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Yucca Mountain Site Characterization Project

Transportation Cask Decontamination and Maintenance at the Potential Yucca Mountain Repository

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TRANSPORTATION CASK DECONTAMINATION AND MAINTENANCE AT THE POTENTIAL YUCCA MOUNTAIN REPOSITORY

by

SAND--89-7007

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ABSTRACT

This study investigates spent fuel cask handling experience at existing nuclear facilities to determine appropriate cask decontamination and maintenance operations at the potential Yucca Mountain repository. These operations are categorized as either routine or nonroutine. Routine cask decontamination and maintenance tasks are performed in the cask preparation area at the repository. Casks are taken offline to a separate cask maintenance area for major nonroutine tasks. The study develops conceptual designs of the cask preparation area and cask maintenance area. The functions, layouts, and major features of these areas are also described.

This work was completed December 1989.

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The authors gratefully acknowledge the contributions of the individuals listed below and their support in providing information on cask-handling experience at spent fuel receiving facilities.

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Steven Schilthelm
Steven Schmid
Joseph Stapf

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(Cont'd)

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EXECUTIVE SUMMARY

This study identifies necessary cask decontamination and maintenance operations at the potential Yucca Mountain repository and develops a preliminary conceptual design of the associated facilities. These facilities (the cask preparation area and the cask maintenance area of the repository waste-handling building) are designed to meet the cask decontamination and maintenance requirements outlined in "Generic Requirements for a Mined Geologic Disposal System" (DOE, 1986a). General arrangements of the facilities are developed using a modular approach so that the design concepts can be adapted, with minor modifications, to other potential spent fuel handling facilities in the Federal Waste Management Systems (FWMS).

The nature and extent of cask decontamination, maintenance, and reconfiguration that will be needed at the repository are highly uncertain. The associated operations depend on many factors, including the configuration of the FWMS (e.g., with or without other spent fuel handling facilities), the functional requirements of each element in the FWMS, and the design features of the casks to be used in the system. Because the development of casks to be received at the repository is still in an early stage, a reference cask design is chosen. This study is based on a reference FWMS configuration and various assumptions regarding cask decontamination, maintenance, and reconfiguration at the repository. These configurations and assumptions provide a basis for developing conceptual designs of the facilities necessary to conduct the above operations. This work was done during the pre-Advanced Conceptual Design phase as reflected in SAND84-2641, Site Characterization Plan-Conceptual Design Report.

An extensive literature review and a survey of spent fuel handling facilities have been conducted, and the results are used to determine the cask processing operations, facilities, and equipment recommended to perform similar operations at the repository. These operations serve as a basis for identifying cask decontamination and maintenance tasks and for designing the facilities for performing these tasks. Functional block flow diagrams of cask processing operations, including routine and nonroutine cask decontamination and maintenance tasks, have been prepared.

The cask preparation area is designed to facilitate routine cask decontamination and maintenance, as well as other routine cask preparation operations needed to unload fuel and ship the cask offsite. Major features of this area include: (1) separation of the cask preparation area from the receiving and shipping bay and (2) capability of transferring casks to the cask maintenance area for nonroutine operations. Because casks may be radioactively contaminated when they are transferred into the cask preparation area after spent fuel unloading, the area is designed as a separately ventilated area to prevent the potential spread of contamination to the receiving and shipping bay. The capability of transferring casks from the routine handling path in the cask preparation area to the maintenance area (offline) increases the availability of the cask preparation area for processing additional casks while nonroutine cask decontamination and maintenance operations are conducted offline.

Routine cask decontamination tasks in the cask preparation area include manually wiping the cask exterior surface (localized areas), the cask outer cavity, and the cask-to-hot-cell adapter during cask preparation for shipment offsite. Also, routine cask maintenance tasks are performed in the cask preparation area, including visual inspection of cask components and containment verification tests of unloaded casks prior to shipment offsite. These maintenance tasks are commonly termed "preventive maintenance."

The cask maintenance area facilitates nonroutine decontamination and maintenance and permits cask reconfiguration (e.g., fuel spacer changeout). The area includes various shielded cells with filtered ventilation exhaust to accommodate (1) operations that need to be performed remotely and (2) operations where high levels of contamination are present.

The cask exterior, interior cavity, and internal components (fuel basket and spacer) can be decontaminated in the cask maintenance area. There are separate facilities and equipment for each of these decontamination operations. A remote automated spray system, equipped with high-pressure nozzles, is used to thoroughly decontaminate the entire cask exterior surface, if necessary. Two methods of cask interior cavity decontamination are implemented in the facility design: (1) flushing, which is done for casks requiring minor cask cavity decontamination, and (2) manually decontaminating the cavity (with or without the fuel basket present) with long-handled wet vacuum and sluicer instruments, which is performed on casks requiring extensive inner cavity decontamination. Facilities similar to those for cask exterior decontamination are provided for decontaminating fuel baskets and fuel spacers removed from the cask cavity.

The cask maintenance tasks that can be performed in the cask maintenance area include the replacement of removable and interchangeable cask components. The components include fuel baskets, fuel spacers, closure head seals, valves and valve components, fasteners, and other hardware. Storage areas for the components are also incorporated into the design.

manner that accommodates an MRS in the FWMS. They are also developed using a modular design approach so that they can be adapted, with minor modifications, to the MRS.

1.3 Organizational Approach

The report consists of seven sections plus two appendices.

Section 1.0 is the introduction.

Section 2.0 presents the bases for the conceptual design of the cask decontamination and maintenance facilities. These bases consist of the functional requirements and performance criteria, a description of the reference cask system, and major assumptions.

Section 3.0 discusses the operations necessary for processing transportation casks at the repository.

Section 4.0 addresses the conceptual design of the cask preparation area, where routine cask decontamination and maintenance operations are performed.

Section 5.0 addresses the conceptual design of the cask maintenance area, where nonroutine cask decontamination and maintenance operations are performed.

Section 6.0 presents the conclusions and recommendations of this report.

Section 7.0 lists the references.

The appendices present supplemental information, including personal communications (addressing operational experience with cask processing at existing waste-handling facilities) and cask internal contamination data.

1.0 INTRODUCTION

1.1 Purpose

The purpose of this study is to identify transportation cask decontamination and maintenance tasks needed at the potential Yucca Mountain repository and to develop design concepts for the associated facilities. The design concepts developed in this report can serve as a basis for further stages of design of the repository.

1.2 Scope

This study assesses transportation cask processing at the repository receiving facilities to develop a basis for the facilities and equipment needed to conduct cask decontamination and maintenance operations. The facilities are designed to meet the requirements stated in "Generic Requirements for a Mined Geologic Disposal System" (DOE, 1986a).

This report describes a reference cask design and summarizes general industry practices and experience with cask handling. This information forms a basis for recommended cask-processing operations at the repository. Cask reconfiguration operations are also addressed as part of this study.

Because spent fuel casks are the primary type of cask received at the repository and decontamination and maintenance of other casks (e.g., high-level waste casks) would not be as frequent or extensive, this study emphasizes spent fuel cask processing.

The conceptual designs of the facilities discussed in this study are developed based on the assumption that spent fuel is shipped to the repository directly from reactor facilities; i.e., no Monitored Retrievable Storage facility (MRS) exists in the Federal Waste Management System (FWMS). However, the facilities described here are designed in a

2.0 BASES FOR DESIGN

In this section, design criteria are presented, the reference transportation cask system is described, and the assumptions about cask-processing operations are given. These criteria, descriptions, and assumptions serve as the bases for the conceptual designs developed in this study.

2.1 Design Criteria

2.1.1 Functional Requirements

DOE (1986a) defines the receiving system of the repository as the system for accepting high-level radioactive waste shipments from the external transportation system. The components of the receiving system covered in the scope of this study are the facilities necessary for the preparation, decontamination, and maintenance of transportation casks. Other cask-handling and cask-processing features are considered, as necessary, to address the operational interfaces with the external transportation system.

The general functional requirements identified in DOE (1986a) for the cask-processing facilities are to "receive and unload radioactive waste from the external transportation system" and to "prepare and dispatch transportation system components for a return trip." The relevant criteria contained in the aforementioned document are discussed below.

2.1.2 Performance Criteria and Constraints

2.1.2.1 General

The repository receiving facility shall be designed to handle both truck and rail shipments of high-level radioactive waste (DOE, 1986a). The waste will be transported in shipping casks designed specifically for rail and truck transportation modes. The reference transportation cask system for this study is discussed in Subsection 2.2.

The facility design should ensure that the receiving, shipping, and inspection functions of the repository interface with external transportation systems in an efficient and cost-effective manner. The required functions include "performing decontamination operations, seal changes, and replacement of the cask removable components, such as baskets and sleeves" (DOE, 1986a). Additionally, DOE (1986a) states that "the repository receiving facility should include provisions for lag storage for the casks and storage of the interchangeable cask components."

2.1.2.2 Radiation and Contamination

According to DOE (1986a), the repository receiving facility shall provide the capability to check for radiation and contamination on transportation components and to decontaminate them, if necessary. Radiation and contamination surveys of casks at the repository will be performed to demonstrate compliance with transportation requirements, to reduce personnel radiation exposures to levels as low as reasonably achievable (ALARA), and to implement contamination control procedures, if required.

Transportation casks to be processed at the repository will be designed to meet the radiation dose rate limits of 10 CFR 71.47 (NRC, 1986) and 49 CFR 173.441 (DOT, 1986). These regulations require that the maximum levels of radiation be limited to 200 mrem/hr at any point on the external surface of the package and 10 mrem/hr at any point 2 m from the accessible surface. The levels of radiation from the reference casks assumed in DOE (1986a), however, are given as 50 mrem/hr at the cask surface and 10 mrem/hr at 2 m from the cask. Cask-processing systems and features shall be designed so that workers can perform the associated operations without receiving radiation exposures greater than 1 rem/yr (DOE, 1986b).

DOT (1986) specifies maximum levels of removable contamination on the exterior surfaces of shipping casks during transportation. According to 49 CFR 173.443, at any time during transportation, the level of removable radioactive contamination on the external surface of the cask shall not exceed 220 dpm/cm^2 for beta-gamma emitters and 22 dpm/cm^2 for alpha emitters (DOT, 1986). The repository is also required to limit the external surface contamination to 10% of the above levels prior to the shipment of unloaded casks offsite (DOT, 1986). Provisions will be necessary to decontaminate casks that become contaminated to levels that exceed these limits (e.g., after spent fuel unloading). The facility design should incorporate confinement barriers and other features to prevent the uncontrolled spread of radioactive contamination.

DOE (1986a) states that the total buildup of contamination in cask cavities shall not exceed the limits of 49 CFR 173.427 (DOT, 1986), which stipulates that if the "internal contamination does not exceed" 2,200 dpm/cm^2 for beta-gamma emitters and 220 dpm/cm^2 for alpha emitters, then the package can be shipped as an "empty radioactive material package." However, decontamination of unloaded casks to comply with the "empty package" limits may be extensive and time-consuming. Spent fuel handling facilities that were surveyed (Appendix A) do not perform such decontamination operations, but return unloaded casks with some internal contamination. The above criterion is discussed in further detail in Subsections 2.3.5 and 3.4.2.

2.2 Reference Transportation Cask System

The conceptual design of the facilities for processing transportation casks (especially decontamination and maintenance) at the repository depends on the FWMS configuration (i.e., with or without an MRS) and the associated cask types and their designs. First, if an MRS were incorporated, a smaller number of casks would be received and processed at the repository than if no MRS existed in the FWMS (BNI, 1989). Secondly, because spent fuel received from the MRS would be contained in canisters and the casks containing the canisters are loaded in a dry environment, the levels of cask interior and exterior contamination would be lower than those for spent fuel casks shipped from reactor facilities. Additionally, MRS-to-repository spent fuel casks would not require reconfiguration of their internals to accept different fuel types and lengths, as would from-reactor casks, because the canisters containing the spent fuel would be uniform in dimension.

Based on the above, the requirements for cask decontamination, maintenance, and reconfiguration at the repository would be greater if no MRS were incorporated into the FWMS. Therefore, this study is based on the transportation cask system associated with the FWMS configuration in which no MRS is present. However, MRS-to-reactor casks are also generally addressed so that they may be easily accommodated at the repository if an MRS is adopted.

2.2.1 Cask Types

Most of the radioactive waste shipments will arrive at the repository in casks specifically designed for spent fuel truck or rail modes of transportation (SNL, 1987). Other types of casks, designed for the transport of various forms of high-level waste (HLW) (e.g., vitrified HLW and nonfuel-bearing waste) will also be received at the repository. Because most of the casks to be received at the repository will be spent fuel casks, and spent fuel presents the highest potential for cask contamination, the processing of spent fuel casks is emphasized in this study.

DOE (1986a) summarizes the characteristics and common features of the truck and rail casks that are assumed to arrive at the repository. Among the spent fuel casks discussed are a 25-ton legal-weight-truck (LWT) cask, a 40-ton overweight-truck (OWT) cask, a 100-ton 4-axle rail cask, and a 125-ton 8-axle rail cask. The "Draft 1988 Mission Plan Amendment" (DOE, 1988) states that the design and development of OWT casks have been deferred; therefore, OWT casks are not considered in this study.

In June 1987, DOE selected contractors for the design of the following from-reactor spent fuel casks: two LWT cask designs (with weights of approximately 25 tons) and three rail-and-barge cask designs (with weights of approximately 100 tons) (DOE, 1986c). DOE intends to select one or more of the truck and rail cask designs for use in the transportation of spent fuel to the repository.

If an MRS is incorporated into the waste management system, other types of casks may be procured for transporting spent fuel (either as intact assemblies or consolidated fuel) in canisters from the MRS to the repository. Large rail casks are expected to be used to transport spent fuel from the MRS to the repository (DOE, 1987).

This study assumes that three types of spent fuel casks will be accommodated at the repository: (1) LWT cask (approximately 25 tons), (2) rail/barge cask (approximately 100 tons), and (3) MRS-to-repository cask (approximately 125 tons).

2.2.2 Description of System

2.2.2.1 General

Casks are transported in a horizontal orientation on specially designed truck trailers or railcars. During transport, the carrier (truck trailer or railcar) supports the cask and provides tiedown points for the personnel barrier that surrounds the cask. A typical transportation cask system is illustrated in Figure 2-1.

Three types of personnel barriers are used for transportation cask systems currently operating in the U.S. One design consists of a single structure that must be removed from the carrier frame before the cask can be unloaded from the carrier (NAC, 1988). The other two designs - a sliding type and a clamshell type - are nonremovable. They remain on the frame during unloading of the cask from the carrier. Because DOE (1986c) states that personnel barriers should remain on the carrier when they are opened to access the cask, nonremovable types are assumed to be incorporated in the cask transport system.

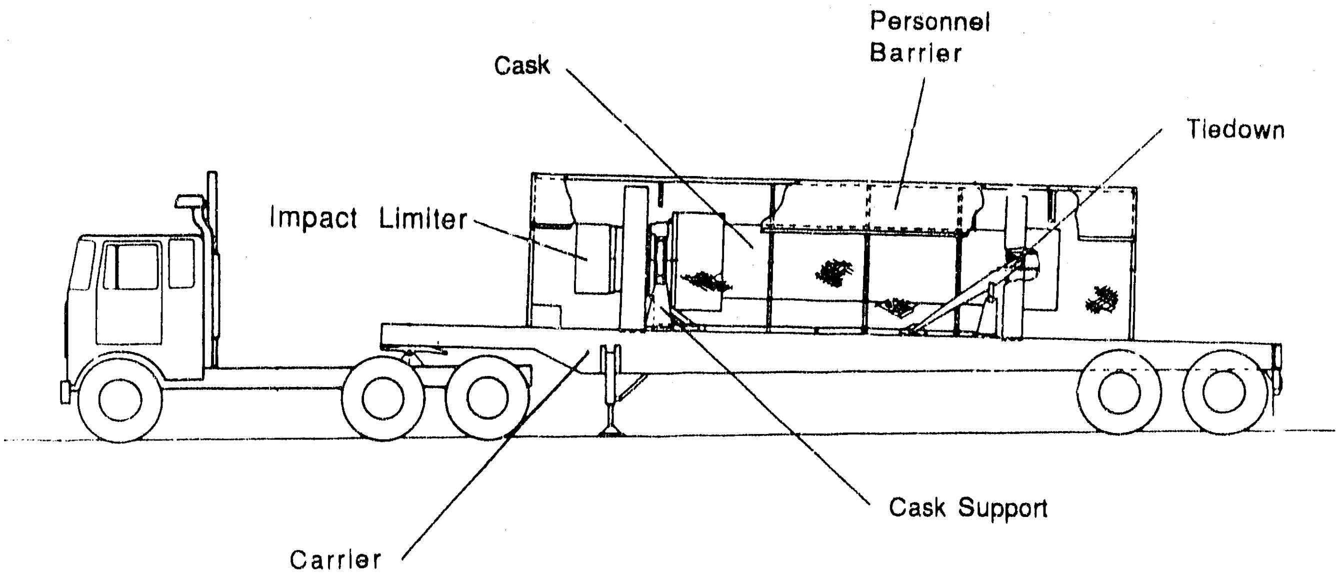


Figure 2-1. Schematic of a Typical Transportation Cask System
Source: DOE (1978)

Structural members on the carrier support the cask at the two pairs of cask trunnions (described in Subsection 2.2.2.2) located at each end of the cask body. Tiedown mechanisms secure the cask to the supports on the carrier at each cask trunnion. A typical cask tiedown arrangement is illustrated in Figure 2-2.

2.2.?.2 Reference Cask Design Features

Two types of spent fuel casks are shown in Figures 2-3 and 2-4. Cask design features referred to in this study are described below. A spent fuel cask typically consists of three types of components:

- o Cask containment and shielding components
- o Components to hold the waste form in position
- o Other miscellaneous components

Cask Containment and Shielding Components. This category comprises the cask body, the closure head(s), and the valved penetrations.

Cask Body. The spent-fuel cask body typically is of double-shell construction. The inner shell (typically stainless steel and/or lead) provides shielding for gamma radiation; the outer shell (polyethylene, or resin) provides shielding for neutron radiation. The inner and outer surfaces of these casks (from reactor facilities) are required to be smooth to facilitate decontamination, as specified in DOE (1986c).

Closure Head(s). The shielded closure head provides containment of the spent fuel in the cask cavity. The closure head is usually constructed of stainless steel with a uranium

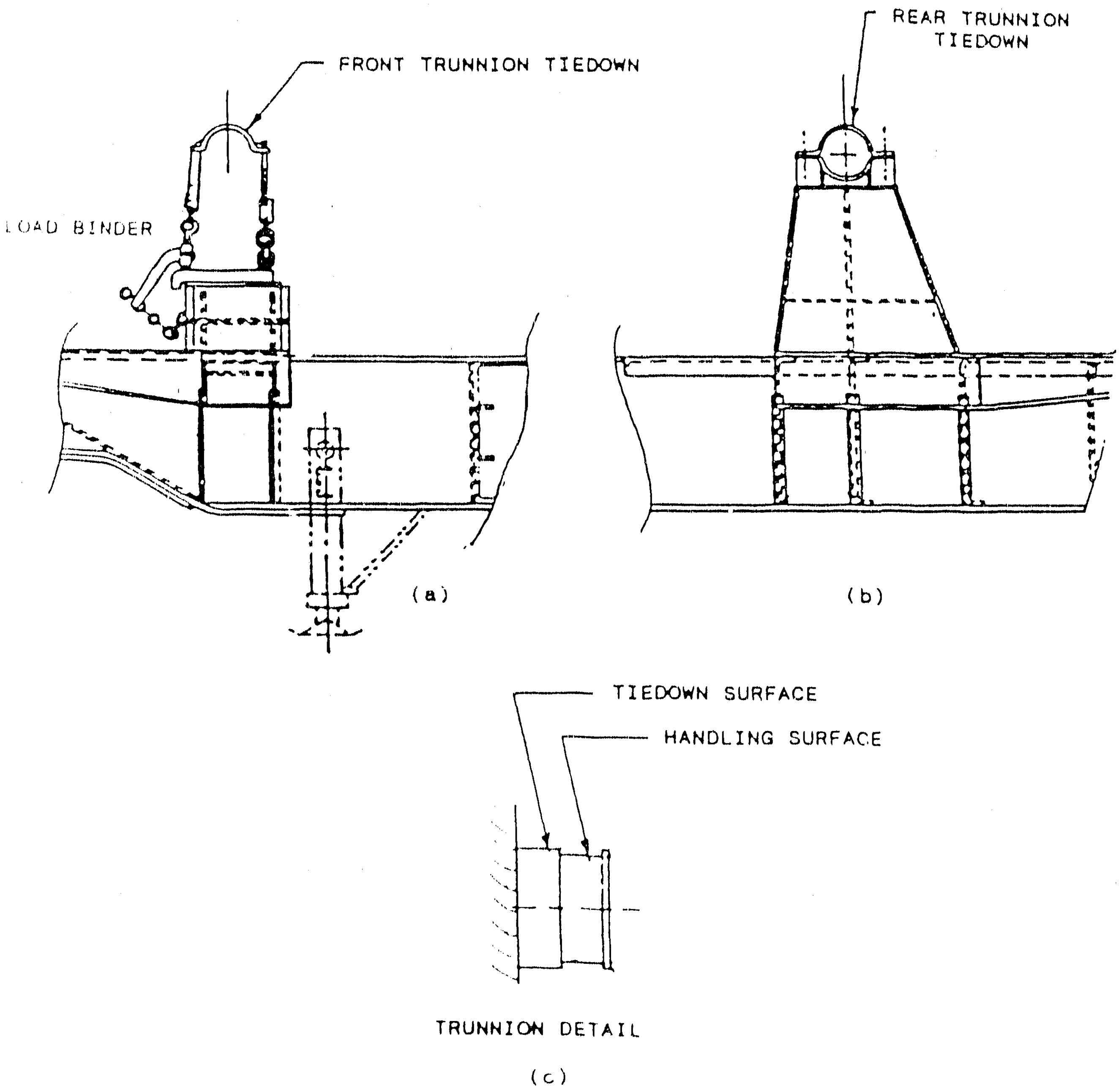


Figure 2-2. Typical Cask Tiedown Arrangement
Source: TN (1988)

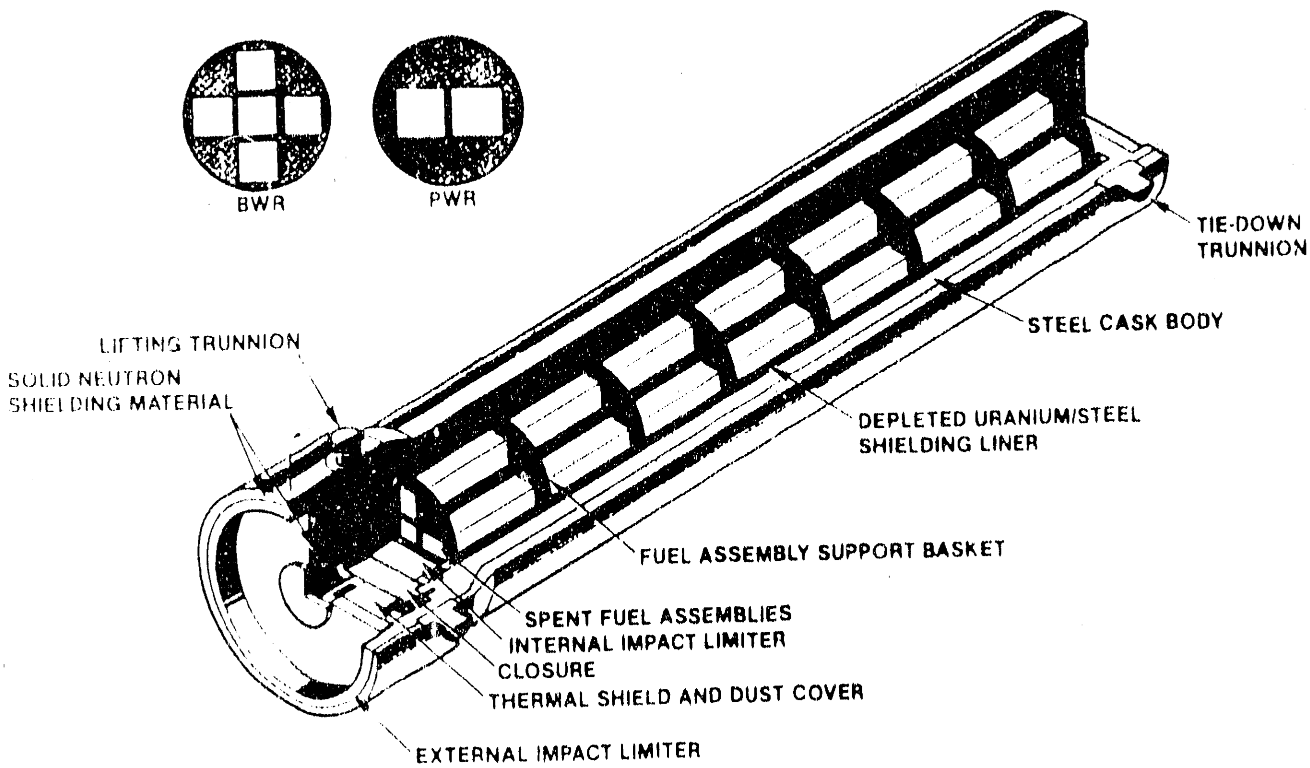


Figure 2-3. Spent Fuel Transportation Cask, Single-Containment Configuration

Source: DOE (1988)

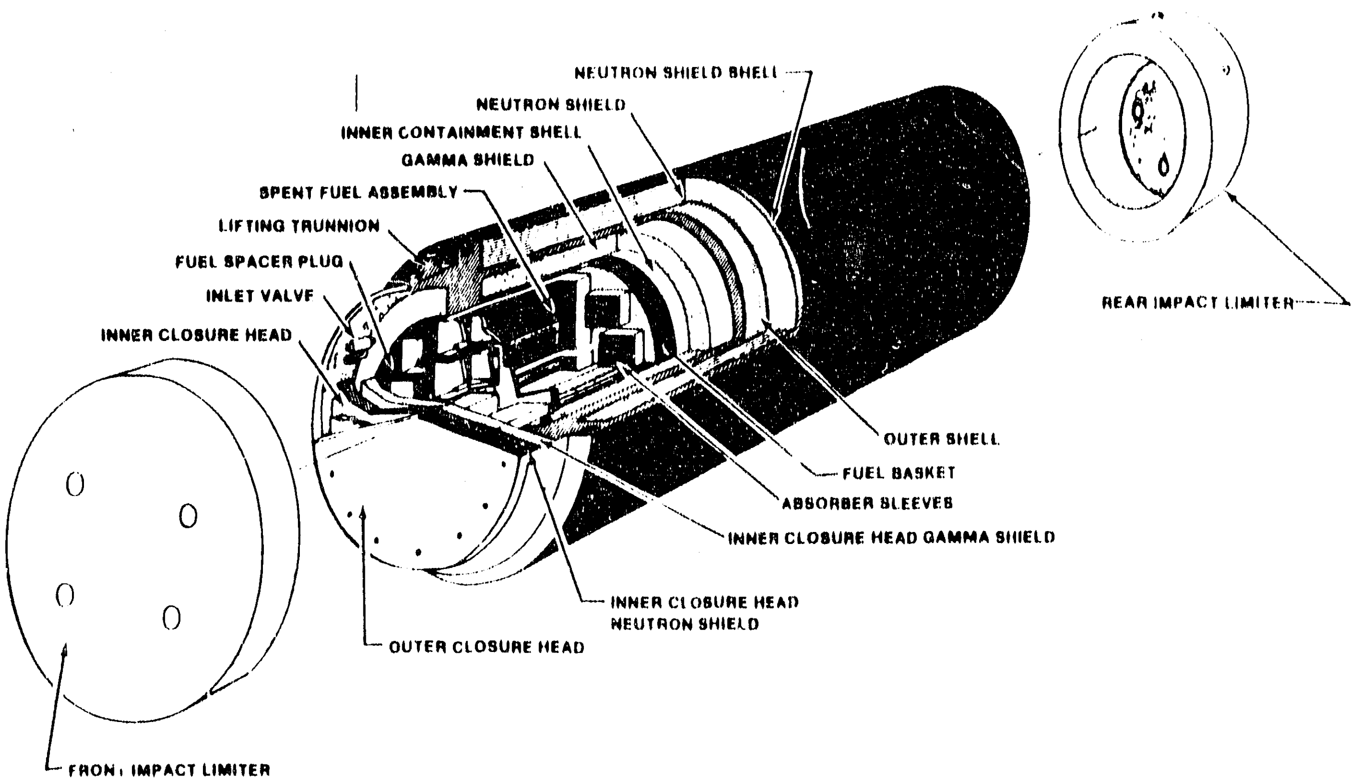


Figure 2-4. Spent Fuel Transportation Cask, Double-Containment Configuration

Source: DOE (1986a)

inner core for radiation shielding, and is fastened to the cask body either by bolts or by a combination of nuts and threaded studs. In general, there are threaded inserts (helicoils) in the cask body to accommodate the bolts or studs and thus prevent damage to the cask body.

O-ring(s) form a leaktight seal between the closure head and cask body. The O-rings are typically held to the inside of the closure head by grooves and/or retaining clips. Metal or elastomer-type O-ring seals are commonly employed on shipping casks currently used in the U.S. (NAC, 1988; TN, 1988; Warrant, 1989). Because the seals lose their ability to keep the primary containment leaktight after several uses, they must be periodically replaced. Some cask designers suggest replacement of seals for every loaded shipment; others suggest replacement for every 5 and even up to 15 loaded shipments (NAC, 1988). For purposes of this report, closure head seals are assumed to require replacement at the repository on a nonroutine basis.

Some casks currently used in the U.S. incorporate a double-containment configuration (Johnson, 1988) consisting of an inner closure head for primary containment and an outer closure head for secondary containment. Figure 2-3 shows a single-containment cask configuration; Figure 2-4 shows a double-containment cask configuration. This study assumes that the reference casks have double containment. (Casks with single containment will require fewer operations, so the recommended cask-handling concepts will accommodate both types of casks.)

Valved Penetrations. Valved penetrations through the cask closure head(s) are typically provided for gas-sampling, flushing, venting, and leak-testing the containment(s). The valves are usually equipped with seals similar to those furnished for the closure head. Like the closure head seals, these valve seals must be replaced periodically (NAC, 1988; TN, 1988).

Components to Hold the Waste Form in Position. This category comprises the fuel basket and fuel spacers.

Fuel Basket. The internal cask cavity (or primarycontainment) of spent fuel casks is typically designed to accommodate a removable fuel basket for carrying fuel assemblies. Baskets are designed to accommodate either pressurized water reactor (PWR) type assemblies or boiling water reactor (BWR) type assemblies; the cross-sectional dimensions of the two types of assemblies differ. Fuel baskets are usually constructed of aluminum, with some designs incorporating a neutron-absorbing material for criticality control (Johnson, 1988). Although the rail casks transporting spent fuel from reactor facilities are required to have removable and interchangeable fuel baskets, truck casks may be designed specifically for one type of fuel (DOE, 1986c). For the purpose of this study, truck casks designed for use in the federal waste management system are assumed to have removable and interchangeable fuel baskets.

Fuel Spacers. Another component associated with the spent fuel cask cavity is the fuel spacer. The fuel spacer supports the fuel assemblies axially inside the fuel basket during cask transport and handling. There are different fuel spacer lengths for different lengths of fuel assemblies. Individual spacers, mounted to the fuel spacer assembly plate, support fuel assemblies in each channel of the fuel basket. In most current cask designs, the fuel spacer assembly is bolted to the inside of the closure head. A typical fuel spacer assembly is illustrated in Figure 2-5.

For casks being designed to transport fuel from reactors, DOE (1986c) states that "fuel spacers should be provided in the basket if necessary to position shorter fuel assemblies near the basket entrance." Because of the problems experienced with fuel spacers located in the bottom of the basket, as discussed by Schmid (Appendix A-1), this study assumes the fuel spacer assembly to be attached to the underside of the closure head.

Miscellaneous Components. This category comprises the trunnions and the impact limiters.

Trunnions. As shown in Figures 2-3 and 2-4, a pair of trunnions is located near each end of the cask body. The cask is supported and secured to the carrier frame at each trunnion during transport. For cask handling, a specially designed lift rig (or yoke) engages the pair of trunnions located near the head end of the cask. Some cask designs have four lifting trunnions (spaced 90° apart in the same plane) for redundant lifting systems. DOE (1986c) requires that from-reactor casks incorporate this design feature. Redundant lifting methods are assumed to be required for cask handling at the repository. A typical redundant lifting yoke is illustrated in Figure 2-6 (NAC, 1988). The two trunnions located near the base of the cask are used as the pivot points for rotating the cask to the vertical position when unloading the cask from the carrier (or to the horizontal position when loading the cask onto the carrier).

Impact Limiters. The impact limiters are usually bolted to each end of the assembled shipping cask. The structures are designed to soften the impact resulting from a 30 ft drop on an unyielding surface in order to meet the requirements of 10 CFR 71 (NRC, 1986). Typical impact structures are constructed of balsa wood enclosed in an aluminum weldment. Some casks, such as General Electric's IF-300, integrate the impact limiters into the cask body (NRC, 1979). Impact limiters of this design are termed "nonremovable." It is assumed that casks to be received at the repository will have removable impact limiters, as illustrated in Figure 2-4.

2.2.2.3 Additional Reference Cask Features

DOE (1986c) gives preliminary cask physical performance specifications and cask interface guidelines, which are assumed to be applicable to all casks in the waste management system. DOE (1986c) does

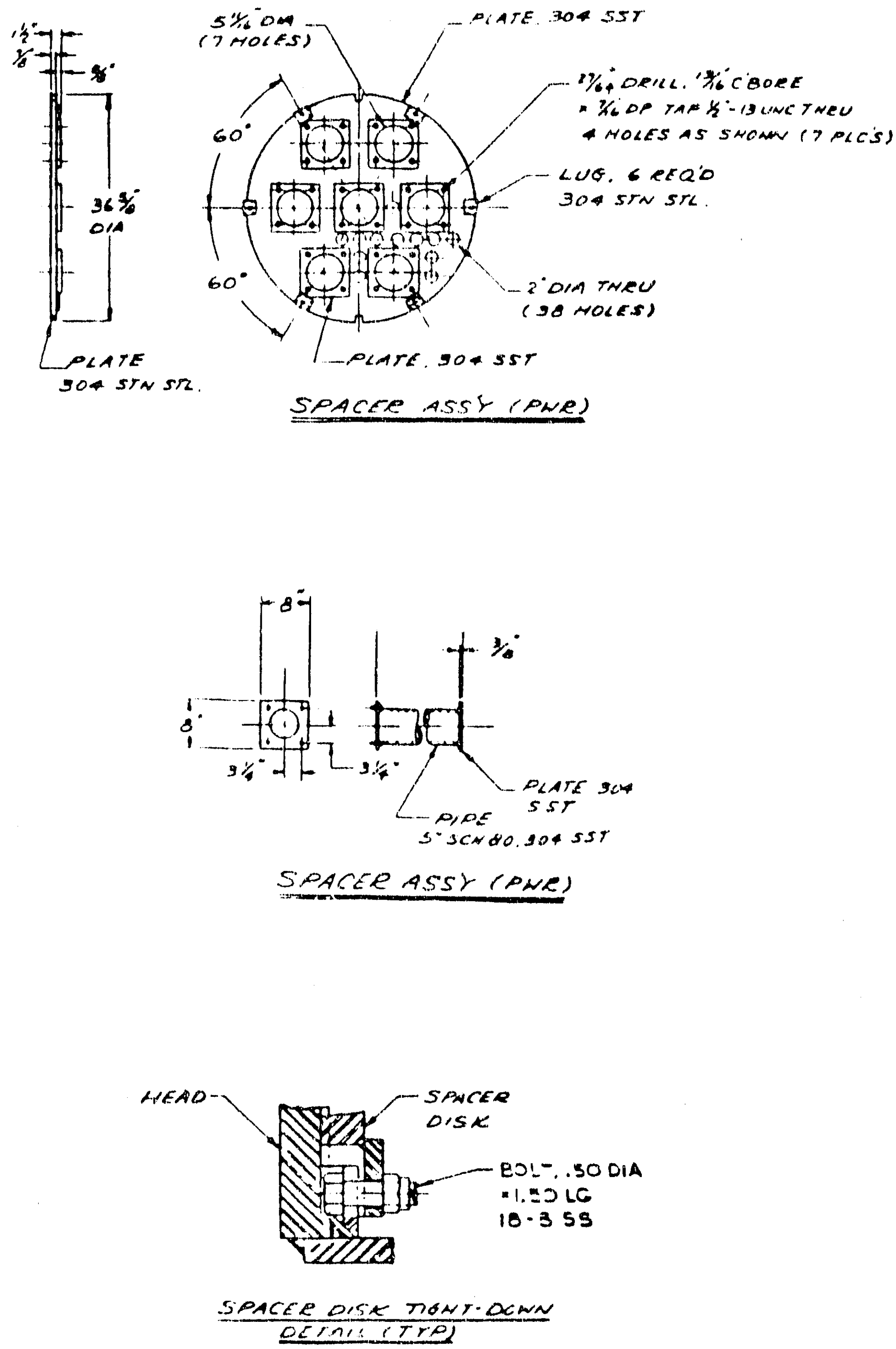


Figure 2-5. Typical Cask Fuel Spacer Assembly

Source: NRC (1979)

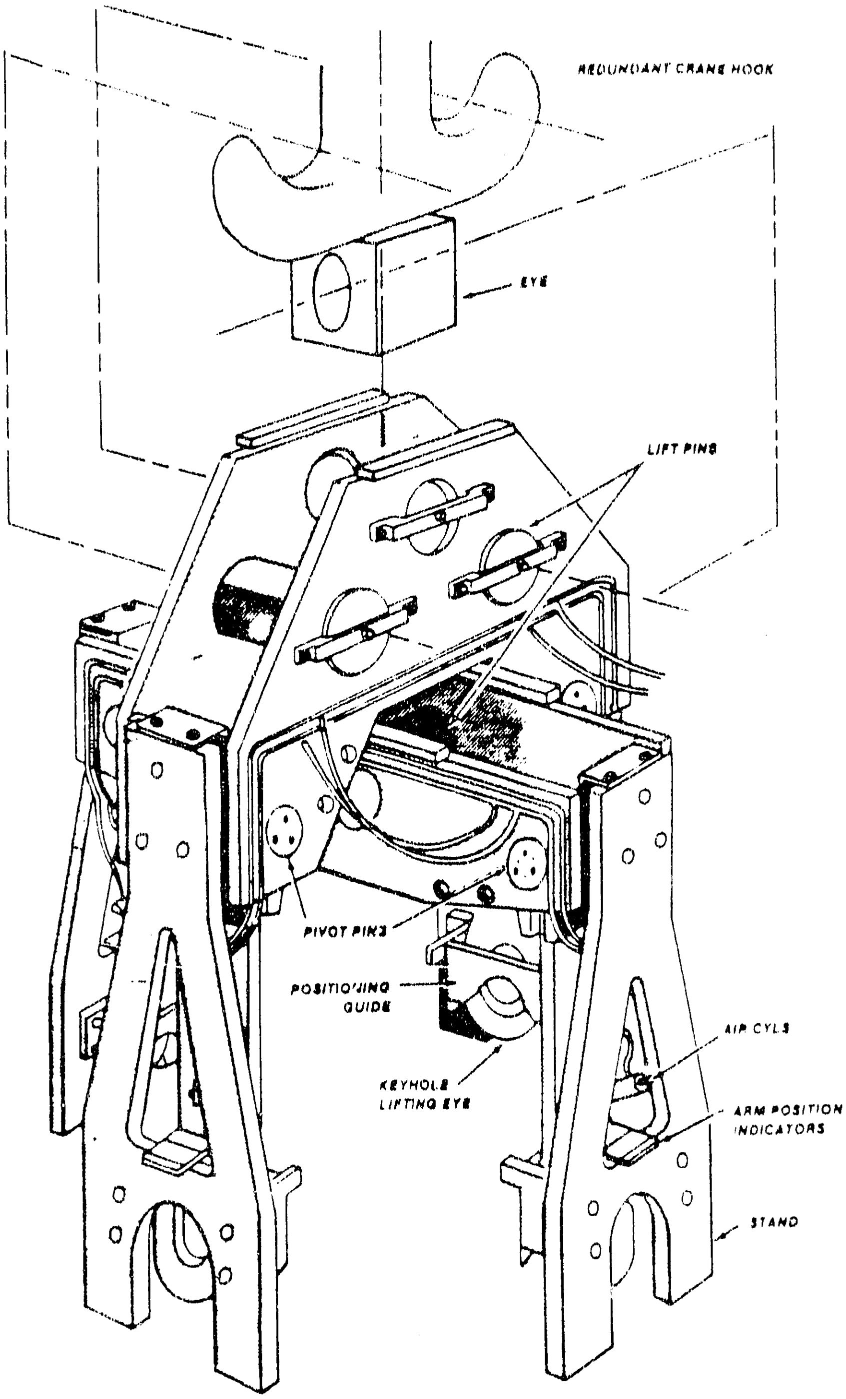


Figure 2-6. Redundant Type Cask Lifting Yoke

Source: NAC (1988)

not specify the details of the cask designs, but does identify several important characteristics that affect the conceptual design of the cask-processing facilities at the repository. These characteristics include size and weight limits, standardized cask features, and component interchangeability between casks of the same design. Reference cask size and weight limits are presented in Table 2-1.

Standardization of cask features increases cask interface operational efficiency and limits the amount of interface equipment for processing casks throughout the waste management system. Items for standardization (within a given weight class or specific operation) given in DOE (1986c) are as follows:

- o Gas sampling and containment verification methodology
- o Trunnion sizes and configuration
- o Release mechanisms for tiedown and attachment to carrier
- o Sizes and types of connections and backup closures for gas and/or liquid penetrations
- o Head (lid) fastener configuration and sizes

Component interchangeability between casks of the same design reduces the need for spare parts, reduces spares storage requirements for spare parts, and increases cask availability. DOE (1986c) requires the following components to be interchangeable between casks of the same design:

- o Fuel baskets
- o Fuel spacers
- o Removable impact limiters
- o Valves and valve covers

TABLE 2-1

CASK SIZE AND WEIGHT LIMITS

Cask Type	LWT[a]	100-Ton Rail/Barge	125-Ton[b] MRS-to-Repository
Cask diameter, max[c]	6 ft	8.5 ft	10 ft
Cask height, max[d]	18 ft	18 ft	18 ft
Crane hook load, max[e]	25 tons	100 tons	125 tons

Source: DOE, 1986c

a. LWT = legal-weight truck.

b. MRS-to-repository cask dimensions are assumed.

c. Excluding removable impact limiters.

d. Assumed; corresponds to "loading height" in DOE (1986c).

e. Gross weight of cask and lifting equipment.

- o Seals
- o Fittings and connectors
- o Lifting gear (for specific cask type)
- o Bolts/threaded inserts and similar hardware
- o Auxiliary equipment

2.3 Assumptions

The major assumptions that serve as the bases for the cask-processing operations (specifically decontamination and maintenance) at the repository are discussed below.

2.3.1 Cask Fleet Size

The conceptual design of the facilities for cask decontamination and maintenance is based on an assumed cask fleet size of 145 casks for shipment of spent fuel from reactor facilities to the repository. This fleet consists of 130 truck casks and 15 rail casks. The cask fleet size is estimated on the basis of the spent fuel cask throughput rates presented in SNL (1987) in conjunction with estimated times for transportation and cask turnaround at the reactor facilities and repository.

2.3.2 Central Cask Maintenance Facility (CMF)

A stand-alone central cask maintenance facility (CMF) site is assumed to exist in the federal waste management transportation system. The CMF is located on a site in which the land is owned by DOE, but no other government-owned facility is available to share in the cost of providing any service or utility (Attaway, 1988). The primary function of the CMF is to perform cask Certificate of Compliance (CoC) testing

Attaway, 1988). Other functions of the CMF include servicing, maintenance, repair, modifications, and configuration control of all cask system elements (Attaway, 1988).

2.3.3 Cask Maintenance at the Repository

The repository should efficiently prepare and dispatch casks for return to the external transportation system. This may necessitate certain cask maintenance operations. Although a central CMF is assumed to be a part of the federal waste transportation system, in some cases, casks may not need to be sent to the CMF if maintenance could be performed at the repository. Additionally, cask components may become damaged or worn to the extent that transportation or further handling of the cask is not safe.

For this study, it is assumed that the repository will have the capabilities of performing minor maintenance operations on transportation casks in order to increase cask availability and transportation system efficiency. Minor maintenance operations are considered to include replacing cask removable components (described in Section 2.2.2.3) that are damaged or require replacement because of wear and tear. Cask maintenance operations to be conducted at the repository are discussed in Subsection 3.4.4.

2.3.4 Cask Reconfiguration

The cask internal structures will need to be changed periodically to adapt the casks to different fuel types (PWR and BWR) and lengths. This function can vary from changing fuel spacers for the shipment of different-length fuel to a complete basket changeout for the shipment of a different type of fuel. Attaway (1988) indicates that a high percentage of the cask reconfigurations will involve a simple change of the fuel spacer to accommodate a change in the length of the fuel assembly. Shappert (1988) states that cask reconfiguration may occur at the reactor facilities, repository, MRS, or CMF, depending on the scope of reconfiguration and logistical considerations.

Because casks are processed through the repository in each shipment, this study assumes that the repository will be capable of performing the cask reconfiguration function of fuel spacer changeout. Major cask reconfiguration tasks requiring fuel basket changeout are assumed to be performed at the CMF; the repository will provide limited capabilities for fuel basket changeout to meet the requirements of DOE (1986a), stated in Subsection 2.1.2.

Casks are assumed to require fuel spacer changeout at the repository about twice annually. Therefore, based on the assumed cask fleet size indicated in Subsection 2.3.1, the repository would need to perform fuel spacer changeout operations on about 260 truck casks and 30 rail casks annually. The frequency of the fuel spacer changeout at the repository is highly dependent on transportation system scheduling and cask fleet size, and should be addressed in future studies as reconfiguration requirements are further defined. Repository reconfiguration operations are discussed in more detail in Subsection 3.4.5.

2.3.5 Decontamination of the Cask Interior

As discussed in Subsection 2.1.2.2, DOE (1986a) states that the inner cavities of unloaded casks shall be decontaminated to 2,200 dpm/cm^2 for beta-gamma emitters and 220 dpm/cm^2 for alpha emitters, prior to returning the casks to the external transportation system. This requirement has been a subject of great controversy (see paper by Pope and Rawl in Appendix E of Rennich, 1988). Extensive cask disassembly and decontamination operations would be required to meet these limits. This would significantly increase cask turnaround time at the repository and could result in significant occupational radiation exposures. Additionally, it is even questionable whether it is possible to verify that contamination levels in the cask cavity will remain

3.0 CASK-PROCESSING OPERATIONS

This section identifies the operations necessary to meet the functional requirements and performance criteria for processing transportation casks at the repository. Cask-processing operations are described in order to identify where and when decontamination and maintenance tasks need to be performed and to furnish a background for these tasks. Cask decontamination and maintenance operations are identified to provide a basis for the conceptual design of the associated facilities, described in Sections 4.0 and 5.0.

Cask-processing operations at the repository can be divided into five general categories:

- Receiving
- Cask preparation for fuel unloading
- Fuel unloading
- Cask preparation for shipment offsite
- Shipping

Cask-processing operations (e.g., cask preparations and maintenance) are usually dictated by the cask Certificate of Compliance (TN, 1988). The operations described in this section apply to the reference cask system described in Subsection 2.2, and are identified on the basis of the reviews and surveys of cask-handling experience at nuclear facilities and other repository design requirements discussed in Section 2.0.

3.1 Receiving

There are four major cask-receiving operations:

- Inspection of the shipment

- Removal of the ancillary equipment
- Survey of radiological conditions of the cask
- Unloading the cask from the carrier

A functional block flow diagram of these major cask receiving operations, along with their associated tasks, is shown in Figure 3-1. A discussion of these operations is given below.

3.1.1 Inspection of the Shipment

Upon arrival at the repository site, the incoming shipment undergoes a series of preliminary inspections, including a review of shipping documentation, a radiological inspection, and a visual inspection for contraband and for damage that may have occurred during transport.

3.1.1.1 Review of Shipping Documentation

The shipping papers required by DOT (1986), per 49 CFR 172.200 through 172.205, are reviewed to verify that the shipment is proper and that pertinent radiological information is included in the shipping documentation. The shipment is then admitted to the admittance and inspection area.

3.1.1.2 Radiological Inspection

In accordance with 10 CFR 20.205 (NRC, 1986), the shipment is promptly inspected (within 3 hr of arrival during working hours and within 18 hr of arrival during off hours). The inspection includes both a radiation and contamination survey of the transport system for compliance with the requirements of 49 CFR 173.441 and 173.443, respectively (DOT, 1986). If these requirements are not met, the NRC must be notified, per 10 CFR 20.205 (NRC, 1986). If there are any significant problems

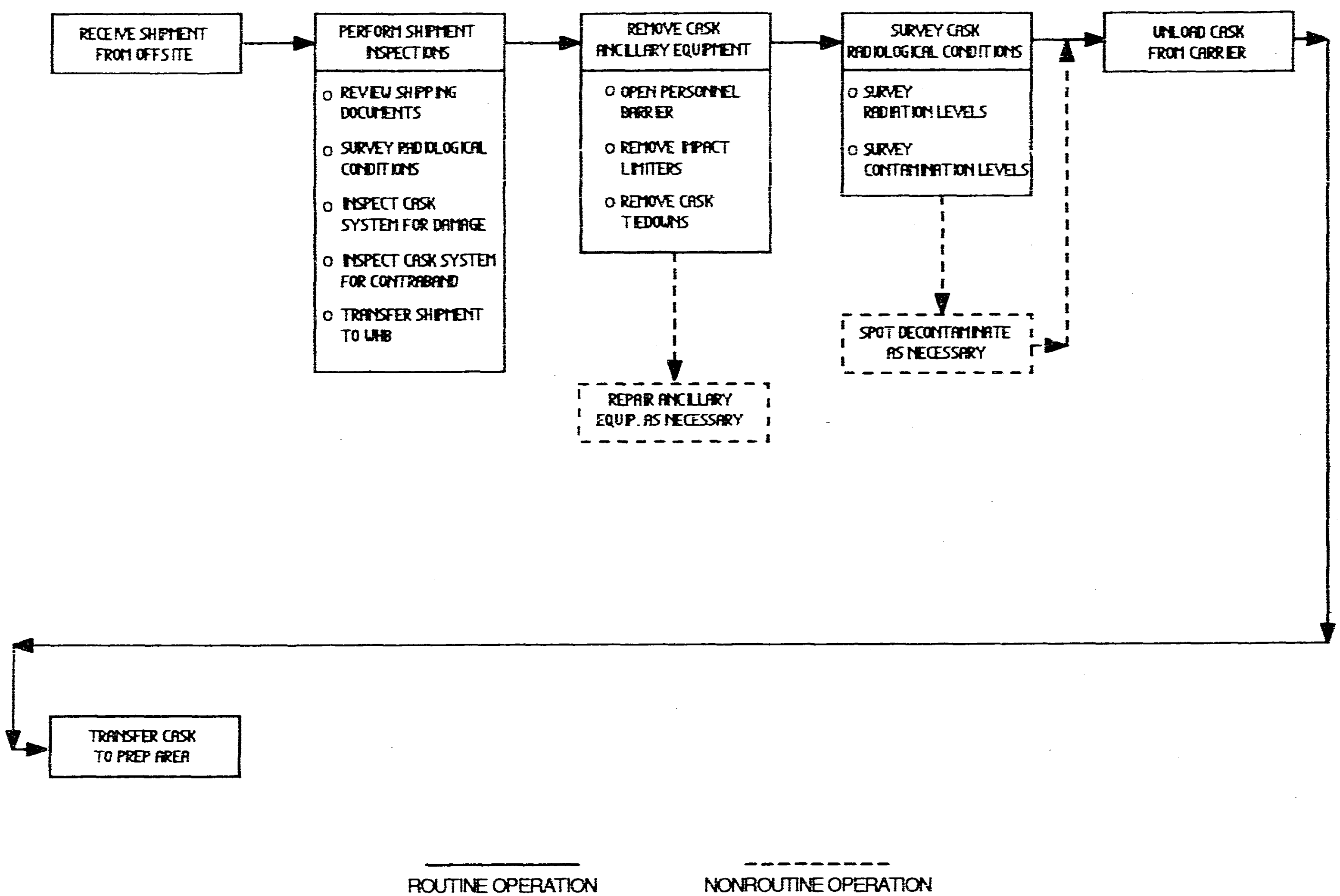


Figure 3-1. Functional Block Flow Diagram - Receiving

with contamination of the shipment (very infrequent and unusual circumstances), the affected areas would be covered or contained and the cask transferred to the WHB for corrective action.

3.1.1.3 Visual Inspection

The shipment is visually inspected for contraband (DOE, 1986a) and damage. If contraband is found or if any other security problems are identified, necessary corrective actions are taken on the spot. Should any of the cask system components be damaged, the components are identified for remedial action (e.g., maintenance). Minor maintenance will be performed at the repository and major maintenance at the CMF.

3.1.2 Removal of Ancillary Equipment

After the preliminary inspections have been completed, the cask is transferred to the WHB, where the cask system ancillary equipment is removed so that the cask can be removed from the carrier. The ancillary equipment includes the personnel barrier, impact limiters, and cask tiedowns. Methods and equipment required for performing the operations depend on the design of the ancillary equipment. The operations for removal of ancillary equipment are described below and are based on the reference equipment design presented in Subsection 2.2.2.

The security seals on the personnel barrier are inspected for tampering and then removed. The personnel barrier fasteners are released, and the personnel barrier is opened to access the cask.

Once the personnel barrier has been opened, the security seals on the impact limiters are inspected and removed. The impact limiters are unbolted, removed from each end of the cask, and stored. DOE (1986c) states that the carrier design should have provisions for the storage of the impact limiters, thus reducing the storage area requirements of the receiving facility. Because of this requirement, impact limiters are assumed to be stored on each end of the carrier.

The cask tiedowns, which secure the cask to the carrier at the trunnions, are subsequently released to allow the cask to be removed. This operation usually consists of removing a specific number of bolts and releasing load binders at each trunnion (as described in Subsection 2.2.2).

The ancillary equipment is visually inspected for damage as the components are removed. Repairs to any damaged ancillary equipment can be performed in the WHB while the cask is being unloaded. Significant damage may warrant dispatching the equipment to the CMF for remedial action.

Eger (1979) tabulates some of the types and frequencies of repairs that were needed for transport vehicles during spent fuel shipments to GE-Morris. These repairs were needed only infrequently (about 1% of the shipments) and typically included minor tasks such as replacement of broken bolts and fasteners.

Robotic methods for removing (or displacing) ancillary equipment have been proposed and researched and are being developed and demonstrated (Strip, 1987; Yount, 1984; Berger, 1986). Because the ancillary equipment is located close to the loaded cask, robotic handling has the potential to significantly reduce occupational radiation exposures. DOE (1986c) states that the cask tiedowns and impact limiters should be compatible with contact, remote, and remote-automated handling methods. Features required to facilitate robotic removal of ancillary equipment are discussed by Griesmeyer (1988).

3.1.3 Survey of Radiological Conditions of the Cask

A radiological survey of the cask exterior surfaces is usually performed prior to unloading the cask from the carrier. The survey consists of measurements of direct radiation and removable surface contamination and is performed to meet the requirements of 49 CFR 173.441 and 173.443, respectively (DOT, 1986). Additionally, the survey determines if the cask needs to be decontaminated prior to further handling.

Some transportation casks received at the repository may be slightly contaminated on their exterior surfaces, as discussed in Subsection 3.2.1. For "exclusive use" shipments of radioactive materials, 49 CFR 173.433(b) (DOT, 1986) states that the removable (nonfixed) radioactive contamination on any package at any time during transport shall not exceed 220 dpm/cm^2 for beta-gamma emitters and 22 dpm/cm^2 for alpha emitters, when averaged over an area of 300 cm^2 (DOT, 1986). If the contamination survey indicates that these limits are exceeded, the incident must be reported to NRC, as stipulated in 10 CFR 20.205 (NRC, 1986).

In addition to meeting the above requirements, the contamination and radiation surveys identify whether it is necessary to take corrective action (e.g., decontamination) or preventive measures to limit the spread of contamination and reduce operational exposures prior to further handling of the cask. Decontamination operations that may be required are discussed in Subsection 3.2.1. If high radiation levels are detected, manual operations near the affected areas are controlled to reduce occupational exposures.

A contamination survey of the impact limiters, where they interface with the cask body, is also performed (Schilthelm, Appendix A-2). If necessary, the contaminated surfaces are decontaminated by manually wiping the affected areas.

At spent fuel-handling facilities operating in the U.S., the contamination survey is performed manually. Typically, most of the swipes are taken at predetermined locations, and the remaining are taken at random locations. The swipes are analyzed and the results obtained. The contamination survey can take two operators from 1 to 2 hr (Appendix A). Because the repository will perform this operation a significant number of times and the operation requires close proximity to the cask (if performed manually), remote or remote-automated methods have the potential for significantly reducing occupational radiation exposure.

Application of robotic methods for performing the operation is under development (Griesmeyer, 1988). The Remote Radiation Survey and Analysis System (RRSAS) Program at Sandia National Laboratories was initiated in January 1986 to investigate robotic performance of the visual inspection, contamination survey, and radiation survey of cask systems (Griesmeyer, 1988). A conceptual design of an RRSAS for conducting the radiological survey is illustrated in Figure 3-2.

Any decontamination before unloading would most likely be limited to parts of the cask that are contacted by handling equipment. Decontamination of these areas would be desirable, depending on the levels of contamination, to prevent contaminating the cask-handling equipment and to minimize the potential for subsequently spreading contamination. Based on the information presented in Subsection 3.2.1, decontamination is not expected to be routinely needed before the cask is removed from the carrier. If it is needed, the decontamination will most likely involve only a manual wiping of the trunnions.

3.1.4 Unloading the Cask from the Carrier

Once the results of the radiological survey have been evaluated and any corrective measures that may be required while the cask remains on the carrier have been completed, the cask is ready to be removed from the carrier. A cask lifting yoke is attached to a crane, which is then positioned over the cask head end. The yoke is lowered to the cask and attached to the cask lifting trunnions. The crane then rotates the cask to a vertical position, lifts it free of the rear cask supports, and transfers it to the facility where cask preparation takes place.

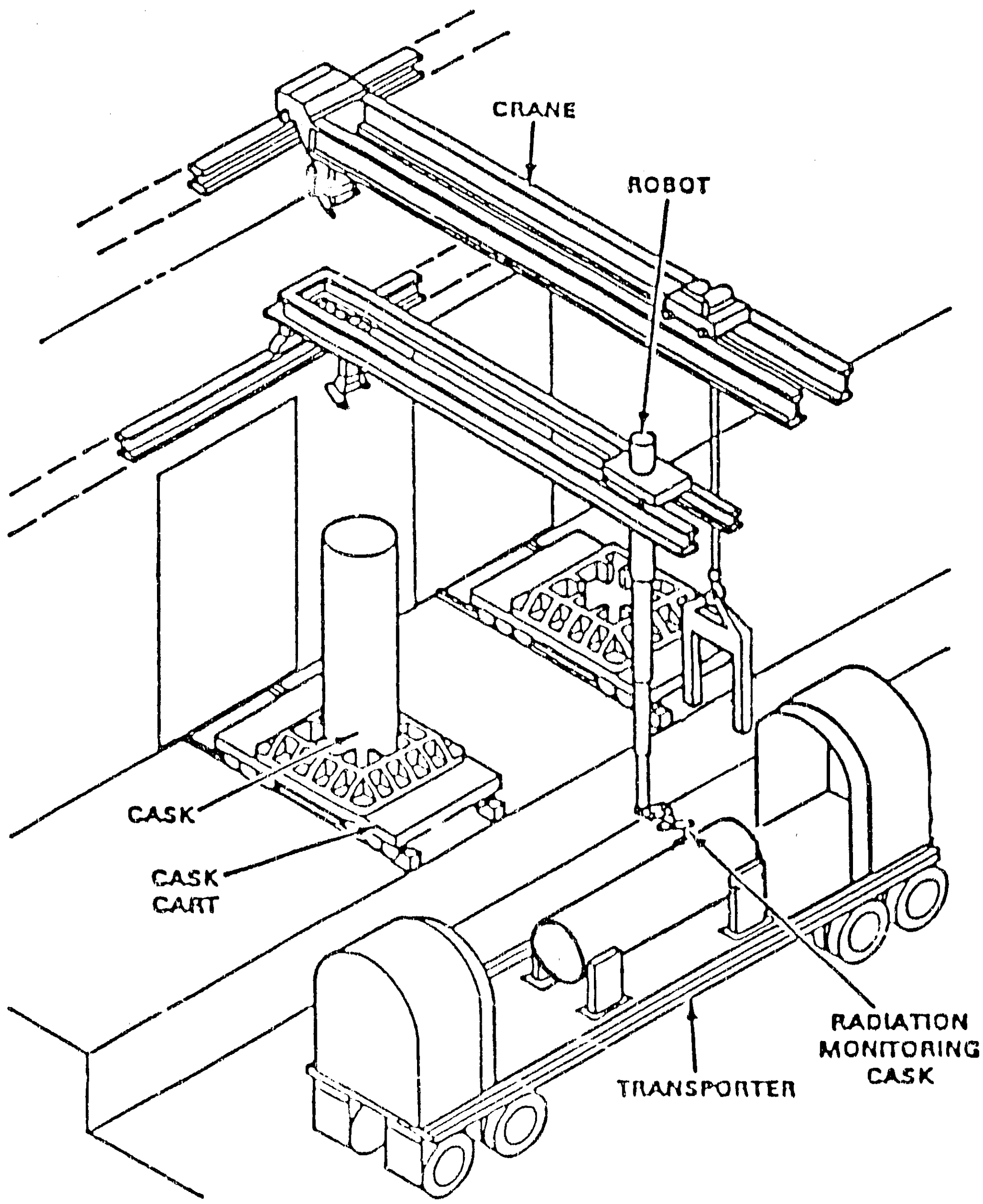


Figure 3-2. Conceptual Design of the Remote Radiation Survey and Analysis System (RRSAS)

Source: Griesmeyer, 1988

3.2 Cask Preparation for Fuel Unloading

The major operations for cask preparation for fuel unloading are decontamination of the cask exterior (if necessary) and sampling the cask cavities (which involves removing the outer lid). Recommended operations at the repository are based on operational experience with cask preparation for fuel unloading at waste-handling facilities. A functional block flow diagram of the recommended operations for preparing the cask for fuel unloading is presented in Figure 3-3. These operations are discussed below.

3.2.1 Decontamination of the Cask Exterior

If a cask is significantly contaminated when received, its exterior may have to be decontaminated to prevent the spread of contamination during further cask-handling operations. The contamination survey, as discussed in Subsection 3.1.3, determines the need for this decontamination. Operational experience with contamination of casks received at spent fuel-handling facilities is used to provide a basis for cask decontamination operations at the repository.

Past experience indicates that casks received at waste-handling facilities are usually not significantly contaminated. Kennedy (1981) reported that 5 out of 48 (about 10%) spent fuel shipping casks surveyed were contaminated to levels exceeding the maximum allowable limits for transportation of 220 dpm/cm^2 beta-gamma and 22 dpm/cm^2 alpha (DOT, 1986). Schmid (Appendix A-1) indicated that only 1 in 120 shipments exceeded the above contamination limits. On the small fraction of casks received at waste-handling facilities, the contamination was typically limited to localized areas (Appendix A). Mullen (Appendix A-4) indicated that contamination of NLI 1/2 casks received at Idaho National Engineering Laboratory's Test Area North (INEL-TAN) facility was limited to areas on and around the trunnions, with occasional slight contamination on the upper and lower surfaces of the cask

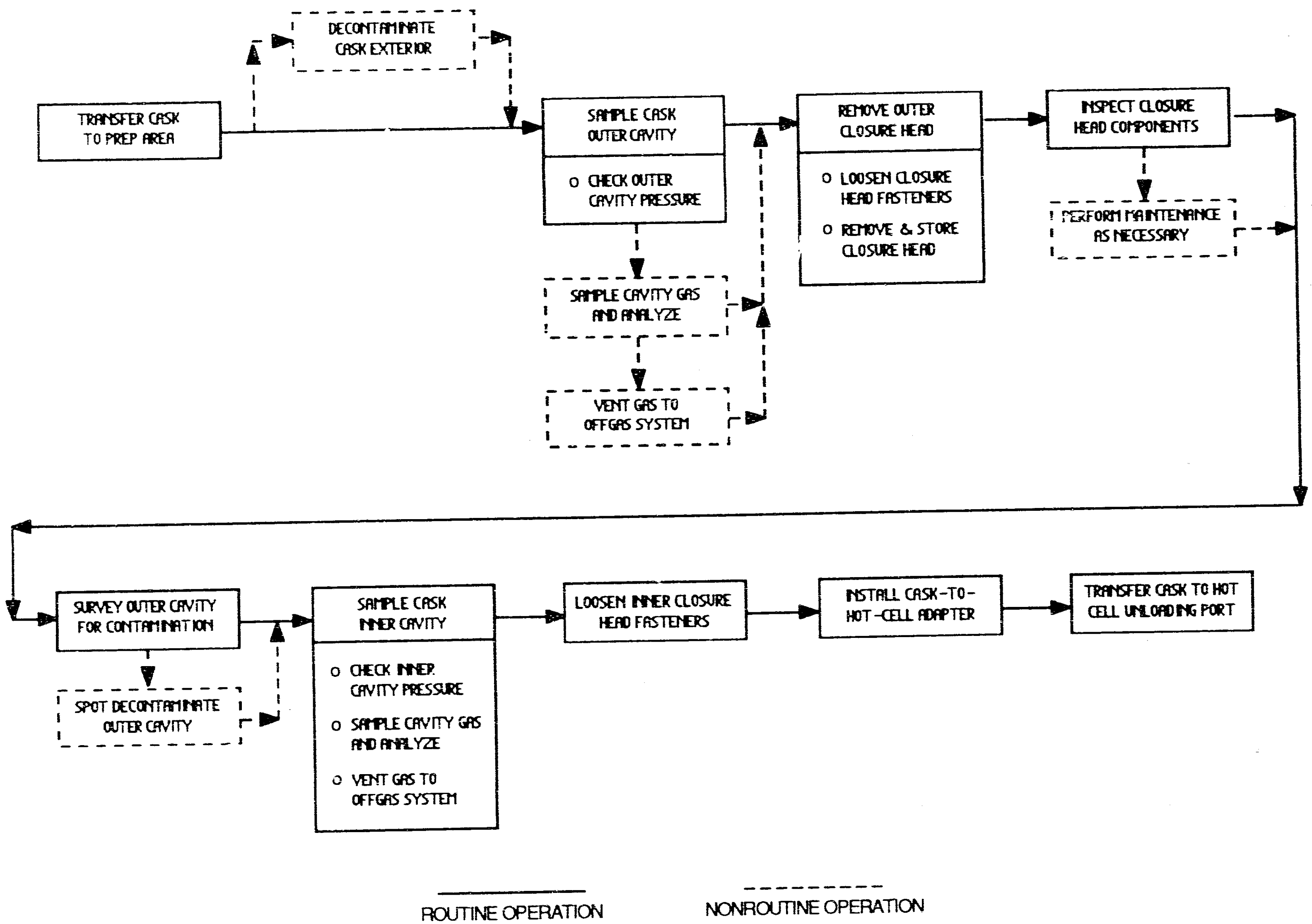


Figure 3-3. Functional Block Flow Diagram - Preparation For Fuel Unloading

body. These areas are not covered by the protective inflatable shroud used during the cask loading operations in nuclear power plant spent fuel pools.

Although the levels of contamination on a small fraction of casks received at waste-handling facilities have exceeded the transportation limits, these levels do not necessarily indicate the need for immediate decontamination (prior to further cask handling). In the facilities surveyed in Appendix A, casks were seldom decontaminated prior to fuel unloading. Exterior decontamination of casks received at Idaho National Engineering Laboratory's Idaho Chemical Processing Plant (INEL-ICPP) is seldom performed and, when it is, it is typically limited to wiping any local hot spots on the casks (Denny, Appendix A-5).

On the basis of the above experience and repository requirements, decontamination of spent fuel casks prior to unloading at the repository is expected to be a nonroutine operation, and is most likely to be limited to manually wiping local areas on the cask exterior that could otherwise spread contamination during further cask handling. The areas include those that interface with tools and equipment necessary for performing subsequent cask preparation operations for fuel unloading.

On rare occasions, extensively contaminated or dirty casks may require a thorough wash and decontamination using high-pressure hot water in combination with decontamination solutions. Thorough decontamination methods are discussed in Subsection 3.4.1.

3.2.2 Sampling of the Outer and Inner Cavities of the Cask

After the cask has been removed from the carrier, transferred to the cask preparation area, and decontaminated (if necessary), the outer and inner cavities of the cask are sampled. Cask cavity sampling is typically included in cask operating procedures (Watson, 1980; Appendix A). The reasons for sampling the cask cavities are discussed below, along with the methods and experience at operating facilities. This information provides a basis for determining the appropriate methods for cask cavity sampling at the repository.

3.2.2.1 Sampling of the Outer Cavity

For casks with double containment (i.e., two lids), the volume between the inner and outer lid (outer cavity) is sampled to determine if the inner lid seal has maintained its integrity during transport. Because the operating pressure of the inner cavity in most transportation casks currently used in the U.S. is above atmospheric pressure (Johnson, 1988), the outer cavity (normally at ambient pressure) will be at elevated pressure if the inner lid seal loses its integrity (assuming that the outer lid seals don't leak). Also, if radioactive fission product gas is released from spent fuel rods, it could migrate into the cask outer cavity if the inner lid seal leaks. In such a case, removing the outer lid of the cask could result in the release of the radioactive gas into occupied areas of the cask preparation area. Therefore, the outer cavity is sampled to determine the condition of the inner seal and to prevent the potential release of radioactivity into the cask preparation area.

Operating procedures for the NLI 1/2 (NRC, 1980) and NLI 10/24 casks (double-containment configuration design) include a routine pressure check of the outer cavity prior to removing the outer closure head. The pressure check involves removing a cover plate from the outer cavity drain valve box, attaching a pressure gauge and isolation valve assembly to the drain valve, and obtaining a pressure reading (NRC, 1980). If excessive pressure exists in the outer cavity, steps are taken to obtain and analyze a sample of the cavity gas.

Obtaining a gas sample requires a sample bottle, valves, and connections that are attached to a standard connector on the cavity penetration valve assembly for withdrawing the gas sample (TN, 1988). Gas samples can be analyzed for radioactivity levels using a gamma detector and/or for isotopic inventory using a mass spectrometer (NAC, 1988). Gamma radiation readings are not considered significant unless they are in the high tens of mR per hour range (NAC, 1988). The time required to manually obtain and analyze the gas sample is typically in the range of 1/2 to 1 hr (Schiltheim, Appendix A-2; Mullen, Appendix A-4).

High gas sample activity does not preclude unloading; it indicates that problems could be encountered in removing the fuel assemblies and that special procedures may be required. If high activity is detected in the outer cavity gas sample, the gas should be vented and the cavity purged to the filtered ventilation exhaust system. Experience with cask shipments indicates that the existence of fission gas in the outer cavity of the cask is very unlikely.

Based on the above operational experience, a routine pressure check of the outer cavity of the cask will be performed at the repository. If high pressure is detected, a gas sample is taken and analyzed with a gamma detector. If high radioactivity is detected, the gas sample is further analyzed with a mass spectrometer. Because most casks shipped to other nuclear facilities have been received without high pressure in their outer cavities, obtaining a gas sample will be a nonroutine operation at the repository.

Typical cask cavity-sampling equipment is illustrated in Figure 3-4. The equipment consists of a skid that contains a vacuum pump, a motor, a filter, a vacuum gauge, and valves. Various other connectors and attachments for the cask (not shown) are also needed. Similar equipment is recommended to support cavity-sampling operations at the repository.

After the pressure check of the outer cavity (and gas sampling and venting, if required), the outer closure head is removed. Removal of the outer closure head begins with loosening the closure head fasteners (and removing them if they are not captive to the head). The closure head is removed from the cask and transferred

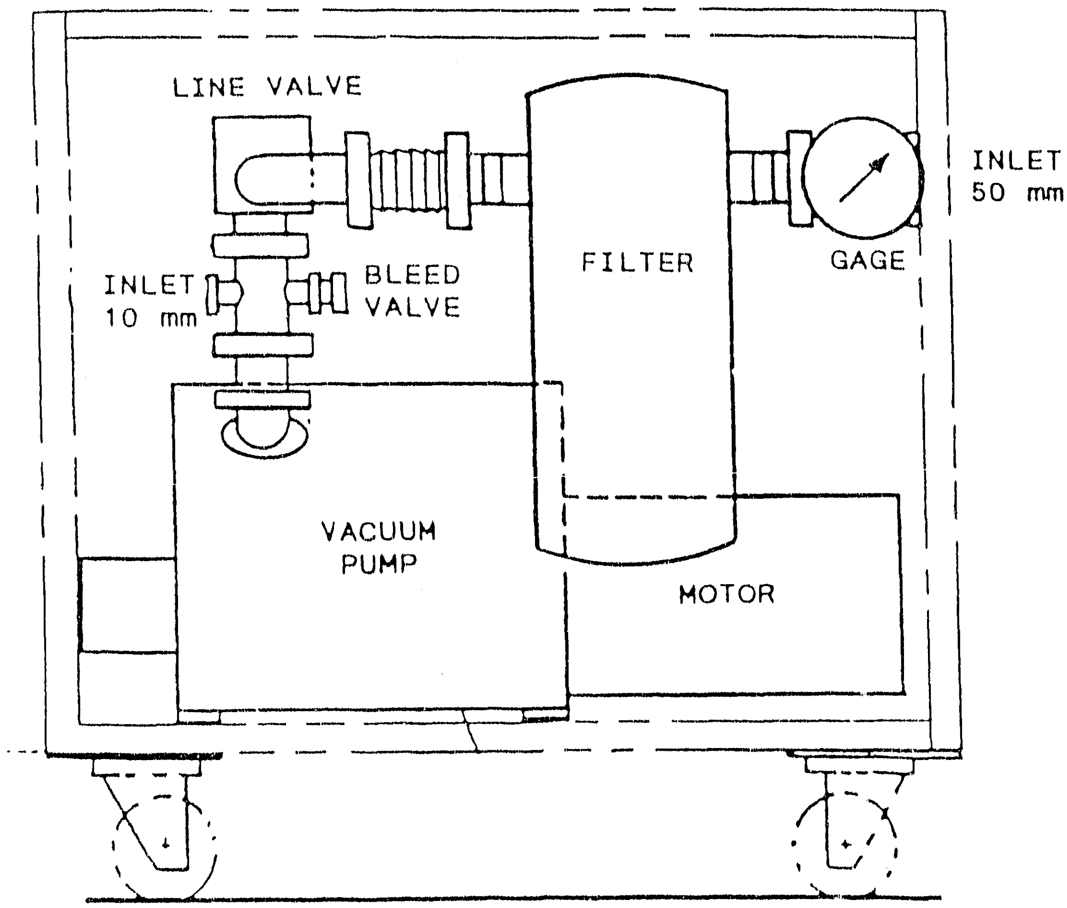


Figure 3-4. Typical Cask Cavity-Sampling Equipment

Source: TN (1988)

to storage using an appropriate lifting fixture attached to a crane. A support stand is usually provided to prevent damage to the closure head seal during storage and to allow visual inspection of the seal for wear and potential damage.

Swipes are taken in the outer cavity to determine if contamination exists (particularly in areas that are to be accessed for further operations, such as inner cavity gas sampling and loosening the inner closure head fasteners). According to Schilthelm (Appendix A-2), routine smears of the outer cavity of the NLI 1/2 indicate that the area is typically free of removable contamination.

3.2.2.2 Sampling of the Inner Cavity

With the outer closure head removed, the inner cavity penetration valves on the inner closure head are accessible for sampling the inner cavity. Sampling the inner cavity determines the general condition of the fuel prior to unloading and characterizes any radioactive gases that would be released into the unloading hot cell when the inner closure head is removed.

Since dry fuel unloading operations are proposed for the repository, operational experience at dry unloading facilities is used to determine the methods to be recommended for the repository. For dry unloading operations, inner cavity sampling routinely includes a pressure check and obtaining gas sample of the inner cavity (TN, 1988; NAC, 1988).

Elevated pressures may exist in the cask inner cavity that could be sufficient to unseat the inner closure head (after the bolts are loose) and allow an uncontrolled release of cavity gas to the cask preparation area (NAC, 1988). Therefore, if high pressures are found, the inner cavity gas is vented through a confined system to the filtered ventilation exhaust system. Before the inner cavity gas is vented, a gas sample is routinely obtained and analyzed (Mullen, Appendix A-4). Gas sampling and analysis of the inner cavity are similar to gas sampling and analysis of the outer cavity. Mullen (Appendix A-4) indicated that gas sampling and analysis at INEL-TAN typically takes approximately one hour before the operators are confident of the results and the cask cavity can be vented.

Based on the above operational experience, cask-handling operations at the repository will include a routine pressure check and gas sample of the inner cavity, analysis of the gas sample, and venting of the gas to the filtered ventilation exhaust system. Once the operations have been completed, the inner closure head bolts are loosened and the cask is prepared for fuel unloading.

Because cavity sampling and closure head removal operations are performed close to the loaded cask, remote or remote-automated methods may significantly reduce operational exposures. Robotic methods for performing these operations have been proposed and researched, and are being developed and demonstrated (Yount, 1984; Berger, 1986; Strip, 1987). Features necessary to facilitate robotic methods for performing the operations are discussed by Griesmeyer (1988).

3.3 Fuel Unloading

The repository operations for unloading waste from casks are based on dry unloading into a hot cell, as proposed in SNL (1987). Major tasks associated with fuel-unloading operations include mating the cask to the hot cell, accessing the cask cavity, removing the fuel, visually inspecting the cask inner cavity components, and quantifying residual contamination in the unloaded cask. In the following subsections, various tasks are discussed that are typically performed or have been proposed at waste-handling facilities during fuel unloading. The recommended operations for fuel unloading at the repository are also discussed. The recommended operations are illustrated in the functional block flow diagram presented in Figure 3-5.

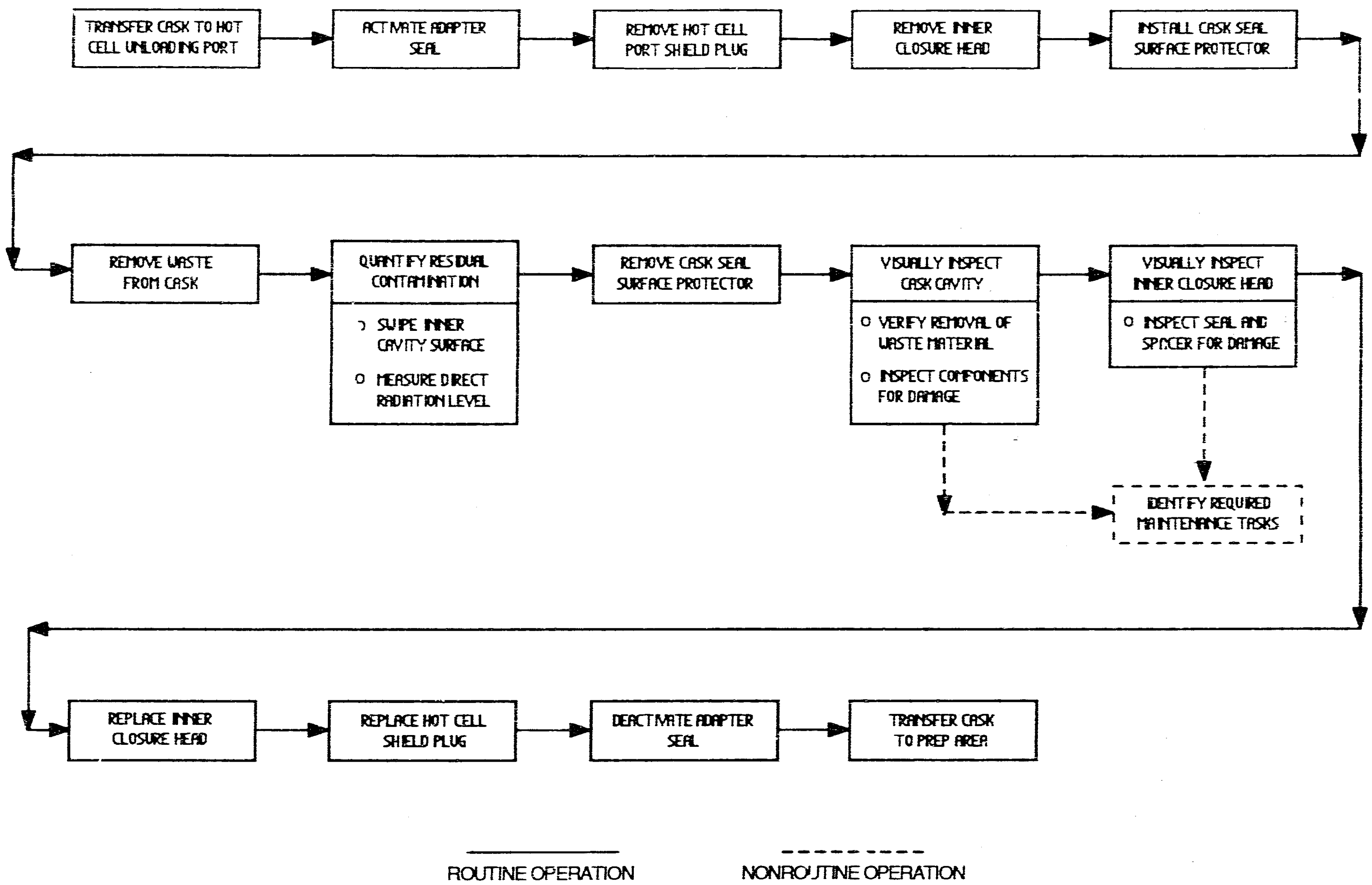


Figure 3-5. Functional Block Flow Diagram – Fuel Unloading

3.3.1 Cask-to-Hot-Cell Mating

The general method of unloading waste from casks received at the repository, as presented in SNL (1987), involves positioning the cask under the unloading hot cell and lifting the waste from the cask through a port in the hot cell floor. The cask is mated to the port in the hot cell floor using an annular device that provides a ventilation barrier between the hot cell and the area where the cask is positioned for unloading. The radioactive corrosion products (crud) on the surfaces of spent fuel assemblies are known to spall off the surfaces during dry unloading operations (McKinnon, 1987a, 1987b; Dziadosz, 1986). The ventilation barrier provided by the annular device confines this radioactive contamination to the cask inner cavity and hot cell environment and reduces the potential of contaminating the cask exterior surface, as well as the area where the cask is positioned for fuel unloading.

Dennis (1988) proposes that a cask-to-hot-cell adapter be placed on the top of the cask to mate with the unloading hot cell port. The adapter is sized to fit between the cask head and the underside of the hot cell floor around the unloading port. An inflatable seal on the top rim of the adapter is inflated when the cask is positioned at the unloading port. During fuel-unloading operations, the cask-to-hot-cell mating device and cask outer cavity may become contaminated. Contamination on the adapter and the outer cavity surfaces may be introduced into the cask preparation area, where the adapter is removed after fuel-unloading operations.

In the dry cask unloading operations at COGEMA's TO facility (at the La Hague plant), the cask is mated to the unloading hot cell using a mechanical closure device that is lowered from the cell and is connected to the cask, so that only the top of the cask is exposed to the environment of the unloading cell (Blomeke, 1988). According to Bonnet (1986), the use of the retractable device at COGEMA's TO facility has been successful in preventing contamination of the cask's exterior surface. However, owing to the lack of design details and limited operational information about COGEMA's retractable device, the cask-to-hot-cell adaptor proposed by Dennis (1988) is assumed for this study. Cask-to-hot-cell mating devices should be evaluated in future studies.

3.3.2 Fuel Removal

When the cask is positioned and mated to the unloading port, the hot cell port shield plug and cask inner closure head can be removed to allow access to the cask inner cavity. These items are removed using a crane located inside the hot cell and appropriate lifting fixtures, if required. A stand for the inner closure head is usually provided at waste-handling facilities to protect the closure head O-ring seal from damage during storage. Additionally, the stand facilitates visual inspection of the closure head seal and fuel spacer, as discussed in Subsection 3.3.4.

With the inner closure head removed, the seal surface on the top of the cask body is exposed and is susceptible to damage by foreign objects or impacts with handling equipment. Seal surface protectors have been used during fuel-loading and fuel-unloading operations in the industry (McKinnon, 1987a, 1987b; TN, 1988) and have been proposed for routine use in future dry unloading facilities (Watson, 1980). Surface protectors "ensure that crud or particles did not lodge on these surfaces and result in blemishes or scratches that could compromise the finish of the sealing surfaces" (McKinnon, 1987b). Since repair of seal surfaces can be an extensive operation (see Subsection 3.4.4.4), a way of protecting the surface is recommended for fuel-unloading operations at the repository. A typical seal surface protector is illustrated in Figure 3-6.

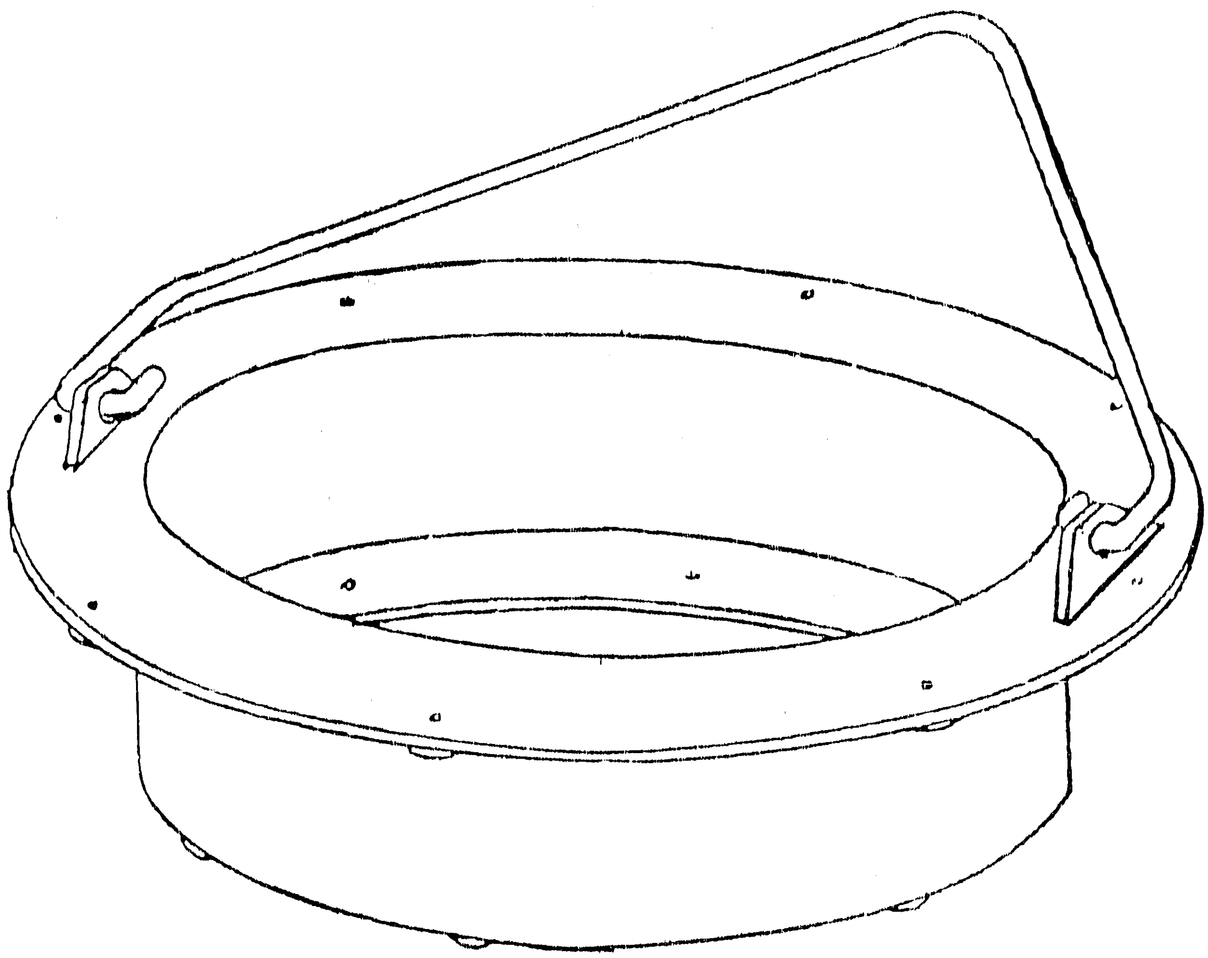


Figure 3-6. Typical Cask Seal Surface Protector

Source: NAC, 1988

After the seal surface protector has been emplaced on the cask, the fuel is ready for unloading from the cask. A fuel-handling tool attached to the crane in the unloading hot cell grapples the assembly and lifts it into the hot cell for transfer to a temporary storage location.

3.3.3 Quantification of Residual Contamination

High concentrations of smearable surface contamination typically remain in the cask inner cavity after spent fuel unloading (NAC, 1988). NAC (1988) states that "the most significant problem associated with fuel unloading is the accumulation of activity in the bottom of casks and baskets." The contamination originates from two primary sources:

- o Contaminated spent fuel pool water to which the cask cavity is exposed during loading operations at the reactor facility

- o Radioactive corrosion products (or crud) on the surfaces of spent fuel assemblies that spall off during cask loading, transportation, and unloading operations

For unloaded casks to be shipped offsite, DOT (1986) requires that the radioactive content of a package offered for transport be included in the shipping documentation (i.e., bill of lading), per 49 CFR 172.203. To meet this requirement, the radioactive content of the residual contamination in the cask cavity needs to be quantified. In addition, as discussed further in Subsection 3.4.2, if buildup of contamination in unloaded casks becomes excessive, some decontamination may be needed prior to shipment offsite.

The Lynchburg Research Center (LRC) and General Electric's Morris (GE-Morris) facilities use similar operations for routinely quantifying the radioactive content of unloaded casks prior to shipment offsite (Schilthelm, Appendix A-2; Schmid, Appendix A-1). The methods used at these facilities consist in obtaining swipes and taking direct radiation measurements in the inner cavity. The results of these surveys are used to calculate the isotopic and gross activity levels in the unloaded cask. The surveys are conducted promptly upon removing the casks from the unloading pool while the cask interior surfaces are damp, minimizing the potential for airborne contamination.

Because dry unloading is proposed for the repository, the radiological survey should be conducted after removing the fuel while the cask is under the unloading hot cell (before the inner lid is reemplaced). Surveying the cask while it is in another location, such as the cask preparation area, could introduce airborne contamination into accessible areas. Also, as discussed further in Subsection 3.4.2, the radiation levels at the top opening of the cask (with the inner closure head removed) could result in increased operator exposures.

Surveying the cask in the unloading hot cell requires a remotely operated radiation detector and smear tool. The radiation detector may have to be directionally shielded to prevent detecting high levels of "background" radiation from spent fuel and other radiation sources present in the hot cell. Smear pads and a smear counter are provided for the contamination survey. The smear counter should be located outside of the hot cell so the smears would be moved through a transfer drawer in the hot cell wall for counting. The equipment and facilities for performing the operations should be evaluated in further studies.

3.3.4 Visual Inspection of Cask Cavity Components

The cask cavity and components are visually inspected to verify that the cask is empty (e.g., no residual waste or other materials) and to determine that no structural damage of the cask internal components is visible. Visual inspection requires a remotely operated viewing system, such as a closed circuit television (CCTV). Dennis (1988) proposes using a CCTV attached to an electromechanical manipulator for the visual inspection task.

To verify that the cask is empty, each channel of the cask basket should be visually inspected. Sufficient lighting should be supplied to allow the entire length of the channel to be viewed.

A visual inspection of the cask cavity for structural damage should include the cask internal components, inner closure head seal surface, bolt holes, and alignment pins. The seal surface protector is removed immediately before inspection of the seal surfaces. The inner closure head seal and fuel spacers on the underside of the closure head should also be inspected. Items requiring maintenance will be identified for remedial action. Minor maintenance operations, discussed in Subsection 3.4.4, will be performed at the repository prior to shipping the cask offsite. Other maintenance will have to be performed at the CMF.

3.4 Cask Preparations for Shipment Offsite

The operations necessary to prepare unloaded casks for return to the external transportation system are presented below. The operations are divided into five general categories:

- Exterior decontamination
- Internal decontamination (or cleaning)
- Cask cavity leak testing
- Cask maintenance
- Cask reconfiguration

A functional block flow diagram of the operations (and their associated tasks) for preparing the cask for shipment offsite is presented in Figure 3-7. Owing to the complexity of cask reconfiguration and nonroutine cask decontamination operations, a

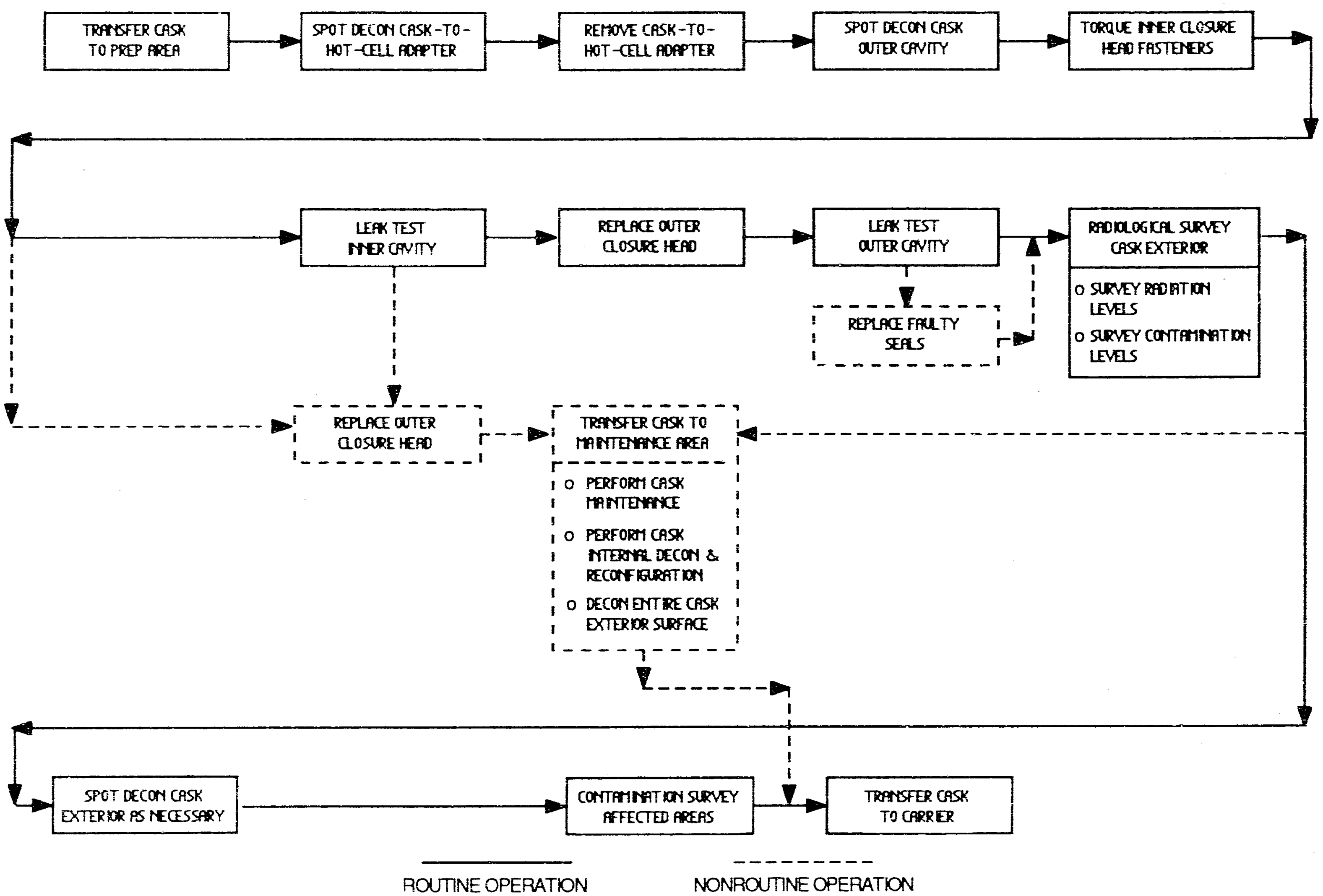


Figure 3-7. Functional Block Flow Diagram -- Preparation For Shipment Offsite

separate block flow diagram is shown for these tasks, in Figure 3-8. The operations are discussed below.

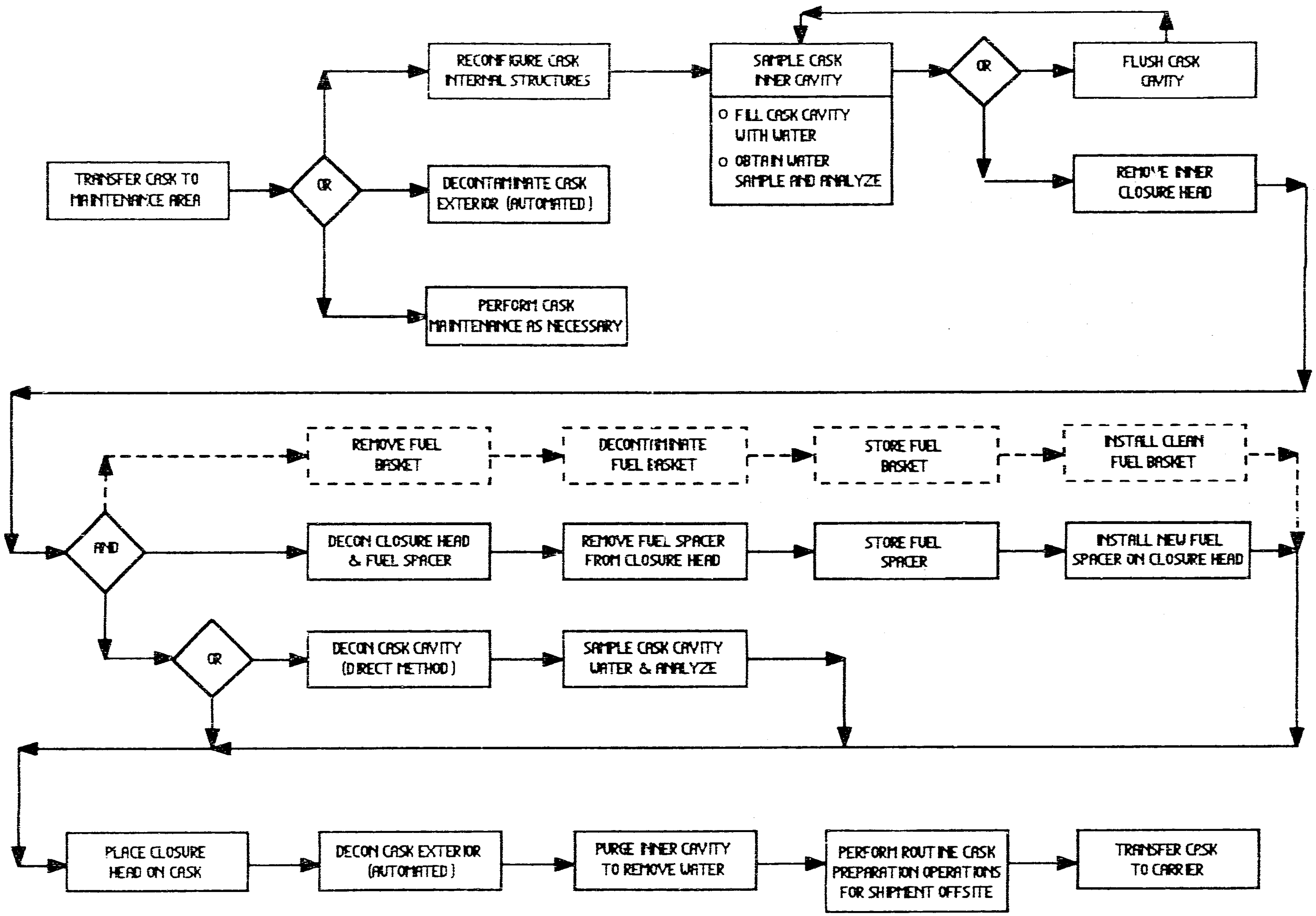
3.4.1 Decontamination of the Cask Exterior

After fuel has been unloaded from the cask, the cask is returned to the cask preparation area. Prior to shipment of the cask offsite, the exterior surface contamination levels must be less than the limits imposed by DOT in 49 CFR 173.423(a). Additionally, other surfaces that may have become contaminated during fuel-unloading operations (e.g., cask-to-hot-cell adapter) will have to be decontaminated to prevent the potential spread of contamination.

The exterior surface of the cask may become contaminated during fuel unloading, as discussed in Subsection 3.3.1. Additionally, when the cask is received at the repository, the levels of contamination on its exterior surface may exceed the DOT (1986) limits for return shipment. Kennedy (1981) reported that approximately 40% of casks surveyed upon receipt at waste-handling facilities slightly exceeded the contamination limits for 49 CFR 173.443(a) (DOT, 1986) for shipment offsite. Mullen (Appendix A-4) also indicated that these limits were frequently exceeded for casks received at INEL.

The cask-to-hot-cell adapter and outer cavity of the cask are also likely to become contaminated during fuel unloading (as discussed in Subsection 3.3.1). Subsequent decontamination of these areas would prevent the spread of contamination during handling operations and minimize airborne radioactivity in the cask preparation area.

Thus, routine decontamination of the cask-to-hot-cell adapter, the outer cavity of the cask, and the exterior surface of the cask can be expected at the repository. The methods and extent of these decontamination operations are described below.



NOTE : All operations shown in this block flow diagram are nonroutine, however removal of of the fuel basket is seldomely expected to be performed; thus indicated by dashed lines.

Figure 3-8. Functional Block Flow Diagram - Cask Maintenance, Decontamination, and Reconfiguration

Prior to removing the cask-to-hot-cell adapter, it is recommended that the adapter be wiped to remove gross contamination, thereby reducing the potential for contamination of the lifting fixture used to remove the adapter and the surface where the adapter is stored.

Removal of the cask-to-hot-cell adapter allows easy access to the outer cavity of the cask. The latter should also be manually wiped to remove any gross contamination from this area of the cask, thus reducing the potential for contamination of equipment used during further operations in the area, such as tightening the inner closure head fasteners and leak testing (discussed in Section 3.4.3).

In parallel with the above operations, a contamination survey of the cask is performed on the cask exterior surface. Swipes are obtained and analyzed to determine which areas (if any) need to be decontaminated for compliance with DOT requirements for shipment offsite. Cask exterior contamination surveys (obtain, count, and record the results of the swipes) have been reported to take anywhere from 1 to 2 hr (Schmid, Appendix A-1; Stapf, Appendix A-3; Mullen, Appendix A-4).

As discussed in Subsections 3.2.1 and 3.3.1, contamination of the exterior surface of the cask is expected to be localized to small areas. Thus, routine exterior decontamination operations are expected to be limited to manual wiping of the contaminated areas. Chemical solutions may be applied on "tough spots," where contamination is difficult to remove. After decontamination, the areas are swiped again to verify that the required limits are met.

Extensive contamination of the exterior surface of the cask after fuel unloading is expected to be infrequent. If the contamination survey indicates excessive contamination over a large amount of the cask surface, a thorough decontamination of the cask would be warranted. Extensive decontamination operations performed at GE-Morris (Schmid, Appendix A-1) and SRP-RBOF (Stapf,

Appendix A-3) involve manually spraying the cask exterior with high-pressure steam lances. Occasionally, chemical solutions have been used to improve the effectiveness of decontamination.

Extensive manual decontamination is time-consuming. Manual decontamination of IF-300 casks at GE-Morris takes nearly 10 hr (Schmid, Appendix A-1). Use of automated methods recommended for thorough cask exterior decontamination at the repository may reduce the cask turnaround time in the event of significant contamination.

An automated system for cask exterior decontamination has been employed at both the La Hague facility in France and the CLAB facility in Sweden (Blomeke, 1988). The system consists of a metallic shell that is placed over the cask and rests on a rotating table, which supports the cask as well as the shell. Tightness between the shell and the rotating table assembly is provided by means of an inflatable seal. The cask is decontaminated in the shell by a high-pressure water spray system. Water is also sprayed on the inside wall of the shell to prevent the shells from becoming contaminated. The shell is also equipped with viewing windows and individual hand-operated spray nozzles. Blomeke (1988) indicates that the system has been successful in cleaning and drying a cask within 3 hr. Blomeke (1988) does not identify the method used for drying the cask; however, manual wiping and automated methods (such as heat lamps) can be used at the repository.

Automated methods, such as those described above, are recommended for thorough cask exterior decontamination at the repository. Provisions for automated drying of the cask exterior subsequent to decontamination is also recommended. The system at the La Hague facility should be further studied for application at the repository.

3.4.2 Decontamination of the Cask Interior

The operations to be performed at the repository to decontaminate (or clean) the cask interior are addressed in this subsection. The contamination of the cask interior is discussed, followed by a discussion of the purpose of decontaminating the cask interior at the repository. Next, methods of decontaminating the cask interior, operational experience, and recommended repository operations are presented. As mentioned in Subsection 2.3.5, the cask cavities are assumed to be decontaminated during reconfiguration operations (discussed in Subsection 3.4.5) to the levels acceptable by the reactor facility to which the cask is to be dispatched. The basis for this assumption is further addressed in this subsection.

3.4.2.1 Contamination of the Cask Interior

The interior cavity and fuel basket of spent fuel casks received at the repository will be contaminated with radioactive material. Gross contamination in the form of solid particles, as well as high levels of "smearable" contamination, will exist on the cask cavity and fuel basket surfaces (NAC, 1988). The source of the particulate radioactive material is the "sloughing off" of crud from the fuel elements. Crud is the activated corrosion products, scale, and precipitants that accumulate on spent fuel during reactor operation and storage (TN, 1988). Some of the crud comes off the fuel during loading of the assemblies into the cask at the reactor facility, during cask transport, and during fuel unloading at the receiving facility (TN, 1988). An additional source of cask cavity contamination is the contaminated spent fuel pool water to which the cask cavity is exposed during fuel-loading operations at the reactor facility (NAC, 1988).

The levels of contamination on the cask cavity and fuel basket, as well as the extent of the surfaces contaminated, may vary significantly. NAC (1988) indicates that, when the cask is in the vertical position, most particles settle to the bottom of the fuel basket, with a portion escaping the basket and becoming trapped in the bottom of the cask. Reported smear sample data for TN-8L transportation cask cavities indicate levels ranging from 180,000 dpm/100 cm^2 to 118,000,000 dpm/100 cm^2 for side smears and 320,000 dpm/100 cm^2 to 123,000,000 dpm/100 cm^2 for bottom smears (McKinnon, 1987b). Levels of contamination in other casks and cask models have been reported within these ranges, for both side and bottom smears, by McKinnon (1987a), Dziadosz (1986), McCreery (1983), and NAC (1988).

Smear sample data obtained from a TN-8L cask during a particular shipping campaign showed an increase in the amount of crud in the bottom of the cask (McKinnon, 1987a). Smears obtained from the bottom of the cask basket showed that the levels of contamination increased from approximately 400,000 dpm/100 cm^2 to 100,000,000 dpm/100 cm^2 over four shipments (McKinnon, 1987a).

Reported contamination levels of spent fuel cask cavities and fuel baskets are summarized in Appendix B.

3.4.2.2 Purpose of Decontamination of the Cask Interior

DOE (1986a) states that the inner cavities of unloaded casks should be decontaminated to 2,200 dpm/cm^2 for beta-gamma emitters and 220 dpm/cm^2 for alpha emitters, prior to returning the casks to the external transportation system. However, meeting these stringent limits would have various negative impacts on repository operations, as discussed below. For this study, the purpose of interior decontamination of the cask is to reduce the buildup of radioactive material in the interior cavity of the cask to avoid cross-contamination of different reactor spent fuel pools during cask-loading operations and to reduce occupational exposures during cask-handling operations.

Meeting the cask interior cavity contamination limits in DOE (1986a) would require extensive cask disassembly and decontamination operations, resulting in a significant increase in cask turnaround time. Moreover, it is even questionable whether decontaminating the cask cavity to these levels can be achieved.

Stapf (Appendix A-3) indicates that extensive decontamination of the inner cavity and fuel basket of casks at the Savannah River Plant's (SRP) Receiving Basin for Offsite Fuel (RBOF) took two operators approximately 8 hr to perform. In the decontamination operation, the fuel basket was removed from the cask cavity, and the basket and cask cavity surfaces were manually decontaminated with steam lances. Even after these extensive operations, the levels of contamination were above the limits stated in DOE (1986a). Performing this operation routinely at the repository would significantly increase cask turnaround time, which according to DOE (1986a) should be a total of 8 hr for a truck cask and 12 hr for a rail cask. Also, performing extensive decontamination operations, similar to that stated above, would result in a significant increase in operator exposures at the repository.

NAC (1988) states that extensive decontamination of cask cavities has resulted in average smearable contamination levels of 50,000 dpm/100 cm^2. Although these achievable levels meet the requirements stated in DOE (1986a), NAC (1988) adds that, because of weeping, the levels have been observed to increase to up to 1,000,000 dpm/100 cm^2 in a relatively short period of time. Thus, it is questionable whether achieving the levels specified by DOE (1986a) for cask internal contamination is practical.

Based on the discussion above, this study assumes that the repository will not decontaminate cask cavities to the levels specified by DOE (1986a). The repository, however, will provide the capabilities of decontaminating the inner cavity of unloaded casks, for the purposes discussed below.

Unloaded casks shipped from the repository to the reactor site may introduce additional contamination into the reactor's spent fuel pool or associated cleanup systems if there is excessive contamination in the cask's inner cavity. Because the levels of contamination in the pool water and the amount of crud on fuel varies from reactor to reactor, cross-contamination is a primary concern when shipping an unloaded cask to a reactor facility other than the facility from which the cask was received.

Another problem associated with the buildup of contamination in the cask cavity is the potential for increased operational exposures during cask handling. Although routine cask-handling operations are performed manually, or "hands on", with the closure head(s) in place (e.g., containing the radioactivity), contamination has been known to build up in the cavity valves (especially bottom drain valves), producing high radiation levels around the valves (Mullen, Appendix A-4). Mullen (Appendix A-4) states that at the end of a shipping campaign, high radiation levels were measured around the drain port of a TN-8L shipping cask. Crud had accumulated in the quick-disconnect valve of the drain port, requiring the valve to be replaced prior to returning the cask to Transnuclear, Inc. Manual cask-handling operations requiring interface with the valves (such as cask cavity flushing, venting, drying, and leak testing) may result in increased operator exposures.

Shappert (1988) states that unloaded casks will be shipped from the repository, MRS, or CMF as radioactive material packages containing Type B, Type A, or limited quantities (defined in 49 CFR 173), depending on the amount of residual contamination in the cask cavity. These facilities would not need to decontaminate cask interiors to levels below the empty package limits. Attaway (1988) indicates that, at the CMF, the cask cavity is assumed to be decontaminated to the levels acceptable by the reactor facility to which the cask is to be dispatched. This assumption is consistent with current cask fleet operations experience by NAC (1988).

This report assumes that, when a cask is returned to the same reactor facility in which it originated, any contamination buildup in the cask cavity will be the responsibility of that facility. The repository will decontaminate the cask cavity when the cask is to be dispatched to another reactor facility to prevent cross-contamination resulting from previous cask use by another facility. This is consistent with current cask fleet operational experience in the U.S. (NAC, 1988). As discussed in Subsection 2.3.5, decontamination of the interior cavity of the cask, if needed, will be performed as a nonroutine operation in conjunction with cask reconfiguration.

3.4.2.3 Methods of Decontamination of the Cask Interior

To determine the extent and methods of interior decontamination required, the cask cavity contamination levels need to be assessed. Before assigning a cask to a facility for use in a shipping campaign, NAC ensures that the levels of mobile contamination in the cask cavity are acceptable by the receiving facility (NAC, 1988). The amount of contamination present in the cask cavity is determined by filling the cask with water, obtaining a sample of the water, and analyzing the sample (NAC, 1988). A similar procedure is routinely used at waste-handling facilities before casks are placed in their spent fuel pools (Schmid, Appendix A-1; Stapf, Appendix A-3; Denny, Appendix A-5).

The procedures for sampling the contamination levels of the inner cavity (discussed above) are recommended, prior to reconfiguration operations at the repository, to indicate the extent and methods of decontamination required. The quantification of residual contamination in the cask cavity (discussed in Subsection 3.3.3) will also provide an indication of the extent of decontamination required.

Two general methods for reducing contamination in the cask cavity have been used by the industry. The first and most common method is flushing the cask cavity with demineralized water. The second method, which is infrequently performed (NAC, 1988), involves removing the closure head(s) and the fuel basket from the cask cavity and using direct methods for removing contamination from the surfaces of the cask cavity and fuel basket. These two techniques and their applicability to operations at the repository are discussed below.

Cask Flushing. NAC (1988) states that flushing is considered only a cleaning operation, whose purpose is to remove as much of the mobile contaminants in the cask cavity as practical (NAC, 1988). Some aspects associated with cask flushing and the applicability of flushing to repository operations are described below, including time requirements, the effectiveness of flushing, generation of radioactive waste, and occupational exposures.

Operations for cask flushing typically require flushing the cask with approximately two volumes of water (NAC, 1988). Flushing the cavity of IF-300 rail casks at GE-Morris is performed at flow rates of about 30 gpm. Based on the cavity dimensions presented in Blomeke (1988), flushing an IF-300 cask with two volumes of water at this flow rate takes approximately 1 hr. Obtainable flow rates for flushing, however, depend on the cask design and, in particular, on the size of the cavity penetration valves used for flushing.

The effectiveness of flushing also depends on the cask design. The configuration of the bottom of the fuel channels and the convolution of the drain lines can inhibit the dislodging of crud during flushing (TN, 1988). NAC (1988) indicates that when crud particles settle in the bottom of the cask, they become trapped on ledges and in seams, where a substantial portion remains even after flushing operations. DOE (1986c), however, states that the interior surfaces of casks designed for use in the Federal Waste Management System should be of sufficient smoothness and contour to limit the accumulation of particulate residue and to facilitate removal.

Flushing the cask cavity generates contaminated liquid waste and increases the potential for increased occupational exposures. Using the cask dimensions presented in Blomeke (1988) and flushing with two cask volumes of water, an NLI 1/2 truck cask generates 220 gal of liquid radioactive waste and an IF-300 rail cask generates 1,800 gal of liquid radioactive waste as a result of flushing operations. Based on these values and the throughput rates presented in SNL (1987), routine flushing of all casks at the repository would generate approximately 750,000 gal of liquid radioactive waste annually.

In addition to the generation of liquid radioactive waste, crud and contamination can accumulate in the drain lines used for flushing (Schmid, Appendix A-1). The buildup of the highly radioactive crud in the drain lines can result in increased occupational exposures during flushing and other manual operations performed in the area. Schmid (Appendix A-1) states that the cask drain hoses at GE-Morris require replacement about once a year in order to reduce occupational exposures.

Therefore, routine flushing of casks is not recommended at the repository because it (1) increases cask turnaround time, (2) generates significant amounts of liquid radioactive waste requiring treatment, and (3) increases operator exposures. Occasional flushing, however, may be desirable to reduce the level of contamination in the cask cavity to that required by the reactor facility to which the cask is to be dispatched (after reconfiguration). It is recommended that the effectiveness of flushing on reducing the levels of contamination in the cask cavity be studied further.

A pumpout system is used at GE-Morris for cask flushing (Eger, 1979). Water is pumped into the bottom of the cask to fill and flush it. Water displaced during flushing is pushed up to a higher collection point from which it flows to the liquid waste collection and treatment facility by gravity. Water is pumped from the bottom of the cask for draining.

Direct Interior Decontamination. If extensive contamination is present in the cask cavity, direct methods for reducing cask interior cavity contamination levels may be required at the repository prior to dispatching the cask to a different reactor facility. Direct methods for decontaminating the cask cavity require removal of the inner closure head to access the cavity.

Direct interior decontamination has been performed with the cask (and fuel basket) submerged in a pool of water (NAC, 1988; Schmid, Appendix A-1) or placed in a dry environment. Because large amounts of liquid radioactive wastes are generated if the cask and fuel basket are immersed in water, a dry environment is recommended for these operations at the repository. It is also recommended, however, that the cask cavity be filled with water for shielding if there are high radiation levels due to extensive contamination buildup, as discussed below.

The buildup of contamination in the cask cavity can produce intense radiation fields. Upon removal of the cask inner closure head for reconfiguration and/or decontamination, operators may be exposed to high radiation levels. The radiation levels at the top opening of casks, with closure head(s) removed, have been reported in the range of 1 rem/hr for an NLI 1/2 truck cask (Schilthelm, Appendix A-2) and up to 40 rem/hr for a TN 8-L truck cask (NAC, 1988). NAC (1988) indicates that levels as high as 200 rem/hr have been experienced with other cask models. Owing to high radiation levels that may result when accessing the unloaded cask cavity, removal of the inner closure head for cask internal decontamination and reconfiguration at the repository is recommended to be performed either remotely and/or with the cask cavity filled with water.

Reconfiguration operations, discussed in Subsection 3.4.5, require removal of the fuel spacer assembly from the inner closure head. Because of the potential for high contamination and radiation levels of the fuel spacer, the spacer should be decontaminated (while attached to the inner closure head) prior to changeout. These operations are described further in Subsection 3.4.5.

Extensive cask interior decontamination operations at the repository may involve removing the fuel basket from the cask cavity. The need for removing the fuel basket for interior decontamination will generally be dictated by the levels of contamination in the cask cavity. The extent of contamination is determined during the operations for quantifying the radioactive content of the unloaded cask (described in Subsection 3.3.3) and the water sample obtained prior to reconfiguration (described in Subsection 3.4.2.3).

If decontamination of the fuel basket is required, it is recommended that the basket be removed from the cask cavity remotely in order to reduce operator exposures. Levels of radiation from fuel baskets (removed in an air environment) have been reported in the range of 500 mrem/hr at 2 in. from the outer surface (after considerable flushing) up to 2 rem/hr (NAC, 1988). When removed in air, the basket is kept wet (or damp) to reduce potential for airborne contamination (Schilthelm, Appendix A-2). NAC (1988) reports that it takes two operators no more than 10 to 15 min. to remove a basket from a cask.

Decontamination of fuel baskets is typically performed manually with lances supplied with either high-pressure water or steam (NAC, 1988; Stapf, Appendix A-3). Since baskets will be highly contaminated and will exhibit high radiation levels, TN (1988) recommends that the basket cleaning area be enclosed and separated from other work areas and be almost entirely remotely operated. TN (1988) adds that separate facilities are recommended for cleaning baskets as opposed to casks. Other recommendations include providing the capability for inspecting the baskets by CCTV and assigning a controlled area for the storage of baskets after they have been cleaned (TN, 1988).

Decontaminating the interior cavity of casks can be performed with the cavity either filled with water or dry. As previously discussed, water helps reduce the potential for airborne contamination as well as provide shielding for operators. It is recommended that decontamination of the cask cavity at the repository be performed with the cavity filled with water to avoid airborne contamination and reduce operator exposures.

Wet decontamination methods have been employed using a wet vacuum (Schmid, Appendix A-1; Brundin, 1986), high-pressure water lances (hydrolazing) (NAC, 1988), and/or long-handled scrubbing instruments (NAC, 1988; McCreery, 1983). Use of hydrolazing and wet vacuuming is recommended for cask cavity decontamination operations at the repository. Hydrolazing provides a means for removing gross contamination that may be loosely bound to the surfaces of the cavity. Wet vacuuming provides the capability of removing the loose particulate matter, as well as contaminated water during hydrolazing. These decontamination methods may be used with the fuel basket in the cask cavity or with it removed.

3.4.3 Leak Testing of the Cask Cavity

Routine leak testing of cask cavities is assumed to be performed at the repository prior to shipping the unloaded cask offsite. The bases of this assumption are discussed below. Following this discussion, leak-testing methods and operational experience are described. The recommended methods for leak testing at the repository are presented.

3.4.3.1 Bases

DOE (1986a) states that the repository is required to prepare transportation components for a return trip. Leak testing of unloaded casks is not necessary to meet regulatory or cask CoC requirements (unless the cask cavity contains Type B quantities of residual contamination, which is unlikely). However, preparation operations should verify that cask components function properly prior to dispatching the cask. Therefore, routine leak testing at the repository is recommended to ensure that cask containment components (i.e., closure head and valve seals) perform their required function before the cask is returned to a reactor facility.

Additionally, leak testing of unloaded casks at the repository is consistent with operational experience at other waste-handling facilities. Leak testing of cask cavities is routinely performed on unloaded casks before shipment offsite at the GE-Morris (Schmid, Appendix A-1), INEL-TAN (Mullen, Appendix A-4), and SRP-RBOF (Stapf, Appendix A-3) facilities. Schmid (Appendix A-1) adds that the routine leak-testing operations are performed at GE-Morris because faulty seals can be more easily repaired and equipment and spare parts are more readily available there than at the reactor facilities.

Routine leak testing of unloaded casks for shipment offsite will be performed at the repository for both inner and outer containments. If faulty closure head or cavity penetration valve seals are detected during leak-testing operations, remedial action, such as seal replacement (discussed in Subsection 3.4.4), will be performed.

3.4.3.2 Leak-Test Methods

Various leak-test methods are employed on casks currently used in the U.S. (NAC, 1988; TN 1988; Schmid, Appendix A-1; Stapf, Appendix A-3). Leak-test methods depend on cask design and facility operating procedures, and include helium tests, pressure tests, hydrostatic tests, and air bubble tests. Hydrostatic tests are typically performed only for annual CoC testing (NRC, 1979; NRC, 1980). Because an air bubble test requires that the cask be submersed in water, it is not recommended for repository operations.

Helium Leak Tests. Helium leak tests are performed by pressurizing the cask containment with helium and running a "sniffer" probe along the edge of the containment boundaries (closure head, valve, etc.) at a specified rate (unit distance per unit time) to detect helium (NAC, 1988). According to Schmid (Appendix A-1), helium leak testing of IF-300 casks takes more time than the pressure tests required by other cask designs; leak testing takes approximately 30 min for the closure head seal and approximately 15 min for each penetration valve seal.

Air Pressure Tests. Air pressure tests involve pressurizing or evacuating a control volume and observing a pressure drop or increase, respectively. The control volume can be either the entire cask cavity or an interspace volume of the containment boundaries. The closure heads of NAC-1 casks are equipped with two O-ring seals, and the interspace volume between the two seals is pressure-tested (NAC, 1988). Some containment penetration valve designs used on casks incorporate a similar concept. Pressure test sensitivity is highly dependent on the size of the control volume being tested and the sensitivity of the equipment and instruments required for the tests (TN, 1988). Sensitivity of the tests and the size of the control volume also dictate the time needed to carry out the test.

Although the required test method will depend on the cask operating procedures, pressure tests are assumed in this study. One reason for this assumption is that the equipment and instruments used for pressure tests (NAC, 1988; TN, 1988) are similar to those used for cask cavity sampling (discussed in Subsection 3.2.2). Thus, equipment requirements in the cask preparations area can be reduced.

3.4.4 Cask Maintenance

During cask handling and transportation, cask components are subject to damage and normal wear and tear. Throughout cask-handling operations at the repository, cask components are visually inspected to identify components that require maintenance, such as replacement, cleaning, and other corrective measures. The degree of cask maintenance operations may range from simple tasks to complex tasks involving significant time requirements.

As discussed in Subsection 2.3.3, it is assumed that the repository provides the capability of performing minor maintenance on casks in order to return the casks to the transportation system in an efficient manner. Minor maintenance operations will also be performed to meet the requirements of DOE (1986a), presented in Subsection 2.1.2.1.

3.4.4.1 General

Cask maintenance activities can be categorized as follows: CoC maintenance, maintenance routinely performed for each shipment, and unscheduled maintenance, covering nonroutine activities such as the repair or replacement of parts subject to damage and wear and tear (NAC, 1988). As discussed in Subsection 2.3.2, annual cask maintenance operations for the cask CoC will be conducted at the CMF (Attaway, 1988).

Routine maintenance performed for each shipment typically is limited to visual inspection of cask components and containment verification or leak testing (discussed in Subsection 3.4.3). The visual inspections are performed to identify any need for nonroutine maintenance, discussed later in this subsection. Leak testing is also routinely carried out for containment verification purposes, identifying faulty containment seals that require replacement or maintenance. For certain types of casks, closure head O-ring seals may be replaced frequently or on a scheduled basis (depending on cask design); however, frequent seal replacement is not assumed in this study. Seal replacement is therefore considered a nonroutine operation.

Nonroutine cask maintenance operations to be performed at the repository are generally expected to be limited to replacement or repair of components that can be removed from the cask. Eger (1979) tabulates the types and frequencies of nonroutine cask maintenance tasks that were needed for 486 shipments of spent fuel to GE-Morris. These maintenance tasks were needed only infrequently (1 or 2 shipments out of 486) and typically included minor repairs such as replacement of drain valves. Other cask removable components (discussed in Subsection 2.2.3.3) that may require nonroutine maintenance include closure head seals and fasteners, valves and associated equipment, trunnions, baskets, and fuel spacers. Maintenance operations and experience pertaining to these components are discussed below.

3.4.4.2 Closure Head and Components

Components associated with the cask closure heads that may require nonroutine maintenance include the O-ring seals, fasteners, and threaded inserts (helicoils). Penetration valves are usually considered a part of the closure head, but in this report, maintenance of the valves and associated components are covered in Subsection 3.4.4.3, which deals with cavity penetration valves and components. Replacement of closure head O-ring seals will probably be the most frequent nonroutine maintenance operation at the repository. As discussed in Subsection 2.2.2.2, the closure head seals will periodically require replacement owing to their limited lifetimes. Defects or damage to the seals may be identified during visual inspection. Defects that are not visually evident, but cause a faulty seal, will be identified during the leak-testing operations.

Seal replacement involves removing the closure heads (inner and outer) from the cask body and placing them on stands. Typically, the seal is removed from a retaining groove (retaining clips may also need to be removed), which is cleaned out and filled with vacuum grease, and a new seal is installed (TN, 1988). Schmid (Appendix A-1) indicated that replacement of the closure head seal on an IF-300 cask takes two operators approximately 30 min. O-ring seal replacement operations for an NLI 1/2 inner closure head have been reported to take 15 to 20 min (Schilthelm, Appendix A-2).

Because of the low radiation levels associated with outer closure head seal replacement on unloaded casks, the operation can be performed manually. The need for outer closure head seal replacement will be identified in the preparation area during visual inspection prior to fuel unloading or during containment verification after fuel unloading. Based on the relatively short operational times for seal changes indicated above, the maintenance operation may be performed in the cask preparation area.

Replacement of the inner closure head O-ring seals is more complex than replacement of the outer closure head, owing to the higher levels of contamination and radiation from the inner cavity upon removal of the inner closure head. As is the case with internal decontamination operations, inner closure head seal replacement operations should be performed with the cask cavity filled with water to avoid these radiation and contamination problems.

Closure head fasteners (bolts or studs and nuts) and the threaded inserts (helicoils) typically provided in the cask body to accommodate the fasteners are subject to wear and tear, or may periodically require replacement (NAC, 1988). The heads of the fasteners are susceptible to rounding off due to torquing or removing the fasteners with worn sockets. The fastener threads are susceptible to cross threading if improperly installed or removed. If the closure head (inner and outer) fasteners are damaged or show wear and tear, they should be replaced at the repository. Replacement of inner closure head fasteners may require removal of the head if the fasteners are captive to the closure head. If this is the case, these operations should be performed with the cask cavity filled with water, for reasons previously discussed.

NAC (1988) states that the most frequent unscheduled maintenance item is the replacement of helicoils. Helicoils are threaded inserts in holes that are drilled and tapped in the cask body to accommodate the closure head bolts or studs. Failure occurs either by cracking or by "backing out" of the tapped hole in the cask body (NAC, 1988). The helicoils for inner and outer closure heads are visually inspected during cask-handling operations to identify the need for their replacement. Because replacement of inner closure head fasteners and helicoils requires that the inner closure head be removed, filling the cask cavity with water is recommended, for reasons previously discussed.

3.4.4.3 Cavity Penetration Valves and Components

Penetration valves and components, including quick disconnects, relief valves, valve seals, and O-rings, will need to be repaired or replaced if they fail (NAC, 1988). NAC (1988) adds that "valve seals and seal surfaces require attention periodically depending on the quantities of particulate material present in flush or pool water and on the effectiveness of flushing during cask-handling operations." Other valve components that may require periodic replacement are the valve box cover, cover gaskets, and cover fasteners.

This study assumes that maintenance operations on cavity penetration valves and their associated components will be performed at the repository, if necessary. Maintenance tasks that require extensive disassembly of the valve components for rebuilding may warrant replacing the entire valve assembly to reduce time requirements. Schmid (Appendix A-1) indicated that it takes 1 to 1-1/2 hr to remove the pressure relief valve device on the IF-300 cask. This duration is assumed to be an upper bound for valve maintenance operations at the repository.

TN (1988) indicates that repairs on cask cavity drain valves could result in dislodging accumulated internal contamination, which could cause high radiation levels. The amount of contamination dislodged could range up to several curies (TN, 1988). Therefore, portable shielding and local containments may be needed for valve repair operations at the repository in order to reduce operator exposures and the potential for airborne contamination. Also, maintenance of penetration valves on the inner closure head could require removal of the closure head, which would mean that the cask cavity would have to be filled with water to reduce the potential for airborne contamination and operator exposures.

3.4.4.4 Other Cask Components

Various other cask components, in addition to those addressed above, may require replacement or maintenance at the repository as a result of incurred damage or wear and tear. For example, the cask trunnions, tiedowns, closure head seal surface, and closure head seal retention groove may also need maintenance.

Cask trunnions and the surfaces of the carrier supports may experience galling, as might occur during cask rotation to and from the carrier (TN, 1988). Depending on trunnion design, the trunnion bushings (NAC, 1988) or the entire trunnion component may have to be replaced. NAC (1988) indicates that the need for replacement is typically determined by visual inspection. Similarly, the cask tiedowns may exhibit wear and require maintenance. Removable cask trunnions or trunnion bushings can be replaced in the cask preparation area during other cask preparation operations. Because the tiedowns are associated with the cask carrier, maintenance on the cask tiedowns is performed in the receiving and shipping bay while the cask is removed from the carrier.

During closure head handling and cask handling with the closure head(s) removed, the closure head sealing surfaces and seal retention grooves can be marred, which reduces their effectiveness (TN, 1988). Depending on the extent of marring (e.g., a scratch or a deep dent), the surfaces may require polishing, machining, or a weld overlay (NAC, 1988; TN, 1988). TN (1988) indicates that the repair of a sealing surfaces can be a difficult and time-consuming operation. Because of the complexity of repairs to sealing surfaces, these maintenance operations are assumed to be performed at the CMF.

3.4.4.5 Quality Assurance and Documentation

Quality assurance and documentation of cask maintenance operations will be required at the repository. Qualified personnel, procedures, and spare parts will be provided for performance of the maintenance operations discussed previously. Records of all maintenance and repair operations conducted at the repository are needed to support the requirements of the transportation system (Attaway, 1988).

The repository will have to verify that the maintenance operations are performed in accordance with the requirements of the cask CoC (Attaway, 1988). Established procedures and personnel qualified for conducting the maintenance previously discussed will allow timely performance of the necessary work. The repository will be required to furnish a sufficient supply of certified replacement parts that meet the original design and fabrication criteria identified in the cask CoC (TN, 1988).

The repository will conduct records management activities similar to those required by the CMF, but on a smaller scale. Activities to be included are information acquisition, storage and retrieval, and maintenance documentation (Attaway, 1988). Each maintenance operation performed will be documented and used to update the cask history file. This report assumes that all cask records and documentation will be controlled and maintained at the CMF. Therefore, the repository records management activities will interface with those of the CMF to keep the required documentation up-to-date.

3.4.5 Cask Reconfiguration

Occasionally, casks will require reconfiguring (e.g., the changing of cask interior components) in order to accept a different type or length of spent fuel.

The fuel spacer assembly is typically mounted to the underside of the inner closure head (as discussed in Subsection 2.2.2.2). Replacement of the fuel spacer assembly requires removal of the inner closure head from the cask, exposing the cask cavity. Considerations for removal of the inner closure head from the cask, discussed in Subsection 3.4.2, apply to spacer changeout operations. With the inner closure head removed, necessary decontamination of the cask interior may proceed in conjunction with fuel spacer changeout operations.

Fuel spacer removal operations may be performed either manually ("hands on") or remotely at the repository, depending on the levels of radiation from the spacer assembly. Significant levels of contamination on the fuel spacer assembly may result in high radiation levels and the potential for airborne contamination during changeout operations. NAC (1988) reported a radiation level of 100 mRad/hr during a survey of the bottom of the inner closure head for an NLI 1/2 truck cask. Common industry practice is to manually change fuel spacers (see Appendix A).

Based on the discussion above, fuel spacers are assumed to be routinely decontaminated prior to being removed from the inner closure head for manual changeout. The method proposed for decontaminating the fuel spacer assembly is similar to the method recommended for decontaminating tha fuel basket.

Once the inner closure head and fuel spacer are decontaminated, the closure head is placed on a stand so that the fuel spacer can be removed. At GE-Morris, the closure head is placed on and mounted to a specially designed stand that flips the closure head upside down, facilitating access to and removal of the fuel spacer (Schmid, Appendix A-1). Removal of the fuel spacer involves loosening (and removing, if necessary) the nuts or bolts that fasten the spacer assembly to the inner closure head (NRC, 1978; NRC, 1979; NRC, 1980; Schmid, Appendix A-1). Subsequent to removal, the fuel spacer assembly is stored in a controlled area.

A fuel spacer assembly, of the size required by the reactor facility to which the cask is to be dispatched, is retrieved from storage and emplaced on the inner closure head. Once cask internal decontamination operations are complete, the closure head is placed on the cask. If removal of the fuel basket is required for either decontamination or reconfiguration, a clean basket is retrieved from storage and placed in the cask cavity prior to placing the inner closure head on the cask. Subsequent operations would include those tasks necessary to prepare the cask for shipment offsite, as discussed in previous subsections.

3.5 Shipping

Once all cask preparation operations have been completed, the cask is transferred from the cask preparation area back to the cask carrier for shipment offsite. The operations necessary for shipping the unloaded cask offsite are basically the reverse of those for receiving (Subsection 3.1). A functional block flow diagram of these operations is shown in Figure 3-9.

The cask is transferred from the cask preparation area to the shipping and receiving bay. Using the cask lifting yoke, the cask is lowered and placed on the cask supports of the carrier. The cask tiedowns are engaged and the impact limiters are reemplaced on each end of the cask. The personnel barrier is subsequently closed over the cask.

The cask and carrier are transferred to the inspection area of the repository and prepared for dispatch. Dispatch preparation includes performing a final contamination and radiation survey, similar to that described in Subsection 3.1.1, and is performed to meet DOT (1986) requirements contained in 49 CFR 173.443(a) and 49 CFR 173.441, respectively. Other operations include preparing and compiling the necessary documentation for shipment, including the shipping manifest, discussed in Subsection 3.1.1.

3.6 Summary of Cask-Processing Operations

Cask-processing operations proposed for the repository are presented in Subsections 3.1 through 3.5. For purposes of this study, the areas for cask preparation are separated into two facilities, one for routine operations (cask preparation area) and

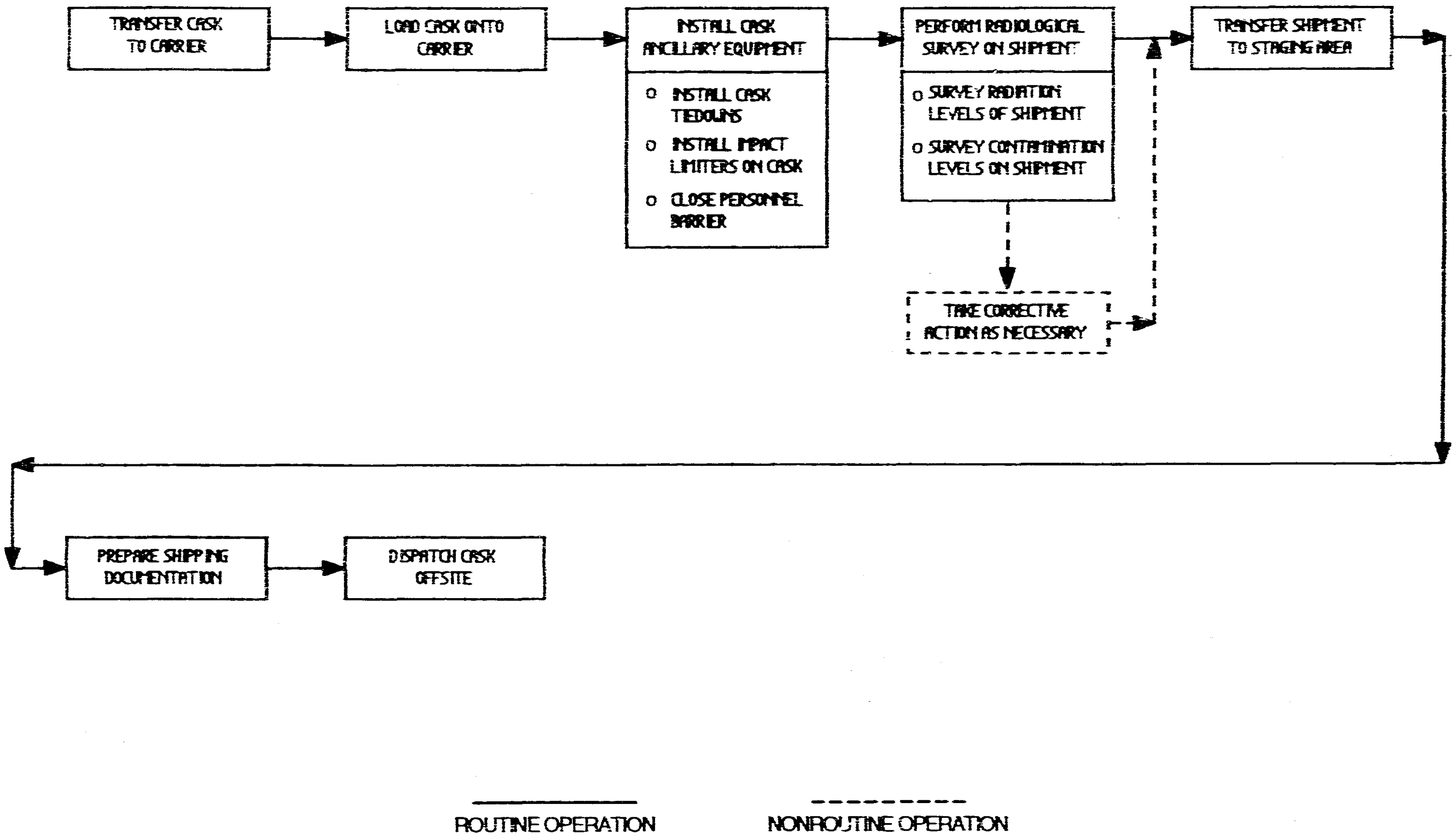


Figure 3-9. Functional Block Flow Diagram - Shipping

the other for nonroutine operations (cask maintenance area). The general layout and interface of the repository receiving facilities for cask-processing operations are illustrated in Figure 3-10.

The functional block flow diagrams and the discussion of cask decontamination and maintenance presented in the previous subsections are used to provide a basis for the conceptual design of the cask preparation area (Section 4.0) and the cask maintenance area (Section 5.0).

4.0 CASK PREPARATION AREA

The conceptual design of the cask preparation area is presented in this section. The cask preparation area is designed to provide the necessary facilities for routine operations (and certain nonroutine operations) associated with preparing casks for fuel unloading and for shipment offsite, as described in Subsections 3.2 and 3.4, respectively. Table 4-1 summarizes the operations that the cask preparation area is designed to facilitate. This work was done during the Pre-Advanced Conceptual Design phase as reflected in SAND84-2641, Site Characterization Plan-Conceptual Design Report.

4.1 General Arrangement

The conceptual design of the cask preparation area is illustrated in Figure 4-1. Major features of the cask preparation area include the following:

- o Separation of the cask preparation area from the receiving and shipping bays
- o Cask preparation stations for routine cask preparation operations
- o Capabilities for transferring casks from the preparation area to a separate area for nonroutine cask operations

The size of the cask preparation area (i.e., the number of cask preparation stations) depends on the required cask throughput rates; therefore, a generic module of two cask preparation stations is shown in Figure 4-1 as an example. Multiple modules may be needed for high cask throughput rates.

The conceptual design of the waste-handling building (WHB) in SNL (1987) incorporated the receiving and shipping bay and the cask preparation area as a common area with the same ventilation system. However, the facility design should incorporate confinement barriers to prevent the spread of contamination. Because some cask preparation operations involve potential

TABLE 4-1

SUMMARY OF CASK PREPARATION AREA OPERATIONS

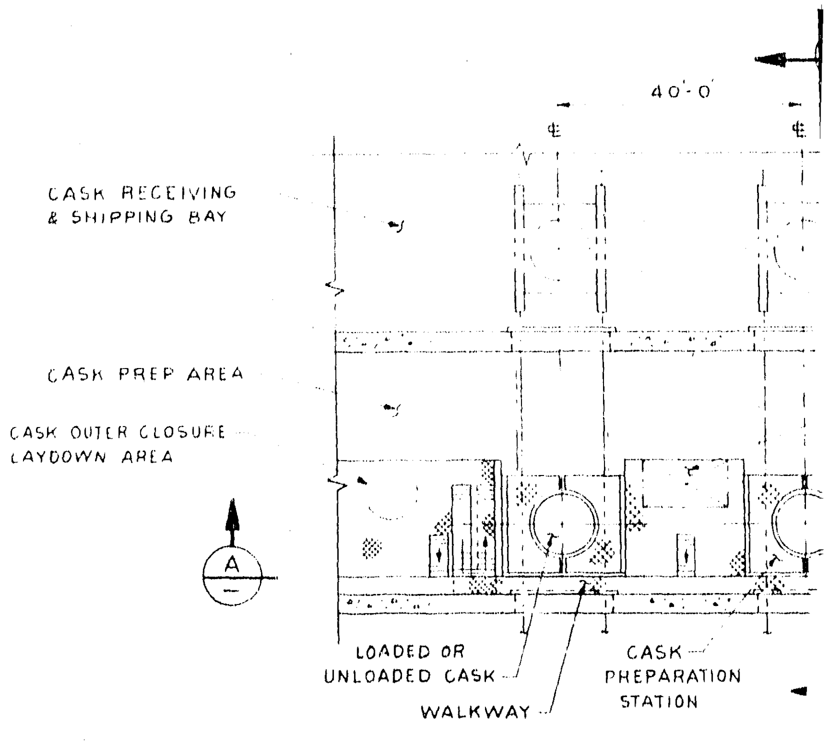
Routine Operations

- Sample cask outer cavity*
- Remove outer closure head*
- Survey outer cavity for contamination
- Sample cask inner cavity*
- Loosen inner closure head fasteners*
- Install cask-to-hot-cell adapter
- Remove cask-to-hot-cell adapter
- Spot-decontaminate cask-to-hot-cell adapter and cask outer cavity
- Contamination survey of cask exterior
- Spot-decontaminate cask exterior
- Leak-test cask inner and outer cavities
- Reemplace and secure closure heads*

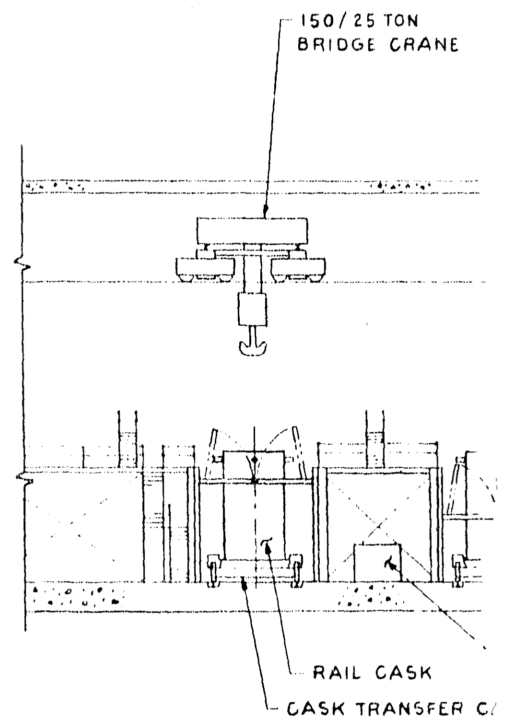
Nonroutine Operations

- Sample outer cavity gas for radioactivity*
- Perform minor maintenance on outer closure head
- Spot-decontaminate cask exterior and outer cavity (prior to fuel unloading)

* Denotes robotic operation



PLAN



SECTION A

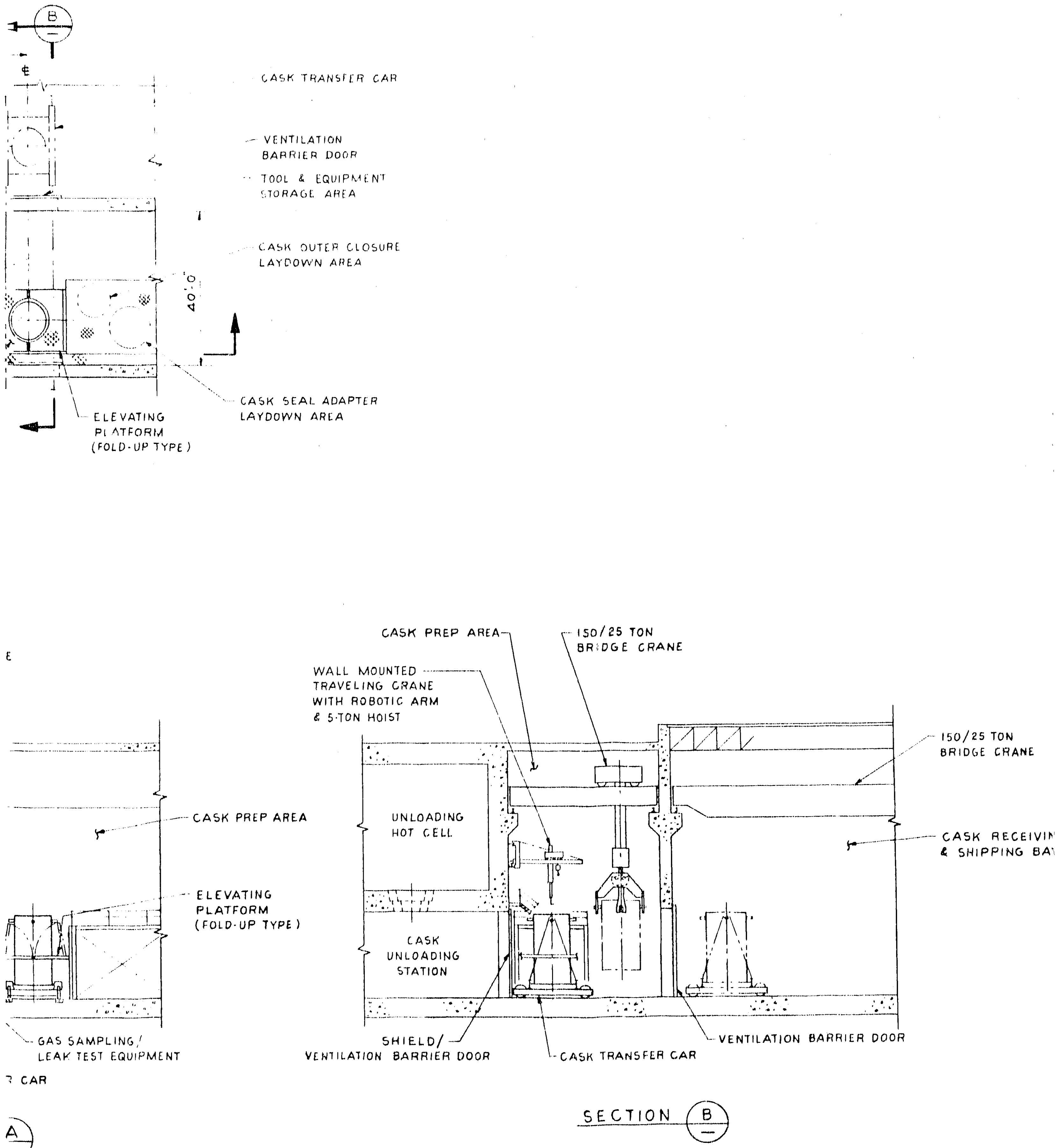


Figure 4-1. Cask Preparation Area Arrangement

contamination (especially after unloading spent fuel from casks), a ventilation barrier is provided to separate the cask preparation area from the receiving and shipping bay. The cask preparation area ventilation is furnished with a filtered exhaust system because of the potential for airborne contamination. Any operations involving potential contamination would be performed in the cask preparation area, so that the receiving and shipping bay need not have a filtered ventilation exhaust system. This separation prevents the potential spread of contamination and significantly reduces the portion of the WHB requiring a filtered ventilation system.

The cask preparation area is separated from the receiving and shipping bay by a wall. Ventilation barrier doors allow the cask to be transferred between the two areas. A cask transfer car moves the cask between the cask preparation area and the receiving and shipping bay, as well as the cask unloading station. The transfer car is designed to accommodate the truck casks and rail casks described in Subsection 2.2. There is a cask preparation station for each cask transfer car in the preparation area.

As discussed previously, the cask preparation area is designed for routine preparation operations. Therefore, capabilities are provided for transferring casks from the preparation area to a separate area (i.e., the cask maintenance area described in Section 5.0) for nonroutine cask preparation operations. The arrangement allows the cask to be transferred within a confined area to prevent the potential spread of contamination to other areas.

A 150-ton bridge crane is used to transfer the cask offline to the cask maintenance area for performing the nonroutine cask preparation operations (described in Section 5.0). A clear path is provided in the preparation area to avoid lifting a cask over other casks when it is being transferred to the maintenance area and to minimize cask lift heights. The bridge crane is designed with sufficient capacity to accommodate redundant lifting methods of the cask types described in Subsection 2.2. There are redundant lifting yokes in the preparation area for each cask type.

The cask preparation stations have the necessary facilities for performing the operations listed in Table 4-1. These facilities are described below.

4.2 Cask Preparation Stations

Major features incorporated into the design of the cask preparation stations are as follows:

- Robotic arm
- Storage, laydown, and elevating work platforms
- Gas-sampling and leak-testing equipment

These features are further described below.

As discussed in Subsection 3.2, manual operations on loaded casks may significantly contribute to occupational exposures at the repository. The remote-automated or robotic operations are based on the methods currently being developed and demonstrated, as discussed by Berger (1986). Routine operations associated with cask preparation for shipment offsite are assumed to be performed manually (at this point, the major radiation sources have been removed from the cask), with a few exceptions. Robotic cask preparation operations assumed for design purposes are identified in Table 4-1.

A wall-mounted traveling crane equipped with a robotic arm is provided in the cask preparation area to facilitate preparing casks for fuel unloading. Depending on the number of cask preparation stations and time associated with the remote-automated operations, the number of robotic arms required in the preparation area will vary. Although floor-mounted robots were proposed in

SNL (1987), a wall-mounted traveling robotic arm is chosen for this study because it covers a larger working volume than a floor-mounted robot (Griesmeyer, 1988). The crane supporting the robotic arm is also equipped with a hoist for handling the cask outer closure head and cask-to-hot-cell adapter.

The cask preparation stations are equipped with various platforms, including an equipment and tool storage platform, an equipment laydown platform, and an elevating work platform. Because most cask preparation operations are performed near the top of the cask, the platforms are at an elevation near the top of the cask to minimize handling times.

To reduce operator exposures during manual operations, the platforms are supported on each side by concrete walls to provide shielding between cask preparation stations where casks may be handled simultaneously. The storage and laydown platforms are equipped with stairways to the floor of the cask preparation area for operator access. Additionally, a walkway along the length of the cask preparation area allows operators to access each of the stations.

The storage platform has sufficient space for the equipment and tools necessary for routine cask preparation operations. One equipment and tool storage platform services two cask preparation stations to increase equipment and tool utilization. The equipment includes robotic end-effector tools, cavity penetration valve attachments for gas-sampling and leak-testing operations, and radiological survey equipment, such as smear tools and holder, a smear counter, a gas counter, and radiation detectors. Rags for spot-decontamination, a container for solid radioactive waste (e.g., contaminated rags), and smear pads are supplied in the storage area.

There is a laydown platform for the outer closure head and cask-to-hot-cell adapter. A closure head support stand, similar to that used at GE-Morris (described in Subsection 3.4), prevents damage and allows visual inspection and replacement of the closure head seal. Lifting fixtures necessary for handling the outer closure head and cask-to-hot-cell adapter are also stored on the platform.

Each preparation station has an elevating platform that encompasses the circumference of the cask. The platform affords operators easy access to the entire cask surface for performing the radiological survey and spot-decontamination operations. The platform folds up to allow transfer of the cask to and from the preparation station. The platform is also designed to extend horizontally toward the cask to accommodate both truck and rail casks. The conceptual design of the platform is similar to that being used at Germany's Gorleben storage facility, illustrated in Blomeke (1988).

The cavity gas-sampling, venting, and leak-testing equipment is located under the storage platform to allow for more laydown space on the platform. The equipment includes a high-volume vacuum pump (and low-volume pump, if necessary) and filter. The vacuum pump exhaust is connected to the filtered ventilation exhaust system. Equipment process lines run up to the equipment storage platform, where necessary gauges and valves are provided. Process hoses on the equipment storage platform interface with the cask and the process lines.

5.0 CASK MAINTENANCE AREA

The conceptual design of the cask maintenance area is described in this section. The facilities needed to perform the cask maintenance operations comply with Appendix B of the Generic Requirements document (DOE, 1986a).

The conceptual design is based on the expected (and assumed) frequency of cask maintenance, decontamination, and reconfiguration operations discussed in Section 3.0. In addition, the cask maintenance area is designed to allow these operations to be performed efficiently while minimizing operator exposures and the potential spread of contamination.

5.1 General Arrangement

The cask maintenance area consists of the following four general facilities:

- Maintenance/preparation stations
- Decontamination and reconfiguration facilities
- Maintenance shop
- Temporary cask storage area

The maintenance/preparation stations are designed to facilitate nonroutine cask maintenance and some routine cask preparation operations for shipment offsite. The decontamination and reconfiguration facilities are designed to facilitate (1) automated cask exterior decontamination, (2) cask inner cavity and internal component decontamination, and (3) cask reconfiguration. The maintenance shop supports cask and equipment maintenance operations.

Figure 5-1 depicts the general layout of the cask maintenance area. Figure 5-2 presents a more detailed arrangement of this area, showing both the facilities and the equipment. Major features of the cask maintenance area are described below. The four general facilities of the maintenance area are described in the subsections that follow.

As illustrated in Figure 3-2, the cask maintenance area is located at the end of the cask preparation area. This arrangement allows casks to be transferred from the preparation area to the maintenance area for performing nonroutine decontamination and maintenance. Time-consuming nonroutine operations are performed offline in the cask maintenance area so that the cask preparation stations described in Subsection 4.2 can be used for processing additional casks. This increases the overall throughput rate of casks in the cask preparation area.

The 150-ton bridge crane described in Subsection 4.2 transfers casks from the cask preparation area to the cask maintenance area. The casks can be placed at either of the two cask maintenance/preparation stations or, if neither of the stations is available, at the temporary cask storage area. As is the case in the cask preparation area, there is enough space for (1) transferring casks to locations in the cask maintenance area (i.e., maintenance/preparation stations and temporary storage area), (2) minimizing the height the cask is lifted, and (3) avoiding lifting the cask over other casks.

As shown in Figure 5-2, there are two process lines for cask maintenance, decontamination, and reconfiguration operations. On the basis of preliminary time estimates, two process lines will accommodate the expected frequency of casks requiring nonroutine maintenance, decontamination, and maintenance. Each process line has a transfer car, similar to those used in the cask preparation area, to move the cask between the maintenance/preparation stations and the decontamination and reconfiguration facilities.

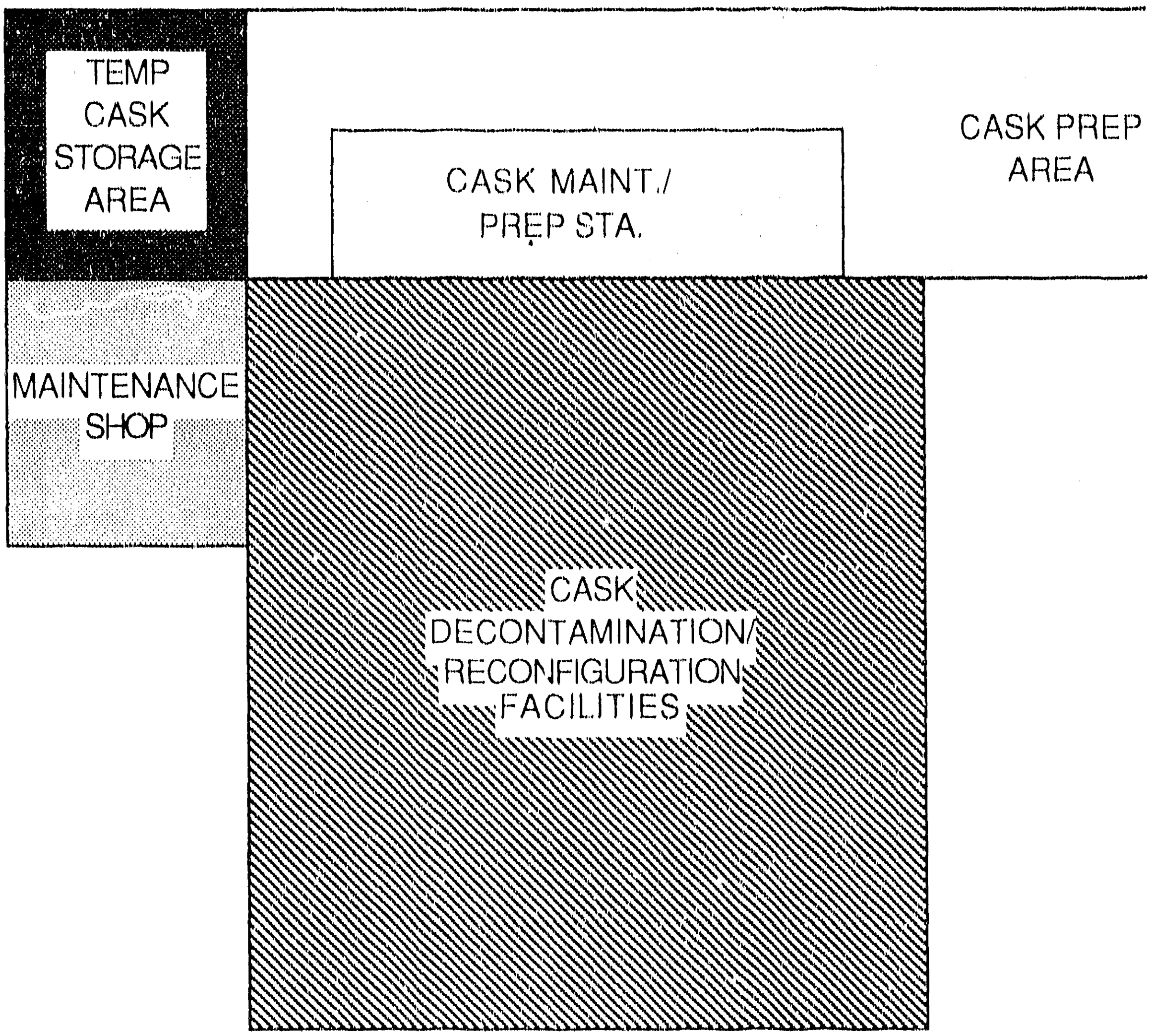
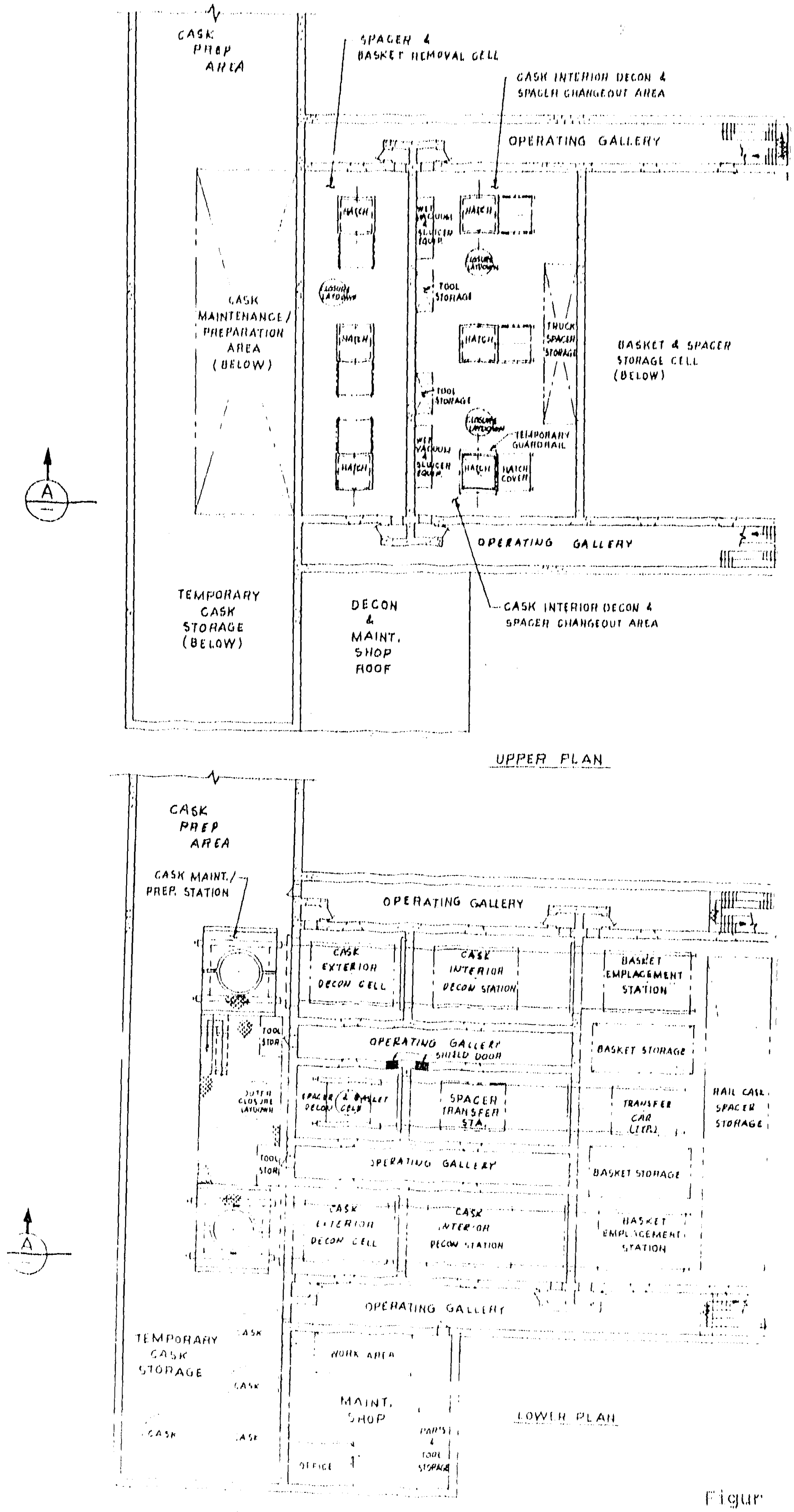
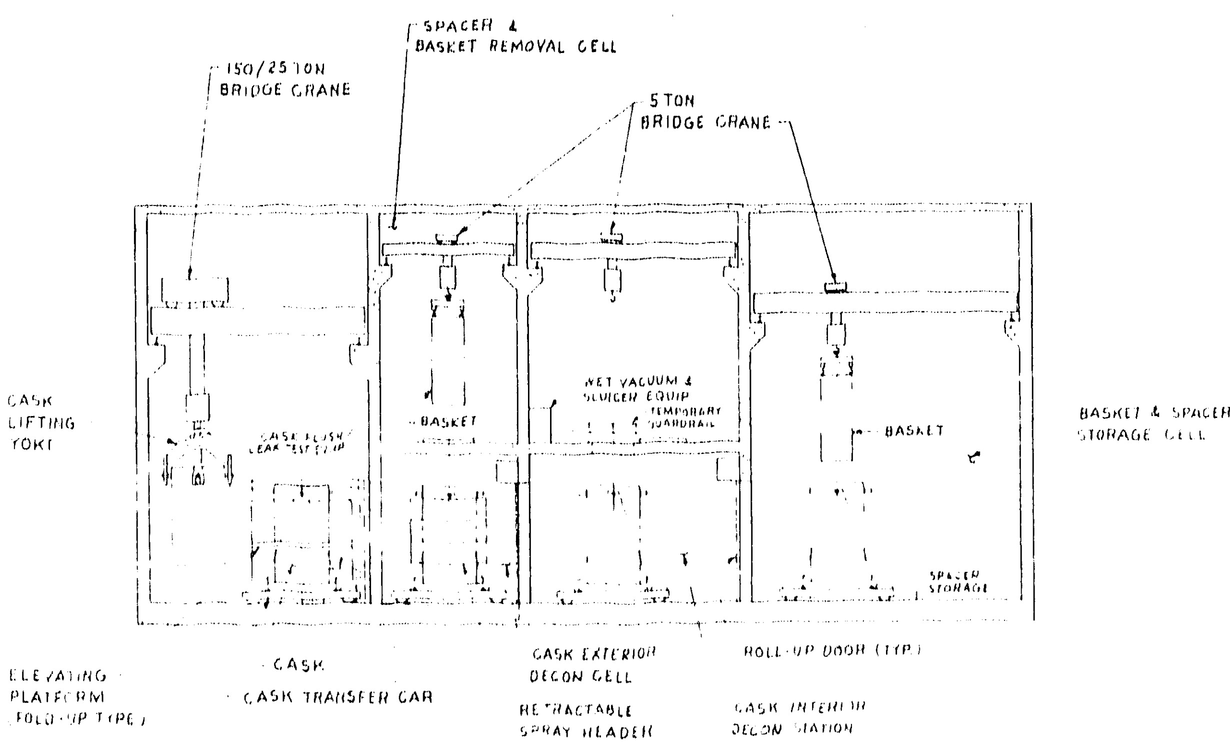


Figure 5-1. General Layout of the Cask Maintenance Area


CASK PREP AREA
SPACER & BASKET REMOVAL CELL
CASK INTERIOR DECON & SPACER CHANGEOUT AREA
OPERATING GALLERY
HATCH
WET VACUUM & SLUICER EQUIP.
CLOSURE LAYDOWN
TOOL STORAGE
CASK MAINTENANCE / PREPARATION AREA (BELOW)
TRUCK SPACER STORAGE
BASKET & SPACER STORAGE CELL (BELOW)
TEMPORARY GUARDRAIL
HATCH COVER
A
OPERATING GALLERY
CASK INTERIOR DECON & SPACER CHANGEOUT AREA
TEMPORARY CASK STORAGE (BELOW)
DECON & MAINT. SHOP ROOF
UPPER PLAN
CASK PREP AREA
CASK MAINT./ PREP. STATION
OPERATING GALLERY
CASK EXTERIOR DECON CELL
CASK INTERIOR DECON STATION
BASKET EMPLACEMENT STATION
TOOL STOR.
OPERATING GALLERY
SHIELD DOOR
BASKET STORAGE
OUTER CLOSURE LAYDOWN
SPACER DECON
SPACER & BASKET CELL
SPACER TRANSFER STA.
TRANSFER CAR (TYP.)
RAIL CASK SPACER STORAGE
TOOL STOR.
OPERATING GALLERY
BASKET STORAGE
CASK EXTERIOR DECON CELL
CASK INTERIOR DECON STATION
BASKET EMPLACEMENT STATION
A
OPERATING GALLERY
TEMPORARY CASK STORAGE
CASK
WORK AREA
MAINT. SHOP
PARTS & TOOL STORAGE
OFFICE
LOWER PLAN

Figur



SECTION (A)

Cask Maintenance Area Arrangement

Cask decontamination support equipment (not shown in Figure 5-2), including a tank, pump, and filter, is used to collect the process liquid waste generated in the cask maintenance area, prior to directing the waste to the repository radioactive waste treatment facilities (described in SNL, 1987).

The four general facilities constituting the cask maintenance area are described below.

5.2 Maintenance/Preparation Stations

The maintenance/preparation stations are similar to the stations in the cask preparation area. There are two stations equipped with cask transfer cars, elevating platforms, and a platform for equipment storage and laydown. The cask transfer car and elevating platform are of the same design as those in the cask preparation area and serve similar purposes.

The following functions are performed at the maintenance/ preparation stations:

- Cask cavity flushing and sampling
- Nonroutine cask maintenance
- Decontamination and maintenance verification
- Cask preparation for shipment offsite

Cask-flushing equipment is provided to flush the cask cavity, to fill the cavity for internal decontamination, to conduct maintenance and reconfiguration operations, and to purge the cavity of any contaminated water. Equipment is also furnished for sampling the levels of mobile contamination in the cask cavity.

Major cask-flushing equipment is located under the equipment storage platform. This equipment consists of supply and drain hoses and pumps (if necessary). Other equipment, such as penetration valve attachments, water sample bottles, and radiological instruments for analyzing the water sample, is located on the equipment storage platform.

Cask maintenance operations that can be performed at the stations are those described in Subsection 3.4.4, except replacement of fuel baskets and fuel spacers. The flushing equipment described above is also used to fill the cask with water to limit airborne contamination and provide shielding for operators performing manual maintenance in the decontamination and reconfiguration facilities, where the inner closure head is removed. These maintenance operations may include replacement of the inner closure head seal, fasteners and helicoils, and inner cavity penetration valves.

Additional facilities, e.g., leak-testing equipment and radiological survey instruments, at the cask maintenance/preparation stations permit decontamination and maintenance verification and other cask preparations for shipment offsite. The equipment and instruments are similar to those in the cask preparation area, described in Subsection 4.2.

If extensive cask decontamination (interior or exterior) or reconfiguration of the cask internal components is needed, the cask transfer car moves the cask through the ventilation barrier doors and into the decontamination and reconfiguration facilities. These facilities are described below.

5.3 Decontamination and Reconfiguration Facilities

5.3.1 General

The decontamination and reconfiguration facilities are used to perform thorough cask exterior and interior decontamination and cask reconfiguration operations. There are two process lines with cask transfer cars that move casks to various cells designed for specific operations. A transfer cart on a third process line moves the fuel basket and inner closure head (with the fuel spacer assembly attached) between cells.

Each cell has shield walls to reduce operator exposures and ventilation barrier doors to prevent the spread of contamination. Operating galleries permit personnel access around the decontamination and reconfiguration facilities and have shielded viewing stations to facilitate remote operation in certain cells. There are personnel access doors for each cell.

The decontamination and reconfiguration facilities comprise seven specific areas designed to accommodate particular operations:

- Cask exterior decontamination cell
- Cask interior decontamination station
- Cask interior decontamination and spacer changeout area
- Spacer and basket removal cell
- Spacer and basket decontamination cell
- Spacer transfer station
- Basket and spacer storage cell

The conceptual design of each of these facilities and the operations associated with them are described below.

5.3.2 Cask Exterior Decontamination Cell

The cask exterior decontamination cell is used to perform a thorough remote-automated decontamination of the cask surface. Remote decontamination operations can also be performed in the cell. The cell confines contamination during exterior decontamination operations, and ventilation exhaust is directed through filters prior to release.

The cell is located adjacent to the maintenance/preparation stations so that casks that require only exterior decontamination can be processed with minimal movement. Other casks that require exterior decontamination after internal decontamination and reconfiguration operations can be decontaminated and then moved directly to the maintenance/preparation station. This arrangement facilitates efficient cask-handling operations. Ventilation barrier doors at each end of the cell allow casks to move to and from the exterior decontamination cell.

A set of spray headers is used to decontaminate the cask exterior surface. The headers are retractable to adjust for differences in cask diameters. Each header is equipped with a system of high-pressure spray nozzles. The spray header system is supplied with steam, water, and chemical solutions. The pressure, temperature, and mixture of the decontamination liquid are adjustable to accommodate specific decontamination needs. Remotely operated spray wands (not shown in Figure 5-2) are provided at the viewing stations to allow operators to perform a directional spraydown of specific areas of the cask.

The floor of the exterior decontamination cell slopes toward a sump, where contaminated liquid waste is collected. This liquid is directed to the repository waste treatment system.

The cask exterior decontamination cell is also designed to accommodate the removal of the inner closure head and fuel basket. A hatch in the roof slab affords access to the spacer and basket removal cell, located above the exterior decontamination cell. The spacer and basket removal cell design and operations are described in Subsection 5.3.5.

5.3.3 Cask Interior Decontamination Station

The station is designed so that cask interior decontamination operations can be performed from above, in the interior decontamination and spacer changeout area. A hatch in the roof of the station permits access between the two areas. Ventilation barrier doors that allow cask movement in and out of the station separate the station from both the exterior decontamination cell and the basket and spacer storage cell. To allow emplacement of fuel baskets (if required), access is provided from the station into the basket and spacer storage cell.

5.3.4 Cask Interior Decontamination and Spacer Changeout Area

The cask interior decontamination and spacer changeout area is designed to facilitate extensive cask interior decontamination and fuel spacer changeout operations. Since these operations are performed manually, as described in Subsections 3.4.2.2 and 3.4.5, respectively, operators occupy this area during interior decontamination and fuel spacer changeout operations.

Hatches in the floor slab permit access to each of the cask interior decontamination stations, where the casks are positioned. A portable railing around the hatch enhances safety when the hatch is open.

Wet vacuum and sluicer equipment is supplied for each cask process line to perform the cask interior decontamination operations. A manually operated, long-handled sluicer, equipped with a vacuum attachment, is used to decontaminate the cask cavity. The sluicer and vacuum are equipped with water and vacuum process lines, respectively. There is an equipment cabinet containing a vacuum pump and necessary gauges, valves, and attachments. The contaminated liquid collected by the vacuum during decontamination is directed to the repository waste treatment system.

The area is also designed to facilitate fuel spacer changeout. A 5-ton bridge crane in the cell removes the inner closure head (with fuel spacer attached), through the hatch that accesses the spacer transfer station below (described in Subsection 5.3.7). A stand, similar to that described by Schmid (Appendix A-1), is used to support the inner closure head for fuel spacer changeout.

After the fuel spacers have been removed from the closure head and decontaminated, they are stored in a storage area. Because truck cask fuel spacers are changed more frequently than rail cask fuel spacers, the interior decontamination and space changeout area has a truck cask spacer storage area. Storage space is available for an assumed number of 40 truck spacers (assemblies) of about 2 ft in diameter. Because of their larger size, rail cask fuel spacers are stored in the basket and spacer storage area described in Subsection 5.3.8. The 5-ton crane transfers the rail spacers to and from the spacer transfer and inspection station for storage and retrieval, respectively. There is a storage area for the tools necessary for fuel spacer changeout operations.

In addition to interior decontamination and reconfiguration, the facility has the capability of replacing inner closure head seals if the operation cannot be performed at the maintenance/ preparation stations, previously described. The inner closure head stand used for fuel spacer changeout can also accommodate seal replacement.

5.3.5 Spacer and Basket Removal Cell

The spacer and basket removal cell is designed to be capable of remotely removing the inner closure head (with the fuel spacer attached to it) and fuel basket from either of the cask exterior decontamination cells and transferring them to the spacer and basket decontamination cell (described in Subsection 5.3.6). Because of the high radiation and contamination levels associated with baskets and spacers, this cell is designed as a contained area, equipped with a filtered ventilation exhaust to prevent the spread of contamination and shield walls to reduce operator exposure.

A 5-ton bridge crane handles both the inner closure head and fuel basket. The crane is operated remotely from either of the viewing stations in the operating galleries at each end of the cell. Two hatches permit access to the casks in the cask exterior decontamination cells located below. A CCTV enables the operator to view crane operations through hatches when removing the components from the cask. Another hatch in the middle of the cell floor is employed to transfer the inner closure head and fuel basket to the spacer and basket decontamination station located below, as described in the subsection that follows.

There is sufficient laydown area in the spacer and basket removal cell for the necessary lifting fixtures as well as the inner closure head, if required.

5.3.6 Spacer and Basket Decontamination Cell

The spacer and basket decontamination cell is designed to facilitate remote-automated and remote methods for decontaminating fuel spacers (attached to the inner closure head) and fuel baskets. As recommended by TN (1988), the spacer and basket decontamination cell is enclosed and separated from the cask cleaning areas. The facility design and the equipment furnished in the cell are the same as those used for the cask exterior decontamination cell.

The decontamination cell receives inner closure heads and fuel baskets from the spacer and basket removal cell through the hatch in the cell ceiling. A transfer car, designed to accommodate inner closure heads and fuel baskets, supports the components during decontamination and transfers them out of the cell for further processing. A roll-up ventilation barrier door separates the cell from the spacer transfer station.

5.3.7 Spacer Transfer Station

The spacer transfer station is designed to allow the decontaminated inner closure head and fuel spacer to be transferred into the interior decontamination area located above. The station also permits remote visual inspection of fuel baskets and spacers, if necessary, as recommended by TN (1988). Although the potential for contamination and radiation levels are relatively low in this area, the station is designed as a contained area and is equipped with filtered ventilation and shield walls. Even after decontamination of the fuel basket, the expected levels of contamination warrant the use of filtered ventilation and shielding of the station. Roll-up ventilation barrier doors at each end of the station allow the transfer car and its cargo to interface with both (1) the spacer and basket decontamination cell and (2) the basket and spacer storage area.

In addition to the viewing windows located on each side of the station, there is a remotely operated CCTV system in the station to allow visual inspection of fuel baskets (as recommended by TN [1988]). After visual inspection, baskets are transferred to the basket and spacer storage cell for storage.

The station also allows rail cask spacers to be transferred between the internal decontamination and spacer changeout area and the basket and spacer storage cell.

5.3.8 Basket and Spacer Storage Cell

The basket and spacer storage cell permits the storage of fuel baskets (for both truck and rail casks) and rail cask fuel spacers, and facilitates remote emplacement of baskets in casks. Because of the levels of contamination on decontaminated fuel baskets (up to 1,000,000 dpm/100 cm^2 [NAC, 1988]), the storage area design provides containment, filtered ventilation, and shielding.

A remotely operated, 5-ton bridge crane is used for handling the fuel baskets and spacers. The crane is operated from the viewing stations in the operating galleries, at each end of the area (both upper and lower floors). The cask cavity can be observed from windows in these stations and via the CCTV mounted on the crane.

If casks require a fuel basket, the cask transfer car is moved from the interior decontamination station to the basket emplacement station in the basket and spacer storage cell.

A ventilation barrier door connects the storage area with the spacer transfer and inspection station.

The cell is designed to store an assumed number of 6 truck cask baskets (approximately 2 ft diameter), 4 rail-cask baskets (approximately 5 ft diameter), and 20 rail-cask spacer assemblies. Equal numbers of PWR and BWR fuel baskets can be furnished.

5.4 Maintenance Shop

The maintenance shop supports the cask and equipment maintenance operations. It is sized to accommodate the storage of cask replacement parts, a work area, and support offices.

Certified cask replacement parts, such as closure head O-ring seals, valves and valve components, fasteners, helicoils, and other hardware, are stored in the shop. Replacement parts are supplied for the cask types addressed in Subsection 2.2.

The shop contains a work area equipped with tools, work benches, decontamination equipment, and calibration instruments. There is an electropolishing tub for the decontamination of tools and parts. Calibration instruments are furnished for equipment and tools used for both the cask preparation area and the cask maintenance area.

The shop also contains a QA office for cask maintenance documentation and a health physics office.

5.5 Temporary Cask Storage Area

The temporary cask storage area is used when the maintenance/ preparation stations are occupied or a transfer car in the cask preparation area is not readily available. The temporary storage area is sized for the storage of 4 casks (either rail or truck).

6.0 CONCLUSIONS AND RECOMMENDATIONS

6.1 Study Results

This study discusses the design requirements and performance criteria in DOE (1986a) and other documents pertaining to cask decontamination and maintenance, specifically in the areas of contamination control, replacement of removable cask components, and storage of interchangeable cask components. Conceptual designs of the cask preparation area and cask maintenance area are developed to comply with these requirements. It is recommended that these concepts be considered in further stages of design of the repository receiving facilities.

An in-depth analysis of cask-processing operations has been performed in this study to identify cask decontamination and maintenance tasks required at the repository. The analysis provides a basis for the conceptual design of facilities necessary to accommodate the tasks. A summary of the cask processing operations and associated facilities is shown in Figure 6-1.

Various cask-processing operations are identified in this study that have not been considered in detail in previous conceptual designs, including quantification of cask internal residual contamination, cask containment leak testing, and internal decontamination. It is recommended that the cask-processing operations identified in Section 3.0 of this report be addressed further in future repository design studies.

The cask preparation area and cask maintenance area described in this study are designed using a modular approach so that the concepts may be incorporated into the design of other cask-handling facilities (e.g., the MRS). They are also designed to be easily modified as the repository responsibilities for cask maintenance, internal decontamination, and reconfiguration operations are further defined.

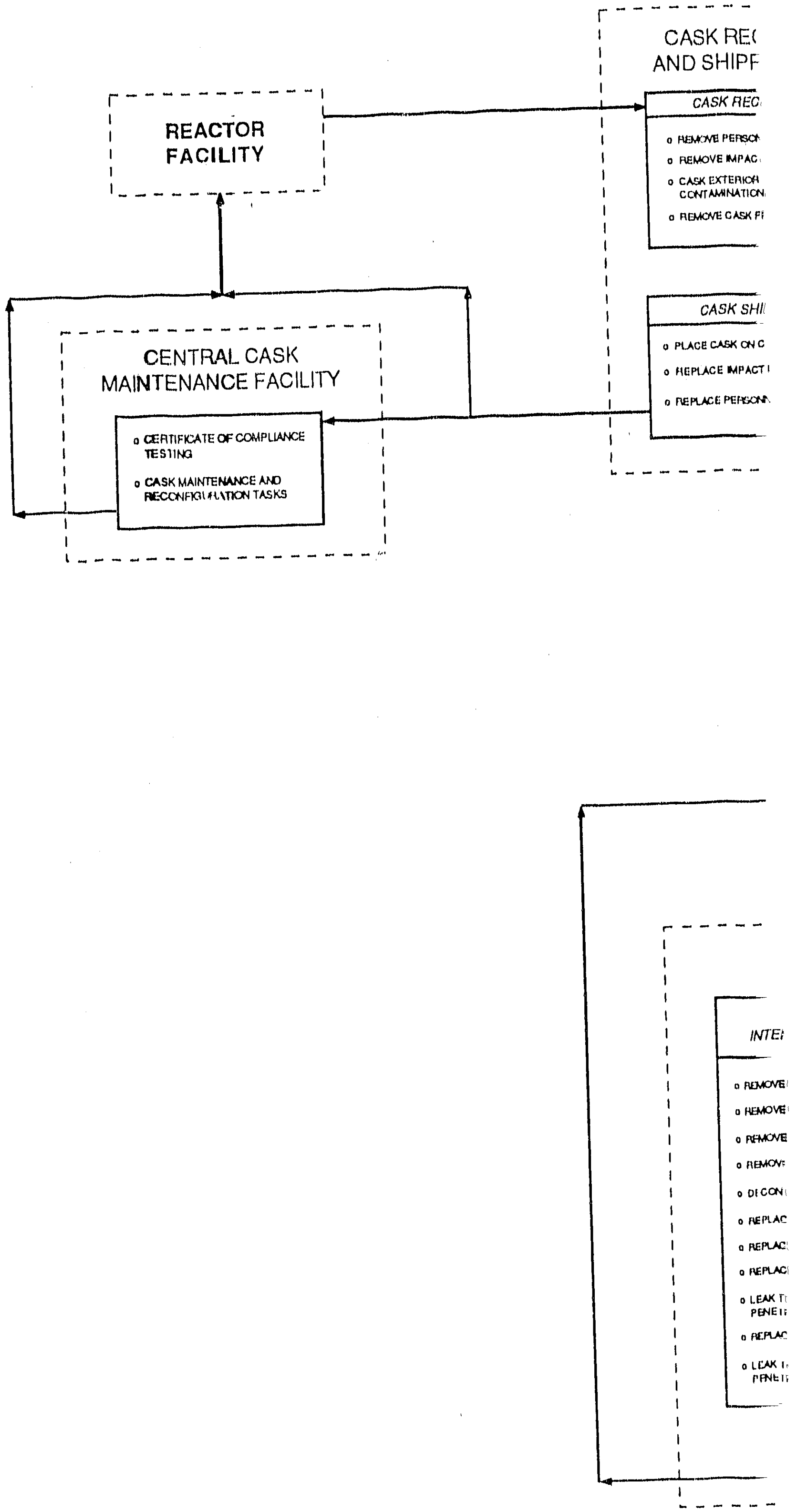
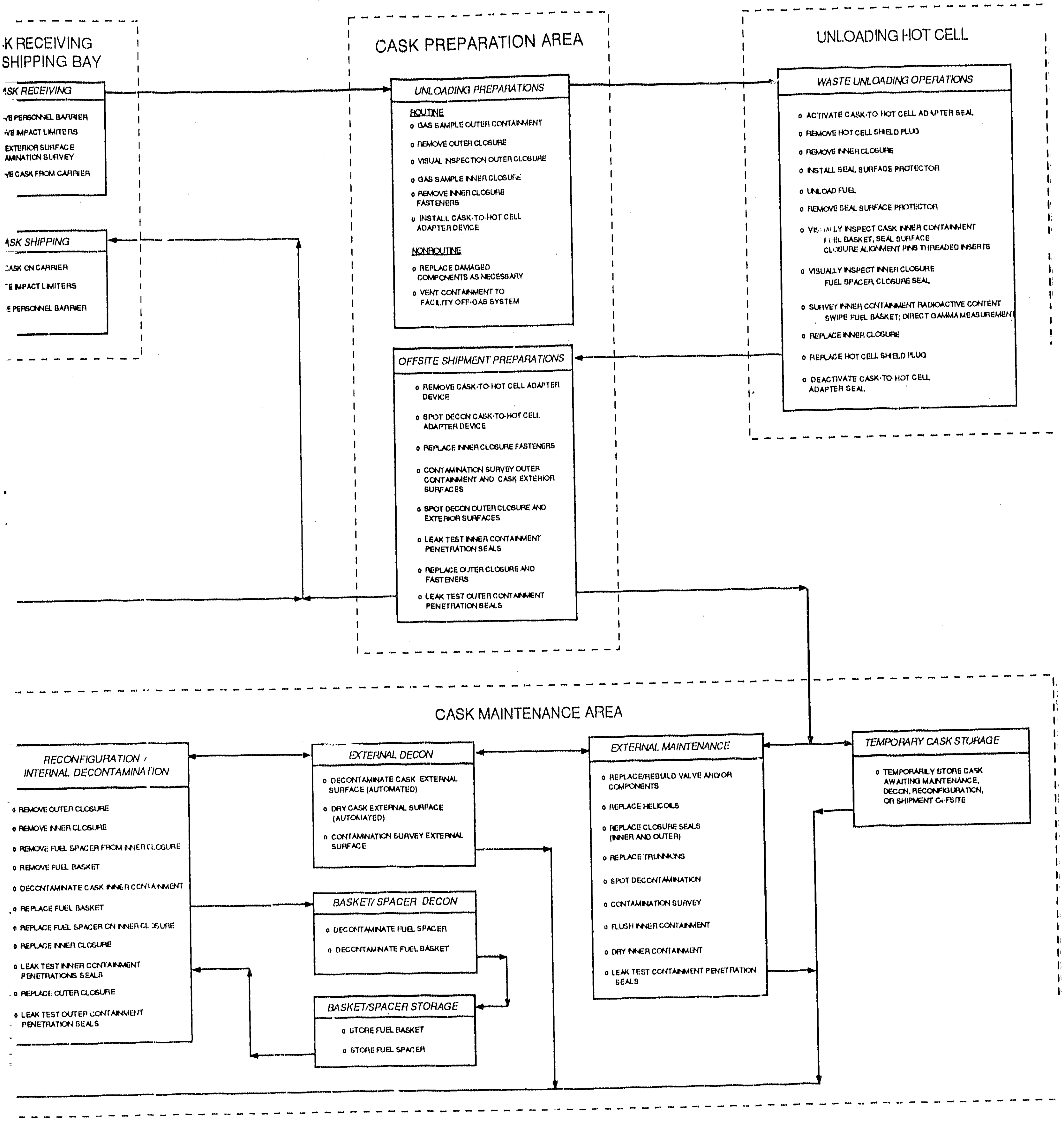

REACTOR FACILITY
CENTRAL CASK MAINTENANCE FACILITY
o CERTIFICATE OF COMPLIANCE TESTING
o CASK MAINTENANCE AND RECONFIGURATION TASKS
o PLACE CASK ON C
o REMOVE IMPAC
o CASK EXTERIOR CONTAMINATION

Figure 6-1.



Summary of Cask Processing Operations

Even if the Federal Waste Management System (FWMS) includes a cask maintenance facility (CMF), it is recommended that cask reconfiguration operations for fuel spacer changeout be performed at the repository. This maximizes cask availability and reduces the number of casks that have to be sent to the CMF. Reconfiguration requirements of the FWMS facilities are recommended for further study.

6.2 Areas for Further Study

Because of the lack of design information for casks being developed for use in the FWMS, the cask-processing operations identified in this report are based on an assumed cask system design. As new casks are developed, the cask-processing operations and associated repository design should be updated for applicability to the specific cask designs.

A review of requirement documents for the various facilities in the FWMS (DOE, 1986a; Attaway, 1988; Shappert, 1988) indicates that requirements for cask reconfiguration at each of the facilities are not clearly specified. Reconfiguration requirements will depend on a variety of factors, such as cask fleet size and transportation scheduling. The requirements for cask reconfiguration at the repository are recommended for further study.

As discussed in Subsections 2.3.5 and 3.4.2, the limits for interior contamination in unloaded casks for shipment offsite stated in DOE (1986a) may be impracticable or unattainable. The acceptable levels of interior contamination of unloaded casks specified in transportation system requirements documents (Shappert, 1988; Attaway, 1988) are less stringent. The requirements for internal contamination should be studied further and, for the sake of consistency, revised in the relevant requirements documents.

The cask interior decontamination operations developed in this study are based on various assumptions, including the expected levels of contamination, the acceptable levels of contamination, and the estimated frequency and effectiveness of cask internal decontamination. It is recommended that the buildup of contamination in cask interiors be studied further to better identify associated decontamination requirements.

The conceptual design of the cask preparation area developed in this report is based on the use of robotic methods for performing preparation operations on loaded casks. The feasibility of robotic operations and the ability to reduce operator exposures should be addressed in future studies. Comparisons of manual, remote, and remote-automated (robotic) methods should be considered in the areas of cost, operability, maintainability, and occupational exposures.

Dry cask unloading and maintenance operations, similar to those proposed at the repository, are used at COGEMA's La Hague Plant (Blomeke, 1988). Published information pertaining to design and operation details is limited. Therefore, a tour of the La Hague facilities should be made to observe operations and design details to facilitate the development of the repository design.

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Appendix A-1

Personal Communication
General Electric Morris Operations

From: Douglas J. Hartman
Of: Bechtel National, Inc.
At: San Francisco, CA

To: Steve Schmid
Of: General Electric
At: Morris, IL

Date: Various times between January 18, 1988 and March 2, 1989

D. Hartman and S. Schmid discussed the handling and processing of spent fuel transportation casks at General Electric's Morris Operations (GE-Morris). The facility receives spent fuel shipments mainly via rail using IF-300 transportation casks; several shipments by truck utilizing NLI 1/2, NAC-1, IF-100, and IF-200 transportation cask have also been received. The facility is designed for cask-unloading operations directly adjacent to the spent fuel storage pool.

A health physics survey of the shipment, consisting of radiation and contamination measurements, is performed prior to unloading the cask from the carrier (railcar or truck trailer). Schmid stated that approximately 40 contamination swipes are taken from the exterior surface of the IF-300 cask and about 10 swipes are needed for a contamination survey of the carrier. It takes two operators from 30 to 40 min to perform the contamination swipes of the incoming shipment. An average of 90 min is required to count the swipes and obtain the results. According to Schmid, approximately 10 out of 120 loaded casks received at the facility have exceeded the limits of 49 CFR 173.443(a) for removable surface contamination (22 dpm/cm^2 beta-gamma, 2.2 dpm/cm^2 alpha), and on one occasion, a cask exceeded the limits of 49 CFR 173.443(b) (220 dpm/cm^2 beta-gamma, 22 dpm/cm^2 alpha).

After the cask has been unloaded from the carrier, its exterior surface is routinely washed and decontaminated, if required. Dirt or oils on the cask tend to make subsequent decontamination more difficult. The IF-300 rail casks received at GE-Morris frequently have significant amounts of diesel oils on their exterior surface from locomotive exhaust. A solution of trisodium phosphate and hot water is typically used for the wash and decontamination of the exterior surface of the cask.

The IF-300 cask cavity is filled with deionized water. A sample of the water is obtained for analysis to determine the general condition of the spent fuel, as well as the "mobile" radioactive contamination buildup in the cavity. A gamma scan of the water in the sample bottle is performed to determine the isotopic concentration of the sample. Schmid provided values of the cavity water sample that he felt were representative of what is usually experienced for the IF-300 cask. These values are as follows:

- Initial water sample reads 16,000 dpm/ml of Co-60. After the cavity has been flushed for 30 min, the concentration is reduced to 1,800 dpm/ml of Co-60.

- Concentration of cesium is typically in the range of 10^{-3} μCi/ml. The facility license limit for fuel unloading is 10^{-1} μCi/ml.

Subsequent to obtaining the water sample, the IF-300 cask cavity is flushed with the deionized water at a flow rate of 30 gpm for about 1/2 hr, corresponding to approximately one volume of the cask cavity. The flush solution and cavity cover gas are directed through the facility drain lines to the spent fuel storage pool line filter. According to Schmid, because of the buildup of crud in the cask drain hoses, the hoses require replacement about once a year to reduce operational radiation exposures.

For the NLI 1/2 transportation casks, the pressure of the volume between the inner and outer closure heads (outer cavity) is routinely checked prior to removing the outer closure head. Sampling of the primary containment (inner cavity) of the NLI 1/2 is similar to sampling of the IF-300.

After the primary containment has been sampled and flushed, the closure head bolts are loosened and most of them removed. The remaining bolts are removed prior to submerging the head of the cask in the fuel pool. Because of the spring-loaded design of the closure head Graylock O-ring seal, the bolts on the IF-300 cask head are loosened sequentially.

Schmid indicated that it takes two operators from 1 to 3 hr to loosen and remove the 32 bolts (using air wrenches) on the IF-300 cask closure head.

Once the cask has been placed at the bottom of the fuel pool, the closure head is lifted off the cask and removed from the pool, and remains suspended from the crane. The closure head seal is visually inspected for damage or wear and tear. Schmid stated that the closure head seal on the IF-300 cask is replaced every 5 shipments (or 10 closures). The T-section O-ring seal is held in place to the closure head by three retaining clips and set screws. Schmid noted that it takes two operators approximately 30 min to replace the seal.

After fuel unloading, the cask cavity and closure head seal surfaces are visually inspected using an underwater camera. The cask is removed from the storage pool, and the cavity is drained upon completing the visual inspection of the cask cavity. Before the closure head is reemplaced on the IF-300 cask, the cavity is surveyed to determine the radioactive content of residual contamination buildup for the shipping manifest. The inner closure head on the NLI 1/2 needs to be reemplaced to drain and purge the inner cavity of any free-standing water. The closure is removed to survey the inner cavity. Schmid said that a combination of a contamination swipe and direct radiation measurements is used to calculate the radioactive content of the unloaded cavity.

A swipe is obtained from the fuel basket, near the head of the cask, and analyzed to determine the isotopic distribution of the radioactivity in the cavity. Although the surface is damp during the swipe, the swipe, according to Schmid, is used strictly for qualitative purposes, thus not affecting the results of the calculated gross activity in the unloaded cask. Direct radiation measurement of the cask cavity is subsequently obtained. Schmid pointed out that for the IF-300 cask, typical radiation levels run on the order of 40 R/hr at the top opening of the cask and up to 100 R/hr near the bottom of the basket.

Schmid indicated that the calculated gross activity levels in an unloaded IF-300 cask cavity are on the order of 7 Ci, consisting mostly of Co-60, Ni-63, and Fe-55. The average activity levels correspond to Type A quantities as defined in 49 CFR 173.431. Thus, the unloaded casks are shipped as Type A packages of radioactive materials. Schmid said that he has never run across unloaded casks containing Type B quantities of radioactivity.

After the radiation measurements of the cask cavity have been taken, the closure head is reemplaced and the bolts are torqued. Schmid stated that the cask cavity is not routinely flushed after fuel unloading. The cask cavity of the IF-300 is purged to remove any standing water and then filled with helium for leak testing. Each cavity penetration valve and the closure lid seals are leak-tested. A thermostatic conductivity sniffer probe is utilized for detecting helium leakage through the valves or closure head seals. Schmid noted that the residual water typically in the cask cavity after draining and purging does not significantly affect the sensitivity of the leak test. He added that each penetration valve seal requires about 15 min for leak testing, as opposed to around 30 min for the closure head seal.

Even though leak testing is not required by the regulatory agencies for Type A packages, Schmid noted that it is routinely performed on IF-300 casks because if any faulty seals are detected, the facilities and spare parts are readily available on site. He added that the helium leak test is tedious and takes more time than the pressure tests required on other cask types. He suggested that routine leak tests be made simple and as easy to interpret as possible.

Before the cask is loaded on the carrier, the exterior surface of the cask is decontaminated to one half the DOT limits specified in 49 CFR 173.443(a) for shipment offsite. Because of the complex geometry of the exterior of the IF-300 cask, the decontamination operations include the use of spray wands (supplied with high-pressure steam or decontamination solution) and manual scrubbing. Schmid stated that more than 10 hr is spent decontaminating the exterior of the IF-300 prior to shipment offsite.

During annual (or internal) maintenance or cask reconfiguration, the IF-300 cask is placed in the spent fuel pool to accommodate the removal of the fuel basket. Schmid said that it takes approximately 1-1/2 hr to remove the fuel basket. An underwater vacuum is used to remove loose contaminants from the fuel basket and cask cavity.

On IF-300 casks, fuel spacers, provided for each fuel channel of the fuel basket, are attached to a mounting plate that bolts to the underside of the closure head. The fuel spacer "assembly" is reemplaced by placing and mounting the closure head on a stand that is designed to flip the closure head upside down. The bolts that hold the spacer assembly are removed, and a crane lifts the spacer assembly from the closure head.

Bottom spacer configuration for the IF-300 requires that the individual spacers be lowered into each fuel channel and rest on the bottom of the cask basket. Schmid stated that the spacers will occasionally migrate up the fuel channel during transport of an unloaded cask. After the cask has been upended, the spacers may not reposition themselves at the bottom of the basket, in which case manually repositioning of the fuel spacers is required.

Annual maintenance and testing of the IF-300 include leak testing of the closure lid and penetration valves. The leak-testing procedure for the closure lid seal is similar to that performed routinely for shipment of the cask offsite, except that the sensitivity of the test is significantly enhanced. Penetration valve testing requires removal of the valve, as is the case with the cavity pressure relief device. The device on the IF-300 cask needs to be tested annually. This testing involves the removal of the valve from the cask, which is a 1 hr operation. Additional annual maintenance includes neutron shield fluid testing, trunnion load testing, and cask support plate testing.

Appendix A-2

Personal Communication
Babcock and Wilcox - Lynchburg Research Center

From: Douglas J. Hartman
Of: Bechtel National, Inc.
At: San Francisco, CA

To: Steve Schilthelm
Of: Babcock and Wilcox
At: Lynchburg, VA

Date: Various times between February 24, 1988 and March 2, 1989

D. Hartman and S. Schilthelm discussed handling and processing of spent fuel transportation casks at Babcock and Wilcox's Lynchburg Research Center (LRC). Spent fuel is shipped to LRC in the NLI 1/2 truck transport cask. On occasion, the NFS-4 (NAC-1) truck cask has been utilized for the shipment of spent fuel to the facility.

The LRC facility is designed for cask unloading in a spent fuel pool. The cask-handling facilities at LRC consist of a shipping and receiving bay, a cask preparation area, and a spent fuel unloading/storage pool. A ventilation barrier separates the cask preparation area from the shipping and receiving bay. Because of the limitation on the depth of the pool, a hot cell is located over part of the pool to accommodate the removal of spent fuel from the cask.

Most spent fuel shipments received at LRC are in the form of rods, as opposed to intact assemblies. Special baskets (or tubes) are provided for the NLI 1/2 cask to accommodate the fuel rods. Each basket has a capacity of approximately a dozen rods. The entire basket is lifted from the cask into the hot cell for unloading the fuel rods.

A health physics survey of the incoming shipment, consisting of radiation and contamination measurements, is performed prior to unloading the cask from the carrier. Routinely, 50 contamination swipes of the NLI 1/2 cask exterior and 12 of the trailer are obtained. In addition, about a half dozen swipes of the impact limiters are obtained after the latter are removed from the cask. According to Schilthelm, this is done because the limiters are stored in the shipping and receiving bay (a noncontamination area). Schilthelm stated that nearly all of the shipments received at LRC have met the regulatory limits for removable surface contamination. Decontamination of the exterior surface of casks received at LRC is rare.

Cask preparations for unloading fuel from the NLI 1/2 begin with checking the pressure in the volume between the inner and outer closure heads (outer cavity). This pressure check is performed to verify that the inner closure head seal integrity was maintained during transport. The outer closure head is removed after the pressure check. Schilthelm said that 15 to 20 min are required to unbolt, remove, and store the outer closure.

Removal of the NLI 1/2 outer closure head provides access to the inner cavity penetration valves for performing a pressure check and for sampling the primary containment (inner cavity). Swipes of the cask outer cavity are obtained prior to these operations. Schilthelm stated that the outer cavity is typically free of removable contamination.

Two methods have been used for sampling the inner cavity at LRC. In the first (and more common) method of inner cavity sampling, the cavity is purged with deionized water and a sample of the water obtained. The water sample is analyzed for gamma emitters. Schilthelm indicated that there are no facility limits of radioactive concentrations found in the samples for fuel unloading. Since the fuel pool contains so much failed fuel, there is little concern about the results of the water sample analysis. Schilthelm added that significant amounts of Kr-85, diluted in the water sample, have occasionally been detected.

In the second method of inner cavity sampling, a sample of the cover gas is obtained. This method involves purging the cavity with deionized water and securing a sample of the displaced gas for analysis. Approximately 1/2 hr is required for obtaining and analyzing the gas sample. Schilthelm pointed out that this method is used only if required by the client.

After the cask inner cavity has been sampled, the inner closure head bolts are loosened and all but a few removed. The remaining bolts are removed before the cask head is submerged in the pool. Schilthelm stated that the cask exterior surface is sprayed down with deionized water as it is lowered into the pool. The "film" of deionized water has proved to be effective in reducing the amount of pool water contamination that is attracted to the cask surface during fuel unloading.

Once the cask has been placed in the fuel pool, the inner closure head is removed from the cask and taken out of the pool for visual inspection. Fuel-unloading operations are subsequently performed. According to Schilthelm, the inner closure head seal surfaces are visually inspected while the cask is being removed from the pool.

As the cask is removed from the pool, the exterior surface is sprayed with deionized water and then hand-wiped dry. Schilthelm said that since LRC's fuel pool is relatively clean, wiping down the cask exterior surface usually decontaminates the surface enough so that it meets DOT standards. He added that the levels of cask exterior surface contamination are kept down to about 10 dpm/cm^2 (beta-gamma) for shipment offsite.

After the cask has been removed from the pool, the inner closure head is reemplaced and the inner cavity is purged to remove free-standing water. Schilthelm stated that the inner cavity of the unloaded cask is not routinely flushed. He added that some facilities to which the casks were to be returned did require cavity flushing at LRC prior to shipment offsite. The inner closure head is removed after purging to quantify the radioactive content of the unloaded cask cavity for the shipping manifest. Schilthelm indicated that a combination of a swipe and direct radiation measurements is used to quantify the radioactive content of contamination buildup in the cask cavity.

A swipe of the inner cavity surface, near the top end of the cask, is obtained. Schilthelm stated that the efficiency of the swipe is typically low because the contamination forms an oxide layer that makes it difficult to remove. Because inner cavity swipes at LRC have sometimes produced radiation levels on the order of 1 mR/hr, Schilthelm warned that care should be taken not to apply too much pressure when swiping the cavity. Unless the shipment contained failed fuel upon receipt at LRC, the swipe is analyzed only for gamma emitters. The predominant peaks of the gamma scan identify the isotopic content.

After swiping, a direct radiation measurement is taken of the inner cavity. Radiation levels at the top opening of the NLI 1/2, with the closures removed, are on the order of 1 R/hr. The results of the swipe and radiation measurements are used to calculate the isotopic and gross activity levels. Schilthelm stated that calculated gross activity levels of unloaded NLI 1/2 casks typically average from 100 mCi to 500 mCi. These levels, resulting mostly from Co-60 and cesium, correspond to Type A quantities.

According to Schilthelm, the cask Certificate of Compliance (CoC) requirements for leak testing do not need to be met if the cask radioactive content does not exceed that of Type A quantities. He added that he has not come across any unloaded casks at LRC that have had residual contamination buildup exceeding Type A quantities of radioactivity.

Routine cask maintenance at LRC is limited to visual inspection of the cask components for wear and tear. Inner closure O-ring seals have been replaced at the facility, the operation taking 15 to 20 min.

Schilthelm stated that fuel baskets have been removed from the cask cavity in the cask preparation area at LRC. The baskets typically produce radiation levels on the order of 50-60 mR/hr at 1 m. He added that, upon removal, the baskets are covered with plastic before they have a chance to dry. This is done in order to avoid airborne contamination problems.

Appendix A-3

Personal Communication
Savannah River Plant - Receiving Basin for Offsite Fuel

From: Douglas J. Hartman
Of: Bechtel National, Inc.
At: San Francisco, CA

To: Joseph Stapf
Of: Westinghouse Savannah River Co.
At: Aiken, S.C.

Date: Various times between January 14, 1988 and April 3, 1989

D. Hartman and J. Stapf discussed the handling and processing of spent fuel transportation casks at the Savannah River Plant's Receiving Basin for Offsite Fuel (SRP-RBOF). Spent fuel has been received at the facility in a wide variety of casks including the NLI 1/2 and NFS-4 (NAC-1) truck transportation casks. The facility currently receives only spent fuel from research reactors, the majority of which comes from overseas. The facility is designed for cask unloading in a spent fuel unloading/storage pool.

A contamination survey of the exterior surface of casks received at the facility consists of 20 to 30 swipes. Stapf said that the number of swipes taken may vary considerably, depending on the cask type. He stated that it takes from 1 to 1-1/2 hr to obtain, count, and record the results of the swipes. Significant levels of contamination on the exterior surfaces of the casks received at the facility are infrequent. Nearly all the shipments received at the facility have met the regulatory contamination limits of 49 CFR 173.443(b) (220 dpm/cm^2 for beta-gamma emitters and 22 dpm/cm^2 for alpha emitters). Thus, decontamination of the cask exterior prior to fuel unloading is seldom performed. Stapf added that experience at the facility with "weeping" of contamination from the cask surface has been limited to localized areas of the cask. Higher levels of contamination are generally found on weld seams and valve ports.

Cask preparations for unloading fuel from the NLI 1/2 begin with routinely venting the outer cavity to the facility offgas system. Next, the outer closure head captive bolts are loosened and removed. Removal of the bolts takes about 15 min. The outer closure is removed, and preparations are made for sampling the primary containment (inner cavity). Prior to sampling the inner cavity, the top surface of the inner closure head is surveyed for contamination. (Generally, the surveys indicate the contamination level to be low. Stapf stated that instances have occurred where the levels of contamination were higher than the operators would like to see. The high levels were attributed to poor decontamination methods at the cask loading facility.) Next, covers and extensions of the inner cavity penetration valves on the inner closure head are removed. The inner cavity cover gas is routinely vented through the penetration valves to the facility offgas system. Accessing the valves and venting the cavity takes from 20 to 30 min.

Stapf indicated that sampling of the inner cavity is performed by filling the cavity with deionized water, allowing it to sit for 10 to 15 min, and obtaining a 100 to 150 ml sample of the water. He added that it takes approximately 45 min to fill the inner cavity of an NLI 1/2. About a 1 ml portion of the water sample is placed on a metal planchet and dried on a hot plate. The dried sample is analyzed for both beta-gamma emitters and alpha emitters. Approximately 45 min is required to obtain and analyze the water sample. The limits for placing the cask into the pool for unloading are dependent on a combination of the activity of the water sample, the volume of the cask cavity, and the condition of the fuel pool.

Inner closure head bolts are subsequently loosened and all but a few removed. The remaining bolts are removed before the cask head is submerged in the pool. Once the cask has been placed in the fuel pool, the inner closure head is removed and placed on the floor of the pool. Stapf stated that a manual hoist is used for removing the fuel assemblies from the cask. After fuel unloading, the inner closure head is reemplaced on the cask, which is subsequently removed from the pool, drained of basin water, and placed in the cask preparations area.

Preparation of the unloaded cask for shipment offsite includes purging the inner cavity with air to remove any free-standing water and performing any leak tests required by the SARP. Typically, the inner cavity and basket are not decontaminated unless prior arrangements have been made for a specific shipment. The facility was not provided with the capability to use more aggressive decontamination solutions and remote decontamination techniques required to remove heavy contamination from a severe fuel cladding failure or residue from a highly contaminated loading basin.

Prior to shipment offsite, the cask exterior is decontaminated with a steam lance. The lance is supplied with both steam and deionized water where the mixture of the two can be adjusted. The temperature and pressure are also adjustable. Clayton Cleaner, a mildly caustic soap, is usually added to the water to facilitate cleaning action.

For one unique program, Stapf stated that steam lance decontamination of the cask cavity and fuel basket has been performed at SRP-RBOF. The cask is placed in the decontamination pit of the cask preparations area, and the fuel basket is raised out of the cask using an overhead crane. The basket is decontaminated manually with a steam lance to levels of approximately 1,000 to 10,000 dpm/100 cm^2 beta-gamma. The cask cavity is decontaminated by the same method to levels of about 10,000 to 12,000 dpm/100 cm^2. Stapf stated that it takes two operators approximately 8 hr to perform the decontamination operations. Approximately half the time involves decontamination operations and half for allowing the surfaces to dry, to swipe, and to analyze the swipes. The starting level of contamination is estimated to be about 2x the level at completion of the cleaning operation.

On one occasion an empty cask, previously retired from service, was received at SRP with a significantly contaminated cavity. Decontamination of this cask was a major effort, requiring strong chemicals in a shielded Canyon cell normally used to remotely decontaminate reprocessing equipment. This decontamination cell is not a part of the RBOF facility and therefore was not designed to easily accommodate shipping casks for decontamination.

Appendix A-4

Personal Communication
Idaho National Engineering Laboratory - Test Area North

From: Douglas J. Hartman
Of: Bechtel National, Inc.
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To: Carlan Mullen
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At: Idaho Falls, ID

Date: Various times between February 11, 1988 and March 6, 1989

D. Hartman and C. Mullen discussed spent fuel transportation cask handling and spent fuel unloading performed at the Idaho National Engineering Laboratory (INEL) Test Area North (TAN) Hot Cell Facility The TAN Hot Shop (Cell) Facility is a large (50 ft x 170 ft x 75 ft) concrete-shielded negative-pressure air atmosphere hot cell equipped with remote electromechanical handling equipment capable of handling spent fuel shipping and dry fuel storage casks up to 100 tons. Numerous remotely operated manipulators and hot cell support systems and capabilities are available to accommodate air transfer of spent fuel assemblies and large or small radioactive components. A smaller (10 ft x 30 ft) hot cell is located adjacent to the Hot Shop for performing remotely detail examination and testing on radioactive materials.

The Hot Shop Facility has received, handled, and unloaded/loaded numerous shielded transport casks. A partial list of casks received or handled at the facility, along with the approximate number of unloadings or loadings, is given below.

Cask Name	Type		Number of Loadings
NL-1 (single fuel assembly)	Road		5
CNS-128 (waste liner TMI EPICOR)	Road		48
TN-8L (3 fuel assemblies)	Road		30
TMI NUPACT-125-B (7 canisters)	Rail	to date remaining	37 23

Cask Name	Type		Number of Loadings
CNS Castor V-21 (21 fuel assemblies, dry storage)	Onsite only		1
TN-24 (24 fuel assemblies, dry storage)	Onsite only		1
Westinghouse MC-10 (24 fuel assemblies, dry storage)	Onsite only		1
FMIRC (LOFT single assembly, fresh fuel)	Onsite only		11
Numerous INEL onsite only casks for transport of fuel and radioactive wastes	Road/rail		100 plus
TN-BRP West Valley (42 BWR fuel assemblies, transport/dry storage)	Rail	scheduled	Oct. '89
TN-REG West Valley (24 PWR fuel assemblies, transport/dry storage)	Rail	scheduled	Oct. '89

The major spent fuel shipping campaign associated with the TAN Hot Shop Facility used a trailer-mounted, over-the-road overweight (40-ton), three-fuel assembly TN-8L transport cask. This cask was leased from Transnuclear Inc. and was transported under contract with TRI-State Carrier. Three separate shipping campaigns were conducted sequentially using the TN-8L cask. A total of 69 PWR fuel assemblies from Virginia Power Company's Surry Plant; 17 PWR Turkey Point fuel assemblies from the Engine Maintenance, Assembly, and Disassembly (E-MAD) Nevada Test Site Facility; and three partially disassembled PWR fuel assemblies from the Battelle Columbus, Ohio, facility were received, unloaded, and placed in dry spent fuel storage casks.

As part of this storage cask testing project, three approximately 100-ton spent fuel storage casks were received at the TAN Hot Shop, offloaded from their transport carrier support frames, and prepared for fuel loading. After the casks had been loaded with spent fuel, each cask was prepared for temporary storage and then moved to a cask test pad adjacent to the Hot Shop by a special designed cask transporter.

The TMI core debris currently being transported to the INEL for temporary storage and examination has also been a major shipping, cask, and fuel canister handling experience for the TAN Hot Shop Facility. As the table above indicates, nearly 100 shipping casks will be unloaded and 400 canisters containing fuel debris will be handled and placed in temporary storage.

As the TN-8L shipping casks were received at the facility, a receiving survey was performed which consisted of reviewing the shipping papers, performing a radiological survey, and inspecting the cask and trailer per a Transnuclear receiving inspection checklist. This inspection generally took approximately 2 hr. On one occasion, however, during the TMI EPICOR resin waste shipping campaign, a CNS-128 waste liner shipping cask and transport trailer arrived at the facility significantly covered (1 to 2 in.) with ice and road dirt. The ice was removed by applying a jet of warm water with a high-pressure spray washer to melt the ice. This operation took approximately 4 hr, and no radiological problems resulted. All other shipments have been received and unloaded at the facility without significant unloading delays.

The TN-8L spent fuel casks used to transport the Surry Power Plant fuel have been loaded with spent fuel under water at the power plant's fuel storage pool. In this arrangement, an inflatable shroud prevents most of the outer surface area of the cask from coming in direct contact with contaminated water in the storage pool. However, certain portions of the cask, such as the top and bottom of the cask and the lifting and rotation trunnions, do come in contact with contaminated pool water. At the Hot Shop, all cask handling and fuel unloading is conducted in air, with the outer surfaces of the cask covered with a plastic sheet to protect them from airborne radioactive contamination.

On a few occasions, the casks, when surveyed at the Hot Shop during initial receiving, were found to be slightly contaminated above the allowable shipping limits. This contamination was detected near the lifting and rotating trunnions located at the upper and lower portions of the cask. These areas were not protected by the inflatable shroud used when the cask was loaded in the reactor spent fuel storage pool.

The lubricant placed on the trunnions for unloading the cask from the carrier tended to attract contamination and probably came from surface joints near the cask body and trunnion interface. The variation of temperature and humidity level between the Surry Power Plant and the INEL may account for the sweating of this contamination from the joints. No contamination problems occurred during the fuel transport from the the E-MAD Nevada Facility, probably because both fuel loading and unloading were performed in air and temperature and humidity were similar at both facilities. The TN-8L casks that were shipped back to Surry were decontaminated and shipped at one half of the allowable contamination transport level from the INEL to provide a safety factor. Health physics personnel from Surry and the INEL were sent to each other's facility to witness radiological techniques in an attempt to eliminate contamination problems. During the shipping campaigns, those casks found to exceed the shipping contamination levels were not decontaminated prior to unloading in the Hot Shop because the levels were low and would not contribute to existing Hot Shop contamination levels.

Prior to the cask fuel unloading, the casks were covered with a plastic sheeting to prevent them from being contaminated during the air transfer of the fuel assemblies to the dry spent fuel storage casks. Because of the surface temperature of the shipping cask, standard poly sheeting could be used. However, surface temperatures of the storage casks required the use of teflon sheeting to prevent melting as well as contamination.

The TN-8L cask unloading followed standard procedures provided by Transnuclear for the cask, modified as required to interface with the Hot Shop equipment and operating requirements, and were reviewed and approved by Transnuclear. Fission product gas of the cask containment was sampled by attaching a gas collection valve tree furnished with the cask to a sample cylinder and a connection on the cask lid. This was done to verify that vented gases, if they contained fission gas, would not exceed facility stack gas operational limits. The radioactivity levels of the gas in the sample cylinder were counted in an adjacent health physics office using a mass spectrometer. This operation typical took about an hour and was required before cask venting and lid bolt removal could proceed. No fission gas indications were detected in the unloading operations of fuel shipped from the Surry Power Plant or the E-MAD Facility.

No major contamination spread resulted from the air transfer of spent fuel from the TN-8L casks to the spent fuel storage casks. Plastic sheeting was used on the cask personnel work platform to minimize the amount of decontamination required after each cask unloading. Decontamination generally consisted of removing the plastic sheeting in an inward folding manner to trap any contamination inside the plastic sheet and a radiologic survey to verify that contamination levels were operationally acceptable. This process took approximately 3 to 4 hr.

After the fuel had been transferred to the storage casks and the lid placed on the storage casks, the above decontamination and radiological survey was completed and the TN-8L cask was prepared for loading into the transport trailer per Transnuclear procedures. Prior to placing the cask lid on the cask, an internal radiological survey was conducted to determine the contamination levels in the cask cavity. The lid was installed, bolted, and torqued, and the cask cavity was backfilled with nitrogen gas. The cask was leak-tested and its outer surfaces were radiologically surveyed and decontaminated as required. The cask was then placed on the transport trailer and removed from the Hot Shop, and final shipping preparations (including a final radiological survey and preparation of the shipping papers) were conducted.

All operations were conducted using detailed operation procedures with comment sheets and information fill-in sheets. A detailed report could be developed by reviewing the facility records. This could be valuable in developing cask-handling time relationships and would allow a very detailed estimate of specific cask- and fuel-handling operation times.

The low levels of contamination detected on the outer surfaces of the casks were removed using standard manual decontamination techniques. This operation took no more than 1 to 2 hr and was performed in combination with the final radiological surveys.

To collect samples of the curd and to perform radiological surveys inside the cask, was an aluminum reach pole with a sticky tape on one end was used. The tape was placed on the interior bottom of the cask and any loose material was collected on its surface. The pole was removed from the cask interior and the tape with attached crud placed in a plastic sample bag. The radiological surveys were obtained in a similar manner, except that a standard smear tab was used instead of the tape and the aluminum pole was moved laterally across the bottom of the cask. Surveys were also taken on the upper interior surfaces of the cask by a technician reaching down into the cask cavity from the top of the cask lid opening. These surveys provided the information on the internal contamination for the shipping paper preparation.

The fuel assemblies were specifically identified and characterized for the testing of dry spent fuel storage cask and rod consolidation performed at the Hot Shop and therefore may not be representative, as far as crud is concerned, of fuel that may be received at a repository. Further information on crud characterization from certain fuel assemblies shipped to the Hot Shop is available in the final informal report, entitled "Dry Rod Consolidation Technology Project at the Idaho National Engineering Laboratory" EGG-WM-8059, April 1988.

At the completion of the E-MAD fuel shipping campaign, one of the TN-8L casks had a high radiation level reading measured at the lower drain port at the bottom of the cask. Transnuclear asked that the radiation level be lowered while the cask remained inside the Hot Shop. It was determined that contamination had collected in the quick-disconnect coupling at the bottom drain port on the cask and that this was the source of the high radiation readings. The quick-disconnect coupling was replaced, and the radiation measurement was reduced to allowable shipping levels.

The TN-8L cask unloading turnaround time averaged between 18 and 24 hr. The actual turnaround time was a function of the time the cask was received at the facility. Selective overtime was used to optimize single-shift facility trained personnel. Other factors that impacted cask turnaround time included other Hot Shop programmatic work schedules, Hot Shop equipment maintenance and breakdown, and dry spent fuel storage cask testing work performed in combination with the cask fuel unloading.

Appendix A-5

Personal Communication
Idaho National Engineering Laboratory-Idaho Chemical Processing Plant

From:	Douglas J. Hartman	To:	Ronald Denny
Of:	Bechtel National, Inc.	Of:	Westinghouse Idaho, Inc.
At:	San Francisco, CA	At:	Idaho Falls, ID

Date: Various times between November 18, 1988 and March 7, 1989

D. Hartman and R. Denny discussed the handling and processing of spent fuel transportation casks at Idaho National Engineering Laboratory's Idaho Chemical Processing Plant (INEL-ICPP). Denny stated that most of the shipments received at the facility are onsite shipments using the NFS-100 cask. He added that the facility has received offsite shipments of Fermi fuel in the NLI 1/2. ICPP has handled a large variety of different cask types. According to Denny, these casks are designed for noncommercial reactor fuel and are dimensionally smaller than casks designed for commercial power reactor fuel. The ICPP facility design provides for both wet cask unloading in a spent fuel unloading/storage pool and dry cask unloading in a hot cell. Denny noted that, to date, no spent fuel has been unloaded in the hot cell.

Denny stated that casks received at ICPP are fairly clean. Decontamination of the cask exterior surface for casks received at the facility is infrequently required. The operation is typically limited to wiping any hot spots on the cask.

Cask preparations for fuel unloading consist of checking the pressure and sampling the cask containment (cavity) to determine the condition of the fuel. Denny indicated that the cask containment is sampled by filling the cask cavity with water and directing a portion of the water to a bucket as the cavity is being drained. A health physician subsequently performs a gross direct radiation measurement of the water contained in the bucket.

As the cask is lowered into the fuel pool for unloading, its exterior surface is sprayed with deionized water. Denny indicated that a "film" of deionized water will remain on the cask, limiting the amount of pool water contamination that comes into contact with the cask surface while the cask is in the fuel pool. Denny noted that casks rarely remain in the pool for more than 2 or 3 hr during fuel-unloading operations. He added that gross radioactivity levels of the pool water at the ICPP facility run about 10^{-7} μCi/ml. Once the cask has been positioned in the pool, the closure head is extracted from the cask and removed from the pool for visual inspection of the seal.

Denny stated that closure head seals have sometimes been replaced at the facility. The operation involves removing the seal from the closure head, cleaning the seal groove (or seat), applying vacuum grease to the seat, and installing a new seal. Denny noted that the operation takes about 1/2 hr.

After the fuel has been unloaded from the cask, the cask is raised from the pool. Once the cask head rises above the surface of the water, a syphon hose is inserted into the cask to drain the cavity. In addition, the cask cavity and closure head seal surfaces are visually inspected at this time. Denny stated that on the NFS-100, if the cavity is drained using only the two 1/2 in. drain valves at the base of the cask, the operation can take approximately 3 hr. Denny added that draining the cavity of the NFS-100 using the syphon takes only about 1/2 hr.

Once the cask cavity has been drained, the closure head is reemplaced on the cask and the cask exterior surface is decontaminated. Denny stated that the decontamination operation is routinely limited to manually wiping the cask surface dry. On occasion, commercial cleaning solutions are used on spots where contamination is difficult to remove. Denny added that the cask cavity penetrations are not leak-tested before shipment offsite.

APPENDIX B

CASK INTERIOR CONTAMINATION DATA

TABLE B-1

COMPILATION OF CASK INTERIOR CAVITY CONTAMINATION DATA

Cask Type	Location	10^4 dpm/100 cm^2	Ref.	Notes
REA (storage)	Inside of fuel tube	3,536	1	90% - ^{60}Co, 7% ^{137}Cs, 3% - ^{54}Mn
TN-8L	Basket bottom, side wall	248	2	99% - ^{60}Co
	Basket bottom surface	2,980		99% - ^{60}Co
TN-8L	Basket bottom, side wall	115	3	First shipment; 99% - ^{60}Co
		26		Fourth shipment; 99% - ^{60}Co
	Basket bottom surface	137		First shipment; 99% - ^{60}Co
		10,109		Fourth shipment; 99% - ^{60}Co
TN-8L	Basket bottom, side wall	18	4	First shipment; 100% - ^{60}Co
		11,460		Fourth shipment; 99% - ^{60}Co
	Basket bottom surface	32		First shipment; 100% - ^{60}Co
		12,279		Fourth shipment; 98% - ^{60}Co, 2%- ^{54}Mn
NAC-1	Side of cavity - average	600	5	Beta-gamma
	- maximum	3,700		Beta-gamma
	Bottom of cavity	6,100		Beta-gamma
	Cask basket	1000's		
		25 to 100		After cleaning
Not Specified	Cask basket	0.1 to 1.0	Appendix A-3	After decontamination with steam lances
	Cask cavity	1.0 to 1.5		

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