REVISED ACTIVATION ESTIMATES FOR SILICON CARBIDE- H. L. Heinisch (Pacific Northwest National Laboratory[1]), E. T. Cheng (TSI Research) and F. M. Mann (Westinghouse Hanford Company)

OBJECTIVE

The objective of this work is to review the information on activation of silicon carbide with respect to use as a low activation material in fusion energy systems.

SUMMARY

Recent progress in nuclear data development for fusion energy systems includes a reevaluation of neutron activation cross sections for silicon and aluminum. Activation calculations using the newly compiled Fusion Evaluated Nuclear Data Library result in calculated levels of ^{26}Al in irradiated silicon that are about an order of magnitude lower than the earlier calculated values. Thus, according to the latest internationally accepted nuclear data, SiC is much more attractive as a low activation material, even in first wall applications.

PROGRESS AND STATUS

The International Atomic Energy Agency/ Nuclear Data Section has long promoted the international compilation and evaluation of nuclear data. Under IAEA/NDS, international nuclear data developers and users exchange information and reach consensus, not only on the reliability of the data, but also on the priorities in addressing deficiencies in the data base. Recently there has been significant progress toward the completion of a high quality, non-restricted nuclear data library, the Fusion Evaluated Nuclear Data Library (FENDL), specifically developed to support the design analysis of ITER and other fusion energy systems[1]. One of the consequences of the FENDL development is the inclusion in it of some neutron activation cross sections that are significantly smaller than the values used in earlier evaluations of activation of potential fusion materials[1].

The recently completed FENDL/A-2.0 activation library was made from existing international nuclear data files developed in the European Community, the Russian Federation, Japan, the Peoples Republic of China, and the United States. It was compiled using a comprehensive selection procedure adopted by an IAEA/NDS Selection Panel[2]. No additional evaluation work was performed on information in these files, and many cross sections, including the subject Al and Si cross sections, are theoretical estimates. Verification of these cross sections by experimental measurement is highly desirable and remains a top priority in nuclear data development.

Long term environmental limitations on SiC due to the production of ^{26}Al have been noted in evaluations of neutron activation of SiC in a fusion device first wall environment since at least 1988[3-6]. Production of ^{26}Al from Si proceeds by the two step reaction with neutrons: ^{28}Si(n,x)^{27}Al(n,2n)^{26}Al. Thus, two neutron activation cross sections govern its production. In FENDL/A-2.0 both cross sections are smaller than the cross sections used earlier, such as those in the REAC*3 activation code[7]. The ^{28}Si(n,x)^{27}Al cross section is smaller by an average factor of about 4.5 in the energy range 13.5 MeV<E<15 MeV, while the ^{27}Al(n,2n)^{26}Al cross section is smaller by about a factor of 2 in that range. (The threshold energies for the ^{28}Si and ^{27}Al reactions are E=10 MeV and E=12 MeV, respectively). Thus, the effect of using the

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FENDL/A-2.0 cross sections is that ^{26}Al production is predicted to be about an order of magnitude less than that predicted using REAC*3 cross sections.

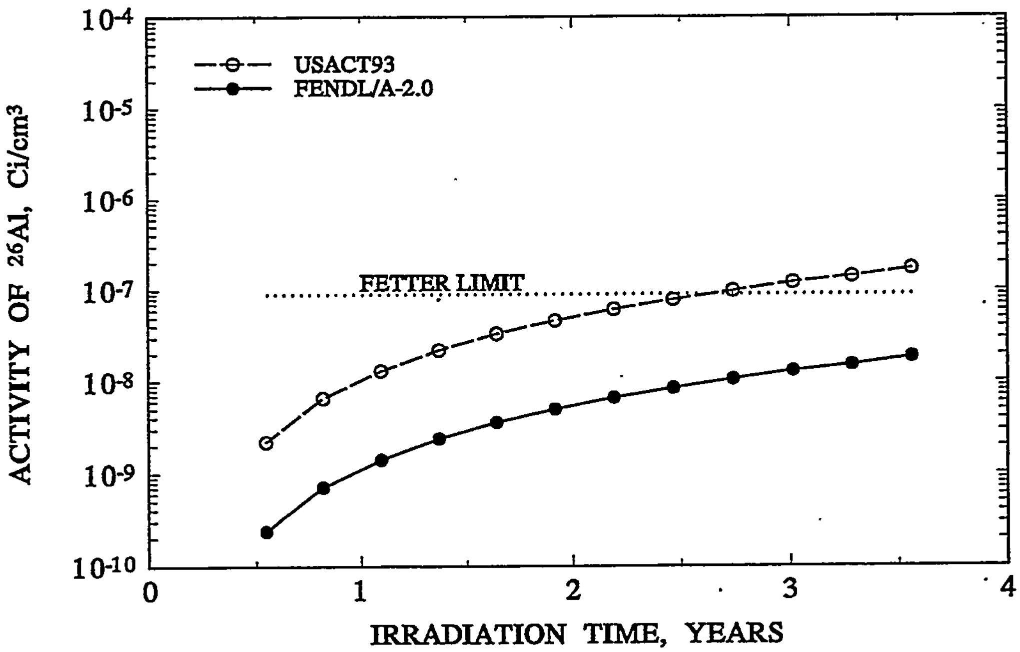

Figure 1. The buildup of ^{26}Al in SiC irradiated in STARFIRE for 3.5 years (12.5 MWY/m^2) in the first wall using the original REAC cross sections (USACT93) and FENDL/A-2.0. The limit for ^{26}Al activity calculated by Fetter et al.[3] is indicated.

The effects of this smaller level of ^{26}Al production on the potential use of SiC in fusion energy devices can be seen by estimating the changes that would occur if the new cross sections were used in activation calculations such as those in Ref.[6]. Figure 1 shows the activity of ^{26}Al for SiC irradiated in the first wall of STARFIRE to a loading of 12.5 MWY/m^2 as calculated with REAC*2 (an earlier version of REAC*3)in [6]. Also plotted is the same curve scaled by the ratio of the FENDL/A-2.0 cross sections to those used in REAC*2. The activity calculated using FENDL/A-2.0 cross sections is estimated to be about an order of magnitude less than the REAC*2 values, which means the Fetter limit on ^{26}Al[3], based on 10 CFR 61 methodology, will be reached in about 7 years, or at a wall loading of about 25 MWY/m^2 in STARFIRE. Butterworth[4] compared the activity of SiC irradiated in the DEMO first wall as a function of decay time to the "hands on limit" of 25 μSv, finding it to be about 40 times higher than the limit. Using FENDL/A-2.0 cross sections in Butterworth's calculations would bring the activity to within a factor of 4 of the hands on limit, which makes SiC significantly more attractive. Both of these comparisons have been done in neutron spectra that are not representative of a fusion energy device designed to be constructed of ceramic materials, where the actual values of ^{26}Al production may be somewhat different. Thus, comparisons to absolute limits will depend on the neutron spectrum considered. However, the relative changes in ^{26}Al production due to the smaller cross sections will be the same in any neutron spectrum.

FUTURE WORK

Activation calculations will be performed for SiC in ARIES, a conceptual fusion energy device specifically designed for ceramic structural materials, using the FENDL/A-2.0 cross sections. Experimental measurements of neutron activation cross sections for Si are being pursued.

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