ID:1132

Purification of irradiated beryllium from radioactive nuclides using "dry" chlorination method

Baklanova Yu.Yu., Sokolov I.A.
Institute of Atomic Energy Branch of the National Nuclear Center of the Republic of Kazakhstan
Sokolov@nnc.kz

ABSTRACT

- The paper presents the results on the decrease in the activity of the beryllium sample after the studies carried out using the of dry chlorination method [1] for the thermonuclear industry.
- Experimental work was carried out on the chlorination of beryllium and the separation of beryllium chloride from a mixture of products of the technological process.

BACKGROUND

- In the above studies, the problem of beryllium purification from radioactive nuclides, which are resulted from exposure to a neutron flux during operation as a plasma-reversible element of the first wall of thermonuclear reactors, was solved [2].
- ITER will require at least 50 tons of beryllium for the first wall of the vacuum chamber, which has to be replaced every 5 years of operation when the reactor is operating at rated power. At present, the total world production volume is only about 300 tons per year [3], therefore, the return of beryllium to the TNR production cycle is a necessity.

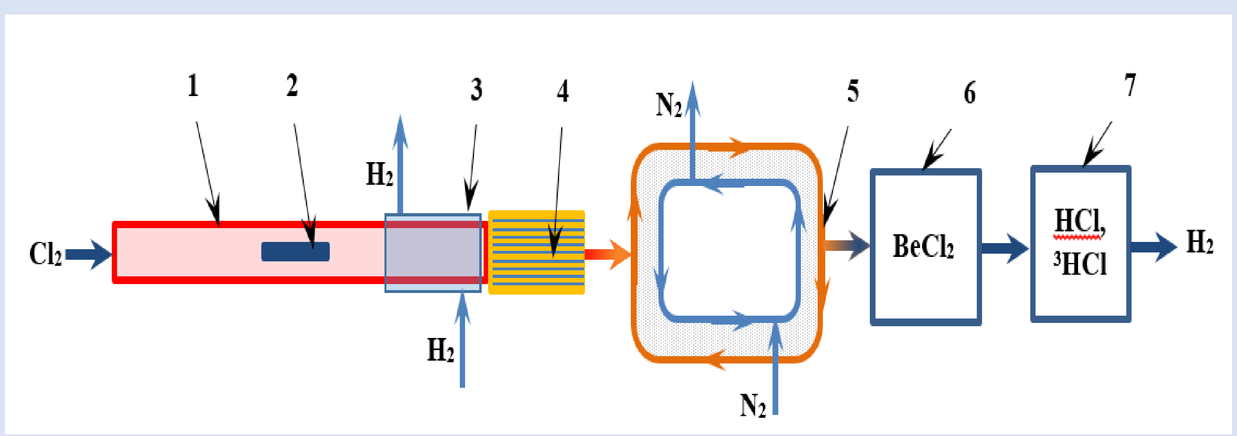
CHALLENGES / METHODS / IMPLEMENTATION

The dry chlorination method [4] of irradiated beryllium is shown in the Figure. The Be sample is heated in a reaction chamber to a temperature of 730 °C. Then the supply of Cl_2 is switched on. Based on the surface reaction between chlorine and irradiated beryllium, chlorides of the main radionuclides are formed: $BeCl_2$, $CoCl_2$ и ^3HCl , etc. H_2 is supplied to the resulting gas mixture, which binds free Cl_2. Passing through a filter with a nickel element temperature of ~600°C , $CoCl_2$ is precipitated from the gas mixture, which undergoes a phase transition. Then the gas mixture is transported through the heat exchanger to the $BeCl_2$ collection tank, which is heated to a temperature of ~500°C. Then the gases HCl, ^3HCl and H_2 are fed into the tritium chloride collection tank, where HCl and ^3HCl dissolve in water, and an insignificant stream of H_2 was released into the atmosphere.

Measurements of the radioactive impurity activity in the samples of materials were carried out using the gamma-spectrometric complex "CANBERRA" InSpec-tor-2000 with the detector GC1518.

The determination of the ^3H content was carried out by liquid scintillation method on a beta-spectrometer "TRI-CARB 2900".

Chloride production and separation scheme

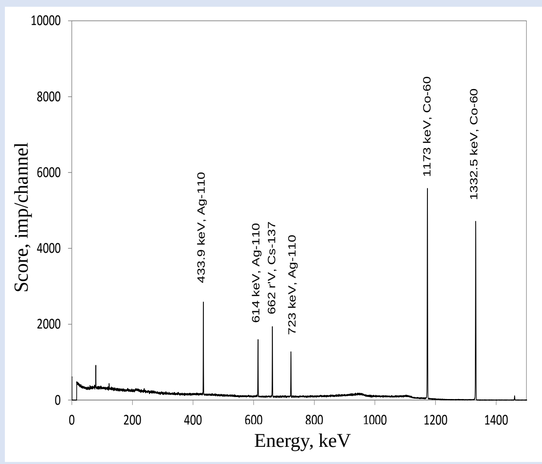


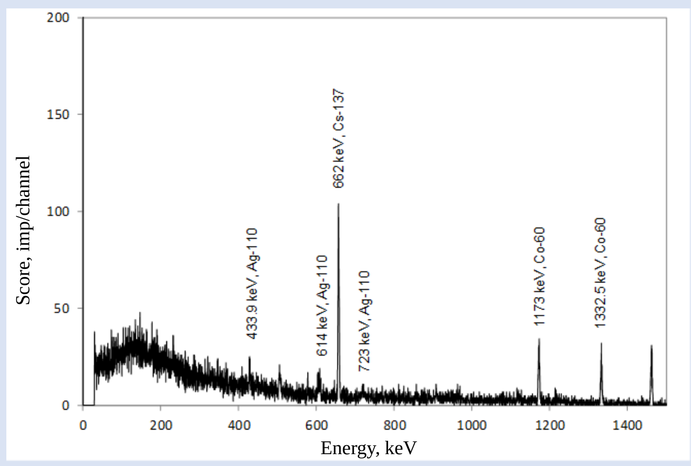
1 – reaction chamber; 2 – irradiated beryllium(^3H, ^{60}Co, ^{108}Ag, ^{137}Cs);
3 – gas mixture(^3HCl); 4 – filter for ^{60}Co; 5 – heat exchanger;
6 – tank for $BeCl_2$; 7 – tank for ^3HCl.

OUTCOME

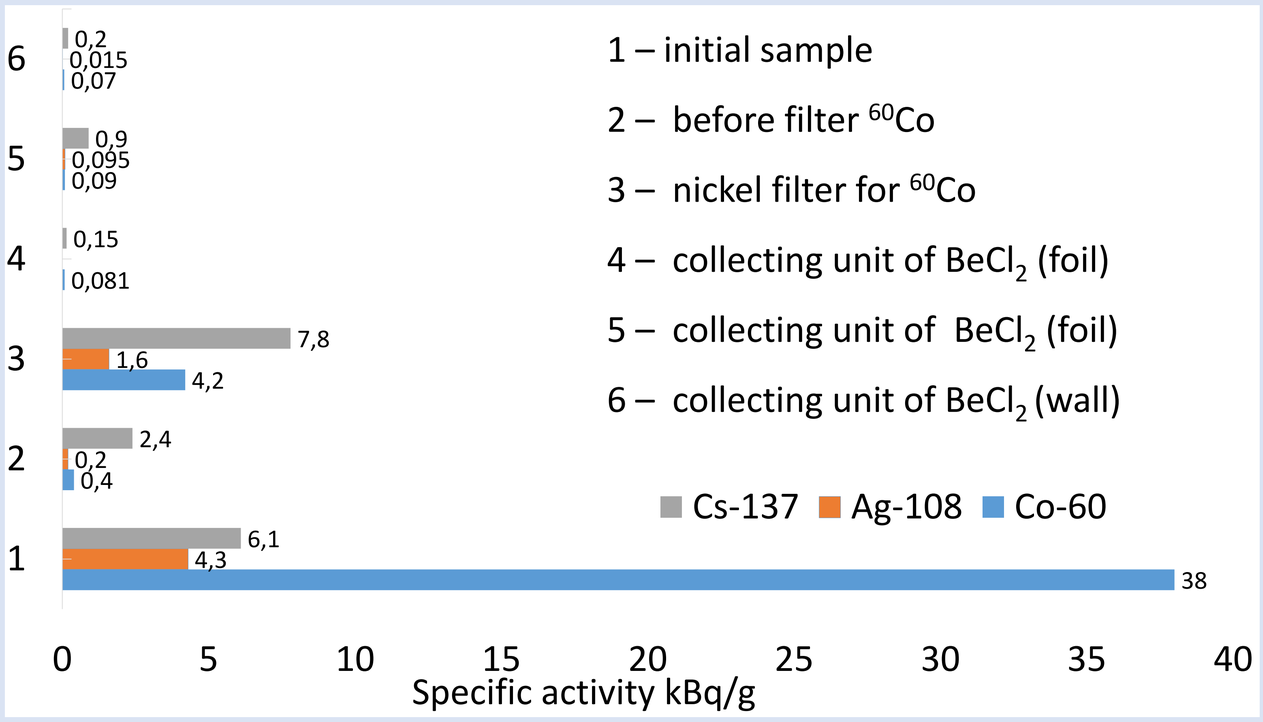
The decrement of the mass of the beryllium sample according to the results of its weighing before and after the experiment was 8.787 g. The gamma-radiation spectrum of the initial Be and $BeCl_2$ is shown in the graphs. During the chlorination process, radioactive impurity elements were deposited on the internal surfaces of the unit in the gas path. The diagram shows the results of measurements of the specific activity of sediments. The interaction time of chlorine with beryllium was approximately 2000 s. The surface interaction rate was ~0.115 $mg/cm^{-2}•s^{-1}$. The deposits were white and slightly greenish, typical of solid beryllium chloride. Approximately 3% of the total amount of tritium contained in irradiated beryllium reacted with chlorine was retained in the tritium chloride storage device.

The spectrum of gamma radiation of the initial Be (left) and $BeCl_2$ (right)





Results of determining the specific activity of beryllium samples



CONCLUSION

- The measurement results confirmed the fact of a chemical transport reaction, during which purified beryllium chloride is separated from irradiated beryllium, cobalt chloride is deposited on an appropriate filter, and tritium chloride is partially dissolved in the tritium chloride storage ring.
- One of the key technological parameters that determine the productivity of the installation was calculated - the rate of surface interaction of beryllium and chlorine 0.115 $mg/cm^{-2}•s^{-1}$.

ACKNOWLEDGEMENTS / REFERENCES

1. Tatenuma K., et. al. Beryllium Recycle Technology. June 2007.
2. Kolbasov B. N, et. al. The use of beryllium in fusion reactors: resources, impurities, detritisation after irradiation.
3. Minerals Information: Beryllium Statistics and Information: Mineral Commodity Summaries. http://minerals/usgs/gov/minerals/pubs/commodity/beryllium/mcs-2013-beryl.pdf.
4. Baklanova Yu.Yu., Kotov V.M; innovats. pat.: (19) KZ (13) A4 (11) 30017.