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An Overview of Burnup Credit Application in Spent Nuclear Fuel Management

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ABSTRACT

The current status of burnup credit application has been overviewed for spent nuclear fuel management.

It was revealed that the use of burnup credit is practically limited to spent nuclear fuel storage, for which selected actinides-only are taken into account.

1. Introduction

It is well known that, after nuclear fuel is burned up in reactor, its reactivity is subsequently reduced. The concept of taking advantage of this reduction, which is referred to as burnup credit, is partly adopted in spent nuclear fuel (hereinafter this terminology is denoted as "spent fuel or SF.") management.

Essentially, burnup credit uses the actual physical composition of spent fuel and accounts for the net reduction of fissile material and the buildup of neutron absorber in it as nuclear fuel is burned up. Although burnup credit has so far been used in the storage, transportation and reprocessing of spent fuel, the use prevails mainly in the storage of it. Limited physical and nuclear data for actinides as well as fission products(FPs) in spent fuel have made it impossible to find a generic application of burnup credit.

A lot of effort has thus been paid to determining reliably isotopic composition in spent fuel and related nuclear constants. This has been a challenging issue in the nuclear criticality safety community which will eventually be solved.

In order to provide an informative guide, the current status of burnup credit application has been overviewed in this paper.

2. Current Status of Burnup Credit Application

The practical application of burnup credit for which actinides-only, selectively uranium and plutonium are mainly taken into account is slightly different from country to country. Japan[1] and the U.K.[2] have very cautiously adopted it in the PWR spent fuel storage pool of their reprocessing plant. Prior to adopting the concept, it is prerequisitely necessary to furnish the sophisticated burnup measuring system that makes it reluctant to be accepted by the utilities.

Recently Conde et al.[3] and Ro[4] described activities on the use of burnup credit as a part of spent fuel management in their review papers. Korean utilities have taken burnup credit in PWR spent fuel storage on the basis of the average burnup reported by reactor operators. In France, where burnup credit has been approved for the transportation and reprocessing of spent fuel, burnup measurements are required for verification. Germany will likely adopt a burnup credit strategy similar to that of the US. Spain has approved burnup credit in the wet storage of PWR and BWR spent fuel. Sweden has approved the use of burnup credit in the wet storage of BWR spent fuel. Switzerland has approved burnup credit in the wet storage of BWR spent fuel and allowed burnup credit in French-approved dry PWR spent fuel transportation under international agreements. Eastern European countries have interest in storage and transportation applications for burnup credit. Russia is also interested in reprocessing applications. The USNRC has allowed burnup credit in PWR spent fuel storage on the basis of reactor operation records of the fuel assembly's average burnup, and no post-exposure confirmation measurement of burnup is needed.[5,6] Examples of burnup credit applications are summarized in Table 1. An and An + FP described in the 2^{nd} and 3^{rd} columns of Table 1 mean that actinides-only and actinides as well as fission products are taken into consideration, respectively, while An given in parenthesis of the 4^{th} and 5^{th} columns mean that actinide-only is considered.

Table 1. Example of Burnup Credit Applications

Country	PWR SF Storage		BWR SF Storage		Transportation (An)		Reprocessing (An)	
	An	An+FP	An	An+FP	PWR	BWR	PWR	BWR
Korea	O*							
Japan	O						O	
U.S.A.	O*							
France	O				O	O	O	
Spain	O		O					
Sweden			O					
Switzerland			O			O		

* No need of burnup measuring system.

At the moment, a lack of reliable data in the isotopic compositions and nuclear constants does not make it allowable to apply burnup credit for fission products as well as minor actinides. A lot of effort has been paid to developing a methodology for applying burnup credit for both fission products and actinides, and to demonstrating to the utilities and licensing authorities that adequate safety margins exist. Shin et al.[7] have indicated that there are large differences in the minimum burnup requirements between non-corrected and corrected isotopic compositions in spent fuel. Subsequently, it may suggest that there are discrepancies in nuclear constants or isotopic compositions, or both. Needless to say, this has been a challenging issue in the nuclear criticality safety community, which is expected to be solved in the long-run.

3. Verification of Isotopic and Criticality Evaluation Methods

As a part of improving physical and nuclear data on isotopes in spent fuel, intensive experimental and calculational studies have been performed by several investigators. Recently Suyama et al.[8] pointed out discrepancies between calculated and measured values still remained for some fission products such as Sm, ^{125}Sb and ^{154}Eu. They emphasized that elaborated and tedious work is necessary for verifying minor actinides as well as fission products.

Since the beginning of the nuclear industry, a number of experiments together with computer analyses on criticality safety have been carried out. Accordingly a plenty of data have accumulated to date. However, it is known that there are some data without a high degree of quality assurance and discrepancies between data. In order to compile qualified data, the CSBEP(Criticality Safety Benchmark Evaluation Project) was initiated in October 1992 by the USDOE. The INEEL(Idaho National Engineering and Environmental Laboratory) was assigned to manage the project. An international criticality safety data exchange component was added to the project in 1994 and the project became the ICSBEP(International Criticality Safety Benchmark Evaluation Project). In December of 1994, the ICSBEP became an official activity of the OECD/NEA's Nuclear Science Committee. The work performed by the ICSBEP was already published with the "International Handbook of Evaluated Criticality Safety Benchmark Experiment." It is known that the 1998-version of the Handbook will contain 229 evaluations with benchmark specifications for nearly 1,700 critical or near critical configurations.

On the other hand, the OECD/NEA has sponsored criticality benchmark groups for more than a decade. In 1991 the group decided to do burnup credit criticality verifications. The major objective of the burnup credit group is to demonstrate that the available criticality safety calculational tools are appropriate for application to spent fuel and that a reasonable safety margin can be set up. The benchmarks have been carried out to compare the results among participants using a wide variety of calculational tools and nuclear data libraries. The agreement among participants without fission products is significantly better than spent fuel with fission product cases. The results suggested that the largest component of uncertainty originated from the fission products. This led to re-consideration of the early introduction of burnup credit by taking fission products into account.

4. Conclusions

Summing up the above, conclusions are drawn up as follows;

- Burnup credit application prevails in PWR(or BWR partly) spent fuel storage by taking account of actinides-only(mostly U and Pu) with the exception of minor actinides and fission products. In this case, A simple and reliable measuring system for the utilities or a well-qualified computer code system is needed for confirming burnup, and

- If reliable data for both actinides and fission products in terms of isotopic compositions as well as their nuclear constants become available, a generic application of burnup credit based on the actual physical compositions of spent fuel will come into reality.

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