5.0 FACILITY DESIGN AND DESCRIPTION

5.1 INTRODUCTION

This section contains descriptive information on buildings and other features of GE-MO used for storage of irradiated fuel. Facilities associated with fuel reprocessing are discussed only as they relate to irradiated fuel storage activities.

This information has been consolidated from documents previously submitted and are part of the public record. The majority of descriptive material is based on the “Midwest Fuel Recovery Plant Final Safety Analysis Report” (MFRP FSAR) (NEDO-10178) with amendments and supplements and “The Safety Evaluation Report For Morris Operation Fuel Storage Expansion” (NEDO-20825).

Reproductions of maps and other illustrations in Sections 1 and 3 (especially Figures 1-1, 1-2, 3-1, and 3-2) provide geographical information about the GE-MO tract and show boundaries of property and general arrangement of buildings and other site features. (See Section 1 for use of terms "tract" and "site.") A more detailed layout and contour map of the site and environs is shown in Figure 5-1.

Radioactive material handling activities related to fuel storage are located within the Owner Controlled Area (OCA). There are no scheduled radioactive liquid effluent releases to the environs and no burial of radioactive or contaminated material on the tract. The only radioactive materials leaving the site are the gaseous effluents discharged through the ventilation stack or solid low-level radioactive wastes shipped for off-site burial. Off-site shipments are made in accordance with applicable United States Nuclear Regulatory Commission (NRC), United States Department of Transportation (USDOT), and other State and Federal regulations.

The entire GE tract (Figure 1-3) is enclosed by agricultural fencing with appropriate posting and forms the site boundary as defined in 10 CFR 20.1003 and described in Section 3.

5.2 CONTROLLED, RESTRICTED AND PROPERT PROTECTION

5.2.1 Restricted and Owner-Controlled Areas

Restricted areas, as defined in 10 CFR 20.1003, are within a 15 acre Owner Controlled Area (OCA) on the northern side of the tract (Figure 5-1), enclosed by a chain link fence topped with multiple strands of barbed wire for a total fence height of 8 ft. As depicted in Figure 5-1, facilities located within the OCA include the main building, adjacent ventilation sand filter and emergency equipment building (EEB), ventilation exhaust stack, cask service facility (CSF), utilities and service building, shop warehouse building, administration building, general warehouse, and water system well and elevated water tank. Liquid (nonradioactive) waste discharge lines are routed from the OCA to the sanitary treatment lagoons located south of the protected area. The sanitary lagoons are fenced to control access.

This Figure Withheld under 10 CFR 2.390

Figure 5-1. Site Plan showing principal facilities.

5.2.2 Gates

Entrance to the OCA is from the east-west county road (Collins Road), which bounds the tract on the north side. Entrances for personnel, road and rail traffic are at the northwest corner of the OCA. Entry is controlled from a guard station in the foyer of the administration building which includes the personnel entrance and is adjacent to the road and rail gates. An unmanned gate is located south of the OCA. The south gate provides access for construction equipment and is normally locked. A parking area for employees and visitors is provided north of the OCA.

5.3 PRINCIPAL STRUCTURE

The principal structure at GE-MO is the main or process building. This building was constructed to contain mechanical and chemical operations and processes for recovery of uranium and plutonium from spent nuclear fuel.

This Safety Analysis Report is concerned only with use of this structure for fuel storage. Consequently, only those portions of the main building and other facilities associated with fuel storage activities are discussed in detail.

5.3.1 Main Building Design Basis

Design, materials and construction of the process building is in accordance with the Uniform Building Code and meets requirements of governing ordinances and authorities having jurisdiction (circa 1967). Facilities necessary for normal plant operation and confinement of radioactive materials were designed to resist earthquake and tornado conditions.

Section 4 describes significant criteria selected for design of the main building and other principal structures and describes principal means of satisfying these criteria.

5.3.2 Fuel Storage Facility Layout

Fuel storage facilities at GE-MO utilize the following portions of the process building:

a. cask receiving and decontamination areas;

b. fuel unloading pit;

c. fuel storage basins[1];

d. basin support systems (basin water cooling and filtration, etc.);

e. control room;

f. electro-decontamination room.

5.3.2.1 Process Building Plan and Sections

Appendix A.14 contains plan and section drawings of those portions of the process building associated with fuel storage. Drawings of other structures associated with fuel storage are included.

5.3.2.2 Confinement Features

The principal means of confinement of radioactive materials in a fuel storage facility is inherent in the fuel itself. Radioactive fuel pellets are contained within fuel rods; these stainless steel or zirconium alloy tubes are hermetically sealed when manufactured which prevents release of radioactive materials including gases that evolve from fuel during irradiation. Anu potential escaping gas from defective fuel rods would be filtered and then vented via the 300 ft. stack. Any such release would be a small fraction of 10 CFR 20 limits (Section 7). The fuel storage environment is benign relative to fuel cladding design conditions. Consequently, low temperatures and favorable water chemistry of the storage environment are not perceived to promote clad deterioration.

Irradiated nuclear fuel was received at GE-MO in shielded shipping casks which were designed, loaded, and transported in accordance with NRC and DOT regulatory requirements. Prior to shipment to GE-MO, fuel was inspected for defects; known defective fuel was not normally accepted for storage by GE-MO. Prior to unloading fuel for storage, cask flush water may be sampled to detect fuel damaged in transit. Fuel bundles were unloaded maintaining a minimum of 9 ft of water shielding for operating personnel. Cask unloading equipment and facilities are designed to minimize the effect of dropping or tipping over a cask.

Fuel bundles are stored in stainless steel basket assemblies designed to protect fuel from physical damage and to maintain fuel in a subcritical configuration. Baskets are locked into grids in the fuel basins to provide seismic restraint.

The basins are constructed below ground with stainless steel lined, reinforced concrete walls about 2 ft. thick poured in contact with the sides of a bedrock excavation. The south wall of the basin is about 4 ft. thick, because it was intended to stand independent of the surrounding rock to facilitate possible future expansion. Geophysical characteristics of the rock foundation would result in low permeability in the unlikely event of a major basin leak. A leak detection system and pump-out facilities are provided for the space between concrete walls and floor and the stainless steel liner.

A ventilation system is provided for the basins and other areas. It is designed so that air passes sequentially from areas of low contamination potential to areas of higher potential.

Basin water is circulated through a system that reduces radioactive contamination by ion exchange and filtration. A suction system is provided to vacuum basin floors and floating debris is removed by skimmer intakes. Radioactive materials collected by these systems are processed in the Radwaste System.

Irradiated fuel from light water reactors has been received and stored at GE-MO since 1972. These activities have reaffirmed irradiated fuel can be handled and stored safely with no impact on the environment[2]. There has been no detectable deterioration of fuel in storage (as determined by measurement of basin water activity) indicating the fuel is stable while in the storage basin environment.

5.4 FUEL STORAGE SYSTEMS

Following paragraphs describe fuel storage systems. The functional sequence of fuel storage operations is described and illustrated in Section 1.

5.4.1 Cask Handling Crane, and Handling Equipment

A two-motion, radio-controlled crane of 125 ton capacity is mounted on overhead rails which are parallel to and centered on the rail spur which serves the CRA. Lift height of the crane is approximately 34 ft. above grade. The horizontal travel area of the crane extends from the CRA over the BDP and finally over the cask unloading basin. The cask handling crane does not extend over any part of the storage basins.

The crane is equipped with rail keepers ("up-kick lug") to prevent the crane from derailing and falling into the CRA, BDP, or cask unloading basin.

Handling equipment will be used in conjunction with the cask crane to lift the cask from the transport vehicle and to move the loaded or empty cask.

5.4.2 Decontamination Area (BDP)

The decontamination area (BDP) (Figure 1-4) is used for incoming cask preparation and outgoing decontamination of fuel shipping casks. These operations include tightening or loosening cask head closures, incoming cask wash down, and sampling of cask coolant. The area is used for other activities involving decontamination.

5.4.2.1 Area Description

The BDP, about 27 ft. by 20 ft. in plan, is located inside the process building. The floor is a reinforced concrete pit, 3.5 ft. below grade, sloped to a sump located near the southwest corner of the pit. A stainless steel platform is centered on the north-south axis of the pit, welded to horizontal rails set in concrete. The platform is about 21 ft. by 8 ft. by 0.375 in. thick. The slightly raised platform allows for liquid runoff during cask wash and decontamination activities. The above-grade structure enclosing the decontamination facilities is of steel frame and insulated siding construction adequately airtight to maintain ventilation control. The roof is approximately 50 ft. above grade and is of steel deck, rigid insulation and built-up roofing construction. The cask entry doors below the craneway are vertical dual doors about 30 ft. high and 11 ft. wide. A separate lift-type door is provided for the craneway.

Equipment, such as yokes, fixtures, and special tools required to receive and process casks, is moved into the BDP as required. Work platforms are provided for access to the upper parts of casks. A pump system is provided to flush casks internally. The BDP pit sump contents are pumped to the Radwaste System. Radiation shielding is provided for fixed lines carrying cask flush water.

5.4.2.2 Low-Level Solid Waste

Solid radioactive waste generated at GE-MO is collected and periodically packaged for shipment to a commercial low-level contaminated waste disposal site. This waste consists primarily of disposable protective clothing, shoe covers, cleaning wipes, rags, rubber gloves, and similar materials used in various cask preparation and handling operations. Shipment of low-level waste off-site to approved disposal facilities for incineration of combustible materials and re-melt of metals are preferred methods for treatment and disposal.

Contaminated resins are transferred to High Integrity Containers (HICs) and dewatered for subsequent burial at an approved site. Low-level waste packages are transported in shielded or unshielded trucks or semi-trailers dedicated to transfer of this type of waste[3].

5.4.2.3 Low-Level Liquid Waste

See Appendix Section B.23 for description.

5.4.3 Cask Unloading Pit

The cask unloading pit (Figure 1-5) is a two-level, water-filled basin adjacent to the BDP and connected to the fuel storage basins.

5.4.3.1 Description

The cask unloading pit is a reinforced concrete structure[4], poured against bedrock, with a stainless steel inner liner. General dimensions are shown in Figure 1-5. The cask unloading basin and other basin areas are filled with demineralized water to a reference level of 50 ft., or 2.5 ft. above grade, to provide cooling of stored fuel and radiation shielding during fuel unloading, transfer, and storage operations. The cask unloading pit is serviced by all three facility cranes: the cask handling crane, the fuel handling crane, and the basin crane.

Floors of the shelf and the cask unloading pit are provided with devices to dissipate impact loads from the maximum cask-drop accident. The set off shelf is provided with a fabricated, stainless steel crushable pad and a 2 in. steel plate on top of the stainless steel liner. The floor of the cask unloading pit is covered with a 1.75 in. thick steel plate, under the 0.25 in. thick stainless steel liner.

5.4.3.2 Basket Positions

Three fuel basket positions are provided along the south wall of the cask unloading pit (fuel storage system components are described in Section 5.4.4). Empty baskets may be positioned in the basin before or after the cask is lowered to the floor. Using the fuel handling crane (Section 5.4.3.6), the crane operator engages a bundle with the fuel grapple, withdraws a bundle from the cask, and places the bundle in a predetermined position in a designated fuel basket. Basket designation and bundle position are determined by administrative procedures.

5.4.3.3 Doorway Guard

The only location throughout the facility where fuel basket contents could be discharged as a result of a postulated basket drop is at the cask unloading pit entrance to the fuel storage basin. During all other basket movements, the bottom of the basket is no more than 3 ft. above the basin floor (about 12 in. above the grid or about 27 in. above the floor). Under these conditions, a basket drop would not generate forces sufficient to eject fuel bundles from the baskets. Length of the basket assembly and height of the mounting grid prevent a base-up position with sufficient elevation to allow fuel ejection from the basket. (Also, see Section 8.6.2) However, if a basket were dropped in the doorway just inside Basin 1, the basket might tip toward the cask unloading pit and eject fuel bundles which could fall to the floor. Although consequences of this postulated accident do not present a serious safety hazard to either public or employees, a doorway guard is installed at the entrance to the fuel storage basin.

The doorway guard consists of a frame made of stainless steel pipe (Figure 5-5). It is supported in the doorway on the cask unloading pit side by hinges on the bottom attached to door brackets, and cables on the top. Each of the two cable assemblies includes a rod 0.25 in. diameter and 8.75 ft. long. Keepers are provided to ensure the cables stay on the pulleys. Underwater pulleys are attached to brackets on the cask unloading pit wall.

Before fuel is loaded in a storage basket the guard is in the retracted or vertical position. The guard is lowered to the basket transfer (or angled) position prior to movement of a basket through the doorway. The basket lifting tool is lowered through the guard and attached to the basket located directly below the guard. The basket is then lifted through the guard and moved laterally into the fuel storage basin. Baskets must be moved to the eastward fuel basket position before being lifted to the doorway.

The doorway guard is designed to function as an energy absorbing device. Energy imparted to the guard by a basket falling against it is absorbed by stretching the two stainless steel rods (up to 40% elongation).

The fixed length of the basket lifting tool (grapple) prevents a basket from being lifted over the guard. A basket must be lifted through the guard and then moved laterally into the fuel storage basin. In this way, if a basket is dropped and it tilts toward the cask unloading pit, the guard will prevent it from tilting past a horizontal position.

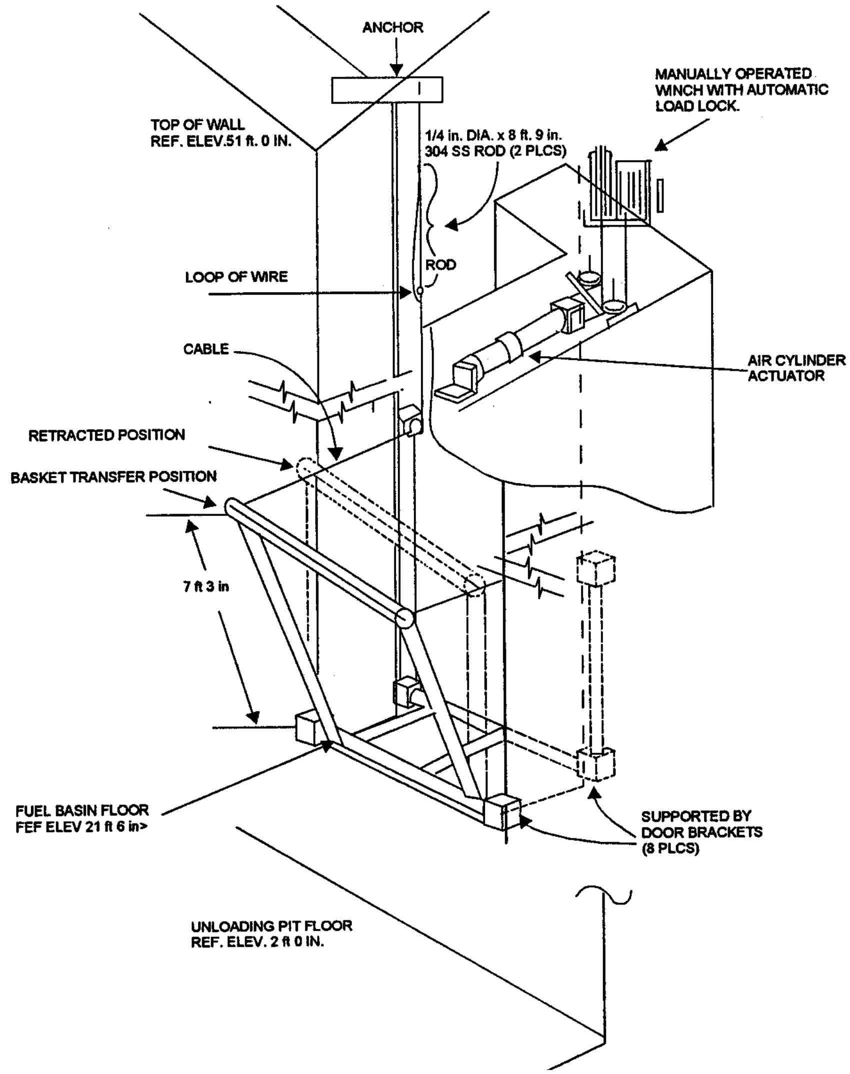

Figure 5-5. Unloading Pit Doorway Guard

5.4.3.4 Fuel Grapples

Fuel grapples are designed to transfer fuel bundles between a cask and storage baskets. The 5 ton capacity fuel handling crane is used to move the grapple to engage the fuel bundle. Grapples are fabricated to meet requirements of specific fuels. Typical BWR and PWR grapples are discussed in following paragraphs.

The BWR fuel grapple is constructed of two 20.5 ft. tubular sections joined lengthwise with a lifting bail and latching control mechanism at the top and a means of latching the fuel at the bottom. The grapple can be positively engaged through design features depicted in Figure 5-6. It can be disengaged only when the weight of the fuel bundle is not applied. The control mechanism for the grapple's hook is a manually operated handle connected to the latch by a cable running down the center of the grapple. An emergency release feature is incorporated into the design for use if the release cable fails.

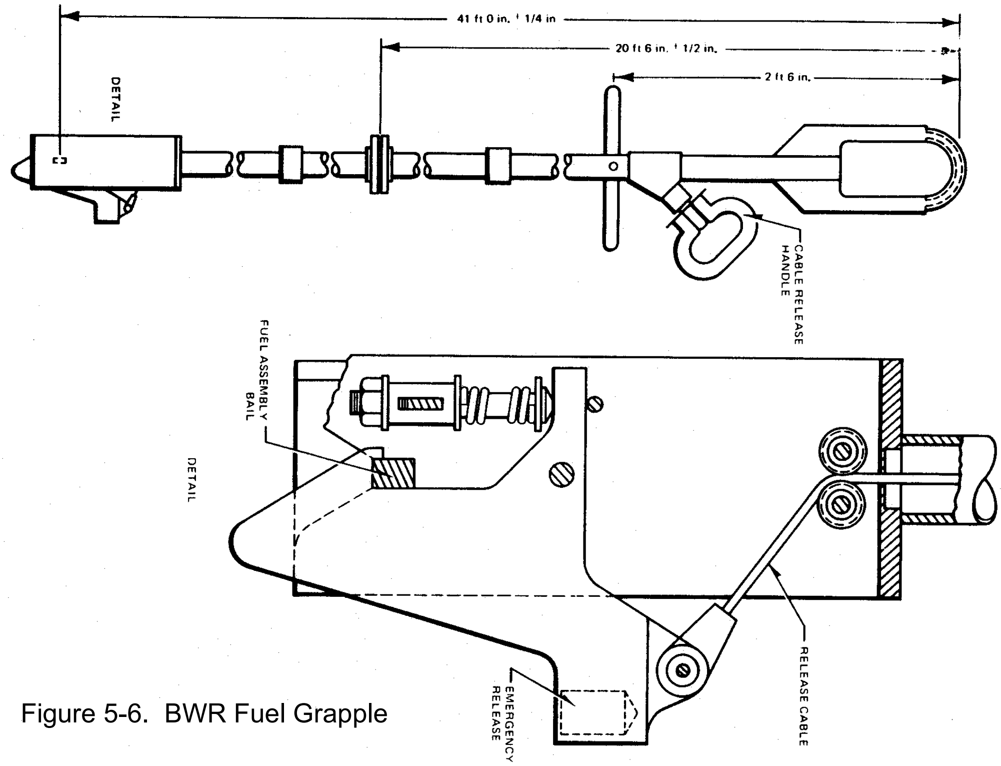

Figure 5-6. BWR Fuel Grapple

The PWR grapple (Figure 5-7) is 50 ft. long and constructed of stainless steel. At the top is a lifting bail and operating mechanism. At the bottom is the latching mechanism designed for the specific type of fuel bundles to be handled. The PWR fuel bundle has a "picture frame" upper plate. When the grapple is lowered onto the bundle, two guide pins on the grapple fit into holes in opposite corners of the picture frame, thus aligning the grapple. After the grapple is lowered to touch the upper plate of the fuel bundle, the four evenly-spaced grapple fingers are forced outward by manual rotation of the handle of the locking mechanism. This operation forces a cylinder down among the pivoted fingers, positively locking them in place. Once the bundle is locked in position on the grapple, it is ready for transfer to the storage basket.

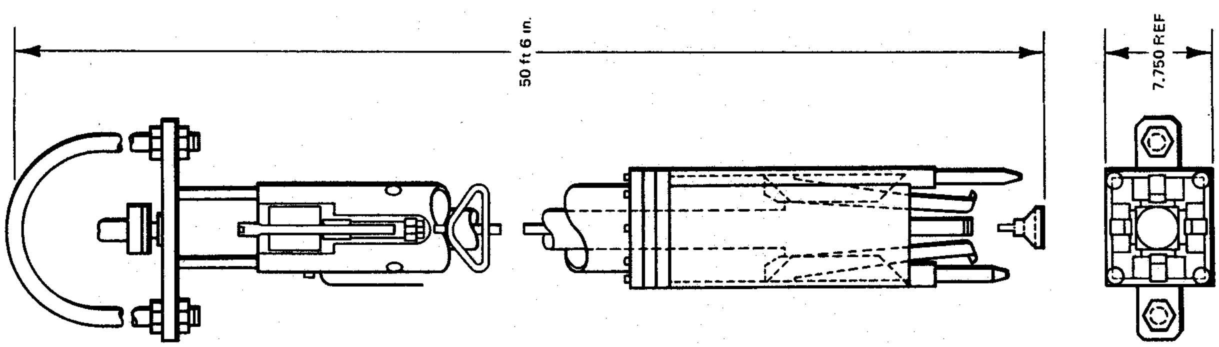

Figure 5-7. PWR Fuel Grapple

5.4.3.5 Basin Crane

The (fuel storage) basin crane is a manual control bridge crane of 7.5 ton capacity. Lift travel is limited by use of a long shank hook extension to prevent lifting of fuel baskets to within 9 ft. of the water surface. Travel limits of this crane extend from the cask unloading basin to the south end of the fuel storage basins. A platform on the south side of the crane bridge near water level facilitates operation of the basin crane. The fuel handling crane is operated from a platform on the north side of the basin crane. Bridge wheels and retainers are designed to maintain the basin crane in position under earthquake conditions. Derailment, if it occurs, would not result in either bridge or trolley falling into the basin. Repositioning on the rails can be accomplished manually with the use of hoists and jacks. Interruption of service of this crane has no safety connotation.

5.4.3.6 Fuel Handling Crane

The fuel handling crane (also referred to as basin auxiliary crane) is used to handle fuel bundles in the cask unloading basin. This crane has a 5 ton capacity with stepless speed control and is supported from rails attached to the underside of the cask crane support members. Provisions for meeting seismic conditions are similar to those for the basin crane including restraints (rail keepers) to prevent the crane from derailing and falling into the basin. The bridge is of the underslung monorail type, and the trolley is a rigid, one-piece weldment capable of withstanding vertical, lateral, or torsional strains. Bumpers for both bridge and trolley prevent overtravel. Interruption of service of this crane has no safety connotation.

5.4.4 Fuel Storage System

Fuel is transferred between cask and storage baskets the cask unloading pit. Loaded baskets are moved into the storage basin by use of the basin crane (Section 5.4.3.5). Fuel baskets are latched into a supporting grid structure on the basin floor that provides seismic restraint.

The original intent for fuel storage at GE-MO was to provide short-term storage for fuel to be reprocessed. Thirty-two fuel baskets of relatively low storage density were provided to contain fuel bundles in the basin[5]. The unit storage densities[6] originally provided were approximately 0.2 TeU/ft^2 for BWR fuel and 0.1 TeU/ft^2 for PWR fuel in baskets and approximately 0.5 TeU/ft^2 for PWR fuel in storage racks. The present design provides more effective use of the total basin area for long-term storage by permitting unit storage densities of approximately 0.35 TeU/ft^2 for either BWR or PWR fuel. This modification was authorized by amendment to Materials License No. SNM-1265, dated December 1975.

5.4.4.1 Fuel Integrity In Storage

Regulations for safe storage of irradiated nuclear fuel require structural integrity to be maintained under severe accident conditions or catastrophic natural phenomena to prevent failure of fuel rods or a criticality excursion and to effectively control contamination levels in basin water. Integrity of fuel cladding is the primary barrier to release of radioactive material from fuel pellets.

Based on current experience and assessment of relevant literature, storage of spent nuclear fuel in storage basins for periods greater than 20 years is considered reasonable[7,8,9,22]. Fuel cladding is designed to withstand a far more severe environment in a reactor than that encountered in a storage basin.

Considerations include:

a. Zircaloy-clad fuel has been stored satisfactorily in basins since 1964 and stainless steel clad fuel has been stored since 1970. There are no indications of clad deterioration from the basin environment.

b. Low temperature and favorable water chemistry are not likely to promote cladding deterioration.

c. There are no obvious degradation mechanisms which operate on cladding under basin conditions at rates that would cause failures in the time frame of interim storage.

Literature[7,8,9,22] shows no significant effects of pool storage on fuel rods. Questions have been raised regarding long-term storage (20 to 100 years) because of possibilities of corrosive effects from inside the cladding and from effects at the external crud-cladding junction. However, tests at Windscale on 9-year storage fuel do not show such attacks. It should be noted that the effect of small cladding defects in individual fuel rods is relatively minor due to chemical inertness of fuel pellets in water and cleanup capabilities of the filtration and ion exchange systems provided to control basin water contamination.

5.4.4.2 Equipment Description

The GE-MO fuel storage system utilizes uniformly-spaced baskets (26 in. square baskets on 27 in. centers). A schematic drawing of arrangement of PWR and BWR baskets is shown in Figure 5-8 and engineering drawings are located in Appendix A.14. Baskets for storage of BWR fuel bundles consist of either nine 8.5 in. stainless steel round tubes, or nine 6.25 in. stainless steel square tubes, while those for PWR fuel bundles consist of four 12 in. schedule 5S stainless steel pipes. The bottom of each basket is closed while holes in the basket wall permit convection flow through the basket. The closed-bottom area traps material that may fall from a fuel bundle, such as corrosion material on surfaces of the fuel bundle. The square tube BWR baskets have flow holes in the bottom and the wall to promote convective water flow through the basket.

Stainless steel baskets reduce neutron interaction between adjacent fuel bundles, permitting more efficient use of space. The resultant combination of separation and stainless steel neutron absorption ensures that the effective multiplication factor (k_{eff}) for an array of baskets will be < 0.95 at the 95% confidence level.

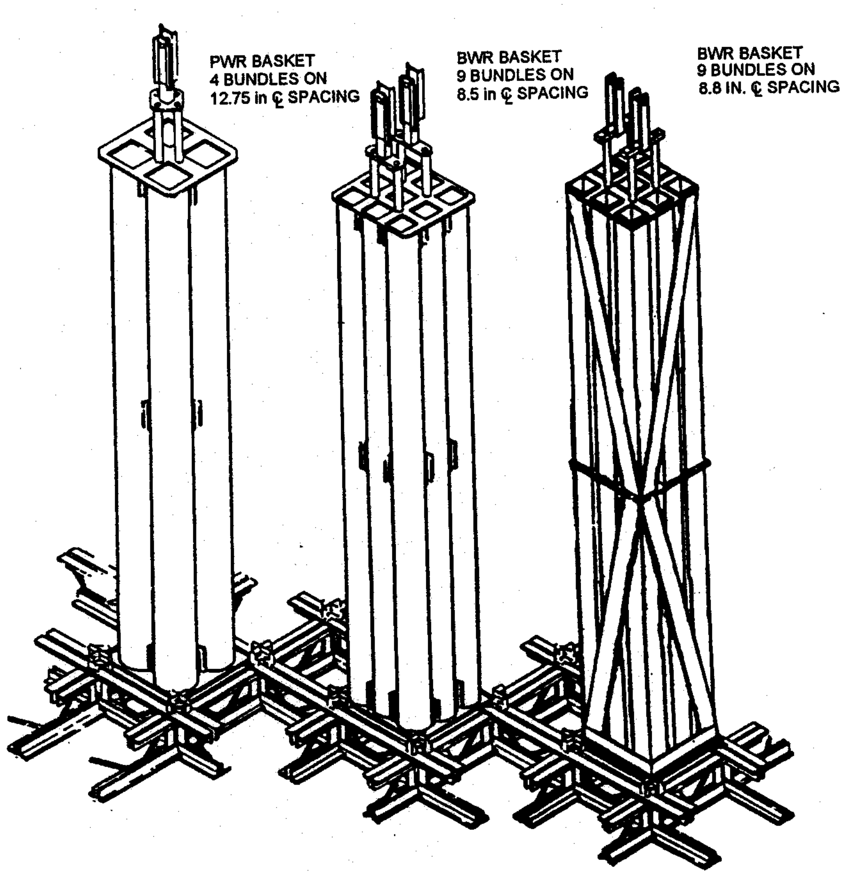

Figure 5-8. Morris Fuel Storage System. Constructed of stainless steel, the system provides a secure, flexible system for storage of LWR fuels. The three types of baskets mount interchangeably in the support grid.

Pipes or tubes are attached firmly together and supported by a substructure, forming an independently movable basket. To lift the basket, special hooks are used to engage lifting rods that protrude above the basket. Outside substructure dimensions of PWR and BWR baskets are identical; therefore, each will fit interchangeably into a standard supporting structure.

Baskets are locked in position on a mounting grid of stainless steel members on the basin floor. A three-basket mount is installed in the cask unloading pit and a similar mount may be installed in the transfer corridor so baskets can be temporarily placed in the cask unloading pit or in the corridor in a manner equivalent in safety to that used in the main basin area. These mounts are called basket retainer frames, and are equivalent to the mounting grid used in the fuel basins.

Figures 1-13, 5-8 and 5-9 show views of the grid. Grids are installed in the basins in large modules (typically 4 by 14 basket units per module), which are limited to the size that can be moved and installed safely and conveniently in the fuel storage area. Grids are braced against the walls using wedges. An analysis of load effects on basin walls and liner indicates basin walls will withstand seismic and thermal loads transmitted by the support grid. As a result of the analysis, a solid film lubricant (Electrofilm)[10] was used on wedges to reduce the coefficient of friction between grid and wall to accommodate thermal and seismic movement.

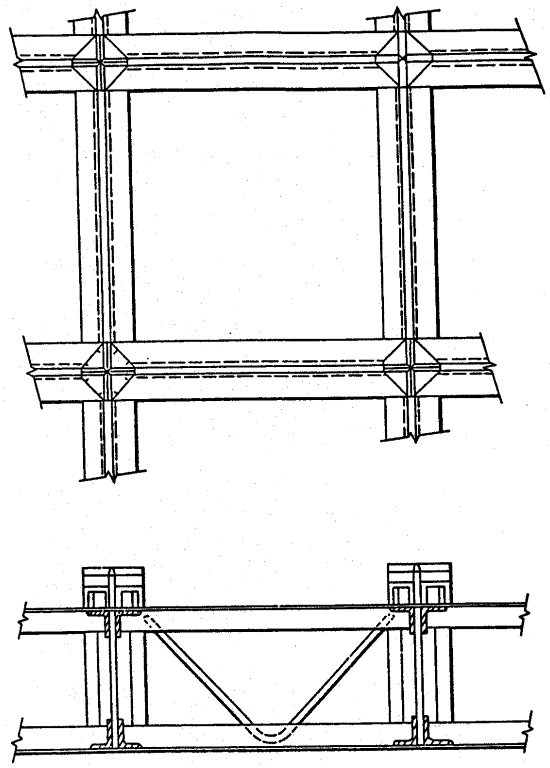

Figure 5-9. Typical Grid Assembly

Grids are fabricated from stainless steel structural material. Basket weight is supported by the stainless steel angle structure of the grid. At each intersection of cross members, a locking block is attached to the top of the grid structure, secure to the baskets in place.

Each basket has four cam-activated latches (Figure 5-10). Latches extend from each corner of the basket base and engage locking blocks on the grid when the latches are activated by linkage to the four lifting rods at the top of the basket assembly. When the weight of the basket (full or empty) is supported by the lifting rods, the cam-operated latch assemblies are retracted and will not engage the locking blocks. When the basket is set in place on the grid and lifting rods are released (tension removed), the weight of the lifting rod assemblies cause latch assemblies to engage locking blocks.

Design criteria basis and safety analysis of the fuel basket system, including criticality analysis, are contained in Appendices A and B. The grid-basket system has been subjected to seismic testing to design criteria. Appendix A.14 includes engineering drawings of baskets and support grids. The fuel storage system has a minimum design life of 40 years but because of the nonaggressive service environment, a much longer useful life is indicated.

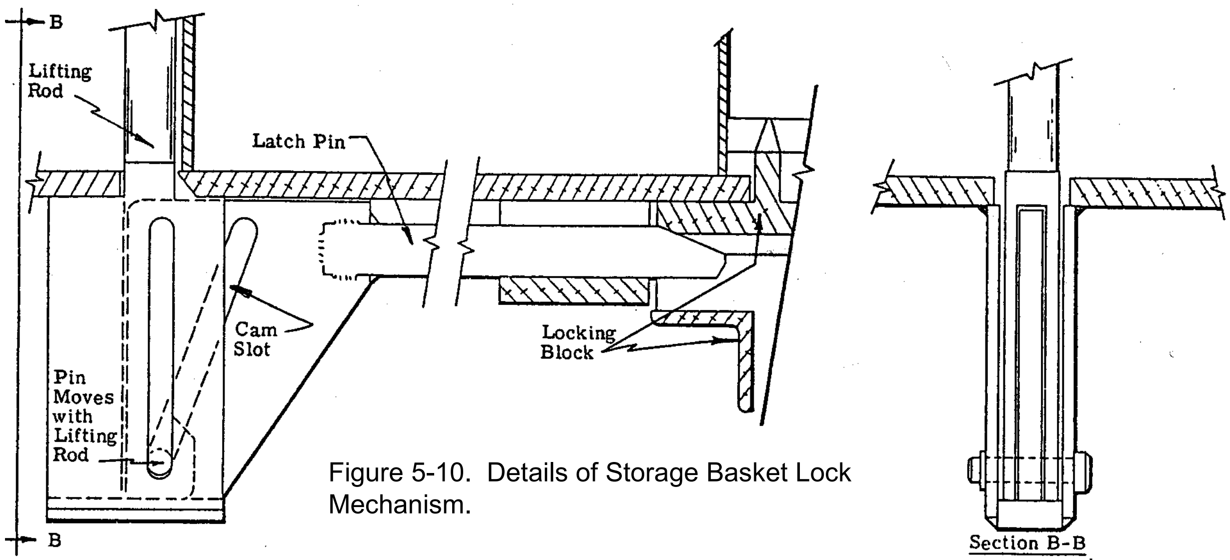

Figure 5-10. Details of Storage Basket Lock Mechanism.

5.4.4.3 Heat Transfer from Stored Fuel

Heat transfer from stored fuel has been calculated for both BWR and PWR fuels and differential temperatures from fuel to basin water determined (Appendix A). Calculations included determining hole sizes in the basket wall that allow adequate water flow. Final basket assembly design is such that, even with some hole plugging (not considered a credible event), fuel temperatures remain satisfactory. Even with basin water cooling systems inoperative, maximum water temperature would be 123 °F[23]. See Appendix A.9.

5.4.4.4 Basket Lifting Tools

The BWR and PWR basket lifting tools (or basket yokes) are identical in function. However, the BWR yoke has two lifting hooks and the PWR yoke has one hook in order to match respective basket lifting bails.

Both lifting tools are constructed of stainless steel. Each tool is approximately 14 ft. long, a feature that precludes inadvertently lifting fuel closer than 9 ft. to the surface of basin water.

5.5 FUEL STORAGE BASINS AND SYSTEMS

This section describes fuel storage basins (Basins 1 and 2) and includes information about concrete and construction techniques employed when basins, main building, and other related facilities were built. Information regarding reinforced concrete construction is referenced in other sections of this report. General configuration and size of the water-filled fuel storage basins are shown in Figure 1-5.

5.5.1 Storage Basin Description

Basin 1 has an area of about 900 square ft.; Basin 2 has an area of about 1,500 square ft. There are a total of 414 fuel basket positions: 150 in Basin 1 and 264 in Basin 2.

Fuel storage basins and the cask unloading pit are constructed of reinforced concrete poured on bedrock with a welded stainless steel liner. Fuel storage basins are filled with demineralized water to a nominal depth of 28.5 ft. Water level may be lowered 2 ft. for maintenance or other purposes but at least 9 ft. of water is normally maintained above the top of stored fuel. If the water level falls more than 2 ft., pump suction inlets will be exposed. There is no means of accidentally draining the basin, nor can any basin water systems inadvertently drain the basin (i.e., the water systems are designed with nonreversible pumps, no drainage system, etc.). Basin water level is indicated in the CAS/SAS. The system includes an audible low-level alarm.

Cask handling, cask loading, and fuel storage areas are constructed of concrete, steel, and other materials which are either nonflammable or fire-retardant No significant amount of flammable materials is used in these areas, and other potential fire dangers (bottled gases, etc.) are introduced only under stringent administrative control. No fire detection or automatic fire suppression systems are required in these areas or in the basin pump room and its extension. Fire extinguishers are strategically located and plant personnel are trained for fire surveillance. Further protection is provided by surveillance patrols.

Reinforced concrete in basin walls and floors were designed and constructed in accordance with the applicable national standards and meet conditions consistent with longevity as described in NUREG-1801, "Generic Aging Lessons Learned Table A5.1-e and Appendix A-8. The GE-MO basin water chemistry provides an excellent media for SS materials consistent with IAEA-TEDOC-1012 [22] and Appendix A-8.

5.5.1.1 Foundation and Excavation

The basins are founded on shale bedrock (Figure 5-11). Samples of the shale have been tested at ultimate compressive strengths ranging from 6,000 to 11,000 psi. Appendix B contains a site survey and foundation report prepared for MFRP construction[12]. The excavation site was over excavated and back-filled to the south of Basin 2 to facilitate possible expansion of storage capacity at some later date. All loose and disturbed rock was removed prior to concrete construction. Backfill consisted of controlled and compacted granular soils. Concrete mud mats were poured to fill any area excavated more than 4 in. deeper than required (except for the south wall of Basin 2). The basin wall structure is designed to resist pressures from backfill and soil water where over excavations were made (south of fuel basin and vaults, Figure 5-11).

Figure 5-11. Excavation and Foundation Construction.

5.5.1.2 Concrete Structure

Storage basin floors were poured on bedrock and range in thickness from 30 to 54 inches. Basin walls extend 3.5 ft. above grade.

Materials used for basin concrete construction are typical of other concrete construction at GE-MO. Materials used for reinforced concrete structures were:

- Cement conforming to ASTM C150 type 2
- Washed sand
- Washed and graded aggregate
- Reinforcing steel per ASTM A15, intermediate grade

Concrete pours had slump tests and laboratory samples taken, usually at the truck discharge, but at times at the point of placement - particularly on canyon containment walls. Concrete samples were taken for every pour of 100 yards or less, whenever a pour composition changed and one per 100 yards for pours greater than 100 yards. A full-time concrete inspection program was in effect during construction.

Reinforcing steel used in the basins is intermediate strength with 40,000 psi minimum yield strength. Structural welds that carry loads from one element or reinforcing bar to another were not used. Where required, loads were transferred from bar to bar by conventional reinforcement bar laps secured in assemblies by steel tie wires. In special cases, U-bolts were used. The only welding permitted was tack-welding reinforcing steel to brace assemblies away from forms or to secure embedded items in position during the concrete pour. In most cases, assembly bracing or embed securing was done by use of additional reinforcing steel or structural steel tack welded to the reinforcing steel assembly. Embeds were either welded or clamped to this steel. Tack welds were made no larger than necessary to produce sound, crack-free welds.

5.5.1.3 Basin Liner

The unloading and storage basin complex is completely lined with 304L stainless steel sheets placed flush against concrete walls and floors and welded to a gridwork of stainless steel back-up members embedded in the concrete (Figure 5-13). The cask unloading pit floor liner is 0.25 in. thick and is placed over a 1.75 in. thick steel plate provided for distributing impact loads over the underlying concrete structure. Additional energy absorbing means, as may be required by cask drop accident considerations, will be installed for receipt of larger-sized casks.

The set off shelf liner, also 0.25 in. thick, is placed directly on the concrete structure with an energy absorbing assembly placed on top of the liner (seen in Figure 1-13).

For the remainder of the storage basin complex, the floor liner is 0.187 in. thick. Walls of the cask unloading pit, including shelf area are lined with 11 gauge sheet steel. For the fuel storage basin walls, the liner is 11 gauge sheet steel from floor level to approximately 16 ft. up the wall and 16 gauge sheet steel from there to the top of the basin.

Large liner sheets (generally on the order of 6 ft. by 16 ft.) were welded continuously along each edge to the gridwork of back-up bars and also were slot welded to embedded plates at intermediate locations so the liner is held against the concrete wall to reduce potential for puncture damage. To facilitate fit-up and ensure high integrity, liner sheets were welded to embedded stainless steel angles at wall-to-wall and floor-to-wall joints. The liner terminates on a stainless steel angle at the top of the basin. Specifications for liner installation include approved joint design welding procedures and welder qualification requirements. All welds were visually inspected and vacuum box tested to ensure leak tightness[13]. Final verification of liner integrity was provided during basin filling.

Figure 5-12. Stainless Steel Basin Liner. Both storage basins and the unloading basin are completely lined with stainless steel sheets (304L) placed flush against the concrete walls and floor, welded to a grid of stainless steel embedments.

Because of the nonaggressive basin liner service environment, corrosion testing of 304L liner sheet steel was not required. However, a substantial quantity of 304L sheet steel material was subjected to corrosion tests, with few lots exceeding the 0.003 in. per month in Huey Tests as specified in ASTM 262. Many rates were lower than 0.001 in. per month with no evidence of pitting or cracking.

The specified Huey Test is based on exposure to 65% HNO_3 at boiling temperatures whereas actual service is in neutral demineralized water at about 80 °F average temperature (maximum of 120 °F). In demineralized water at the lower temperatures, it is estimated that corrosion rates are reduced by a factor of more than 1,000 relative to those observed in accelerated tests. On this basis, a conservative rate of in-service liner corrosion would be 0.003 in. per month. For the thinnest (upper basin wall) liner, a 50% reduction in thickness from "one-side" corrosion at such a rate would require 10,000 months.

Basin liner corrosion, to the extent that it occurs, is expected to be a general attack with essentially no effects from galvanic corrosion. System pH is controlled and metal ions present in the system are minimized by use of demineralized water. Water purity is maintained by circulating basin water through a filtration and ion-exchange cleanup system.

5.5.1.4 Basin Liner Leakage Control

To facilitate drainage of water from between the concrete structure and the stainless steel liner (water that may seep in through the concrete as well as any liner leakage), 0.5 in. square drain slots on approximately 3 ft. centers are provided in concrete basin walls and floors back of the liner. These lead to a 1 in. square collection header located behind the floor-to-wall joint at the basin perimeter, which drains to a single sump at the bottom of the cask unloading pit. The sump consists of a 6 in. diameter vertical pipe embedded in the west (exterior) wall of the unloading pit, extending above water level to a point approximately 1 ft. below floor level and connecting to the perimeter collection header.

The sump contains a liquid level detector line and necessary piping for a removal system. Auxiliaries for the level detection and removal system are located in the basin pump room. The removal system employs an air-lift working in conjunction with an air operated pump. Operation of sump equipment has met design requirements.

5.5.1.5 Earthquake and Tornado Analyses

The basins were designed for earthquake and tornado conditions in accordance with criteria presented in Section 4. Earthquake, tornado and missile analyses are contained in Appendix B. Although much of the building is unused and not relevant to fuel storage, the structure does form a portion of the basin area east wall, as well as containing the ventilation tunnel, control room (SAS), and other support functions.

5.5.2 Basin Water Clean-Up System

The interconnected basins are supplied with demineralized water from the on-site well and water treatment facilities. These facilities include prefilters to control organic material in incoming water. The basin water clean-up system includes a suction system for underwater "vacuum cleaning" and a resin-precoat filter system with associated equipment.

The purpose of the basin water treatment system is to maintain water clarity and quality, minimizing concentration of radioactive materials in the water. Basin water clarity is maintained such that objects at the bottom of the storage basin are visible from the pool surface with or without optical devices at the surface[14]. Radioactive material in basin water originating from fuel element surfaces and leakage from defective fuel rods is controlled to ensure that radiation and contamination levels are **ALARA**. Basin water quality is controlled to prevent potential corrosion attack and stress corrosion cracking of system components.

5.5.2.1 Water Quality and Characteristics

Water added to the basin has a minimum quality of 0.56 μmho/cm with pH > 5.5 and < 8.0. Based on the operating experience of various reactors, and storage pools, conductivity and pH are the most important water quality indicators and are the only indicators of water quality commonly measured at such facilities.

Based on operating experience, factors of turbidity and organic material are not considered to be as important as conductivity and pH. Turbidity would present a temporarily inconvenient operating condition that would be remedied by adjusting filter media or procedures. Control of organic material by prefilters is considered adequate to maintain this contamination below acceptable limits.

5.5.2.2 Radioactive Materials in Basin Water

Experience with fuel storage at GE-MO indicates the concentration of radioactive material in the basin water is typically 2.6×10^{-5} and 4.2×10^{-4} μCi/ml for radiocobalt and radiocesium, respectively.

Principal radioactive contaminants in the storage basin water include fission products Cesium-134 and Cesium-137 with typical concentrations of 3.3×10^{-7} and 4.2×10^{-4} μCi/ml, respectively. Activation product Cobalt-60 is present in a typical concentration of 2.6×10^{-5}μCi/ml. A maximum concentration of 5×10^{-3} μCi/ml was measured at the end of a 3-week period during which the filter was purposely not operated. Similar levels of contamination have occurred in recent years.

Since removal mechanisms and relative proportions of the two principal contaminants differ, operational controls for the basin are based on exposure levels. Technical Specifications include a limit on concentration of radioactive material in basin water for which special corrective action is required. If the gross β concentration reaches 0.02 μCi/ml a cleanup campaign will be initiated.

5.5.2.3 Basin Water Filter System

The filter system maintains water clarity and removes dissolved materials. A 250 gpm pump delivers water from the skimmers or vacuum hoses to the coated tube filter (a 115 square-foot DeLaval unit, about 2.5 ft. in diameter by 6 ft.) and back to the basin. The filter is precoated with Solka Floc, a cellulose filter base. This base can be overlain with diatomaceous earth, Powdex resins, or Zeolon as desired. Sludge from the filter is collected in a small tank (approximately 600 gal.) and ultimately transferred to the Radwaste System.

The basin clean-up filter is housed in a heavily shielded, restricted access room with electric lock entry control. A Special Work Permit (SWP) is required for entry. The filter is changed remotely by a programmed controller (Figure 5-15) that flushes filter media from the filter septums into the sludge tank. Therefore, personnel are not routinely exposed to radioactivity accumulated in the unit.

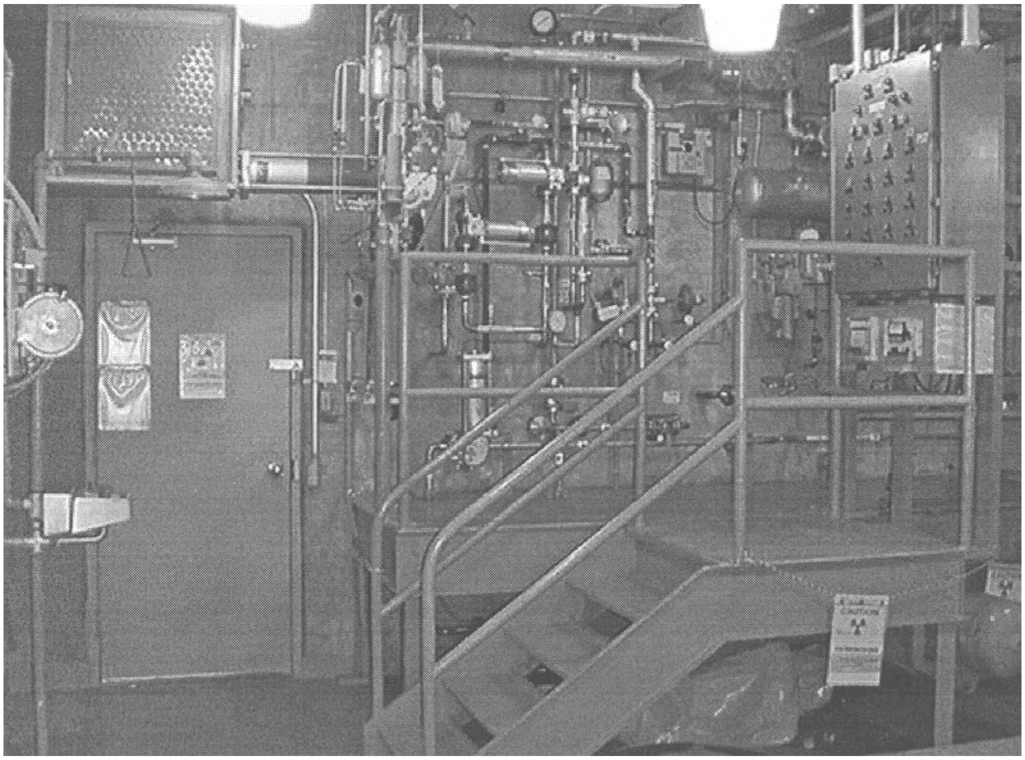

Figure 5-15. Basin Filter Controls: View shows basin filter programmed controller and associated instruments and piping. Filter is housed in shielded room behind locked door to the left.

An inherent advantage of the Powdex system is the ability to accommodate a variety of water purifiers. For example, a quantity of Zeolon[15], a synthetic alumino-silicate molecular sieve having a high affinity for cesium, may be added to the normal recharge used for the Powdex system. In practice, two kilograms of Zeolon-100 are added with the mixed cation-anion Powdex resins during filter make-up. The zeolite acts as a true ion exchanger and, under clean basin water conditions, partitions radiocesium so that about 90% is sorbed by Zeolon and 10% remains in the water. This partitioning ratio remains constant irrespective of the radiocesium transfer rate (from fuel to basin water) since chemical concentration levels in the water do not measurably exhaust the chemical exchange capacity of the ion exchanger[16].

5.5.2.4 Safety Evaluation

Failure of the basin water treatment system is not critical to safety of the fuel storage system. Redundant or spare filters are not required. The system has been out of service for several weeks without marked deterioration of basin water quality. Typical basin water isotope concentration levels are shown in Table 5-1. Isotope concentrations vary, depending upon rate of addition of fuel to the basin and method of operation of the basin filter.

Data in Table 5-1 indicate that the activity levels in basin water do not contribute significantly to personnel exposure. There is little accumulation of contamination on the basin liner at waterline.

Table 5-1
TYPICAL ISOTOPE CONCENTRATIONS IN BASIN WATER

Isotope	Typical Concentration[a] (μCi/ml)
Cs-134	3.3×10^{-7}
Cs-137	4.2×10^{-4}
Co-60	2.6×10^{-5}
H-3	1.1×10^{-4}

[a] The concentration of other radionuclides which are low-energy beta emitters is less than the total radiocesium and cobalt. In terms of radiotoxicity they are insignificant compared with cesium and cobalt.

5.5.3 Basin Water Cooling System[17]

The heat load as of October 1996 is about 1×10^{6} BTU/hr. At this point in the fuel and fission product decay cycle, the heat load should decrease about ten per cent each two years.

5.5.3.1 Equipment Description

Basin water heat dissipation is accomplished through the use of 2 parallel heat pumps and heat exchangers each forming a closed loop. Typically, one unit has the capacity to maintain the basin water temperature and the second unit will function as a back-up. Historically, basin water temperature has been maintained under 40 °C with typical temperatures less than 35 °C.

5.5.3.2 Safety Evaluation

Failure of the basin cooling system is not critical to safety of the fuel storage system. In the event that both heat exchanger units should fail, there is enough time to supply make-up water to the basin while the cooling system is repaired or replaced. With both heat exchanger units inoperative and the current fuel load, the temperature of the basin water will slowly rise (<2 °F/day) and approach an equilibrium temperature of about 123 °F. See Appendix A.9.

Potential leaks in the cooling system that could occur as a result of an accident have been analyzed and results are given in Section 8. It was concluded that the consequence of a leak in the system is insignificant[18]. Coolers are periodically inspected for leaks. Accumulation of radioactive contaminants in the cooling system components is monitored, and the system decontaminated when required (Section 7.3.2.3).

5.5.4 Ventilation Exhaust System

Facilities provided for filtration, monitoring, and release of effluent air are described in following sections (Figure 1-22 and Appendix A.14). Discussion of radioactive contaminants in effluent air is contained in Section 7.

5.5.4.1 Air Tunnel

A below-grade reinforced concrete tunnel runs the east-west length of the main building along its north wall. The tunnel was originally intended to collect all building ventilation exhaust air (via ducts from various cells, hoods, etc.) for routing to the ventilation exhaust filter. The rectangular cross section of the tunnel is on the order of 20 square feet, increasing in area toward its outlet at the sand filter. A 3 in. deep stainless steel floor pan is provided for collection of condensate. The floor slopes toward a collection point (41.5 ft. elevation) from which a drain line is routed to the off-gas cell sump. Instrument ports are located near the tunnel outlet for radiation off-gas monitors. Provisions are made for future extension of the tunnel to an additional sand filter, if ever required. Air from the basin area is drawn into the air tunnel via the canyon area.

5.5.4.2 Ventilation Exhaust Filter

A reinforced concrete structure, 75 ft. by 80 ft. in plan and 15 ft. in height, houses the low-velocity, upward flow sand filter through which effluent air is drawn before discharge from the stack. It is located immediately east of the main building and is connected to it by an underground extension of the ventilation air tunnel. The tunnel extension leads to a central air distribution duct at floor level (about 40 ft. reference elevation) of the filter structure.

The filter bed is about 8 ft. deep and is comprised of layers of graded gravel and sand. Openings are provided in the central duct to distribute incoming air laterally through the gravel bed which forms the bottom layer of the filter. The floor is sloped for positive drainage back through the air tunnel to the off-gas cell sump. Outlet from the upper, open portion of the filter structure is through ports in the west wall leading to an adjacent reinforced concrete structure (the equipment building) 24 ft. by 80 ft. in plan, housing exhaust blowers as well as a diesel-electric generator and associated switchgear, effluent air sampling system and two air compressors. This arrangement places all equipment and auxiliaries essential to exhaust system operation within reinforced concrete structures for protection against earthquake and tornado conditions.

5.5.4.3 Emergency Equipment Building (EEB)

The EEB is divided into three rooms:

a. Fan Room: Exhaust blowers are located in an area, 19 ft. by 35 ft. in plan, with a grade level concrete slab floor. Inlet ducting for the blowers connects directly to openings in the filter enclosure wall. Each blower unit consists of an electric motor and fan capable of providing 13,000 cfm of flow at 6 in. of water pressure differential. Normal system configuration is one unit operating with the second available for back up use. Other equipment in the fan room includes the system for continuous sampling of air entering the sand filter from the main building, and a sampling system for air being routed to the stack.

b. Compressor Room and Compressed Air System: Two air compressors, the primary air receiver and the dual bed air dryer are located in this area of the equipment building. Failure of the compressed air system is not critical to safety of the fuel storage system. The system is discussed here because it does perform some auxiliary non-safety related function involved with fuel storage, and are located in the emergency equipment building.

   Instrument air is supplied from the receiver to drying equipment in the equipment building from which it is delivered to an instrument air receiver in the main building. The air is used for instruments and air operated valves. The instrument air system is served preferentially upon loss of compressor air supplies to the main receiver; low pressure in the main receiver automatically valves off the process air system.

c. Generator Room[19]: (Not essential to fuel storage activities and discussed here because it is located in the emergency equipment building.) The remaining area of the filter building is 21 ft. by 23 ft. in plan and houses the diesel generator and auxiliaries. The diesel-driven 400 kVA unit is designed for automatic startup upon total loss of commercial power and is provided with both battery and air-pressure starting systems. Battery racks, with continuous charger, and two air bottles for the starting systems are located in the generator room as is all switchgear required for the secondary power supply system. A 1,000 gal diesel fuel tank is located adjacent to the generator room and both electrically driven and manual pumps are provided for transferring fuel from the storage tank to the 33 gallon day-tank located in the generator room. The radiator for the diesel engine is mounted in a wall opening and is provided with a heavy grill for protection against wind borne missiles. This opening is in the west wall of the equipment enclosure and faces the main building, the east wall of which is about 30 ft. away, so that some additional protection against damage from wind borne missiles is provided.

5.5.4.4 Effluent Air Release

A 4 ft. diameter reinforced concrete pipe is provided for routing air from exhaust blowers to the main stack which is located approximately 350 ft. south of the sand filter and equipment building. The pipe is essentially at grade level and has a protective earth covering. It is equipped with a covered instrument enclosure to house monitoring equipment and a bolted-cover manhole to provide an alternative release point in the event flow through the stack is blocked due to stack failure. A stainless steel drain line is provided for routing condensate to the stack condensate collection system. The main stack is an all-welded steel unit which reaches a height of about 300 ft. (91.4 m.) above grade, and is supported on a reinforced concrete foundation by external cable guys. It is provided with an inner stainless steel liner. A spray nozzle system is located in the upper part of the stack for washdown purposes.

5.5.4.5 Earthquake and Tornado Protection

Provisions of earthquake and tornado protection for sand filter, exhaust duct, and stack are in accordance with design criteria and requirements stated in Section 4; also see Appendix B.

Earthquake and wind analysis of the main stack defines design wind velocity at 110 mph. This value is in accordance with Uniform Building Code recommendations and established engineering practice. Based on this velocity, the stack is capable of withstanding wind impressed loads and forces. Within the context of stack design the term "extreme conditions" is defined as conditions greater than design wind velocities. The stack is located sufficiently distant from other facilities so that structural failure would not result in damage to any fuel storage systems or structures. The earth-covered duct between exhaust fan enclosure and stack is provided with a port that can be opened to permit grade-level release of ventilation air in the unlikely event that structural failure resulted in severe restriction of stack flow.

5.5.5 Main (Process) Building Facilities

The main building contains certain facilities other than fuel basin areas that are directly or indirectly involved in fuel storage. Some of these have been discussed in preceding sections, such as the ventilation tunnel which extends almost the length of the building, passing underground to the ventilation filter building and servicing the Radwaste System. See illustrations, Appendix A.14.

5.5.5.1 Building Entrance Area

The main building entrance door, vestibule and lobby are located near the midpoint of the south service area, essentially at grade level. Between the gallery exterior wall and corridor which parallels the south canyon wall at this point are rest rooms, change room, shower room, and decontamination room required for control of personnel access to and exit from potentially contaminated areas of the main building. The corridor which services the change room complex leads to the mechanical cell operating gallery and fuel storage basin.

5.5.5.2 Gallery Area

Adjacent to the process canyon and structurally attached thereto are multi-level galleries which allow personnel access to the main building. The galleries extend the full length of the process canyon on the north and part way on the south sides and are connected by transverse corridors at the east end of the building. The gallery structure is of steel frame with reinforced concrete floors, walls and roof areas as was required for protection of equipment and functions under extreme conditions including tornado-generated missiles. Access to limited occupancy zones is provided by locked doors. Air locks are provided at major access points as required to maintain differential air pressure control during movement between ventilation zones.

5.5.5.4 Control Room, or Secondary Alarm Station (SAS)

The Control Room (or SAS) is located in the south gallery area intermediate level (65 ft. floor elevation). The room is about 75 ft. by 21 ft. in plan, with direct stairway access to the building lobby and secondary access to the unused computer room. Principal items of control room equipment include the main process control panel across one side of the room, and various monitoring equipment. Fuel storage functions monitored in the control room are listed in Table 5-2. Although some functions are normally controlled only from the control room (e.g., basin cooler pump and fan controls and well-water pump control), the noncritical nature of all control systems permits replacing controls with local control. The control room (SAS) is one of two Alarm Stations (other is in the Administration Building (CAS)). At least one (CAS or SAS) is continually staffed.

Table 5-2

CENTRAL ALARM STATION MONITORING OF FUEL STORAGE FUNCTIONS

The following functions are monitored in either the Control Room (SAS) or CAS..

BASIN SYSTEMS

- Filter System
  - Sludge Tank Level Indicator and Alarm
  - Filter Differential Pressure
- Water Chillers
  - Basin Cooling Unit CU102-8 Shutdown
  - Basin Cooling Unit CU102-9 Shutdown
  - Chiller Inlet Temperature
  - Chiller Outlet Temperature
- Basin Water
  - Water Temperature
  - Water Level Alarms
  - Leak Detection and Alarm
  - Water Addition Control and Measurement*

COMMUNICATIONS

- Radio Off, On Site
- Telephone
- Intercom - Public Address

SECURITY SYSTEMS

- Closed Circuit TV Systems
  - Main Gate Monitor
  - Basin Entry and Exit Monitors

Basin Area Monitors

VENTILATION SYSTEM

- Intake Plenum
  Pressure, Temperature Indicators and Alarm
  Controls and Indicators*

- Exhaust Plenum
  Controls and Indicators*

- Stack
  Air Flow
  Sampler Pump Run Controls, Indicators and Alarms

STORAGE VAULTS

- Cladding Vault
  Leak Detection Indication and Alarm

*Control Room Operation - Local Lockout Capability

- Low Activity Waste (LAW) Vault
  Intrusion System Indication and Alarm

- Dry Chemical Vault (DCV)
  Intrusion Detection and Alarm

UTILITY SYSTEMS

- Air Systems
  Pressure Indication and Alarms
  Compressor Run Controls*

- Water Systems
  Well Water Pump Run Controls*
  Water Tower Temperature Alarms and Indicators
  Demineralized Water Indicator and Alarm
  Utility Cooling Water Run Controls, Indicator and Alarms

ELECTRICAL SYSTEMS

- Diesel Generator
  Instrumentation, Indicators and Alarms

- Power Bus
  Indicators and Alarms
  Ground Faults and Malfunctions

HEAT PUMP SYSTEM

- Temperature, Flow, Condition Alarms and Indicators

SUMPS

- Basin Pump Room and Addition Alarms
- Hydraulic Equipment Room Alarms
- Canyon Areas
  Indicators for Decon Cell, Off Gas Cell and Mechanical Cell sumps.

*Control Room Operation - Local Lockout Capability

RADWASTE SYSTEM

- Evaporator Malfunction Alarm
- Tank Level Alarms
- High Filter Differential Pressure Alarms

MISCELLANEOUS

- Protected Area Door Controls and Indicators
- Evacuation, Take Cover Alarm Controls
- Fire Alarm Panel and Smoke Detectors
- Area Radiation Monitor (ARM) Indicators and Annunciators
- Criticality Alarm Indicators, Annunciator and Controls

*Control Room Operation - Local Lockout Capability

5.5.5.5 Off-Gas Cell

Process off-gas treatment facilities are located in the off-gas cell. It is roughly ell shaped, occupying the south side of the canyon opposite the anion exchange cell and spanning the full width of the canyon (19 ft.) at its east end. The cell floor is lined with stainless steel which extends up the cell walls to 3 ft. above the floor level. The lined sump is equipped for pumping collected liquids to the Radwaste System.

A vertical ventilation panel is provided near the canyon centerline to span the opening between the northside cell cover (42 ft. above the cell floor) and the southside cover (10 ft. lower). There are three equipment positions in the 19 ft. south wall of the cell. At one position is located the old low activity waste evaporator. Other equipment (process vent scrubber, etc.) is unused and not involved in fuel storage systems.

5.5.5.6 Radwaste System Evaporator

The new Radwaste System Evaporator is electrically heated. It is accessed through the PuNp Load Out Area on the 48' elevation in the Process Building. Evaporator bottoms are periodically transferred to steel barrels and stored in the UF^6 Room for subsequent shipment for treatment and subsequent burial. Steam vapor from the evaporator is demisted and routed to the air tunnel, then through the sand filter to the stack.

5.5.5.7 Ventilation Supply Room

Blowers and associated equipment to supply main building ventilation air are located in a room, 39 ft. x 21 ft. in plan, on the top floor of the south gallery area of the main building (81 ft. reference elevation). Personnel access is from the Control Room by way of the Computer Room and emergency power room with additional access from the Instrument Gallery. Two hooded air intake openings are provided in the reinforced concrete roof (elevation approximately 93 ft.). Air conditioning system coolers also are located on the south gallery roof.

5.5.5.8 Basin Pump Room Addition (BPRA)

In 1980 an addition was made to the original basin pump room (BPR) as shown in Figure 1-4 to house chemical decontamination equipment for basin water cooling system decontamination, and equipment to utilize heat from basin water as an energy source to heat the Main Building, including the fuel storage area. Because of its isolation from main building areas, the BPR and BPRA are cooled by a separate air conditioner.

a. <u>Basin Pump Room Addition (BPRA) Building</u>: The BRPA is located near the west wall of the existing pump room (BPR). The addition is a pre-fabricated steel building built on a concrete slab with outside dimensions of about 20 ft. by 30 ft. in plan. A space of about 4 feet separates the BPRA from the BPR wall except for an enclosed walkway connecting the BPR to the BPRA. A concrete pad extends along the north wall of the BPRA and a double door is located in the center of this wall. An air conditioner compressor mounting pad is located outside the north side of the BPRA.

   An above grade reinforced concrete vault housing a basin water-to-freon heat exchanger is located in the southwest corner of the BPRA. The vault drains to a sump which may be emptied by pumping collected water to the Radwaste System. Piping between the BPR and BPRA is routed overhead, passing through the enclosed walkway and connecting to existing piping systems in the BPR.

b. <u>Systems and Equipment</u>: A new pump was installed in the existing BPR to circulate basin water though the heat exchanger located in the heat exchanger vault. Four GE heat pumps are mounted on a steel rack adjacent to the heat exchanger vault. Freon is circulated from the heat exchanger and heat pumps to existing heating and cooling units located in the ventilation room of the Main Building. These units were modified to adapt to the new system. The heat pump system is reversible to provide either heating or cooling of fresh air entering the Main Building ventilation system.

A 600 gallon stainless steel tank is located in the BPRA and serves as the collection point for basin area low level radwaste streams. A pump, adjacent to the tank, transfers liquid from this vessel to the low level radwaste evaporator system.

The BPRA and existing BPR are air cooled by a system located in the addition. The compressor for this system is mounted outdoors on the pad at the west end of the BPRA.

5.5.5.9 Basin Chiller Room

In 2000 an addition was made to the basin pump room addition (BPRA) as shown in Figure 1-4 to house heat exchangers for the basin water cooling system.

a. Basin Chiller Room (BCR) Building: The BCR is attached to the west wall of the existing pump room addition (BPRA). The room is a pre-fabricated steel building built on a concrete slab with outside dimensions of about 18 ft. by 20 ft. in plan. The access door to the chiller room is in the west wall of the BPRA.

   An above grade reinforced concrete vault housing 2 basin water-to-freon heat exchangers is located in the northeast corner of the BWCR. The vault drains to a sump which may be emptied by pumping collected water to the Radwaste System. Piping between the basin and the chiller heat exchanger is routed overhead, passing through the BPR and BPRA connecting to existing piping systems in the BPR.

b. Systems and Equipment: Two new pumps were installed in the existing BPR to circulate basin water though the heat exchangers located in the heat exchanger vault. Two 100 ton air cooled heat pumps are mounted outside, on concrete piers to the west of the chiller room. One of these is enough to maintain basin water temperature. The second unit is a back-up. Freon is circulated from the heat pumps to the heat exchangers to chill the basin water.

   The BCR is air cooled by a system located in the BPRA.

5.5.5.10 Electro-Decontamination Room (EDR)

The former ultrasonic cleaning area - Figure A.14-1, was modified for use as an electro-decontamination (EDR) (electro-polishing) facility for parts, assemblies, tools and fixtures. The facility is used to process items which have been previously cleaned by mechanical and/or chemical methods. Electro-polishing is then used to remove fixed or occluded contamination.

The room is equipped with ventilation systems, utilities, and other features required for electro-polishing. Walls and floors are coated with a non-permeable material to prevent contamination of concrete. Tanks are fabricated from stainless steel. The electro-polishing tank contains a phosphoric acid solution which can be heated to between 40 °C and 80 °C. Low watt/density electric heaters ensure slow heating of the acid solution. This tank and the first rinse tank are equipped with rear mounted lateral vent hoods, and a hood is provided for maintenance use.

An air cooled rectifier system provides direct current densities of 50 to 250 Amp/ft^2 at 8 to 12 volts. The rectifier has a capacity of 2,500 ampere, with current and voltage limiting and automatic shutdown within one half Hertz after a short circuit.

A safety shower and eye bath are a part of the facility.

5.6 WASTE VAULTS

Three below-grade vaults were constructed as part of the MFRP:

a. Low Activity Waste (LAW) Vault - originally provided for on-site interim storage of low-level wastes from aqueous processes.

As of July 1994, all additions to the LAW Vault were terminated. Waste streams are now processed by the new radwaste system (see Appendix B.23). As of October 1996, the LAW Vault is empty and dry, but still contains radioactive material as contamination adhering to the vault walls and floor. The LAW Vault connecting piping has been removed or capped, and the vault is laid away. There are no current plans for use of the LAW Vault.

b. Cladding Vault - originally provided for interim storage of compacted, leached hulls and other contaminated metal scrap from fuel reprocessing operations. This vault has been emptied and cleaned. CRA and CSF drains which previously went to the Cladding Vault have been capped. Stack drain has been routed to the stack condensate system. This vault is not being used, but is being held available on a contingency basis.

c. Dry Chemical Vault (DCV) - provided for interim storage of contaminated dry process chemicals of low activity level[21]. This vault was emptied in 1993. The DCV connecting piping has been removed or capped, and the vault is laid away. There are no current plans for use of the DCV.

Local hydrology (e.g., drainage patterns to water courses and soil ion exchange capacity) is not of major significance in ensuring safety of fuel storage operations.

Subsurface water conditions encountered during MFRP construction were more severe than expected. Therefore, concrete density and monitoring and control equipment were designed to handle these conditions. No significant difficulties with this equipment have occurred.

Storage vaults were designed and constructed to provide high integrity confinement of contained materials and include systems for detecting leakage into or out of these tanks. The systems permit detection of radioactive material in highly-diluted samples (caused by water intrusions) and provide pump-out capability to collect and dispose of intrusion water as well as any leakage from stored material.

5.6.1 Cladding Vault

A below-grade cylindrical vault, 45 ft. in diameter and 72 ft. deep was provided for underwater storage of leached cladding hulls and other metallic scrap.

5.6.2.1 Cladding Vault Construction

The cladding vault is constructed of reinforced concrete about 2 feet thick, and is lined with stainless steel. The top of its 2.5 ft. thick reinforced concrete cover is at 41.5 ft. elevation. The vault is located adjacent to the LAW vault on the south side of the main building (Figure 1-4). It is connected to the mechanical cell in the canyon by a reinforced concrete waste disposal cart tunnel (top about at grade level) which extends across the top of the vault to a 235 sq. ft. cart equipment pit. The pit roof has two access openings with shield plugs. The vault is equipped with leak detection and sampling systems similar to those for the fuel storage basins, with level recorder and unit alarm in the control room (SAS) and local control in the mechanical cell operating area.

Intrusion water around the vault is pumped to the Radwaste System.

5.6.2.2 Cladding Vault Description

a. Elevation: The circular floor of the cladding vault is 80.5 ft. below grade level and the interior height of the structure is 72 ft. The floor of the waste disposal cart tunnel which connects the cladding vault and the mechanical cell in the main building canyon area is approximately at the same level as the underside of the vault roof (8.5 ft. below grade) which is about 1 ft. above the maximum liquid level in the vault. The floor of the equipment pit located adjacent to the vault is 14 ft. below grade level. The top of the cladding cart tunnel and equipment pit roof is 0.75 ft. above grade and that of the vault proper is 6 ft. below grade.

b. Construction: The cylindrical vault structure is reinforced concrete lined with stainless steel. Excavation extended roughly 82 ft. into the underlying bedrock which was sufficiently sound to provide clean vertical surfaces for 2 ft. thick concrete walls to be poured against, using conventional interior forming. The reinforced concrete floor is approximately 4 ft. thick. The equipment pit and the cart tunnel also are of reinforced concrete and tied to the vault structure. The roof of the cart tunnel which extends across the vault and the cover of the equipment pit is approximately 4 ft. thick. The remainder of the vault top cover is 2.5 ft. thick reinforced concrete.

c. Vault Liner: The cylindrical vault structure is completely lined with 0.125 in. thick (11 gauge) 304L stainless steel sheets placed flush against the concrete walls and floor. As in the storage basins, the sheets are welded continuously along each edge to a gridwork of stainless steel angles and plates embedded in the concrete. At the floor-to-wall joint, the sheets are welded to a stainless steel angle. Quality control and verification procedures parallel those applied to the storage basins.

d. Leak Collection, Monitoring and Pump-Out Provisions: Drain slots are provided in the concrete walls and floor, between the liner and concrete. These lead to a perimeter collection header behind the floor-to-wall junction. The perimeter header is sloped to a low point which is connected to a single leak collection sump. The sump consists of a 6 in. diameter vertical stainless steel pipe embedded in the vault wall which extends from the top of the vault to approximately 1 foot below the vault floor level. It contains a liquid level detector line and necessary piping for a 5 gpm (nominal) pump-out system. Auxiliaries for the level detection and pump out systems, including a monitoring sample station, are located in the mechanical cell gallery of the main building. Water from the pump-out system is routed to the Radwaste System.

5.7 SUPPORT FACILITIES

Support facilities are described in the following sections. As in previous sections, those functions related exclusively to fuel reprocessing are omitted or discussed only briefly.

5.7.1 Utility and Service Building

On the north side of the main building is located the single-story high-bay utility and service building (Figure 1-4). It is 71 ft. by 50 ft. in plan and is of conventional steel frame, insulated siding and roof construction on a grade level concrete foundation. The building is divided into a utility section which houses the demineralized water system; primary electrical switchgear, training room, operations ready room, and first aid room; and a personnel section containing change room, lunch room, and office areas. The arrangement takes into account the normal industrial safety requirements for major electrical equipment. Consideration also is given to isolation of normal industrial functions and equipment from all potential sources of radioactive contamination. Utility services are not critical to safety of fuel storage operations. Interruption of these services for short periods of time, up to several months, would have no off-site impact as long as basin water level is maintained. Principal features are described in the following paragraphs.

5.7.1.1 Utility Section

The 1,700 sq. ft. utility section of the building is divided into two major rooms, the larger of which houses water demineralization and three smaller room partitions for training, an operations ready room, and a first aid room. The demineralizer system consists of ion exchange resin provided by a contract service. It is capable of treating 25 gpm continuously. Pumps required for operation and distribution are located nearby and a 1,000 gal. demineralized water surge tank is mounted on an overhead platform in the room.

A separate 300 sq. ft. room in the utility section houses the primary electrical distribution switchgear for the plant. Incoming power from the CECo distribution system is reduced to 480 volts prior to entry into the utility building.

5.7.1.2 Outside Facilities

The following facilities are directly associated with utility system operations (Figure 1-4):

a. A chain link fence surrounds a rectangular area 62 ft. by 30 ft. in size located on the east side of the building, and encloses the terminal structure of two 34,000 volt incoming overhead transmission lines and two CECo owned 1,500 kVA transformers which reduce the incoming supply to 480V. The fenced area is locked to preclude accidental access to high voltage equipment.

5.8 UTILITY SYSTEMS

Water, electric service, and sewage systems are described in the following sections.

5.8.1 Water Supply

Water to meet potable, utility and fire-fighting requirements is obtained principally from a 788 ft. deep, 12 in. diameter well located within the OCA, southeast of the administration building (Figure 1-4). A submersible, 100 gpm vertical turbine pump is provided, capable of developing 100 ft. of head. This pump is connected to the emergency power distribution system. The pump discharges through filters to a 50,000 gal. elevated water sphere, located near the well. Tests have confirmed a continuous pumping rate of 250 gpm from this well.

An electric water heater in the well house is used to prevent freezing of water in the sphere.

Water is rendered potable by filtration and chlorination before delivery via underground lines to various personnel occupancy areas. Process-related requirements are supplied from the utility water system.

5.8.1.1 Utility Water Supply

Underground piping is provided to distribute utility water from the elevated storage tank to the utility building for supplying the demineralizer system, and to various points in the main building for uses not requiring demineralized or potable water.

5.8.1.2 Demineralized Water Supply

Demineralized water is used for fuel storage basin supply. This water is supplied from the series cation-anion demineralizer located in the utility building which is capable of treating 25 gpm continuously (50 gpm instantaneously) from the utility water supply system. Distribution to points of use is via a pump-pressurized header system. There is a 1 in. line to the basin to furnish make-up water. Basin water level is maintained under manual control of the basin operator, who would normally add water when basin water level dropped 2 in., which is low enough to affect basin cleanup system operation. A back-up-low-level alarm in the CAS/SAS activates if basin water level drops 6 in. below normal.

5.8.1.3 Fire-Fighting Water Supply

Potable and utility water usage is limited by location of outlet piping to the topmost 8,000 gal. of water sphere capacity, with the remaining 42,000 gal. reserved for fire protection. Distribution is via a standard underground piping system located beneath historical frost penetration in accordance with underwriter and building codes.

5.8.1.4 Backup Water Supplies

Parallel fuel storage basin pumps and heat exchangers reduce the likelihood of complete loss of basin cooling capability. In the highly unlikely event that cooling system capability could not be restored within 50 days[23] (or more, depending on circumstances), makeup can be provided from demineralized or utility water storage or from other emergency sources, including water pumped from the DNPS cooling lake, or even from the river[21]. Emergency pumping equipment could be brought to the site and placed in operation within the 50 day period with no impact on public health or safety from stored fuel.

5.8.2 Electrical Supply

GE-MO fuel storage activities require an electrical peak load capacity of 725 kW, with an average load requirement of 500 kW. Principal load requirements come from crane operation, ventilation system requirements, control and instrumentation requirements, and operation of auxiliary systems (e.g., air, and water).

Although interruption of any of these functions would not result in an unsafe condition, secondary power sources (originally intended for fuel reprocessing requirements) are provided that ensure continuing operation of equipment and services, including security systems, important to plant operation.

5.8.2.1 Normal Electrical Power Source

The normal source of electric power for GE-MO is the CECo distribution system. Supply is via two separate 34,000V pole-mounted lines from the DNPS Switchyard to GE-MO power terminal facilities located adjacent to the utility building. Each of these lines serves one of two CECo owned 1,500 kVA transformers. A current limiting bus connects the 480V power terminals of each transformer to a bus system in the load center switchgear located in the utility building.

The substation type load center consists of metal-enclosed, high current capacity, manually and electrically operated air circuit breakers and bus bar systems for distribution of power to seven motor control centers and an essential services load center which feeds two motor control centers.

Bus sections and associated circuit breakers are provided with protective relays which deenergize appropriate portions (or all) of the system in the event of overload or short circuit conditions.

5.8.2.2 Essential Services Power Facilities

The loss of electrical power, even for many hours, would not result in a situation presenting a hazard to employees or the public because of stored irradiated fuel. However, a diesel generator is available. All electrical loads which contribute directly to plant capability under abnormal conditions are supplied from an essential services distribution system. This system consists of metal-enclosed, high current capacity load center type switchgear through which 480V, three phase power is supplied to one motor control center in the EEB and one motor control center located in the main building. The 400kVA diesel driven standby generator located in the EEB generator room is provided with appropriate controls so it can automatically supply power to the essential services load center in the event both utility incoming power sources are lost. Interlocks are provided within the load center switchgear that prevent the diesel driven generator from being connected in parallel with the incoming utility power system.

Special electrical subsystems are provided to meet particular power needs such as those for instrument operation and system control functions. Control power of 24 VDC is supplied from two rectifiers. The demand is such that one rectifier can carry normal plant load as well as keep batteries charged. Rectifiers convert 480 VAC power from the essential services power distribution system and are located in the same room as the rectifiers. Power is routed from the subsystem location in the gallery area electrical equipment room to a distribution network within the main building control panel and to control relay cabinets located directly behind the main control panel, in the BPR, in the utility building and in the EEB.

5.8.2.3 Distribution System

Industrial type motor control centers provide power to each individual use point. These control units utilize local or remotely operated magnetic contactors sized for the particular load requirements being served. Distribution systems throughout the plant utilize commercial electrical cabling of specified capability. Routing between buildings is via underground concrete-encased conduit. Power distribution cables are routed in standard electrical cable trays and conduit. Within the main building, the bulk of power supply cabling and wiring for instrumentation and control functions are carried in separate wiring trays with appropriate protection against unwanted interactions, fire damage, etc.

5.8.2.4 Operating Characteristics

Electrical power required for normal fuel storage operations can be supplied by either of two incoming power lines from the CECo distribution system. Upon loss of either line, a manual, two-of-three circuit breaker system can be actuated to switch load to the single operating line. The bus-tie breaker cannot be actuated unless one incoming line breaker is open. To restore normal operation after the supply outage, the bus-tie breaker is opened and incoming line circuit breakers are closed. Some distribution system circuit breakers as well as control system lockout switches and relays must be manually reset.

The essential services power distribution system is normally fed from the No. 1 bus bar. If power to this bus bar section is lost, the power supply for the essential services power distribution system automatically transfers to the No. 2 bus.

In the unlikely event that power from both incoming supply lines is disrupted, the following sequence of automatic operations will take place:

a. The standby diesel generator will start.

b. The essential services load center will separate from the normal supply source.

c. For load shedding purposes, some circuit breakers in the two essential services motor control centers will open.

d. After the diesel-driven generator is up to speed, the circuit breaker connecting the generator to the essential service power distribution system will close and restore power to some lighting systems, basin cooling water pump(s) and other important loads.

e. With power available to the essential service power distribution system, preselected loads will be automatically and sequentially restarted (e.g., one air compressor to maintain instrument and process air, supply and one ventilation exhaust fan to maintain minimum air pressure differentials).

   An ammeter in the CAS/SAS indicates output of the diesel driven generator. Lights on the main control panel indicate status of the two utility power sources. Separate annunciators on the main control panel are provided to alert the SAS/CAS operator to a malfunction in the diesel generator system, 24 VDC system and utility supply system.

5.8.3 Site Natural Gas Supply

All use of natural gas was discontinued in 2002 and natural gas service is no longer available on site.

5.8.4 Sewer Systems

At GE-MO, industrial and sanitary sewage system are combined and discharged to sanitary lagoons and a holding basin with no direct discharge of any process or sanitary liquid effluent to local water ways. The systems meet requirements of the State of Illinois, and appropriate permits for operation have been issued.

5.8.5 Rail Transportation Facilities

Rail service to the site is provided by a spur track from the DNPS siding, approximately 0.5 mile north of the plant site, which connects to the Elgin, Joliet and Eastern right-of-way serving the general area. The spur track is designed to carry heavy cask car loads at low speed (ASCE 100 lb. rails, appropriately limited curves and grades). After crossing the county road, the track is divided into three spurs and enters the OCA.

The eastern spur enters the cask receiving area in the main building, terminating in a car bumper set in a heavy concrete block to protect the decontamination and basin areas from involvement in a rail accident. The spur is sloped to the north, and a manual derail is located north of the receiving area to stop a runaway car. The center spur serves the cask service facility. The western spur is a storage track, terminating in a standard car bumper, with capacity to store four cars.

5.9 ITEMS REQUIRING FURTHER DEVELOPMENT

GE-MO fuel storage activities have been underway since January 1972, and, except for a continuing program of improvements based on operating experience, no specific equipment or facility item is now known to require further development.

5.10 REFERENCES

1. Fuel storage basins are designated Basin 1 and Basin 2. Basin 2 was originally the high-level waste storage basin, converted to fuel storage under Materials License No. SNM-1265, Docket 70-1308, December 1975.

2. K. J. Eger, Operating Experience - Irradiated Fuel Storage - Morris Operation, Morris, Illinois, General Electric Company, NEDO-20969B.

3. Noncontaminated waste is accumulated in dumpsters which are mechanically emptied into a commercial garbage truck for disposal at a licensed land fill site. Trash is monitored before leaving the site to assure no radioactive material is included in uncontaminated waste.

4. Refer to Section 5.5 for discussion of reinforced concrete design bases common the main building and associated structures, including the cask unloading basin.

5. When the fuel storage basin was almost full, storage racks were installed in the high activity waste basin - now Basin 2 - on an interim basis (see letter dated April 6, 1973, requesting amendment to License No. SNM-1265).

6. Densities expressed in metric tons of uranium and abbreviated TeU.

7. B. F. Warner, the Storage in Water of Irradiated Oxide Fuel Elements, British Nuclear Fuels, Ltd.

8. A. B. Johnson, Jr., Behavior of Spent Nuclear Fuel in Water Pool Storage, Battelle Pacific Northwest Laboratories, September 1977 (BNWL-2256).

9. P. R. C. Winter, Battelle Pacific Northwest Laboratories, telex to H. A. Klepfer, General Electric, September 28, 1977.

10. Electrofilm, Inc., North Hollywood, California 91605.

11. The heat transfer calculations have not been changed from the old basis. It is doubtful that boiling would ever occur under credible conditions.

12. Site survey and foundation report by Dames & Moore, Park Ridge, Illinois, see Appendix A.

13. This method was selected as an alternative to dye-penetrate checking.

14. Process photographs of actual operations (typical Figure 1-13) were made through up to 50 ft. of basin water.

15. Proprietary product of Norton Co.

16. L. L. Denio, D. E. Knowlton, and E. E. Voiland, Control of Nuclear Fuel Storage Basin Water Quality by Use of Powdered Ion Exchange Resins and Zeolites, June 1977, (ASME 77-JPGC-NE-15).

17. The capacities shown for the cooling systems are based on basin water at 120 °F, ambient air at 95 °F.

18. Also referred to as "emergency generator," a term originating from the original design as a reprocessing facility. Loss of electric power at the fuel storage facility would not constitute an emergency.

19. Except LAW vault intrusion water; piped to process water.

20. This vault contained natural or depleted uranium, fluoride salts, and other materials used during MFRP testing. This vault is currently empty.

21. Loss of cooling is discussed in Chapter 8, "Accident Analysis."

22. “Durability of Spent Nuclear Fuels and Facility Components in Wet Storage,” International Atomic Energy Agency Report IAEA-TECDOC-1012

23. “Fuel Basin Water Evaluation: Conductivity Change and Evaporation Rate,” T. D. Maikoff, August 2004.