Addressing the issue of EPZ sizing for SMR

CRP on Development of Approaches, Methodologies and Criteria for Determining the Technical Basis for Emergency Planning Zone(s) for Small Modular Reactor Deployment

Technical Meeting on Challenges in the Application of the Design Safety Requirements for Nuclear Power Plants to Small and Medium Sized Reactors, September 4th, 2017

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Outline:

1. **EPZ and design requirements**
2. Setting up the problem: current situation on EPZ for operating reactors (mostly large LWR)
3. SMR features that may impact EPZ
4. Key aspects to be taken into account for EPZ determination
5. The CRP on SMR EPZ: background, objectives and expected outcomes
6. Conclusions
Design safety requirements vs EPZ

• Requirements in relation to emergency planning zones and distances are provided in the IAEA Safety Standard Series. No. GSR Part 7 and addressed in the associated lower level EPR publications.

• It is **not** appropriate to consider emergency planning zones and distances as a *design requirement* (they are neither defined or determined in/by the design).

• Emergency planning zones and distances sizing may be influenced by both design aspects and site related aspects.
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Emergency planning zones and distances for LWRs

[IAEA EPR-NPP-Public Protective Actions 2013, Section 4, Fig. 4 and Table 3]

- **PAZ - Precautionary action zone**:
  - ≥ 1000 MW(th): 3 to 5 km
  - 100 to 1000 MW(th): 15 to 30 km
- **UPZ - Urgent protective action planning zone**:
  - ≥ 1000 MW(th): 100 km
  - 100 to 1000 MW(th): 50 km
- **EPD - Extended planning distance**:
  - ≥ 1000 MW(th): 300 km
  - 100 to 1000 MW(th): 100 km
- **ICPD - Ingestion and commodities planning distance**:
  - ≥ 1000 MW(th): 300 km
  - 100 to 1000 MW(th): 100 km

Severe deterministic health effects possible
Stochastic health effects possible
Severe deterministic effects offsite

Example: Very high doses around the Chernobyl NPP

Also applicable to LWRs

Killed trees from external radiation
Stochastic effects

Example: Thyroid cancer increase in Belarus (no increase in other cancers seen)

Thyroid cancers by 1998 at > 350 km
Reference publication for LWRs

- Overview document
- For off-site decision makers
- Addresses public protective actions for a severe emergency at a LWR
- In plain language

Published for LWRs but:
- **Basic concepts apply to all designs**
- The suggested sizes for EPZ/D may differ for other kind of reactors
Other references

• Extensive Safety Standards and technical guidance in EPR area
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SMR features that may impact EPZ:

1. Probability vs need for EPR
2. Uncertainties and timing vs ECS
3. Size and timing of release vs EPZ
1. Probability vs need for EPR

Safety Standards Series No. GSR Part 7:

- Requirement 1 para. 4.2.: “The emergency management system shall […] enable an effective emergency response to reasonably foreseeable events (including very low probability events).”

- Requirement 4 para. 4.20.: “The government shall […] include consideration of: (a) Events that could affect the facility or activity, including events of very low probability and events not considered in the design;…”
1. Probability vs. need for EPR (SMRs)

Educated guess for SMRs:

SMRs may have a lower probability of an accident, but the approach will be the same as for all other activities, facilities or sources:

- Very low probability events and events not considered in the design need to be reflected in the development of EPR arrangements.
2. Uncertainties and timing (LWRs)

- Initially in an emergency the information available may be very limited and unreliable.
- **Response actions** need to be implemented **early on** to be effective.
- Severe releases are possible shortly after the beginning of the emergency → There may be **little time available** to protect the public.
- **Complex response arrangements** will not be able to cope with the absence of information or with high uncertainties.

- **NEED** for an emergency classification system (ECS).
2. Emergency Classification System (ECS)

Characteristics:

- Basis to identify, declare and notify the emergency
- Reliable under emergency conditions
- Based on observables and/or operational criteria (i.e. EALs)
- Clearly understandable to non-technical off-site decision makers
- Triggers the fast and coordinated on-site and off-site response
Safety Standards Series No.
GSR Part 7:

Requirement 5 para. 5.16.: “... The emergency classification system shall be established with the aim of allowing for the prompt initiation of an effective response in recognition of the uncertainty of the available information.”
Educated guess for SMRs:

The approach will be the same as for all other facilities:

- **Need** to establish an **emergency classification system** that reflects the **possibility** of severe emergencies.

- **Uncertainties**: Unlikely to be **significantly** affected by new designs.

- **Timing**: May be impacted by new designs. The failure of additional safety systems needs to be considered nonetheless.
3. Affected areas (LWRs)

Expect the release to be:

- Unpredictable in time, duration, rate and size
- Of long duration (days/weeks)
- With a changing radionuclide mixture
- Unmonitored (if monitored probably not relevant for offsite PPA)

Local wind directions cannot be used to predict the plume movement.

There is no down wind!
(expect a couple of hours of steady wind direction, at best)
3. Affected areas (LWRs)

- Long term release
  - Wind shifts
  - Other complex meteorological phenomena
  = Impossible to accurately project affected area

- Impossible to accurately project affected area
  + Monitoring takes a long time
  = Take urgent protective actions in all directions based on plant conditions
3A. Affected areas vs duration of release

**DURATION OF THE RELEASE**

Impact on the *directions* in which effects are possible

*360° for an LWR*
3A. Affected areas vs duration of release (SMRs)

Educated guess for SMRs:
The duration of the release will have an impact on the areas possibly affected. Rough estimate:

If the release lasts minutes → Possibly only the areas downwind may be affected (only if stable wind direction). **Problem**: It is very difficult to know the exact timing, effective height and meteorological conditions.

If the release lasts hours → Wind shifts are expected and multiple areas around the facility may be affected. **Problem**: It becomes increasingly difficult to predict.

If the release lasts days or more → All areas around the facility are expected to be affected. **Problem**: A detailed prediction is nearly impossible and cannot be the basis for a reliable and justified response.

**Educated guess for SMRs**: 360° will be required
3B. Affected areas vs size of release

SIZE OF THE RELEASE

Impact on the distances to which effects are possible

For a LWR within the orders of magnitude of:

PetaBq – ExaBq
Educated guess for SMRs:

- The size of the release will have an impact on the distance to which health effects are possible and therefore on the size of the emergency planning zones and distances.

- The size of the release may be affected by new reactor designs. The possible failure of additional safety functions needs to be considered nonetheless.

- Larger inventory = Larger potential
  Smaller inventory = Smaller potential

- The impact will not be the same (or linear) for all zones and distances (impact on PAZ expected to be smaller than for other emergency planning zones and distances).
3B Size of the release vs EPZ/D sizing

Concentration [arbitrary unit] in the plume for typical meteorological conditions, as a function of plume travel distance from the release point.
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Key aspects to be taken into account for EPZ determination

- Hazard assessment (including very low probability events and beyond design basis accidents)
- Estimation of source term and timing
- Dose projections to the public
- Establishing criteria for implementing response actions (i.e. generic criteria)
- Evaluate effectiveness of response actions
- Consider available resources
- Integrate into overall protection strategy
- Adapt to local / national circumstances
- Optimize
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CRP on EPZ for SMR deployment

• Duration:
  – 1 January 2018 – 31 December 2020

• MSs’ participation (expected):
  – MS with active SMR projects (Argentina, Canada, China, France, India, Republic of Korea, Russian Federation, USA, etc.)
  – Additional countries have expressed their interest (Chile, Jordan, Indonesia, Malaysia, Pakistan, Poland, Saudi Arabia, Singapore, South Africa, Tunisia, United Kingdom, Finland)
  – Others
  – Inputs from different SMR design will be considered

• RCM-1 planned in Q1 2018
Background and Objective

• Main field of activity
  – Provides a forum for R&D and technical exchange for MS to address aspects of emergency preparedness & response (EPR) specific for SMR deployment, particularly the size of Emergency Planning Zones (EPZs)

• Background
  • Requests from MS with near-term deployable SMR designs (China, Argentina) and newcomers interested in SMR (Indonesia, Saudi Arabia) for the Agency to provide guidance on determining the technical basis for EPZs for SMR

• Objective
  – To develop approaches and methodologies for determining the need for off-site EPR including the size of EPZs for SMRs taking account of the enhanced safety performance of SMRs and evaluating design-specific, defence-in-depth and site-specific technical basis to be provided by SMR developers, nuclear regulators, emergency planners and users/utilities
Overall Expected Outcome and Results

• Overall Expected Outcome
  – Technically sound and consistent technical basis and information that could be used as an input into the new guidance on EPR arrangements, including EPZ/D, for SMR. This includes the identification of technology specific factors for different SMR that may influence: source term and timing of the release; possible sequences to be considered for emergency classification system
  – Definition of consistent approaches, methodologies and criteria for determining the need for off-site EPR, including EPZ/D size, for SMR deployment

• Expected associated outcome
  – IAEA TECDOC and/or other publication(s) that discuss specific design and safety aspects as well as technical basis and approaches/methodologies that would enable determining the size of EPZ for SMR
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Conclusions (SMRs)

EPR arrangements need to be developed accounting for events of very low probability and events not considered in the design. Aspects that likely will still be needed for SMR:

– Emergency classification system and protective actions planned in advance to cope with uncertainties in the urgent phase of the emergency

– The timing to implement protective actions may be affected by these new reactor designs, possibly giving more time for the response

– The duration of the release may be impacted by new reactor designs, but response actions may still be required in all directions

– The size of the release may be affected by new reactor designs, changing the size of emergency planning zones and distances. The impact will not be the same for all zones and distances.
Conclusions (SMRs)

The new CRP will provide valuable information to:

- Define relevant aspects driving the source term to be considered and possible source terms to be considered
- Determine possible timing for onset of severe releases and influencing factors
- Possible sequences relevant for an emergency classification system
- Develop sound methodologies for EPZ/D sizing for SMR
- All this information is expected to provide the basis for the development of more detailed guidance for SMR EPZ/D sizing
Thank you!