projects and the associated approval routes.
- While it is applicable to existing research reactors, it is also recommended for use by organizations planning a new experiment, or plan to put a new research reactor into operation.
- Currently, it is under revision to take into account the feedback from its application.



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Categorization of utilization projects and approval routes

NS-R-4 Par 7.87:

”*Proposals for the utilization and modifications shall be categorized and relevant criteria for categorization shall be established. Proposals for the utilization and modification shall be categorized either according to the safety significance or on the basis of a statement of whether or not the proposed changes will put the operation of the reactor outside the Operational Limits and Conditions (OLCs)*” .

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Categorization of utilization projects and approval routes

IAEA SS No. 35-G2:
Basis of the categorization: Hazard potential

- The hazard potential is not only that which is due to the experiment itself but also any change in the hazard which is due to the reactor and the associated facilities as a result of the implementation of the change.

- The categorization criteria and the associated routes of approval should be included in the Safety Analysis Report (SAR) and approved by the regulatory body.

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Categorization of utilization projects and approval routes

IAEA SS No 35-G2 establishes four categories:

- Projects having major safety significance: Projects that will result in changes to the OLCs.
- Projects having significant effect on safety: Include complicated experiments which require special review.
- Projects having minor effect on safety: Most of experiments fall into this category. Research reactors by their nature are often used for repetitive sample irradiations or, with minor changes, for existing experiments. Most of the NAA and beam tube experiments fall into this category.
- Projects having no impact on safety: Careful considerations should be given before specifying that it has no effect on safety.

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Categorization of utilization projects and approval routes

- Depending on the safety significance of the project, formal licensing process may be required for its final approval.
- Utilization projects having major safety significance shall be subjected to safety analysis and to procedures for design, construction, and commissioning that are equivalent to those for the reactor itself.
- The operating organization’s safety committee may play an important role in the safety review of experiments with minor effect on safety.

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Categorization of utilization projects and approval routes

- The safety committee and the reactor manager may establish and maintain criteria which will allow the reactor manager to approve minor changes without resubmission to the safety committee or regulatory body.

- Such criteria should be based on adequate analysis and included in the SAR, and should be approved by the regulatory body before its implementation. These criteria should cover:

  - *List of materials forbidden to be irradiated with limits on the amounts of materials allowed to be irradiated;*
  - *Conditions for encapsulation and associated testing requirements;*
  - *Operational radiation protection aspects including procedures for handling of irritated samples and managing of the generated radioactive waste.*

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Categorization of utilization projects and approval routes

- The safety committee may also endorse the safety arrangements for a range of experiments of a general type rather than for one specific experiment. The reactor manager providing the approval of individual experiments in this range.

- Records of experiments (and minor modifications to them) approved by the reactor manager shall be reviewed at appropriate intervals by the safety committee to ensure that there are no disagreements with the interpretation of the criteria for approval.

- Experiment records should also be subjected to inspection by the regulatory body for the same reason.

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Specific safety considerations in research reactor experiments

- Reactivity worth: The reactivity worth of the irradiated samples should be within the authorized limits for non-fixed experiments.

- Flux perturbations: Interaction of the proposed experiment with the core components or other experiments should be considered. Flux perturbation should be evaluated in particular in the vicinity of safety devices.

- Safety devices: Whenever possible, experiments should be designed to minimize the need for active safety devices (e.g. inherent safety features, fail safe, etc.). Protection systems for experimental devices shall be designed to protect both the device and the reactor.

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Specific safety considerations in research reactor experiments

- **Radiation protection:**
  - *The proposed experiment should not affect the overall radiation protection concept of the reactor initial design;*
  - *In conducting an experiment the radiation exposure of the workers involved shall be kept as low as reasonably achievable;*
  - *No experiment should be approved unless a plan for management of the generated radioactive waste is established, including the identification of the final destination of the experimental device;*
  - *NAA laboratories and beam tubes area should be designated as controlled areas, with adequate radiation/contamination monitoring programme:*
    - Fixed area radiation monitors;
    - Routine radiation/contamination survey;
    - Monitoring of water leakage from beam tubes.

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Specific safety considerations in research reactor experiments

- Heat generation: Failure potential of many experiments is related to the possibility of overpower or insufficient cooling. Thus, the identification of heat generation/removal is one of the main concerns in sample irradiation experiments.

- Cooling: Special considerations should be given to the impact of the experiment on the cooling capabilities of the reactor.

- Pressure: Pre-cautions should be taken when irradiating material that can readily decompose (or change state), or whose chemical reactivity may be enhanced, producing an overpressure or gases which may be flammable and/or explosive.

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Specific safety considerations in research reactor experiments

- Compatibility of materials: Special attention should be paid to the possibility of incompatibilities between materials under the conditions of use which could lead to a failure of containment.

- Corrosion: Special precautions should be taken when irradiating:

  - *Corrosive materials (e.g. mercury, rhenium, magnesium);*
  - *Materials that may have enhanced corrosive properties as a result of irradiation;*
  - *Certain corrosion products (such as silver) tend to plate out on cooling circuit surfaces, thus creating contamination and radiation problems during handling and maintenance.*

- Protection against external hazards: The design of experiments should include measures to mitigate external hazards.

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Concluding remarks

- The feedback form the IAEA safety review missions indicated the need to improve safety of experiments. Areas of improvements include establishing adequate criteria for safety categorization and identification of approval routes, including effective involvement of the safety committee.

- Installation of complex experiments in an existing research reactor (e.g. cold neutron source and high pressure and high temperature loops) constitutes a modification of major safety significance rather than just a new experiment.

- This requires safety analysis, commissioning process, and review and assessment of the regulatory body in the frame of the approval process.

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Concluding remarks

- The NAA and beam tubes experiments also require careful considerations mainly in relating to the suitability of materials to be irradiated and to the operational radiation protection and waste management programmes.

- Conduct of these experiments should be subjected to inspection by the regulatory body to ensure that there is no disagreements with the criteria of categorization and approval.

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Thank you for your attention!

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