Atmospheric Dispersion Modeling and Radiological Safety Analysis for TRIGA Mark-II Research Reactor

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Abstract

The objective of this research work is to determine a precise modeling methodology for atmospheric dispersion and radiological safety analysis that can better predict the radiological consequences in terms of accidental airborne radionuclide release from 3 MW TRIGA Mark-II research reactor, Bangladesh. Atmospheric dispersion modeling for the release of radioactive gases and volatiles is an important contribution for various stages in the nuclear technology safety criteria like licensing requirements for the selection of nuclear reactor site, normal operating conditions stage, and finally, accidental release in case of reactor accident. The magnitude of these radioactive releases depends on several factors such as the source term, weather and topography. To calculate the source term that was generated from the inventory of peak radioisotope activities released from TRIGA research reactor, isotope generation and depletion code ORIGEN2.1 has been used here. A health physics computer code ''HotSpot'' was utilized for estimating the releases of various radionuclide groups at various downwind distances. The application of this code yielded to radiation dose profile around the site using meteorological parameters specific to the area under study. The atmospheric transport modeling then applied to calculate the Total effective Doses (TEDs) and how it would be distributed to human organs as a function of distance downwind. The doses were calculated for various atmospheric Pasquil stability classes (categories A-F) with site-specific averaged meteorological conditions. The meteorological data, such as, average wind speed, frequency distribution of wind direction, etc. have also been analyzed based on the data collected near the reactor site. Two hypothetical accident scenarios were selected, assuming that the activities were released to the atmosphere after the design basis accident. The results of effective doses obtained remain within the recommended maximum effective dose. This ensures the safety of workers and the population at the plant site.

Keywords: Atmospheric dispersion, TRIGA, radionuclide, ORIGEN, HotSpot, total effective doses

1. Introduction

The threat of nuclear or radiological accident caused a wide discussion at emergency and response personnel especially accidents that lead to the release of radioactive materials into the atmosphere. Effluents released from the stack or at the ground level are transported and diffused by wind and turbulence present in the atmosphere, respectively. This combined phenomenon is called atmospheric dispersion [1]**.** This radiological dispersion can cause serious radiological and dosimetric consequences for the population and the environment.

The magnitude of radioactive releases depends not only on the amount of the source term, but also on the weather conditions like wind and atmospheric stability. Atmospheric dispersion modeling and radiation dose calculations for hypothetical or possible release of radionuclides are important for background radiation data and licensing requirements [2]. This modeling is basically an attempt to describe the functional relation between pollutant emission and its resulting concentration.

It has been shown that nuclear research reactors do not, under their normal operation, release any significant amount of radioactivity to the environment. However, under accidental situations with severe core damage, some significant amounts of radionuclides may be released to the atmosphere. Radionuclides that are anticipated to be released through the stack can result in direct radiation exposure to the workers and the public in the downwind direction, and even be deposited on the ground and vegetation. Therefore, radiation dose calculation to assess radiological consequences is a very important exercise. Even though in previous studies, fuel burnup calculations were carried out for 3 MW TRIGA Mark-II research reactor, there is still need to understand the atmospheric transport of radionuclides using the site specific average meteorological conditions and to calculate the doses to be received at different receptor locations downwind in order to propose mitigation measures in the event of an accident. In this work we have determined the possible fission products from 3 MW TRIGA Mark-II research reactor core of Bangladesh. An isotope generation and depletion code ORIGEN2.1 is used for radionuclides inventory estimation in the reactor core, which is the source term. The code uses one-group cross-sections provided by neutron transport modeling program to calculate fuel depletion in time domain. The use of this new source term criterion assumes release fractions of 1, 0.4, 0.3, 0.05 and 0.02 for noble gases, halogens, alkali metals, the tellurium group and the Ba–Sr group, respectively based upon US-NRC regulatory guide 1.183, to determine the exclusion area from a limit on Total effective dose (TED) of 0.25 Sv [3]. On the other hand, release factors for noble gases, halogens and particulates used in an IAEA document on research reactor are 100%, 40% and 1%, respectively [4].

To assess the impact of precipitation on the dispersion of the radioactive cloud in the emergency stage we used the health physics computer code HotSpot (version 2.07.2,

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