# Development of Accessible Codes for Nuclear Safety Analysis in Thailand

W. VECHGAMA1\*, N. PROMPRASERT2, N. KHUNSRIMEK2, S. RASSAME2,

P. KRISANANGKURA3, K. SILVA4,

1Nuclear Technology Research and Development Center, Thailand Institute of Nuclear Technology (Public Organization), Bangkok, Thailand

2Department of Nuclear Engineering, Faculty of Engineering, Chulalongkorn University, Bangkok, Thailand

3Bureau of Technical Support for Safety Regulation, Office of Atoms for Peace, Bangkok, Thailand

4National Energy Technology Center, National Science and Technology Development Agency, Pathum Thani, Thailand

\*Email contact of the corresponding author: wasin@tint.or.th, wasinvechgama@gmail.com

**EXTENDED ABSTRACT**

Since 2011 the accident of the Fukushima Daichi Nuclear Power Plant (F1NPP) has happened and spread the radioactive effect over many parts of the world [1]. The consequences of radionuclides have become a big problem leading to the unsteadiness of nuclear energy [2]. Nuclear safety issues were dramatically concerned to increase the trustworthiness of nuclear power plants (NPP) [3]. Computational nuclear safety analysis is one of the well-known methods for learning and developing source modeling and simulation tools to understand postulate accident progress and consequences [4]. The understanding of the fluctuation during nuclear accidents is a common factor to trigger the development of the safety design of nuclear reactors and the appropriate accident management from the source term release.

Thailand has concerned about the radioactive effects from possible severe accidents of NPPs especially around the Association of Southeast Asian Nations (ASEAN) region [5]. Nowadays, no NPPs have been although operated in ASEAN countries including Thailand, the understanding of nuclear safety analysis is necessary to prepare the accident management plan for preventing and mitigating potential severe accidents of NPPs as in the accident 1FNPP in the past. Moreover, this nuclear safety analysis of Thailand is one of the missions under the ASEAN Network on Nuclear Power Safety Research (ASEAN NPSR). The goal of ASEAN NPSR is to strengthen Research and Development (R&D), Human Resource Development (HRD), and Regional Cooperation (RC) in the field of nuclear power safety in the ASEAN region in order to support the formulation of a regional strategy for accident management in an Emergency Preparedness and Response (EPR) consistently with the International Atomic Energy Agency (IAEA) Safety Standards in order to protect people and the environment from nuclear severe accident consequences and increase the public acceptance of nuclear energy.

Due to Thailand that is a newcomer country for nuclear energy, the development of source modeling and simulation tools for nuclear safety analysis mainly focused on the understanding of nuclear consequences. This is because the public apprehension of nuclear consequences is still a serious issue leading to stopping the NPP program of Thailand inevitably [6]. In the nuclear safety analysis of Thailand, the development of source modeling and simulation tools includes non-accessible codes requiring licenses of owners to use and accessible codes published by their owners. The objective to study these codes is to reinforce human development in the nuclear safety field to lead to public acceptance of nuclear energy in Thailand. Moreover, the development of these source codes intends to publish the Graphical User Interface (GUI) versions to ASEAN countries through the collaborative nuclear power safety research projects under ASEAN NPSR to contribute to the human development in the nuclear safety field and public acceptance of nuclear energy in ASEAN region.

Currently, there are three main research topics, aiming to grasp the overview of the nuclear accident progress and consequences using the studies through source codes. The first one is thermal-hydraulic analysis in reactor coolant systems using the source code of SCDAP/RELAP5 developed by Innovative Systems Software (ISS) [7]. Thailand has received the licenses of ISS to perform the thermal-hydraulic analysis of advanced reactors in order to understand the progress of fuel behaviors during nuclear accidents.

Next, the second and third research topics were studied by accessible source codes that were developed from previously existing algorithms. These two parts are our focus in this paper. The second research topic is an assessment of fission product behavior in containment vessels using Analysis of Radionuclide Transport and Deposition/Modification 2 (ART Mod 2) code. Japan Atomic Energy Research Institute (JAERI) was the first owner who developed the ART Mod 2 code before releasing it to the public [8]. ART Mod 2 code was performed to understand fission product releases within containment vessel during the nuclear accident that has the potential to leak to the environment and impact on the public. The results of the ART Mod 2 simulation helped indicate the potential consequences and guide the plan to cope with the critical situation. Thailand Institute of Nuclear Technology (TINT) is the key person who has developed and updated the model and platform of Modified ART Mod 2 code together with Chulalongkorn University (CU) since 2012. Modified ART Mod 2 code has been modified and validated the models to evaluate fission product behavior of cesium compounds in containment vessels in 2019 [9]. Four models of aerosol deposition phenomena were modified and validated including gravitational settling, Brownian diffusion, diffusiophoresis, and thermophoresis in order to improve the accuracy of the calculation. Currently, Modified ART Mod 2 was used to assess the fission product behavior from reactor pressure vessels and spent fuel pools in the single-unit accident [10] and the complete accident system of the multi-unit accident [11] respectively.

The third research topic is on the consideration of accident consequence assessment methodology through the study on atmospheric dispersion assessment using Nuclear Accident Consequence Analysis (NACAC) code in order to be able to understand nuclear consequences leading to planning the EPR to manage radiation exposure within the ASEAN region [12]. Especially in the case of NPPs in ASEAN neighboring countries, the accidents of NPPs in these countries have risks to occur as in the nuclear accidents in the past. TINT and CU have developed an in-house atmospheric dispersion calculation code of NACAC together with National Energy Technology Center (ENTEC) and Office of Atoms for Peace (OAP). NACAC code is designed to evaluate the radionuclide dispersions on the atmosphere using the Gaussian puff model that referred to algorithms in the offsite consequence assessment code developed by the JAERI [13]. NACAC was verified and validated by comparing its results with the JRODOS in the case of a hypothetical severe accident at Ninh Thuan NPP in a short period [12]. Currently, NACAC is been developed to be able to calculate the radionuclide dispersion under the fluctuated conditions over a long period.

In summary, the development of accessible source modeling and simulation tools of Thailand both Modified ART Mod 2 and NACAC is continuously implemented to lead to GUI versions that can readily reach other users. The use of these accessible source codes is expected to support the collaborative research project among Thailand, ASEAN countries, and non-ASEAN countries in order to lead to the strengthening of international networks of ASEAN NPSR, the accurate understanding of the nuclear risk of people, and the increase in public acceptance of nuclear energy in the ASEAN region.

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