HTGR Technology Course for the Nuclear Regulatory Commission

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Module 5d

Prismatic HTGR Refueling Design

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General Atomics

Outline

- **Prismatic refueling system functions and requirements**
- **Refueling system design description**
- **Fort St. Vrain experience**
- **Used fuel management plan**

Prismatic Refueling System Key Functions

- Remove and replace fuel in reactor
- Provide interim used fuel storage
- Receive, inspect, and store new fuel
- Provide for long term storage and disposal
- Provide control and inventory accountability
- Replace selected reflector elements
- Perform in-core inspection and maintenance

Prismatic Refueling System Key Requirements

- Minimize refueling time consistent with fuel cycle time allocation for planned outage
- Provide for storage of used fuel and discharged reflectors from 10 years of plant operations plus one core volume including reflectors
- Provide space to expand storage facility to accommodate used fuel and reflectors discharged over the plant life
- Provide for expanding used fuel storage facility without impacting power production
- Provide interface with US DOE used fuel disposition system

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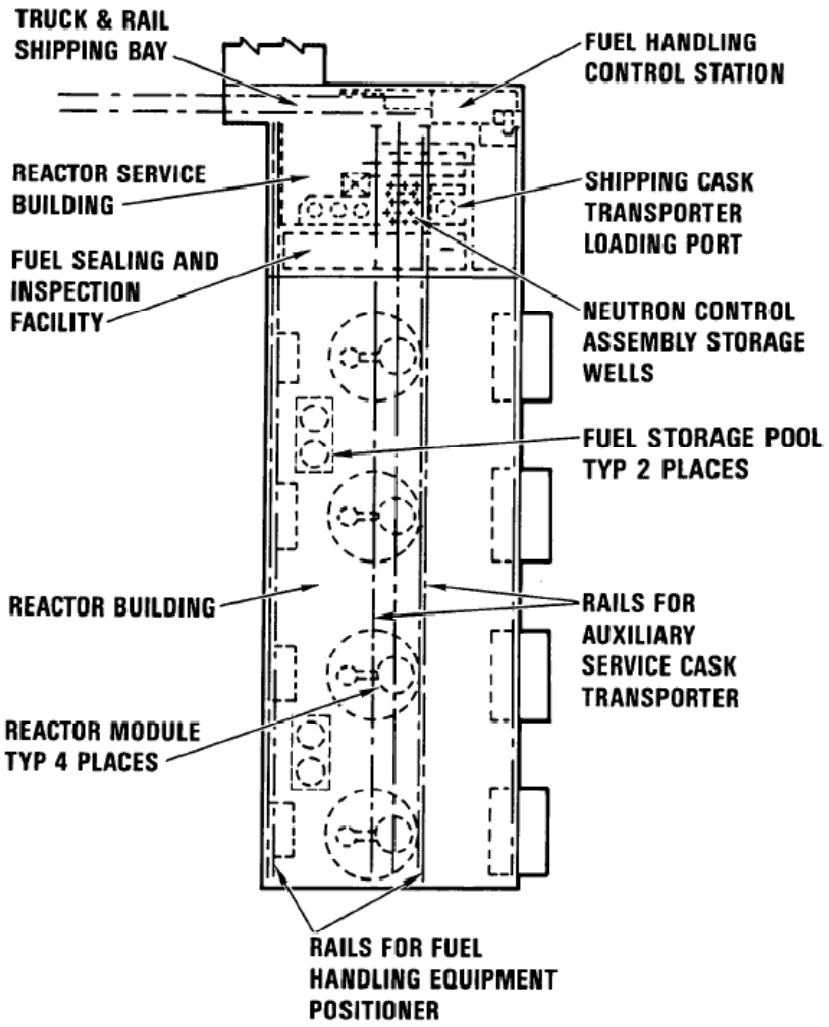
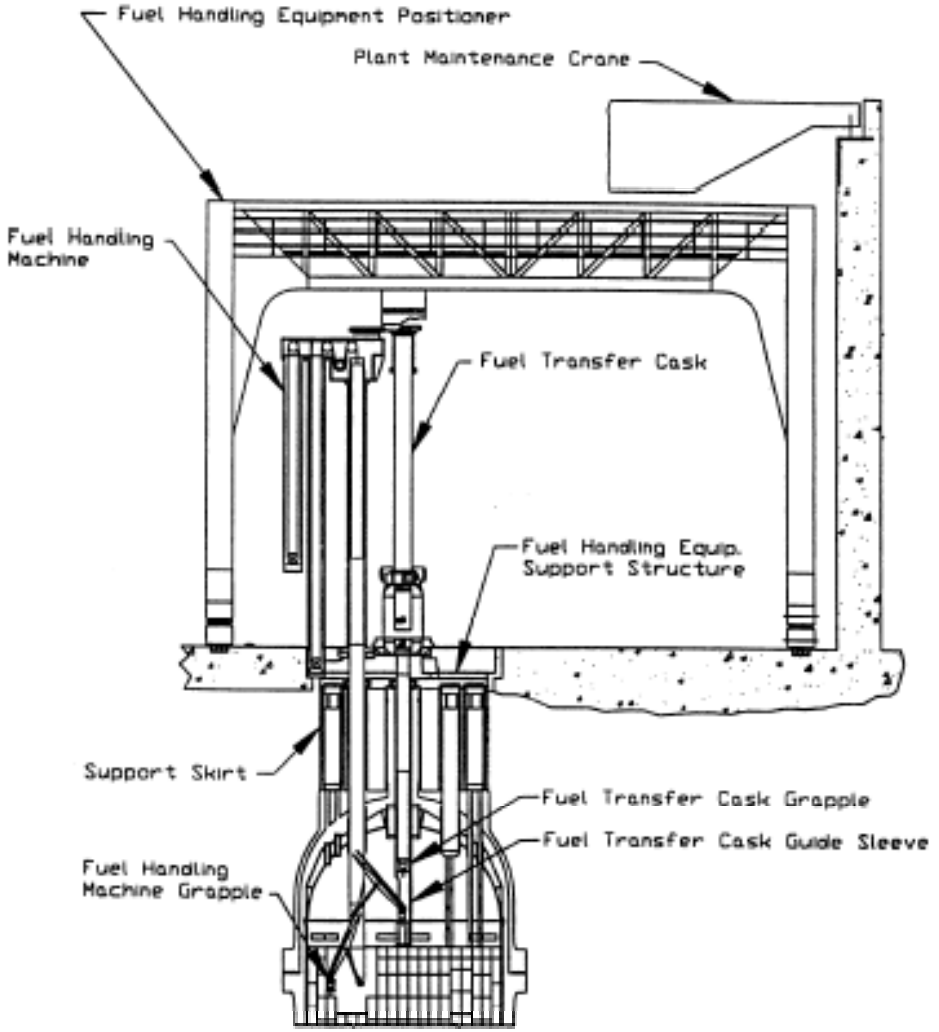
Refueling System Arrangement for 4-Module HTGR Plant

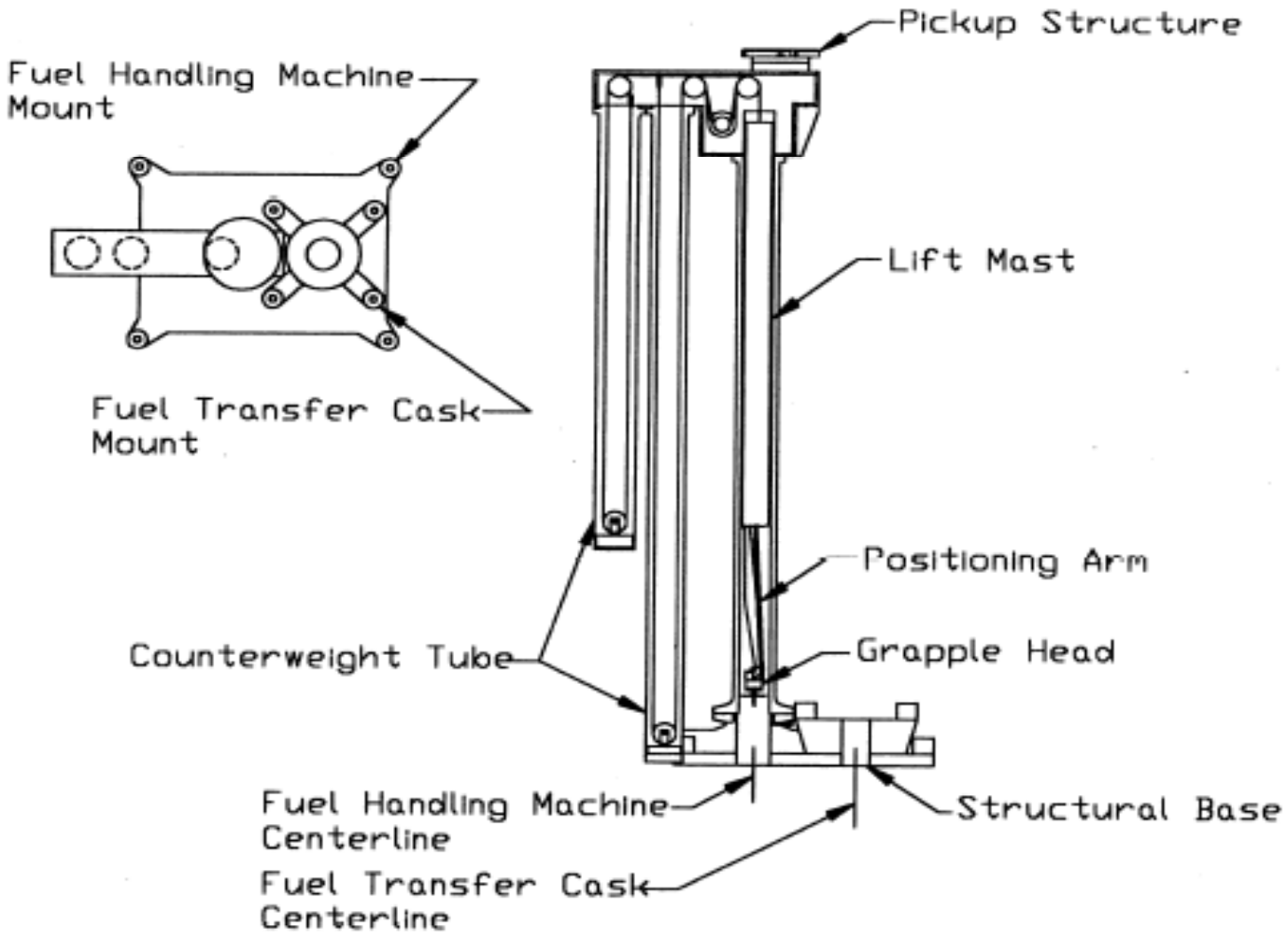


Refueling System Equipment - MHTGR

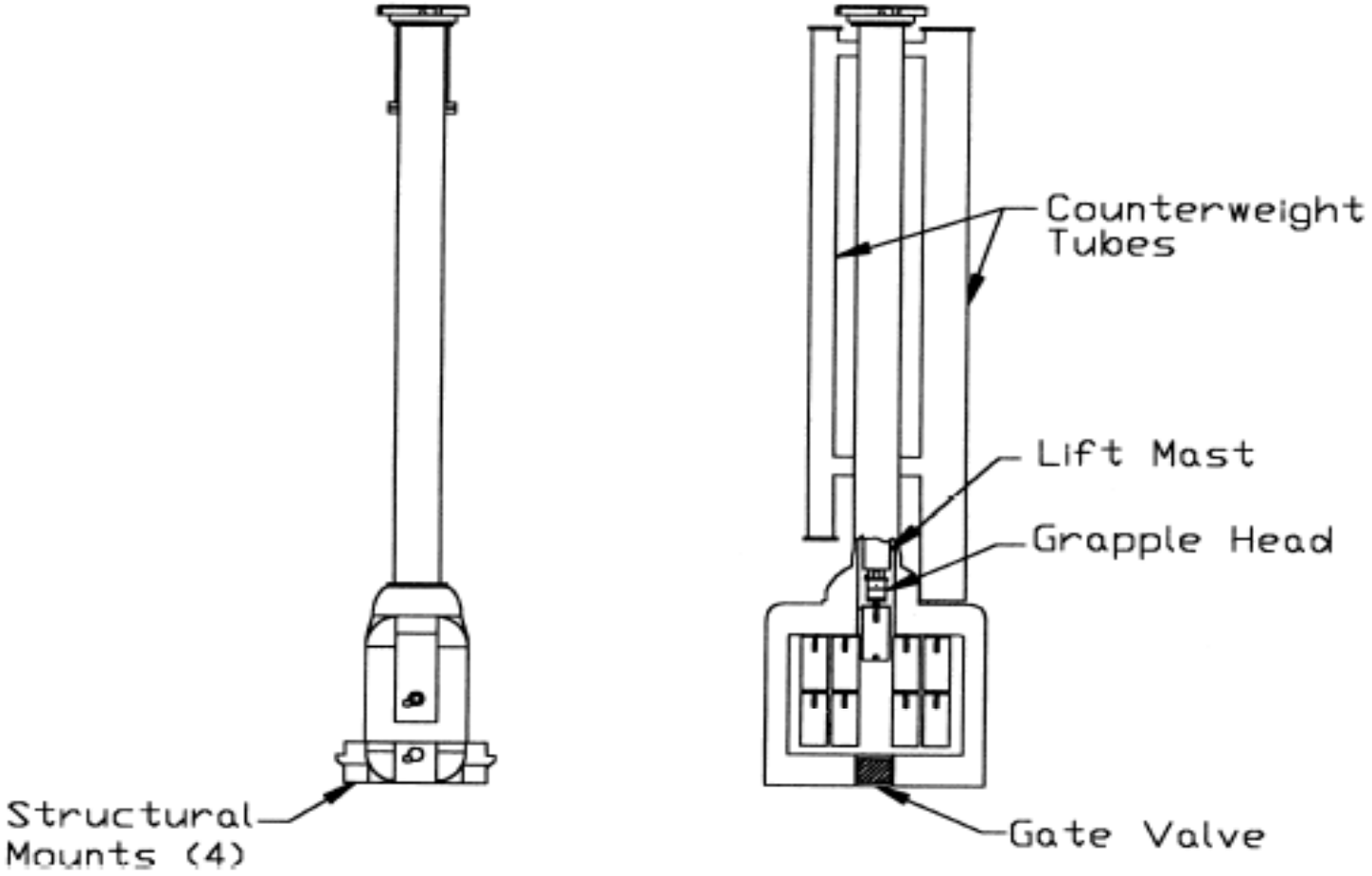
- **Main refueling equipment items are:**
  - **Fuel Handling Equipment Positioner**
  - **Fuel Handling Machine**
  - **Fuel Handling Equipment Support Structure**
  - **Fuel Transfer Cask**
- **Fuel handling machine grapples fuel elements from core for placement in fuel transfer cask**
- **Fuel transfer cask transfers the fuel elements to/from fuel storage pool**



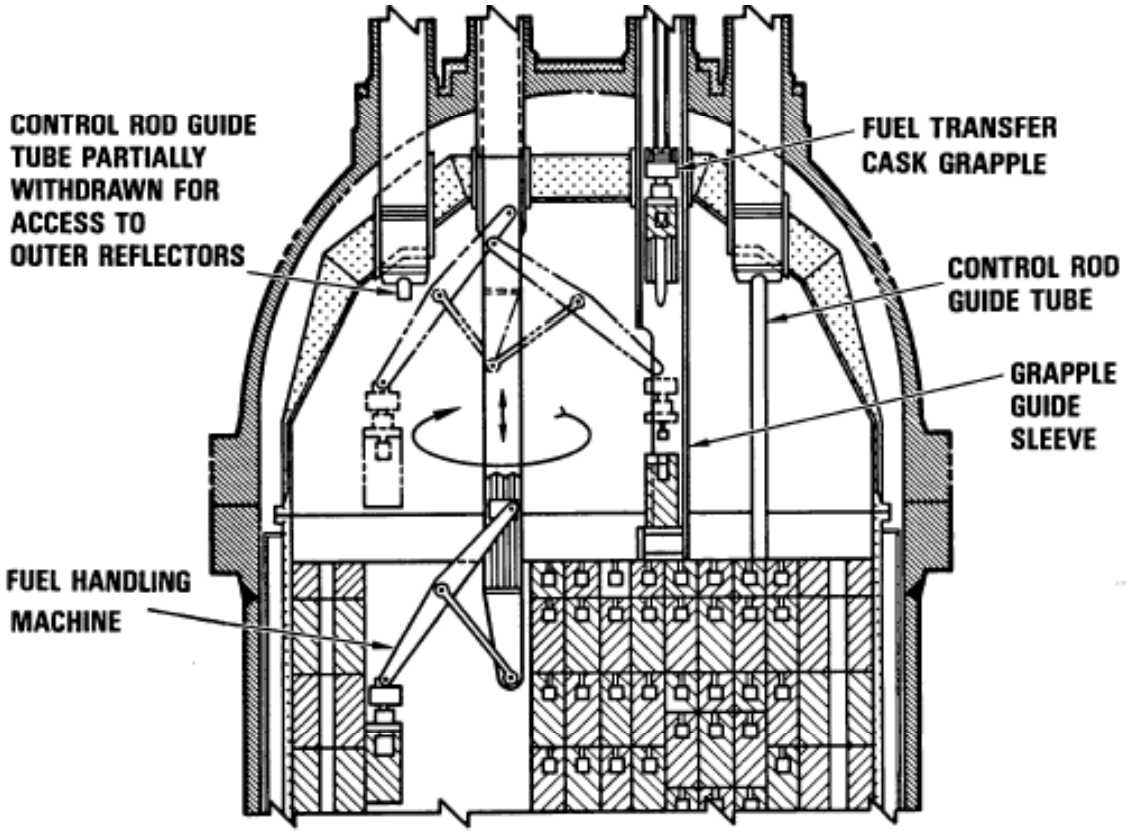
Fuel Handling Machine – MHTGR



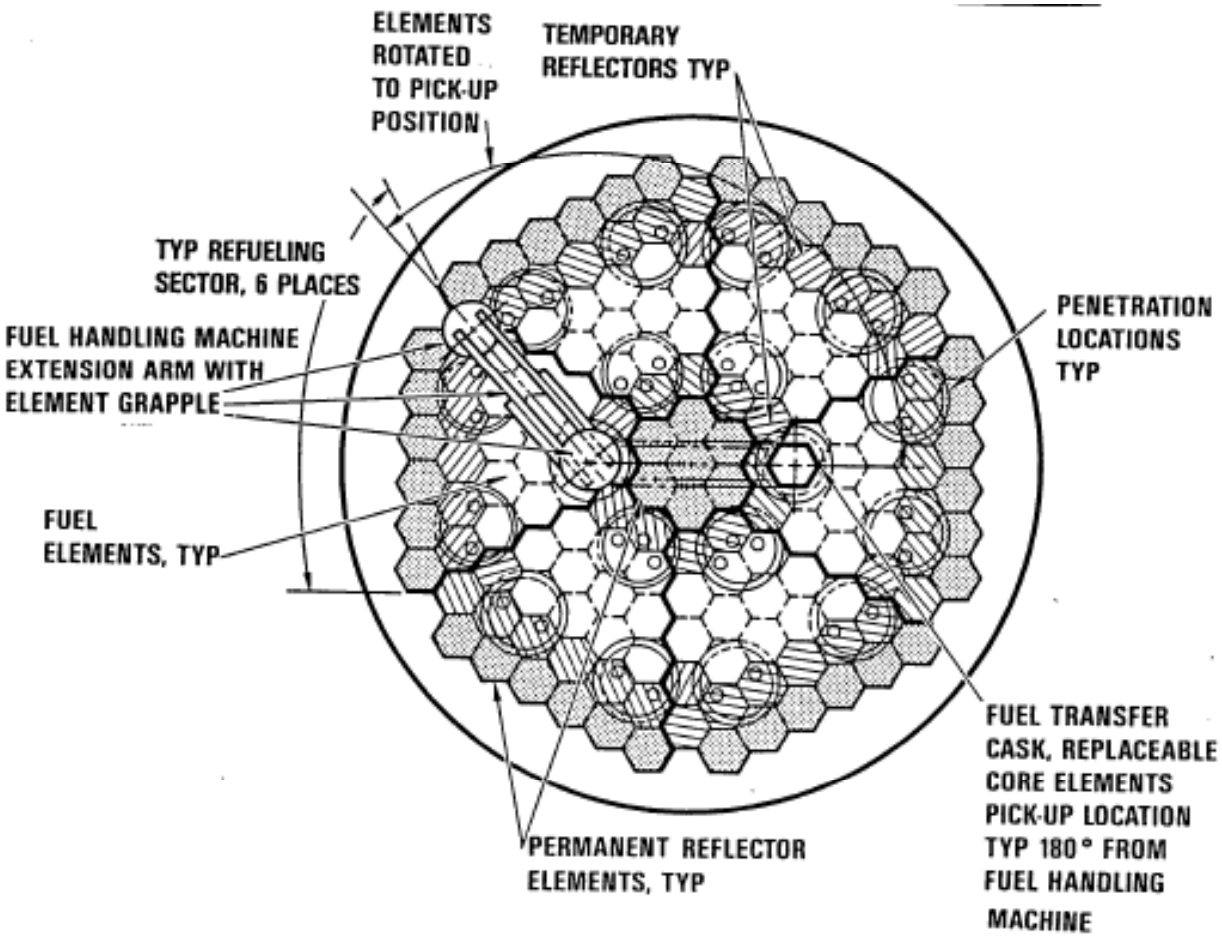
Fuel Transfer Cask - MHTGR



In-Vessel Refueling Operations - MHTGR

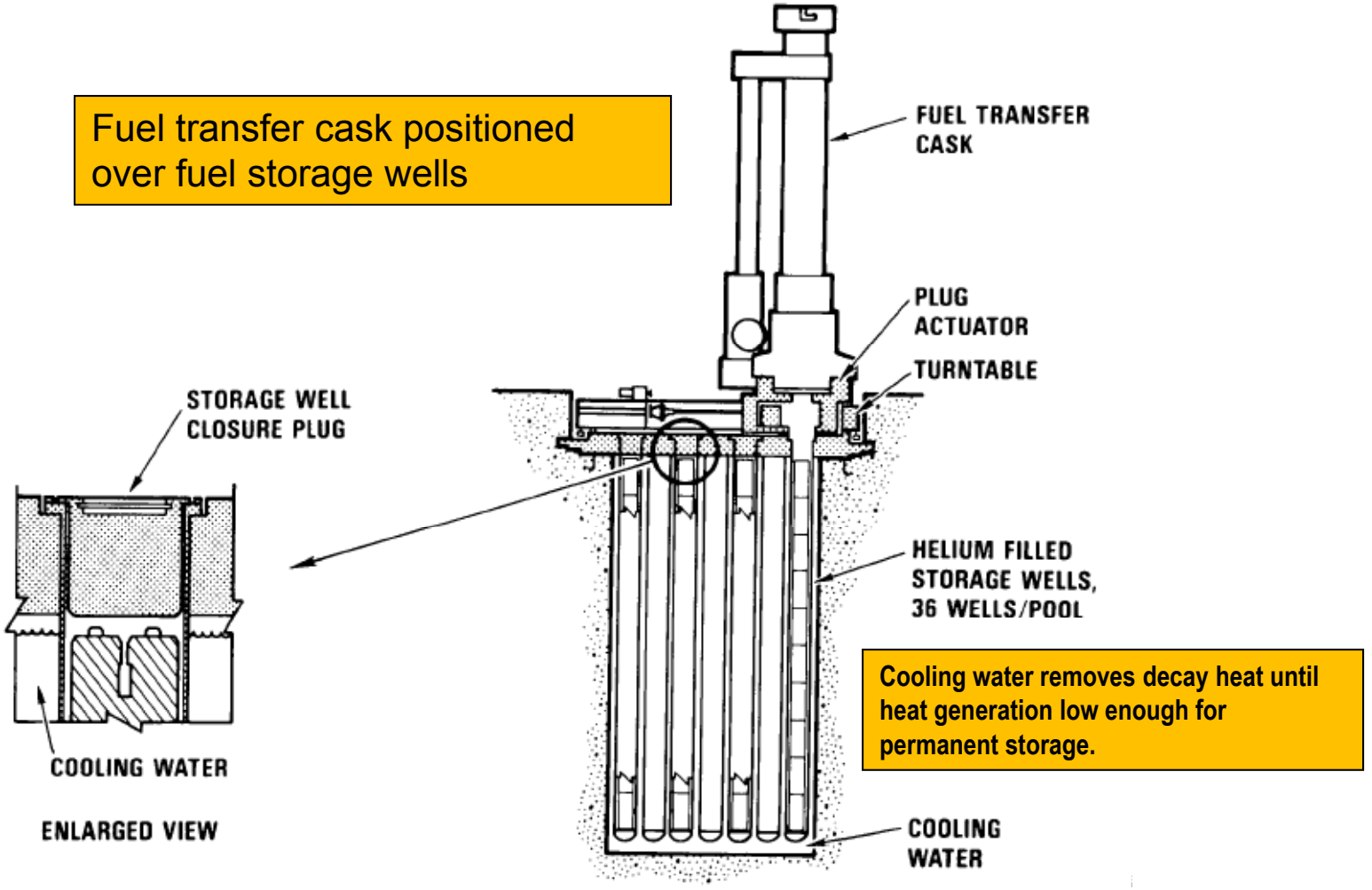


Arrangement of Refueling Equipment and Penetrations - MHTGR



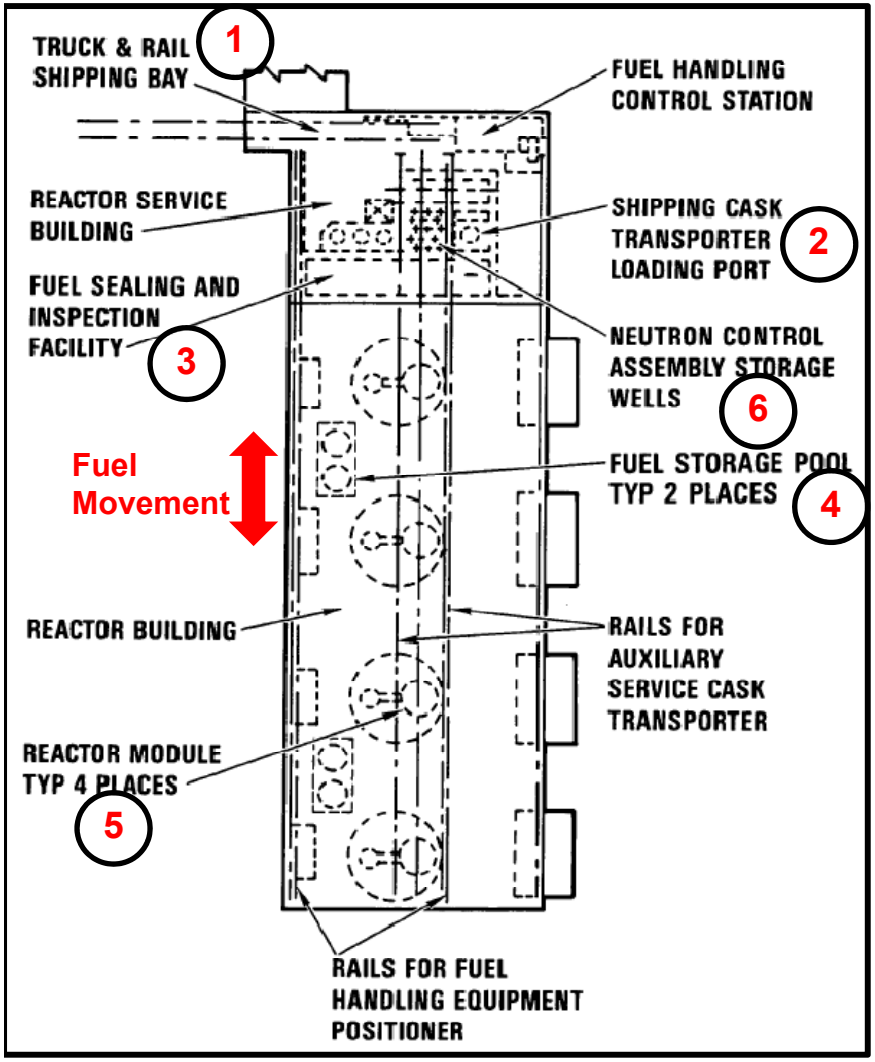
Local Storage Facility - MHTGR

Fuel transfer cask positioned over fuel storage wells



Cooling water removes decay heat until heat generation low enough for permanent storage.

Refueling System Overall Process



Location	Action
1	New-fuel received at Shipping Bay
2	Shipping Casks placed in Storage Racks
3	New-fuel Unsealed & inspected
4	Positioner moves new-fuel to storage pool
5	Transporter moves Auxiliary Service Cask to reactor module & removes Control Rod Drive
6	Transporter moves CR Drive to Neutron Control Storage Well
5	Positioner moves Fuel Handling machine & Fuel Transfer Cask to Reactor Module and removes 1/6 Sector of used-fuel
4	Positioner moves used-fuel to Storage Pool and places new-fuel & some used-fuel in Fuel Transfer Cask
5	Positioner moves Fuel to Reactor Module • New- & Used-fuel Placed in Reactor • Moves FHM & FTC to neutral position
6	Transporter moves Aux Service Cask to Neutron Control Storage Wells & retrieves Control Rod Drive
5	Transporter moves Aux Service Cask to Reactor Module • Replaces Control Rod Drive • Seals reactor • Moves Aux Service Cask to neutral position

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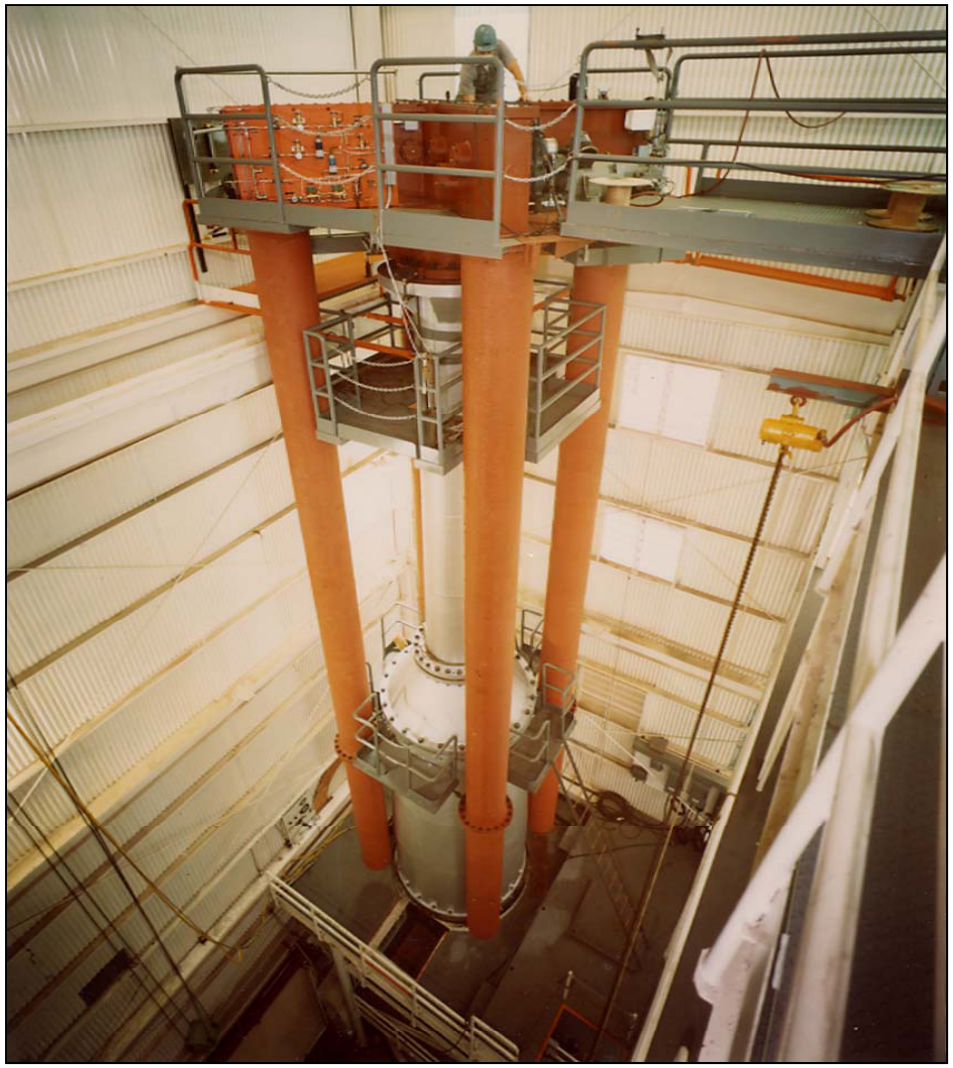
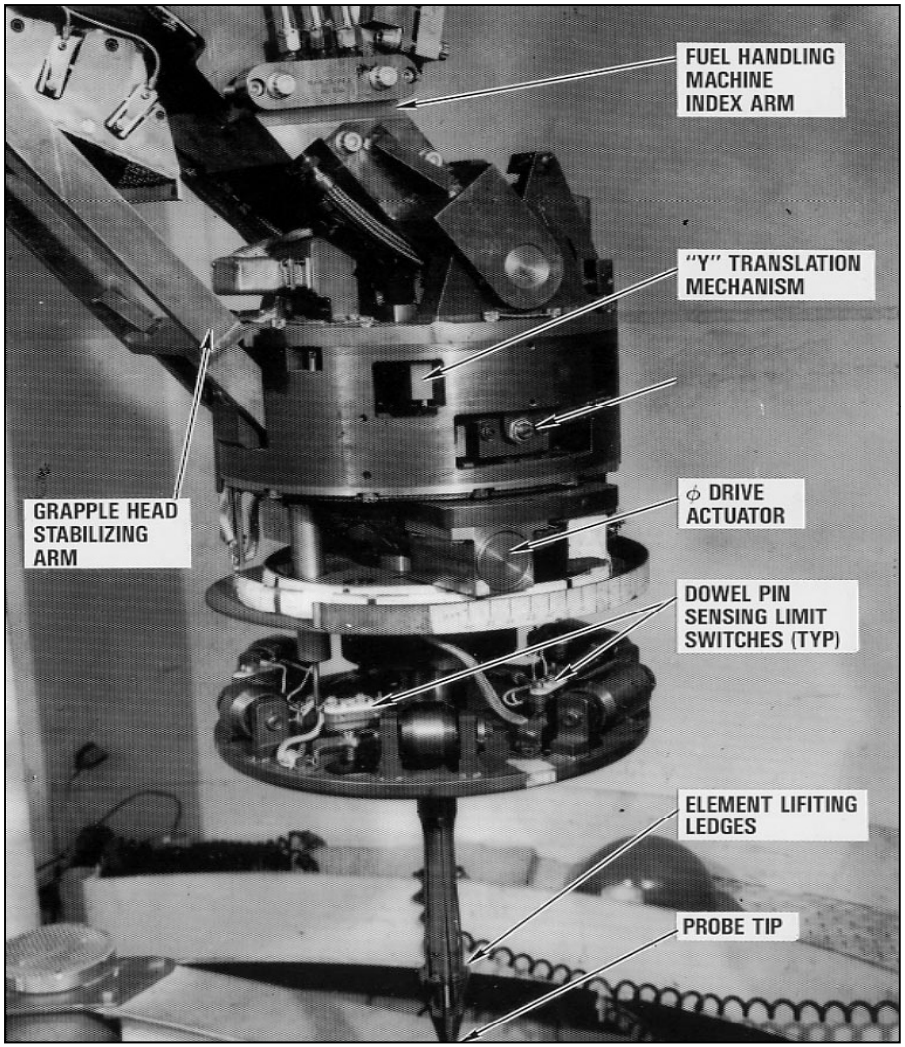
Fort St. Vrain Fuel Handling Machine



Fort St. Vrain Grapple Head



Lessons Learned and Key Features Proven at Fort St. Vrain

- Reliable grappling of graphite fuel blocks
- Remote pickup and deposit for offset core alignment
- Fuel block handling speeds and acceleration and deceleration
- Use of dry-film and wet lubricant applications
- Shielding protection
- Control of primary coolant atmosphere

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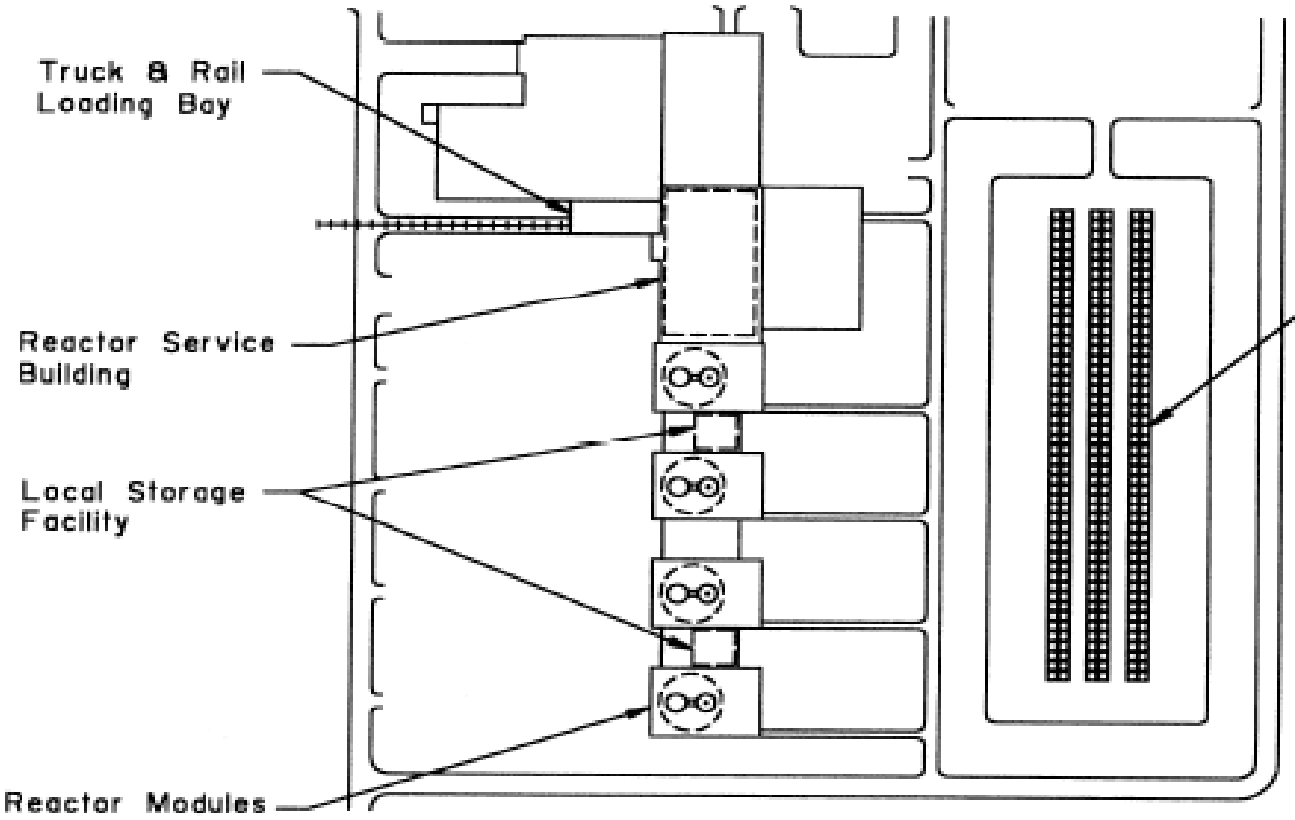
Used-Fuel Management Plan

- Cool used fuel in local used fuel storage facility until fuel is ready for storage in dry storage casks
- Place used fuel in storage canisters in reactor service building
- Load storage canisters into concrete storage cask
- Move storage cask to on-site storage facility
- Store until final disposition is available
- Load storage canister into shipping cask
- Ship used fuel storage canisters to final disposition facility

On-Site Used Fuel Storage Facility - MHTGR



- Used Fuel Storage Facility
- Below grade, hardened concrete structure
- FSV ISFSI* is example

*ISFSI = Independent Safe Fuel Storage Installation

Summary

- Refueling accomplished remotely using automatic, computer controlled operations
- Major equipment and facilities employed include:
  - Fresh fuel receipt and storage facility
  - Fuel handling machine
  - Fuel transfer cask
  - Fuel handling equipment positioner
  - Local, water-cooled used-fuel storage facility
  - Used-fuel packaging facility
  - On-site dry, used-fuel storage casks for long-term storage
- Basic refueling process and key equipment items proven at Fort St. Vrain
- Long-term storage of used-fuel accomplished using dry storage casks

Suggested Reading

- "Preliminary Safety Information Document for the Standard MHTGR", HTGR-86-024, Section 9.1.1.
- "Conceptual Design Summary Report Modular HTGR Plant", DOE-HTGR-87-092, Section 3.7