HFD-43414

SITE FUEL HANDLING
SUBSYSTEM DESIGN DESCRIPTION

4 x 350 MWt MODULAR HTGR PLANT

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LIST OF ABBREVIATIONS AND ACRONYMS

ASC	Auxiliary Service Cask
ANSI	American National Standards Institute
ASME	American Society of Mechanical Engineers
CRS	Core Refueling Subsystem
CWRA	Civilian Waste Repository Act
DOT	Department of Transportations
DSS	Decontaminatin Service Subsystem
FHCS	Fuel Handling Control Station
FHEP	Fuel Handling Equipment Positioner
FHM	Fuel Handling Machine
FSIF	Fuel Sealing And Inspection Facility
FTC	Fuel Transfer Cask
HEI	Heat Exchange Institute
HTS	Heat Transport System
ICD	Interface Control Document
NI	Nuclear Island
NSSS	Nuclear Steam Supply System
OPDS	Overall Plant Design Specification
QAL	Quality Assurance Level
PSWS	Plant Service Water Subsystem
RB	Reactor Building
RAB	Reactor Auxiliary Building
RESF	Reactor Equipment Service Facility
RIV	Reactor Isolation Valve
RSB	Reactor Service Building
SFHS	Site Fuel Handling Subsystem
SFCWS	Spent Fuel Cooling Water Subsystem
SDD	System Design Description
SSDD	Subsystem Design Description
TBD	To Be Determined

LIST OF DEFINITIONS

[TBD]

PREFACE

The objectives of the HTGR plant project is to produce safe, economical power. Supporting this objective, four major goals and their associated plant states are identified as follows:

1. Maintain Plant Operation
   - 1.1 Maintain Safe Energy Production
   - 1.2 Maintain Safe Shutdown
   - 1.3 Maintain Safe Refueling
   - 1.4 Maintain Safe Startup/Shutdown

2. Maintain Plant Protection (in the event that plant operation cannot be maintained in the normal operating envelope)
   - 2.1 Protect the capability to maintain safe energy production
   - 2.2 Protect the capability to maintain safe plant shutdown
   - 2.3 Protect the capability to maintain safe plant refueling
   - 2.4 Protect the capability to maintain safe plant startup/shutdown

3. Maintain Control of Radionuclide Release (in the low probability event of failure to maintain plant protection)
   - 3.1 Control radiation
   - 3.2 Control personnel access

4. Maintain Emergency Preparedness (in the extremely low probability of failure to maintain control of release of radionculide).

The Overall Plant Design Specificaion (OPDS) is the top-level technical document for the HTGR plant. The OPDS (based on owner requirements and regulatory requirements) establishes the overall performance, functional, institutional, interface, operational, safety, maintenance, inspection, and decommissioning requirements for design of the plant.

In response to the OPDS, a series of lower tier documents, System Design Descriptions (SDDs), Subsystem Design Descriptions (SSDDs), Buildings and Structures Design Descriptions (BSDD), Component Design Specifications (CDSs), and Interface Control Documents (ICDs), desceibe and control the individual designs. Traceability of requirement source from plant-level requirements to equipment-level requirements shall be maintained throughout this hierrachy of design documents

SUMMARY

The Site Fuel Handling Subsystem (SFHS) is a system common to four reactor modules consisting of equipment and facilities located in the Reactor Service Building to supply, store and remove fuel and reflector blocks. It also provides for the placement of new elements into the interim fuel storage facilities prior to refueling operations, shuffling of new and irradiated elements among interim storage locations, and recovery and transfer of irradiated elements from interim storage locations to the Fuel Sealing and Inspection Facility. Equipment included in the SFHS provides for sealing spent fuel in gas-tight containers, placing containers into offsite shipping casks, and handling casks into and out of the Reactor Service Building.

SECTION 1

SUBSYSTEM FUNCTIONS AND DESIGN REQUIREMENTS

1.1 Subsystem Functions

The function of the Site Fuel Handling Subsystem (SFHS) as determined by the functional analysis for the Integrated Approach Goal 1 operations is to perform all fuel handling tasks which can be performed without requiring shutdown of individual reactor modules. These tasks include receiving, storing, and inspecting new fuel and reflector elements, placing new elements into the fuel storage pools in anticipation of core refueling, removing spent fuel and reflectors from the fuel storage pools and packaging them for shipment, and finally loading the packaged elements into their respective shipping casks.

The system in conjunction with the Core Refueling System (CRS) transfers elements between the spent fuel storage facility and the Fuel Sealing and Inspection Facility (FSIF) in supporting other Integrated Approach Goals 2 and 3 requirements.

1.2 Subsystem Design Requirements

The subsystem design requirements discussed below include subsystem specific requirements and applicable top-level utility and regulatory requirements.

1.2.1 Subsystem Configuration and Essential Features Requirements

The SFHS shall have equipment and facilities to supply, store and remove new and spent fuel and reflector blocks.

(3414.0102.001)*

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* Traceability Numbers

[The SFHS equipment and facilities shall be shared among all four reactor . modules.]

(3414.0102.002)

[The SFHS equipment used to process spent elements within the FSIF shall be designed for remote operation.]

(3414.0102.003)

1.2.2 Operational Requirements

The SFHS shall be designed to handle, inspect, and package spent elements for shipment.

(3414.0102.021)

[The SFHS shall be capable of transporting new and spent fuel elements.]

(3414.0102.022)

The SFHS shall receive, inspect, and store new core elements.

(3414.0102.023)

The SFHS design shall assume that:

- o The minimum design interval between refueling outages of nonadjacent modules is [15] days.
- o The minimum interval between refueling outages of adjacent modules is [10] months.
- o A maximum of two modules will be refueled in any [10] month interval.

(3414.0102.024)

1.2.3 Structural Requirements

[The SFHS shall be designed to handle fuel elements that are within the physical size and weight limits specified below:]

Maximum weight: 154 kg (340 lb)
Maximum height: 0.79 m (31.22 in.)

(3414.0102.031)

For generic and plant level structural requirements, refer to OPDS (Ref. 1).

(3414.0102.032)

1.2.4 Environmental Requirements

[All SFHS equipment shall be capable of operating in a temperature range of 0.0°C (32°F) to 40°C (104°F) and a maximum relative humidity range of 0 to 95 percent.]

(3414.0102.041)

[Many SFH Subsystem components are exposed to significant radiation from surface contamination. The design of the affected components shall incorporate features limiting the damaging effects of the total expected exposure to the specified radiation sources to levels consistent with the materials properties used for design analysis.]

(3414.0102.042)

For generic and plant level environmental requirements, refer to OPDS (Ref. 1).

(3414.0102.043)

1.2.5 Instrumentation and Control Requirements

[Control of the SFHS equipment shall be accomplished from a local control panel.]

(3414.0102.051)

The instrumentation and control equipment for the SFHS shall be integrated with the Fuel Handling Control Station (FHCS) provided with the Core Refueling Subsystem (CRS).

(3414.0102.052)

For generic and plant level I&C requirements, refer to OPDS (Ref. 1).

(3414.0102.053)

1.2.6 Surveillance and In-Service Inspection Requirements

This SFHS does not perform any safety-related function and therefore no safety-related surveillance and/or in-service inspection is required.

Routine surveillance shall be performed as part of maintenance.

1.2.7 Availability Assurance Requirements

For generic and plant level availability assurance requirements, refer to OPDS (Ref. 1).

(3414.0102.071)

1.2.8 Maintenance Requirements

For generic and plant level maintenance requirements, refer to OPDS (Ref. 1).

(3414.0102.081)

1.2.9 Safety Requirements

The SFHS is not classified as safety-related. Thus there are no safety requirements.

For generic and plant level safety requirements refer to OPDS (Ref. 1).

(3414.0102.091)

1.2.10 Codes and Standards Requirements

The analyses and trade studies for determining the codes and standards and other industry and regulatory requirements which should be applied to the engineering of Spent Fuel Handling Subsystem have not yet been performed.

1.2.11 Quality Assurance Requirements

[TBD]

1.2.12 Construction Requirements

For generic and plant level construction requirements, refer to OPDS (Ref. 1).

(3414.0102.121)

1.2.13 Decommissioning Requirements

For generic and plant level decommissioning requirements, refer to OPDS (Ref. 1).

(3414.0102.131)

SECTION 2

SUBSYSTEM FUNCTIONS AND DESIGN REQUIREMENTS

2.1 Summary Description

The Site Fuel Handling Subsystem (SFHS) consists of equipment and facilities located in the Reactor Service Building which are used to handle hexagonal graphite fuel and reflector blocks. This equipment interfaces closely with the core refueling equipment described in Reference 2. The SFHS uses some of the equipment in the Core Refueling System to transfer fuel elements between the spent fuel storage facility (part of Core Refueling Subsystem, HFD-43413) and the fuel sealing and inspection Facility (FSIF).

The FSIF is the focal point for all site fuel handling operations. This facility is strategically located in the Reactor Service Building (RSB) and all elements entering or leaving the reactor site must pass through the FSIF.

The SFHS includes all of the equipment used to perform the following operations at the FSIF:

- o Receiving new elements
- o Inspecting new elements
- o Inspecting spent or damaged elements
- o Packaging spent fuel for shipment
- o Positioning packaged spent fuel within the shipping cask
- o Packaging spent reflector elements for shipment
- o Positioning spent fuel in shielded casks for onsite storage.*

Other SFHS equipment located outside the FSIF includes components for components closing, sealing, and handling the fuel shipping casks within the RSB. The equipment required for site fuel handling operations is listed in Appendix E.

The actual shipment of spent fuel from the reactor site will be the responsibility of the DOE (or its agent) in accordance with the provisions of the Civilian Waste Repository Act (CWRA). The DOE will provide empty shipping casks to the site on a predetermined schedule. The Nuclear Island bridge crane will be used to remove the shipping cask from its transporter. The site fuel handling equipment will be used to: 1) open the cask, 2) position the cask below the shipping port of the FSIF, 3) position canisters of spent fuel in the cask, 4) close and seal the cask, and finally, 5) reposition the cask for lifting onto its transporter. The site fuel handling equipment is to be capable of performing the preceding tasks for either a truck mounted shipping cask or a railcar mounted shipping cask.

2.2 Subsystem Configuration

Fuel and reflector block handling operations are shown schematically in Figure 2-1. Figures 2-2 through 2-4 show the physical arrangement of the SFHS equipment. New fuel and reflector blocks enter the site by truck. Each block is individually packaged in a shipping container resembling a 55 gallon drum. New elements are stored in their containers in storage racks located in the Reactor Service Building (RSB). Following inspection, elements required for an impending core refueling operation are transferred through the FSIF to the spent fuel storage pools. The transfer is accomplished using the FSIF hoist, the Fuel Transfer Cask (FTC), and the Fuel Handling Equipment Positioner (FHEP). During the core refueling operation, the Core Refueling System replaces the new fuel and reflectors in the storage pools with irradiated elements.

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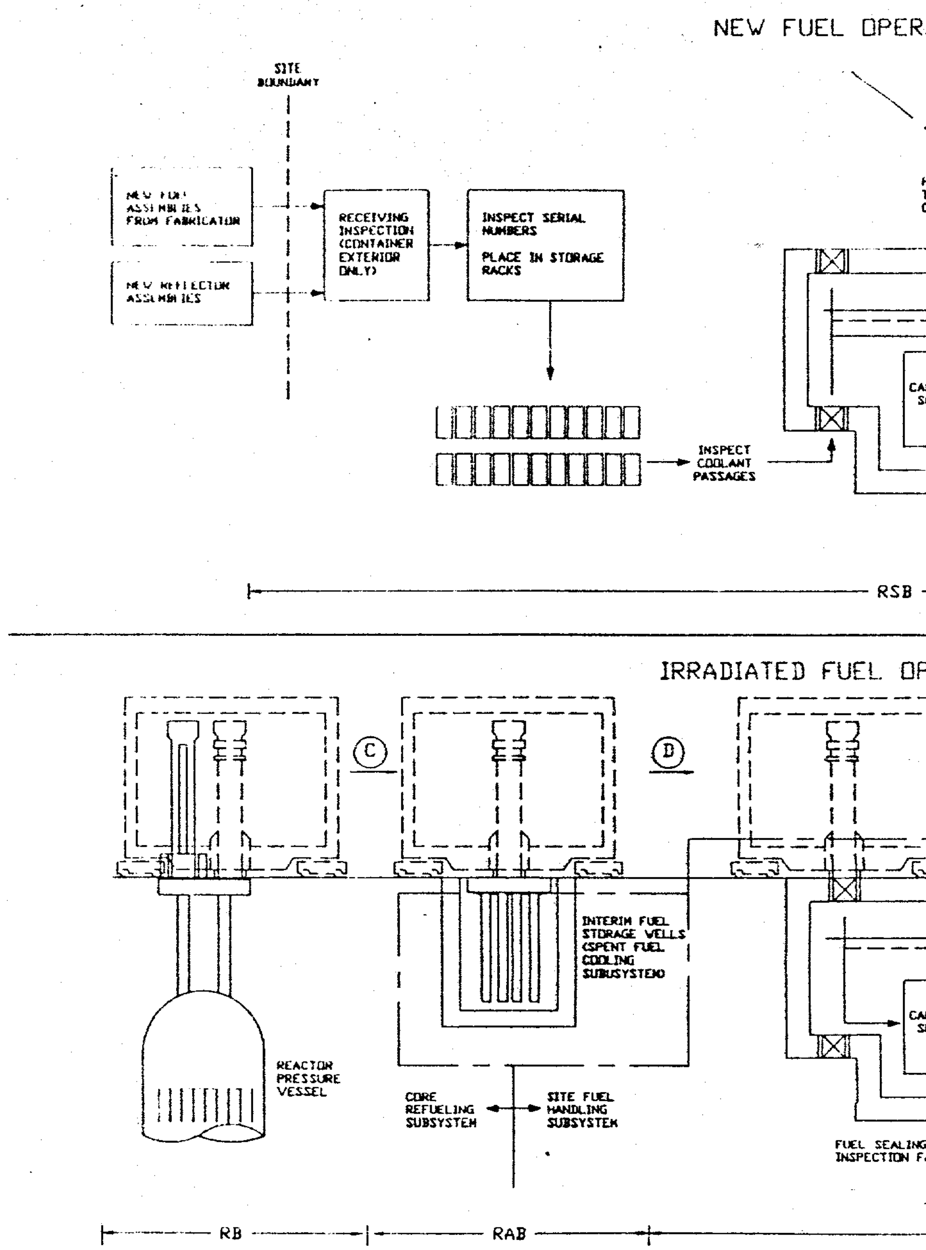
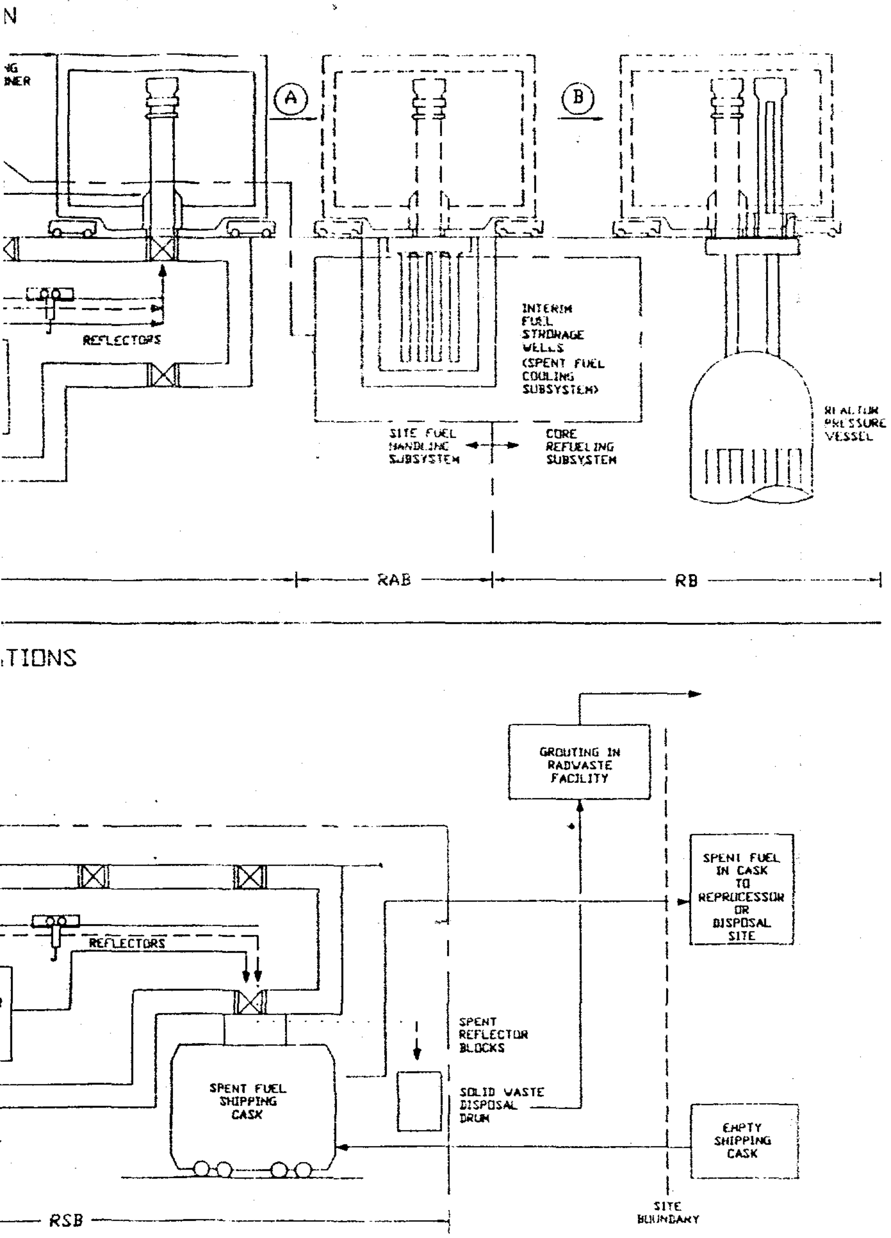
* Spent fuel storage casks are not part of the standard MHTGR design, but can provide expendable on-site storage for spent fuel if necessary.


NEW FUEL
SITE BOUNDARY
FROM FABRICATOR
RECEIVING INSPECTION (CONTAINER EXTERIOR ONLY)
INSPECT SERIAL NUMBERS
PLACE IN STORAGE RACKS
INSPECT COOLANT PASSAGES
RSB
IRRADIATED FUEL
C
D
INTERIM FUEL STORAGE WELLS (SPENT FUEL COOLING SUBSYSTEM)
REACTOR PRESSURE VESSEL
CORE REFUELING SUBSYSTEM
SITE FUEL HANDLING SUBSYSTEM
FUEL SEALING
RB
RAB



APPLIED TECHNOLOGY

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Figure 2-1

No.	DATE	REVISIONS	BY	CHKD	DESIGN SUPV	ENGR	PROJ ENGR	APPR
0	8/1/86	ISSUED FOR SDD/SSDD	CAD	FJD			TMS	

SCALE | DESIGNED | DRAWN MLK/ACAD | CHIEF ENGR

BECHTEL NATIONAL, INC.
SAN FRANCISCO

GCRA/HTGR
4x350MW(t) MHTGR

SITE FUEL HANDLING OPERATIONS
BLOCK DIAGRAM

JOB No.	DRAWING No.	REV.
14508	M-0700	0

17 x 22 "C" SIZE

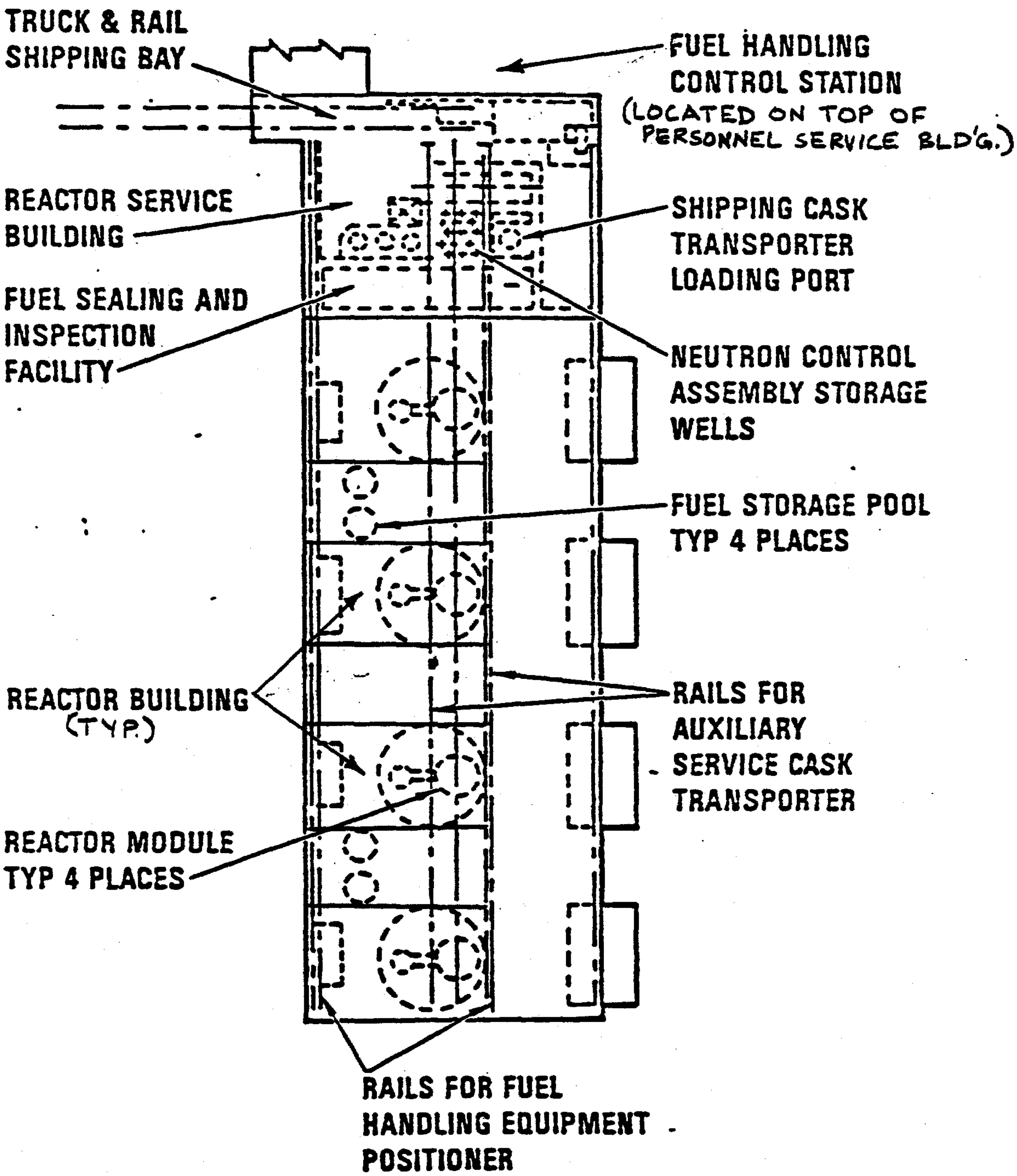

Figure 2-2 SITE FUEL HANDLING — GENERAL ARRANGEMENT

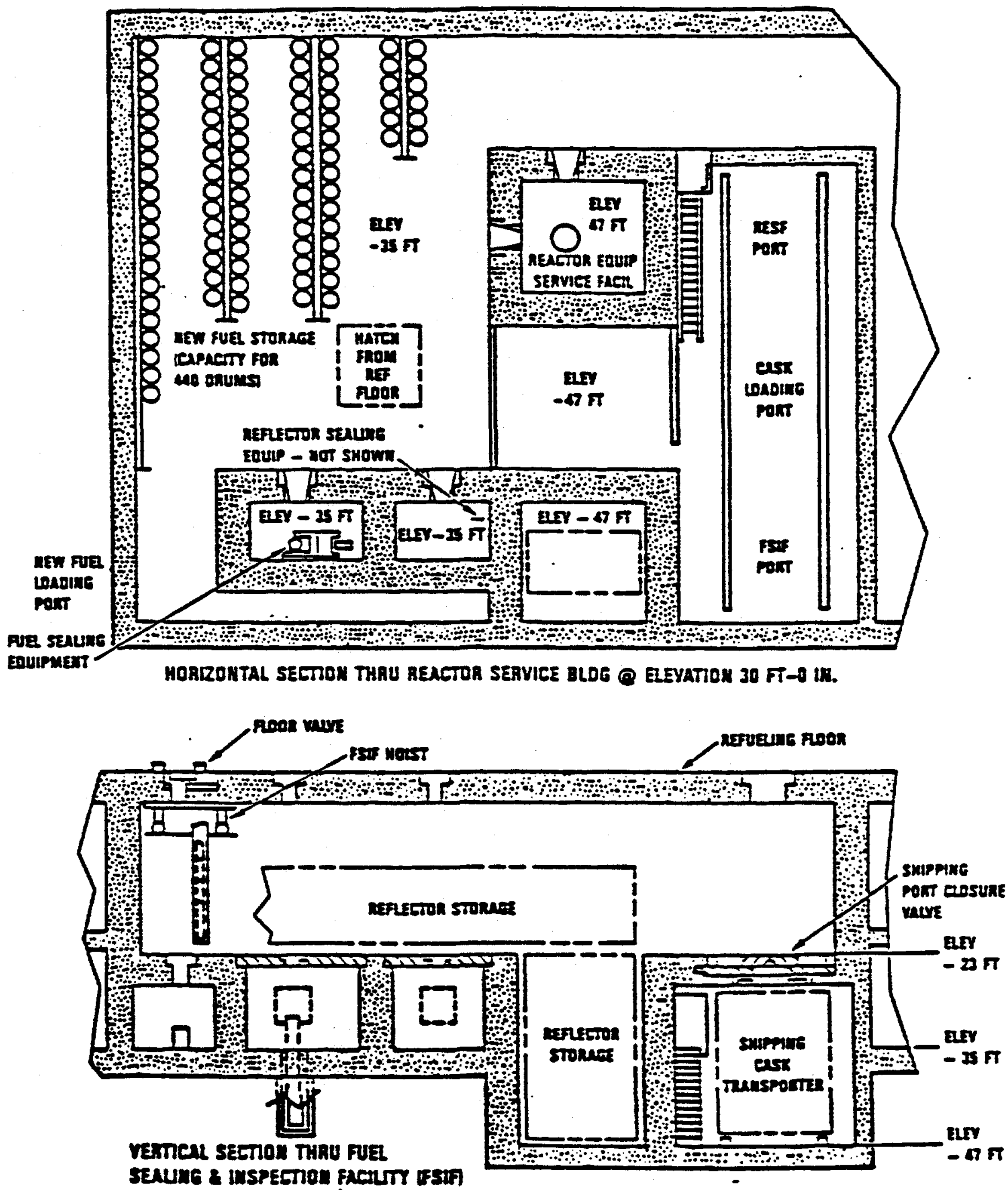

Figure 2-3 SITE FUEL HANDLING – REACTOR SERVICE BUILDING

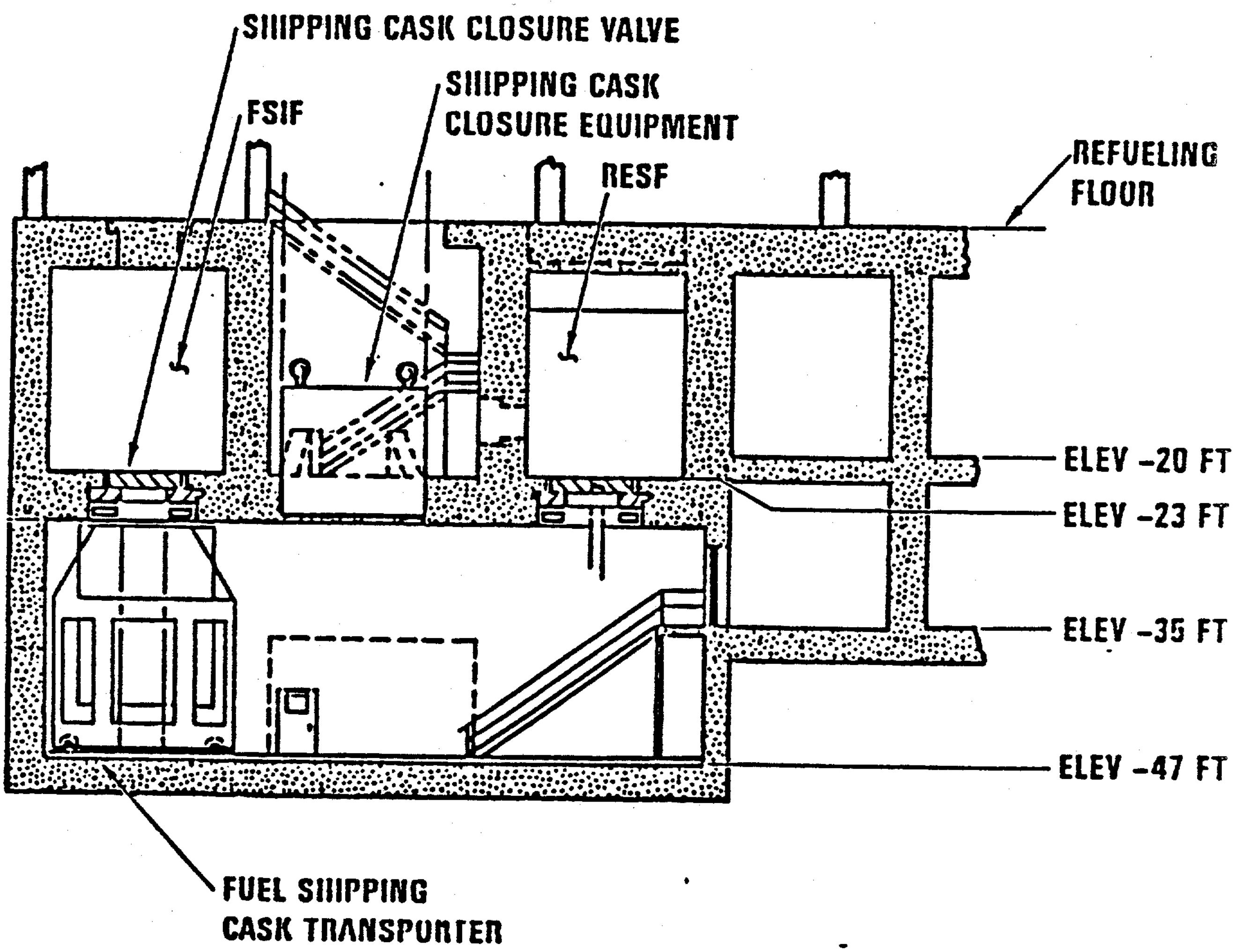

Figure 2-4 FUEL SHIPPING EQUIPMENT

After an appropriate decay period (minimum of 100 Days for fully exposed fuel blocks), the elements are moved, with the FTC and FHEP, to the FSIF. The FSIF is located in a shielded concrete vault in the RSB. Spent reflector blocks are placed in shielded drums and treated as solid radioactive waste. Spent fuel elements are inspected, placed into metal cannisters (See Figure 2-5) which are then sealed using the equipment shown in Figure 2-6, and loaded into spent fuel shipping casks. Spent fuel is then shipped offsite for disposal. The standard MHTGR design is based on an ability to store up to one year's production of irradiated elements on site.

2.3 Subsystem Performance Characteristics

2.3.1 Subsystem Operating Modes

Site fuel handling operations are unaffected by the operating status of the reactor modules. Normally, one or more reactor modules will be in operation while SFHS activities are carried out.

The site fuel handling operations involve processing groups of core elements on an intermittent basis rather than dealing with a continuous flow of elements. The operating staff is expected to schedule the various site fuel handling operations in a sequence which will assure that periodic core refueling outages can be accomplished on schedule and that incoming and outgoing shipments of core elements are processed in a timely fashion. The various SFHS operating modes are described below:

- New Fuel Receiving, Inspection, and Storage (Mode 1)

  Individual fuel and reflector blocks are received into the plant through the NI Warehouse. Shipping container seals are maintained until the material has been moved to the RSB. Upon receipt in the RSB, the seals are broken and serial numbers on the elements are confirmed and entered into the computer memory of the fuel handling control system. Containers are then resealed and placed on storage racks. Drum handling equipment can be used to move fuel in containers.

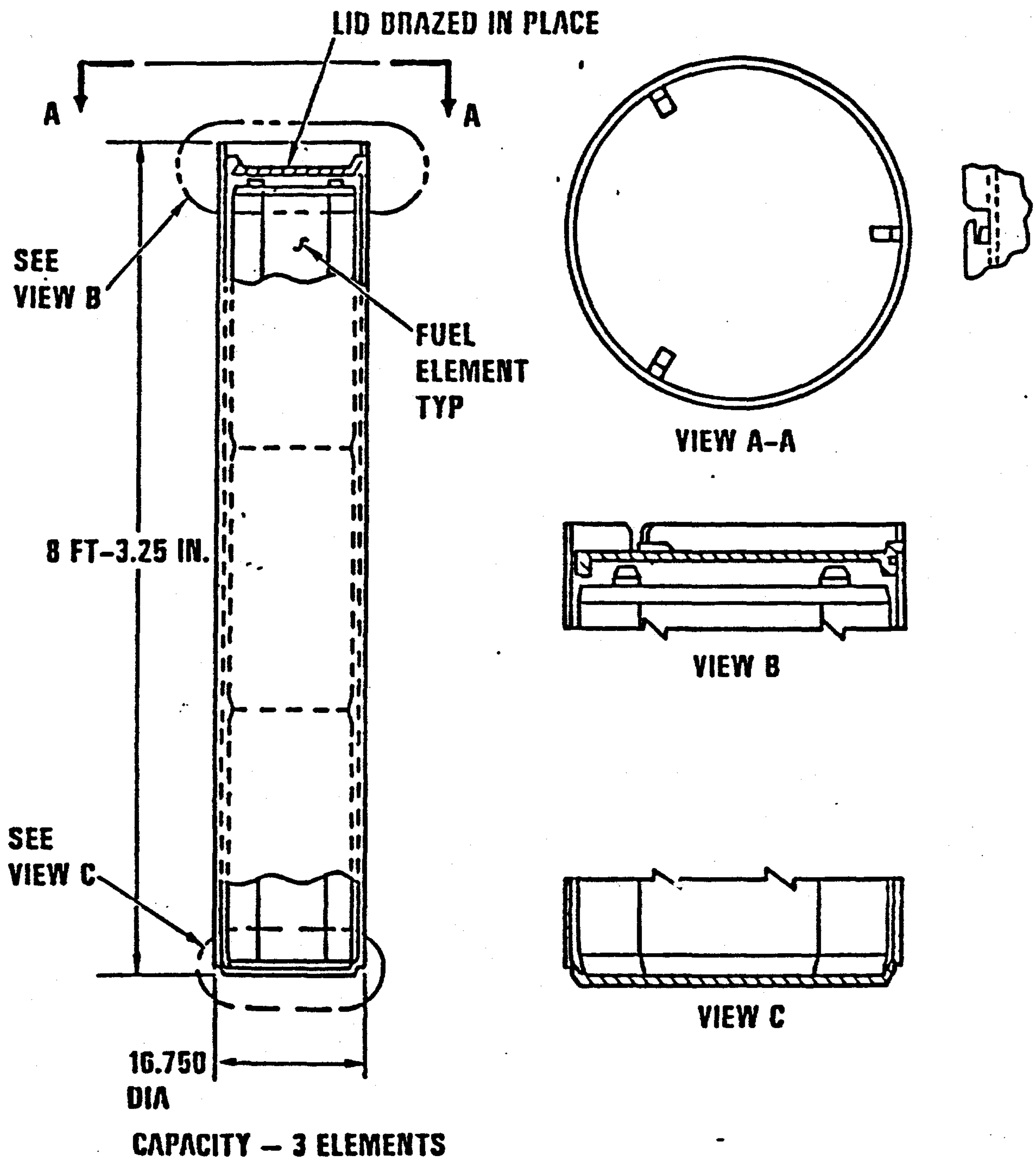

Figure 2-5 SPENT FUEL SHIPPING CONTAINER

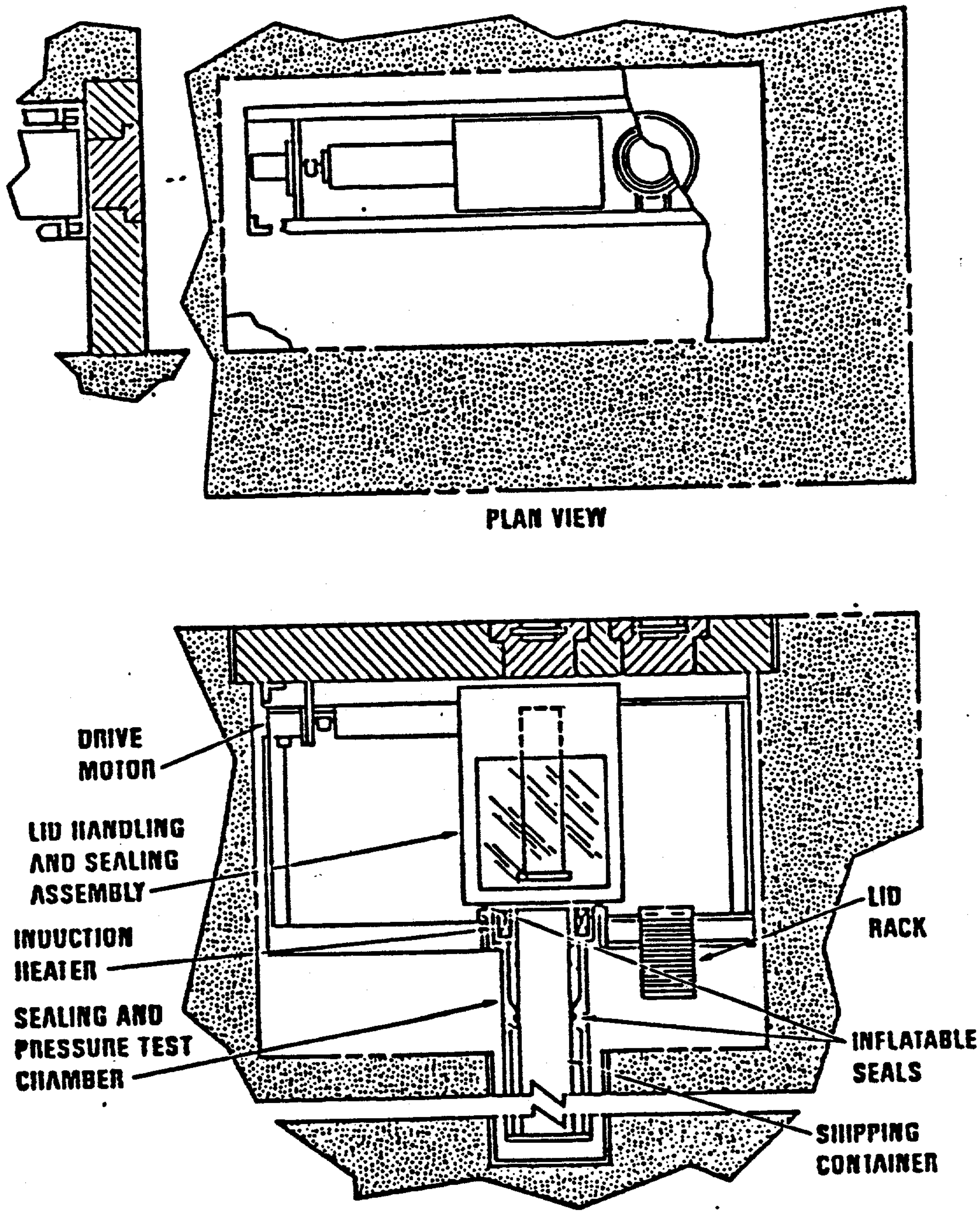

Figure 2-6 FUEL SEALING EQUIPMENT

- o Preparations for Core Refueling (Mode 2)

Efficient core refueling requires careful planning of the refueling sequence and replacement of new core elements at specific locations within the fuel storage pools so that they may subsequently be removed from the pools and placed in the reactor in the proper sequence with minimal delay.

When the planning has been completed, the physical tasks of retrieving the new elements from the new element storage facility, unpacking, inspecting, and placing the elements in the spent fuel storage facility (located in the spent fuel storage pools) is initiated.

Individual elements are selected by serial number for retrieval from the new fuel storage facility and transported to a location beneath an access part in the FSIF. At this point, the drum closure and the packing material protecting the upper surface are manually removed and the exposed surfaces of the element are visually examined for physical damage. At this point, remote handling of the element is initiated.

The FSIF is equipped with a remotely operated crane. One of the two hoists on this crane is equipped with a remotely operated element grapple. The element grapple is positioned over the access port in the floor of the FSIF, and the element grapple is lowered through the access port and into engagement with the new element in its shipping drum. At this point the balance of the initial inspection is completed. When the inspection has been completed, the empty shipping container is removed to the new element storage facility for eventual return to the fuel fabrication facility and the element is lifted into the FSIF. The FSIF hoist then positions the element in a temporary storage location beneath an access port in the roof of the FSIF.

When a group of five elements have been accumulated at this temporary location, the fuel transfer cask (FTC) is used to transport the five elements to the fuel storage pool and place them in the specified storage well locations. Other core refueling equipment also used during this operations includes the fuel handling equipment transporter, the plug actuator, turntable assembly and the fuel handling control station.

During the interval while the FTC is installed over the access port in the ceiling of the FSIF, it is attached to and supported by the floor valve assembly. The floor valve which is securely attached to the refueling floor consists of a remotely operated gate valve with various inflatable seals, electrical connectors to the FTC, purge lines, and a physical configuration designed to interface with the base of the FTC.

The floor valve contains sufficient gamma shielding to protect operating personnel from high level radiation sources in the FSIF during those intervals when the FTC is not installed over the floor valve. The purge lines leading to the floor valve provide for changing the internal atmosphere of the FTC from helium which is typically required at the storage wells to air which is the environment within the FSIF.

Preparations for refueling continue until all of the new elements needed for the next refueling have been inspected and placed in the storage pools. It is expected that preparations for the next refueling will be conducted in parallel with the other site fuel handling tasks described below.

- Packaging Spent Reflector Elements for Shipment (Mode 3)

The spent reflector elements removed from the modular HTGR core require only a minor amount of gamma shielding in order to reduce the surface dose of the packaged element to an acceptable limit for direct contact handling and also qualify the packaged element for disposal as low-level radioactive waste.

The spent reflector elements generate no decay heat and can therefore be removed from the spent fuel storage pools immediately after the completion of the refueling outage to provide room for the new elements required for the next refueling.

The spent reflector elements are transported from the spent fuel storage pools to the FSIF with the FTC which in turn deposits them in the temporary storage well beneath the access port. Each spent reflector element is then transported to the reflector packaging station within the FSIF with the element grapple of the overhead crane in the FSIF.

The procedure for packaging spent reflectors involves placing them within a 55 gallon drum containing a precast shielding liner and remotely installing a drum closure. The shielding medium is shaped to assure the proper position of the element within the drum and reduces the surface dose rate to an acceptable limit for direct contact handling. A remotely operated grapple attached to the second hoist mechanism on the FSIF crane is used to move the entire package from the reflector drumming station and lower it to the floor below the FSIF access port.

The packaged reflector is then transported to the solid radioactive waste facility with conventional drum handling equipment where a grouting material is injected into the drum to eliminate voids and further stabilize the element within its storage drum. Subsequent on-site storage and off-site is provided by the solid radioactive waste subsystem.

Each of the four reactor modules produces [132] spent fuel elements during its 20 months operating interval. Therefore the nominal packaging rate for spent reflectors is [26.4] elements/month.

- o Packaging Spent Fuel Elements for Shipment (Mode 4)

The fuel shipping container for spent HTGR fuel (illustrated in Figure 2-5) consists of a cylindrical tube with cast end caps brazed into the cylinder. The length of the cylinder may be adjusted to provide a capacity for either two elements, three elements and/or five elements in a vertical stack.

The cylindrical containers are provided with the bottom end cap securely brazed in place, and all joints leak-tested with the exception of the final joint securing the top closure to the container wall. The top closure contains a brazing preform which will melt to form the final joint when the required amount of heat is applied with a circular induction heater.

The fuel sealing equipment (illustrated in Figure 2-6) consists of two subassemblies located inside the FSIF plus additional controls and instrumentation located outside the FSIF. The lower subassembly is essentially a fixed cylinder with an induction heating element and a horizontal seal face at the upper end and an inflatable seal at its lower end. Empty shipping containers of various lengths are deposited within the fixed cylinder by the second hoist and grapple on the FSIF crane.

The second fuel sealing subassembly is a translating dome which can be moved laterally to allow insertion of the shipping containers and spent fuel elements inside the fixed cylinder. When the dome is positioned over the fixed cylinder an inflatable seal in the horizontal seal face can be actuated into contact with the bottom surface of the dome. When the seals are actuated, purge lines leading to the lower cylinder provide the capability to control the atmosphere within the container and at the seal joint.

A grapple mechanism provided in the upper assembly is capable of engaging the top closure and moving it a few inches in the vertical axis. This feature permits the temporary removal of unbrazed lids so that the empty container may be loaded with spent fuel.

The packaged fuel elements are removed from the fuel sealing station with the FSIF crane and transported to the fuel shipping port for placement in a fuel shipping cask or in a temporary container storage rack pending the arrival of the shipping cask.

Each of the four reactor modules produces 330 spent fuel elements during its 20 month operating interval. Therefore the normal packaging rate for spent fuel is 65 elements per month. The spent fuel must remain in the storage pools until its heat generation rate has decayed to acceptable levels for offsite shipment and shipping schedules have been established. This storage interval is expected to vary from 3 months to 12 months.

The shipping port closure valve provides radiation shielding over the shipping port when there is spent fuel in the temporary container storage rack and the shipping cask is not positioned below the port.

- <u>Spent Fuel Shipping</u> (Mode 5)

The actual shipment of spent fuel will be the responsibility of the DOE or its agent under the terms of the civilian radioactive waste management program. There are, however, several site fuel handling operations which are related to the shipment of spent fuel. These operations involve removal of the empty shipping cask from its transporter (using the NI bridge crane), removal and refurbishment of the shipping cask closure, positioning the cask below the fuel shipping port of the FSIF, loading containers of spent fuel into the cask, remote installation and leak testing of the cask closure, and installation of the loaded cask on its transporter.

Despite the clearly defined functional requirements for these operations, there is a great degree of uncertainty related to the specific details, since the DOE has not yet selected the cask designs which it will use for any type of fuel. Despite these restrictions. the general expectation is that the spent HTGR fuel can be shipped in casks like those tentatively selected for light water fuel. The relative lengths of light water fuel compared to HTGR fuel allows five elements to be stacked in a column for shipping but will not allow six elements. As indicated above, the fuel sealing equipment can accommodate containers holding either two, three, or five elements. This flexibility in container size will accommodate many different cask sizes; however, it is expected that the truck shipping cask will hold one column of five spent elements, and the rail shipping cask will hold four columns of five spent elements.

The site fuel handling equipment required for shipment of spent fuel is illustrated in Figure 2-4, and consists of shipping cask transporter, the cask closure removal equipment and miscellaneous cask handling adapters.

2.3.2 Subsystem Steady State Performance

Specific features to accomplish radionuclide control design requirements are as follows:

1. Embedded gate valves shall be used at the access ports to the FSIF to prevent radioactivity release from spent core elements temporarily stored within the FSIF.

2. The embedded gate valves at the FSIF ports shall provide adequate biological shielding when no other equipment is secured to the access ports.

3. Helium purge and supply equipment shall be used in conjunction with the portable core refueling equipment to limit the release of radioactivity during core element transfer operations.

4. The SFHS equipment used to process spent elements within the FSIF shall be designed for remote operation by operators located outside the shielded walls of the FSIF.

5. The SFHS equipment used to service and transport fuel shipping casks shall provide biological shielding for the reactor plant personnel during any interval when the cask closure is removed from the shipping cask.

The SFHS performance is tabulated in Table 2-1.

2.3.3 Subsystem Response to Plant Transients

For all plant transients listed in References 3 and 4, there is no change in operating modes of the Site Fuel Handling Subsystem. However, in cases of loss of offsite power and a large earthquake, the SFHS is not available.

2.3.4 Subsystem Failure Modes and Effects

The unavailability of the SFHS due to a component failure is not expected to have any impact on the plant availability and investment protection capability.

Abnormal operation of the SFHS includes operation at reduced capacity and recovery from various casualty events.

- Reduced Capacity

  Should one piece of the site fuel handling equipment fail, the specific task is normally interrupted while the defective component is replaced or repaired. Manual tooling and other design features are provided to assure that the faulty component can be replaced or repaired without excessive delay.

- Casualty Events

  The ability to recover quickly from postulated casualty events is an important feature of the site fuel handling equipment because the subsystem cannot be returned to operation until repairs are completed

Table 2-1

SITE FUEL HANDLING SYSTEM
PERFORMANCE

SFHS Mode	Average Rate	Max. Rate	Requires FSIF	Affected by Reactor Operator
New Fuel Receiving Inspection and Storage	65 elements per month	Est. [200] elements per month	No	No
Preparation for Core Refueling	65 elements per month	[TBD]	Yes	No
Packaging Spent Reflector Elements	[60] per year	[4] per day	Yes	No
Packaging Spent Fuel Elements	65 elements per month	[4] per day (after cooling period)	Yes	No
Spent Fuel Shipping	65 elements per month	[160] elements per month	Yes	No

The remote nature of many site fuel handling operations creates additional motivation for design features that mitigate the effects of casualty events and well developed recovery procedures for these postulate events.

The following paragraphs identify some of the casualty events which may affect site fuel handling equipment and give general information on applicable mitigating features or recovery procedures which are provided.

In general, the site fuel handling equipment is designed to fail "in place" upon a loss of electrical power. Typical mitigating design features include redundant components powered from alternate power supplies or provisions for manual actuation.

The primary protection from control system malfunctions is provided through the use of independent safety sensors and control logic which monitors the primary control sensors and logic and interrupts erroneous actions or commands. Diagnostic information regarding the cause of the interruption is provided to accelerate the recovery procedure.

Redundant features are provided to mitigate the effects of many mechanism malfunctions. The redundant features within an assembly are provided to prevent damage to surrounding components and structures or are used to place the assembly in a configuration where removal for maintenance is possible. For example, most remotely operated drives have redundant position and/or load sensors such that a failure of one sensor will not permit unsafe operation of the equipment.

The combination of low heat generation rates, high specific heat capacity in the fuel element and its surroundings, and the ability of the element to survive at elevated temperatures provides ample time to take corrective action in the event of a malfunction in the site fuel handling equipment while processing spent fuel elements.

2.4 Subsystem Arrangement

The physical location of the SFHS is shown in Figures 2-2 through 2-4. Because the CRS and SFHS are shared among all reactor modules in the plant, buildings and systems have been arranged to facilitate easy movement of the FTC to all of the storage and access locations required. The FHEP, which physically carries the FTC with its load of fuel and reflector blocks, is mounted on rails. One rail is set in the operating floor and the other rail is set at an elevation approximately 30 feet above the floor. All of the points where elements must pass through the operating floor are arranged between these rails.

The spent fuel storage pools are located in the Reactor Auxiliary Buildings between the first and second reactors and between the third and fourth reactors. Each pool is equipped with two circular arrays of fuel storage wells. A total of four arrays provide 72 storage thimbles, each of which can hold ten elements. They are grouped in pairs between the reactors in order to minimize the length of the fuel handling trajectory. The arrays are immersed in the spent fuel storage pools. Forced cooling removes the decay heat from the pool.

The new fuel storage, FSIF, and shipping cask handling equipment are all located in the RSB. The arrangement of these facilities has been selected to permit easy interfacing between the various site fuel handling operations.

2.5 Instrumentation And Control

The instrumentation and control equipment for the SFHS is integrated with the Fuel Handling Control Station (FHCS) provided with the Core Refueling Subsystem (CRS). This integration assures proper coordination between the SFHS equipment and the CRS equipment during site fuel handling tasks that require the use of the fuel transfer cask.

Each of the major items of site fuel handling equipment is controlled from local control panels. However, data from each of local panels is monitored by a central controller which prevent improper operation of interfacing equipment. The central-controller also monitors the movement of individual core elements and transfers this information to the portion of the FHCS which maintains element accountability records.

Specific details of the instrumentation and control components for the SFHS have not been developed but should be compatible with the details incorporated into the CRS equipment as discussed in Reference 4.

SECTION 3

COMPONENT FUNCTIONS AND DESIGN REQUIREMENTS

[TBD]

SECTION 4

SUBSYSTEM AND COMPONENT INTERFACES

4.1 Subsystem Interface Requirements

Interface requirements, at the subsystem level, are presented below showing the subsystem on which the requirement is imposed, a brief description of the type of interface, and a statement of the requirement and the general location of the interface.

4.1.1 Interface Requirements Imposed on Other Systems

Interfacing System	Nature of Interface	Interfacing Component	Interface Requirement
4.1.1.1 Electrical Group			
AC Power Supply Subsystem	Electrical Power	Equipment terminal board	Provide [TBD] kW @ 480V to operate the Site Fuel Handling System equipment
AC Power Supply Subsystem	Instrument & Control Power	Local Control Panels	Provide [TBD] kW 120V AC power for instruments and controls
4.1.1.2 Reactor Services Group			
Hot Service Facility	Decontamination	Decontami-nation skid	Decontaminate the SFHS equipment as required

Interfacing System	Nature of Interface	Interfacing Component	Interface Requirement
Reactor Service Building	Housing	Building space	Provide housing for the SFHS components, structures and sub-systems; including the FSIF and new fuel storage
Gaseous Radio-active Waste Subsystem	Process gases	Piping connection from the facility	Receive air or helium from the SFHS components
Liquid Radio-active Waste Subsystem	Process Effluent	Piping from the facility to Radioac-tive Waste Management Building	Receive liquid effluent from the FSIF cell
Reactor Building, Auxiliary Building and Maintenance Enclosure	Housing and Arrangement	Building space	Provide space and rail systems to permit operation of FHEP
Core Refueling System	Spacial Arrangement	Building space	Align with SFHS Access Zones
Nuclear Island Bridge Crane	Spacial Arrangement	Building space	NI Bridge crane must access spent fuel cask transporter and SFHS cask handling location

4.1.2 Interface Requirements Imposed on Subsystem Within the System

[TBD]

4.2 Component Boundary Definition

[TBD]

SECTION 5

SUBSYSTEM CONSTRUCTION

[TBD]

SECTION 6

SUBSYSTEM OPERATION

[TBD]

SECTION 7

SUBSYSTEM MAINTENANCE

[TBD]

SECTION 8

SUBSYSTEM DECOMMISSIONING

[TBD]

SECTION 9

REFERENCES

1. GA Technologies, Overall Plant Design Specification, Modular High Temperature Gas Cooled Reactor, HTGR 86-004, Rev. 1, February 1986.

2. GA Technologies, Core Refueling Subsystem Design Description, HFD-43413, June 1986.

3. GA Technologies, Modular HTGR Plant Design Duty Cycle, Document No. 908728/0. February 14, 1986

4. GA Technologies, Licensing Basis Events for the Modular HTGR, HTGR-86-034, April 1986.

APPENDIX A

TRACEABILITY REQUIREMENTS

Traceability Number	Requirement	Source Ref.	Source Section
3414.0102.001	System shall have equipment and facilities to handle fuel	1	4.3.12
3414.0102.002	[System shall be shared among four reactor modules]		*
3414.0102.003	[System shall be designed for remote operation]		*
3414.0102.021	Capability of handling spent fuel for shipping	1	5.6.1
3414.0102.022	[Capability of transporting spent fuel elements]		*
3414.0102.023	Capability of receiving, inspecting and storing new elements	1	5.6.1
3414.0102.024	System shall be designed for prescribed refueling schedule	2	1.2.2
3414.0102.031	[Shall handle fuel elements within prescribed size and weight]		*
3414.0102.032	Generic and plant level structural requirements	1	
3414.0102.041	[Shall operate between prescribed conditions]		*
3414.0102.042	[Design consideration for radiation exposure]		*
3414.0102.043	Generic and plant level environmental requirements	1	
3414.0102.051	[Control shall be from a local panel]		*
3414.0102.052	System I & C shall be integrated with the FHCS	2	1.2.5
3414.0102.053	Generic and plant level I & C requirements	1	5.1
3414.0102.071	Generic and plant level availability assurance requirement	1	5.1
3414.0102.081	Generic and plant level maintenance requirement	1	5.1
3414.0102.091	Generic and plant level safety requirements	1	5.1
3414.0102.121	Generic and plant level construction requirements	1	5.1
3414.0102.131	Generic and plant level decommissioning requirements	1	5.1

* At present these requirements are anticipated and will be confirmed by Functional Analyses.

APPENDIX B

DRAWINGS

Drawings are presented as part of the Reactor Service Building Design Description.

APPENDIX C

TRANSIENTS

[TBD]

APPENDIX D

DESIGN BASIS SEISMIC INPUT

[TBD]

APPENDIX E

EQUIPMENT LIST

The following equipment and fixtures are provided as part of the Site Fuel Handling Subsystem. The SFHS uses some of the equipment in the Core Refueling Subsystem and are listed in Reference 2.

- Shipping Casks
- Shipping Transporter
- Fuel Handling Equipment Positioner
- Container Sealing Equipment
- Leak Test Equipment
- Dual Hoist Crane
- Shipping Cask Closure Equipment
- Shipping Port Closure Equipment
- Fuel Element Grapple
- Manipulators
- Split Gate Valve
- Floor Valve Assembly
- Fuel and Reflector Storage Racks
- Reflector Packaging Equipment

APPENDIX F

PARAMETERS LIST

[TBD]

APPENDIX G

PROPRIETARY CLAIMS

[TBD]