General Electric Systems Technology Manual

Chapter 11.8

Refuel and Vessel Servicing Equipment

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11.8 REFUELING AND VESSEL SERVICING EQUIPMENT

Learning Objectives:

1. Recognize the purposes of the Refueling and Vessel Servicing system.

2. Recognize the purpose, function and operation of the following major components:
   a. spent fuel pool
   b. new fuel storage vault
   c. refueling platform
   d. reactor building overhead crane
   e. fuel preparation machines
   f. jib cranes
   g. new fuel inspection stand

3. Recognize the design features of the new fuel storage vault and spent fuel pool that prevent criticality.

4. Recognize how the Refueling and Vessel Servicing system interfaces with the following systems:
   a. Reactor Manual Control System (Section 7.1)
   b. Fuel Pool Cooling and Cleanup System (Section 11.7)

11.8.1 Introduction

The purposes of the Refueling and Vessel Servicing System are to:
- provide the facilities for the handling and storage of new and spent fuel
- provide the equipment used for vessel refueling
- provide the equipment used for the servicing of vessel internal components

The functional classification of the Refueling and Vessel Servicing System is that of a power generation system.

11.8.2 System Description

The Refueling and Vessel Servicing System consists of three subsystems:
- the Fuel Servicing Subsystem
- the Fuel Handling and Storage Subsystem
- the Vessel Servicing Subsystem.

The Fuel Servicing Subsystem includes the equipment necessary for receiving, inspection, channeling, and sampling of the fuel assemblies.

The Fuel Handling and Storage Subsystem provides the equipment necessary to receive, prepare, and install new fuel. In addition it provides the equipment necessary

for removing, preparing, and shipping spent fuel. This subsystem also provides the storage facilities for new fuel, spent fuel, and other irradiated vessel components.

The Vessel Servicing Subsystem provides the equipment necessary to remove, store, inspect, and install reactor vessel internal and external components. The reactor vessel is serviced from the refueling floor and from the under vessel area.

11.8.3 Component Description

The major components of the Refueling and Vessel Servicing System are discussed in the following paragraphs.

11.8.3.1 Fuel Servicing Subsystem

The Fuel Servicing Subsystem includes the equipment necessary for the inspection, and channeling of the fuel assemblies.

The new fuel arrives at the site packed in special shipping containers that contain two fuel bundles. The fuel bundles are both enclosed in a steel container. The steel container provides support for the entire length of the bundles. The containers are lifted the refueling floor using the reactor building overhead (polar) crane. At that time the individual fuel bundles are removed from the containers and inserted into the new fuel inspection stand.

The new fuel inspection stand consists of an upper and a lower platform, each with safety guard rails. The stand holds two fuel bundles mounted on rotatable bearing surfaces. The rotating bearing surfaces are equipped with hand operated, locking devices to hold the bundles in the desired quadrant positions during inspection. Clamp plates on the top of the stand hold the bundles in place in the inspection stand.

In use, the new fuel inspection stand accommodates two inspectors, one on each platform. The fuel bundle inspection consists first of a visual check of the bundle for fingerprints, grease, dust, etc. Any such marks are removed using commercial grade cleaners and lint free rags. The visual inspection also ensures that there are no dents, cracks, or other physical damage to the fuel bundle. Other inspection checks include fuel rod seating, spacer checks, tie rod nut locking checks and rod clearance checks.

Preparation of the fuel bundles for loading in the reactor core requires the installation of channels on the new fuel bundles. These may be new channels or ones previously used on other fuel bundles. The fuel channel is installed at one of the following points:

- at the factory by the manufacturer
- during the fuel inspection process at the plant
- when it is placed in the spent fuel pool fuel preparation machine

Installation of irradiated previously used channels is always performed underwater in the spent fuel pool fuel preparation machines.

The fuel preparation machine is used both for stripping reusable channels from the spent fuel bundles and for rechanneling the new fuel. The machine is also used with a fuel inspection fixture to provide an underwater inspection capability. Two fuel preparation machines are mounted on a wall of the spent fuel pool.

A channel storage rack is provided to hold up to 20 fuel channels for use during fuel bundle preparation. The channel storage rack is located in the spent fuel pool and centered between the two fuel preparation machines.

Jib cranes, consisting of a motor driven swing boom monorail and a motor driven trolley are mounted along the edge of the spent fuel pool. Use of the jib crane leaves the refueling platform free to perform general fuel shuffling operations. Jib cranes are capable of moving fuel or other components that weigh no more than 1000 pounds. Different grapples are designed for the different servicing tasks. Various grapples can carry fuel bundles, control rods, fuel support pieces or other objects associated with refueling.

11.8.3.2 Fuel Handling and Storage Subsystem

From the inspection stand the new fuel is placed in either a new fuel storage vault or into the spent fuel pool. The new fuel storage vault has storage racks that can store 240 new fuel assemblies. The spent fuel pool has storage racks sufficient to store up to 2,176 new or spent fuel bundles.

The arrangement of the fuel assemblies in the new fuel storage vault ensures that K_{eff} will not exceed 0.95. In the dry (normal) condition, K_{eff} is maintained <0.95 because of under moderation. In the flooded condition, the geometry of the fuel storage array ensures that K_{eff} will remain <0.95. In both cases subcriticality does not depend upon the presence of any neutron absorbing materials.

The spent fuel pool is designed to maintain K_{eff} <0.95 when flooded with un-borated water. The spent fuel pool racks are designed to maintain the spent fuel in a geometry that precludes the possibility of criticality. The spent fuel pool is designed so that no single failure of structures or equipment will cause either of the following:

- inability to maintain irradiated fuel submerged in water
- the ability to re-establish normal fuel pool water level

In order to limit the possibility of pool leakage, the pool is lined with stainless steel. In addition to providing a high degree of integrity, the lining is designed to withstand abuse that might occur when equipment is moved about. No inlets, outlets, or drains are provided that might permit the pool to be drained below a safe shielding level. Lines

extending below this level are equipped with siphon breakers, check valves, or other devices that prevent inadvertent pool drainage.

When the new fuel is to be used in the reactor, the reactor building overhead crane removes the fuel bundles from the new fuel storage vault. The fuel is then placed in the fuel preparation machine. The new fuel is then placed in the spent fuel pool storage racks by the refueling platform.

The refueling platform is the principal means of transporting fuel assemblies between the reactor and the spent fuel pool. The refueling platform supports a refueling grapple, a frame mounted hoist and a monorail hoist. It provides the operators with a work surface for almost all vessel servicing operations. The platform travels on a track extending along each side of the dryer /separator storage pit, the reactor and the spent fuel pool. The platform design permits travel over the safety railings placed around the pools.

The refueling grapple is suspended from a trolley system that can traverse the width of the platform. The trolley includes the operator's cab which contains all the controls for the following:

- the refueling platform
- the trolley
- the refueling grapple
- the frame mounted hoist.

The refueling grapple is a telescopic, stainless steel structure with an air operated grapple mounted on the end of the mast. The mast consists of a fixed section and three telescopic sections having a triangular shape. The main hoist raises or lowers the stainless steel mast. This allows operation of the grapple between 8 feet and 56 feet below the top of the platform tracks. The 8 foot upper travel limit ensures adequate shielding between the fuel on the grapple and the refueling platform. The grapple is designed such that it cannot be opened when lifting a fuel bundle.

11.8.3.3 Vessel Servicing Subsystem

The Vessel Servicing Subsystem provides the equipment necessary to remove, store, inspect, and install various reactor vessel components. The reactor vessel is serviced from the both the refueling floor and the under vessel area.

There are three floodable volumes on the refueling floor, the spent fuel pool, the reactor cavity and the dryer/separator storage pool. Dry laydown areas are provided on the refuel floor for the following

- the drywell head
- the vessel head
- the vessel head insulation.

The reactor building overhead crane (polar crane) is a bridge type crane spanning the interior of the reactor building. Its services include handling the drywell head, vessel head, steam dryer, and steam separator during refueling. The crane has a 125 ton capacity with a 35 ton auxiliary hoist.

In order to perform the required reactor servicing, the reactor is shut down according to prescribed procedures. During the cooldown the reactor pressure vessel is vented and filled to above the flange level to promote cooling. The shield blocks are removed from above the drywell head region after the reactor is shutdown.

Immediately after vessel cooldown the drywell head is removed. The unbolted drywell head is lifted by the reactor building overhead crane to its refuel floor storage space.

All interfering piping, instrumentation, and vessel head insulation are removed from the reactor vessel head. The vessel head strongback and carousel is then positioned on the reactor vessel head by the overhead crane. The strongback attaches to the vessel head at four points via lifting eyes on the vessel head. The four connecting points have a leveling adjustment to ensure the head is level prior to lifting.

The head stud tensioners are used to remove and reassemble the reactor vessel head retaining nuts. The assembly includes eight stud tensioners in a carousel suspended from the head strongback. The carousel structure has a circular, rail mounted, 1 ton, power hoist for each tensioner. This permits working on eight studs at each operation.

After the retaining nuts are removed, the vessel head is lifted to its storage location on the refueling floor. The six vessel studs in line with the fuel transfer gate through the reactor cavity wall are removed from the vessel. These studs are removed to provide a path for fuel movement from the reactor cavity to the spent fuel pool.

Access to the fuel assemblies requires the removal of the steam dryer and separator. The steam dryer is removed using the dryer separator strongback and stored in the dryer pool. The shroud head steam separator assembly can now be removed after the shroud head bolts are loosened using the shroud head bolt wrench. The shroud head separator assembly is removed using the dryer and separator strongback. This is then stored in the separator pool. Since the shroud head is expected to be highly radioactive, the separator assembly is usually transferred under water. Once access to the fuel is possible; the refueling platform is moved into place to commence fuel movement.

The reactor vessel service platform is a motor driven structural steel assembly designed to provide close access to the vessel internals. The platform rides on a self contained rail which also serves as its lifting strongback. This rail attaches to and is supported by the reactor vessel flange. Located on the service platform is a jib crane, a work well, and several smaller openings through which various vessel internal components are

serviced. The vessel internals are serviced with the aid of assorted long handled tools and accessories.

The primary function of the under reactor vessel servicing equipment is to remove and install control rod drives, control rod guide tubes, and neutron detectors.

The equipment handling platform is located below the reactor pressure vessel. The platform is capable of rotating forward and reverse for 360 degrees with access to the following:

- control rod drives
- source range monitor (SRM) drives
- intermediate range monitor (IRM) drives
- electrical connections for the incore detector assemblies (SRM, IRM and LPRM)
- transverse incore probe (TIP) tubing and connectors.

The control rod drive handling equipment is pneumatically powered and designed to remove and install the control rod drives. This equipment is used in conjunction with the equipment handling platform.

11.8.4 System Features and Interfaces

A short discussion of the system features and the interfaces this system has with other plant systems is given in the following paragraphs.

11.8.4.1 Fuel Movement

To move fuel, the fuel grapple is aligned over a fuel assembly in the reactor. The mast is then lowered and attached to the fuel bundle bail handle. The fuel bundle is then raised out of the core to the 8 foot upper travel limit. The trolley and bridge are lined up to move through the refueling slot in the reactor well wall to the spent fuel storage pool. In the spent fuel; pool the bridge and trolley are aligned over a position in the storage rack. The fuel bundle is then lowered into the rack and then the fuel grapple is released from the fuel bundle bail handle. The new fuel is then moved from the spent fuel pool storage pool to the reactor vessel in the same manner. Some fuel moves are required from one vessel location to another in order to align fuel per the cycle design. These fuel moves will take a bundle from one in core location and place it in another in core location. The same process is followed for this these in core movements, but he fuel is lowered into a new core location instead of the spent fuel pool location.

Spent fuel can be removed from the spent fuel pool and transferred off site or to on site dry fuel storage pads. A special shipping cask or transfer cask is needed for these evolutions.

11.8.4.2 Fuel Sipping

During reactor operation, the offgas radiation level is monitored. If a rise in offgas activity has been noted the leaking fuel bundle is localized by inserting control rods. The reactor core is sampled (sipped) during shutdown to locate any leaking fuel assemblies. Fuel sipping can be done either in the core with a special sipping head attachment on the main grapple or in the spent fuel pool with a fuel sipping container. Both methods stop water circulation through the bundle and allow fission products to concentrate if a bundle is defective. If a defective bundle is found, it is transferred to the fuel storage pool and stored in a defective fuel container.

11.8.4.3 Control Rod Removal

A control rod is removed from its cell by first removing two diametrically opposite fuel assemblies and then inserting a blade guide in their place. This is followed by the removal of the remaining two fuel assemblies. The control rod is then withdrawn from the core. Then the blade guides and the fuel support casting are removed.

It is possible to disconnect a control rod from its control rod drive from the open vessel or from the under side of the vessel. When the control rod is uncoupled from inside the vessel, the control rod latch tool is used. When uncoupling from the under the vessel a disconnecting mechanism that is part of the control rod drive and an uncoupling tool are used. The rods are generally uncoupled from the above the vessel due to high radiation levels in the under vessel area. Once the control blade is uncoupled, it is removed to the control rod storage rack in the spent fuel pool.

11.8.4.4 Control Rod Drive Mechanism Removal

When the reactor is shut down, cooled down, and depressurized, the control rod to be removed is fully withdrawn and uncoupled from its drive. The uncoupled control rod velocity limiter provides the barrier between the reactor vessel and the under vessel area. The position indication probe and CRD housings supports are then removed from the mechanism. The handling platform is rotated so that the centerline of the platform opening aligns with the CRD being removed. The CRDM is then unbolted from the flange and lowered into the transfer cart. The CRD transfer cart is then moved into the reactor building for transport to a CRD storage and repair room.

11.8.4.5 System Interfaces

Fuel Pool Cooling and Cleanup (FPCC) System (Section 11.7)

The Fuel Pool Cooling and Cleanup (FPCC) System removes decay heat from the fuel assemblies and maintains clarity and purity of the pool water.

Reactor Manual Control System (Section 7.1)

The Reactor Manual Control System provides rod withdrawal blocks and interlocks when the Refueling platform is in use. The detailed description of these rod withdrawal blocks is given in table 7.1-1 in Section 7.1.

11.8.5 Summary

The purposes of the Refueling and Vessel Servicing System are to:

- provide the facilities for the handling and storage of new and spent fuel
- provide the equipment used for vessel refueling
- provide the equipment used for the servicing of vessel internal components

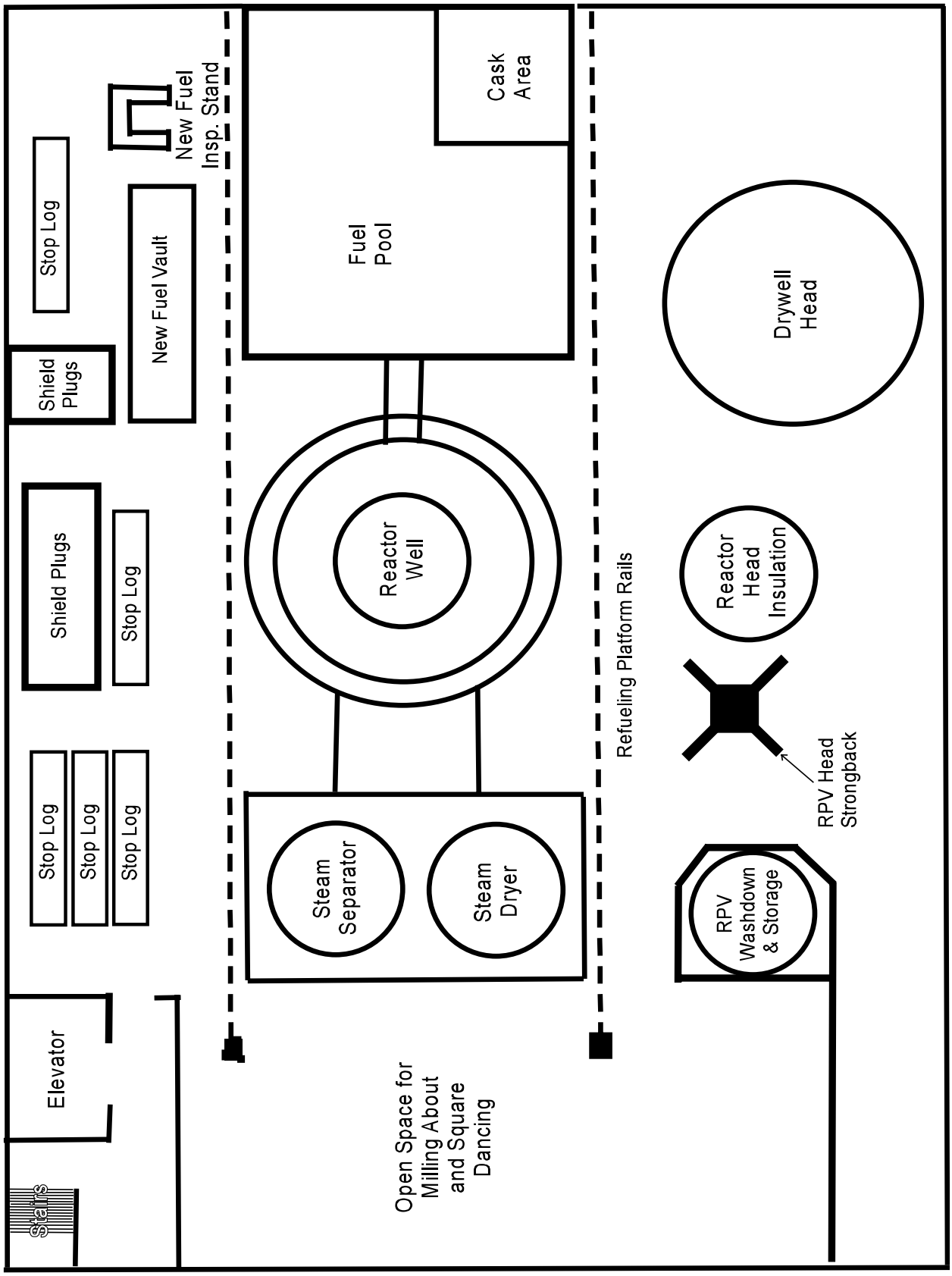

Figure 11.8-1 Typical Refueling Floor Arrangement