IODINE POOL SCRUBBING UNDER SEVERE ACCIDENT IN A NUCLEAR POWER PLANT

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The amount of iodine created inside the fuel during a power plant operation is relatively small with regards to other fission products; however, the total iodine activity is one of the most important among other the fission products, that is, iodine isotopes produce a large amount of decay heat (roughly 50% of the total decay heat). If a severe accident occurs in a nuclear power plant, fission products from a fuel might be released into the environment. Iodine, which is a major fission product generated in RCS, can enter the containment in several forms including CsI and I2. The NUREG-1465 report indicated that most of the iodine enters the containment as a particular form as cesium iodide (CsI) (95%), and the remaining is a vapor species such as atomic iodine (I) and hydrogen iodine (HI) (5%). During the severe accident, it is possible that the radioactive materials including the iodine may be released into the containment, and finally into the environment. The iodine, especially in a vapor form, is a major contributor to the potential source term that can be released into the environment.

The iodine interacts variously with other materials such as solid, liquid, and radiation under severe accident conditions, and the interaction processes are very complicated. Temperature and other controlling thermal-hydraulic parameters govern the transfer of iodine between the aqueous and gas phase and to the surfaces. Several homogeneous and heterogeneous reactions have a significant dependence on the gas and water temperatures. The I2 adsorption on the surfaces additionally depends on the gas flow velocity along the walls. Under wet conditions, the wall condensation rate drives the I2 diffusion toward the surfaces. Other important boundary conditions for many reactions are indirectly dependent on the thermal hydraulics and aerosol behavior. A crucial parameter directly affecting most of the reactions is the local or bulk dose rate that depends on the fission product concentrations in the containment atmosphere, on the walls and in the sump. The iodine species can be dissolved in a liquid phase by converting a non-volatile iodine species into a volatile species I2, and finally released into the containment. The iodine dissolution may be induced by some hydrolysis processes and reactions with other species generated by water radioactivity. To determine the concentration of iodide ions, I−, and its contribution to the gaseous phase iodine concentration, the rate of reaction products I2 (I2) should be known as a function of the initial conditions in water, such as the initial iodide ion concentration and pH variation under gamma irradiation. Some correlations have been issued to modeling this process, and used in several codes such as IODE, IMPAIR, and MELCOR code. However, some uncertainties still remain, for example, INSPECT code can estimate well the oxidation rate of iodine (I2) and iodide ion (I−) when the I− concentration is about 0.1mM but overestimate them when I− concentration is larger than 1mM.

The gaseous iodine retention in a pool such as a wet-type FCVS (Filtered Containment Venting System) and a sump was evaluated. Iodine pool scrubbing behavior was modeled and sensitivity studies were performed such as the pool temperature, vapor velocity in a bubble, and iodine concentration. And the oxidation rates of iodine ions were also estimated under gamma irradiation conditions in pool. That is, a new correlation for the oxidation of iodide ions under gamma irradiation conditions was suggested and was also verified using experiment data with the NaI solutions at an initial concentration of 1 to 5mM, pH value of 3.0 to 6.0, and gamma dose rates of 0.4 to 10.0 kGy·h−1, and irradiation time of 1 to 7 h.