Simulation of induced radioactivity on Steel collimator plug for PGAA facility of Moroccan Triga Mark II reactor under different neutron irradiation levels

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Abstract

The main objective of this study is to assess the behavior of steel collimator plug (steel plug) to be in serted inside the NB1 beam tube of 2MW Triga Mark II research reactor. This steel plug is purposed to reduce the cross-section and focus neutron beam coming from the reactor core. This study is held under the framework of safety assessment for PGAA commissioning in which the steel plug insertion takes a crucial role. For this purpose, the aspect involved in this study is the radioactivity induced in the steel plug by neutron radiation. In order to perform this study, an approximate Triga Mark II react or MCNP model was used to calculate neutron spectrum inside the NB1 beam tube at the exact positi on of the inner part of the steel plug.

This spectrum was used as input to perform this evaluation. In order to choose the convenient steel, two calculations were made for two kinds of steel which are respectively E195 steel and 304L Stainless Steel.

Results were calculated using in-house FORTRAN language based program and validated using "*Neutr on Activation Calculator"* developed by NIST (Center for Neutron Research), which is used for induce d radioactivity evaluation.

The results show that radioactivity induced in E195 Steel is much lower compared to induced radioacti vity in 304L Stainless Steel for the neutron fluency conditions of the Triga Mark II research reactor.

Introduction

The main purpose of the collimator plug in a PGAA facility is to shape neutron beam crossing the NB1 beam tube of the Triga Mark II reactor. It allows having at the outlet a narrow and quasi-parallel neutron beam. It also plays the role of a shield by eliminating all diverging and scattering neutrons. It consists of two main components, each of which plays a special role, namely, 5cm holed steel rings assembled with a total length of 100cm (steel plug) and boron containing material with the same shape (Figure 1). The steel plug reduces fast neutrons and boron containing material thermalizes and absorbs slow neutrons. This study is restricted only to assess the behavior of the steel plug of the collimator.

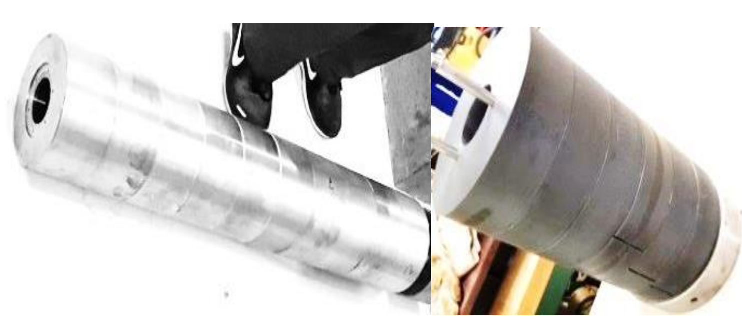

Figure 1. On the right the B_4C-HDPE rings; on the left the steel plug.

Methodology

In order to obtain the attenuation of the neutron flux traveling through the steel plug, an MCNPX collimator model was used (Figure 2). Using this model, the mean neutron flux attenuation was generated for each 1cm of the steel plug to be an input for both FORTRAN based language program and *Neutron Activation Calculator* to evaluate the radioactivity induced in the two materials

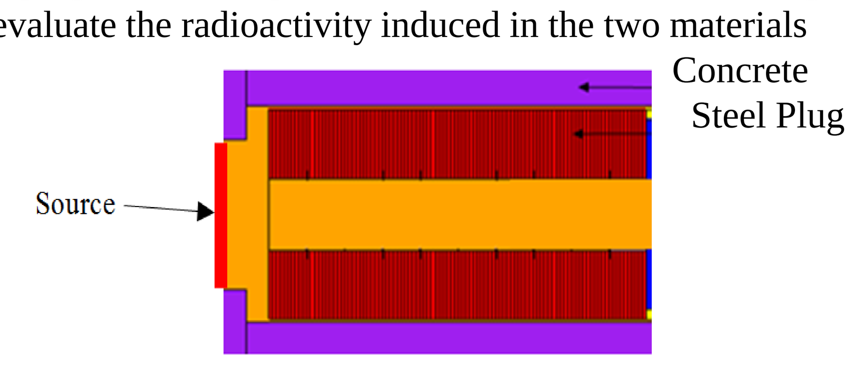

Figure 2. 2D model of the collimator obtained using MCNP code.

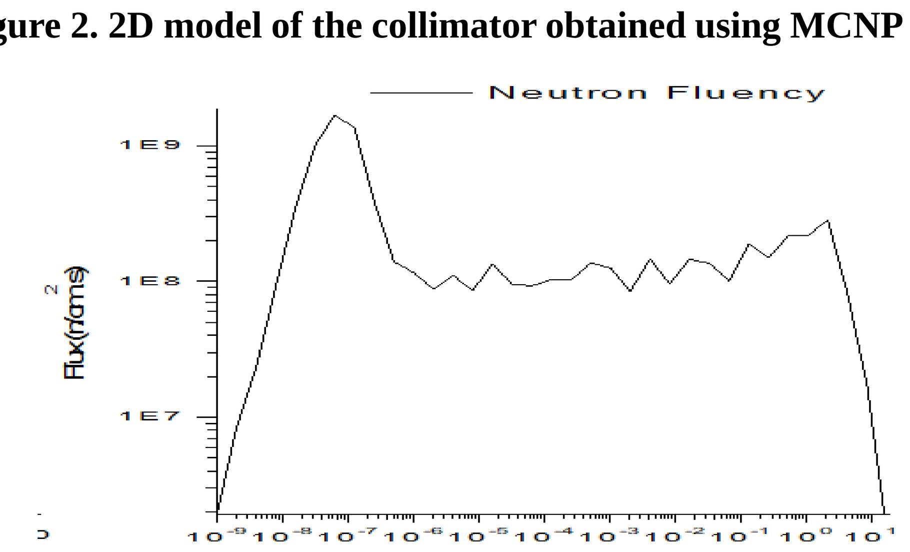

Figure 3 Neutron fluency rate at the inlet of the steel plug

Figure 4 shows the attenuation of the neutron flux at the collimator.

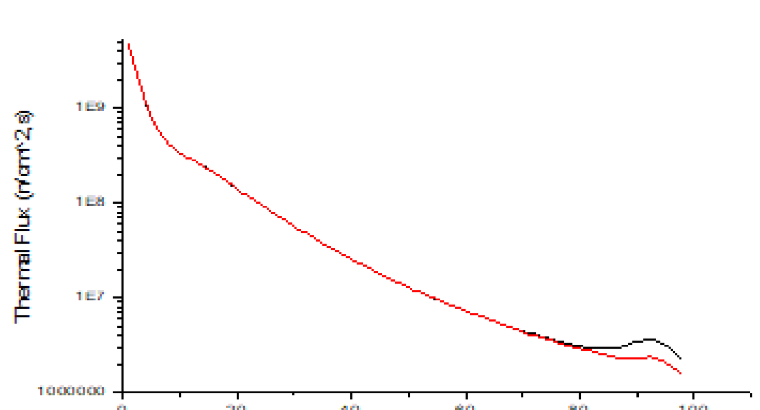

Figure 4. The attenuation of neutron flux traveled the collimator.

To justify the choice of the steel "AISI E195", a comparison of the results obtained with those of the steel type "304L" used for decades in the generations I and II of pressurized water reactors (PWR)

Results

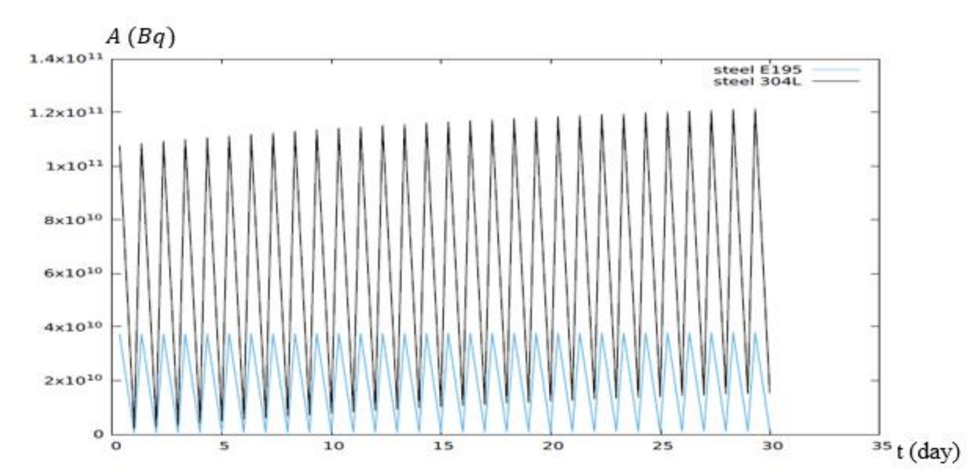

Figure 5. Variation of the radioactivity induced in the collimator in E195 steel and 304L according to the time during 1 month.**.**

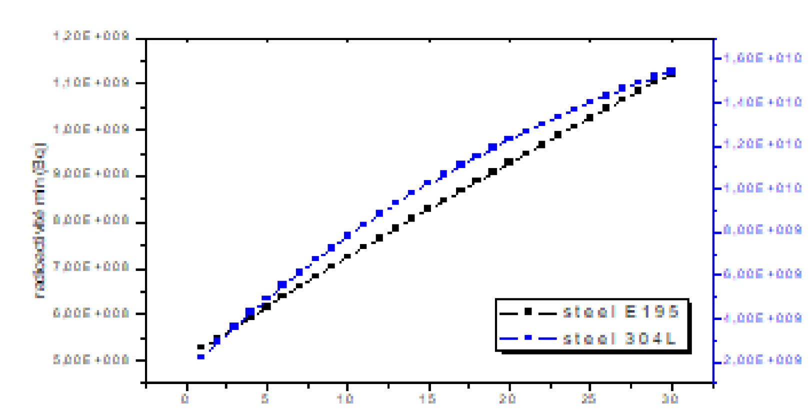

Figure 6 Induced activity for 8h/d and for one month irradiation for E195 and 304L steels**.**

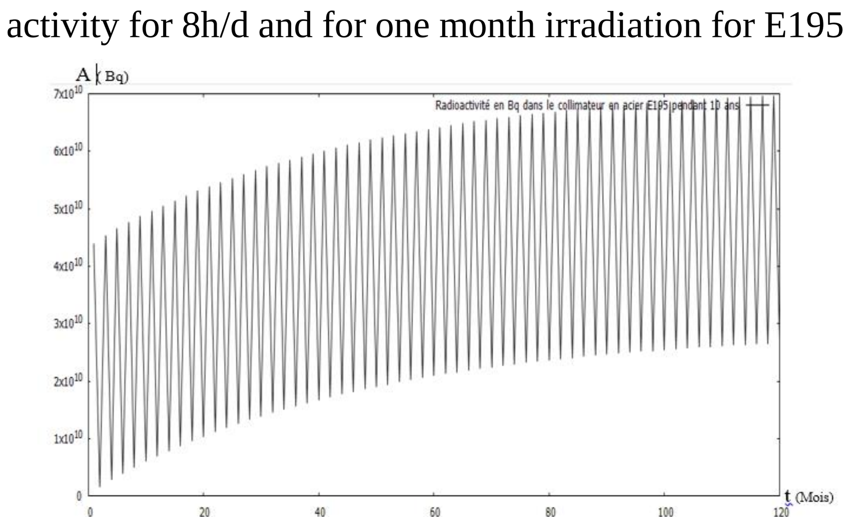

Figure 7. Induced activity for 1 month/2Month operating reactor for E195 steel**.**

Table I. Classification of the different parts of the collimator according to the norms of the waste nuclear.

The N° of zone of collimator	Cycle of irradiation	end if irradiation E195		Classification	end of refroidissement E195		Classification
	T (Mount)	A (MBq)	A (MBq/g)		A (MBq)	A (MBq/g)	
1	0	34170.66	12,307099	MA	1221.88	0,440079	FA
	118	54181.445	19,514297	MA	20700.91	7,455757	MA
2	0	5207.2	1,8754547	MA	186.2	0,067063	TFA
	118	8256.63	2,9737547	MA	3154.5712	1,136168	MA
3	0	2152.464	0,7752437	FA	76.97	0,027722	TFA
	118	3412.99	1,2292419	MA	1303.984	0,46965	FA
4	0	931.4581	0,3354792	FA	33.31	0,011997	TFA
	118	1476.94	0,5319431	FA	564.29	0,203238	FA
5	0	572.792	0,2063	FA	20.482	0,007377	TFA
	118	908.229	0,3271129	FA	347.003	0,124979	FA
6	0	324.341	0,1168165	FA	11.598	0,004177	TFA
	118	514.281	0,1852264	FA	196.489	0,070769	TFA
7	0	199.51	0,0718567	TFA	7.134	0,002569	TFA
	118	316.344	0,1139363	FA	120.864	0,043531	TFA
8	0	133.0054	0,047904	TFA	4.756	0,001713	TFA
	118	210.896	0,0759575	TFA	80.576	0,029021	TFA
9	0	149.421	0,0538163	TFA	5.343	0,001924	TFA
	118	236.9246	0,0853321	TFA	90.521	0,032603	TFA
10	0	123.934	0,0446368	TFA	4.43164	0,001596	TFA
	118	196.512	0,0707769	TFA	75.080212	0,027041	TFA

Conclusions

E195 steel is the most suitable for PGAA installation because the activity induced is lower than the activity induced in 304L steel

Bibliography

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3. "*Neutron activation Calculator*" http://www.wise-uranium.org/rnac.html . .