

SAFETY ANALYSIS OF SMALL MODULAR REACTORS IN THE CONTEXT OF THE POLISH REGULATORY FRAMEWORK

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Abstract

Safety analysis of innovative reactors, such as **SMRs**, is a crucial and emerging topic within the Polish regulatory process. This poster focuses on the current Polish regulations related to safety analysis and attempts to place them in the context of advanced reactors. Selected topics related to safety analysis are discussed, potential obstacles are identified, and conclusions that can be useful for the **National Atomic Energy Agency (Państwowa Agencja Atomistyki - PAA)** or other involved organizations are drawn.

The Polish regulatory framework

The National Legal Framework for Nuclear Power in Poland, including all relevant documents, is available on the PAA website [1]. The main Act is the Atomic Law [2]. The hierarchy of Polish atomic-related legal documents is presented in Fig. 1.

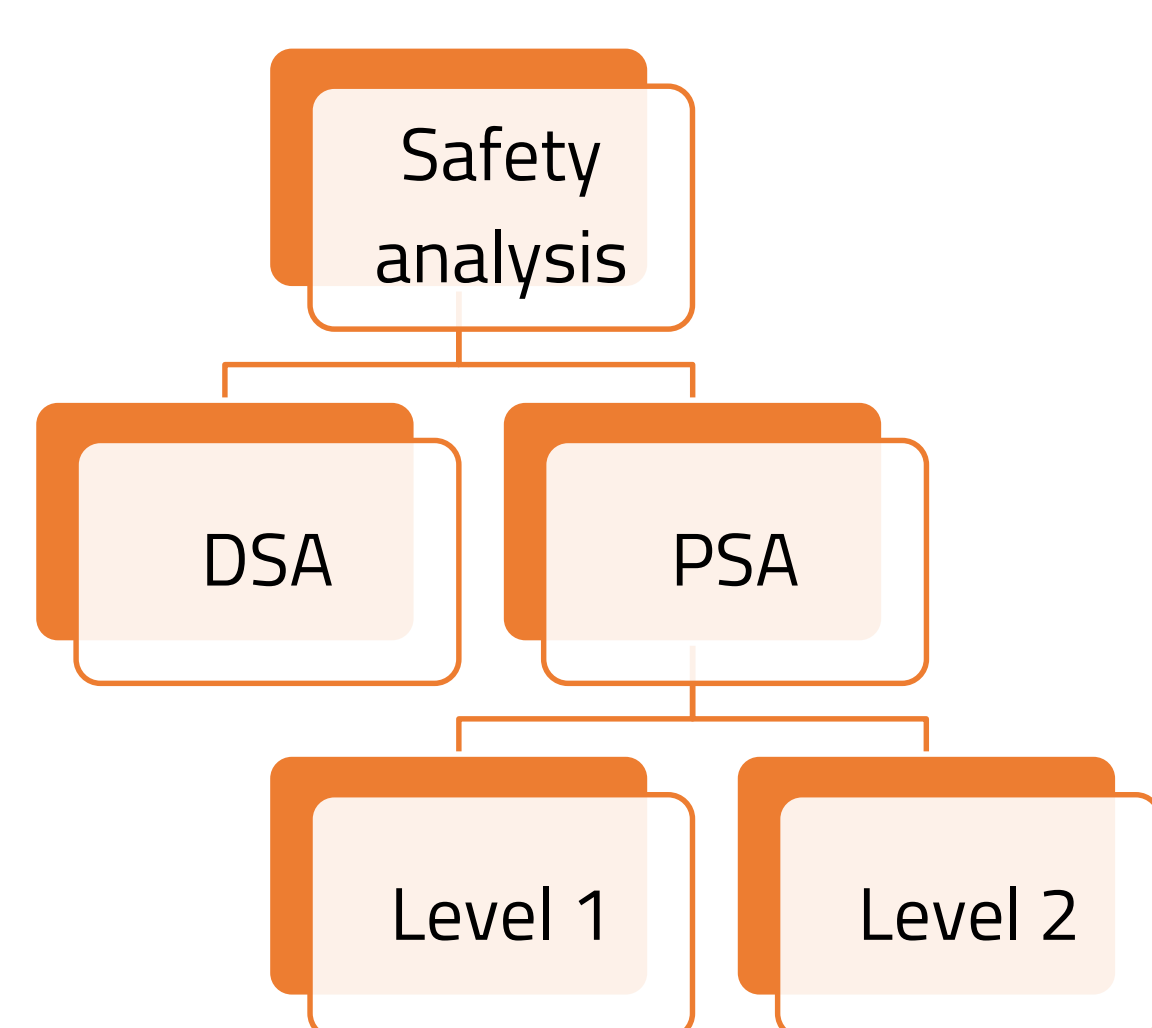
Regulations and requirements for safety analysis, as well as the content of the PSAR, are published in the **Regulations of the Council of Ministers related to safety analysis [3]** and **nuclear facility design [4]**. These two documents form the basis for performing safety analysis for plants to be constructed in Poland.



Figure 1. Hierarchy of the licensing related documents.

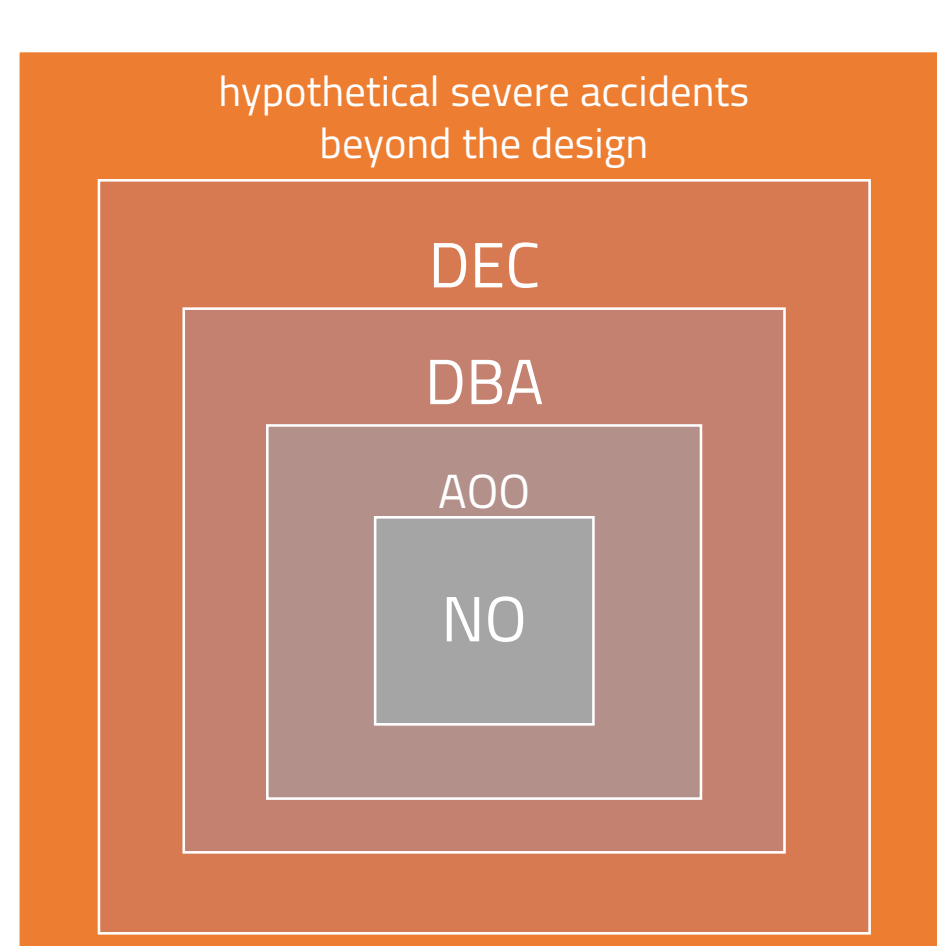
Safety Analysis in the Polish Framework

In the Polish framework, safety analysis is divided into deterministic and probabilistic parts: Deterministic Safety Analysis (**DSA**) and Probabilistic Safety Analysis (**PSA**). Both approaches are required by Polish law. The PSA is limited to Level 1 and Level 2, while Level 3 is not required [3].



Plant States and Safety Analysis

In Polish regulations, plant states considered within safety analysis are grouped into categories: Normal Operation (**NO**), Anticipated Operational Occurrences (**AOOs**), Design Basis Accidents (**DBAs**), and Design Extension Conditions (**DECs**). There is also a category for **hypothetical severe accidents beyond the design** (Ref. [3], App. I).



Safety analysis covers both NPP operational states (NO, AOOs) and accident conditions (DBAs, DECs). The main goal and scope of safety analysis is to prove that safety requirements related to

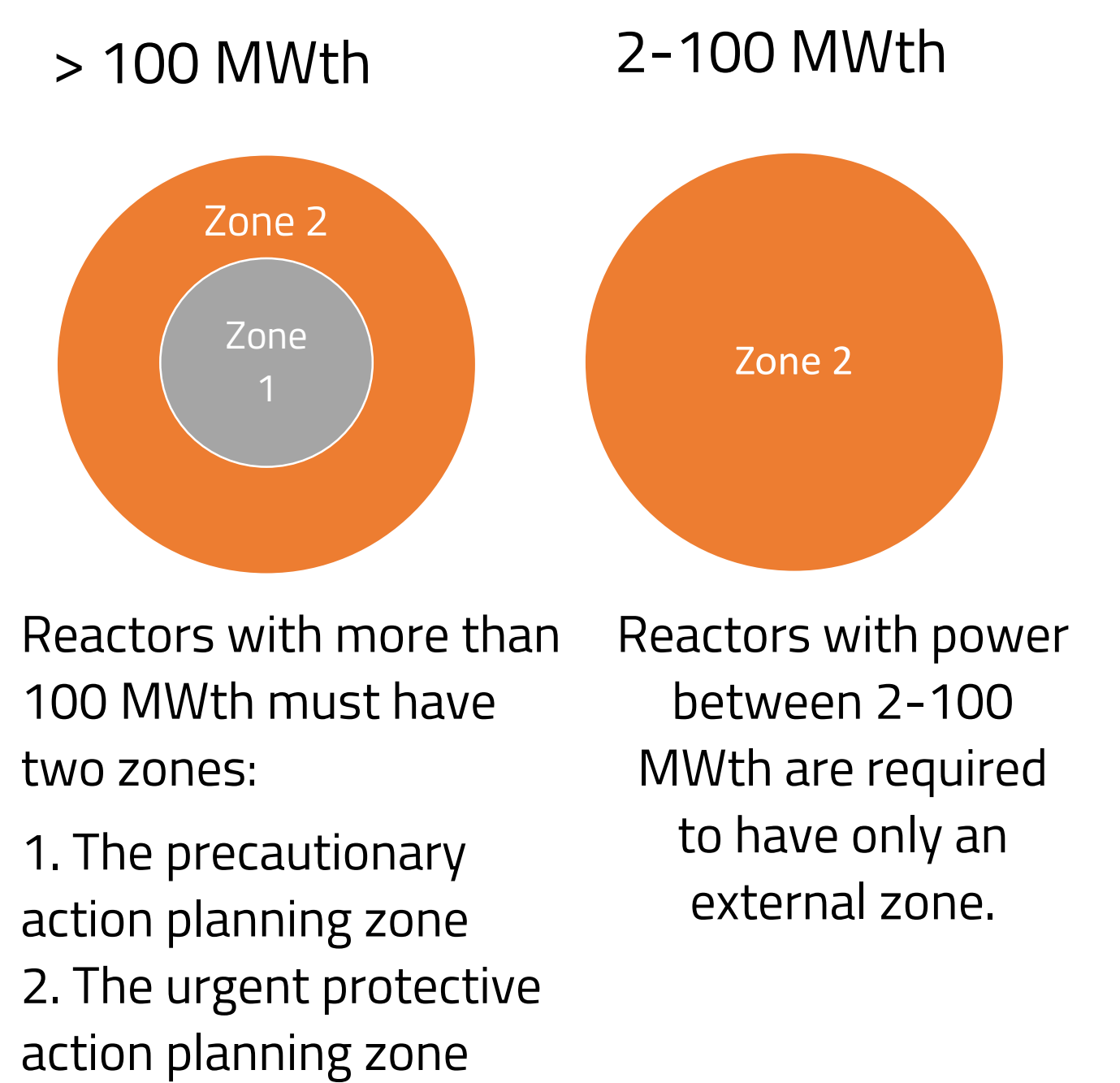
- radiological doses,
- consequences,
- intervention levels
- probabilistic criteria

given in the Atomic Law (Art. 36f 2. [2]) and Design Regulation (§9 and §10 in [4]) are fulfilled.

Emergency Planning Zone

One of the tasks to be covered by safety analysis is determining the Emergency Planning Zone (EPZ), which must be identified for a nuclear power plant (NPP).

Zones must be identified through safety analysis, considering potential consequences of releases characterized by a frequency higher than 1 per 10^7 years. The inner zone focuses on the prevention of deterministic dose effects, while the external zone is dedicated to reducing the risk of stochastic effects. For reactors with $<2\text{MWth}$ zones are not necessarily defined. More details on the EPZ can be found in Art. 86l and Art. 86m [2], and in [5].



Safety Analysis in the Design Process

Contemporary safety analysis is an integral part of the plant design process, as outlined in Polish regulations related to the design of nuclear facilities [4]. Firstly, the classification of Systems, Structures, and Components (SSC) must be based on deterministic safety analysis, supported by probabilistic analysis if needed (§11.3 in Ref. [4]).

Furthermore, the Postulated Initiating Events (PIE) applied to safety analysis are considered in the design process (§16 in Ref. [4]), with PIEs defining a set of design basis accidents (§26, Ref. [4]). The list of PIEs, which includes both internal and external events, serves as an input for safety analysis (§6 and §7, Ref. [3]).

Additionally, design limits for the plant must be confirmed by safety analysis ([4], Def. 8). The Defence-in-Depth concept (Ref. [4] §3) and related barrier sequences should incorporate safety systems identified through safety analysis.

DSA and PSA

The specific requirements for DSA are detailed in Chapter 3 of Ref. [3]. Notably, §14.1 and 2 in Ref. [3] mandate the consideration of the single failure criterion (SFC) and Loss of Offsite Power (LOOP) after PIE in safety analysis for AOOs, DBAs, and DEC states. This approach is quite conservative and may be reviewed, as current practice tends to avoid LOOP and SFC in DEC (see Ref. [10]).

Probabilistic Safety Analysis specific regulations are detailed in Ref. [3], Chapter 4. There are three probabilistic safety objectives, expressed as frequency limits. (Ref. [4] §10).

Conclusions and discussion

- Polish regulations are undergoing substantial revision, particularly in the areas of safety analysis (both DSA and PSA) and design regulations.
- There is currently no significant difference between safety analysis for large power reactors and SMRs.
- There is only a distinction for reactors with lower thermal power ($<100\text{MWth}$, potentially $\sim 25\text{MWe}$), which may impact the determination of the EPZ and the safety analysis.
- Current regulations are primarily oriented towards LWR technology, so the situation for non-LWR technologies is more complex.

References

- National Legal Framework for Nuclear Power – collection of documents (Krajowe Ramy Prawne dla Energii Jądrowej) <https://www.gov.pl/web/paa/krajowe-ramy-prawne>
- "Polish Atomic Law", Journal of Laws of 2001, No. 3, Item 18, Prepared based on Dz. U. z 2023, Item 1173, 1890.
- Regulations of the Council of Ministers: "on the scope and method for the performance of safety analyses prior to the submission of an application requesting the issue of a license for the construction of a nuclear facility and the scope of the preliminary safety report for a nuclear facility" B26. Reg 31.08.2012 (Dz. U. z 2012 r., poz. 1043).
- Regulations of the Council of Ministers: "on nuclear safety and radiological protection requirements which must be fulfilled by a nuclear facility design" B27. Reg 31.08.2012 (Dz. U. z 2012 r., poz. 1048).
- Organizational and technical recommendations of the President of the National Atomic Energy Agency - designation of emergency planning zones and distances extending around the organizational unit performing activities classified into category I or II of threats", 2021,