3.0 REACTOR

3.1 GENERAL DESIGN SUMMARY

Both of the Calvert Cliffs reactors are of identical design. Consequently, reference throughout this section is made to a single reactor and, unless otherwise noted, implies either Unit 1 or 2.

The reactor is of the pressurized water type, using two reactor coolant loops. A vertical cross-section of the reactor is shown in Figure 3.1-1. The reactor core is composed of 217 fuel assemblies and 77 Control Element Assemblies (CEAs).

The fuel assemblies are arranged to approximate a right circular cylinder with an equivalent diameter of 136" and an active height of 136.7".

The fuel assembly consists of 176 rods (pins) and 5 guide tubes. The pins may contain fuel and/or a neutron poison. The assembly is held together by spacer grids and is closed at the top and bottom by end fittings.

Lateral support and positioning of the fuel rods within an assembly is provided by spacer grids. The spacer grids are welded to five full-length guide tubes. The guide tubes provide channels which guide the CEAs over their entire length of travel and form the longitudinal structure of the assembly. In selected fuel assemblies the central guide tube houses incore instrumentation (ICI). Design characteristics of demonstration or lead fuel assemblies are discussed in Section 3.7.

The fuel is low enrichment uranium dioxide (UO_2) in the form of ceramic pellets clad in Zircaloy or ZIRLO for Westinghouse fuel (as part of an advanced cladding test program, some fuel pins in Batches 2NT, 1RT, 2TF, and 2TW utilize cladding other than Zircaloy or ZIRLO) tubes which are welded into a hermetic enclosure. Starting with Unit 2 Cycle 19 and Unit 1 Cycle 21, AREVA/Framatome fuel uses M5® alloy cladding. Initially the fuel was managed in a three-cycle, mixed central zone, fuel management plan (Figure 3.4-3). Starting with Unit 2 Cycle 8 and Unit 1 Cycle 10, the 24-month cycle core utilized low leakage fuel management. Starting with Unit 1 Cycle 11 and Unit 2 Cycle 10, low fluence fuel management is employed to reduce the fluence on the critical vessel weld. Low fluence fuel management includes replacement of fresh fuel located on the core flats with once or twice-burned fuel. In Unit 1 Cycle 11 and Cycle 12 low fluence fuel management also included the addition of Guide Tube Flux Suppressors (GTFSs) in selected assemblies near the periphery. Sufficient margin is provided to ensure that power peaks are minimized.

The reactor coolant enters the upper section of the reactor vessel, flows downward between the reactor vessel wall and the core barrel, passes through the flow skirt where the flow distribution is equalized and into the lower plenum. The coolant then flows upward through the core, removing heat from the fuel rods, exits from the reactor vessel and passes through the tube side of the vertical U-tube steam generators where heat is transferred to the secondary system. The reactor coolant pumps return the coolant to the reactor vessel.

The reactor internals support and orient the fuel assemblies, the CEAs, and the incore instrumentation and guide the reactor coolant through the reactor vessel. The reactor internals also absorb static and dynamic loads and transmit the loads to the reactor vessel flange. They will safely perform their functions during normal operating, upset, emergency, and faulted conditions. The internals are designed to safely withstand forces due to deadweight, handling, temperature and pressure differentials, flow impingement, vibration, and seismic acceleration.

Reactivity control is provided by two independent systems: (1) the Control Element Drive System (CEDS) which controls CEA motion, and (2) the Chemical and Volume Control System (CVCS) which is used to control the Reactor Coolant System (RCS) boric acid concentration.

Boric acid dissolved in the coolant is used as a neutron absorber to provide long-term reactivity control. In order to reduce the boric acid concentration required at Beginning of Life (BOL) operating conditions and lower power peaking, mechanically fixed burnable poison rods (BPRs) may be provided in certain fuel assemblies. Originally, the neutron poison was boron carbide which is dispersed in alumina pellets; the pellets are clad in Zirconium alloy to form rods which are similar to the fuel rods. Gadolinia and erbium oxide, mixed into fuel pellets, are also being used as a neutron burnable absorber. Beginning with Unit 2 Cycle 16 and Unit 1 Cycle 18 Zirc Diboride (ZrB_2), applied as a coating on the fuel pellets, was used as a neutron burnable absorber. Poison rods are also called shims. Beginning in Unit 2 Cycle 19 and Unit 1 Cycle 21, Gadolinia (Gd_2O_3) mixed into the fuel is used as the neutron burnable absorber.

The CEAs consist of five Inconel tubes filled with neutron absorbers. Four tubes are assembled in a square array around the central fifth tube. A spider joins the tubes at the upper end. The hub of the spider couples the CEA to the drive assembly. The CEAs are activated by magnetic jack Control Element Drive Mechanisms (CEDMs) mounted on the reactor vessel head.

The maximum reactivity worth of the CEAs and the associated reactivity addition rate are limited by system design to prevent sudden large reactivity increases. The design restraints are such that reactivity increases do not result in violation of the fuel damage limits, rupture of the reactor coolant pressure boundary, nor disruption of the core or other internals sufficient to impair the effectiveness of emergency cooling.

Control Element Assemblies are moved in groups to satisfy the requirements of shutdown, power level changes, and operational maneuvering. The control system is designed to produce power distributions that are within the acceptable limits of overall nuclear heat flux factor and Departure from Nucleate Boiling Ratio (DNBR). The Reactor Protective System (RPS) and administrative controls ensure that these limits are not exceeded.

In order to assure control of axial power distribution (APD), particularly in the event of axial xenon oscillation, eight CEAs designated as Part Length CEAs (PLCEA) were initially installed. They have since proved unnecessary and were removed along with their extension shafts. Control Element Assembly guide tube plugs were inserted into the locations previously occupied by the PLCEAs. They have also proved unnecessary and were removed before Unit 1 Cycle 8 and Unit 2 Cycle 7.