BURNUP CREDIT ACTIVITIES IN THE UNITED STATES

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Abstract

This report covers progress in burnup credit activities that have occurred in the United States of America (USA) since the International Atomic Energy Agency's (IAEA's) Advisory Group Meeting (AGM) on Burnup Credit was convened in October 1997. The Proceeding of the AGM were issued in April 1998 (IAEA-TECDOC-1013, April 1998). The three applications of the use of burnup credit that are discussed in this report are spent fuel storage, spent fuel transportation, and spent fuel disposal.

1. INTRODUCTION

Light water reactor (LWR) systems which are used by the commercial nuclear power industry in the USA use fuels with low concentrations of fissile uranium (less than 5.5% initial concentration of U-235 by weight). The LWR systems used in the USA are boiling water reactor (BWR) and pressurized water reactor (PWR) systems. The fission process consumes the fissile U-235 and produces new isotopes, which include various actinides and fission products. The actinides produced include fissile materials (e.g., Pu-239 and Pu-241) and neutron absorbers (e.g., Pu-240 and Pu-242). Hundreds of fission products are also produced; however, only a small number of them are significant neutron absorbers. Consideration of the reduced reactivity from the changes in isotopes for the purpose of determining reactivity of spent fuel is known as burnup credit.

The USA does not reprocess its spent nuclear fuel, and the fuel from about 100 reactors is stored at the reactor sites in pools or in dry storage units. New reactors are not expected to be built in the USA, and a geological repository is planned for the ultimate disposal of the spent fuel from these reactors. The USA expects to receive about 85,000 tU of commercial spent nuclear fuel after the end-of-life for all current reactors. After a start-up period, the fuel will be accepted into the U.S. Department of Energy's (DOE's) Civilian Radioactive Waste Management System (CRWMS) at a rate of about 3,000 tU per year. Spent fuel and high-level radioactive waste will be accepted from 78 facilities, which include 73 commercial sites and five DOE sites. Some of the reactors share common sites. The proposed disposal site at Yucca Mountain is located in southern Nevada (NV). It is being characterized and studied to determine its suitability as a repository. If suitable and licensed by the U.S. Nuclear Regulatory Commission (NRC), acceptance of spent fuel and high-level nuclear waste will begin in 2010. The period for receiving the total 70,000 tU capacity of the repository is estimated to be 30 years.

Only spent fuel that has been discharged from a reactor and cooled five years or more will be accepted into the CRWMS. This older fuel has undergone significant and rapid decay of its gamma and heat emitting radioactive contents, and the neutron absorbers have begun to stabilize. The reactivity potential of the spent fuel continually decreases for a few hundred years after discharge from the reactor. Then slight, but continued, increases in reactivity occur, peaking at between 10,000 and 30,000 years, the cycle repeats, peaking again at about 300,000 years and decreasing thereafter. However, these peaks in reactivity do not exceed the value at five years after discharge.

In the USA, the use of burnup credit for spent fuel management has been pursued by the private sector and by the Federal government. The private utility companies and their member sponsored research and development organization, the Electric Power Research Institute (EPRI), have pursued burnup credit for various storage applications.

Burnup credit development activities conducted by the Federal government in the USA have been performed primarily by DOE. DOE began these efforts in the mid-1980's to support its CRWMS activities, which include storage, transportation, and disposal of spent nuclear fuel from light water reactors. In the mid-1990s, DOE submitted an initial version of a topical report to the NRC for the use of actinide-only burnup credit for transport of PWR fuel. Thus began a series of formal exchanges that led to NRC issuing guidance documents on actinide only transportation burnup credit in 1999.

The private sector has generally been interested in burnup credit, and has been successful in its efforts to gain approval for burnup credit in wet (pool) storage applications. The industry has been actively involved in the transportation and storage aspects of burnup credit conducted by the DOE. EPRI has been a focal point for industry involvement in burnup credit. EPRI has worked with DOE on burnup credit, and has conducted a number of activities that have been beneficial to the transportation burnup credit efforts.

In 1998, DOE relinquished its role in transportation burnup credit, passing the torch to the private sector. Since then, EPRI has increased its involvement, and cask vendors, instrumentation and transport service organizations, and utilities have become involved in burnup credit activities. In addition, the Nuclear Energy Institute (NEI) has initiated interactions with NRC to assist in defining industry needs in the area of burnup credit for transportation and dry storage of spent fuel. NEI is an organization that is supported by the nuclear industry. NEI represents the nuclear industry in dealing with the federal government on broad issues that face the entire industry.

The DOE also plans to use burnup credit for disposal of spent nuclear fuel. The waste package (WP) which is being designed for disposal of spent nuclear fuel in a deep geological repository is expected to provide criticality control during some time period after disposal. The regulatory period for the repository will be 10,000 or more years. Over this time, degradation of conventional criticality control features cannot be completely precluded. Consideration of the actual reactivity of spent nuclear fuel over the time of disposal is therefore needed. The consideration of the actual reactivity of commercial spent nuclear fuel (burnup credit) is part of the risk-informed, performance based methodology being used to analyze disposal systems.

2. PROJECTED SPENT FUEL INVENTORY

Current projections for spent fuel discharges from commercial nuclear power plants in the USA are based on an assumption that there will be no new reactors built. This assumption leads to an estimate of about 85,000 tU of spent fuel when all current reactors are retired. The mixture of PWR and BWR reactors for the USA is 67% and 33%, respectively. This estimate of spent fuel discharge exceeds the 70,000 tU capacity of the repository site being studied. The repository limit includes about 63,000 tU of commercial spent fuel and 7,000 tU of other radioactive waste. The fate of this excess commercial spent fuel (~22,000 tU) is still to be decided.

An important factor in making decisions regarding the use of burnup credit for storage, transport, and disposal of spent fuel is the number and types of spent fuel assemblies that must be dealt with. For either type of spent fuel (BWR or PWR), two important properties needed for such decisions are their burnup and initial U-235 enrichment values. The projected inventories of 124,761 PWR and 166,942 BWR spent fuel assemblies for the USA are arranged by burnup and initial U-235 enrichment in Tables I and II [1]. Although there is twice the projected discharge mass of PWR spent fuel, the smaller mass of BWR assemblies results in their larger number.

The data in Tables I and II are projections that could be affected by several factors. The projected cumulative spent fuel discharge of about 85,000 tU, for the case of no new reactors in the USA, is expected to be realized in 2042. The accumulation of discharged spent fuel in 1996 was about 40 tU, and about 48 tU in 2000. Factors that could increase the inventory of discharged spent fuel include renewing existing reactor licenses to extend reactor operating lives an additional 20 years, and construction of new reactors. The former is happening now, the latter is not considered likely. Factors that could decrease the inventory of discharged spent fuel include early shut-down of reactors (before their 40 year licenses expire), and increasing operating cycles by using fuel with higher initial enrichment and burning the fuel longer. Both situations are expected. Some reactors have been shut-down prematurely, and fuels are being designed to accommodate longer operating cycles.

3. SPENT FUEL STORAGE

The NRC issued guidance on criticality analysis of spent fuel storage in August 1998 [2]. Anyone interested in the NRC guidance is advised to refer to the report directly.

The guidance is intended to help NRC licensees conduct criticality safety analyses of fuel storage pools for unirradiated and irradiated light water reactor fuel. The guidance is limited to applications for pool storage reviewed by the NRC's Reactor Systems Branch. That is, the guidance does not apply to other areas that the NRC regulates, such as transportation, dry fuel storage, or disposal. The guidance is intended to clarify current NRC practice regarding review of licensee safety analyses for pool storage. The guidance also gives NRC staff positions on storage approaches being proposed. The guidance addresses criticality analysis methods for pool storage of LWR fuel, including BWR fuel and PWR fuel. The document provides general guidance on criticality analysis, and specific guidance for treating abnormal conditions and the double contingency principle, new fuel storage, spent fuel storage, and additional considerations that the NRC staff felt needed clarification.

Table I. PWR Spent Fuel Inventory.

Burnup GWd/t	Initial U-235 Enrichment (%)									
	0-1.0	1.0-1.5	1.5-2.0	2.0-2.5	2.5-3.0	3.0-3.5	3.5-4.0	4.0-4.5	4.5-5.0	5.0-5.5
70-75							1		18	35
65-70							2	65	1080	195
60-65							5	873	4704	533
55-60					1	2	57	3512	6026	361
50-55					1	9	933	8547	5444	183
45-50					48	274	5066	11440	2460	25
40-45		1	1	1	110	2433	10367	7484	476	
35-40	4			48	544	8569	8135	1470	12	
30-35			1	33	3329	7584	1550	873	8	
25-30			36	1027	3708	2410	453	117	36	
20-25		12	190	1758	880	508	59	162	28	
15-20	4	32	1821	3896	137	184	20	111	4	
10-15			1393	302	47	113	11	74		
5-10		25	9	3	35	92	76	14		
0-5	8		3		1		1	28		

Table II. BWR Spent Fuel Inventory.

Burnup GWd/t	Initial U-235 Enrichment (%)							
	0-1.0	1.0-1.5	1.5-2.0	2.0-2.5	2.5-3.0	3.0-3.5	3.5-4.0	4.0-4.5
70-75								
65-70							10	240
60-65							104	900
55-60						20	1122	2354
50-55						270	5373	3734
45-50						2907	11548	2277
40-45					155	10948	10573	542
35-40			111	24	1019	22216	3199	
30-35			3	242	11220	13748	33	
25-30		28		3251	17094	2227	26	
20-25		27	176	7594	6792	217	49	
15-20	52	53	3000	5636	917	10	229	
10-15	140	435	6997	1875	547	203	173	
5-10	572	588	286	461	307		54	
0-5	1116	2	181	666	58	1	7	

The NRC guidance provides useful information for those wishing to use burnup credit to store spent fuel in pools. The NRC guidance provides several specific considerations when "credit for the reactivity depletion due to burnup" is used. An additional consideration, which applies to cases of burnup credit or storage of fuel with different enrichments, is the possibility of misloading. The guidance further states that assuming a single loading error is usually sufficient, and "under the double contingency principle, credit for soluble boron, if present, is acceptable for these postulated accident conditions. The guidance addressing partial credit for boron gives two conditions that must be satisfied: 1) for full density unborated water it must be shown that keff < 1.0, and 2) for water borated to a licensee specified concentration, it must be shown that keff is no greater than 0.95. Although the guidance does not preclude burnup credit for BWR spent fuel, only utilities with PWR pools have used burnup credit.

The use of burnup credit for wet storage of spent fuel is generally a final step in maximizing pool capacities. Utilities have used various methods of reracking pools prior to pursuing burnup credit. Furthermore, burnup credit for wet storage has only been used for PWR systems in the USA. About two-thirds of the reactors in the USA are PWR systems and about half of those reactors use burnup credit in their spent fuel storage pools. The goal of reracking and using burnup credit is to assure sufficient spent fuel storage capability without having to expand or build new fuel storage pools. Another storage approach being pursued for spent fuel is the use of dry storage systems. The method avoids the need to find space in existing pools or build new pools. However, the fuel must be sufficiently cool to be stored dry, requiring initial storage in a pool.

4. SPENT FUEL TRANSPORT

4.1 Introduction

To support development of advanced technology spent fuel transportation casks DOE began to pursue the use of burnup credit in the mid-1980's. The approach that DOE planned to follow in its pursuit of burnup credit was first presented to the NRC at a DOE sponsored workshop held in February 1988. The workshop was first of many meetings, and a great deal of correspondence between NRC and DOE on the subject of burnup credit. In 1988, the DOE strategy was to seek NRC approval of "full" burnup credit that would cover the range of initial enrichments and burnup values of all spent fuel in the anticipated inventory. Although the full burnup credit approach was not actually intended to take credit for all possible negative reactivity changes that could be attributed to burnup, it would take credit for an amount considered practical. That is, it would account for all fissile actinides, most neutron absorbing actinides, and a small number of fission products that accounted for about 80% of the available credit for all fission products.

Based on its interactions with NRC, which began in 1988, DOE submitted its first proposed burnup credit methodology to NRC in May 1995 [3]. The Topical Report was an actinide only approach, that is, it did not seek credit for fission products. Although DOE ceased work on advanced technology casks by 1996, the transportation burnup credit activities continued, and the NRC review and comment of the 1995 report led to a revised version of the report submitted in May 1997 [4]. This version of the report provided additional support for the proposed methodology for actinide only burnup credit for spent fuel up to 5% initial enrichment and 50 GWd/t burnup. The proposal was not accepted by NRC.

Following feedback from NRC, DOE decided to develop a final version of the actinide only approach. During development of the second revision of the actinide only burnup credit topical report, DOE concluded that achieving NRC acceptance of the use of burnup credit for transport of spent fuel would be more effectively pursued if requests were made a part of specific cask certification applications. Therefore, submittal of the revised report marked the conclusion of these activities by DOE and the start of efforts to transfer the technology to the private sector.

The final version of the DOE topical report was submitted to NRC in October 1998 [5]. DOE proposed an approach that limited initial enrichment and burnup to 4% and 40 GWd/t, respectively. At the completion of their review, NRC issued interim guidance on transportation burnup credit (ISG-8) on 17 May 1999, and a revision to the guidance in August 1999 [6, 7]. The initial guidance endorsed the use of a limited version of DOE's final proposal for actinide only burnup credit for transport of spent fuel. The revised guidance was more generic. It rescinded the apparent endorsement of DOE's proposed approach, but permitted more flexibility to prospective applicants for approval of burnup credit for spent fuel transport.

NRC offered its initial guidance on 17 May 1999, at a public meeting between NRC and NEI. Participants at the 17 May 1999 meeting were informed by NRC's Spent Fuel Project Office (SFPO) that the guidance represented a first step in a process, intended to expand the credit for burnup. SFPO is the NRC organization responsible for licensing of spent fuel transport and storage systems. SFPO will be supported by NRC's Office of Research (RES) in their efforts to expand the credit given for burnup. The NRC described a two phased research activity to be conducted by RES to expand credit beyond initial guidance issued by SFPO in ISG-8. The phases the NRC's research effort are described as follows:

1. In the first phase, RES will evaluate available information. This effort is expected to result in a modest increase in Actinide-Only burnup credit within six months. The NRC surpassed their promise by issuing revised guidance (ISG-8, Rev 1) in August 1999.
2. A second phase effort, expected to take two to three years, will define data and experimental needs required to further expand the credit given for burnup as a result of the first phase activities. This expansion is expected to include some credit for fission products. The first part of this second phase is well underway. NRC issued a first report on priorities of burnup credit issues in February 2000 [8].

At the May meeting, NRC advised that their ability to fund burnup credit research efforts was limited. Therefore, research and data acquisition needs identified to support any expansion of the burnup credit would be industry's responsibility.

The NRC guidance is in the form of a recommendation to those wishing to use burnup credit for transportation of spent fuel in an NRC approved cask. The guidance indicates that NRC has suggested a basic methodology. The applicant must adapt the basic methodology to the specific cask being proposed for burnup credit, acquire the data required, and provide all analyses to show that regulatory criticality criteria are satisfied.

4.2 Benefits of Using Burnup Credit

The motivation for pursuing burnup credit for transport of spent fuel in the USA has been the opportunity to reduce the number of projected shipments needed to move spent fuel from the reactors located across the country to a repository. For PWR casks, burnup credit has been used to eliminate the need for flux traps, which results in closer packing of spent fuel and significantly increased capacities. These increased capacities result in fewer shipments. The consequences of fewer shipments include reduced exposure to public and workers, and lower costs of shipping. The cost benefit, which has been addressed for the CRWMS is considerable [9]. As an example, if all transport to a repository is done using truck casks, the estimated cost of $US 3 billion without burnup credit can be reduced to $US 1.5 billion, a saving of $US 1.5 billion. For the truck transport case, burnup credit was assumed to can increase cask capacities from two to four PWR assemblies. For rail, capacities are typically 24 PWR assemblies without burnup credit, and 32 with burnup credit. The corresponding costs for rail transport were estimated to be $US 535 million and $US 401 million, a savings of $US 134 million. Rail transport costs are lower than truck transport costs with or without burnup credit, and savings are less dramatic.

4.3 Truck Casks

In the USA, one can categorize general highway freight systems into two groups. These are called legal weight truck (LWT) shipments and over-weight truck (OWT) shipments. The weight limit for an LWT system, which includes tractor, trailer, and cargo, is 80,000 pounds (36,280 kg or 36.3 t). The significance of this designation is the fact that shipments meeting this weight limit can travel without restriction on interstate highways. Systems exceeding the LWT limit, are designated as OWT shipments. The OWT shipments must meet specific vehicle and weight distribution requirements, and be permitted by each state they transit.

Although OWT restrictions are not onerous, many truck cask systems in the USA are designed to meet LWT limits. Generally, this means that the cask is limited to about 22,680 kg (50,000 pounds), the remainder allocated to the weight of the tractor and trailer. The LWT weight restriction has resulted in numerous truck casks with capacity limits of one PWR or two BWR assemblies. In 1988, DOE contracted with several cask vendors to develop advanced technology casks to support its CRWMS efforts. One of the casks developed under this program was the GA-4, which could carry up to four PWR assemblies. This achievement was accomplished by optimizing the design and using innovative technical approaches. One of those approaches was to use burnup credit. Although it is not the only factor, it is significant.

In addition to the GA-4, DOE contracted for the development of the GA-9 LWT cask with a capacity of nine BWR assemblies. Like the GA-4 cask, the high capacity of the GA-9 was achieved by optimizing the design and using innovative technical approaches. However, burnup credit was not one of the innovations needed for this BWR cask.

4.4 Dual-Purpose Rail Systems

The use of rail casks for spent fuel transport for disposal in the USA is generally preferred over truck transport. This preference is strongly influenced by the number of shipments required and the travel distances expected. The capacities of rail casks are at least a factor of five greater than truck cask capacities. The average distance from reactors in the USA to the proposed site at Yucca Mountain is about 4,000 km (2500 miles). Furthermore, the rail system in the USA, and the locations of the reactor sites and proposed repository are compatible with rail transport. It should be noted that the general advantages and preference for rail transport does not exclude the need for LWT casks in the system. There are several reactors in the USA with facility or near-site constraints that make truck transport the option of choice.

The recent emergence of dual-purpose rail cask systems in the USA is another factor that affects the choice of transport mode. While awaiting the start of operation of the federal repository, many utilities have started to use dry storage at their reactor sites to supplement pool storage. Initially, single purpose storage systems were used, but recently utilities have been opting for canister based systems that can be used to store spent fuel now and be transported off-site later with a minimum amount of fuel handling. Burnup credit has been identified as a means of increasing capacities of these systems.

PWR storage only systems achieved capacities that were comparable to those attainable from using burnup credit by an administrative control approach. Basically, a PWR storage cask was loaded in a pool, which contained some minimum concentration of boron. In addition to the normal internal cask moderator control, the loaded cask was then required to be located in an area absent of water. The approach is not compatible with dual-purpose systems. For these systems, approval for transport burnup credit is a necessity to achieve the desired capacities.

Several dual-purpose cask vendors anticipate seeking NRC approval for cask system designs that use burnup credit. The typical design is a modification of a non-burnup credit configuration of a cask. For these upgraded systems, capacities are expected to increase from 24 PWR assemblies without burnup credit to 32 with burnup credit. Although burnup credit for BWR systems has not been broached yet, at least one cask vendor is considering the option.

4.5 Private Sector Activities

The DOE technology transfer initiative, which began upon submittal to the NRC of the second revision of the Actinide Only Topical Report, appears to be moving forward successfully. The letter from DOE that transmitted Revision 2 of the Actinide Only Topical Report stated that DOE would no longer continue its transportation burnup credit efforts [8]. The letter recognized that progress in transportation burnup credit would be most effective if applied to specific cask design applications. For that reason, the technology would be transferred to the private sector. At least three cask vendors who are likely candidates for seeking burnup credit are expected to do so prior to 2001.

General Atomics (GA) is the developer of the GA-4 truck cask. GA has not expressed any immediate intentions of seeking burnup credit for their cask. However, it is included because it was specifically designed with burnup credit in mind, and it is the only current LWT cask design that is a candidate for burnup credit. The GA-4 cask was approved by the NRC on 27 October 1998. The approval allows shipment of four PWR assemblies with initial enrichment of up to 3.2% U-235 without burnup credit. To achieve the 3.2% initial U-235 enrichment, GA uses enriched boron in the fuel support structure (basket). Although the allowable initial U-235 enrichment is about 3% with natural boron, the small increase in initial enrichment allows a significant increase in fuel that could be shipped at full capacity (see Table I). The demand for LWT cask systems is expected once a repository begins operations. GA will likely see an emerging market for the GA-4 cask, and seek burnup credit.

GNB, a German based company with operations in the USA, is developing the CASTOR X/32 S. The cask is a dual-purpose system similar to the traditional CASTOR designs, except that the containment structure is made of forged carbon steel instead of the ductile iron castings that have come to characterize the CASTOR casks. It is designed to hold 32 PWR assemblies in a single dual-purpose unit that is used for storage and transport. This is not a canister-based system, which makes fuel configuration changes more difficult. For canister-based systems, the same cask body can be used with separate canister designs with and without burnup credit. This makes it relatively easy to convert a design once burnup credit is approved. GNB seems to have overcome this obstacle by using an innovative licensing approach. The cask is designed for 32 PWR assemblies with or without burnup credit. When burnup credit is not used poison rods (e.g., new control rods) will be inserted into the fuel assemblies for criticality control. When burnup credit is approved, the poisons rods will not be needed. GNB is expected to submit an application for a CASTOR X/32 S with burnup credit to NRC in August 2000.

Holtec International currently has an NRC Certificate of Compliance for their Hi-Storm dual-purpose system. The current design has a 24 assembly PWR canister. Holtec International has had discussions with NRC about a modification to the design, which uses burnup credit to allow the use of a 32 PWR assembly canister. They are expected to submit an application for this burnup credit version of the Hi-Storm to NRC in September 2000.

NAC International currently has an NRC Certificate of Compliance for their NAC-UMS dual-purpose system. That system is approved for 24 PWR assemblies or 56 BWR assemblies. NAC, who has recently decided to seek burnup credit for the NAC-UMS system, met with NRC in June 2000 to discuss their plans. They expect to submit an application for the PWR configuration at the end of the year 2000. The burnup credit design will increase the PWR capacity to 32 assemblies. Interestingly, NAC is also looking at burnup credit for their BWR design. They anticipate increasing its capacity to 69 BWR assemblies by using burnup credit. However, they have given no firm date for their BWR design change.

Although there are other vendors developing dual-purpose systems in the USA, they seem to be continuing with non-burnup credit designs. There are several reasons for such a decision, which are noted here. Although NRC has issued guidance for burnup credit, the certainty and difficulty of getting an approval for its use is not yet known. Companies that focus their business on BWR plants find no compelling reason to seek burnup credit. The current restriction in the NRC burnup credit guidance related to burnable poison rods is discouraging. Finally, the industry trend toward the use of higher enrichments and burnup levels may introduce a thermal constraint on cask capacities that will make burnup credit less attractive.

5. SPENT FUEL DISPOSAL

DOE has the responsibility of managing the geologic disposal of high-level radioactive waste (HLW) and spent nuclear fuel (SNF) in the USA. This work includes consideration of criticality. Pursuant to this, the DOE has developed a risk-informed performance based disposal criticality analysis methodology [11]. The methodology provides a systematic approach for evaluating a combined system of a waste form, waste package, engineered barrier, and repository for limiting the potential for criticality through the entire postclosure period of the repository. The methodology includes the building of hypothetical scenarios that lead to intact, partical degraded, and degraded configurations, defining parameters for each configuration, evaluating criticality potential for the range and specific values of parameters, and the process for estimating the probability of critical configurations and their consequences. The methodology also includes the process for combining probability and consequence estimates with total system performance assessment (TSPA) radionuclide transport modeling to obtain an estimate of criticality risk, which is measured by the expected increment in dose rate at the accessible environment due to all potential criticalities. The portion of the methodology concerned with evaluating criticality potential includes consideration of burnup credit for commercial SNF. This criticality analysis methodology includes consideration of burnup credit for commercial SNF.

The NRC does not have specific regulations or guidance for burnup credit applications for disposal. Recently, NRC has issued a proposed rule for the federal repository. It will be included in the Code of Federal Regulations (CFR) Title 10, Part 63 [12]. The proposed regulation for disposal does not include any specific design criteria for post-closure criticality control. The proposed regulation considers criticality as one of the processes or events that must be considered for the overall system performance. The NRC has issued a *Safety Evaluation Report for the Disposal Criticality Analysis Methodology* [13], which addresses burnup credit issues for disposal in general.

The use of burnup credit in disposal applications has an additional importance compared to transportation and short-term storage applications. Over the long time period considered for disposal, conventional criticality control features such as moderator exclusion barriers, poison (neutron absorbing) plates, and geometry features (e.g., flux traps) will degrade and change. The reduced reactivity associated with irradiated fuel is the only feature that may last. It is of key importance to large capacity waste packages that must provide criticality control for 10,000 or more years.

The disposal burnup credit methodology takes credit for the reduced reactivity associated with the build-up of the primary principal actinides and fission products in irradiated fuel. The disposal burnup credit is referred to as Principal Isotope (PI) Burnup Credit. DOE plans to use PI burnup credit for the criticality evaluations of waste packages loaded with irradiated BWR and PWR fuels from commercial reactors.

6. SUMMARY AND CONCLUSIONS

Burnup credit is being used in the USA for spent fuel storage in pools. The approach, approved by NRC for about half the PWR systems, has been used to avoid the need to expand existing pools or build new ones where additional storage is needed. The use of dry storage systems at reactors is a recent development that also offers a way of avoiding the high costs and licensing difficulties anticipated if pool expansion or new construction is needed.

Burnup credit has been pursued for transport of spent fuel as means of reducing the numbers of shipments required to move a given fuel inventory. The benefits of fewer shipments include those of health and safety, and cost. For the inventory of spent fuel expected to be discharged by all reactors in the USA, which is about 85,000 tU, savings potentials for all truck and all rail transport, using burnup credit, have been estimated to be as much as $US 1.5 billion and $US 134 million, respectively. The advent of dual-purpose casks that can both store and transport fuel has introduced an interesting dilemma in the USA. Single-purpose storage systems have been permitted for burnup credit-like configurations without the need for burnup credit. However, for dual-purpose, storage-transport systems, the option is lost for storage unless burnup credit is approved for transport. Recent developments in the USA suggest that NRC is preparing the necessary technical basis to approve burnup credit for spent fuel transport, and that a number of cask vendors are about to submit applications for such approvals.

The principal isotope burnup credit methodology being used for disposal in the USA takes credit for the reduced reactivity associated with the build-up of the primary principal actinides and fission products in irradiated fuel. Burnup credit is needed in disposal applications because the intrinsic reduced reactivity of irradiated fuel may provide the only criticality control over long time periods, when conventional features fail. Burnup credit will be used for BWR and PWR fuels from commercial reactors.

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