Method for Verification of the Hydrogen and Boron Content of the RCSB for Storage of HEU at the HEUMF

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INTRODUCTION

BoroBond™[1], which is a ceramic material containing natural boron carbide (B_4C, a neutron absorber) and water (a neutron attenuator), is the filler material of the Rackable Can Storage Boxes (RCSBs) that will store highly enriched uranium in cans at the Highly Enriched Uranium Materials Facility (HEUMF). Both attenuation and absorption are essential for criticality safety of the fissile material stored in RCSBs. This BoroBond™ material has not yet been used for storage of highly enriched uranium (HEU). To characterize the neutron attenuation and neutron absorption properties of this material, ORNL has performed an extensive series of measurements which included: fast neutron and gamma time-of-flight transmission measurements utilizing the Nuclear Materials Identification System (NMIS), thermal and epithermal neutron counting with ^{3}He proportional counters, and activation analysis with gamma spectrometry using a high purity germanium (HPGe) detector. These measurements were performed for a series of 12x12-in square blocks of thickness varying from 2 to 12 inches, with natural B_4C contents of approximately 0, 2.3, 4.6, and 9 wt %, and varying water contents achieved by baking the blocks to remove approximately 5/6 of the water. These measurements were also performed with a special mockup of the RCSB of BoroBond™ material with ~4.6% natural B_4C. All three methods used Cf-252 sources and each of the measurement methods are described in detail in other papers at this conference [1,2,3].

This paper does not describe these measurements in any detail, but suggests a method of verifying and quantifying the B_4C and hydrogen content of the RCSBs at the factory, upon receipt at Y-12, and at any time later while in use at the HEUMF. The data from these measurements can be used to assess the uniformity of the BoroBond™ in the RCSB, be stored for future comparisons and be used to benchmark calculational methods.

[1] BoroBond™ is a product of Eagle-Picher Technologies, LLC.

DESCRIPTION OF WORK

Unfortunately, no single method investigated could quantify both the hydrogen and B_4C contents independently. The fast neutron time-of-flight transmission method is sensitive to the water content and not to the B_4C content. Thus, fast neutron transmission can be used to determine the water content. Thermal and epithermal neutron counting with ^{3}He proportional counters and gamma spectrometry are both sensitive to both the water and B_4C content. Gamma spectrometry directly measures the gamma rays produced when a neutron is absorbed by boron. Without water present to slow the neutrons, the boron capture rate is greatly reduced. Since ^{3}He proportional counters mainly detect thermal neutrons, these measurements are also sensitive to water and B_4C content. The thermal and epithermal neutron counting measurement detect neutrons that have not been captured by boron. What this means for both gamma ray spectrometry and thermal neutron counting is that there are different combinations of water and B_4C content that yield the same measured result. However, if the water content is known from the fast neutron time-of-flight transmission measurements, the B_4C content can be obtained by the other methods.

Verification Method

The fast neutron time-of-flight transmission method can quantify the water content of the RCSBs. Knowing the water content, the B_4C content will be obtained from the gamma ray spectrometry method, which is preferred over thermal neutron counting because it measures the gamma rays produced in boron capture. The fast neutron time-of-flight transmission and gamma ray spectrometry methods could be implemented as follows. The data could also be used to assess the uniformity of the BoroBond in the RCSB and archived for future comparisons.

The fast neutron time-of-flight transmission, would use two ^{252}Cf sources in ionization chambers inserted in two specially provided 6-

inch deep holes, each equidistant from four fissile storage can locations in the RCSB. Each fissile storage can location would contain one of six fast plastic scintillation detectors connected by cables to the associated electronics. The symmetry of the source-detector arrangement allows easy assessment of the uniformity of the BoroBond™ material in the RCSB. Although these exploratory studies used a HPGe gamma detector, it is recommended that a lower resolution NaI (cheaper and room temperature) gamma ray detector be used for the at-the-factory measurements. The source-shield-detector arrangement for gamma spectrometry was adjacent to the sides of the RCSB. So as to not have to correct for the decay of the source, it is recommended to use an Am/Be source (433 year half-life) that could later be used at Y-12 if desirable. With the water content determined from the fast neutron transmission, gamma ray spectrometry can be used to quantify the B_4C content.

CONCLUSIONS

Extensive measurements at the Oak Ridge National Laboratory (ORNL) with BoroBond™ blocks of varying thickness, natural boron carbide (B_4C) content, and water content, and with a simplified mockup of the RCSB of fixed natural B_4C and water content, have led to a method of quantifying the water content of RCSBs by fast neutron time-of-flight transmission measurements and quantifying the B_4C content with gamma spectrometry assuming the water content is known. The time-of-flight transmission measurements results can be used to assess the uniformity of the BoroBond in the RCSB. The data from both measurements could be stored for future comparisons to initial measurements. These methods can be implemented at the RCSB production site, or subsequently at the Y-12 National Security Complex during the operating lifetime of the RCSBs at the HEUMF.

REFERENCES

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