DETERMINING THE CONTENT OF ^{10}B IN BORIC ACID BY MEANS OF THE THERMAL NEUTRON ABSORPTION TECHNIQUE

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Boron and its compounds are extensively used in nuclear industry as strong thermal neutron absorbers. In particular, boric acid (H_3BO_3) is added to the primary circuit coolant of pressurized water reactors (PWR) to control the chain reaction. Owing to the application of the neutron-absorbing coolant, the irregularities in the power density distribution and fuel consumption within the reactor core can be avoided, with the result that performance of nuclear power plant can be improved. Natural boron is a mixture of ^{10}B and ^{11}B isotopes with abundances of about 20 % and 80 %, respectively. Thermal neutron absorption cross sections of ^{10}B and ^{11}B are 3839 b and 0.0055 b, respectively. Therefore, the actual factor affecting the reactor performance is the concentration of ^{10}B isotope in the coolant. A continuous monitoring of that concentration is of great importance. Uncontrolled increase or reduction of ^{10}B content would lead to an operational upset. It is known that the isotopic composition of natural boron varies significantly depending on the origin of the raw material. Furthermore, ^{10}B added to the reactor coolant is steadily burnt out during the reactor operation. For those reasons chemical methods are not adequate for determining the content of ^{10}B of in the reactor coolant. This resulted in motivation for the development of measurement systems sensitive specifically to ^{10}B isotope. Techniques based on the thermal neutron absorption appeared to be especially suitable for this purpose. Different versions of such devices designed for continuous on-line or off-line monitoring the concentration of ^{10}B in the reactor coolant have been developed and perfected since the beginning of the PWR technology. All instruments of this type require calibration. For the sake of metrological traceability of the measurement system, any calibration procedure should finally refer to a certified boric acid isotopic reference material. However, because of high cost, the isotopic reference materials are seldom, if ever, used directly for preparation of calibration solutions. Usually some secondary standard of boric acid is used for this purpose.

The aim of this work was to improve with the aid of MCNP modelling the thermal neutron absorption technique developed earlier and to apply it to determining the content of ^{10}B in boric acid. A good deal of attention was given to optimizing the measurement set up and procedure in order to reduce an uncertainty of assays. With the use of 1370-ml sample, ^{252}Cf neutron source emitting about 2 x 10^7 neutrons/s and assuming 60-minute total counting time, the relative standard deviation of 0.12 % can be attained for determining the mass fraction of ^{10}B in water solution of boric acid in the range 160-750 ppm.

Through the measurement of the mass fraction of ^{10}B in an intentionally prepared water solution of boric acid (C) the mass fraction of ^{10}B in this boric acid (C_{BA}) can be easily determined. Namely, $C_{BA} = C/C_A$, where C_A is the mass fraction of boric acid in its water solution. If boric acid is of stoichiometric purity, the isotopic composition of boron can be derived from C_{BA} .

Owing to good precision and reliability the presented technique is suitable for preparing secondary standards for ^{10}B assays and could be helpful in nuclear plants with pressurized water reactors.