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Operational Assessment of the Can in Can Concept

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S.M.Birk ______________________ 6.28.12 ______________

Sandra M. Birk
Manager, Nuclear Materials Disposition and Engineering

Date

DOE/NE Fuel Cycle Technologies Program
Office of Used Fuel Disposition Research and Development

Operational Assessment of the Can-In-Can Concept

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Objective

This paper considers the motivations for the proposed can-in-can packaging concept for used commercial nuclear fuel, assesses the operational challenges to implementation, and examines the implications and timing of a decision to employ the can-in-can concept.

Background

The can-in-can concept is to design cans for used commercial nuclear fuel that are small enough to enable flexible storage and transport configurations and robust enough to be suitable for direct disposal. Expanding on this idea, the intent is for a larger outer can to be designed to accept a number of these small cans and optimize the materials and configuration to meet storage and transportation requirements.[1] The concept of a standardized disposal can is not new. The U.S. Navy has a standard can to allow for uniform handling of its fuel. The INL also developed a standard can to accept the broad range of DOE fuel, and the approach offers some applicable insights.[2]

The envisioned benefits of the can-in-can concept are 1) standardized packaging that could comply with a wide range of storage, transportation, and disposal requirements while simplifying future facility requirements, 2) a versatile small can that minimizes the need for bare fuel handling, and 3) a single storage and transportation package design that accommodates a broad range of current and future fuels supported by demonstration confirming storage and transportation safety over extended storage periods. To take full advantage of these aforementioned benefits, the can-in-can concept has been proposed for implementation at the utilities. The can-in-can concept has been postulated as an alternative should direct disposal of used fuel prove untenable.

Generic Repository Requirements

In the absence of a selected repository site, generic repository options broadly define the repository environment. International efforts have identified several credible alternatives such as mined crystalline, mined clay/shale, mined bedded salt, and deep borehole. In combination with U.S. efforts to research and license a repository at Yucca Mountain, Nevada, these efforts provide the basis for likely disposal requirements. Reconsidering waste forms in the context of a range of potential disposal media helps define disposal requirements based on practical physical options and limitations independent from site selection. The small can is intended for use as or within the disposal waste package based upon heat transfer calculations forfuel loads that satisfy thermal constraints on container integrity for several identified geologic media.

Without decay times in excess of ~100 years or more, thermal considerations severely limit the packing density for used light water reactor fuel in many of the potential disposal environments. Thermal analysis indicates that a disposal package containing no more than 4 PWR assemblies per can or 9 BWR assemblies per can is compatible with most repository options of interest.[3] On this basis, the can has been tentatively sized to accommodate no more than 4 PWR or 9 BWR assemblies.[4] However, such repository packing density restrictions may become unnecessary with the extended interim storage. Storage terms of 100 years or more are being contemplated. Accordingly, acquisition of supporting data to extend existing dry storage licenses and efforts to provide for prolonged dry storage while accounting for trends in increasing fuel burnup are industry priorities.[5, 6]

The loading constraint is motivated by the need to limit thermal output per disposal package, but the choice has a secondary effect of a lower maximum temperature during the drying cycle compared to existing cask loads with a similar nominal burnup. (The smaller fuel load of the small can more readily satisfies the thermal constraints on drying under NRC-SFST-ISG-11.[7] However, the potential benefit in preventing hydride cracking of the cladding may be offset by residual moisture given reduced heat available to facilitate drying.) A risk associated with committing to the can-in-can concept is that the ‘generalized repository requirements may be overly restrictive if, for example, long storage periods times and/or a more heat tolerant repository. Or the generalized repository requirements could be not restrictive enough if deep borehole disposal requiring packages sized for individual assemblies. Future disposition paths could obviate reliance on the can altogether (e.g. reprocessing or other future disposal technologies).

<u>Pathways to Disposal</u>

In order for used fuel to be moved from an operating reactor to any disposal destination, several intervening operations are expected to occur: underwater handling and pool storage, drying and packaging for dry storage, on-site transfer, cask configuration or repackaging to meet off-site transportation requirements, and transfer to consolidated storage or disposition site. Figure 1 illustrates with a block diagram the general pathway to disposal both for existing fuel handling operations and for the can-in-can concept.

The existing operations have already been approved within the existing licensing envelope as defined by 10 CFR 71[8] and 10 CFR 72[9] and the NRC guidance documents NUREG-1536[10], NUREG-1567[11], and NUREG-1927[12]. Fuel movements have been analyzed. Shielding and worker locations have been considered. Facility space, handling capacity, and the available equipment are adequate to support the existing processes and configurations. Hazards have been identified and mitigated. Personnel have been trained. Infrastructure and protocols have been established to satisfy licensing requirements: changes are strictly controlled. Retrofit to accommodate the can-in-can concept would be financially expensive and would 1) take time, 2) require physical upgrades, and 3) require additional regulatory review for alterations to approved configurations and processes. And an additional effort to re-package the used fuel currently in dry storage would still be needed to achieve full standardization.

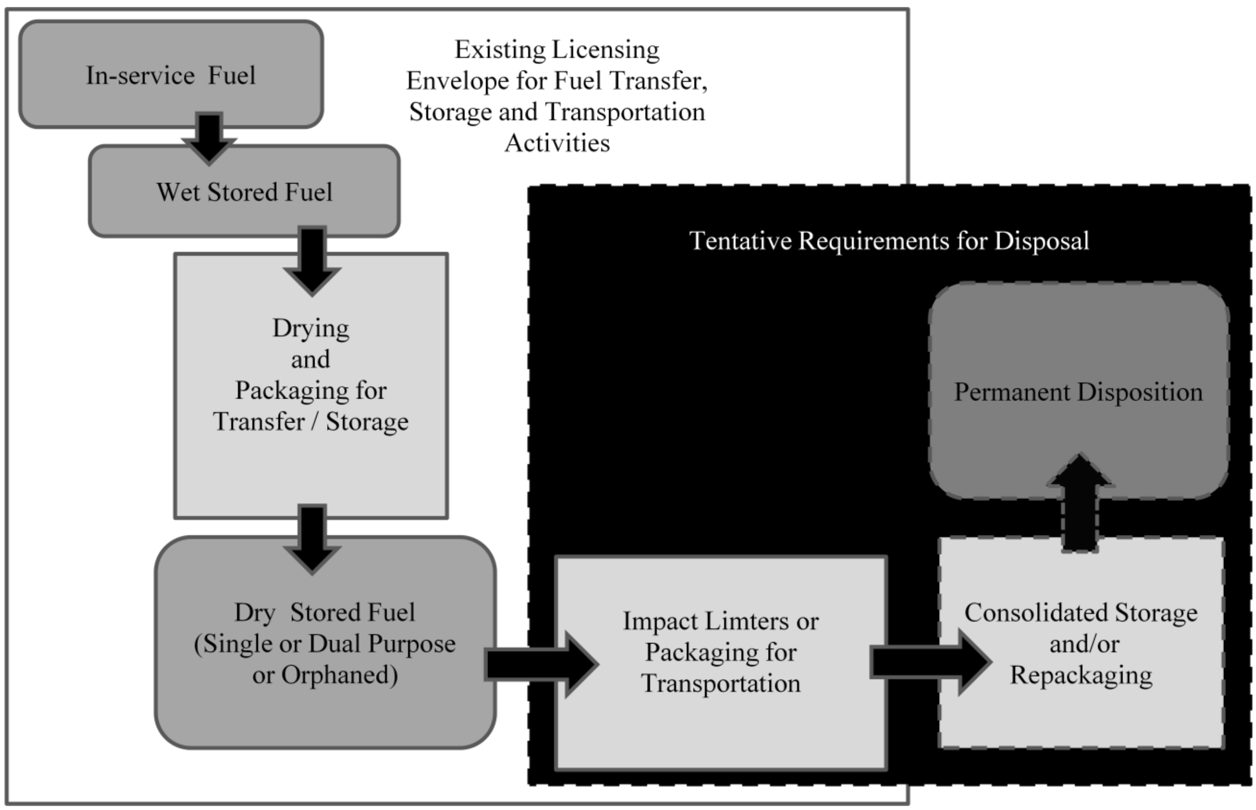

Figure 1. Generic Pathway to Disposal

Transportation of commercial fuel has long been accommodated by commercial cask vendors. Storage bunkers could be designed to accommodate the small cans, and the cask vendors can readily develop inserts to accommodate the small cans in their existing transportation casks. The size of the larger can appears to be inefficiently small for handling and storage purposes and unwieldy large for transportation.

While many of the fuel or fuel package degradation mechanisms have been identified, the rates and limiting conditions for degradation in a disposal environment remain to be determined. The grey box at the end of the generic path in Figure 1 represents the uncertainty associated with future requirements for final disposition of used nuclear fuel. The Yucca Mountain licensing experience demonstrates the level at which used fuel policy may be reversed; however, 10 CFR 60 can be tentatively applied to the disposal of used fuel.

Note that the "Impact Limiters or Packaging" step between dry storage and consolidated storage and/or repackaging is within both the existing licensing envelope and the boundary of tentative requirements. This is intended to suggest that while existing regulation allows for fuel transportation, more efficient engineering design beyond the scope of existing practices may take advantage of radiologic decay and demonstrate improvements that may be acceptable for future use.

<u>Existing Practices</u>

If standardized packaging occurs at the utility at the time of transfer from wet storage to dry storage, the anticipated benefit is the elimination of later potential bare-fuel handling. However three considerations make this a weak argument: 1) any future change in strategy that leads to repackaging precludes the benefit, 2) increasing the duration of can use increases material aging prior to repository placement, and 3) any requirement to retrofit existing facilities to accommodate the can-in-can concept is expected to be prohibitively expensive and is likely to be resisted by the utilities to the extent that it interferes with other plant operations. A brief examination of conventional drying protocol illustrates some of the investment these utilities have in their existing systems.

Most used fuel is being placed in canister-based storage systems – which place the fuel in a canister which is dried, inerted, and seal welded. The following process is typical for storage canisters (and bolted storage casks) accepting bare fuel assemblies.

The empty canister and transfer cask (or bolted storage cask) are (is) submerged in fuel storage pool. Fuel is loaded into the canister (or cask) underwater. Primary shielding is provided by the depth of the water. Shielding lid (or secondary/temporary shielding for transfer) is installed. Loaded (flooded) cask is removed from water. The exterior surfaces are decontaminated. Canister (or cask) is staged for drying process and drained with inert cover gas applied to address ISG-22 (limiting potential for fuel oxidation during handling and drying operations). Load is dried (usually under vacuum, but use of forced helium gas is also an accepted practice). Canister is seal-welded, place in a transfer cask, and transferred to dry storage (accepted into another cask or vault). (Or bolted cask is sealed and transferred to storage location.) Planning may or may not include a mechanism for off-site (truck or rail) transportation.

One major loss of fuel handling efficiency comes with the change in fuel loading. Because the small can in the can-in-can concept is sealed with the intent of controlling the storage, transportation, and disposal environment, it becomes the vessel that needs to be (decontaminated and) dried and sealed. Drying a can of just a few assemblies (4 PWR or 9 BWR) may proceed more quickly than drying a full storage canister or cask (24-37 PWR or 52-89 BWR assemblies), but there will be many more vessel sealing operations and the need to stage partially filled larger cans throughout those operations. Even if the small can could be dried more efficiently on a per assembly basis, the change in loading reflects a 6- to 10-fold increase in the number of container handling operations.

Facility constraints may or may not allow for concurrent drying of multiple cans, and such an option introduces somewhat more complicated operating protocol. A small can is not a cask (in the transfer or transport sense) and may need different or additional shielding or different operating protocol for radiation protection. And workers tend to receive a greater radiological dose during handling operations than during the stationary and remotely operated drying process.

Also, the drying process for these small cans may require multiple adaptations to account for retained water or other configuration-specific limitations. For example, the ½" Schd. 40 lines marked "drainage pipe" on both PWR and BWR small cans are a nominal 185" long.[4] Such a long constrained "drain" may plug easily and seems reminiscent of the narrow drain tube and "dashpot" impediments to drainage inherent to and overcome by some of the earlier commercial industry drying efforts.[13, 14] There is not yet adequate detail to assess how much water might be inaccessible to the drainpipe, but such small drying loads set up a critical path serial process, where space constraints may make multiple parallel drying operations impractical.

Regardless of the cost and schedule uncertainty, the additional fuel handling time and operator radiation exposure are compelling arguments against imposing a standardized can-in-can packaging operation on existing reactor facilities.

Summary

Implementation is complicated by existing utility facilities and licensed fuel handling practices that have evolved to account for storage and transportation requirements in the absence of disposal considerations. The can-in-can concept aspires to take a longer view of commercial used fuel disposition to consolidate the necessary processes and eliminate potentially redundant ones. Given the government obligation to take custody of the fuel for disposal, the utilities are divested of responsibility for these longer term issues, and they lack an incentive to embrace the can-in-can packaging concept.

Specific disposal requirements as associated with the, as yet undefined repository and waste package design, could preclude use of the proposed canister, requiring another repackaging operation. The 4 PWR / 9 BWR small can fuel load is intended to maximize repository options while providing for standardization. However, other delaying repackaging could allow a higher payload by capitalizing on decay time in extended storage. Depending on the disposition criteria, repackaging for disposal after dry storage may be inefficient in terms of materials and labor. Even so, development and use of a dry-to-dry transfer option in conjunction with repackaging would allow for positive determination of dryness.

Economy of scale for standardized packaging would be best achieved at a consolidated location compared to standardized packaging at utilities. Existing drying and dry storage operations have already been approved within a defined, achievable operating envelope. Retrofit is time-consuming, costly, and may be hampered by location-specific challenges and conflict with ongoing operations. Facility space, handling capacity, and the available equipment are adequate to support the existing processes and configurations. The number and type of handling iterations to load and dry small cans and place and seal five small cans in a large can are likely to increase worker dose (associated with handling a 5- to 10-fold increase in the number of packages). Work around to handle small cans individually (in the event that a large can does not fit within space constraints) would be particularly inefficient and complicated by the need to stage a partly-filled large can.

The can-in-can design is not sufficiently mature to enable a detailed evaluation of the drying operation. The loading process is presumed to involve submerging the small cans within the large can, raising questions regarding decontamination and how to dry and seal each can (in parallel or in series). And none of the large can drawings appear to indicate a mechanism for drainage. Small cans tentatively show a long, small diameter, single drain line that should be expanded (if possible within practical constraints) and duplicated to allow for flow reversal to alleviate plugging and to facilitate the aspiration of water from the can.

Table 1. Pros and Cons for the Can-In-Can Concept Proposed for Implementation at the Utilities

Pros	**Cons**
Uniform handling requirements for future facilities (with potential for economies of scale)	Forces package configuration to reduce thermal output for disposition purposes without credit for decay over the duration of dry storage
Provides a single, standard demonstration prototype for storage, transportation and disposal	Competing size/load constraints for can-in-can life cycle versus DOT transportation and existing facility capabilities
Efficiency (number and duration) in handling operations and waste minimization	Expensive to transition from current practices
Minimizes packaging waste	Maximizes material aging prior to disposition
Reduces need for bare fuel handling	Increases ALARA worker radiological dose over current practices

Table 1 summarizes the pros and cons associated with implementing the can-in-can concept at the utilities by comparison to existing practices based on the assumption that existing practices employ non-standard packages not suitable for final disposition. Ultimately, the caveat in this analysis is that can-in-can package configuration choices may or may not support downstream disposition strategies.

Conclusion

In principle, standardization has value when future activities can capitalize on the uniform features provided. However, the costs of implementation are high. There is no incentive for industry and little incentive for government agencies to change current practices in the absence of defined requirements. Again, costs are high and benefits may be easily negated by future decisions. In the absence of a safety or economic driver to justify the costs of transition, the can-in-can concept is not suited to implementation by retrofit at the utilities. However, several of the benefits can be attained while many of the disadvantages can be avoided by storing fuel bare (i.e. postponing packaging until disposition criteria are defined). This approach would be feasible if the increased storage capacity were made available at a centralized facility, thus eliminating the capital investment needed to build such a storage facility at each site.

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