Production of radionuclides in the cooling water for electomagnetic horns at the J-PARC neutrino experimental facility

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The cooling water for electromagnetic horns is exposed to intense high-energy protons, neutrons and charged pions at the J-PARC neutrino experimental facility. High-energy secondary particles produce various radionuclides in the cooling water; dominant radionuclides were ^{3}H and ^{7}Be, and various γ-emitting nuclides were also detected by radioactivity measurements with a high-purity Ge detector. Concentrations of individual nuclides in the circulating cooling-water were determined, and the origin of each nuclide was discussed by means of Monte Carlo simulations. Various calculation results demonstrated that ^{3}H and ^{7}Be were directly produced in water by spallation of oxygen in water molecules and other nuclides were produced in metal components and transferred into water by chemical and/or physical processes.

Behaviors of radionuclides in water were found to be dependent on elements. Some nuclides behave complicatedly and distribute inhomogeneously in the water-circulation system. As a typical case, ^{7}Be nuclides exist in the form of water-soluble ions, colloids (mainly 3 to 20 nm), and relatively large particles (> 1 μm) in water.

Although most of the ^{7}Be was collected by the ion-exchange resin unit installed in the water circulation system, a part of ^{7}Be was left in water after passing through the ion-exchange unit. Furthermore ^{7}Be tends to adsorb on metal piping and various components. These characteristic behaviors of ^{7}Be are in contrast with those of ^{3}H (T), which exists in the form of water molecules (HTO) and distributes homogeneously in the system.

Existing states of nuclides were examined by laboratory-scaled ion-exchange column experiments and ultrafiltration experiments. Behaviors of radionuclides in the water circulation system was discussed on the basis of their existing states in water.

References

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