FUNCTIONS OF THE CASK MAINTENANCE FACILITY

A White Paper

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1.0 INTRODUCTION

The Office of Civilian Reactor Waste Management (OCRWM) is planning to develop and implement a national spent fuel and high level waste transportation system. This transportation system will obtain spent nuclear reactor fuel and other high level waste at the nuclear waste generators (reactors and other facilities) and transport it in specially designed shipping casks to a national geologic repository for deep permanent disposal. An above-ground monitored retrievable storage (MRS) facility may also be present in the system. If the MRS is authorized, most of the spent fuel will be transported from the waste generators to the MRS for pre-packaging and interim storage until such time as the fuel can be transported and finally placed in a geologic repository. The basic components of the national spent fuel transportation system include the spent fuel repository interface, the monitored retrievable storage facility (if authorized) interfaces, the shipping cask systems, the cask maintenance facility, and other transportation support systems or facilities.

The shipping cask systems are the mobile components of the transportation system, designed to safely transport spent nuclear fuel between different facilities under both normal and accident conditions. The cask system will consist of the heavily shielded cask, the cask transport vehicle (truck trailer or railcar), and any associated ancillary equipment (covers, impact limiters, lifting devices, etc.). The cask and certain parts of the cask system must be operated within the limits imposed by a certificate of compliance (COC) granted by the Nuclear Regulatory Commission (NRC).

Each cask system must transport spent fuel safely during the life of the system. To maintain the operational effectiveness and safety of the cask systems, a cask maintenance facility (CMF) will be included as an integral part of the transportation system.
2.0 PURPOSE

The need for a cask maintenance facility has evolved as a result of the observed experiences of current spent fuel transportation in this country and in others.\textsuperscript{1,2} While shipments of spent fuel are infrequent in this country at the present time, approximately one thousand cask shipments per year are expected when the transportation system is fully operational.\textsuperscript{3} At this shipment rate, from an overall system efficiency viewpoint, a dedicated facility with trained staff will likely be the most cost-effective method of providing the quality assurance and control guarantees that will be necessary to maintain the safety of each cask. This will be accomplished by periodic inspection and testing of the casks to verify that the casks are being maintained within the conditions set by the COC. Such a facility will have to be capable of lifting 150 ton loads, have road and rail access, have radioactive material containment and shielding capability, and be operated under an NRC license (or equivalent). A cask maintenance facility with these design aspects can logically also perform any other functions involving spent fuel casks (except loading/unloading spent fuel) which require these same facility design aspects. The planning activity of the transportation system and the design effort of the CMF require that the functions to be performed by the CMF be explicitly defined.

The purpose of this paper is to

1) define the potential transportation system functions to be performed at the CMF;

2) examine the impact of this functional definition on the overall transportation system;

3) identify any unresolved issues concerning the interaction of the CMF with other elements of the transportation system; and

4) make recommendations to resolve any unresolved issues so that decisions can be made early in the transportation system planning process.
The current transportation system planning documents address the concept of a cask maintenance facility only in general terms. However, the facility will interact with all the other major components of the national transportation system and the waste generators. The choice of system functions that are selected for the CMF will affect:

- the design of the repository and/or MRS,
- the design of the CMF,
- the magnitude of the NRC licensing process for the CMF,
- the operational difficulty of the spent fuel transportation tasks,
- and the operational scheduling of the spent fuel transportation.

Because of this system impact, definition of the basic functions of the CMF at the present time is essential. Such definition will provide a basis for the planning, design, scheduling, and licensing activities of the transportation system; it will assist in preventing future interface problems; it will help to avoid delays that could occur in planning and decision-making associated with transportation operations system development, and it will also indicate which maintenance-related tasks must be performed at other facilities.

Once the basic issues concerning the cask maintenance facility are decided the next phase in its development will be the performance of a feasibility study (preconceptual design). During the feasibility study more detailed issues will be addressed and the functional requirements for the facility will be more fully developed.
3.0 OPERATIONAL DESCRIPTION AND FUNCTIONS OF A CASK MAINTENANCE FACILITY

The cask maintenance facility will provide a variety of services necessary to ensure the operability of the cask system and other related equipment.

Empty casks will arrive at the collocated or independent CMF site by either truck or rail shipment. A CMF that is integral to the repository or MRS would accept casks by internal transfer from the main facility. The cask and its transport vehicle (truck trailer or railcar) will be brought to a preparation area for road grime/ice removal (if necessary) and dismantling of access barriers, impact limiters, and other ancillary equipment. After this preparation, the cask will be lifted from the vehicle with a large crane. The unloaded vehicle will be removed from the CMF and the cask will be lowered into a service area. In the service area, the exterior of the cask will be inspected and the gross decontamination systems will be connected to the cask. While the cask is being flushed to remove any water soluble or loose debris, most necessary exterior maintenance can take place. When the flushing operation is complete, the internal radiation level of the cask will be assessed. If the cask radiation level is low enough, the cask will be opened for interior service in the lightly shielded service area. If the cask radiation level is too high, the cask will be moved into a more heavily shielded bay for service by remotely operated equipment, or additional internal decontamination will be performed.

Based on current cask experience, the internal structure of the cask is not expected to require removal at every service; generally, it will be inspected only. If internal structure changeout is required to accommodate a particular fuel type, however, the cask will be moved into the heavily shielded bay for this function. Once the cask has been inspected, it can be serviced or repaired as needed to maintain the cask within the restrictions of the COC. Maintenance that had been
deferred until the COC inspection and preventative maintenance may be performed. Additional internal decontamination to lower levels may be done if it is found that a periodic thorough decontamination is operationally desirable. Cask modifications may also be made at this time if dictated by design or COC changes.

When all cask maintenance is completed, the cask will be closed, leak tested and moved into the external decontamination stand for final exterior inspection and cleaning. The cask transport vehicle will be brought up and the cask will be loaded onto the vehicle. Ancillary equipment will be installed; the cask system will be prepared for shipment. When the work is completed, the cask and vehicle will be moved from the CMF to a staging area for final dispatching.

In addition to the actual cask maintenance the CMF will perform inspection, service, and repair of the cask system ancillary equipment as well as any specialized equipment needed for cask use. The entire cask system maintenance effort will be completely documented, and the records stored for future activity.

Eight distinct major transportation system functions (Table 1) are to be performed by the CMF. In the following sections, a brief operational description of the facility will be given, each specific function will be defined, and the magnitude of the function will be identified. Then the importance of each function in relation to the overall transportation system will be addressed, and the impact on the overall transportation system will be noted.

3.1 Cask Inspection for Compliance with the NRC Certification

Spent fuel shipping casks are operated within the authority of a COC granted by the NRC. In essence, the COC is the primary quality assurance and control document by which the NRC Division of Fuel Cycle and Material Safety permits spent fuel to be shipped in a specific cask design. The COC contains a description of the type, form, and maximum
quantity of material that can be carried in the cask, any operating restrictions on the cask, and the specifications for inspection and maintenance of the cask. A cask that fails to comply with these criteria must be withdrawn from service until corrective action has been completed.

The actual COC specifications for inspection and maintenance that will be used at the CMF will largely depend on the final designs adopted for the transportation system cask fleet. Current procurement activities are emphasizing that cask fleet designs should minimize these COC inspection and maintenance requirements. It is still expected, however, that inspections, tests, and parts replacement will be required periodically for each cask. The NRC will ultimately dictate the frequency and standards to which each COC cask service must conform, and it is unlikely that the future NRC requirements will be significantly less stringent than those presently in use.

The periodic inspections of the casks to verify that the casks are operating within the requirements of the COC will be performed at the CMF. As a minimum, a simple cask design currently requires annual dimensional inspection, seal replacement, and leak testing. More complex designs may require hydrostatic testing, specific gravity testing, or thermal performance testing. It is expected that the CMF will require documented cask examination procedures, formally trained cask inspectors, calibrated test equipment for the performance of the inspections, and a formal inspection documentation system. This inspection function must be performed on radioactively contaminated objects that can weigh in excess of 100 tons, and it may be performed remotely in shielded areas, depending on the level of contamination.

The COC will also require that inspection be performed on each cask in the fleet before it can be used to transport spent fuel. These acceptance tests are necessary to ensure that the cask is constructed to the design specifications. While it is possible to perform these tests at the vendor's location, it is preferable to have the "hands on"
acceptance testing performed by the independent inspection team which will be intimately familiar with the cask inspection requirements.

The impact of the inspection function on the transportation system is that of out-of-service time while a cask is being inspected at the CMF. It should be noted that the more frequent and stringent the COC inspection requirements, the greater the cask out-of-service time will be. The cask design activity is planning to minimize this time period by providing a cask that necessitates only infrequent inspection requirements and that can be easily and quickly inspected. The design of the handling interfaces and service connections will also affect the duration of the cask inspections. The contamination level of the cask when it arrives for inspection will affect the ease and duration of the cask inspection. These requirements for frequency and duration of inspection will in turn affect the decision regarding where the CMF will be located.

3.2 Cask Service and Repair

Spent fuel shipping casks and their ancillary equipment will gradually accumulate operational damage, both internally and externally. For example, trunnion surfaces may be galled, sealing surfaces may be scratched, valves may require replacement, or cask internal structures may become damaged. More frequently, threaded fasteners are stripped and require repair. A cask impact limiter may require external repair by welding or other service. A cask may fail to meet one of the inspection criteria and will require corrective action. The CMF will service and repair the casks and their ancillary equipment. The magnitude of this maintenance function, like the inspection function, will also depend primarily on the design of the cask used in the national transportation system. The CMF will maintain a stock of repair parts for the casks and their ancillary equipment. The CMF will be equipped with the necessary repair tools and equipment, as well as complete packages of cask engineering specifications and drawings, certified repair procedures, and quality acceptance criteria for use by
CMF personnel. The personnel performing the repairs will be formally trained and qualified to perform the repairs. From a transportation system viewpoint, a cask may eventually be damaged to the extent that it is not economically repairable, and scrapping the cask may be more cost-effective. The CMF personnel will have the experience and information necessary to make that decision.

The cask service and repair function, like the COC inspection function, may require large object material handling and shielded remote maintenance capabilities. The impact on the transportation system of this cask service and repair function is, like the COC inspection function, out-of-service time for a cask. The cask design activity is planning to minimize this time period by providing a design that necessitates only infrequent maintenance requirements and that can be easily serviced or repaired.

3.3 Off-site Repair and Inspection

It can be anticipated that operational damage to a cask or its ancillary equipment will require repair at a location away from the site of the CMF. If the cask should require in-situ maintenance, the CMF personnel will provide either telephonic guidance or the expertise and equipment to repair the damage. An example of this kind of damage might be a trunnion bearing surface gouge sustained during fuel loading at a reactor. Additionally, the extent of the damage will determine whether simple field dressing of the gouge is adequate or if replacement of the component is needed. If a transportation accident occurs, the CMF will provide a team to evaluate cask damage (including on-scene leak testing) to verify that the cask can be moved to its destination or to a nearby location for further evaluation. While this type of occurrence should be infrequent, using the CMF to provide this off-site repair and inspection function will eliminate the need for the transportation system to have the function elsewhere and will provide highly trained and experienced personnel.
The advantage of having this function at the CMF is that the rapid response of the CMF minimizes cask or ancillary equipment out-of-service time, and the off-site repair and inspection function can be readily available if required, without adding significant cost to the transportation system.

3.4 Cask Internal Structure Changeout

The CMF will provide an internal structure changeout function for the casks. The present nuclear power plants in this country utilize fuel assemblies that often differ significantly in dimensions and other characteristics. One method of minimizing the number of different casks in the transportation system is to adopt a versatile cask design that has interchangeable internal structures (often called "baskets") to fit different fuel designs. When a cask requires changeout of its internal structure from one fuel design to another, it will be shipped to the CMF for the changeout before being shipped to the reactor site. Current experience indicates that this changeout function requires shielded remote handling capabilities because of the internal structure contamination levels. The CMF would store an inventory of different internal structures in a shielded area.

Use of the CMF for this function makes use of facilities, equipment, and personnel that are already in place for cask inspection and maintenance. The personnel most knowledgeable of the operational and quality management aspects of the cask designs will be located at the CMF, spare internal structures will already be maintained at the CMF for the cask service and repair function, and changeout activities can be easily scheduled with inspection and service functions to minimize cask downtime. The use of the CMF for the internal structure changeout function eliminates the costs of providing this capability in a less efficient manner elsewhere in the transportation system.

3.5 Specialized Equipment Maintenance

The handling of casks at generator sites requires the utilization of
specialized handling, testing and other operational equipment. An example of this equipment is the lift beam and crane hook adapter that allows handling a standard cask with a non-standard crane design. Such fixtures may be hydraulically operated and electronically controlled. They must be periodically load tested and serviced like other material handling equipment and can be damaged during operations. Some of the different reactor facility designs are expected to necessitate special adaption equipment that will allow a standard cask design to be utilized at a reactor site that has interface difficulties. The CMF will inspect, service, and repair this special adaption equipment as well as inventory it until it is needed.

Use of the CMF for this function makes use of facilities, equipment, and personnel that are already in place for cask inspection and maintenance. The personnel most knowledgeable of the operational and quality management aspects of this specialized equipment will be located at the CMF. Much of the test equipment needed will already be at the CMF as will be decontamination systems that can process the specialized equipment. From the transportation system point of view, the CMF is the best location for this function since the testing and servicing of this specialized equipment can be closely coordinated with the dispatching of the casks from the CMF.

3.6 Transportation Equipment Decontamination

The CMF will decontaminate casks, cask internal structures, and cask ancillary equipment in order to perform inspection and maintenance. Implicit in this function is the specification of the frequency and the levels to which an item is decontaminated.

The CMF will already require systems and equipment to decontaminate casks and internal structures to levels that will allow the most cost-effective inspection and maintenance for CMF operation. The CMF's inspection and maintenance functions will consume less cost and time if they can be performed in unshielded or lightly shielded areas. This
preparatory decontamination function needs to be able only to
decontaminate casks and internal structures to levels necessary for
inspection or maintenance to take place. The magnitude of this
preparatory decontamination function depends on a) the contamination
level of the cask when it arrives at the CMF, b) the work scheduled to
be performed on the cask, and c) the design of the cask (ease of
decontamination).

Superimposed on this preparatory cask decontamination function,
however, is a more complex decontamination function that is
transportation system-wide. The magnitude of this system
decontamination function depends on a) the contamination levels that
are acceptable at the different facilities that interface with the cask
and b) the design of the cask (ease of decontamination). The
repository or MRS can accept spent fuel assemblies; therefore, internal
cask contamination should not present operational problems for those
facilities. The CMF, however, will not be designed to accept spent
fuel; the presence of spent fuel residue or very high contamination
levels in an empty cask will have a significant impact on CMF
licensing, design, and operations. The reactor sites, however, where
the spent fuel is loaded, desire fairly well decontaminated empty
casks; a well decontaminated cask has less potential impact on reactor
spent fuel pool operations. In addition to the requirements of the
waste generators, the overall transportation system management is
likely to require a thorough internal and external decontamination of
casks and equipment on a periodic basis in order to remove any residual
contamination that would build up gradually with time. Thus, the
decontamination requirements of the transportation system will probably
be more stringent than the decontamination requirements driven purely
by the CMF inspection and maintenance functions.

The question becomes, "to what levels should the CMF be equipped to
decontaminate and how frequently must this be done?" Superimposing a
very stringent transportation system decontamination function on the
CMF's preparatory decontamination function can have a large impact on
the CMF waste management systems, as well as the design, operations, and licensing of the CMF. These issues will be examined in more detail in section 4.0. The CMF will have to perform a transportation system-based cask decontamination function rather than a CMF-based function, but the magnitude of the function cannot be determined until these issues are resolved.

The CMF will also be equipped to decontaminate vacuum drying systems, lift beams (including hydraulic systems), test equipment, exteriors of cask vehicles, and exteriors of ancillary equipment as necessary. It should be noted, however, that this function is expected to be infrequent and require relatively small effort. This function will not be totally unique to the CMF, since the exterior of the cask system must meet Department of Transportation (DOT) contamination limits before it is shipped from any of the facilities in the transportation system.

3.7 Records Management

The CMF will have a records management function that includes information acquisition, storage and retrieval, report generation, maintenance documentation, and facility operations information handling. Creation and maintenance of extensive quality assurance and control documentation will be required in order to verify that cask systems are maintained within the limits specified by the COC. This documentation is crucial to the transportation system; without it, the system will not be permitted to operate. Other entities in the transportation system may require access to the records.

3.8 Cask System Modification

During its lifetime, a cask system may require modification, and the CMF will modify cask system designs as improvements are necessary. The magnitude of the modification function is not expected to be large.
The CMF, however, will be equipped and staffed to perform this as an extension of the cask maintenance function; thus, the logical location for this function in the transportation system is the CMF.
4.0 EFFECTS OF CMF FUNCTIONS ON THE SPENT FUEL TRANSPORTATION SYSTEM

The cask maintenance facility will interface with many other components of the waste management system. There are both physical interfaces (such as mating to standard equipment designs) as well as operational interfaces (who ships to the facility, who the facility ships to). These interfaces include two major issues that will affect the cask maintenance facility design and location.

4.1 The Effects of the Transportation System Decontamination Function on the System Operations

As noted in Section 3.7, the internal decontamination of casks required by the overall transportation system will affect the magnitude of the cask decontamination function (and consequently the system operations costs) as well as design and licensing aspects of the CMF. Presently OCRWM documents indicate that a cask arriving at a reactor for spent fuel loading must have levels of contamination low enough to meet DOT standards for "empty" containers. In effect, compliance with this requirement would mean that a cask entering a reactor would have internal surface contamination levels below 2200 disintegrations per minute per square centimeter (dpm/cm²) as measured by taking wipe samples. This is a very low contamination level for a system that normally contains spent reactor fuel. Depending on the cask design, achievement of this level may not be technically feasible without dismantling the cask and removing surface material once a cask has carried spent fuel.

The achievement of these low levels of contamination prior to a cask leaving the repository or MRS will require extensive dedication of resources to the effort. If it is not desired to tie up the repository or MRS function, the decontamination could be performed at the CMF.

With the system decontamination function located at the CMF, the probable system cask flow when the required internal contamination
level is 2200 dpm/cm² would be as follows:

- casks unload spent fuel from reactors at the repository (or MRS)
- casks have loose residual fuel debris flushed out at the repository (or MRS)
- casks are closed and moved under normal DOT "spent fuel" regulations to the CMF for decontamination
- casks are more thoroughly decontaminated (and inspected or repaired as necessary) at the CMF
- casks are closed and shipped under DOT "empty" regulations to reactors for spent fuel loading.

In essence, all casks scheduled to go to reactors after having carried spent fuel will go through the decontamination function at the CMF. This could mean up to 1000 cask decontamination operations at the CMF per year (in addition to inspection and maintenance activities), which is a major impact on the CMF design, waste handling systems, and licensing activities. The DOT "empty" cask criteria greatly increase the magnitude of the cask decontamination effort required in the OCRWM transportation system.

The reactor community is concerned that an empty cask will contain enough residual contamination that it will present a severe burden to the spent fuel pool water cleanup systems. If, as an alternative to having the casks meet the DOT "empty" standard, the casks were adequately decontaminated after fuel unloading at the repository (or MRS), the objective of keeping the casks from contaminating the fuel pools could be achieved. The probable system cask flow when the casks are cleaned (as necessary) at the repository (or MRS) instead of meeting the DOT "empty" standard would be as follows:

- casks unload spent fuel from reactors at the repository (or MRS)
o casks have loose residual contamination removed at the repository (or MRS)
o casks are closed and shipped under DOT "spent fuel" regulations to reactors for spent fuel loading.

In essence, using this alternative, most casks will be shipped to reactors for spent fuel loading after having been cleaned, as necessary, at the repository (or MRS). Some casks will be shipped to the CMF for scheduled or unscheduled inspection and maintenance, but the bulk of the cask flow will be from the repository (or MRS) to the reactors without a stop at the CMF for decontamination to the DOT "empty" standard.

This would result in avoiding the cost of extensive repository or MRS decontamination efforts or, alternatively routing nearly all cask shipments through the CMF for decontamination. If such extensive decontamination can be avoided at the CMF, it will result in less waste processing and less licensing complexity at the CMF.

4.2 The Effects of the Proposed CMF Functions on Transportation System Logistics

Presently, the frequency of the CMF's utilization can only be estimated. It is clear, however, that as the frequency of CMF usage increases, the more desirable it is to locate the CMF in proximity to the repository or MRS, to reduce the overall system logistical costs. As a result, as the magnitude of the CMF functions increase, it is desirable to decrease the distance of the CMF from the facility where the spent fuel assemblies are unloaded. The selection of CMF site options (integral, collocated or independent) will also likely be strongly affected by the expected magnitude of the CMF functions. A recent preliminary logistical study indicates the effect on overall transportation system cost.4
While the cask has been removed from the cask transport vehicle and is being serviced in the CMF, it is an excellent time period in which to have the cask transport vehicle inspected, serviced, or repaired. Currently cask transport vehicles are not regulated by the COC, but instead must meet DOT vehicle regulations. As a result, performance of cask vehicle maintenance is not part of the CMF function. Depending on the interchangeability of the cask vehicles, the time available for cask maintenance may influence the time available for vehicle maintenance. If a cask transport vehicle is fully interchangeable, the transportation system can simply replace the cask vehicle with a freshly maintained vehicle whenever the cask is ready to leave the CMF. If, on the other extreme, the cask fits only its dedicated transport vehicle, the time in which the cask is at the CMF will determine the time in which vehicle maintenance must be performed (or vice-versa). As system planning progresses, the integration of this vehicle maintenance function with the cask maintenance function will require better definition.
5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 Functions

The eight functions defined in Section 3.0 should be adopted as the baseline functions of the CMF for transportation system planning purposes (Table 1). Attention should now be focused on carefully defining the magnitudes and limitations of these functions within the transportation system so that planning can commence on the facility and its licensing activity in accordance with the transportation system schedule.

5.2 Technical Interfaces

Close coordination must take place between the design activity of the cask system and the design activity of the CMF. The design of the cask system will significantly affect the design, operations, scheduling, and possibly licensing activity of the CMF. In turn, the transportation system operations and scheduling will be affected. A coordination group should be formed to follow the cask design effort and evaluate the impact of the cask design features on the CMF design and transportation system operations.

It is recommended that the use of the DOT "empty" standard as the criterion for internal cask decontamination after fuel unloading be reconsidered. The difference in protection of reactor spent fuel pools that would be achieved by using the "empty" standard and a less stringent, more functional criterion may not be worth the cost of a large scale system decontamination function. A coordinating committee should be formed with transportation operations, the utilities, and the repository/MRS to develop these criteria.
5.3 Technical Issues

The choice of CMF siting (integral, collocated, or placement in close proximity to an MRS or repository) should be made on the basis of the estimated frequency with which the cask fleet is shipped to the CMF, as well as other factors. If the recommendations to not use the CMF for routine decontamination is accepted, then the cost factor to locate the CMF near the repository/MRS is not as strong. Site specific considerations become the most important factors, such as the licensing authority (NRC or agreement state), public acceptance, etc. This decision should be made as part of the preconceptual design effort for the CMF.
Table 1
Functions of a Cask Maintenance Facility

1. Provide centralized examination service to verify that the cask fleet is operating within the requirements of the NRC "certificate of compliance".

2. Provide periodic maintenance and repair of operational damage sustained by casks.

3. Provide a technical capability for unplanned cask repair and inspection at locations other than the CMF.

4. Provide changeout capability for cask internal structures.

5. Provide maintenance for specialized equipment.

6. Provide internal and external decontamination for the cask system.

7. Provide a records management function for cask system maintenance information.

8. Provide modification capability for casks.
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