ADVANCED METHODS FOR DETERMINING EMERGENCY PLANNING ZONES FOR INNOVATIVE SMALL REACTOR DESIGNS

PIOTR KOPKA[1*], SŁAWOMIR POTEMPSKI[1], ALEKSEJ KASZKO[1]

[1] *National Centre for Nuclear Research, Otwock-Swierk, Poland*

* *Corresponding author email: piotr.kopka@ncbj.gov.pl*

Models assessing dose consequences play a key role in nuclear safety analysis, particularly when evaluating radiological impacts resulting from nuclear accidents. With the emergence of new reactor designs, often proposed in closer proximity to populated areas and characterized by significantly smaller Emergency Planning Zones (EPZs), precise consequence analysis becomes increasingly critical. The size and delineation of EPZs determine their practicality and effectiveness. Consequently, the proposed reduction of these zones necessitates robust and highly accurate assessments that account for a wide range of uncertainties, including modeling, assumed scenarios, and variability in meteorological conditions. Relying solely on single weather scenarios or simplified radionuclide transport models proves inadequate for achieving the precision required to determine EPZs encompassing zones of potential exposure during accidents. This study presents an innovative methodology for defining EPZs, tailored specifically to reactors with low thermal power outputs. The proposed method employs statistical analyses of numerous meteorological scenarios using Bayesian techniques and Monte Carlo simulations. By simulating thousands of potential radionuclide release events into the atmosphere, the methodology enables precise delineation of zones such as the Urgent Protective Action Planning Zone (UPZ), Extended Planning Distance (EPD), and Ingestion and Commodities Planning Distance (ICPD), based on dose limits recommended by the IAEA or national regulatory bodies. To validate the method, source terms were estimated or modeled from literature data. The approach was applied to evaluate EPZ sizes for three prominent reactor designs currently under consideration in Europe: High-Temperature Gas-cooled Reactor (HTGR), Molten Salt Reactor (MSR), Integral Pressurized Water Reactor (iPWR). The resulting spatial dose distributions were compared with EPZ dose limits and dose values across varying distances from reactor sites. Analysis of dose maps revealed that reduced EPZs are feasible without compromising public safety. This work demonstrates the potential for adapting emergency planning strategies to align with the characteristics of advanced reactor technologies, ensuring safety while optimizing land use and emergency response.

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