CONCRETE AND STAINLESS STEEL ACTIVATION/DECAY HEAT DATA FOR THE IFMIF-DONES TEST CELL COMPONENTS

G. STANKUNAS
Lithuanian Energy Institute, Kaunas, Lithuania

Activity inventories and decay heat for waste evaluation and decommissioning are essential parameters for development of any nuclear device [1]. The activities in this field aim to provide the detailed calculation results and identify the needs for the IFMIF-DONES facility and components.

The main objective of the study is to perform activation/decay heat calculations for steel and concrete materials located in Target & Test Cell (TC) of the accelerator. This paper contains the data on updated activation, decay heat and dose rates calculations of TC liner and concrete inside biological shielding walls. On this basis new data was provided for the further DONES (one accelerator, 125 mA current, 5 MW beam power to the target) design, or the need for performing additional activation calculations cases not considered so far.

Test Facility consists mainly of two systems: 1) the Test Cell housing the nuclear reaction and 2) the set of hot cells allowing the replacement of the Target Assembly and the TMs, and also the preparation of new modules and the extraction of irradiated specimens. The Test Cell is the system where beams converge with the Li of the Target Assembly to generate high neutron and gamma radiation fields to irradiate Test Modules. Then, high quantity of radioactive materials will be in this cell, as well as liquid metal.

Test Modules inventory show variations from one to the others due to the different materials involved in the modules construction and in the irradiation experiments. Modules are cooled by gas (He) and contain materials such as Stainless Steel 316LN, EUROFER, INCONEL 600, Austenitic steel AISI 316L, sodium–potassium alloy (NaK), ceramic insulators and other.

Biological shielding surrounding the TC is composed of heavy concrete and inner liner. Inner layer is an independent closed framework which is covered with stainless steel (SS) liner from inside with a thickness of 8 mm. Between SS liner and inner shielding a set of water cooling pipes is designed for nuclear heating removal purpose. The thickness of the inner layer is 1 m in the beam direction and lateral direction, while 0.5 meter at the bottom.

The inventory analysis was carried out for the TC liner (Fig.1) The analysis was done by cell based; the liner part consists of 8 cells in the present calculation model (top, bottom, downstream, upstream, two lateral sides and two for TM supports) The average neutron spectrum was calculated for each cell and then passed to the FISPACT code.

Due to the activation of the liner and the concrete wall, the residual dose rate is still very high even if all the removable in-cell components are removed. Time evolution of activation and decay heat with identified dominant nuclides calculated for the TC concrete near TC liner are represented in Figures 2.

The specific activity for the TC liner are mainly influenced by isotopes produced by (n,g) reactions (neutron capture) with low energy neutrons with dominant nuclides that contribute to the decay heat - Co-60 together with Mn-56 and Fe-59. The calculated contact dose rate is 5E+05 μSv/h just after shut down of the beam. The main contributors for dose rate and decay heat of the irradiated TC material remains mostly the same as for activation. Specific activation and decay heat analysis of concrete exposed Mn-54 to be the biggest contributor to the total value.

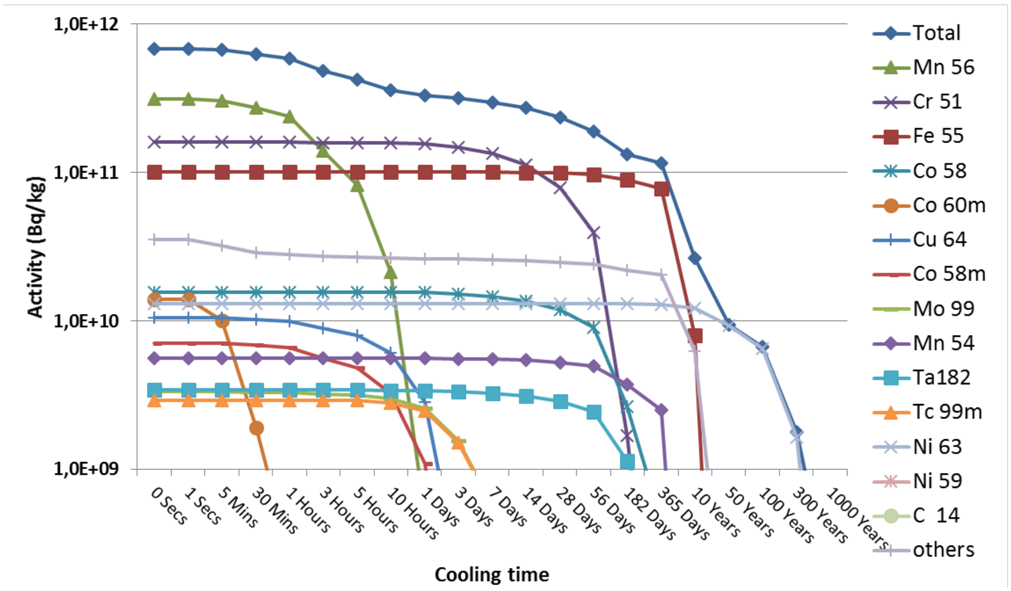

Figure 1. Time evolution of activity induced in the TC liner

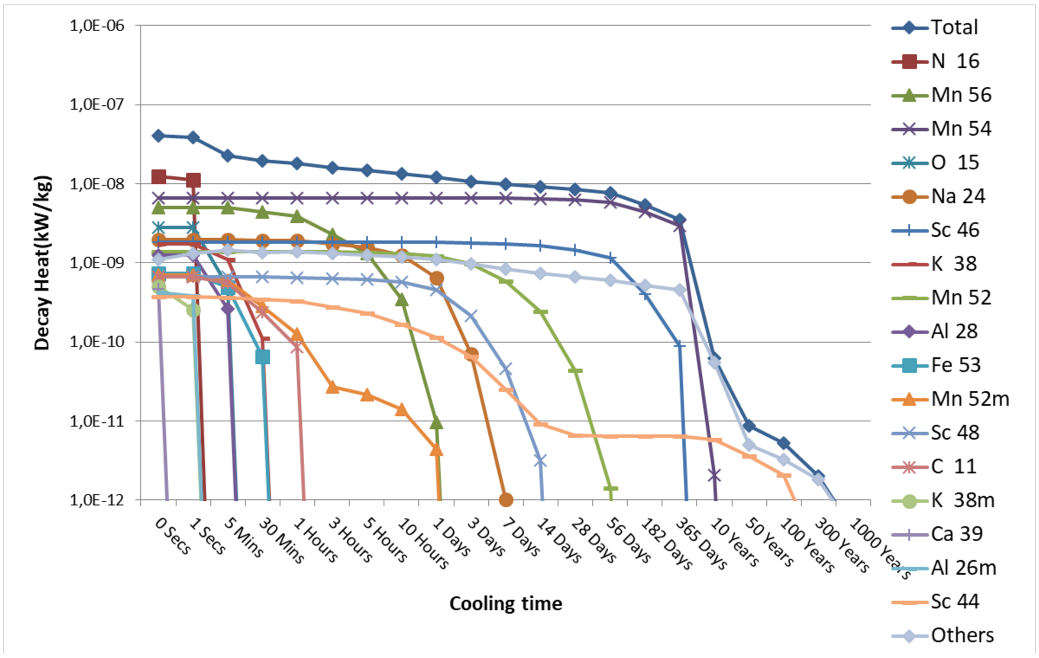

Figure 2. Time evolution of decay heat with dominant nuclides calculated for the TC concrete near TC liner.

REFERENCES

[1] FISCHER U., BIENKOWSKA B., DROZDOWICZ K., FRISONI M., MOTA F., OGANDO F., QIU Y., STANKUNAS G., TRACZ G, Neutronics of the IFMIF-DONES irradiation facility, Fusion Engineering and Design, Volume 146, Part A, Pages 1276-1281, 2019.