7.6 REFUELING INTERLOCKS

7.6.1 Safety Objective

The refueling interlocks are designed to back up procedural core reactivity controls during refueling operation; specifically, the interlocks prevent an inadvertent criticality during refueling operations.

During a refueling operation, the reactor vessel head is removed, allowing direct access to the core. Refueling operations include the removal of reactor vessel upper internals and the movement of spent and fresh fuel assemblies between the core and the fuel storage pool. The service platform, refueling platform, and the equipment handling hoists on the platforms are used to accomplish the refueling task. The refueling interlocks reinforce operational procedures that prohibit making the reactor critical under certain situations encountered during refueling operations by restricting the movement of control rods and the operation of refueling equipment.

7.6.2 Safety Design Basis

1. During fuel movements in or over the reactor core, all control rods shall be in their fully inserted positions.

2. No more than one control rod shall be withdrawn from its fully inserted position at any time when the reactor is in the refueling mode (MODE 5).

7.6.3 Description

The refueling interlocks include circuitry that senses the condition of the refueling equipment and the control rods. Depending on the sensed condition, interlocks are actuated, which prevents the movement of the refueling equipment or withdrawal of control rods (rod block).

Circuitry is provided which senses the following conditions:

a. All rods inserted and in refuel mode (MODE 5).

b. Refueling platform positioned near or over the core,

c. Refueling platform hoists fuel-loaded (fuel grapple, frame-mounted hoist, monorail-mounted hoist),

d. Fuel grapple not full up, and

e. Service platform hoist fuel-loaded.

A two-channel DC circuit indicates that all rods are in. The rod-in condition for each rod is established by the closure of a magnetically operated reed switch in the rod position indicator probe. The rod-in switch must be closed for each rod before the "all rods in and in Refuel Mode" signal is generated; two channels carry the signal. Both channels must register the "all rods in and in Refuel Mode" signal in order for the refueling interlock circuitry to indicate the "all rods in and in Refuel Mode" condition.

The refueling platform is provided with two mechanical switches attached to the platform which are tripped open by a long, stationary ramp mounted adjacent to the platform rail. The switches open before the platform or any of its hoists are physically located over the reactor vessel, thereby providing indication of the approach of the platform toward the core or its position over the core.

The three hoists on the refueling platform are equipped with load weighing sensors that provide the control system signals indicating when a hoist is loaded. The setpoints for these hoist loaded signals are set to trip if the hoist weight is greater than that of a single fuel assembly. This provides positive indication whenever fuel is loaded on any hoist.

The telescoping fuel grapple hoist is provided with an elevation measurement as well as limit switches. The control system detects a condition indicative of a lowered hoist and provides a signal called "hoist is not at Normal Up."

The indicated conditions are combined in logic circuits to satisfy all restrictions on refueling equipment operation and control rod movement, as described in Figure 7.6-1 and Table 7.6-1, and in the following:

Note: Interlocks which inhibit Refueling platform movement over the core may be defeated if fuel movement is inhibited, rod blocks remain in place, and the mode switch is administratively controlled in the “refuel position.”

a. Refueling platform travel toward or over the core is stopped when the following three conditions exist concurrently:

   1. Any refueling platform hoist is loaded or the fuel grapple is not in its full up position,

   2. All rods not fully inserted when in refuel mode, and

   3. Refueling platform position is such that position switch No. 1 is open (platform near or over the core).

b. With the mode switch in STARTUP, refueling platform travel toward the core is prevented when the refueling platform No. 2 position switch is open (platform near or over the core).

c. With the mode switch in REFUEL, refueling platform travel towards the core is prevented when the following three conditions exist concurrently:

    1. Refueling mode one rod permissive relay not energized (Energizing the one rod permissive relay requires all rods to be full-in initially, mode switch in REFUEL, and one rod selected).

    2. The refueling platform No. 2 position switch is open (platform near or over the core).

    3. All rods not fully inserted.

d. The refueling platform frame-mounted hoist "LIFT" electrical circuit is open when the following three conditions exist concurrently:

    1. Frame-mounted hoist loaded,

    2. All rods not fully inserted when the reactor mode switch is in "REFUEL," and

    3. Refueling platform near or over the core.

e. The refueling platform monorail-mounted hoist "LIFT" electrical circuit is open when the following three conditions exist concurrently:

    1. Monorail-mounted hoist loaded,

    2. All rods not fully inserted when the reactor mode switch is in "REFUEL," and

    3. Refueling platform near or over the core.

f. Operation of the telescoping fuel grapple is prevented when the following two conditions exist concurrently:

    1. All rods not fully inserted when the reactor mode switch is in "REFUEL," and

    2. Refueling platform near or over the core.

g. Operation of the service platform hoist is prevented when the following two conditions exist concurrently:

   1. All rods not fully inserted, and

   2. Service platform hoist loaded.

h. With the mode switch in REFUEL, any one of the following three conditions prevents a control rod withdrawal:

   1. Refueling platform over the core with a load on any refueling platform hoist or the fuel grapple not fully up,

   2. Service platform hoist loaded, or

   3. Refuel mode one rod permissive relay not energized. (Once the relay is energized, selection of a second rod is blocked.)

i. With the mode switch in STARTUP, either one of the following conditions prevents a control rod withdrawal:

   1. Refueling platform over the core, or

   2. Service platform hoist fuel-loaded.

The prevention of a control rod withdrawal is accomplished by opening contacts at two different points in the rod block circuitry; prevention of refueling equipment operation is accomplished by interrupting the power supply to the equipment.

During refueling operations, the reactor mode switch is maintained locked in the SHUTDOWN or REFUEL position. Technical Specification Section 3.10 provides allowances for mode switch movement to other positions for testing and other prescribed activities subject to limitations as described in the technical specifications. With the mode switch in REFUEL position, no more than one control rod may be withdrawn; this is enforced by a redundant logic circuit, which uses the "all rods in" signal and rod selection signal to prevent the selection of a second rod for movement with any other rod not fully inserted. The simultaneous selection of two control rods is prevented by the interconnection arrangement of the select push buttons. With the mode switch in REFUEL, the circuitry prevents the withdrawal of more than one control rod and the movement of the loaded refueling platform over the core with any control rod withdrawn.

A bypass for the service platform hoist load interlock is provided. When the service platform is no longer needed, its power plug is removed, which deenergizes the power supply to the hoist; and the platform can be moved to a location away from

the core. Deenergizing the hoist power supply opens the hoist loaded relay contacts, giving a false indication that the hoist is loaded; this indication prevents control rod withdrawal with the mode switch in STARTUP or REFUEL. A bypass plug is provided to allow control rod movement in this situation. The bypass plug is physically arranged to prevent the connection of the service platform power plug unless the bypass plug is removed.

7.6.4 Safety Evaluation

The refueling interlocks, in combination with core nuclear design and refueling procedures, prevent inadvertent criticality. The nuclear characteristics of the core assure that the reactor is subcritical even when the highest worth control rod is fully withdrawn. The combination of refueling interlocks for control rods and the refueling platform provide redundant methods of preventing inadvertent criticality even after procedural violations when the mode switch is in REFUEL position. The interlocks on hoists provide yet another method of avoiding inadvertent criticality.

Table 7.6-1 shows the effectiveness of the refueling interlocks. This table considers various operational situations involving rod movement, hoist load conditions, refueling platform movement and position, and mode switch manipulation. The initial conditions in situations 4 and 5 appear to be in contradiction to the action of refueling interlocks, because the initial conditions indicate that more than one control rod is withdrawn, yet the mode switch is in REFUEL. Such initial conditions are possible if the rods are withdrawn when the mode switch is in STARTUP, and then the mode switch is turned to REFUEL. The scram indicated in situation 17 of Table 7.6-1 is not a result of the refueling interlocks; it is the response of the Reactor Protection System to downscale neutron monitoring system channels when the mode switch is shifted to RUN. In all cases, proper operation of the refueling interlocks is successful in preventing either the operation of loaded refueling equipment over the core whenever any control rod is withdrawn or the withdrawal of any control rod when fuel-loaded refueling equipment is operating over the core. In addition, when the mode switch is in REFUEL, only one rod can be withdrawn; selection of a second is inhibited.

7.6.5 Inspection and Testing

Complete functional testing of all refueling interlocks before any refueling outage will provide positive indication that the interlocks operate in the situations for which they were designed. By loading each hoist with a weight equal to a fuel assembly, positioning the refueling platform, and withdrawing control rods, the interlocks can be subjected to valid operational tests. Where redundancy is provided in the logic circuitry, tests can be performed to assure that each redundant logic element can independently perform its function.

Technical Specification Sections 3.9.1 and 3.9.2 provide limiting conditions of operation and surveillance requirements for the refueling interlocks. Testing of the refueling interlocks is also performed following any repair work associated with the interlocks.