February 14, 1985

THE INTEGRATED SYSTEM FOR THE MANAGEMENT OF SPENT NUCLEAR FUEL AND HIGH-LEVEL RADIOACTIVE WASTE

1. INTRODUCTION AND SUMMARY

The Nuclear Waste Policy Act of 1982, Public Law 97-425 (NWPA), established a program for the management of radioactive waste and assigned to the U.S. Department of Energy (DOE) the responsibility for implementing the program. This paper describes the DOE's concept of an integrated waste management system leading to the permanent disposal of radioactive wastes in a geologic repository.

The system will be capable of accepting and handling commercial spent nuclear fuel (SNF), commercial high-level waste, high-level waste produced as a result of national defense activities, and any other waste forms declared by the U.S. Nuclear Regulatory Commission (NRC) to require permanent isolation. It will be sufficiently flexible to accept all expected forms of waste without imposing requirements on the generators of the waste that would interfere with the orderly operation of their facilities and on-site storage prior to Federal acceptance of title to the waste.

For convenience and brevity, the terms "radioactive waste" and "waste" are used in this paper to mean spent fuel from commercial nuclear power reactors and the high-level waste that results from the reprocessing of spent fuel and from atomic energy defense activities.

The integrated system described in this paper is the current system design being evaluated by the Office of Civilian Radioactive Waste Management (OCRWM). Its primary feature, as compared to previous system concepts, is the inclusion of an integrated Monitored Retrievable Storage (MRS) facility that would package and temporarily store spent nuclear fuel from commercial power reactors.

In order to have a totally integrated waste management system, activities that are conducted by the utilities and other waste generators, prior to transfer of the waste to the Federal Government, must be considered. These prior activities will influence what equipment the Federal Government will need to provide in order to transport the waste from the site at which it is generated and what packaging or repackaging operations may be necessary at Federal facilities. Therefore, the waste management system is defined to include the waste generators. A distinction is made in this paper between the portion of the integrated system for which the waste generators are responsible and those for which the Federal Government is responsible. This paper focuses primarily on the Federal portion of the integrated waste management system and how it would be structured and operated.

This paper includes concepts about the MRS, and the attendant system of which it is a part, for which firm decisions have not been made. Further studies are underway to fully assess the merit of these concepts.

1.1 Functions and Requirements

The purpose of the Federal portion of the integrated waste management system, as embodied in the Act, is to dispose of commercially generated spent fuel and high-level radioactive waste, and high-level waste from defense-related activities, in a manner that protects the health and safety of the public and maintains the quality of the environment. The fundamental purpose of the NWPA is to provide a system that has the long-term effect of minimizing the risk to current and future generations. To do so, the system must be able to perform the following functions:

- Accept commercially produced spent nuclear fuel and high-level waste, as well as defense high-level waste.

- Transport spent fuel and high level radioactive waste from reactors and other sources to disposal sites, including intermediate facilities designed for storage and packaging, as required.

- Prepare, package, and store the waste as needed before permanent disposal.
- Provide permanent disposal for all waste accepted into the system.

1.2 System Configuration

The principal components of the proposed integrated waste management system are the waste generators (primarily reactors), the monitored retrievable storage (MRS) facilities, the geologic repositories, and the transportation system that links these components with each other. Packaging and handling operations associated with each of these components must also be integrated to ensure efficient operation of the entire system.

Spent fuel stored at commercial reactors, that will be accepted by the system for ultimate geologic disposal, may be either various types of intact fuel assemblies or canisters of consolidated spent fuel rods. Most of that spent fuel will be shipped directly from reactor sites to the MRS facility. Spent fuel from reactors located close to a repository, but an appreciable distance from the MRS facility, may be shipped directly to the repository. Solidified high-level waste could be shipped directly to the repository from the sites at which it is generated or to the MRS where it may be combined with other waste for shipment to the repository. Shipments will be made by rail, truck, or barge, using specially designed, shielded transportation casks that comply with applicable safety regulations.

The MRS facility will consolidate and package spent fuel from commercial reactors before shipment to the geologic repository for permanent disposal. In addition, the MRS facility will provide temporary storage for all waste received by DOE and awaiting shipment to the repository. The length of time for which spent fuel will be stored at the MRS facility will depend upon repository operating factors, such as start of operations, waste acceptance rates, and thermal design limits. Shipments from the MRS facility to the repository may be made in dedicated trains or barges to minimize the number of shipments.

The flow of waste from the waste generators to an MRS facility and a repository is illustrated in Figure 1. The MRS will have a finite lifetime. After all waste has been emplaced in the repository, the MRS will be placed in caretaker status, capable of receiving waste from the repository, in the unlikely event that retrievability of waste is necessary. The MRS facility will then be decommissioned and removed from the site. The functions and characteristics of each of the components of the integrated waste management system are described more fully in Section 2 of this paper.

1.3 Implementation Schedule

Acceptance of waste is planned to begin with the initiation of MRS facility operations as early as 1996. The system will be designed to receive spent fuel at or near the projected rate of commercial spent-fuel generation by 1998. The first geologic repository is planned to begin phased operation by no later than January 31, 1998. The second repository would commence operations eight years later. The schedule for the proposed integrated waste management system is shown in Figure 2. Approximate times required for developing, siting, licensing, constructing, and operating the various facilities of the system are depicted.

2. DESCRIPTION OF THE PROPOSED INTEGRATED WASTE DISPOSAL SYSTEM

The principal components of the integrated waste management system are described more thoroughly in this section. The discussion begins with a description of activities related to the storage of spent fuel at the reactor facilities, and to the packaging of that fuel for subsequent shipment to a Federal facility. These activities are and will remain the responsibilities of utilities, and they constitute the primary interface between the Federal portion of the system and the waste generators. The discussion then progresses to a review of principal Federal facilities of the system and concludes with a commentary about the structure and operations of the proposed transportation system. Figure 3 depicts the functions of each of the principal elements of the integrated system.

2.1 Waste Generators

2.1.1 Generators of Spent Nuclear Fuel

Nuclear power utilities will continue to store spent fuel at their commercial nuclear reactor sites until the Federal waste management system is available to accept the fuel. The spent fuel stored at various reactors will differ in its physical, thermal, and radiation characteristics because of differences in fuel assembly designs, the storage techniques used by each utility, fuel cycle operating procedures, and the duration of at-reactor storage.

It is expected that most of the spent fuel that is accepted into the integrated Federal system will come directly from reactor storage pools. However, because of the possibility of limited storage-pool capacity at some reactors, some utilities may pursue the option of storing spent fuel outside of their pools in licensed dry storage casks until that fuel is transferred to the Federal Government. The DOE is cooperating with utilities in licensed demonstrations, and it is anticipated that licensed casks would be available to industry within the next few years. The utilities are also investigating rod consolidation procedures, which represent another method to significantly increase the capacity of some storage pools. Either way, the spent fuel will be in the form of intact fuel assemblies or canisters of consolidated rods.

The utilities will be responsible for loading their spent fuel into licensed, Federally provided transport casks. The Federal Government will then accept title to the spent fuel at the reactor site and transport it to either the MRS or the repository.

2.1.2 Generators of High-Level Radioactive Waste

Liquid commercial high-level radioactive waste is a residual product of the reprocessing of spent fuel for the recovery of useful materials. Only a small amount of commercial high-level waste currently exists. This waste is stored in tanks at a closed commercial planc located at West Valley, New York. After being solidified and prepared for transportation, the waste could be shipped directly from the West Valley site to a repository or to the MRS where it may be combined with other waste for shipment to the repository.

Defense high-level waste is being generated at several DOE facilities, such as those located near Savannah River, South Carolina; Richland, Washington, and Idaho Falls, Idaho. This waste will be solidified at the generation sites into a waste form acceptable for permanent isolation in a licensed repository and then shipped directly to a repository or to the MRS where it may also be combined with other waste for shipment to the repository.

2.2 Monitored Retrievable Storage

Within the context of the proposed system, the MRS facility will (1) receive spent fuel from most or possibly all reactors; (2) consolidate and package, including overpacking of the fuel for permanent disposal in a repository, unless further studies show that overpacking should be done at the repository, and (3) store fuel temporarily pending shipment to the repository. The MRS will be licensed by the NRC. The initial design capacity of the facility is 15,000 metric tons uranium (MTU), but this can be modified as necessary to meet system requirements.

The MRS facilities will be located centrally with respect to the reactors to be serviced. The MRS facility will be designed to receive spent fuel at a rate of 3600 MTU per year. On arrival at an MRS facility, spent-fuel assemblies will be removed from the shipping cask. Each fuel assembly (unless already consolidated) will then be dismantled, and the fuel rods will be consolidated and loaded into canisters. These canisters will be capped, filled with an inert gas, welded shut, inspected, and readied for further handling or packaging operations. The hardware remaining from the disassembly operation will be compacted and loaded into similar canisters.

Canisters that are to be stored at the MRS facility will be removed from a hot cell in which remote fuel handling operations are performed and then stored in dry storage casks, or possibly dry wells. Figure 4 illustrates a concept of the MRS facility and the dry cask storage concept. Vault storage at the MRS is being evaluated.

The spent-fuel canisters will be loaded into licensed transport casks and shipped from the MRS facility to the geologic repository. It is assumed that dedicated trains will be used. The MRS may also repair damaged canisters received from the repository, if needed. As mentioned previously, the lifetime of the MRS is limited to the period necessary to support the emplacement of waste in the repository and the specific period when waste could be retrieved from the repository if necessary.

2.3 Geologic Repository

The geologic repository is designed to provide for the permanent disposal of spent nuclear fuel and high level radioactive waste. At the repository, the canistered waste will be emplaced in a suitable host rock formation approximately 1000-3500 feet below the surface. The repository will be licensed by the NRC.

When fully operational, the repository will be capable of receiving and emplacing the equivalent of about 3,000 MTU of waste per year. The repository is being designed with a disposal capacity of 70,000 MTU.

As illustrated in Figure 5, the repository will consist of both surface and underground facilities. It will be equipped to receive, handle, and emplace underground all of the spent fuel and high-level waste shipped from the MRS facility or from other facilities. The main operations performed in the surface facilities of the repository will consist of: (1) receiving waste canisters; and (2) performing inspections of waste canisters received for emplacement. Additional operations that may be performed in the surface facilities are: (1) the installation of spent fuel canister overpacks if necessary, and if not done at the MRS facility; (2) the installation of overpacks on high-level waste canisters, if necessary, and if not done at the MRS processing facility, (3) repair any damaged waste canisters that are received, if not sent back to the MRS for repairs, and (4) possibly package fuel for disposal received from nearby reactors.

The underground facilities will consist of access shafts, corridors, and emplacement rooms. The waste will be lowered underground and emplaced into boreholes drilled into the floors or the walls of the emplacement rooms. An illustration of an emplaced waste package is shown in Figure 6. The waste will be fully retrievable until it has been demonstrated that the repository is performing within the guidelines set by the NRC (at lease 50 years). The underground facility and shafts will then be closed and sealed, and the surface facilities will be decontaminated and decommissioned.

Current plans call for a second repository to begin operations in the year 2006. It will be similar to the first repository in design, operations, and capacity. The interface between the MRS facility and the second repository will primarily depend upon the relative locations of the MRS, the second repository, and the reactors being served. The necessity for a second MRS facility will be evaluated when the second repository is sited.

2.4 Transportation

The transportation system will have the capability to transport waste from the waste generators to other waste system facilities, as well as between the various facilities of the waste management system. All waste will be shipped in licensed casks designed specifically for that purpose. The DOE will assume responsibility for transport. Depending on the circumstances, waste will be shipped by rail, truck or barge.

Shipments will consist of both consolidated and unconsolidated spent fuel, as well as high-level radioactive waste. Spent fuel will be transported from reactors located in various parts of the country to either the MRS facility or a nearby repository, as well as between the MRS facility and the repository. Solidified high-level radioactive waste will be either transported directly to a repository from the sites at which it was processed or to the MRS for combination with other work forms. The private sector will be relied upon to the extent possible for cask development and transportation operations. Any functions performed by the private sector will be conducted in accordance with the appropriate licensing requirements.

The casks for each transport mode will be designed to accommodate alternative waste forms and canistered waste configurations. Conceptual diagrams of transportation casks are shown in Figure 7.

3.0 Conclusion

This paper describes an integrated waste management system which, when implemented, will satisfy the requirements of the NWPA. Further definition of details of the system and implementation plans are being developed. This integrated system can be implemented only with Congressional authorization for construction of the MRS facility and DOE plans to request such authorization.

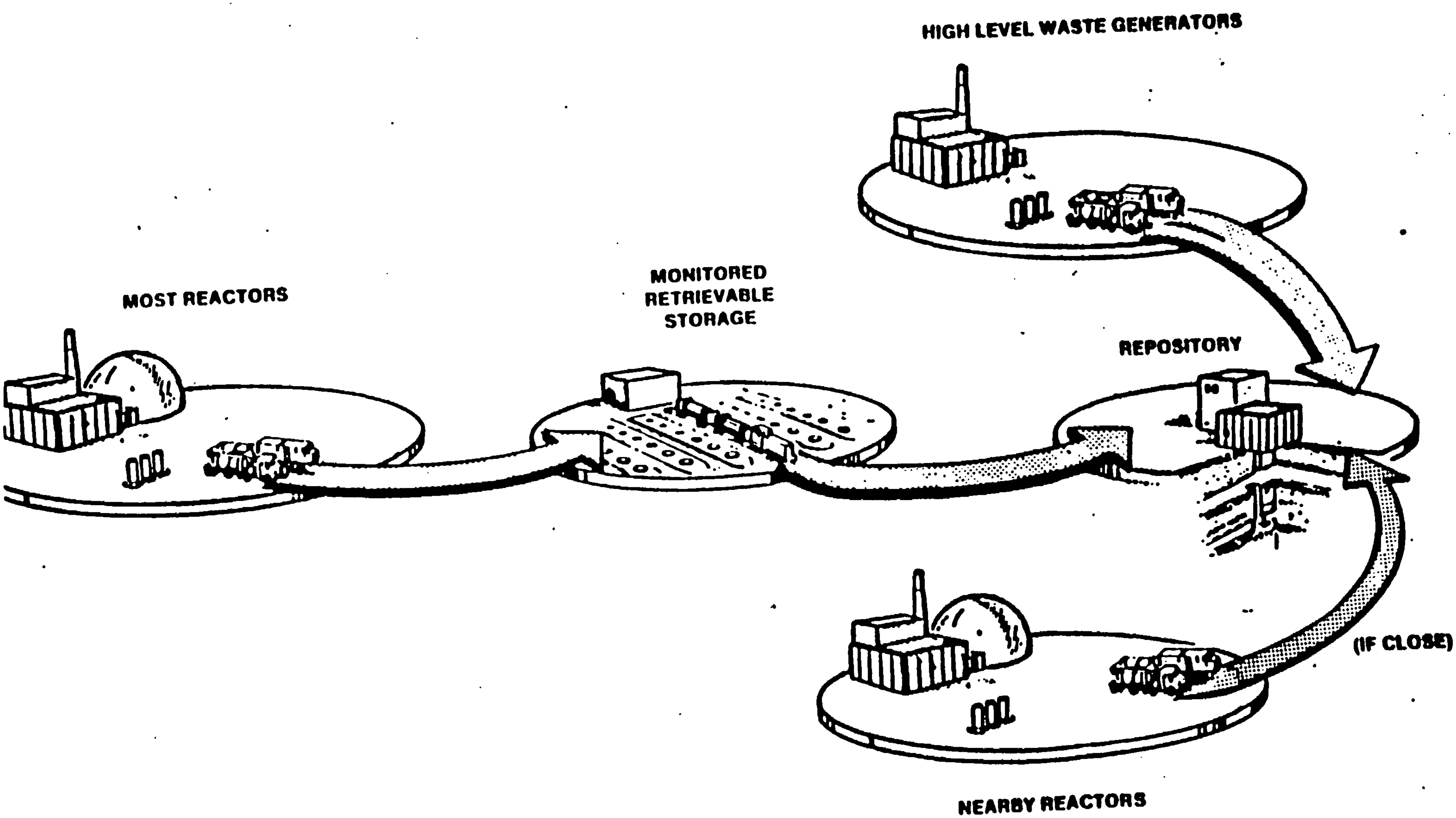


FIGURE 1
ILLUSTRATION OF WASTE FLOW IN THE INTEGRATED WASTE MANAGEMENT SYSTEM

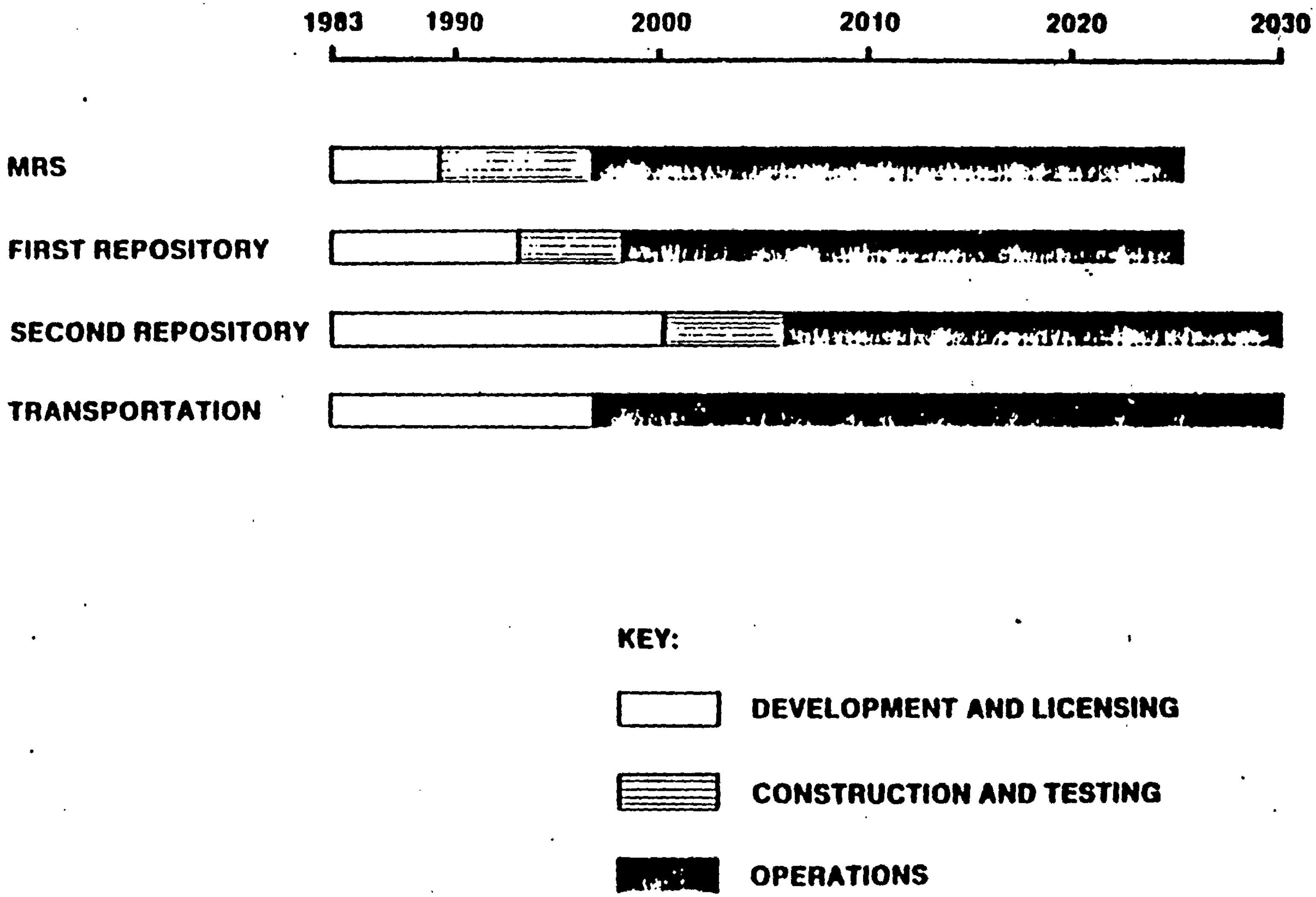


FIGURE 2
SCHEDULE FOR PROPOSED INTEGRATED SYSTEM

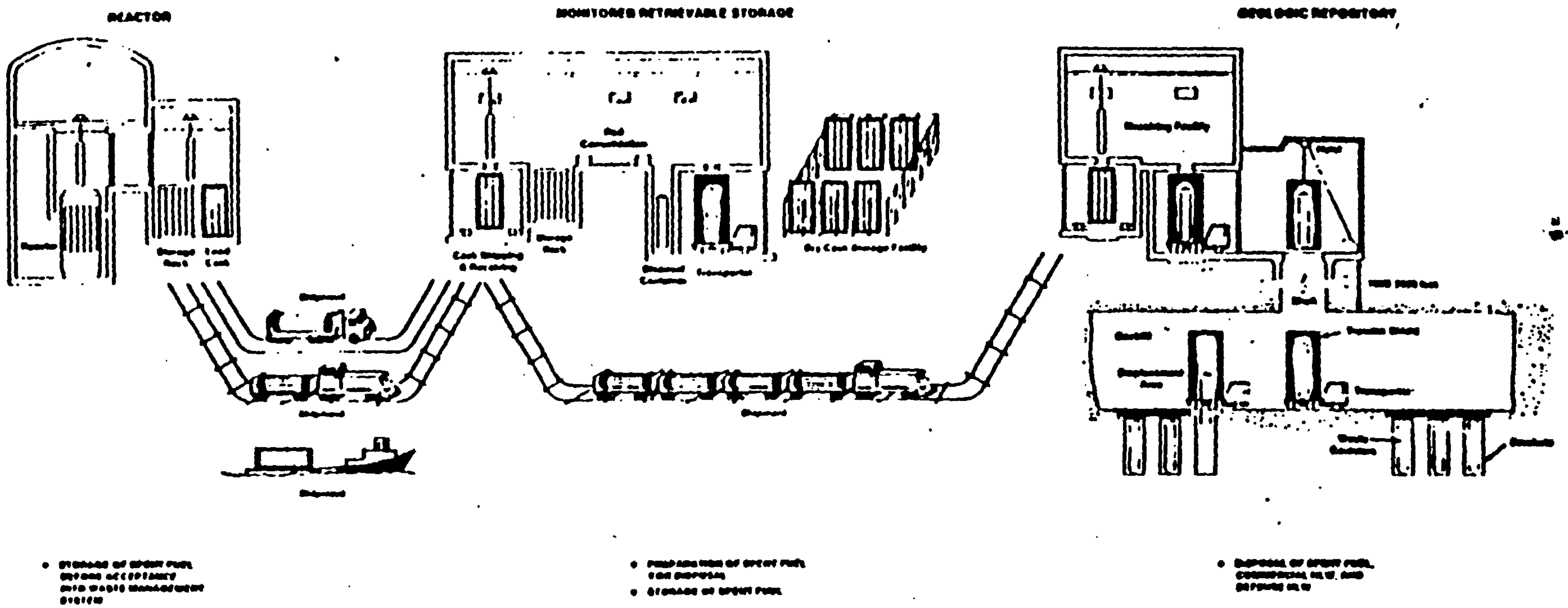
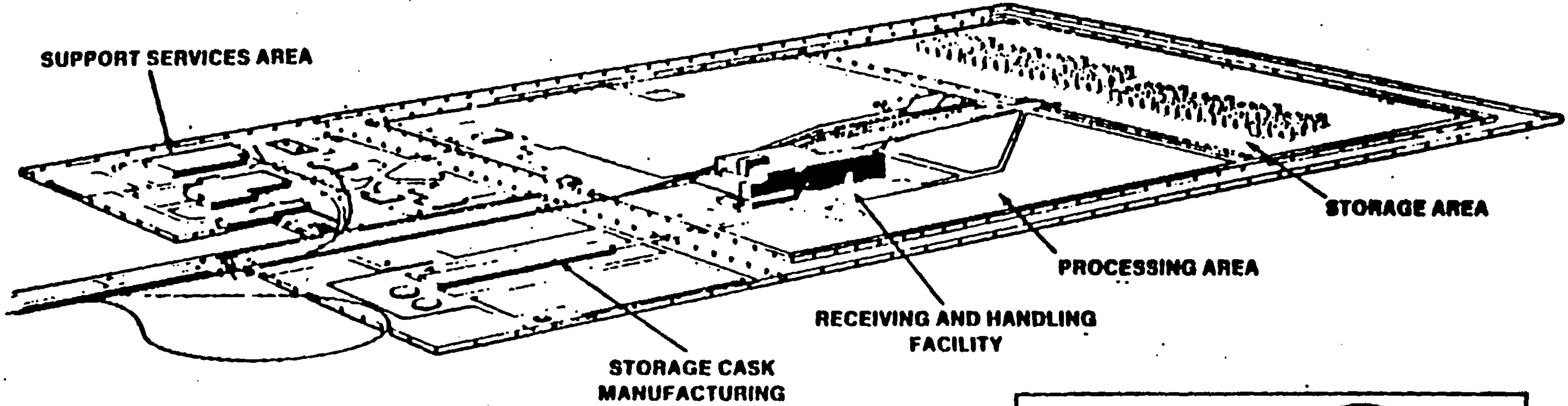
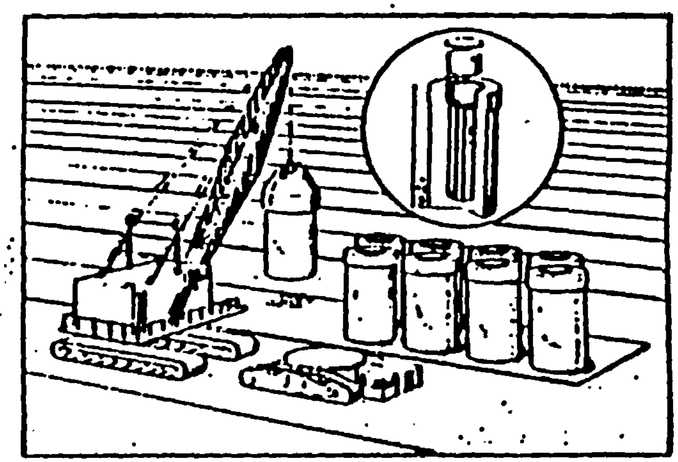


FIGURE 3
INTEGRATED WASTE MANAGEMENT SYSTEM





PRIMARY STORAGE CONCEPT - SEALED STORAGE CASK

FIGURE 4
MONITORED RETRIEVABLE STORAGE FACILITY CONCEPT

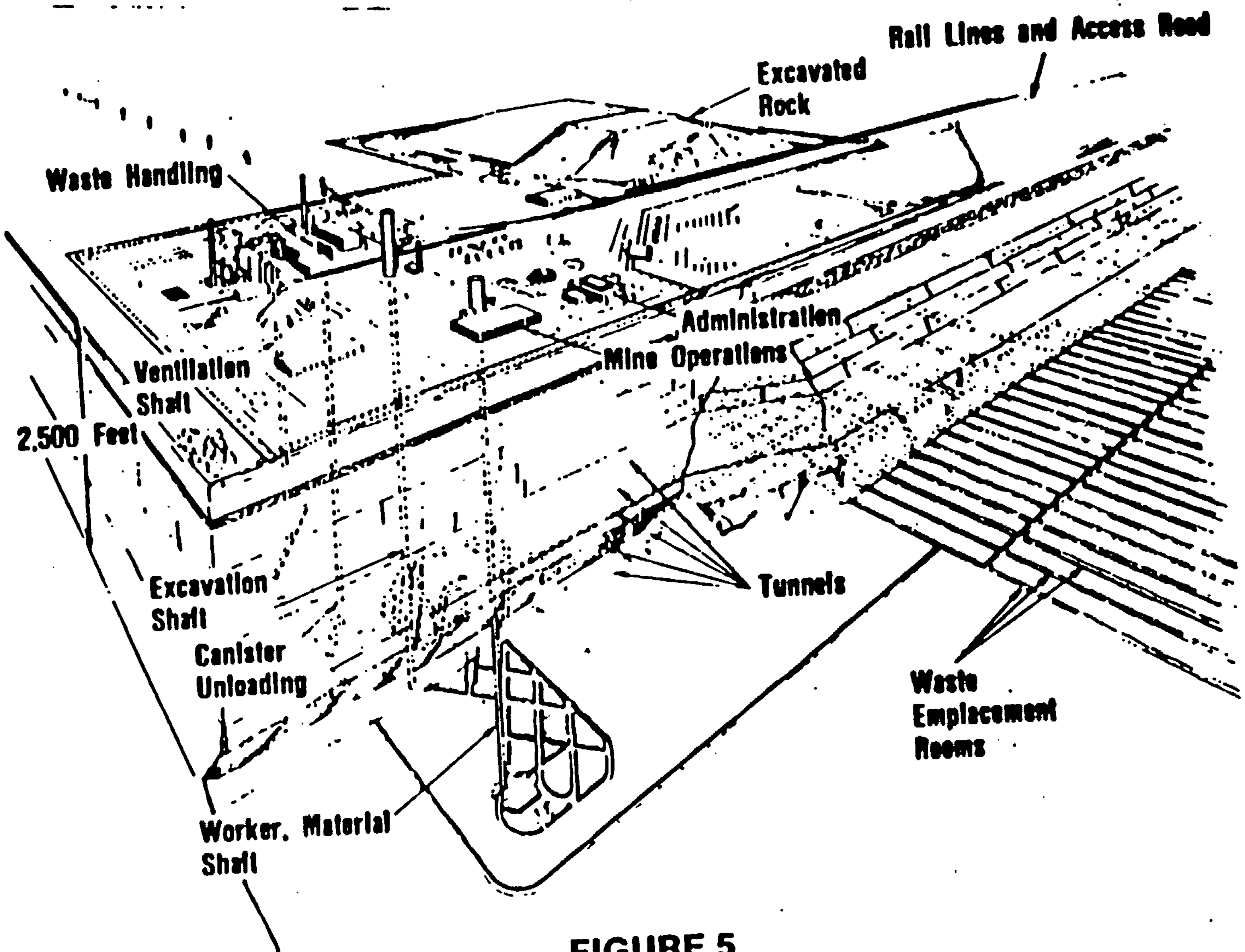


FIGURE 5
REPOSITORY CONCEPT

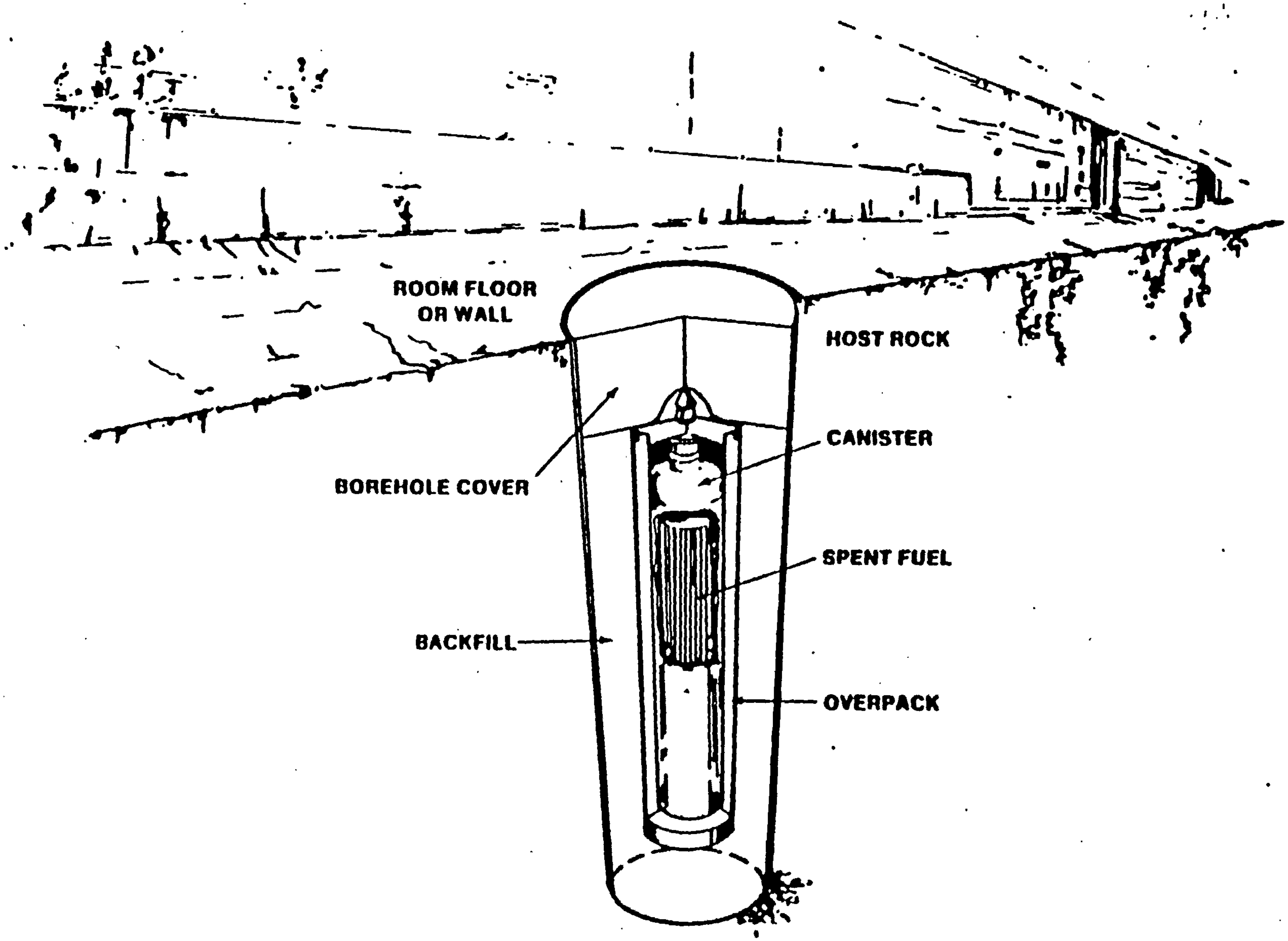


FIGURE 6
WASTE PACKAGE EMPLACED IN REPOSITORY

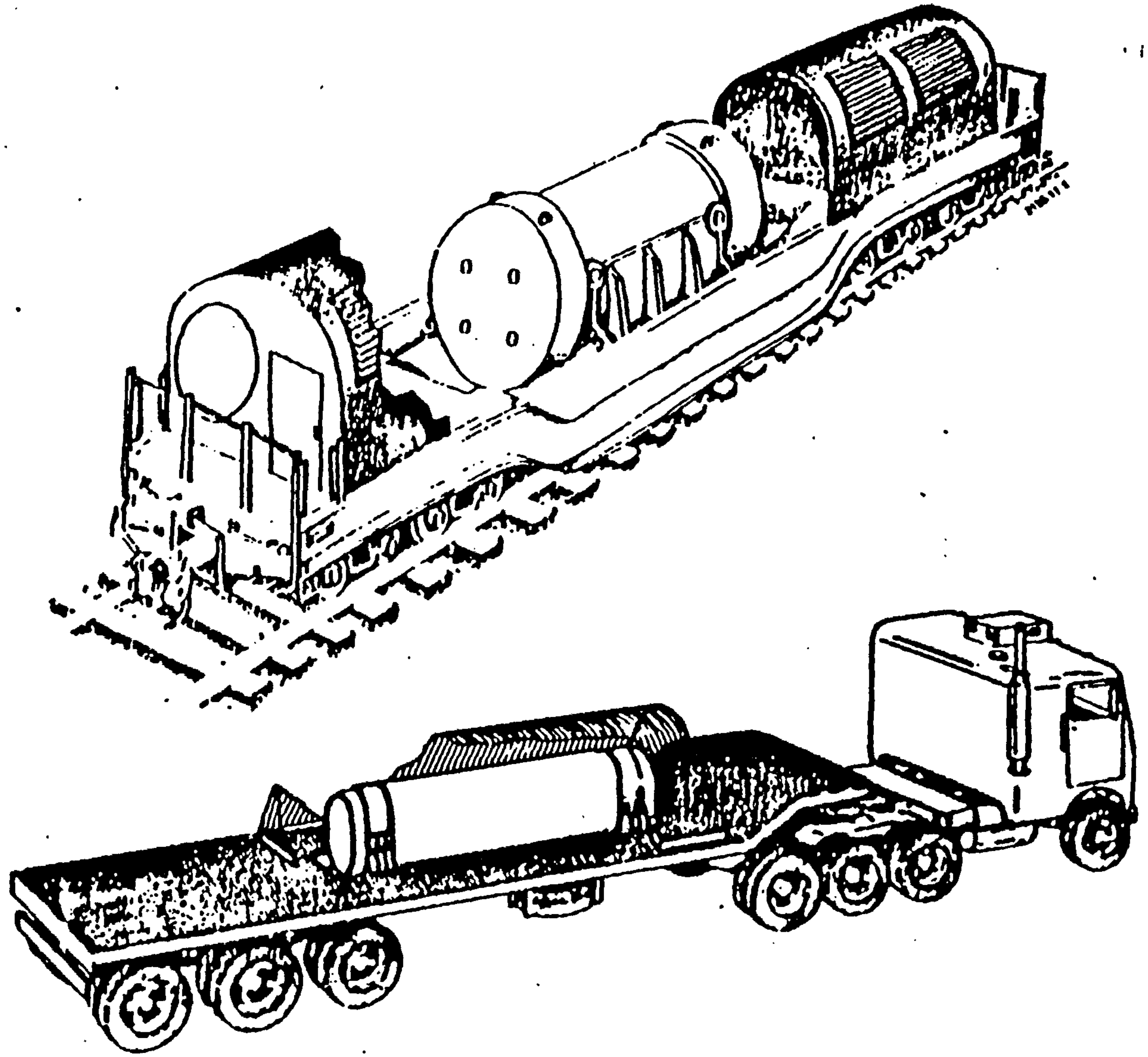


FIGURE 7
REPRESENTATIVE RAIL AND TRUCK TRANSPORT CASK

QUESTION 2: The Department's budget request states that, "Based on preliminary evaluations, the Department currently plans to recommend (in Monitored Retrievable Storage proposal) that Congress authorize the Department to proceed with activities on the critical path for deployment of an MRS facility..." Why is an MRS facility considered essential to the waste management program? Would such a facility be sited centrally or at various locations? Please describe the technology and cost assumptions for MRS facilities. Please describe the specific purpose of MRS and the alternatives considered for fulfilling this role.

ANSWER 2: The Department initially considered MRS as a back-up storage capability to be constructed if there were delays in the availability of the repository. The Office of Civilian Radioactive Waste Management has come to support a role for MRS that does not rely on repository slippage for justification. This MRS would be an integral part of a waste disposal system and would perform many of the functions, particularly waste packaging, traditionally expected to occur at the repository site. Located central to the existing reactors, it would serve as a collection point for wastes, make them repository ready, and improve the transportation system. The repository efforts would then be more focused on the subsurface requirements and the surface facility design, licensing and operating requirements reduced which could also provide additional repository schedule assurances. The MRS could be available sooner than a repository and help provide a more phased implementation of the overall Federal waste

ANSWER 2: (CONTINUED)

disposal system, starting with transportation and packaging for disposal. Improvement in overall system timeliness, availability, flexibility and reliability would be expected. It preserves the repository back-up capability of MRS as well.

To effectively fulfill either an integral or back-up role, MRS facility design must have performance capabilities and flexibility to meet various possible demand scenarios and system needs. The Department has selected storage concepts which are sufficiently mature as to leave little or no uncertainty regarding the ability of the facility to be safely and expeditiously licensed, constructed and operated. Cost assumptions for MRS facilities are based upon facility designs and operational costs prepared by the Department's architect engineer, and on analyses of operational costs for potential MRS applications. Detailed designs and cost estimates are currently being developed to support the mandated proposal to Congress.

QUESTION 3: The budget request includes authorization of $12,900,000 for MRS work in FY 1986. How much of this activity can proceed without specific legislative authorization for construction of MRS? Why is this activity--requiring further authorization, or not--necessary to be undertaken at this time?

ANSWER 3: We believe all the activities identified in the FY 86 budget request can proceed without specific legislative authority for construction of the MRS. These activities include siting analysis, environmental data gathering and analysis, design, design validation, licensing issue analysis, systems support, and program management. It is necessary to undertake these activities during FY 86 because they are on the critical path to MRS deployment and their completion will enable construction as soon as practicable following Congressional authorization as required by the NWPA.

QUESTION 4: The Transportation and Systems Integration activities section of the budget request indicates that "new techniques, systems or facilities could eliminate or minimize many operations previously expected to take place at repository surface facilities." Please describe these techniques, systems and facilities, and the analyses performed to assess their cost, justification, impact on the management system, and deployment scenarios. Please provide the documents representing the analyses of these issues.

ANSWER 4: In 1984, DOE issued an invitation to industry and the utilities for competitive proposals to develop unique ideas for improving the waste management system. Twenty-seven proposals were received and six were selected for award of contracts. These six contracts cover a variety of unique ideas, several of which could result in minimizing operations at the repository surface facilities. Two of these contractors are studying the concept of performing the packaging and handling operations at centralized or regional facilities near the reactors. Three of the contractors are studying the feasibility of "universal" or modular cask and canister concepts that could be used at a centralized packaging facility and, with appropriate overpacks, be suitable for emplacement in any of the geologic media under consideration. The other contractor is studying the feasibility of mobile spent fuel rod consolidation equipment and services that could be used to consolidate fuel at some reactor sites where the option may be of particular merit.

ANSWER 4: (CONTINUED)

These studies are assessing the feasibility of these concepts in terms of their impacts on system costs, health and safety, licensing, and schedule. They are all to be completed by October 1985. Many of the ideas being studied could enhance the operations of the integrated waste management system described in the answer to Question "1" above. Conclusions from the studies will be factored into the design of the integrated waste system, specifically, as they relate to the ongoing design efforts for the repository, the MRS and transportation. Concepts that offer continued promise will be pursued through further design, development and testing. More detailed summaries of each of the six contractors' efforts are attached.

CASK SYSTEMS FOR SPENT FUEL PACKAGING, HANDLING, TRANSPORTATION, STORAGE AND DISPOSAL

The Department of Energy's Office of Civilian Radioactive Waste Management (OCRWM) has awarded Westinghouse Electric Corporation a contract to evaluate three or more integrated metal cask concepts that would result in a reduced number of handling and packaging steps throughout the nuclear waste management system. Westinghouse's subcontractors include Florida Power and Light and Tennessee Valley Authority. The three concepts that will be studied are:

1. Universal Waste Package- This package is an "all-purpose" metal cask which serves the three functions of storage, transportation and disposal at the repository. The cask would serve as a self-shielded waste package that would be loaded, sealed and stored at the reactor site, transported and stored at a Monitored Retrievable Storage (MRS) facility, and emplaced in a repository without ever being reopened. This cask is in fact a disposal canister that has sufficient shielding to preclude the need for remote handling anywhere in the waste management system. The shielding also precludes the need for placing the package in a borehole at the repository, allowing it to be placed directly in the tunnel.

2. Thin-Wall Universal Waste Package with Overpack- In this concept a thin-walled universal canister would be loaded at the reactor site and is not intended to be opened after it leaves the reactor. The canister is placed in an appropriate reusable overpack, for strength and radiation shielding, for storage, and transportation. At the repository, the metal canister is removed from the reusable overpack, and may be placed inside another overpack for emplacement in a borehole. Unlike the reusable overpack, the second overpack is designed for disposal purposes only.

3. Transport/Storage Package with Separate Disposal Package - In this concept, a self-sufficient cask is used for both transportation and storage. The fuel will be transferred to a separate package for borehole emplacement and the T/S cask returned to service.

The study may include additional related metal cask/canister concepts. The study will proceed in five steps. The first step is to define the generic constraints imposed on the systems by DOE and/or the contractor which includes consideration of costs, safety, radiation exposure, flexibility, and applicable regulations and licensing requirements. The second step is to identify and collect the information needed to develop functional criteria, to identify technical, research and development, and institutional issues, and to identify conceptual designs for further study. Where necessary information is not available, it will be developed to the extent needed. The third step is to develop functional criteria which will encompass hardware and other physical (including environmental) features, economics, socioeconomics, and flexibility. In the course of developing the above, research and development needs will be identified; in the process of peer group review, the technical and institutional requirements will be completely defined. This constitutes the fourth step although it overlaps the third step to some extent. The fifth step, preliminary evaluation of the alternatives, will be made using the functional criteria as a ruler. The evaluation will be performed through a combination of three approaches:

- o The engineering systems team will screen the information for technical direction and feasibility.
- o The peer group of utilities, institutions, and industrial representatives will aid the decisionmaking process, and,
- o A decision tree methodology will be used to investigate the combinations and interaction of the decisions which must be made to select the best system.

The study will identify a cask system with the potential to be flexible, to have lower costs, to have lower occuptional and public radiological risk, and without foregoing other options that may eventually be desirable in managing nuclear waste.

The cask system thus identified will be compared with the other PRDA-funded concepts with the objective of selecting the best concept or combination of concepts to be incorporated into the nuclear waste management system.

MULTI-ELEMENT SYSTEM FOR STORING AND TRANSPORTING SPENT FUEL USING A UNIVERSAL CANISTER CONCEPT

The Department of Energy's Office of Civilian Radioactive Waste Management (OCRWM) has awarded G.A. Technologies (with Electrowatt Engineering Services and Duke Power Company as subcontractors) a contract to evaluate a multi-element system for storing and transporting spent fuel which would result in a reduced number of handling and packaging steps. One element, the canister containing spent fuel, will be placed in the three remaining elements, storage casks, closed cycle vault storage modules, and transportation casks. Because the same canister design can be accommodated by different elements, the canister is referred to as a "standard" canister.

In the proposed concept, spent fuel at reactors would be canistered and stored in either intact or consolidated form, with the canister readily transferrable to cask storage, to modular vault storage, or to transport cask without repackaging or redundant fuel handling. Two storage concepts are considered, (a) metal cask storage which is cost effective for a total capacity requirement under 800 MTU, and (b) the modular vault concept which is more cost effective for greater capacity requirements.

The key technical basis of the selection of the multi-element system is comprehensive analysis and understanding of the gross physical inventory of spent fuel requiring packaging, handling, storage, and transportation. For each of the four functions of packaging, handling, storage and transportation, a detailed analysis of the time-dependent spent fuel inventory will be conducted, and the results used (1) to evaluate and develop a standardized canister that maximizes the loading of intact fuel assemblies or consolidated fuel rods and (2) to determine the number of storage and transportation units that minimize the cost and risk of handling, storing, and transporting the spent fuel.

Hardware requirements are then summed to specify a total time-phased requirement for the various system elements (canister, cask(s), and modules) that meet the spent fuel inventory demand.

Two major tasks are envisioned: systems analysis and conceptual design. These are discussed below.

Task 1 - Systems Analysis

An analysis will be performed of the spent fuel inventory, as projected by DOE through the year 2020, and of the missions (at-reactor storage, Federal interim storage, MRS, repository) proposed in the draft mission plan. This analysis will break down the inventory into mission-specific inventories and will provide a time-phased distribution of the spent fuel characteristics. GA will develop a methodology to assist in the system analysis task through application of existing computer software. An inventory computer model and a cost optimization model will be used.

During the last three months of the study, GA will prepare a mission deployment plan and a licensing plan for the system concept. In addition, GA will compare the universal cask concept with the GA-proposed concept.

Task 2 - Conceptual Design

GA will develop a conceptual design of the system concept. Sufficient engineering analysis will be performed in criticality, shielding, thermal, and structural areas to determine a standard canister design and approximate sizes and configuration of the storage and transportation elements.

A cost element and implementation schedule for the proposed multi-element system concept will be prepared. Life cycle costs will be provided on an annual basis and will include capital, operating, and decommissioning costs.

The results of the study will allow OCRWM to compare the GA-proposed concept with the other PRDA-funded concepts with the objective of selecting the best concept or combination of concepts to be incorporated into the nuclear waste management system.

MINIMAX CONCEPT OF PACKAGING AND HANDLING SPENT FUEL

The Department of Energy's Office of Civilian Radioactive Waste Management (OCRWM) has awarded Ridihalgh, Eggers & Associates (REA) a contract to develop and evaluate the "Minimax" concept, a system concept for packaging and handling spent fuel. REA chose that name because the system is intended to have "minimum" impact upon existing components of the fuel cycle, while preserving "maximum" flexibility in the development of future components. The study will be conducted with the assistance of REA's subcontractors Sargent & Lundy, Science Applications and Commonwealth Edison.

The novelty of this concept is the inclusion of one or more "Packaging and Encapsulation Facilities" (P&E) which are intended to receive spent fuel from nearby reactors and to repackage the fuel as needed for shipment to, and emplacement in, repositories.

Such facilities would be regionally located to receive fuel from reactors within about a 250-mile radius which would have been shipped by truck or rail using whatever state-of-the-art casks are available and compatible with the individual reactors. Under these circumstances, there would be minimum impact on the reactors in terms of costs, handling and exposure. The number of reactors making shipment to each P&E facility would be limited to the number of reactors located within the 250-mile radius, and therefore risk and public concern would be reduced.

The P&E facility would be capable of handling all shipments, truck or rail, consolidated fuel or unconsolidated assemblies, and fuel skeletons. It would have the same capability as the front end of currently planned repositories and would prepare the fuel for ultimate emplacement, without further packaging, in any geologic medium. Under this concept, then, any spent fuel handling and resultant exposure, costs, etc., would be limited to large facilities, built with economies of scale, designed for day-in, day-out repackaging by skilled crews. The largest possible rail container would be used to reduce the number of shipments, risk, and exposure, and to permit highest net weights without sacrificing shield strength.

It may be possible to license P&E facilities more quickly than repositories and, at the same time, ease the siting and licensing problems of repositories by eliminating, in large part, major functions of the latter (i.e., packaging and encapsulation).

REA proposes four tasks as described below:

Task 1 Develop System Requirements and Design Bases

System requirements and design bases will be assembled or developed for the components of the nuclear waste management system, including Minimax components. System requirements will include relevant regulations, and statutory and other requirements. Design bases will include the key assumptions that form the bases for sizing facilities, selecting design features and analysis of system performance.

Task 2 Further Develop Minimax Concept

A concept description will be prepared in accordance with the system requirements and design bases developed under Task 1. The description will include all the main components (reactors, P&E facility, MRS, repository, transportation), additional components (Federal Interim Storage, commercial reprocessing, and low-level waste disposal), and institutional relationships (utilities, state LLW compacts, DOE, NRC, states, transportation companies).

Task 3 Develop Subsystem Data Required for Concept Evaluation

The data developed will include assessments of doses, costs, implementation schedules, staffing requirements, etc. This task will result in documents describing the relevant performance characteristics of the major components of the Minimax system.

Task 4 System Characterization

The concept will be characterized and evaluated from the standpoint of cost, safety, licensing, institutional, transportation, safeguards and security, and environmental impacts. The characterization will examine how changes or delays in implementation in parts of the system can affect the system as a whole.

The results of this study will allow OCRWM to compare the Minimax concept with the other PRDA-funded concepts with the objective of selecting the best concept or combination of concepts to be incorporated into the nuclear waste management system.

CENTRALIZED PACKAGING FACILITY TO SUPPORT THE SPENT FUEL MANAGEMENT SYSTEM

The Department of Energy's Office of Civilian Radioactive Waste Management (OCRWM) has awarded E.R. Johnson Associates (JAI) a contract to study the use of a centralized packaging facility (CPF). JAI's subcontractors are International Energy Associates, Ralph M. Parsons, Transnuclear and Nuclear Fuel Services.

The CPF is intended to receive consolidated or unconsolidated spent fuel from most reactors and to repackage the fuel for ultimate emplacement in a repository or for long-term storage in an MRS. The system with the CPF will be compared with the reference system where there is no CPF, and the two repositories and the MRS have their own receiving, handling and packaging facilities. The cost and institutional desirability of the CPF system is to be established and compared with the reference case. Specific attention is to be given to (1) the reduced requirements for receiving, handling and packaging at repositories as a result of using the CPF, and (2) the impact of shipping intact fuel versus consolidated fuel in square (pool-compatible) canisters from reactors to the CPF.

The Centralized Packaging Facility will be a very large, efficient facility capable of receiving truck or rail shipments from reactors, consolidating, and repackaging spent fuel for shipping to and emplacement in a repository. Since shipments to the latter will be in the most efficient package available, the total number of cask-miles will be reduced relative to the reference case.

JAI will perform the analysis in three major tasks as described below.

Task 1 - Development of Packaging System Requirements and Criteria

This task is to establish design criteria for a CPF, minimum requirements for receiving/handling facilities at repositories, and transportation cask design requirements for various spent fuel packages.

The spent fuel packages that will be investigated include intact assemblies, consolidated fuel shipped from reactors in square packages with the same cross-sectional dimensions as the original fuel assembly, and packages suitable for emplacement in each of the three geologic media of salt, tuff and basalt.

Task 2 - Development of Conceptual Designs of a Multi-Purpose Packaging Facility and Associated Systems

This task is to perform a preliminary conceptual design of a CPF, of receiving and handling facilities at repositories, and transport casks for various spent fuel packages. The designs will meet the requirements and criteria established in Task 1 above.

Task 3 - Performance of System Assessments

This task includes estimating costs of facilities and system life cycle costs for the reference case and the CPF case, evaluating the regulatory and institutional acceptability of each case, and comparing the two cases with respect to costs and regulatory and institutional acceptability. In comparing the two cases, sensitivity analysis will be performed with respect to major assumptions such as discount rate, capacities and throughputs, startup dates, etc.

It is anticipated that with the CPF, receiving, handling and packaging facilities at each repository will be reduced sharply; although they cannot be eliminated since there will continue to be direct shipments of spent fuel from nearby reactors and problem shipments from all sources that must be separately handled. Nevertheless, the substantial capital savings combined with the freight savings are expected to offset, more or less, the added costs of a separate facility. Major gains will be reduced public awareness and exposure, eased licensing requirements, reduced environmental impact, improved public health and safety, and probably reduced development risk.

The results of this study will allow OCRWM to compare the Centralized Packaging Facility concept with the other PRDA-funded concepts with the objective of selecting the best concept or combination of concepts to be incorporated into the nuclear waste management system.

USE HALF-SQUARE AND FULL-SQUARE CANISTERS FOR INCREASED PACKING DENSITY AND DEVELOP DESIGN PARAMETERS FOR TRUCK CASK, STORAGE SILO AND EMPLACEMENT CANISTER

The Department of Energy's Office of Civilian Radioactive Waste Management (OCRWM) has awarded NUS Corporation a contract to investigate innovative canister geometries for increased spent fuel packing density and to develop design parameters for a truck cask, a storage silo and emplacement canisters which take advantage of the increased packing density. Commonwealth Research, an affiliate of Commonwealth Edison, is a non-funded participant in this contract.

NUS has identified certain innovations that have the potential for simplifying and standardizing the packaging and handling of spent fuel, and for reducing costs throughout the waste management system. The NUS concept involves three interrelated ideas:

1. Design a rectangular half-square storage canister to hold the fuel rods from single fuel assemblies. Two half-square (rectangular) canisters will fit into a single fuel rack location (in spent fuels pools) which normally accommodates one assembly.

2. Define the optimum geometrical arrays of square and half-square canisters for use in cylindrical storage, transport and waste disposal containers. These arrays would also be evaluated for handling as single undivided unit, similar to a canister, thereby minimizing handling and costs. Figure 1 illustrates how the NUS concept results in less wasted space in the case of smaller cylindrical packages. Cylindrical packages larger than those shown in Figure 1 will also be investigated, expanding on this concept, as shown in Figure 2 for PWR fuel (concepts for BWR fuel would be similar to those shown for PWR fuel).

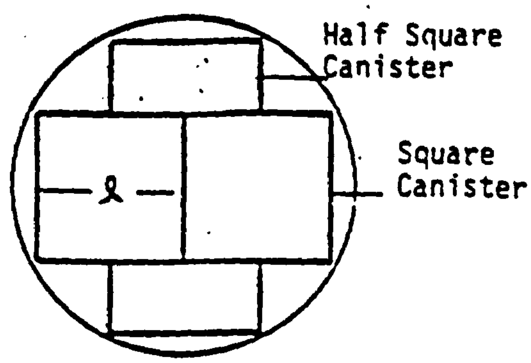
3. Evaluate the feasibility of a truck cask for shipping spent fuel in the new efficient-geometry arrays of 6 PWR or 16 BWR consolidated assemblies. These arrays sizes appear to be near optimum throughout much of the system.

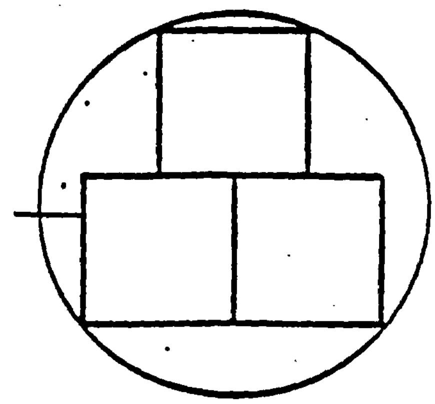
FIGURE 1

COMPARISON OF NUS SYSTEM WITH CONVENTIONAL SYSTEM IN WASTE PACKAGE DESIGN

	NUS	CONVENTIONAL

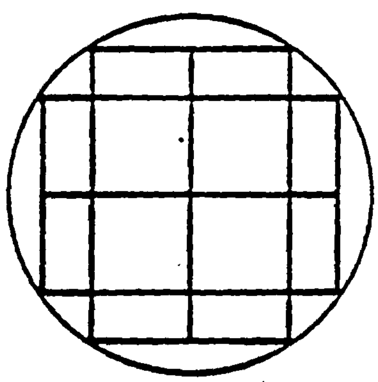
PWR

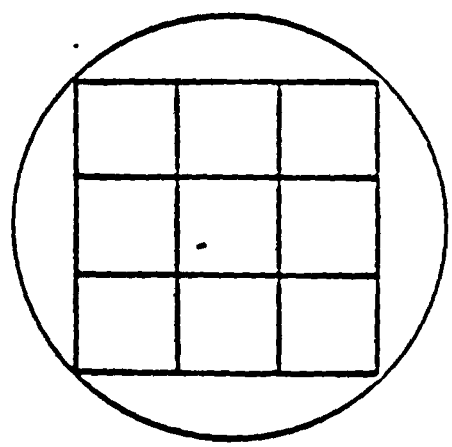




NUS		CONVENTIONAL	
Diameter d	= 2.236 ℓ	d	= 2.577 ℓ
EFFICIENCY	= 0.764	EFFICIENCY	= 0.575
PACKAGE COST	= \$29,100	PACKAGE COST	= \$35,900
	= \$10.52/kg U		= \$12.96/kg U

BWR

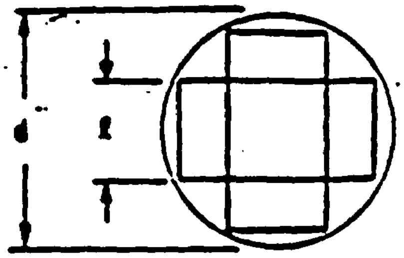




NUS		CONVENTIONAL	
d	= 3.606 ℓ (18 ASSEMBLIES)	d	= 4.243 ℓ (18 ASSEMBLIES)
EFFICIENCY	= 0.784	EFFICIENCY	= 0.637
PACKAGE COST	= \$31,200	PACKAGE COST	= \$39,700
	= \$10.26/kg U		= \$11.67/kg U

FIGURE 2

BASIC CONFIGURATIONS IN NUS SYSTEM - PWR FUEL (ALL CONSOLIDATED FUEL)



$d^2 = 5\ \ell^2$

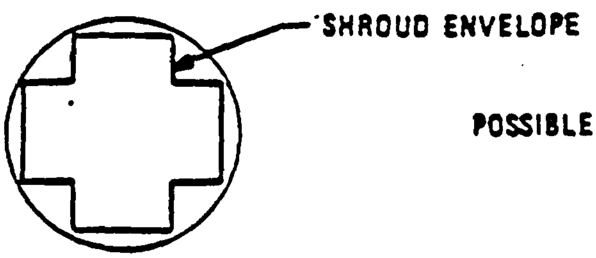
$d = 2.236\ \ell$

$n = 3$ SQUARES (6 CONS. ASSEMBLIES)

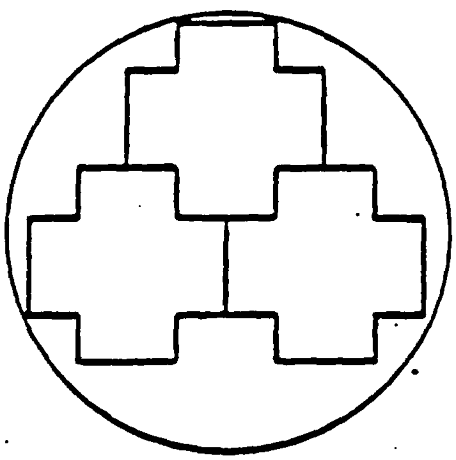
GEOMETRIC EFFICIENCY

$$= \frac{\text{AREA ACTUALLY OCCUPIED}}{\text{AREA WITHIN CIRCLE}}$$

$$= \frac{4 \times n}{\pi \times d^2/\ell^2} = \frac{4 \times 3}{\pi \times 5} = 0.764$$



POSSIBLE APPLICATION : – TRUCK CASK SHIPMENT
– FINAL DISPOSAL PACKAGE

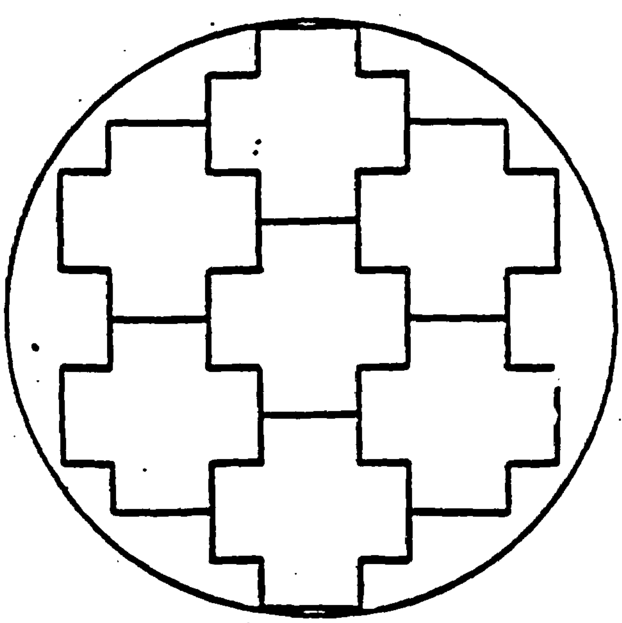


$d^2 = 19.1\ \ell^2$

$n = 9$ SQUARES

$$\text{EFFICIENCY} = \frac{4 \times 21}{\pi \times 19.1} = 0.601$$

POSSIBLE APPLICATION: INTERMEDIATE-SIZED ON-SITE STORAGE · CONCRETE CAISSON



$d^2 = 37\ \ell^2$

$n = 21$ SQUARES

$$\text{EFFICIENCY} = \frac{4 \times 21}{\pi \times 37} = 0.723$$

POSSIBLE APPLICATION: LARGE DRY CASK STORAGE - LEAD/STEEL CASK

The proposed work has been broken down into major activities as described below.

Task 1 - System/Economic Evaluations

Systems studies will be conducted with respect to packaging, storage, and transportation requirements and costs in order to screen the minimum cost options, to provide system descriptions for use in dose and risk assessments, to evaluate the economics of systems using the NUS designs, and to evaluate present government policies which the system may impact.

Task 2 - Engineering Design

NUS will prepare designs of half-square canisters as a unit and in certain geometric arrays, designs of shrouds encircling the arrays, and cost estimates of the hardware required.

Task 3 - Engineering Analysis

NUS will evaluate arrays of half-square canisters in storage, transportation and disposal containers against existing criteria for limits on temperature, radiation dose, and nuclear criticality.

The results of the study will allow OCRWM to compare the NUS-proposed concept with the other PRDA-funded concepts with the objective of selecting the best concept or combination of concepts to be incorporated into the nuclear waste management system.

EXTRA LARGE STORAGE CASKS WITH TRANSPORTABLE ROD CONSOLIDATION UNIT AND ASSOCIATED EQUIPMENT

The Department of Energy's Office of Civilian Radioactive Waste Management (OCRWM) has awarded Transnuclear a contract to study three interrelated concepts for spent fuel management. Each concept is intended to increase packing density and/or payload and can be used independently. The three concepts are (1) a transportable dry consolidation hot cell that can be moved from one reactor site to another, (2) the use of equilateral triangular cross-section canisters for consolidated fuel, and (3) the largest practical cask for both storage and/or transportation, with either intact or consolidated fuel. Necessary adjuncts are wet and dry transfer casks and lag storage casks for use between the pool and dry operations. Transnuclear's subcontractors are BEI and Commonwealth Edison.

The transportable dry-consolidation hot cell, unlike in-pool consolidation concepts, will require little modification to in-pool storage practices. This will provide a utility with the choice of conducting consolidation with their own personnel, or hiring contractor specialists. In the latter case, the utility will not be burdened with concerns regarding personnel training and equipment procurement and maintenance. The proposed design of the consolidation unit will permit the use of any reasonable size or shape of canister for the rods from assemblies. The contractor proposes the use of canisters with an equilateral triangular cross-section which duplicates the naturally densest packing array possible. While this shape is not, and is not intended to be, compatible with current pool storage and assembly cross-sections, it is the most compatible shape canisters intended to be placed in round casks (for example, six triangular canisters can be grouped to form a hexagonal cross-section).

The high packing density achievable using the above concept will be incorporated into the design of Extra-Large Storage Casks (XLSC) capable of storing at least a reload batch from a typical LWR (about 28 MTU). Even much larger XLSC concepts will be examined. Such large cask capacities will result in decreased unit storage costs.

Successful development of the three concepts would reduce worker radiation exposure, handling, the number of shipments, public awareness and exposure, and costs.

Transnuclear proposes five major tasks as described below:

Task 1 - Design Criteria for Extra Large Storage Cask and Associated Equipment

Conceptual design criteria will be developed for at-reactor spent fuel subsystems which include the following:

1. Four combinations of casks and fuel , i.e., transportable/stationary XLSC's with intact/consolidated fuel.

2. Wet and dry transfer casks.

3. Transportable rod consolidation hot cell.

4. Lag storage or "surge" cask for use between the pool and the dry operations.

Task 2 - Conceptual Design and Feasibility Study of Rod Consolidation Equipment

A conceptual design and feasibility study of the dry mobile hot cell will be performed with respect to safety, licensing, costs, institutional acceptance, and operational characteristics.

Task 3 - Conceptual Design and Feasibility Study of XLSC's

Conceptual designs for the four combinations of casks and fuel will be developed, including designs of auxiliary transfer casks and lifting devices. Transportation constraints will be investigated to determine the largest possible capacity for a transportable cask.

Task 4 - Modifications to Waste System Facilities

Necessary modifications to various facilities in the nuclear waste system will be identified to assure operational success with the new designs.

Task 5 - System Assement

This task will examine the feasibility of the selected conceptual subsystems from the viewpoint of costs, safety and regulatory aspects.

The results of the study will allow OCRWM to compare the Transnuclear-proposed concepts with the other PRDA-funded concepts with the objective of selecting the best concept or combination of concepts to be incorporated into the nuclear waste management system.

QUESTION 5: What is the nature of the Department's current commitment, in policy and/or in contract, relating to the receipt and management of spent nuclear fuel beginning January 31, 1998, and pursuant to Section 302(a)(5) of the Nuclear Waste Policy Act?

ANSWER 5: The "Standard Contract for Disposal of Spent Nuclear Fuel and/or High-Level Radioactive Waste" published in the Federal Register on April 18, 1983 (48 FR 16590), defines the scope of the Department's commitment with respect to acceptance of title of spent fuel (SNF) and/or high-level waste (HWL), transportation and disposal. The contract states "The services to be provided by DOE under this contract shall begin, after commencement of facility operations, not later than January 31, 1998, and shall continue until such time as all SNF and/or HLW from the civilian nuclear power reactors ... has been disposed of."

Secretary Hodel, in a response to Senator J. Bennett Johnston on September 7, 1984, provided the DOE opinion that even in the event a repository is not yet fully operational, "the Act vests the Department with the necessary authority to accept spent fuel and high-level radioactive waste beginning January 31, 1998." A copy of that letter is attached.

THE SECRETARY OF ENERGY
WASHINGTON, D.C. 20585

Attachment I.b.

September 7, 1984

Honorable J. Bennett Johnston
Ranking Minority Member
Committee on Energy and
Natural Resources
United States Senate
Washington, D. C. 20510

Dear Senator Johnston:

I am writing in response to your letter of June 21, 1984, which dealt with disposal of spent nuclear fuel under the Nuclear Waste Policy Act. In your letter, you expressed dissatisfaction with the completeness of the General Counsel's response of May 30, 1984, and stated you had requested "an opinion on the legal obligation of the Department and the Department's authority to take title to spent nuclear fuel in the event that a repository has not yet commenced operation" by January 31, 1998.

In our original letter, the Department stated a firm commitment to accept for disposal, on an orderly schedule, high level radioactive waste and spent nuclear fuel not later than January 31, 1998. The Nuclear Waste Policy Act provides clear intent and direction for acceptance and disposal of spent fuel and high level radioactive waste by the Department. The Department is authorized to implement the Act through contractual commitments. To this end, the Department plans to incorporate into its contracts provisions which specify the minimum amount of spent fuel and waste which the Department will be obligated to accept, not later than January 31, 1998. Since these contracts have not yet been modified, it would be premature for the Department to speculate on particulars that might ultimately be incorporated in any or all of the contracts. However, unless waived, the usual remedies and defenses provided to parties contracting with the government would be available. Pursuant to my authority, it is my intention that this commitment in the contracts, together with the overall thrust of the Act, will create an obligation for the Department to accept spent fuel in 1998 whether or not a repository is in operation. This should enable utilities to plan for their projected waste disposal needs with confidence and certainty.

EXTENDED BURNUP

Question 1: What is the scope and status of the extended burnup study being conducted jointly by the Office of Converter Reactor Deployment and the Office of Civilian Radioactive Waste Management? Describe current plans for the burnup program, and the relationship of the study to the plans.

Answer: The study is a joint activity of the Offices of Civilian Radioactive Waste Management (OCRWM) and Nuclear Energy (NE). The NE organization is studying the effects of extended burnup on the front of the fuel cycle and OCRWM is studying these effects on the back end. The OCRWM and NE studies are being coordinated and the the results will be combined into a single executive summary that will provide the total costs and benefits of extended burnup to the entire nuclear fuel cycle.

The two parts of the study are being conducted by contractors who are now nearing the completion of their tasks. We plan to provide Congress with the study consisting of an integrated executive summary report plus the individual front-end and back-end reports at the end of March 1985.

DOE under the Extended Burnup program is continuing existing projects toward completion and is keeping all five domestic fuel suppliers participating in the program. The results of the cost/benefit study should provide a factual basis for a reconsideration of the merits of continued government funding of the program.

COPPER CANISTERS

QUESTION 1: Please provide an overview of the DOE's "Copper Evaluation Plan." Will this plan be the sole basis upon which copper will be evaluated?

ANSWER 1: Copper evaluation plans have been developed for each of the non-salt projects in the first repository program. These plans have been developed in consultation with the Copper Development Association and the International Copper Research Association. The objective of both the basalt and tuff project plans is to comprehensively evaluate copper as a potential waste package material and provide sufficient information so that DOE can decide if copper should be pursued further or eliminated from consideration in the first repository program. The evaluation will include corrosion testing and materials interaction testing under expected repository conditions, structural performance testing, fabrication and welding technology assessment, economics assessment, and design analyses. The evaluation will be completed at the end of FY 1986, and Congress notified of the results.

A briefing on the waste package program, specifically focused on the copper studies, was provided to the staff of the House Interior and Insular Affairs Committee on February 19.

QUESTION 2: We have been informed that a preliminary decision on whether to continue the evaluation of copper will be made at the end of the fiscal year. What factors will be considered in making this decision, in comparison to factors that will be considered for the remainder of the evaluation program should the October 1985 determination be favorable?

ANSWER 2: DOE is not planning to make a preliminary determination on copper at the end of FY 1985. The evaluation plans in place, in the basalt and tuff projects are based on a two-year testing, design, and analysis program. DOE does not plan on making a decision on whether to pursue copper further or to eliminate it in the first repository program until the completion of the evaluation programs at the end of the FY 1986. However, DOE will report to Congress, in accordance with the requirement of the 1985 Appropriations Bill, the results of our copper investigations through FY 1985.

QUESTION 3: If copper is not chosen for the first repository, will it be considered for the second repository? If so, how extensive will its evaluation program be?

ANSWER 3: Copper will be considered for the Crystalline Rock Project in the second repository program regardless of the outcome of the evaluation studies underway in the first repository program. The evaluation to be conducted as part of the crystalline project will be accomplished as an integral part of the planned waste package design and materials testing activities. These activities are currently planned to be initiated in the FY 1986-1987 time frame at the earliest. The extent of the copper evaluation is currently being planned.