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Radioactive Nuclides Production in the KSTAR Tokamak

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Abstract

The deuterium-deuterium reaction in the KSTAR tokamak, which has been constructed in Korea, not only generate neutrons with a peak neutron yield of 2.5 x 10^{16} per second through the operation of 300s pulse length, but also this tokamak are activated. This environment will restrict the work around and into a vacuum vessel after shutdown in the health physics point of view. The production nuclides of structure material in KSTAR tokamak was evaluated by MCNP4C2 and an inventory code, FISPACT during and after shutdown. The absorbed dose and decay property was obtained.

1. Introduction

Neutrons with 2.45 and 14.06 MeV was generated by D-D and D-T reaction in the KSTAR tokamak, and these neutrons activated structure materials of KSTAR tokamak effectively. Many problems in radiation protection result from the activation. Especially, this involves great difficulties in maintenance and repair works to be conducted after an operational shutdown. Because vacuum vessels, carbon graphite, copper back-plates, magnet and cryostat materials were activated, an access around or into a vacuum vessel is so limited in a health physics point of view and a standard amount of exposure dose is needed about working time for radiation protection. In order to reveal and get the neutron production isotopes, a neutron flux was obtained using MCNP4C2[1]. Furthermore, a production nuclides in structure materials were obtained by FISPACT program[2].

2. KSTAR Tokamak and Calculation

The mission of the Korea Superconducting Tokamak Advanced Research (KSTAR) Project

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is to develop a steady-state capable superconducting tokamak to establish the scientific and technological bases for an attractive energy source[3,4]. The KSTAR tokamak consists of a vacuum vessel, in-vessel components, a cryostat, thermal shield, superconducting magnets and magnet supporting structures. This calculation was performed using MCNP4C2[1] with the KSTAR tokamak model that was constructed to include plasma facing component (graphite, back-plates), vacuum vessel, coolant, PF and TF coil, coil casings, port(horizontal beam ports, vertical ports and coolant ports). However, one top-half quadrant section of the KSTAR tokamak[5] was selected for neutron flux calculation because it has complete up-down symmetry and 12 horizontal ports are assumed to be the RF port type as shown in Fig. 1. The baseline shielding material in the double-walled vacuum vessel was assumed to be borated water. The toroidal field magnets were supported by means of the vacuum vessel.

3. Results and Conclusions

The radioactive nuclides on each structure in tokamak was obtained using neutron flux and identified neutron production nuclides which contributed to the dose rate for each structure after shutdown and this operation time, irradiation time, is 300s.

In the case of graphite limit, there appear the neutron production nuclides of He, Be, B and C after neutron irradiation. However, the ^{12}B and ^{13}B just contributes to the dose rate during very short time.

The neutron production isotopes of the copper back-plate generate more than those of graphite limit. $^{62, 64, 66}$Cu and ^{62}Co is the major contributory material to the dose rate within about 1 day after shutdown in the back-plate. Almost these nuclei disappeared in a nuclide of contribution to dose rate after a few day while ^{60}Co is a dominant nuclide and influence the dose as shown in Fig. 2.

In the case of the inner vessel supporting material constructed by SS316LN, the major nuclides to dose rate on after neutron irradiation, such as ^{28}Al, ^{52}V, ^{56}Mn and ^{101}Mo. In case that the shutdown is kept enough, the ^{54}Mn, ^{58}Co and ^{60}Co can not be ignored to the dose rate as shown in Fig. 3.

^{64}Cu, ^{65}Ni and ^{92}Nb were the major nuclides in the magnet structure composed of NbSn3 during about 1 month, but the ^{94}Nb, ^{60}Co and ^{125}Sb occupied the dose rate after the ^{64}Cu, ^{65}Ni and ^{92}Nb disappeared as shown in Fig. 4.

From above preliminary results, after a few days the nuclides of short half life drastically decrease dose rate on structure. It will offer a guiding principle as the radiation protection point of views when a maintenance and repair is performed in tokamak.

References

[1] J. F. Briesmeister, "A General Monte Carlo N-Particle Transport Code, Version 4C," LA-13709-M, Los Alamos National Laboratory, 2000.

[2] R. A. Forrest, "FISPACT-2001:User manual" EURATOM/UKAEA Fusion Association, Culham Science Center, Abingdon, Oxfordshire OX14 3DB, UK, 2001.

[3] G. S. Lee, *et al*., Fusion Eng. Des., 46, 405(1999).

[4] D. I. Choi *et al*., "The KSTAR Tokamak" IEEE Transactions in Plasma Science, 1998.

[5] J. H. Park, *et al*., J. Nucl. Sci. Technol., Sup. 1, 276(2000).

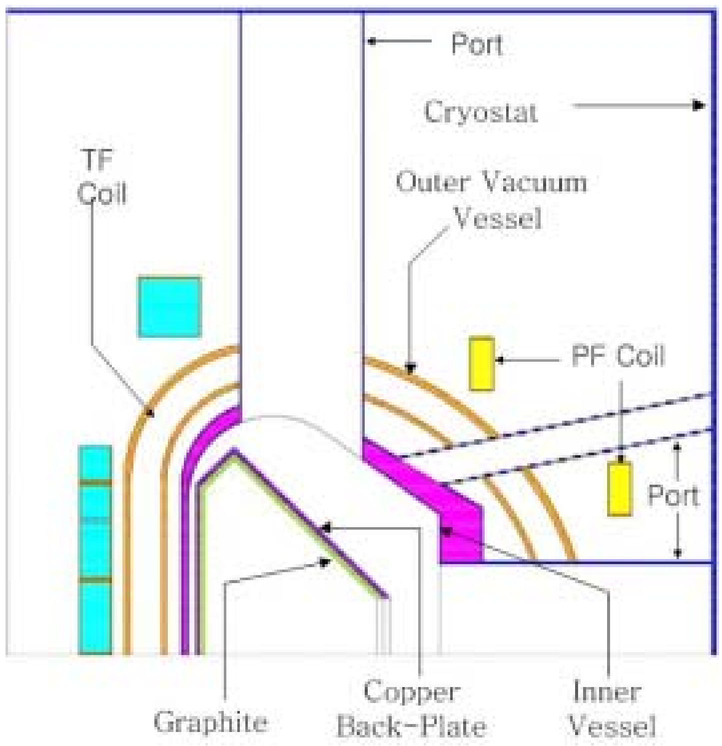

Fig. 1. Cutaway View of The KSTAR Tokamak.

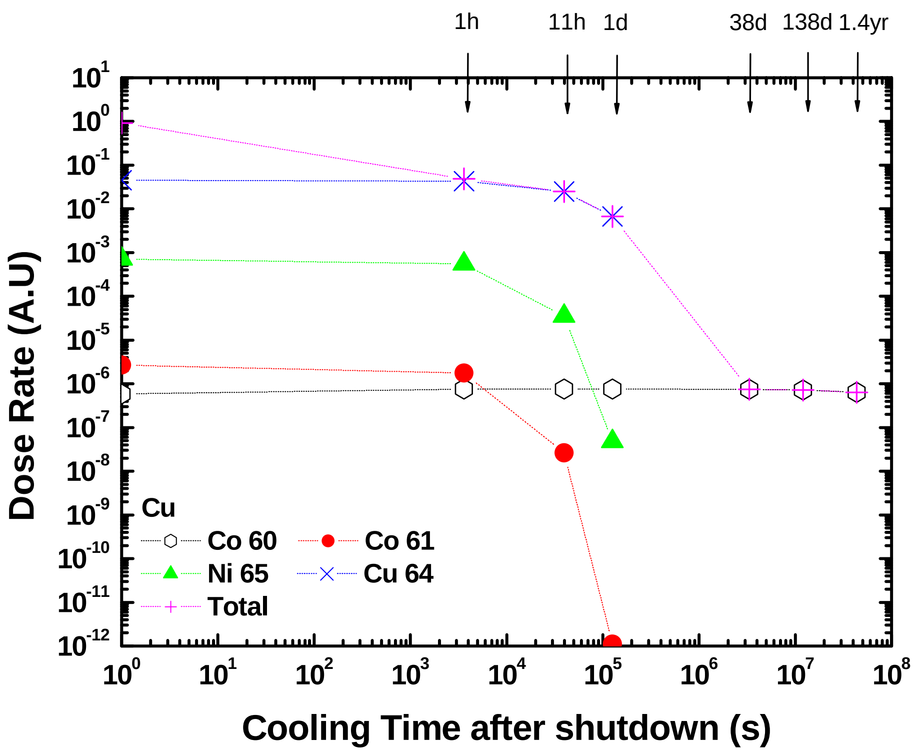

Fig. 2. Dose Rate for Copper Back-Plate.

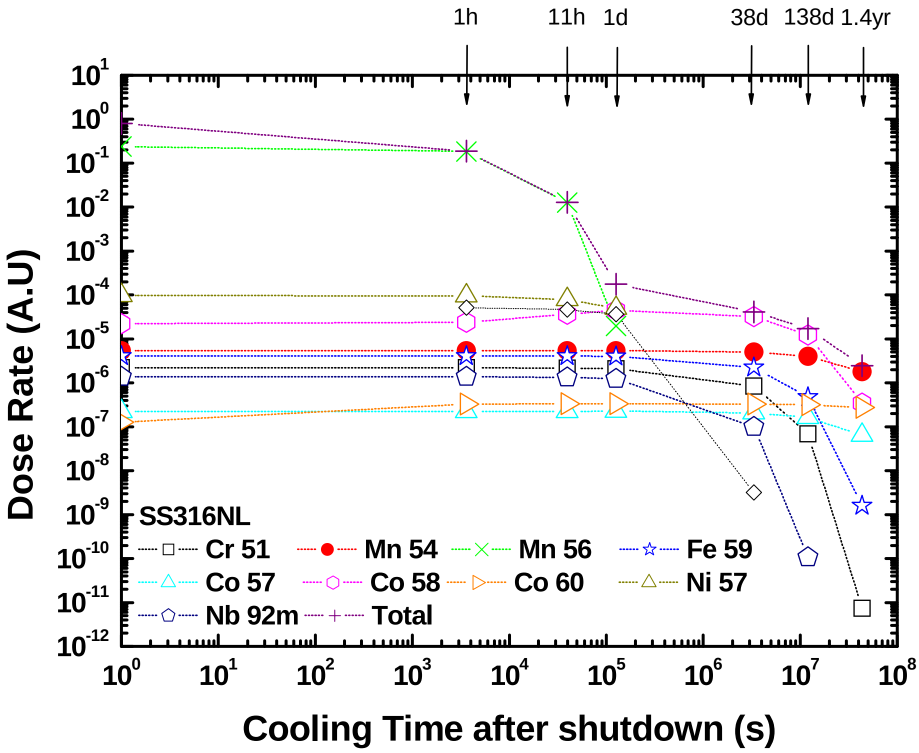

Fig. 3. Dose Rate for Inner Vacuum Vessel.

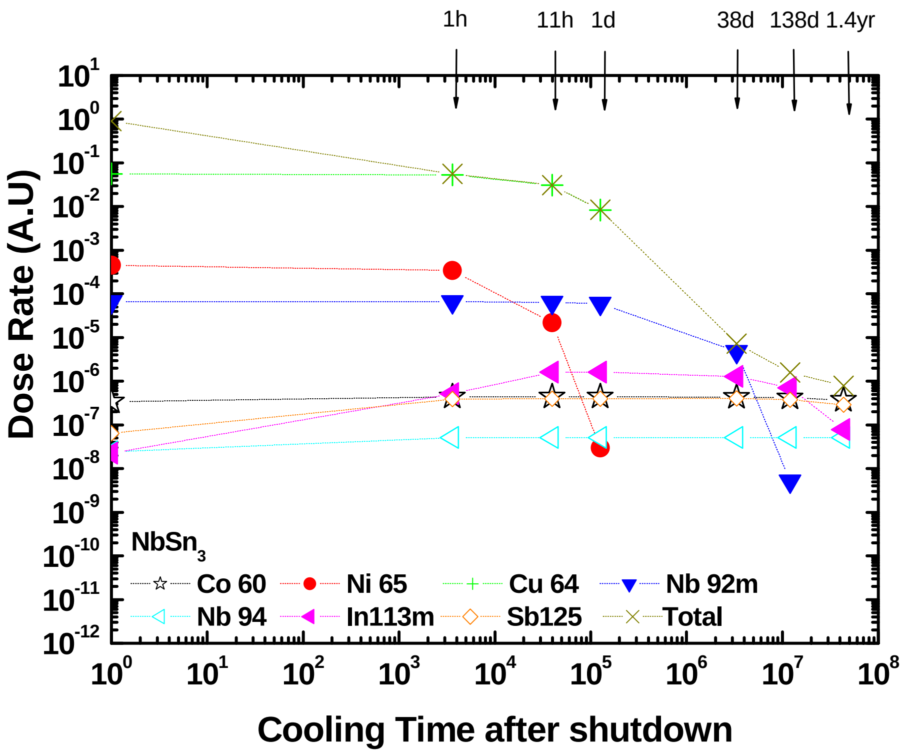

Fig. 4. Dose Rate for PF Magnet Coil.