IAEA
International Atomic Energy Agency
Atoms for Peace and Development

Technical Meeting on Synergies in Technology Development between Nuclear Fission and Fusion for Energy Production

Emergency Preparedness and Response: Towards Identifying Synergies Between Fission and Fusion Reactors

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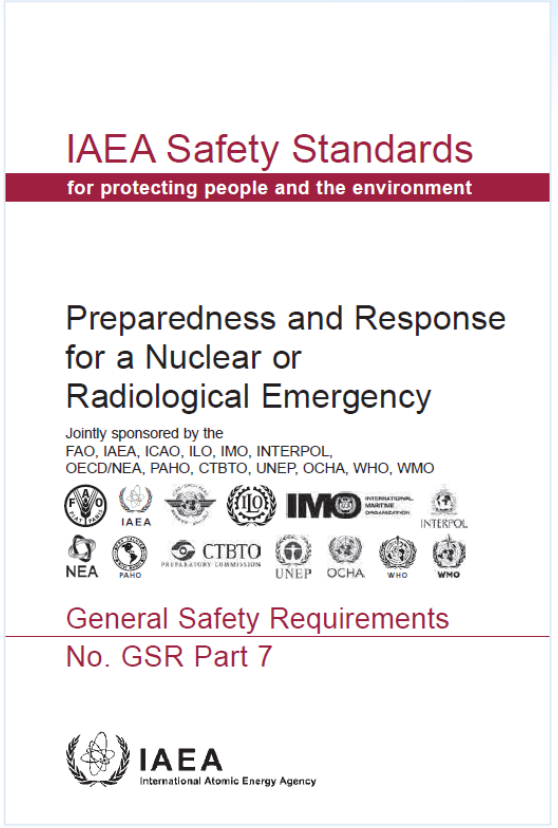
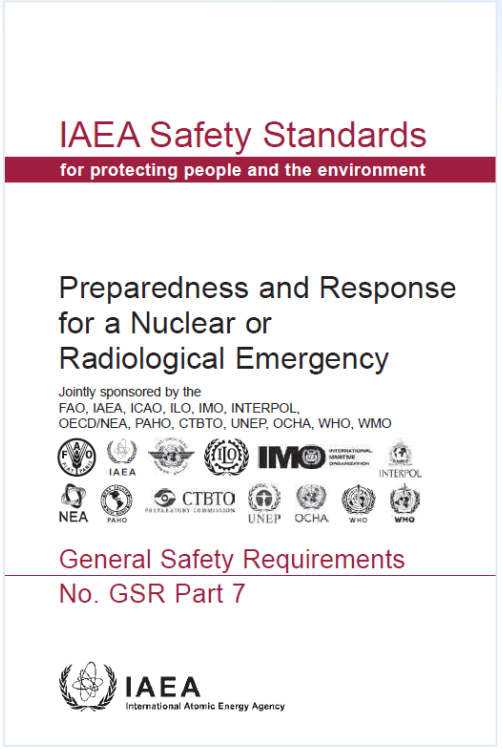
IAEA Safety Standards Series No. GSR Part 7

- Endorsed in 2015 in a joint sponsorship of 13 international intergovernmental organizations
- Provides the safety requirements for an adequate level of preparedness and response for any nuclear or radiological emergency that could occur in relation to a facility, an activity or a source, irrespective of the cause
- Follows a graded approach to define these requirements and their application at the national level to ensure that the emergency arrangements are commensurate with the hazards associated with a facility, an activity or a source, and the related potential consequences



IAEA Safety Standards Series No. GSR Part 7

- GSR Part 7 calls for Member States to perform a hazard assessment to inform
  - decision on the level of Emergency Preparedness and Response (EPR) needed
  - the associated emergency arrangements to be implemented for the facilities, activities and sources on their national territory, or those located abroad that might have impacts within their national jurisdiction in case of an emergency



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- GSR Part 7 defines five Emergency Preparedness Categories (EPCs) on the basis of the expected radiological consequences on-site and off-site, with EPC I to III associated with facilities

EPC	Short description
I	Facilities for which on-site events (including those not considered in the design) are postulated that could give rise to **severe deterministic effects off the site** that would warrant precautionary urgent protective actions, urgent protective actions or early protective actions, and other response actions
II	Facilities for which on-site events are postulated that could give rise to **doses to people off the site** that would warrant urgent protective actions or early protective actions and other response actions
III	Facilities for which on-site events are postulated that could warrant **protective actions and other response actions on the site**

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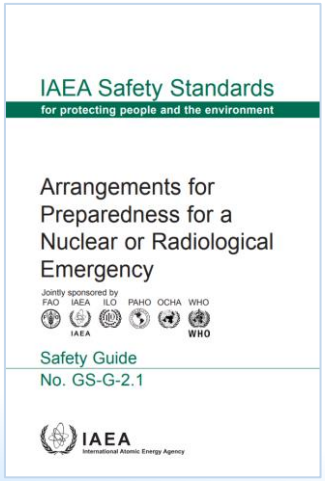
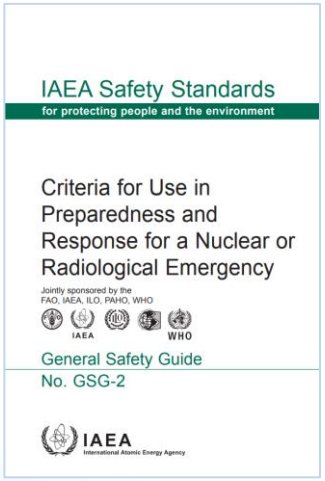
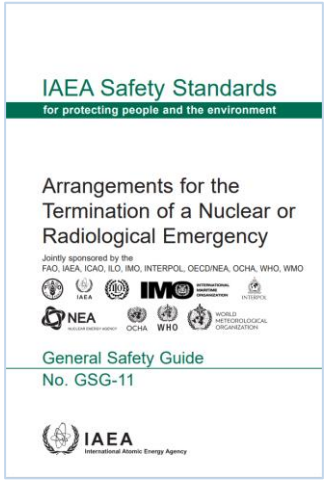
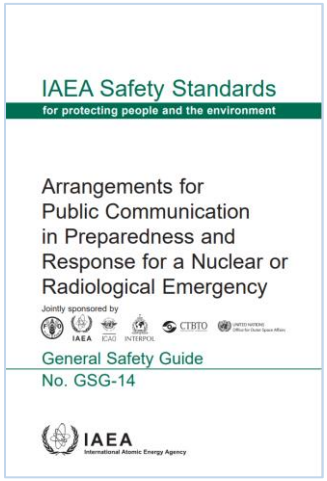
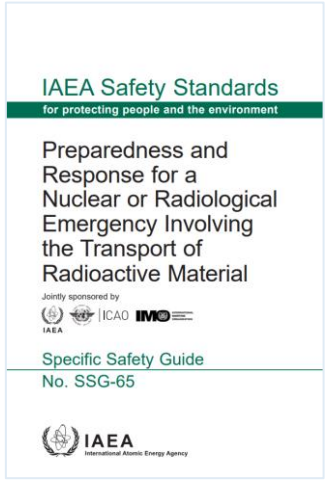
- EPCs I, II and III help determine the level of preparedness to be implemented for facilities
- Safety Guides in the area of EPR provide further guidance and recommendations to help Member States apply the safety requirements in EPR at the national level











IAEA Safety Standards for EPR

- In 2021, the IAEA's Incident and Emergency Centre (IEC) reviewed IAEA Safety Standards in the area of EPR for their applicability to "next generation reactors"

- The scope of this review did not include nuclear fusion reactors, but it was focused on small modular reactors and other non-water-cooled reactors

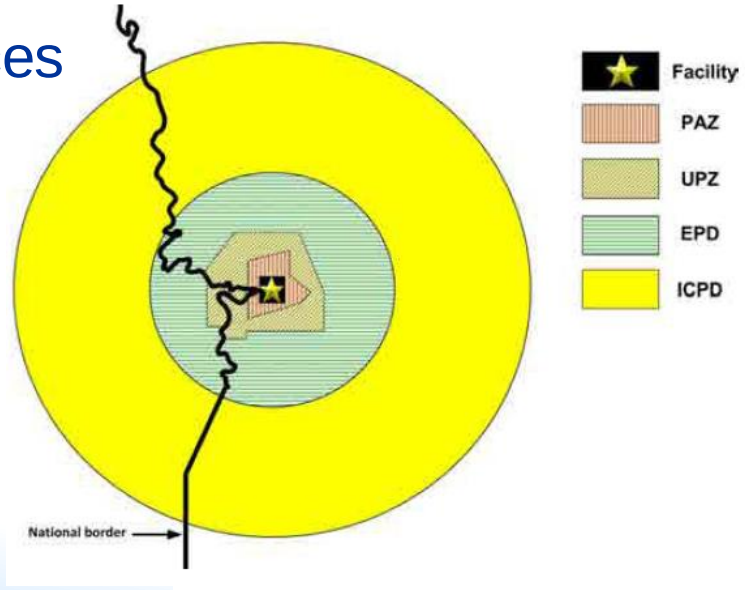
- The outcome of the review was that the IAEA safety standards in EPR are technology neutral and thus applicable for these next generation reactors

EPR for fusion reactors

- EPR safety standards are believed to be applicable for fusion reactors, but up to a certain extent
- Further research is needed to understand the hazards associated with such new reactors and potential consequences in case of an emergency
- Based on the existing EPR safety standards, appropriate emergency arrangements for fusion reactors need to be decided based on a hazard assessment that includes:
  - Events of very low probability and events not considered in the design, including those triggered by a nuclear security event
  - Events involving a combination of a nuclear or radiological emergency with a conventional emergency
  - Events at similar facilities located abroad

EPR for fusion reactors

- Based on such a hazard assessment, specific EPC(s) to categorize fusion reactors will be identified
- Respective requirements from GSR Part 7 will apply to that EPC allowing to identify:
  - Operational arrangements needed
  - Characteristics of emergency response facilities (location, staffing, protocols with off-site services)
  - Need for Emergency Planning Zone(s)
  - Need for Emergency Planning Distances



Schematic representation of EPZs and EPDs for an LWR

EPR for fusion reactors

Even if most the requirements, guidance and recommendations in the IAEA safety standards in EPR may apply to preparedness and response for an emergency at fusion reactors, practical implementation is expected to require further work and specific developments

EPR for fusion reactors

What are the hazards associated to fusion reactors, including radiation and non-radiation related hazards?

Radiation exposure?

Fire?

Explosion?

Toxic release?

Other?

EPR for fusion reactors

Can radiological consequences be expected on-site and off-site that might result in radiation induced health effects among affected population and on-site staff? What inventory of radioactive release can be expected and what can be the pathways for such a release in the environment?

EPR for fusion reactors

What non-radiation related consequences associated, e.g., with the use of novel materials and techniques, can be expected on-site and off-site? What will their impact be on EPR?

Economic?

Social?

Psychological?

Other?

EPR for fusion reactors

What is the kinetics of potential emergency scenarios at fusion reactors? How does this relate to the time available for effective decision-making and timely implementation of public protective actions?

EPR for fusion reactors

What mitigatory and public protective actions would be effective to mitigate the consequences of an emergency at a fusion reactor?

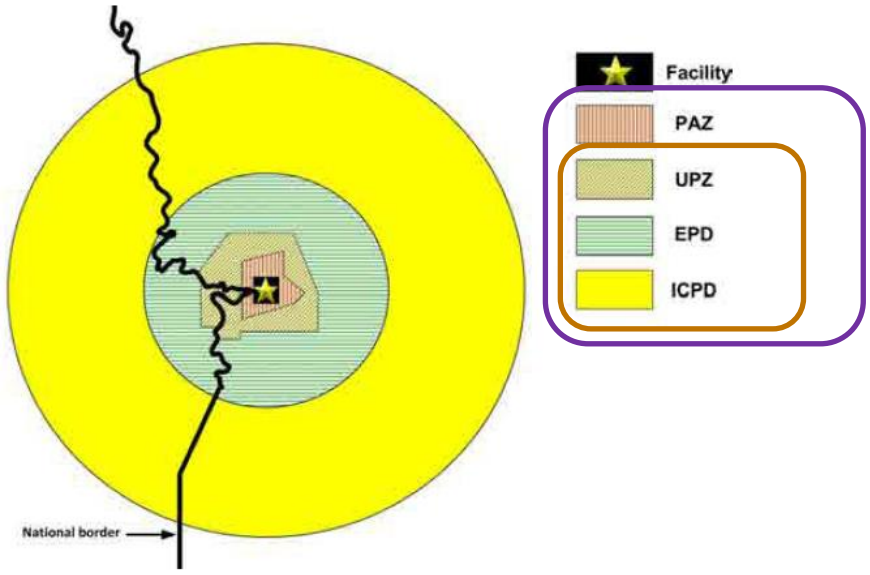
Evacuation? Sheltering?

Local food/water consumption banning?

Relocation? Other?

EPR for fusion reactors

In which EPC(s) are fusion reactors to be categorized? If fusion rectors are categorized under EPC I or II, what should be the size of the associated EPZ and EPD?



Requested for EPC I
Requested for EPC II

Schematic representation of EPZs and EPDs for an LWR

EPR for fusion reactors

Which on-site conditions can be indicative of an emergency situation and the associated level of emergency response to be activated? How can these on-site observables fit into the existing emergency classification system applied for other reactors? What associated emergency action levels will apply?

Conclusion

Answers to these questions will help provide more definite answers to the required level of EPR for fusion reactors

Answering these questions requires expertise beyond the EPR community

Therefore, it is essential that experts involved in other areas, such as scientific research, development of the technology, operation, work closely with the EPR community as early as possible

This will allow informed decisions on EPR along with the progress made in the development of fusion reactors, for the benefit of Member States wishing to embark on this new technology

IEC stands ready to contribute to this in a joint cooperation with experts from Member States and to identify analogies and discrepancies in EPR needs between fission and fusion reactors

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Thank you!