Multipurpose Transportation, Aging, and Disposal Canisters for Used Nuclear Fuel – Getting From Here to There and Beyond - 8252

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ABSTRACT

The idea of a universal canister system, in which used fuel can be placed at reactor sites, transported and – without ever needing to be re-opened –, disposed of in a geologic repository, is certainly not new. Originally proposed by DOE in the early 1990s as the Multi-Purpose Canister (MPC) system, this common sense idea has always had considerable appeal as a means to reduce used fuel handling and simplify repository surface facility operations. However, difficulties in launching the development of such a system, in the face of large uncertainties in repository design and limited program funding, caused the original MPC project to be abandoned in 1997. Then, after eight years of inactivity in this area, DOE, while experiencing difficulty completing the repository surface facility design and having missed a December 2004 deadline for submittal of a repository license application to the Nuclear Regulatory Commission (NRC), re-proposed the concept. Under this renewed initiative, the MPC systems were renamed as Transportation, Aging, and Disposal or TAD canister systems. DOE's repository design had advanced significantly at this point and industry, having gained considerable experience through the design, licensing, manufacture, and loading of over 800 used fuel dry storage systems, was well positioned to provide DOE with the meaningful technical input that would be necessary to bring the TAD concept to reality.

With a firm foundation on which to build, industry actively engaged DOE in an extensive series of interactions to facilitate TAD development. This paper describes the evolution of the TAD concept through the industry/DOE dialogue that occurred over an 18 month period beginning in January 2006. It discusses the technical issues that were addressed and resolved through this collaboration. Successful completion of this dialogue led to the issuance, by DOE, of a final TAD design specification in July, 2007. This specification is being used by DOE as a fundamental input to the Yucca Mountain license application that DOE expects to submit to the NRC no later than June 2008. DOE is now in the process completing a procurement of TAD demonstrations. As part of these demonstrations, DOE expects industry vendors to seek and obtain storage and transportation licenses for the TADs by 2010 and for utilities to deploy them at reactor sites by 2012.

INTRODUCTION

This paper discusses industry perspectives on the U.S. Department of Energy's (DOE) transportation, aging, and disposal (TAD) used nuclear fuel canister program. It discusses challenges and opportunities that lie ahead for the TAD canister program. In doing so, regulatory and communication issues that must be addressed in order for TAD systems to be licensed under three different parts of NRC's regulations (10 CFR Part 63 – disposal, 10 CFR Part 71- transportation, and 10 CFR Part 72 – storage) are explored. Also described are commercial and contractual hurdles that must be overcome to facilitate the significant reshaping of the US used fuel canister marketplace that will be necessary for widespread TAD deployment. And perhaps most importantly, the value of the TAD as a tool to integrate the overall US used fuel management system is discussed. In this last regard, the TAD has already fostered an unprecedented level of standardization and harmonization between disparate elements of the existing system – bringing reactor operators, vendors, and repository developers together on a wide range of technical issues. As the program continues, this is a benefit that is likely to continue to pay dividends, not just for the advancement of the Yucca Mountain project, but even for the progressive development of future standardized systems that might be deployed in the context of interim storage and/or advanced fuel cycle facility development.

DISCUSSION

Early Attempts at Multipurpose Canister Development

The idea of a universal canister system, in which used fuel can be placed at reactor sites, transported and – without ever needing to be re-opened – disposed of in a geologic repository, is certainly not new. By 1983, with the passage of the Nuclear Waste Policy Act (NWPA), the United States was firmly on a course to select, characterize, and develop a geologic repository site. In the mid-1980s the Tennessee Valley Authority became the first proponent of using a "Universal Cask" to facilitate an efficient implementation of the geologic disposal program [1].

Although much discussed, the Universal Cask proposal received little real support until the early 1990s when representatives of first Virginia Power and then the Electric Power Research Institute (EPRI) began publicly advocating for and evaluating the technical, economic and operational aspects of what was then called the "Universal Container System" [1]. This led to a 1993 proposal to DOE, which was not acted upon, and the creation of an industry task force that became quite active in interacting with DOE. DOE responded to the broad industry support with a 1992 feasibility study, a 1993 conceptual design report, and a 1994 design specification and request for proposals for "Multi-purpose Canister System" or MPC design work [2].

In April of 1995, a single award for MPC Phase I design was issued to Westinghouse. There were continued interactions between DOE and the industry task force throughout 1995 and into 1996, and overall industry reaction to the design work completed by Westinghouse was positive [1]. However, at this point the MPC project began to lose momentum. In spite of the overall positive reaction to the Westinghouse design, the fact that DOE awarded only a single design contract instead of the multiple contracts originally promised narrowed support from across an industry that was expecting a competitive marketplace from which to select MPCs. Also bureaucratic impediments stalled efforts to both move beyond the Phase I design and address the contractual issues between DOE and the reactor owners that would need to be resolved for MPCs to be deployed at reactor sites. Finally, considerable uncertainties in both the final repository design and overall Yucca Mountain funding made any MPC decision-making tenuous at best. Faced with the cumulative weight of all of these obstacles, the MPC program had been essentially abandoned by 1997. It had also become apparent at that point that DOE would not meet the January 31, 1998 date for opening the repository that was mandated by the NWPA.

Reconsideration of the Canister Concept

Even without the MPC program, the Yucca Mountain repository project, although behind the originally mandated schedule, continued to make progress. In 2002 the suitability of the Yucca Mountain site to host a geologic repository for used fuel and other high-level radioactive waste (HLW) was approved by the President, and a large majority in both Houses of Congress. President Bush's signature on the Yucca Mountain Development Act on July 23, 2002 signaled the beginning of the Yucca Mountain licensing process and shortly thereafter DOE began publicly describing its plans to submit a license application to the Nuclear Regulatory Commission (NRC) by the end of 2004. If NRC licenses could subsequently be obtained on the schedule mandated by the NWPA, DOE planned on opening the repository in 2010. Unfortunately, 2004 was not a very good year for the Yucca Mountain project. A series of events during the year caused DOE to miss its promised 2004 license application submittal date. These included:

- A court decision vacating a portion of EPA's Yucca Mountain Radiation Protection Standard,
- A decision – in response to a State of Nevada challenge – by NRC's Pre-application Presiding Officer hearing board that DOE's certification of public availability of documents on the Yucca Mountain licensing support network did not comply with NRC requirements,
- Allegations that U.S. Geologic Survey geologists working on the Yucca Mountain project failed to follow quality assurance procedures.

In the wake of the setbacks incurred during 2004, DOE announced that the Yucca Mountain project would be indefinitely delayed and began refocusing its efforts. One aspect of the project that was undergoing intensive re-examination at this time was the concept of repository surface facilities that were being designed to handle every single used fuel assembly ever produced by the US commercial nuclear industry. DOE had, as the basis for its 2004 licensing effort, developed a design concept that would involve handling all of this fuel dry – essentially creating a giant hot cell on a scale never before attempted. Needless to say, the design of this massive facility was highly complex and licensing, building, and operating it would be extremely challenging. The option of building the extensive pool capacity that would be necessary to move from dry to wet handling was not viewed by DOE as being any easier. Hence, DOE began exploring options to eliminate the need to handle all of the used fuel at the Yucca site – which, of necessity, would mean reviving the MPC concept.

In October of 2005, DOE had completed its re-examination of repository surface facility design and announced a decision to "devise a plan to operate the Yucca Mountain repository as a primarily 'clean' or non-contaminated facility" to " improve the safety, operation, and long-term performance of Yucca Mountain" [3]. In an October 25 letter of Direction to the project's Managing and Operating Contractor, Bechtel SAIC, DOE explained what was meant by this new path [4]. DOE was "revising the current program approach to include the use of Transport, Aging, and Disposal (TAD) canisters for the acceptance of used fuel from the utlitities" [4] The TAD was intended to be designed to be loaded at reactor facilities, stored (if necessary) at reactor facilities until DOE could pick up the fuel, aged at the repository (also if necessary) until the used fuel was cool enough for disposal, and ultimately disposed of inside the Alloy 22 waste packages already designed for emplacement underground. In essence, the universal or multi-purpose canister (MPC) was reborn.

DOE/Industry Collaboration on TAD Development

When DOE first announced the TAD initiative, the reaction of the US commercial nuclear industry was mixed. The introduction of the TAD concept represented a major upheaval to what had, after the 1997 demise of the MPC, become a well established and thriving marketplace for dual purpose – storage and transportation – casks. By October of 2005, industry had already loaded 746 of these dual purpose containers (DPCs) and was projected to continue loading these systems at a rate of 50 to 90 casks per year for the next decade [5]. Also, DOE's decision to make such a significant change in direction only added to industry concerns about the magnitude of the delay in opening the Yucca Mountain repository that had already intensified when the 2004 license application filing due date was missed. Since DOE failed to meet the legally and contractually mandated January 31, 1998 used fuel acceptance deadline, DOE had been promising to open Yucca Mountain in 2010. Now it was becoming apparent that not only would the 2010 opening date not be achieved, but with a major repository redesign underway beginning in late 2005, that the new date would be, in fact, several years later.

Nevertheless, industry support for the Yucca Mountain project remained strong, and there was widespread willingness on the part of industry to assist DOE in its efforts to improve the repository program in ways that would enhance its chances of success. Accordingly, two industry leadership organizations – the Nuclear Energy Institute (NEI) and the US Transportation Council (USTC) – decided to take a pragmatic approach. On November 16, 2005, at NEI's Washington DC offices, NEI and USTC jointly convened an ad hoc task force comprised of representatives of the owners and operators of the majority of the US commercial nuclear reactor fleet and all of the major US DPC vendors to hear DOE explain its plans for the TAD program.

Out of this first meeting, a number of issues were identified. First among these was the size of the TAD canisters. In order to support DOE's planned Yucca Mountain licensing basis and fit within the already designed alloy 22 waste disposal package, TAD capacity would need to be limited to 21 Pressurized Water Reactor (PWR) or 44 Boiling Water Reactor (BWR) used fuel assemblies. This was significantly lower that the capacity of existing DPCs on the market and would result in a need for more casks and, of course higher costs. Also, a wide range of heat load management, requirements for aging at the Yucca Mountain site, potential material restrictions, storability on reactor sites, hardware compatibility, operational interfaces, criticality control, and regulatory topics were identified as requiring further discussion. These discussions began in earnest at the second meeting between DOE and industry held on January 31, 2006 – the 8th anniversary of DOE's default on its mandated waste acceptance deadline. At this meeting, and four subsequent meetings over the next year and a half, DOE and the members of the joint NEI/USTC task force explored these topics in great detail. At two of these meetings, the 2006 and 2007 NEI Dry Storage Forums, NRC staff joined the dialogue. As a result a number of changes were made to what DOE originally proposed – although the size limitation remained – and the interactions culminated with the issuance, by DOE, of a final TAD performance specification in June of 2007, [6]. Table I below summarizes the technical issues addressed during this collaboration and how they were resolved.

Table I – DOE/Industry TAD Dialogue Summary

Topic	**Discussion Summary**
Materials to be allowed & prohibited	DOE and industry considered a wide range of material needs from the multiple perspectives of repository, storage, transportation, and reactor pool requirements. This resulted in a mutually workable list of required, prohibited, and restricted materials in the final TAD performance specification.
Use of carbon steel	DOE's pre-TAD disposal package design included carbon steel in the package internals because of the beneficial role of this material in retarding long-term radioactive releases in the repository environment. Industry communicated that use of bare carbon steel in pools was unacceptable. Industry has also provided information on coatings as a potential mitigating option, however this was not widely viewed as workable. DOE is reassessed its need for carbon steel for repository performance and it was not called for in the final specification.
Shielding requirements	Industry encouraged DOE to "solve local problems locally" and minimize requirements for built-in shielding that would complicate TAD design in favor of putting in place practices and equipment that could be deployed at the Yucca Mountain site to keep radiation exposures As Low As Reasonably Achievable. DOE accommodated most of the industry recommendations in the final specification.
Criticality and reactivity control requirements	DOE's original proposal to require Ni-Gd in the TAD internals generated concern regarding the licenseability of these materials under 10 CFR Parts 71 and 72 for transportation and storage at reactor sites. This concern centered on the absence of benchmarks and fabrication experience. Industry devoted considerable effort toward understanding DOE's position in this area, however, in the end there simply was not sufficient information available to support the use of Ni-Gd and the requirement for these materials was dropped from the final specification.
TAD Physical Dimensions	DOE originally proposed specifying a TAD length requirement with very tight tolerances so that the TAD would fit snuggly in the Alloy 22 disposal package to prevent movement during a seismic event. However, several reactor owners commented that shorter versions of the TAD would be necessary to be compatible with their building dimensions and infrastructure capabilities. DOE responded to this feedback by changing the specification to accommodate a range of lengths and also specifying a TAD waste package spacer (TWPS) to be inserted in the disposal package with the TAD to prevent movement during a seismic event.
Thermal requirements	DOE from the very beginning indicated that thermal management of TADs to meet restrictive disposal requirements would be accomplished through aging at the repository site. The dialogue on thermal restrictions ensured that all TAD thermal requirements were consistent with those already imposed on DPCs under 10 CFR Parts 71 and 72

Topic	Discussion Summary
Canister handling	Industry provided canister handling principles to DOE and encouraged DOE to “solve local problems locally” – meaning minimizing the extent to which facility design limitations would encumber the TAD design. DOE was highly responsive to the industry input. Industry also supported DOE’s safety analysis by providing additional information on crane reliability.
Aging pad seismic requirements	DOE chose, at the time of final specification, to add requirements that the aging over-pack be capable of withstanding an extremely severe seismic event without tip-over that goes well beyond anything that was previously discussed with industry. While problematic, vendors have indicated that this requirement can be met.
Overpacks and transfer casks	DOE, with industry input, arrived at a reasonable approach to overall system design.
Package closure and seal integrity	DOE, with industry input, arrived at a reasonable approach to overall system design.
Regulatory interfaces (between different Parts of NRC regulations)	There was extensive discussion on this issue and outreach to NRC. As a result a process for parallel licensing of TADs under Parts 71 and 72, and Part 63 was developed and agreed to.
Transportation issues	DOE, with industry input, developed a specification for a TAD canister that is completely compatible with existing transportation systems.

Today’s TAD

In the two years since the concept was first proposed, the TAD development program has made remarkable progress. Following the conclusion of the DOE-industry dialogue in early 2007, a number of significant milestones were completed in quick succession (See Table II below). Completion of these milestones essentially required that whatever technical barriers to TAD implementation existed be overcome (Table III lists some of the more important technical parameters of the TAD). The next step in the TAD process will be for DOE to award contracts to vendors to complete demonstration projects to license and deploy TADs at reactor sites. As of the date this paper was completed, DOE was still working on the process of completing this procurement. Both NEI and USTC have indicated to DOE that it is important that DOE support multiple vendor demonstrations to assure that the competitive marketplace that currently exists for DPCs is maintained for TADs.

Table II – Significant TAD milestones

Date	Accomplishment
November, 2005	DOE presents TAD concept to industry
January, 2006	DOE industry technical dialogue on TADs begins
April, 2006	DOE qualifies four vendors to submit proposals for TAD designs
November, 2006	DOE publishes Draft TAD Performance Specification
February, 2007	Vendors complete TAD proof-of-concept designs
June, 2007	DOE publishes final TAD Performance Specification
July, 2007	DOE issues procurement for TAD demonstrations (Vendors are asked to submit proposals for obtaining an NRC license for a TAD and working along with a reactor owner to deploy that TAD at one or more reactor sites)
Augsut, 2007	All four vendors submit proposals for TAD demonstrations

Table III – Important TAD Technical Parameters [6]

Parameter	**TAD Value**
Physical Dimensions	Right circular cylinder with a diameter of 66.5 inches (168.9 cm) and a length of between 212.0 and 186.0 inches (472.4 to 538.5 cm)
Weight	Less than 54.25 tons (49.2 metric tons) combined weight of the TAD canister and TWPS
Capacity	21 PWR or 44 BWR fuel assemblies
Used Fuel Capability	5% initial enrichment 5 year cooled fuel with burnup up to 80 gigawatt-days/metric ton (PWR) or 75 gigawatt-days/metric ton (BWR)
Orientation	Capable of being transported and disposed of in a horizontal configuration and handled and aged at Yucca Mountain in a vertical configuration
Service Life	50 years
Structural	Capable of meeting leak tightness requirements when subjected to seismic and environmental conditions as specified
Criticality Control	Stainless steel neutron absorber plates as specified. For PWR assemblies, ability to accommodate a disposal control rod assembly
Containment	Closure weld, fabrication to codes and standards, fill gas, and leak tightness requirements as specified
Operations	Handling capabilities and lifting features as specified
Materials	Structural baskets made of Type 300 series stainless steel; canister and basket materials compatible with either borated or un-borated pool water; organics, hydrocarbon-based materials, and pyrophoric and Resource Conservation and Recovery Act (RCRA) regulated waste materials are prohibited
Transportation Overpack	Maximum length 230 inches (584 cm) or 333 inches (846 cm) with impact limiters; maximum cask diameter 98 inches (249 cm); maximum cask lid diameter 84 inches (213 cm); maximum weight of fully loaded over-pack without impact limiters 250,000 lbs (112,500 kg) or 360,000 lbs (162,000 kg) with impact limiters and transportation skid
Aging Overpack	Maximum over-pack diameter 144 inches (366 cm); maximum over-pack lid diameter 84 inches (213 cm); Maximum length 264 inches (671 cm); Maximum loaded weight 250 tons (227 metric tons)

The resolution of technical issues achieved in the development of the TAD specification does not mean that the path from this point to the loading of the first TAD will be easy. The remaining challenges can be grouped into two categories, regulatory and economic. The regulatory challenges are largely a matter of ensuring effective communication and coordination while the economic challenges are readily resolvable provided DOE and reactor owners can come to an equitable agreement concerning how, when, and by whom the increased cost of TADs is paid for. Each of these challenges is discussed in the following sections of this paper.

Regulatory Challenges

From a regulatory standpoint, the TAD initially presented both DOE and the industry with what can best be described as a chicken-and-egg situation. Which should come first, the licensing of Yucca Mountain repository under 10 CFR Part 63 or the licensing of TADs for transportation and storage under 10 CFR Parts 71 and 72? The only practical answer is that both licensing processes must proceed simultaneously and progress in parallel. A process where one licensing activity would have to wait for the outcome of the other would add years to the already significantly delayed repository program at best and, more likely, would encounter difficulty even moving forward as all as information from whichever licensing action that was on hold would not be available in a timely manner to support the progress of the licensing action that was attempting to advance – eventually causing both to stall.

In order to facilitate successful parallel licensing, the role of the TAD performance specification would be crucial. The specification had to be sufficiently detailed to support the level of pre-closure safety analysis that DOE would need to successfully prepare a high quality and docketable repository license application. It would also have to provide for sufficient flexibility to allow vendors to prepare applications for Part 71 and 72 licenses that could stand on their own merits. Both DOE and industry worked diligently in the interactions that led to the now final performance specification to ensure that both objectives were preserved. And today, on both sides there is widespread agreement that the current specification has hit the mark in this regard.

NRC also recognized early on that DOE's planning would be "based on the assumption that a TAD canister will be certified for storage and transportation prior to the completion of the NRC staff's review of the performance assessment under 10 CFR Part 63" [7]. NRC also cautioned DOE at this time that "early identification and resolution of cross-cutting issues is key to reducing possible regulatory risk to the applicant." [7] NRC's comments on the draft TAD specification [8], which addressed both the disposal as well as storage and transportation perspectives represented an important step in bringing such cross cutting issues to the forefront and provided both DOE and industry vendors important feedback for use in the preparation of their respective license applications.

Intensive communications on cross-cutting issues, of course, not only needs to feed the development of the respective license applications, but needs to continue throughout the repository and TAD development processes. For the two separate licensing processes to continue to proceed effectively in parallel, issues that could place them on divergent paths must be actively sought out and identified to prevent any possibility of a change being introduced in one process that could invalidate a fundamental assumption that is already being acted upon in the other. Figure 1 below represents a schematic of how the two processes are expected to proceed and highlights the copious opportunities that exist for the iterative flow of information between them.

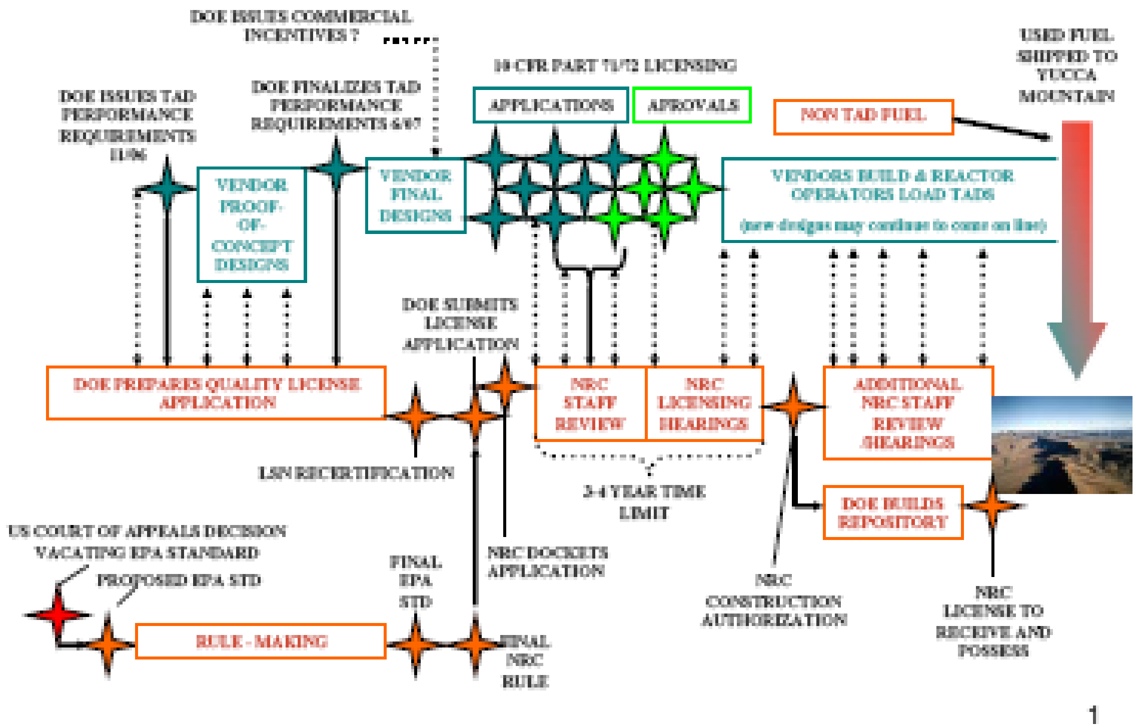

Fig. 1. Integration of the TAD program into Yucca Mountain Licensing

Economic Challenges

There is no question that TADs will be more expensive than existing DPC based systems. This is largely due to the lower capacity of the TADs (21 PWR or 44 BWR assemblies as compared to the 32 PWR and 60 to 68 BWR assembly capacities of today's DPCs [9]). The question that now confronts both reactor owners and DOE is, who pays the additional costs? If Yucca Mountain were operating and already accepting used nuclear fuel, there would be no question, DOE would simply purchase a TAD and ship it to reactor sites. The reactor owners would then load it and DOE would ship it to Yucca Mountain. Under this scenario, none of the additional cost of TADs would be born by the reactor owners. However, DOE's current schedule indicates that the earliest Yucca Mountain could be opened would be 2017 and DOE has publicly conceded that it is more likely to be 2020 or later until the repository is able to receive used fuel. Of course it is also unlikely that all of the used fuel will be shipped to Yucca Mountain at once. DOE has established an acceptance priority ranking schedule based on when a given reactor owner began discharging used fuel that dictates the order in which DOE will arrive at that owners sites to accept used fuel. This means, for some utilities whose first allotment does not come until further back in the queue, it could be several additional years until DOE would be ready to remove any used fuel. Yet, as mentioned earlier, many reactor operators are already loading dry storage systems (DPCs) and many more will be before DOE is ready to begin receiving their used fuel. Yet, DOE plans for TADs to be deployed as early as 2012 [10]. This means that for at least the first decade of TAD deployment, reactor owners will need to store TADs on their sites until DOE is ready to pick them up.

The question of who pays the costs of dry storage at reactor sites is a subject of much controversy, contract negotiation, and litigation between DOE and the reactor owners. Currently reactor owners are bearing these costs (and passing them on to electricity ratepayers in addition to the payments made in to the federal Nuclear Waste Fund (NWF) to provide for DOE used fuel acceptance). A number of reactor owners have been successful in recovering at least a portion of their dry storage costs through contract settlements or court awards resulting from litigation. However, reactor owners are always striving to minimize their on site storage costs. This desire to minimize costs is what has led to ever higher capacity DPC system designs over the years. Therefore, absent assurances that the additional costs of lower capacity TADs will be somehow compensated for by DOE, reactor owners may be reluctant to purchase them for the reactor site storage that will inevitably be necessary. DOE has promised to provide economic incentives to address the reactor owners cost concerns but, as of the date of this paper, DOE has yet to produce these incentives. Consequently the procurement of TAD demonstrations is currently on hold as DOE's procurement is structured such that it can only award a TAD demonstration contract to a vendor that has a commercial customer for the TAD being procured [10].

DOE's ability to provide satisfactory economic incentives to induce reactor operators to purchase TADs in lieu of higher capacity DPCs is the lynchpin upon which the future of the TAD program rests. In theory, it should be a simple and straightforward process for DOE to do this. However, DOE's world is apparently not so simple. DOE of Justice, which seeks to minimize federal liability for the government's failure to begin removing used fuel from reactor sites beginning in 1998, has a significant say in what DOE can and can not agree to pay for. Also, there are restrictions on what DOE can use the revenue provided by the NWF to pay for. This paper will not attempt to dissect the bureaucratic labyrinth that DOE officials must navigate in order to make good on their promise to incentivize the TAD marketplace. Suffice it to say that industry eagerly awaits the completion of this task

One potential incentive that DOE has publicly mentioned, is the possibility that DOE would agree to accept existing DPCs in exchange for commitments from the reactor owners to begin using TADs in the future. This would represent a significant reversal of DOE's longstanding legal position that DOE is not required by contract to accept DPCs – even though they have been specifically designed with transportation to Yucca Mountain in mind. The issue of DPC acceptance at Yucca Mountain is a very important economic consideration for the repository program. If DOE were to require utilities to unload their existing DPCs and reload used fuel into a container, such as a TAD, significant unnecessary costs and worker radiation exposure would be incurred.

DOE has already recognized that it will inevitably be accepting some fuel in DPCs in its licensing and environmental impact assessment efforts, setting a goal of receiving 90% of commercial used nuclear fuel in TADs for its initial licensing basis yet also evaluating the possibility that only 75% of the fuel would arrive in TADs in its recent Supplemental Environmental Impact Statement (SEIS) [11]. There are currently 9,600 metric tons of used nuclear fuel in dry storage, most of it in DPCs (some is in older single purpose storage systems that may or may not be transportable) and industry estimates that by 2017, there will be 22,300 metric tons of used nuclear fuel in dry storage [12]. The current dry storage inventory represents 15% of the 63,000 metric tons of commercial used nuclear fuel that DOE has allotted as part of the 70,000 metric ton limit currently imposed on the nation's first geological repository by the NWPA but only 7% of the 130,000 metric tons of commercial used fuel disposal capability DOE has used in the SEIS [11]. By 2017, the equivalent non-TAD storage percentages will rise to 35% of the NWPA allotment and 17% of the SEIS evaluated capacity.

The numbers above indicate that DOE's objective of receiving between 75% and 90% of commercial used nuclear fuel in TADs and the reactor owners objective of shipping existing DPCs to Yucca Mountain are both mutually achievable, but only if TADs are deployed and commonly in use well before the projected 2017 earliest repository opening date. For this to happen, DOE needs to provide the anticipated incentives. At the time of the writing of this paper, this is clearly an urgent issue.

CONCLUSION – THE TAD AS AN EVOLUTIONARY INTEGRATION TOOL

The TAD program has reached an important juncture. It already represents one of the most significant and tangible accomplishments in the Yucca Mountain project since the site was deemed suitable in 2002. However how the TAD program becomes a tool for the management of used nuclear fuel in the future depends upon the process of meeting current regulatory and economic challenges. Continued intensive focus on addressing these challenges by DOE, NRC, and the US commercial nuclear industry will be required. However, the TAD program has already added significant value as a used fuel management system integration tools. The efforts conducted over the past two years to bring the TAD to this point have already fostered an unprecedented level of standardization and harmonization between disparate elements of the existing system – bringing reactor operators, vendors, and repository developers together on a wide range of technical issues.

The systems integration benefits of the TAD are likely to continue to pay dividends for the US commercial used fuel management program, regardless of what specific path this program takes. In this context, the existing TAD performance specification, and any specific designs that result from it, should be seen as not an end point but a beginning. While the first generation of TADs will be a key input to the initial licensing of the Yucca Mountain repository, it is important to note that the repository program is intended to evolve and that the TAD component of that program should evolve with it. The Yucca Mountain project is likely to take significant advantage of scientific advances and new information over the long period of time that will be required to develop, load, and eventually close the repository. It is for this reason that 10 CFR Part 63 is intended to allow for the repository license to be readily amended. Future repository license amendments can be used to further improve the TAD. Perhaps larger capacity TADs can be developed or, alternately, existing DPCs can be qualified for disposal essentially making them TADs.

The potential systems integration benefits of the TAD program also potentially go beyond the Yucca Mountain program. In coming years DOE may be considering the development of centralized interim storage and/or advanced fuel cycle facilities. The success of these endeavors will also require a significant amount of harmonization between different elements of the used fuel management system. Here the lessons learned from the past two years of TAD development should be most valuable in developing a single system capable of meeting the needs of at reactor and centralized storage facilities as well as recycling centers. Even if DOE were to be tasked with citing a second or alternate repository, the TAD – a system already qualified for storage, transportation, and disposal for one repository – would make a much better starting point for integrating another repository into the used fuel management system than going back to square one. Regardless of what direction the US commercial used fuel management program takes in the future, the gains that have already been achieved through the TAD program should not be lost.

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