IAEA activities on safety of nuclear fuel cycle facilities

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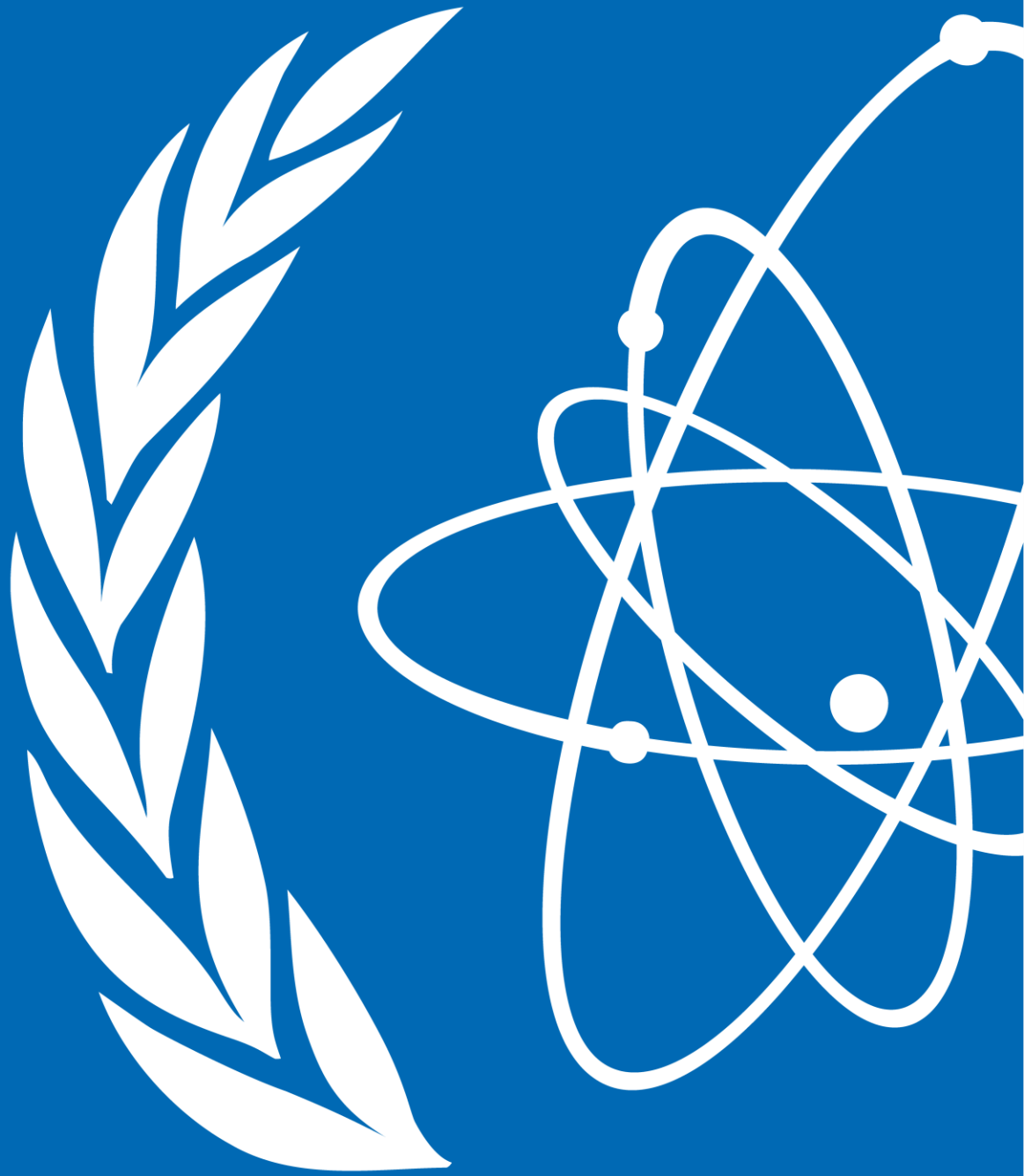
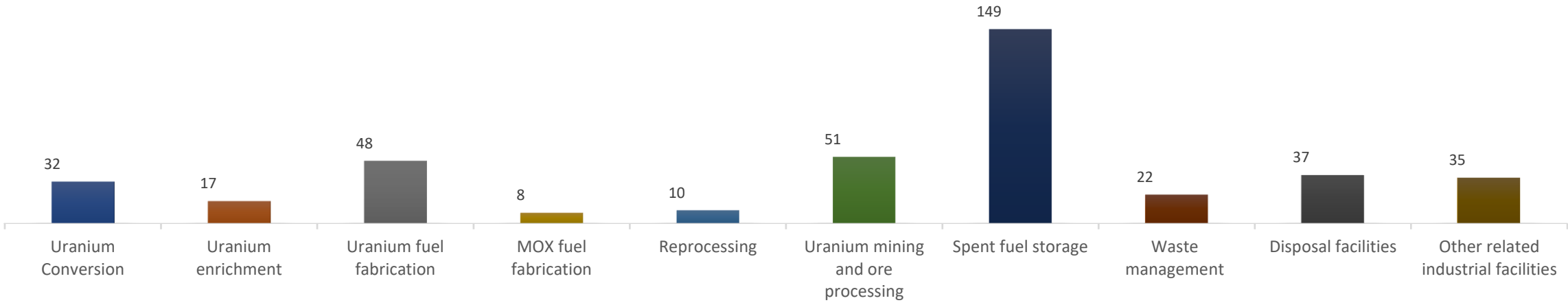


Introduction

- The IAEA activities on the safety of Nuclear Fuel Cycle Facilities (NFCFs) are performed by the Research Reactor Safety Section, Division of Nuclear Installation Safety (NSNI).
- The NFCFs in the scope include:
  - Conversion and enrichment facilities;
  - Fuel fabrication facilities;
  - Spent fuel storage facilities;
  - Reprocessing facilities;
  - Fuel cycle research and development facilities.

NFCFs in Operation

China	HTR Fuel Plant	Fuel Fabrication (U Pellet, Pin, FA)	Fuel for HTR/GHTR	In Operation	Commercial	300000 Spheres/year
United States of America	TRISO-X Fuel Fabrication Facility	Fuel Fabrication (Pebble Bed Type)		In Operation	Pilot plant	



Specific Challenges in Management of spent fuel from HTRs: Examples

High radiological toxicity U, Pu and other actinides as applicable

Isotopic composition and effect on nuclear criticality safety, radiation exposure and heat generation.

Higher potential for the dispersion of radioactive material – Head end operations (dismantling, incineration, crushing, as applicable)

Flammable materials

Off-gas processing and waste disposal

Reprocessing capacities not yet established on large industrial scale

Main Safety functions: NFCFs

- **Confinement and cooling of radioactive material (and any associated harmful materials);**
- **Protection against radiation exposure;**
- **Maintaining subcriticality of fissile material.**

Safety analysis: Postulated Initiating events for Facilities Managing Spent HTR Fuels

- Loss of services (e.g. power, cooling);
- Processing errors, including human errors;
- Equipment failures;
- Internal and external fires;
- dropped loads and handling errors;
- Loss of criticality controls
- extreme meteorological phenomena (in particular earthquakes, flooding and tornadoes)
- Other internal and external hazards, as applicable.

Safety issues and challenges: NFCFs

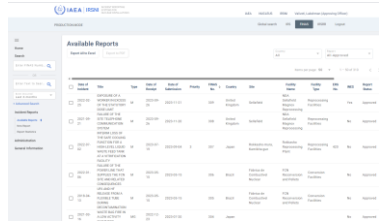
Ageing	Need to establish and implement systematic ageing management programmes
Human factors	Human errors and inadequate consideration of human factors in design, operation of the facilities
Criticality safety	Criticality accidents occurred at NFCFs - warrants the need to pay continued attention to prevention of criticality
Fire & Chemical safety	Continued attention is needed to manage fire and chemical hazards during different phases of the facilities lifetime
Safety - Security	Need to effectively manage the interface between nuclear safety and security
Periodic safety review	Facilities are implementing or planning periodic safety reviews, with the many facilities planning their first one
Regulatory supervision	Inadequate national regulations and need to enhance the enhance the regulatory inspection programmes

Safety issues and challenges

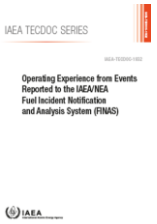
- Identification of safety issues common to NFCFs mainly based on the following sources of information:
  - Feedback from the IAEA meetings on NFCFs;
  - Reports on incidents collected through the FINAS.
- The IAEA activities on the safety of NFCFs are constantly updated to address the identified common safety issues.

IAEA Activities related to Safety of NFCFs

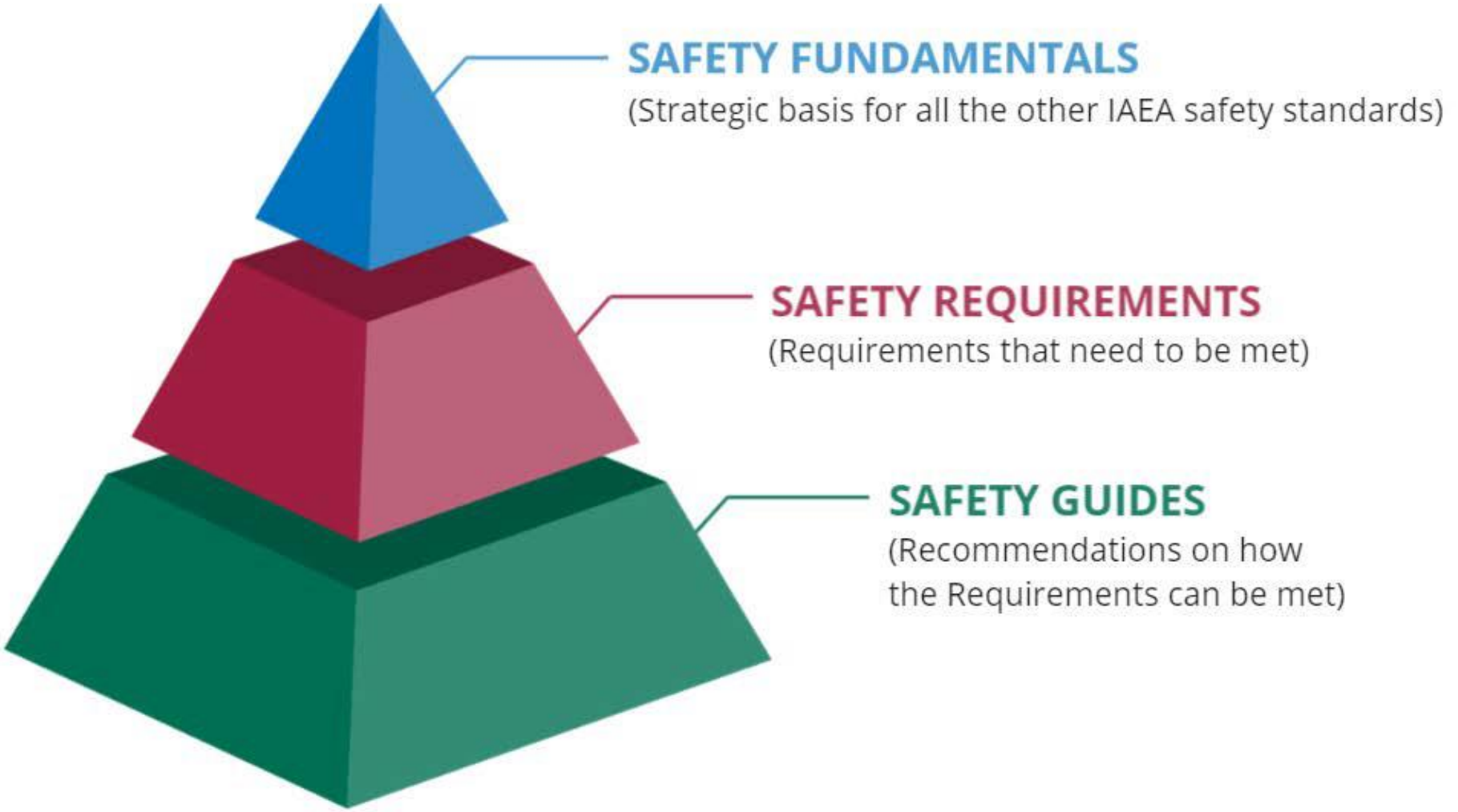
- Development of Safety Standards and supporting documents
- Incident reporting systems
- Organizing peer review missions and advisory services
- Networking & disseminating feedback from experience
- Supporting capacity building



IAEA | Safety Evaluation of Fuel Cycle Facilities during Operation | SEDO

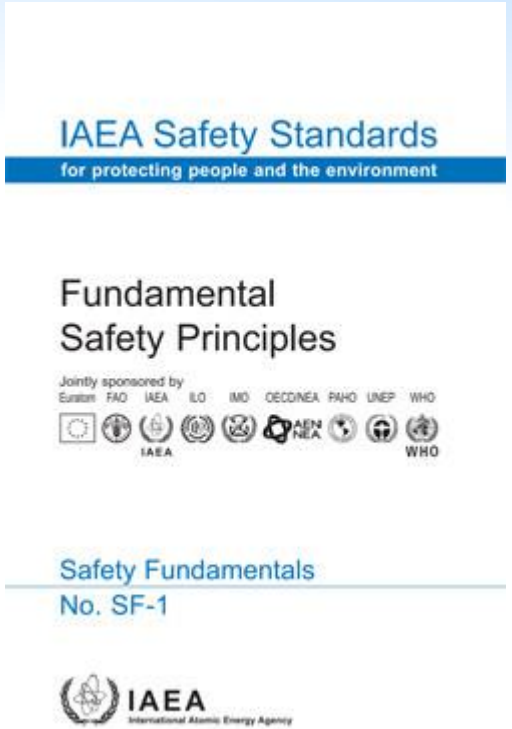


Hierarchy and Structure of the Safety Standards



SF-1 Fundamental Safety Principles

Principle 1: Responsibility for safety
Principle 2: Role of government
Principle 3: Leadership and management for safety
Principle 4: Justification of facilities and activities
Principle 5: Optimization of protection
Principle 6: Limitation of risks to individuals
Principle 7: Protection of present and future generations
Principle 8: Prevention of accidents
Principle 9: Emergency preparedness and response
Principle 10: Protective actions to reduce existing or unregulated radiation risks



The fundamental safety objective is to protect people and the environment from harmful effects of ionizing radiation

General Safety Requirements

All the General Safety Requirements are a single package divided in 7 parts:

Part 1. Governmental, Legal and Regulatory Framework for Safety

Part 2. Leadership and Management for Safety

Part 3. Radiation Protection and Safety of Radiation Sources

Part 4. Safety Assessment for Facilities and Activities

Part 5. Predisposal Management of Radioactive Waste

Part 6. Decommissioning of Facilities

Part 7. Preparedness and Response for a Nuclear or Radiological Emergency

Applicable to all facilities and activities

Applicable to specific types of facilities or activities

Specific Safety Requirements

The Specific Safety Requirements complement the General Safety Requirements. They are individual publications setting out requirements for individual types of facility and activity.

1. Site Evaluation for Nuclear Installations

2.1. Safety of Nuclear Power Plans: Design

2.2. Safety of Nuclear Power Plans: Commissioning and Operation

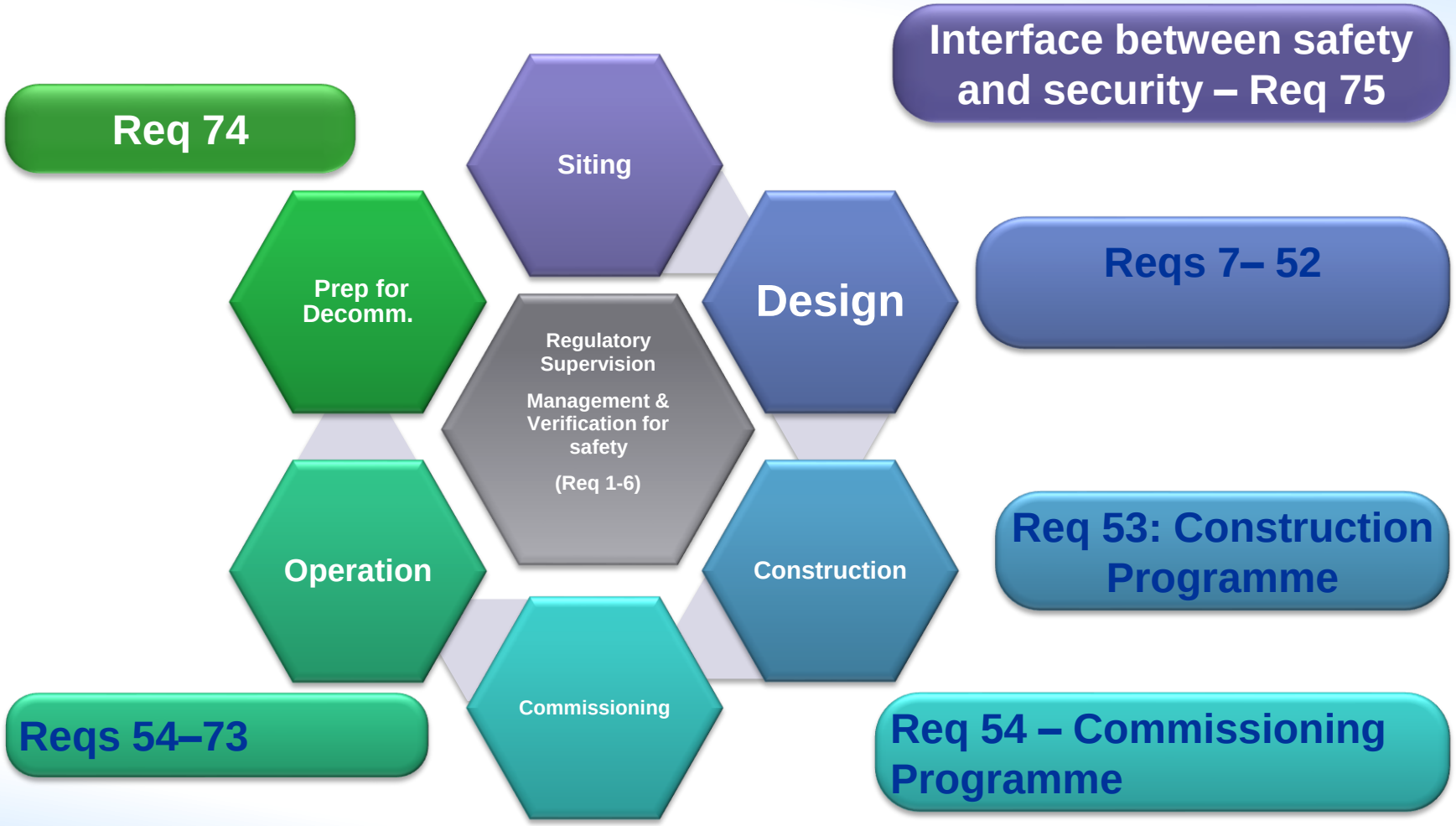
3. Safety of Research Reactors

4. Safety of Nuclear Fuel Cycle Facilities

5. Disposal of Radioactive Waste

6. Regulations for the Safe Transport of Radioactive Material

SSR-4



IAEA Safety Standards

for protecting people and the environment

Safety of Nuclear Fuel Cycle Facilities

Specific Safety Requirements

No. SSR-4

IAEA

International Atomic Energy Agency

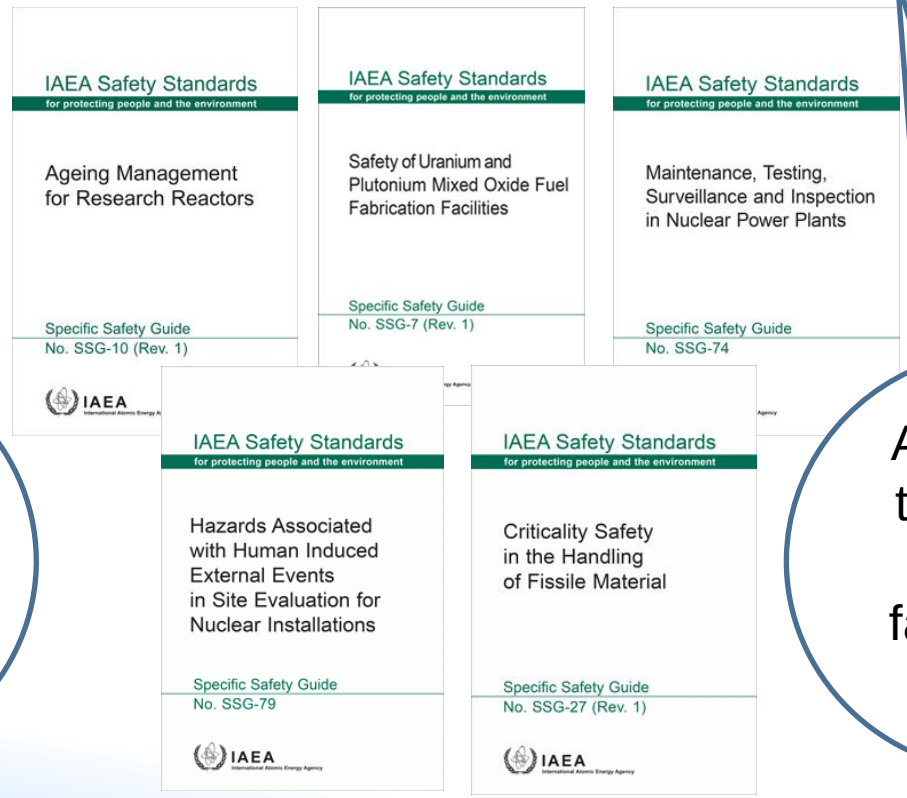
Safety guides

Safety Guides provide recommendations and guidance on how to comply with the requirements

General Safety Guides

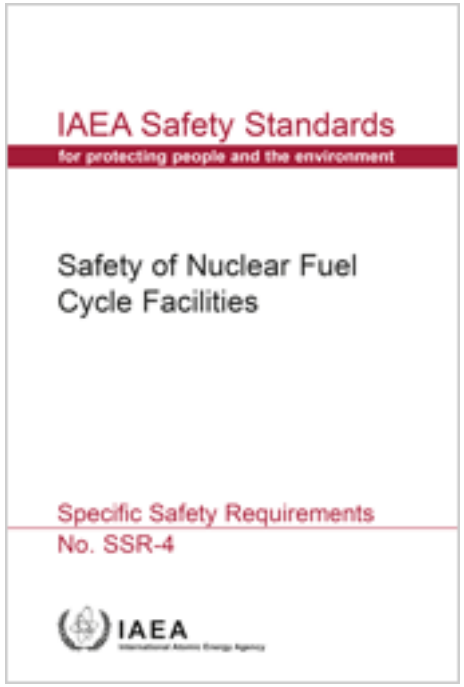
Applicable to all facilities and activities

Specific Safety Guides

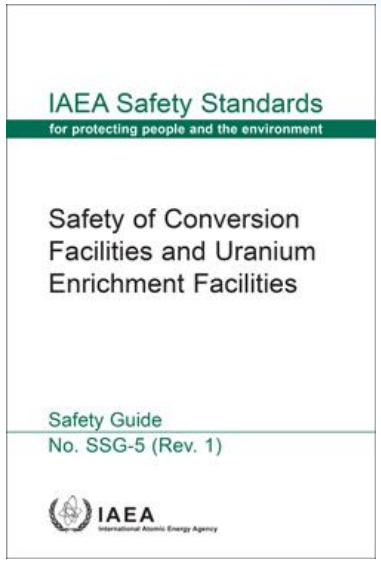


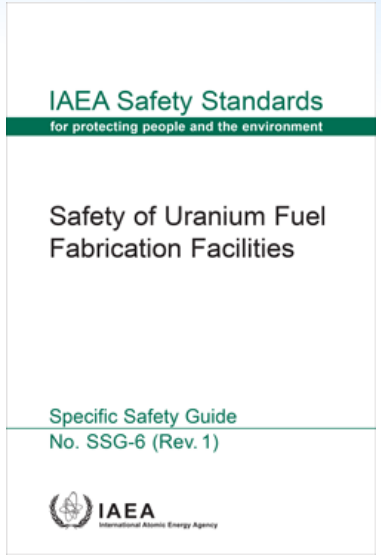
Applicable to specific types of facilities or activities

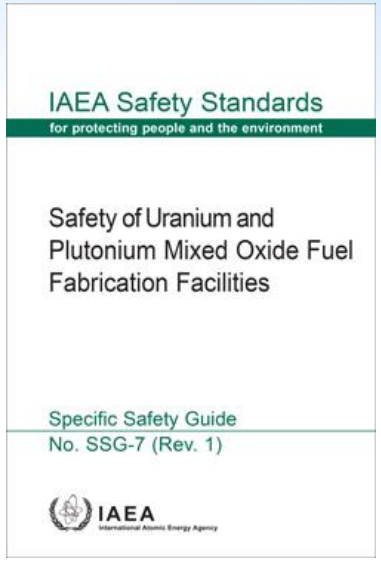
Specific Safety Standards for NFCFs

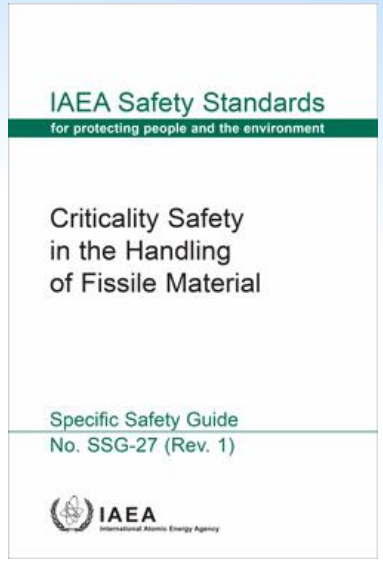


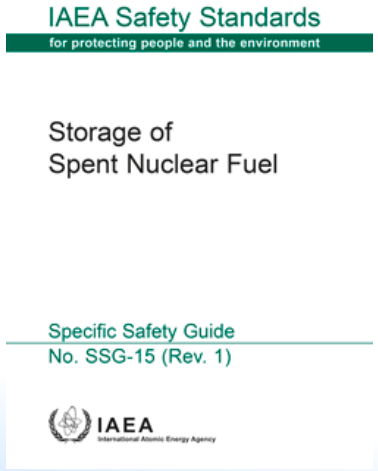
SSR-4 establishes requirements that are to be satisfied to ensure safety of NFCF

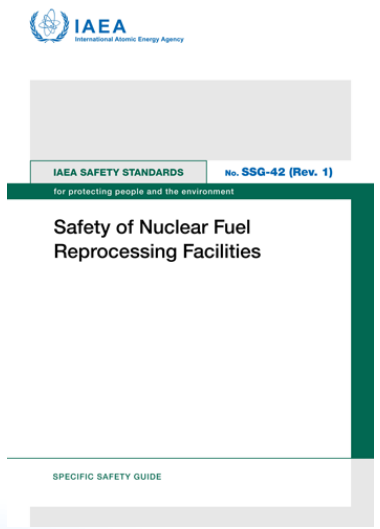


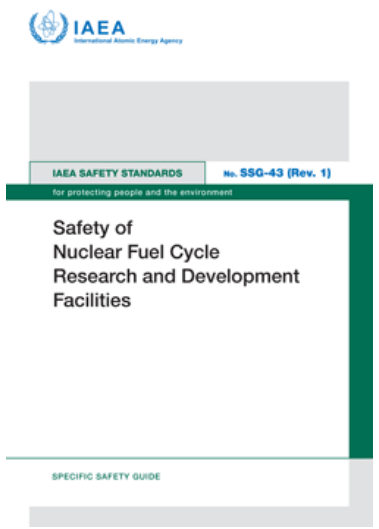








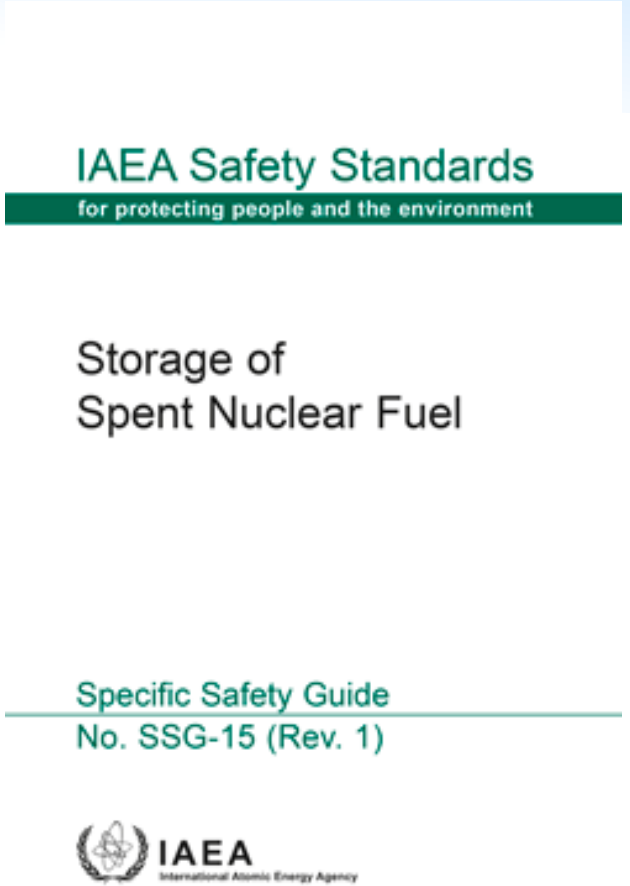




SSGs provide recommendations on meeting Safety Requirements for the different types of NFCF

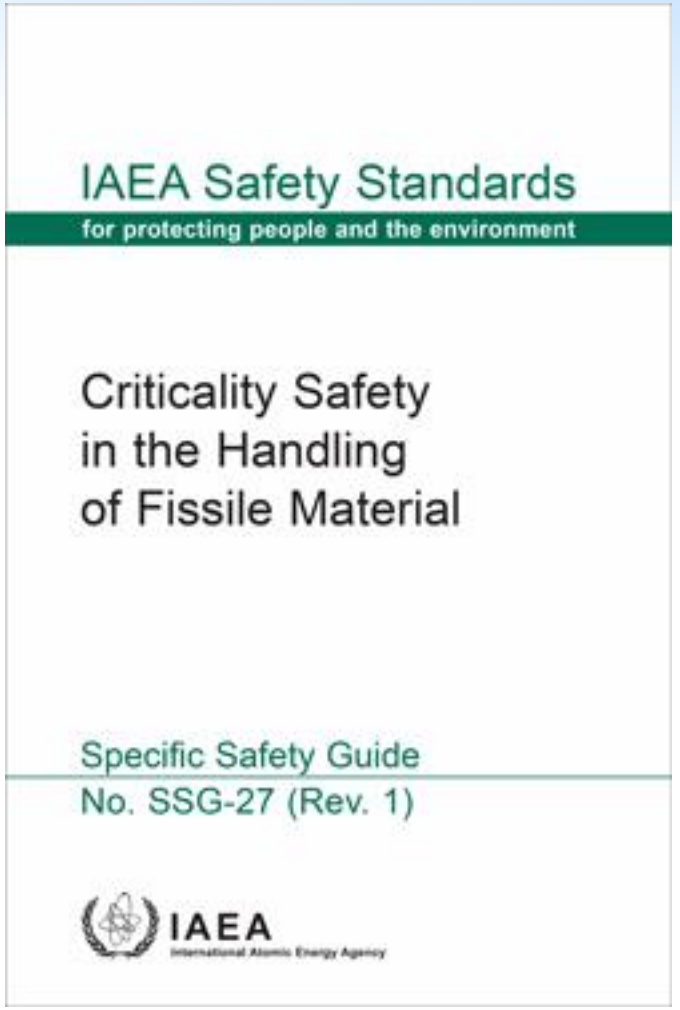
SSG-15 (Rev.1), Storage of Spent Nuclear Fuel

- Covers spent nuclear fuel storage facilities that are either collocated with other nuclear facilities (e.g. nuclear power plant, research reactor, reprocessing plant) or located on their own site.
  - not specifically intended to cover the storage of spent nuclear fuel as long as it remains a part of the operational activities of a nuclear reactor or a spent fuel reprocessing facility
- The scope includes the storage of spent nuclear fuel from water moderated reactors
  - and can, with due consideration, also be applied to the storage of other types of nuclear fuel, such as spent nuclear fuel from gas cooled reactors and research reactors
- The scope includes storage of spent fuel assembly components and degraded or failed nuclear fuel that might be placed in canisters.



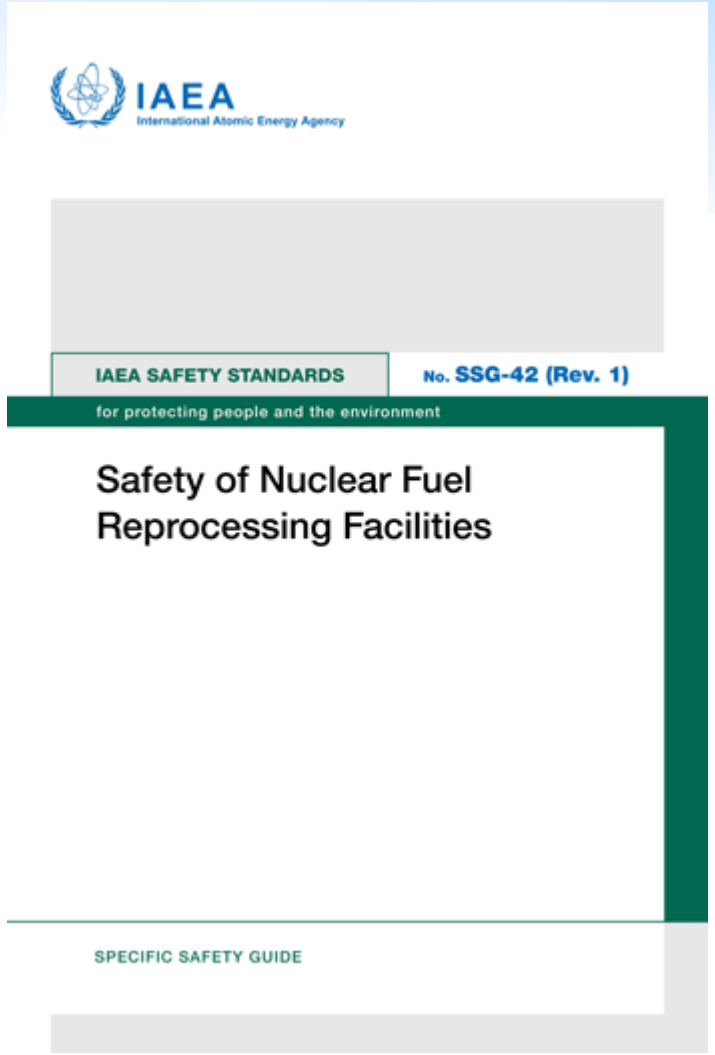
SSG-27 (Rev.1), Criticality Safety in the Handling of Fissile Material

- Applies to all facilities and activities in which fissile material is handled,
  - except those facilities that are intentionally designed to be critical, for example a reactor core in a nuclear reactor, or a critical assembly.
- Applies to the design, operation and post-closure stages of waste disposal facilities.
- Provides recommendations on planning the emergency response to a criticality accident.
- The recommendations provided in this Safety Guide may be applied to operations that are intended to remain subcritical in nuclear power plants and research reactors, for example the handling of fresh fuel and irradiated fuel



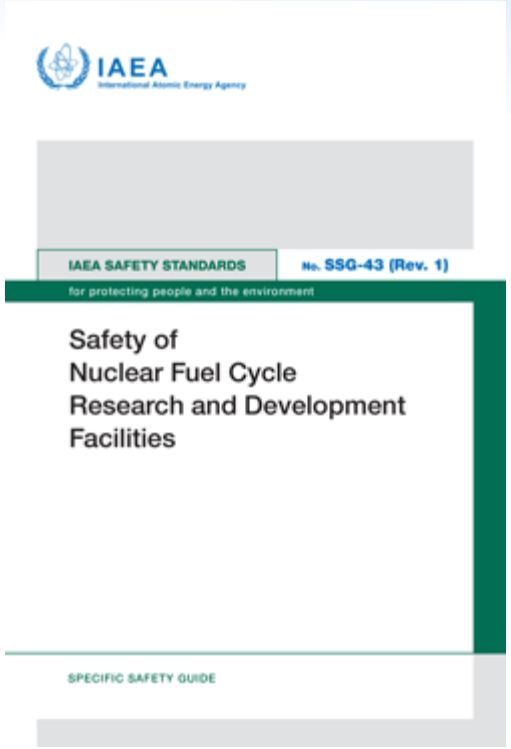
SSG-42 (Rev. 1), Safety of Nuclear Fuel Reprocessing Facilities

- Apply to plants using the PUREX process to reprocess fuels containing uranium and plutonium on a commercial scale.
- Does not specifically address thorium breeder reprocessing (THOREX) as there is insufficient experience of these facilities at a commercial scale in many States.
- However, the similarity between aqueous processes means that these recommendations will apply, with suitable adjustments, to plants reprocessing many types of nuclear fuel.



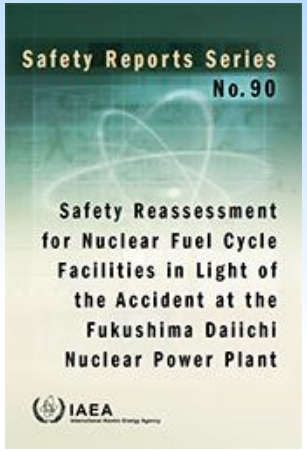
SSG-43 (Rev. 1), Safety of Nuclear Fuel Cycle Research and Development Facilities

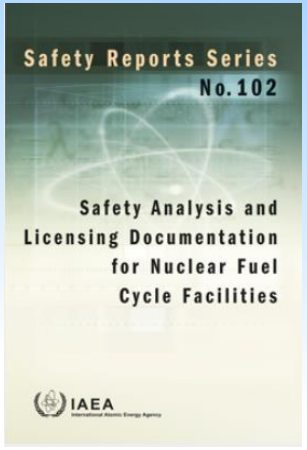
- The scope of this Safety Guide is limited to the safety of the R&D facility, the protection of workers and the public and the management of any wastes generated.
- It does not address any subsequent impacts that the material produced by R&D facilities may have on end users.
- Does not apply to irradiators, accelerators, research reactors, subcritical assemblies or radioisotope production facilities.

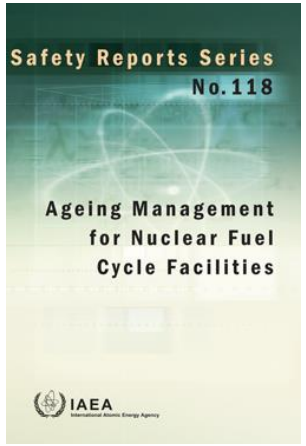


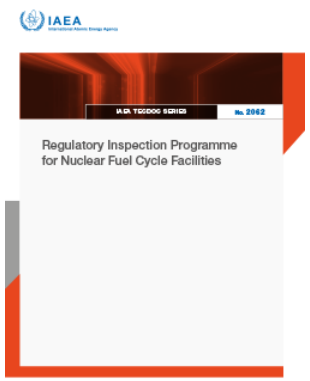
Supporting publications

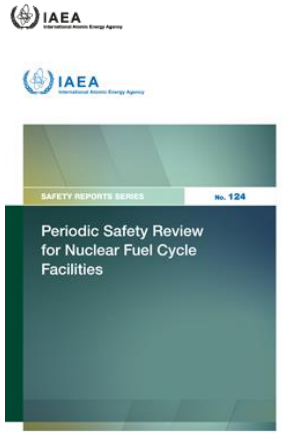
- Safety Reassessment for Nuclear Fuel Cycle Facilities in Light of the Accident at the Fukushima Daichi NPP, Safety Report Series No. 90
- Safety Analysis and Licensing Documentation for NFCF, Safety Report Series No. 102;
- Operating Experience from Events reported to the FINAS, TECDOC-1932;
- Ageing Management for Nuclear Fuel Cycle Facilities – Safety Report Series No. 118
- Periodic Safety Review for Nuclear Fuel Cycle Facilities – Safety Report Series No. 124;
- Regulatory Inspections of Nuclear Fuel Cycle Facilities, TECDOC 2062;
- Chemical hazards and fire safety (Planned);
- Operational radiation protection (Planned).





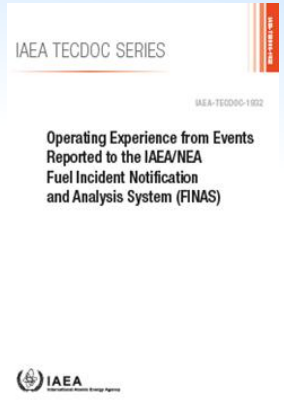


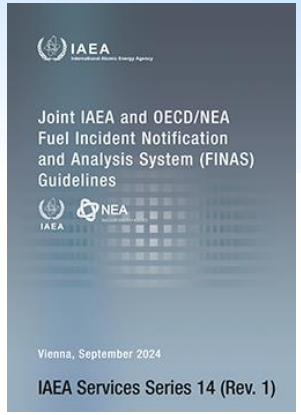


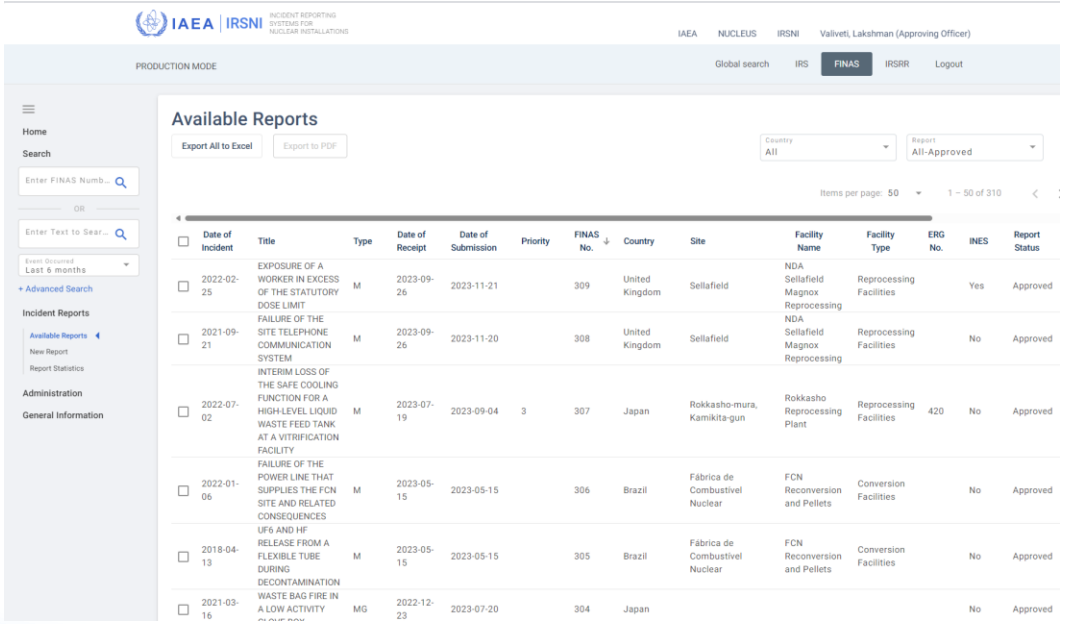


FINAS

- **F**uel **I**ncident **N**otification and **A**nalysis **S**ystem
- Operating (in cooperation with NEA) the web-based incident reporting system;
- Organizing biennial meetings for exchange of operating experience. Last meeting in 2024.
- Membership: 41 MSs;
- 315 events published;
- User-interface improvement (2023)
- Operating experience summary
  - published as TEDOC 1932

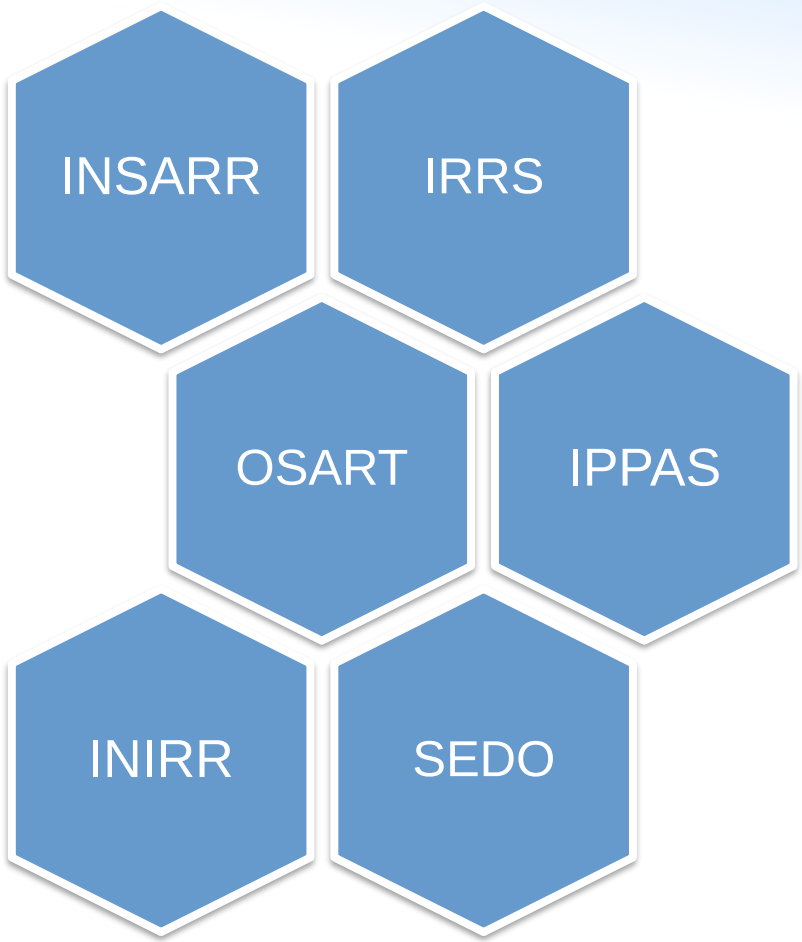






IAEA Review Services

The IAEA offers its Member States a wide array of review services, in which an IAEA-led team of experts compares actual practices with IAEA standards in, for example, nuclear safety and security, energy and safeguards or the health sector



Safety Evaluation of Fuel Cycle Facilities During Operation (SEDO)

- Review service available to Member States to enhance the safety of nuclear fuel cycle facilities during commissioning and operation.
- Based on the IAEA safety standards applicable to nuclear fuel cycle facilities during their commissioning or operation.
- SEDO is developed as modular per review service, the scope and duration are tailored to the needs of the nuclear fuel cycle facility.

SEDO covers facilities for

- Conversion and enrichment of uranium
- Reconversion and fabrication of nuclear fuels of all types;
- Interim storage of fissile material and fertile material before and after irradiation
- Reprocessing of spent nuclear fuel and breeder materials from thermal reactors and fast reactors
- Associated waste conditioning, effluent treatment and facilities for interim storage of waste that allow for retrieval of the waste for later disposal
- Separation of radionuclides from irradiated thorium and uranium
- Related research and development

SEDO Modules

1) Operating organization and facility management
2) Training and qualification
3) Operations
4) Maintenance, periodic testing and inspection
5) Modifications
6) Nuclear criticality safety
7) Radiation protection programme
8) Radioactive waste and effluent management
9) Fire, chemical and industrial safety
10) Ageing management
11) Emergency preparedness and response
12) Commissioning
13) Preparation for decommissioning

Benefits of SEDO missions

- Safety improvements for the facility reviewed.
- High quality benchmarking due to the quality and independence of the reviewers, which may provide a broader safety perspective.
- Prioritization of safety issues.
- Encouragement of self-critical behavior and the conduct of self-assessments.

IAEA Meetings – NFCFs -2025 / 2026

Workshop on Management of the Interface Between Safety and Security for Nuclear Fuel Cycle Facilities

24 – 28 November 2025 – Vienna

Workshop on Operational Safety of Nuclear Fuel Cycle Facilities

16 – 19 March 2026 – Virtual

Workshop on Ageing Management for Nuclear Fuel Cycle Facilities

15 – 19 June 2026 – Vienna

Technical Meeting for the National Coordinators of the Joint IAEA–OECD/NEA Fuel Incident Notification and Analysis System (FINAS)

21 – 23 September 2026 – Paris

IAEA – NEA Joint Workshop on Safety Considerations in the Use of Artificial Intelligence and Robotics in Nuclear Fuel Cycle Facilities

28 – 30 September 2026

Capacity building

- Participation in various Technical Cooperation (TC) Projects related to the safety of NFCFs;
- TC Programme is IAEA's primary mechanism for transferring nuclear technology to Member States, helping them to address key development priorities ;
- Based on Member States' request addressing specific needs;

Focus areas in coming days

- Supporting the application of the Safety Standards for NFCFs
  - Publication of the revisions of Safety Guides completed in 2025
- Continue to promote the exchange of operating experience and sharing safety knowledge.
- Continue to assist in capacity building, especially in regulatory supervision, ageing management, periodic safety reviews, chemical and fire safety, use of advanced technology, fabrication of new fuel for advanced reactors, and management of the interface between safety and security.

If you have any questions or if you need more details on any of the activities, please write to: L.Valiveti@iaea.org