Safety Measure against Tritium in the MLF Muon Target

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For a high power proton driver like J-PARC, radiation safety is a crucial issue for stable and continuous operation. ^{3}H is generated by a spallation process even in low-Z material such as Be, C which are generally applied not only to target materials but also to beam windows and other devices irradiated by high energy particles. In general, ^{3}H diffuses easily in a material at high temperature, goes out to the surroundings environment and eventually increases the risk of an unexpected exposure. On the other hand, quantitative real-time monitoring of ^{3}H in a big volume like exhaust gas from a facility is difficult because ^{3}H emits only low-energy β-ray. Therefore, the treatment of ^{3}H will be a key to facility operation. We developed a buffer tank system as a safety measure against ^{3}H released from the muon production target to the beamline vacuum in MLF J-PARC. The system stores the exhaust gas from the beamline vacuum during the beam operation, and then exhausts the stored gas in a maintenance day after the radiation survey. This disables unexpected ^{3}H release from the facility, and constructs the rigid RI control.

KEYWORDS: tritium, graphite, radiation safety

1. Introduction

In MUSE (Muon Science Establishment), the muon facility MLF J-PARC, a 2-cm thick isotropic graphite (IG-430U by TOYO TANSO Inc.) disk is adopted to the muon production target that generates the world-highest intensity pulsed muon beam consuming about 5% of proton beam [1, 2]. Due to spallation reactions, lots of radio isotopes are generated in the target. The main residual activities in the target are ^{3}H and ^{7}Be after a short cooling period as shown in Table I. According to a simulation using PHITS code [3], ^{3}H is generated by 0.5 TBq/year under 1 MW operation. The radiation dose from such residual activities in the target itself is orders of magnitude lower than that in the surrounding metallic parts in the target assembly [4]. In addition to this, ^{3}H emits only low energy β ray. Thus, the contribution of the ^{3}H is not serious to the external exposure if it stays in the target. However, ^{3}H has a possibility to diffuse in the hot graphite and evaporate from the target surface. In general, ^{3}H forms a volatile chemical state, easily spreads out and sticks on the surface of devices, and eventually increases the risk of internal exposure.

Up to the present, the radiation monitor on the MLF stack has not been detected any ^{3}H in the beamline vacuum exhaust under 500-kW long-term stable operation in which the target temperature reaches just below 500 deg C. The monitor uses silica-gel traps to capture both HT (^{1}H ^{3}H) and HTO (^{1}H ^{3}H O), respectively, and is installed in a bypass line attached to the main stack line. Every operation cycle of 6-day beamtime and 1-day maintenance, a trap is replaced and then measured by a liquid scintillator after pre-treatment of leachate in water. The amounts of exhausted HT and HTO are determined by the ratio of the air flow between the bypass monitor line and the main stack line, and thus the lower detection limit is about 200 MBq. In addition, we confirmed no release of ^{3}H from a proton-irradiated graphite below 800 deg C by a separate experiment with the thermal deposition