## 3.3 MECHANICAL DESIGN

### 3.3.1 SUMMARY

The reactor core and internals are shown in Figure 3.1-1. A cross-section of the reactor core and internals is shown in Figure 3.3-1. Mechanical design features of the reactor internals, the CEDMs and the reactor core are described below. Mechanical design parameters are listed in Tables 3.3-1, 3.3-2, 3.3-3, 3.3-4, and 3.3-5.

The fuel for Unit 2 is essentially identical to that of Unit 1. After the first cycle of Unit 1, a number of minor refinements (shown in Tables 3.3-1 and 3.3-2) were incorporated for the purpose of improving overall fuel performance. The principal changes are that the pellet density has been increased slightly and the overall pellet geometry modified. The increased pellet density, along with improvements in pellet microstructure, has the effect of improving the in-pile dimensional stability of the pellet, thereby lessening the adverse effect of in-pile densification on gap conductance and axial gap formation. The reduced pellet length-to-diameter (L/D) ratio and the use of chamfered pellets have the effect of reducing the severity of interaction between the pellets and the clad. Also, the fuel has been modified to permit replacement of fuel rods. These refinements represent standard practice among Combustion Engineering, Inc. (CE) reactors like the Calvert Cliffs design.

### 3.3.2 CORE MECHANICAL DESIGN

The core approximates a right circular cylinder with an equivalent diameter of 136" and an active height of 136.7". It consists of Zircaloy-4 or ZIRLO (as part of an advanced cladding test program, some fuel pins in Batches 2NT, 1RT, 2TF, and 2TW utilize other cladding materials) clad fuel rods containing slightly enriched uranium in the form of sintered $UO_2$ pellets. Starting with Unit 2 Cycle 19 and Unit 1 Cycle 21, AREVA/Framatome fuel uses the M5® alloy cladding. In addition, there are BPRs in certain fuel batches. The fuel rods are grouped into 217 assemblies. The enrichment of each batch of fuel is shown in Tables 3.3-1 and 3.3-2.

Short-term reactivity control is provided by 77 CEAs. The CEAs are guided within the core by the guide tubes which are integral parts of the fuel assemblies.

#### 3.3.2.1 Fuel Rod Mechanical Design

The fuel rods consist of slightly enriched $UO_2$ cylindrical ceramic pellets. The first cycle fuel rod is shown in Figure 3.3-2. Recent Westinghouse fuel rod designs are shown in Figures 3.3-3A, 3.3-3B, and 3.3-3C. Originally, a round wire Type 302 stainless steel (SS) compression spring, and an alumina spacer disc were located at each end of the fuel column, all clad within a seamless Zircaloy-4 or ZIRLO tube with a Zircaloy-4 cap welded at each end. As part of an advanced cladding test program, some fuel pins in Batches 2NT, 1RT, 2TF, and 2TW utilize other cladding materials. Beginning with Unit 1 Cycle 12 and Unit 2 Cycle 11, the upper alumina spacer disc was removed. Beginning with the Unit 1 Cycle 16 Batch 1V rods manufactured at the Columbia facility, the lower alumina spacer disk was removed. The fuel rods manufactured by Hematite are evacuated and internally pressurized with helium to compensate for the pressure difference across the clad, minimizing clad collapse. The fuel rods built at Columbia are not evacuated prior to being pressurized with Helium. Helium, an inert gas, is chosen as the pressurizing medium because of its thermal conductivity. Cladding creep-collapse time for fuel was analyzed for each cycle until Unit 1 Cycle 8 and Unit 2 Cycle 7. Analysis of modern pressurized water reactor (PWR) fuels has demonstrated that the clad collapse time is significantly longer than its expected useful life. Therefore, cycle-specific clad collapse time is not calculated.

Each fuel rod assembly includes a unique serial number. The unique serial number ensures traceability of the fabrication history of each fuel rod. The fuel cladding is cold worked and stress-relief annealed Zircaloy-4 or ZIRLO seamless tubing. The actual tube forming process consists of a series of cold working and annealing operations.

The $UO_2$ pellets are dished and chamfered on both ends in order to better accommodate thermal expansion and fuel swelling. The pellet length to diameter ratio and the use of chamfered pellets decrease the interaction between the pellet and the clad. However, because the pellet dishes and chamfers constitute about 3% of the pellet, stack height density is reduced. The stack height density and pellet dimensions are given in Tables 3.3-1 and 3.3-2.

The compression spring, located at the top of the fuel pellet column, maintains the column in its proper position during handling and shipping. The alumina spacer disc at the lower end of the fuel rods with magnetic force welds is to protect the weld from radial strain induced by pellet swelling, while the upper spacer disc prevents $UO_2$ chips, if present, from entering the plenum region. Beginning with Unit 1 Cycle 12 and Unit 2 Cycle 11, the upper alumina ($Al_2O_3$) spacer disc was removed. Starting with the Unit 1 Cycle 16 rods built in Columbia, the lower alumina spacer was eliminated. The plenum spring is a low volume plenum spring. This provides greater margin between the EOL internal pin pressure and the rods mechanical design limit than earlier designs. The fuel rod plenum, initially pressurized with helium, provides space for axial thermal expansion of the fuel column and accommodates the gaseous fission products. The greater portion of the fission gas remains in the pellet lattice and does not contribute to the rod internal pressure.

Beginning in Unit 2 Cycle 19 and Unit 1 Cycle 21, the fuel is provided by AREVA/ Framatome and the general design is similar. The cladding is a zirconium alloy, M5$^{®}$. The fuel column is sintered $UO_2$ pellets, 136.7" long (nominally) with a plenum spring at the top of the rod column. Each rod is pressurized with helium and sealed with caps welded at each end. The fuel column continues to have low enriched axial blanket pellets at both ends. The fuel rod is shown in Figures 3.3-3 and 3.3-16.

### 3.3.2.2 Burnable Poison Rod Mechanical Design

Fixed burnable poison (neutron absorbing) rods are included in selected fuel assemblies to reduce the BOL MTC. They replace fuel rods at selected locations. The various sheets of Figure 3.3-4 show assembly configurations for various fuel bundles. The poison rods are mechanically similar to fuel rods, but contain a column of burnable poison pellets instead of fuel pellets. The poison material consists of alumina with uniformly dispersed boron carbide particles. Mechanical design parameters are listed in Table 3.3-3.

The balance of the column contains Zircaloy-4 pellets. The BPR plenum spring produces a smaller preload on the pellet column than that in a fuel rod because of the lighter material in the poison pellets.

Each BPR includes a unique serial number and a batch identification mark. The serial number is used to record fabrication information for each component in the rod assembly. It ensures traceability of the fabrication history of each rod. The batch identification mark provides a visual check on the pellet boron concentration during fuel assembly fabrication.

For Unit 1 Cycle 10, four lead test assemblies containing Gadolinia as a burnable absorber were introduced. Twelve of the 176 fuel bearing rods in each of the test assemblies contain a mixture of 10 wt% $Gd_2O_3$ and natural (not enriched in U-235) $UO_2$ pellets stacked over an active length of 122.7" within the rod. The top and bottom 7" of the column contain natural $UO_2$ pellets without Gadolinia. The test assembly poison rod pellets are otherwise mechanically identical to fuel pins.

For Unit 2 Cycle 9, four demonstration assemblies containing Erbium as a burnable absorber were introduced. Each assembly consists of 80 standard pins at 4.3 wt% U-235, 52 standard pins at 3.4 wt% U-235, and 44 Erbium bearing pins. The fuel stack in each Erbium bearing fuel pin consists of a central 115.7" region containing 3.4 wt% U-235, 0.9 wt% $Er_2O_3$, $UO_2/Er_2O_3$ pellets and two 10.5" cutback regions, one at each end of the stack containing standard 3.4 wt% U-235 pellets.

For Unit 2 Cycle 10, Batch 2M burnable absorber pins consist of a 115.7" central region containing the burnable material $B_4C$ with two 10.5" cutback regions containing $Al_2O_3$, one at each end of the stack. This change is being made to enhance thermal margin by lowering the axial peak at BOC.

Beginning with Unit 1 Cycle 12 and Unit 2 Cycle 11, selected fuel pins contain erbia ($Er_2O_3$) as the integral burnable absorber (in lieu of $B_4C$). The erbium fuel pins consist of a central region containing the burnable absorber mixed with $UO_2$ at the batch enrichment and a cutback region at the upper and lower ends of the fuel rods. The cutback region consists of $UO_2$ at the batch enrichment, and enhances the thermal margin by lowering the core average axial peak.

Beginning with Unit 2 Cycle 16 and Unit 1 Cycle 18, selected fuel pins contain $ZrB_2$ as the integral burnable absorber (in lieu of erbia). The $ZrB_2$ fuel pins consist of a central region containing the burnable absorber. The $ZrB_2$ is applied as a very thin coating on the outside surface of select $UO_2$ fuel pellets. The $ZrB_2$ rods have a poison cutback region at the upper and lower ends of the fuel rods.

Beginning in Unit 2 Cycle 19 and Unit 1 Cycle 21, the fuel uses Gadolinia, dispersed in the $UO_2$ fuel as a burnable poison.

#### 3.3.2.3 Fuel Assembly Mechanical Design

The fuel assembly (Figure 3.3-5) consists of 176 fuel rods and poison rods, 5 guide tubes, 5 guide tube sleeves (except as noted by Section 3.7), 8 fuel rod spacer grids, upper and lower end fittings (LEFs), and a hold-down device (Figure 3.3-6). The guide tubes, spacer grids, and end fittings form the structural frame of the assembly. The four outer guide tubes are mechanically attached to the end fittings and the spacer grids are welded to all five guide tubes.

The fuel rod spacer grids for the Westinghouse fuel (Figures 3.3-7, 3.3-7A, 3.3-7B, and 3.3-16) maintain the fuel rod pitch over the length of the rod. The grid provides positive lateral restraint to the fuel rod but only frictional restraint axially. The grids are fabricated from preformed Zircaloy, interlocked in an egg crate fashion, and welded together. The grid supports each fuel rod by two cantilever tab springs or two I-springs and four arches. The springs press the rod against the arches to restrict relative motion between the grids and the fuel rods. The spring and arch positions are reversed from grid to grid to provide additional movement restrictions. The perimeter strips contain features designed to prevent hang up of grids during a refueling operation. The eight Zircaloy-4 spacer grids are welded to each Zircaloy-4 guide tube at eight locations, four on the upper face of the grid and four on the lower face of the grid, where the spacer strips contact the guide tube surface.

The Westinghouse fuel assembly upper end fitting consists of a 304 SS flow plate, a SS hold-down plate, five machined posts, and five Inconel X-750 compression springs. The upper end fitting attaches to the guide tubes to serve as an aligning and lifting device for each fuel assembly. The flow plate is attached to the top ends of the guide tubes and is designed to prevent excessive axial motion of the fuel rods. Inconel X-750 is selected for the compression springs because of its previous use for coil springs and good resistance to relaxation during operation. The hold-down plate, together with the compression springs, comprise the hold-down device. The hold-down plate is axially movable. It is loaded by the compression springs and held down by the fuel alignment plate. The spring load combines with the fuel assembly weight to counteract upward hydraulic forces. The determination of upward hydraulic forces includes factors accounting for flow maldistribution, fuel assembly component tolerances, oxide buildup, drag coefficient, and bypass flow. The springs are sized and the spring preload selected such that a net downward force of at least 150 pounds will be maintained for all normal and anticipated transient flow and temperature conditions. The design criteria limit the maximum stress under the most adverse tolerance conditions to below yield strength of the spring material. The maximum stress occurs during cold conditions and decreases as the reactor heats up. The reduction in stress is due to a decrease in spring deflection resulting from differential thermal expansion between the Zircaloy fuel bundles and the SS internals.

The Westinghouse fuel LEF consists of an Inconel grid welded to a cast SS plate which has flow holes and four support legs. The support legs also serve as alignment posts. Precision-drilled holes in the support legs mate with four core support plate alignment pins, thereby properly locating the lower end of the fuel assembly.

Beginning with Batch 1D and 2D fuel and continuing with subsequent assemblies the bottom spacer grid is used in lieu of a mechanical retention grid to laterally locate the bottom of the fuel rods. The grid allows for removal and replacement of rods. The four outer guide tubes have a widened region at the upper end which contains an internal thread.

Beginning with Batch 1K and 2J fuel and continuing with subsequent assemblies, the height of the LEF was shortened by shortening the support legs. The overall lengths of the guide tubes were increased to compensate for the shorter LEF. The elevations of the Inconel grid and the uppermost Zircaloy grid were changed to maintain their same relative elevations with respect to previous assemblies.

In Batch 2L, a debris-resistant LEF design was used in which a 3x3 array of small flow holes replaces each of the large flow holes of the previous design. Also, wherever possible, additional small holes are added to minimize the increase in the pressure drop of the small hole LEF design, relative to the previous design.

Beginning with Batch 1N and 2M, the fuel incorporates the GUARDIAN™ fuel assembly design to entrap debris. The GUARDIAN™ design employs a redesigned Inconel spacer grid and redesigned rods that have longer, solid Zircaloy-4 lower end caps. Changes incorporated into the GUARDIAN™ fuel assembly include an increase in length of the lower end caps, an increase in the length of the fuel and burnable absorber rods, and a decrease in the length of the plenum regions. The length of the guide tubes is increased to maintain the shoulder gap, and the height of the upper end fitting is reduced to maintain the overall length of the fuel bundle. The change in height of the upper end fitting is accomplished by decreasing the compression region for the hold-down spring without a change in dimension of the spring. The height of the LEF is reduced and "T" stanchions are added to aid fuel handling.

Beginning with Batch 1N and Batch 2M, Zircaloy spacer grids are redesigned to allow fuel rods located along the periphery of the fuel bundle to receive more coolant flow. This is performed through an increase in the outer pin cell size by enlargement of the outside envelope of the spacer grid assembly.

The externally-threaded end of each guide post passes through a hole in the flow plate and is torqued into the internally-threaded guide tube. When assembled, the flow plate is secured between flanges on the guide tubes and on the guide post. The connection with the upper end fitting is locked with a mechanical crimp. Each outer guide tube has, at its lower end, a welded Zircaloy-4 fitting. Either a threaded portion of this fitting passes through a hole in the fuel assembly LEF and is secured by a Zircaloy-4 nut and a SS locking ring, or a fitting with an internal thread engages with a hole in the LEF and is secured by a SS bolt and locking ring. The locking ring is tack welded to the LEF in four places.

The central guide tube inserts into sockets in the upper and lower end fittings and is thus retained laterally by the relatively small clearance at these locations. The upper end fitting socket is created by the center post which is threaded into the lower cast flow plate and tack welded in two places. The LEF socket is machined out of the LEF casting. There is no positive axial connection between the central guide tube and the end fittings.

A SS guide tube sleeve (except as noted by Section 3.7), located in the upper region of the guide tube/post, prevents guide tube wear. Fretting wear was caused by coolant turbulence inducing vibratory motion in the CEAs which rubbed against the guide tube wall. Significant wear has been found to be limited to the relative soft Zircaloy-4 guide tube because the Inconel-625 cladding on the CEAs provides a relatively hard wear surface. Beginning with Unit 1 Cycle 3, (Unit 2 Cycle 2) and continuing in subsequent cycles, SS sleeves were installed in fuel assembly guide tubes with significant wear, and in fuel assembly guide tubes under most CEAs. In addition to the installation of sleeves in guide tubes to prevent wear, some assemblies were fabricated for Unit 2 Cycle 2, Unit 1 Cycle 4, and Unit 1 Cycle 5 with reduced flow guide tubes to reduce CEA vibration.

The sleeve is of slightly cold worked 304 SS, chrome plated on the inside surface. The chrome plating provides resistance to wear without the risk of promoting wear in the CEA Inconel cladding. The nominal wall thickness is adequate for free movement of the CEA and does not significantly increase the maximum CEA drop time. To secure the sleeves in the guide tube, the lower ends of the sleeves are expanded radially so that the guide tubes are permanently expanded. The lower third of the sleeve is also expanded outward so that the outside of the sleeve contacts the guide tube.

Beginning with Batch 1K and 2J fuel assemblies a modified short-sleeve design is used. This allows for reconstitution of the assemblies without having to remove and reinstall the guide tube sleeves. All new fuel assemblies are sleeved with the short-sleeve design (Reference 3).

The five guide tubes have the effect of ensuring that bowing or excessive swelling of the adjacent fuel rods or poison rods cannot result in obstruction of the CEA pathway. This is so because:

a. There is sufficient clearance between the fuel rods and the guide tube surface to allow an adjacent fuel rod to reach rupture strain without contacting the guide tube surface.
b. The guide tube, having considerably greater diameter and wall thickness (and at a lower temperature) than the fuel rod, is considerably stiffer than the fuel rods and would, therefore, remain straight, rather than be deflected by contact with the surface of an adjacent fuel rod.

Therefore, the bowing or swelling of fuel rods would not result in obstruction of the control element channels such as could hinder CEA movement.

The fuel assembly design enables reconstitution (i.e., removal and replacement of fuel rods or poison rods) of an irradiated fuel assembly. The fuel rod and poison rod lower end caps are conically shaped to ensure proper insertion within the fuel assembly grid cage structure. The upper end caps are designed to enable remote grappling of the fuel rod or poison rod for purposes of removal and handling. The five posts may be untorqued and removed from the guide tubes, allowing the removal of the upper end fitting assembly as one unit (a hold-down plate, a flow plate, five posts and five springs) with a single tool. This removal provides access to the fuel rods and poison rods for replacement or servicing. Before loading into the core, the threaded joints which mechanically attach the upper end fitting to the guide tubes are properly torqued and locked.

A unique serial number on each fuel assembly upper end fitting enables verification of fuel enrichment and orientation of the fuel assembly. Indication is also provided on the LEF to ensure preservation of fuel assembly orientation in the event of upper end fitting removal.

The lower end of each rod has a serial number to provide a means of identifying the pellet enrichment, pellet lot, and fuel stack weight. In addition, a quality control program specification requires that measures be established for the identification and control of materials, components, and partially fabricated subassemblies. These means provide assurance that only acceptable items are used and also provides a method of relating an item or assembly from initial receipt through fabrication, installation, repair, or modification to an applicable drawing, specification, or other pertinent technical document.

For the AREVA/Framatome design, the spacer grids are the Zircaloy-4 HTP™ spacers at all elevations except the bottom spacer. The bottom spacer is an Alloy 718 high mechanical performance (HMP™) spacer. The upper end fitting is the standard reconstitutable design that has been used at other CE14 units. The lower end fitting is the FUELGUARD™ design used to provide resistance against debris entering the fuel assembly. Features such as the capability to reconstruct fuel assemblies, individual rod and bundle identification are maintained. The springs are sized and the spring preload selected such that a net downward force will be maintained for all normal and anticipated transient flow and temperature conditions. The fuel assembly is shown in Figure 3.3-16.

### 3.3.2.4 Control Element Assembly Mechanical Design

The CEA (Figures 3.3-8, 3.3-9A, and 3.3-9B and Table 3.3-4) consists of five Inconel 625 tubes (fingers) loaded with a stack of cylindrical neutron absorber pellets. The absorber material is boron carbide ($B_4C$), with the exception of the lower portion of the four corner fingers (original design) and some center fingers (new design) which contain silver indium cadmium (Ag-In-Cd). The silver indium cadmium material reduces clad strain which radiation-induced swelling of boron carbide might cause.

The AREVA/Framatome full strength CEA rod has a slightly different configuration in the lower portion of the rod. The full strength CEA rod design contains a stack support that resides within the annulus of the silver indium cadmium (Ag-In-Cd) stack. This stack support is comprised of a support column that passes through the Ag-In-Cd annulus and a support platform, upon which the $B_4C$ column rests. The stack support prevents the weight of the $B_4C$ column and plenum spring preload from compressing the Ag-In-Cd stack which is susceptible to deformation through creep during operation; a significant contributor to clad strain. The stack support reduces the creep mechanism of the lower absorber and thereby reduces cladding strain.

Above the poison pellet column is a plenum which provides expansion volume to limit the internal pressure from the gases released from the boron carbide such that the primary stress does not exceed the yield strength of the cladding material at operating conditions. The plenum contains a hold-down spring which restrains the absorber material against longitudinal movement while allowing for differential expansion between the absorber and the clad. The spring also maintains the position of the absorber material during shipping and handling.

Each finger is sealed by one Inconel 625 nose cap welded at the bottom and one Inconel 625 end fitting at the top. The end fittings are attached to a spider hub structure in a square array with one finger centrally located. The spider provides rigid support for the control elements. The spider provides a point of attachment for coupling the CEA to the CEA extension shaft. A unique serial number is on each hub to provide identification.

During normal operation all of the CEAs are normally in the fully withdrawn position. Mechanical reactivity control is achieved by vertically maneuvering the positions of the CEA groups by the magnetic jack CEDMs. Each CEDM is positioned on the reactor vessel closure head and is coupled to the CEA by the CEA extension shaft.

There are 37 single CEAs and 20 dual CEAs. Each dual CEA consists of two single CEAs connected to a single extension shaft and carried by a single CEDM. Considering the 20 dual CEAs as 40 single CEAs gives an overall equivalent of 77 single CEAs in the core (Figures 3.3-10 and 3.3-11). The center CEA in group 5 is weakened in absorption capability.

In the withdrawn position the CEA resides in the Upper Guide Structure (UGS), enclosed in CEA shrouds. The shrouds provide guidance and protect the CEA and the extension shaft from coolant cross flow. Within the core, each CEA finger travels in a Zircaloy guide tube. The guide tubes are part of the fuel assembly structure and ensure proper orientation of the CEAs with respect to the fuel rods.

When the extension shaft is released by the CEDM, gravity causes the CEA to insert into the full length of the fuel assembly. The four outer guide tubes of each assembly have a reduced diameter lower section which allows for hydraulic buffering action to slow down the CEAs near the end of their travel. The CEA velocity is decreased to minimize impact. There is a small bleed hole on the side of the buffer section of the guide tube which prevents pressure buildup and allows some coolant flow. This hydraulic damping action is augmented by a spring arrangement attached between the central CEA post and the hub. When fully inserted, the CEAs rest on the central post of the fuel assembly upper end fitting.

A prototype CEA was installed in Unit 2 at the BOC 3. The changes from standard design included a change in cladding material (from Inconel to SS), reconstitutable fingers, and a change in material for the tips of the poison fingers from Ag/In/Cd to $B_4C$. The size of the $B_4C$ pellets used in the tips was decreased from the pellet size used for the remainder of the rod length. A metal liner was added to prevent any $B_4C$ fragments from collecting in the high flux tip. This CEA was discharged at the End of Cycle (EOC) 8.

In Unit 1, nine CEAs were replaced for Cycle 8 and the rest were replaced for Cycle 9. Eight CEAs (FLCEA2, FLCEA5) were replaced in Unit 2 Cycle 7. The replacement CEAs have essentially the same design as the original components with the exceptions that replacement CEAs have reconstitutable corner fingers, and have Ag-In-Cd tips in all fingers (with the exception of the weakened center CEA in Group 5).

For Unit 2 Cycle 8 and Unit 1 Cycle 10, the first 24-month cycles, the weakened CEA in the center CEA position was replaced with a less weak CEA (FLCEA5) with all reconstitutable fingers.

For Unit 2 Cycle 9, the 69 remaining full-strength, old-style CEAs (with $B_4C$ to the bottom of the center finger) were replaced. The replacements (FLCEA1) were non-reconstitutable and have Ag-In-Cd tips in all fingers. In addition, the weakened center CEA was replaced (Unit 2 Cycle 9 and Unit 1 Cycle 11) with a weakened CEA containing SS in the bottom of each of the four weak fingers (FLCEA6) instead of a Zircaloy slug. The Zircaloy slug was found to be subject to hydriding, in this application.

For Unit 2 Cycle 14, the reduced strength re-constitutable CEA (FLCEA6) was replaced with an equivalent reduced strength non-reconstitutable CEA (FLCEA7).

For Unit 1 Cycle 16, the reduced strength re-constitutable CEA (FLCEA6) was replaced with an equivalent reduced strength non-re-constitutable CEA (FLCEA7). Additionally, eight full strength re-constitutable CEAs with 8" Ag-In-Cd poison stacks (FLCEA2) were replaced with eight full strength non-reconstitutable CEAs with 12" Ag-In-Cd poison stacks (FLCEA8).

For Unit 2 Cycle 15, 12 full length CEAs (10 of the standard design and 2 with reconstitutable corner fingers) were replaced with full strength, non-reconstitutable CEAs with 12” Ag-In-Cd poison stacks (FLCEA8).

For Unit 1 Cycle 17, 68 full-length full-strength re-constitutable CEAs with 8” Ag-In-Cd poison stacks (FLCEA2) were replaced with full-length full-strength non-reconstitutable CEAs with 12” Ag-In-Cd poison stacks (FLCEA8). All of the Unit 1 full-length full-strength CEAs are of the 12” Ag-In-Cd poison stack design.

For Unit 2 Cycle 16, 64 full-length full-strength CEAs with 8” Ag-In-Cd poison stacks were replaced with full-length full-strength CEAs with 12” Ag-In-Cd poison stacks.

All of the Unit 2 full-length full-strength CEAs are of the 12” Ag-In-Cd poison stack design.

For Unit 2 Cycle 18, 2 full-length full-strength CEAs with 12” Ag-In-Cd poison stacks were replaced with full-length full-strength CEAs with 8” Ag-In-Cd poison stacks.

For Unit 1 Cycle 20, 2-full length full-strength CEAs with 12” Ag-In-Cd poison stacks were replaced with full-length full-strength CEAs with 8” Ag-In-Cd poison stacks.

For Unit 2 Cycle 19, all of the full-length full-strength CEAs are of the 12” Ag-In-Cd poison stack design.

For Unit 1 Cycle 21, the center CEA is a full-length part-strength CEA of the 8” Ag-In-Cd poison stack design, and the remaining 76 CEAs are of the full-length full-strength 12” Ag-In-Cd poison stack design.

For Unit 2 Cycle 20, the center CEA is a full-length part-strength CEA of the 8” Ag-In-Cd poison stack design, and one CEA is of the full-length full-strength 8” Ag-In-Cd poison stack design. The remaining 75 CEAs are of the full-length full-strength 12” Ag-In-Cd poison stack design.

There are two approved for use CEA designs, full-length part-strength and full-length full-strength. The center CEA is a full-length part-strength CEA of the 12.5" Ag-In-Cd poison stack design. The remaining 76 CEAs are of the full-length full-strength 12.5" Ag-In-Cd poison stack design.

### 3.3.2.5 Neutron Source Design

A discrete neutron source was required for a quick, safe startup of the original core. Two plutonium-238/antimony-beryllium (Pu/Sb-Be) neutron sources were located in guide tubes of peripheral fuel assemblies. The discrete neutron sources are not necessary for restart, and were removed from the reactor for Unit 1 Cycle 9 and Unit 2 Cycle 8.

### 3.3.2.6 Guide Tube Flux Suppressor Design

For Unit 1 Cycle 11 and Cycle 12, GTFSs were installed into selected peripheral assemblies. The basic design of the GTFSs is identical to that of the CEA fingers with regard to the $B_4C$ pellets, $Al_2O_3$ spacer pellets, and the Inconel 625 cladding (Table 3.3-4). The active core region consists of 116.2" of $B_4C$ with 10.25" of $Al_2O_3$ spacers at each end.

### 3.3.2.7 Test Capsule Assembly Design

The Test Capsule Assembly Program is being conducted to evaluate the effects of irradiation at reactor temperatures on materials being considered for advanced spacer grid spring designs. TCA-1, TCA-2, and TCA-3 (inserted beginning with Unit 1 Cycle 12) consist of, from top to bottom, a holddown assembly, an upper extension tube, 7 capsules connected axially by 6 connecting tubes, and a lower extension tube with an endplug. TCA-4 and TCA-5 (inserted beginning with Unit 1 Cycle 13) consist of, from top to bottom, a holddown assembly, an upper extension tube, containing an unused test capsule, 6 test capsules connected axially by 6 connecting tubes, and a lower extension tube with a bottom endplug that contains a test capsule that is used. The SS holddown assembly, located entirely above the core, is similar to the holddown assembly for a flux suppressor and, like a flux suppressor, is designed to preload the capsule assembly against the bottom of the guide tube in which it resides. The capsules, extension tubes, and connecting tubes are fabricated from Inconel CEA tubing and bar stock material. All tubular sections have holes which allow the free ingress and egress of reactor coolant. The upper extension tube is sized to position the used capsules in the middle 80% of the core. The lower extension tube is designed to extend into the buffer region of the outer guide tube in order to center the capsule assembly and to prevent lateral movement. The purpose of the connecting tubes is to facilitate separation of the capsules from one another using a shearing tool in the spent fuel pool.

In Unit 1 Cycle 12, three test capsules were placed in the outer guide tubes of three separate once-burned fuel assemblies.

Four test capsules were placed in the outer guide tubes of four separate fresh fuel assemblies in Unit 1 Cycle 13. Two of these capsules were from Unit 1 Cycle 12 and two are new capsules.

Two test capsules were placed in the outer guide tubes of two separate fuel assemblies in Unit 1 Cycle 14. Both of these capsules were reinserted from Unit 1 Cycle 13. The 2 test capsules (TCA-3 and TCA-5) were discharged at the end of Unit 1 Cycle 14.

#### 3.3.2.8 <u>ZIRLO Cladding (Westinghouse Fuel)</u>

In the late 1990s, Calvert Cliffs identified clad spallation phenomena on its 2nd cycle high duty fuel. That fuel used the CE standard OPTIN cladding material. OPTIN is an Optimized Process Low Tin cladding that falls within the overall Zircaloy-4 material specification. In order to eliminate the spallation phenomena, Calvert Cliffs elected to switch to an alternate clad material that has better water-side corrosion properties. The alternate cladding material selected is the Westinghouse standard ZIRLO clad material. ZIRLO is a Westinghouse proprietary modification of Zircaloy-4 material achieved by reducing the tin and iron content, eliminating the chromium content, and adding niobium. Calvert Cliffs began to phase in the use of ZIRLO cladding starting with some of the rods for Unit 1 Cycle 16 (Batch 1V).

Westinghouse submitted a topical report (Reference 4) to the NRC. On September 12, 2001, the NRC issued a safety evaluation report to approve the use of ZIRLO cladding material in CE reactors. The NRC authorized full batch implementation of ZIRLO cladding without lead test fuel assemblies, but placed the following restrictions on the use of ZIRLO:

a. The corrosion limit, as predicted by the best-estimate model, will remain below 100 microns for all locations of the fuel.
b. All the conditions listed in the safety evaluations for all the CENPD methodologies used for ZIRLO fuel analysis will continue to be met, except that the use of ZIRLO cladding in addition to Zircaloy-4 cladding is now approved.
c. All CENP methodologies will be used only within the range for which ZIRLO data was acceptable and for which the verifications discussed in Reference 4 and responses to requests for additional information were performed.
d. Until data is available demonstrating the performance or ZIRLO cladding in CE designed plants, the fuel duty will be limited for each CE designed plant with some provision for adequate margin to account for variations in core design (e.g., cycle length, plant operating conditions, etc.). Details of this condition will be addressed on a plant specific basis during the approval to use ZIRLO in a specific plant.

e. The burnup limit for this approval is 60 GWD/MTU.

### 3.3.2.9 M5 Cladding (AREVA/Framatome Fuel)

Beginning with Unit 2 Cycle 19 and Unit 1 Cycle 21, new fuel uses M5® cladding. AREVA submitted a topical report (Reference 5) to the NRC. The NRC issued a safety evaluation report to approve the use of M5® cladding material in CE reactors with the following restrictions:

a. The corrosion limit, as predicted by the best-estimate model, will remain below 100 microns for all locations of the fuel.

b. All the conditions listed in the safety evaluations for all the FANP methodologies used for M5® fuel analysis will continue to be met, except that the use of M5® cladding in addition to Zircaloy-4 cladding is now approved.

c. All FANP methodologies will be used only within the range for which M5® data was acceptable and for which the verifications discussed in References 5 or 6 was performed.

d. The burnup limit for this approval is 62 GWD/MTU.

### 3.3.2.10 Axial Blankets

Beginning with Unit 2 Cycle 16 and Unit 1 Cycle 18, the top and bottom 6 inches of pellets in all new fuel pins contain low enriched (2.6 w/o) fuel. This feature reduces axial neutron leakage and increases fuel economics.

All Zirc diboride fuel pins contain axial blankets with annular holes that remove approximately 25% of the volume of the pellet. The annular holes provide additional volume for gas production as a result of the boron coating being converted into helium gas.

Beginning with Unit 2 Cycle 19 and Unit 1 Cycle 21, the fuel uses 6” of low enriched (≤2.0 w/o) axial blankets on the top and bottom of non-gadolina-bearing fuel rods. Twelve inches of low enriched (≤2.0 w/o) axial blankets are used on the top and bottom of gadolina-bearing fuel rods.

### 3.3.2.11 Radial Enrichment Zoning

Unit 2 Cycle 16 and Unit 1 Cycle 18 saw the introduction of radial enrichment zoning. In these cycles, eight pins adjacent to each CEA guide tube (40 in all) and three pins at each assembly corner (12 in all) contained a lower enrichment than the other fuel pins. Beginning in Unit 2 Cycle 17, some of the subbatches are as described above, and in others, three enrichments are used. The three enrichment patterns are intended primarily to reduce calculated steaming rates.

Beginning with Unit 2 Cycle 19 and Unit 1 Cycle 21, the fuel uses two-enrichment radial zoning with the eight pins adjacent to each CEA guide tube (40 in all) and three pins at each assembly corner (12 in all) containing a lower enrichment than the other fuel non-Gadolinia pins.

### 3.3.2.12 Armoring

The Framatome approved topical report, ANF-90-082 (P) (A), for reconstituting fuel assemblies at CCNPP allows for replacing fuel rods with inert rods. Inert rods are identical to fuel rods except they have stainless steel slugs where fuel rods have fuel pellets. Inert rods may be inserted for various reasons such as armoring or removal of a failed fuel rod and backfilling of the vacancy with an inert rod. Armoring is the insertion of up to 9 inert rods in a single peripheral row of an assembly performed by Framatome at either their own manufacturing facility or at the Calvert Cliffs Nuclear Power Plant. The main purpose of armoring is to mitigate grid to rod fretting failures by armoring fuel assemblies against the shroud with up to 9 inert rods in each assembly. Non cycle specific armoring has been evaluated under Reference 9.

### 3.3.3 REACTOR INTERNAL STRUCTURES

The reactor internals are designed to support and orient the reactor core fuel assemblies and CEAs, absorb the CEA dynamic loads and transmit these and other loads to the reactor vessel flange, provide a passageway for the reactor coolant, and guide incore instrumentation.

The internals are designed to safely perform their functions during all steady state conditions and during DBEs. The internals are designed to safely withstand the forces due to deadweight, handling, system pressure, flow impingement, temperature differential, vibration and seismic acceleration. All reactor components are considered Category I for seismic design. The reactor internals design provides limits of deflection where functionally required. The structural components satisfy stress values given in the ASME B&PV Code, Section III. Certain components have been subjected to a fatigue analysis. Where appropriate, the effect of neutron irradiation on the materials concerned is included in the design evaluation.

The components of the reactor internals are divided into three major parts:

a. The core support barrel,
b. The lower core support structure (including the core shroud), and
c. The UGS (including the CEA shrouds and the ICI guide tubes).

The flow skirt, although functioning as an integral part of the coolant flow path, is separate from the internals and is affixed to the bottom head of the pressure vessel (Figure 3.1-1).

#### 3.3.3.1 Core Support Assembly

The major support member of the reactor internals is the core support assembly. This assembled structure consists of the core support barrel, the lower support structure, and the core shroud. The major material for the assembly is Type 304 SS. The core support barrel supports the core support assembly.

The upper flange of the core support barrel rests on a ledge in the reactor vessel flange. The lower flange of the core support barrel supports and positions the lower support structure. The core support plate transmits the weight of the core to the core support barrel by means of vertical columns, an annular skirt, and beam structure. The core support plate provides support and orientation for the fuel assemblies. The core shroud, which provides lateral support for the peripheral fuel assemblies, is also supported by the core support plate. The lower end of the core support barrel is restrained radially by six snubbers.

#### 3.3.3.2 Core Support Barrel

The core support barrel approximates a right circular cylinder with a nominal inside diameter of 148" and a minimum wall thickness of 1-3/4". It is suspended by a 4" thick flange from a ledge on the pressure vessel. The core support barrel supports the lower support structure upon which the fuel assemblies rest. Press fitted into the flange of the core support barrel are four alignment keys located 90° apart. The reactor vessel, the closure head, and the UGS assembly flanges are slotted in locations corresponding to the alignment key locations to provide proper alignment and to prevent excess motion between these components in the vessel flange region.

Since the core support barrel is about 27' long and is supported only at its upper end, it is possible that coolant flow could induce vibrations in the structure. Therefore, amplitude limiting devices, or snubbers (Figure 3.3-12), are installed on the outside of the core support barrel near the bottom end. The snubbers consist of six equally spaced double lugs around the circumference and are the grooves of a "tongue-and-groove" assembly; the pressure vessel lugs are the tongues. Minimizing the clearance between the two mating pieces limits the amplitude of any vibration. The pressure vessel tongues have bolted, lock welded Inconel X shims and the core support barrel grooves are hard faced with Stellite to minimize wear. With this design, the internals may be viewed as a beam with supports at the furthest extremities. Radial and axial expansion of the core support barrel are accommodated, but lateral movement of the core support barrel is restricted by this design.

#### 3.3.3.3 Core Support Plate and Support Column

The core support plate aligns the fuel assemblies and directs coolant flow through them. It is a 147" diameter, 2" thick, Type 304 SS plate with the necessary machined flow distributor holes for the fuel assemblies. Fuel assembly locating pins (four for each assembly) are shrink-fitted into the support plate. An annular skirt, columns, and support beams are located between the support plate and the bottom of the core support barrel. They provide a support for this plate and transmit the core load to the bottom flange of the core support barrel.

#### 3.3.3.4 Core Shroud

The core shroud (Figure 3.3-13) provides an envelope for the core and limits the amount of coolant bypass flow. The shroud is 152-1/2" tall and 147-5/16" in diameter. The shroud consists of two Type 304 SS ring sections, aligned by means of radial shear pins and attached to the core support plate by eight Type 348 SS tie rods for Unit 2 and seven Type 348 SS tie rods for Unit 1. A gap is maintained between the core shroud outer perimeter and the core support barrel in order to provide some coolant flow upward between the core shroud and core support barrel. This minimizes thermal stresses in the core shroud and eliminates stagnant pockets.

The gap between the outside of the peripheral fuel assemblies and the shroud is maintained by eight tiers of stiffening plates attached to the shroud. In locations where mechanical connections are used, bolts and pins are lock welded. All bolts are designed to be captured in the event of fracture. The bolt heads are trapped by lock bars or lock welds and the bolt bodies are trapped by incomplete tapping of holes. Holes are provided in the core support structure to allow coolant to flow upward between the core shroud and the core support barrel, thereby minimizing thermal stresses in the shroud and eliminating stagnant pockets.

The reactor internals have been evaluated and only four (4) or more tie rods are required to be functional, see References 7 and 8.

#### 3.3.3.5 Flow Skirt

The Inconel flow skirt is a 3,500 pound right circular cylinder, perforated with 2-11/16 in. diameter holes, and reinforced at the top and bottom with stiffening rings. The flow skirt is used to reduce inequalities in core inlet flow distributions and to prevent formation of large vortices in the lower plenum. The skirt provides a nearly equalized pressure distribution across the bottom of the core support barrel. The skirt is supported by nine equally spaced machined sections which are welded to the bottom head of the pressure vessel.

### 3.3.3.6 Upper Guide Structure Assembly

The UGS assembly (Figure 3.3-14) consists of:

a. The upper support structure;
b. Sixty-five CEA shrouds;
c. A fuel assembly alignment plate; and,
d. An expansion compensating ring.

The UGS assembly aligns and laterally supports the upper end of the fuel assemblies, maintains the CEA spacing, prevents fuel assemblies from being lifted out of position during a severe accident condition, and protects the CEAs from the effect of coolant cross flow in the upper plenum. The UGS is handled as one unit during installation and is removed for refueling.

The upper end of the UGS assembly is a support plate welded to a grid array of 24" deep beams and a 24" deep cylinder which encloses, and is welded to the ends of the beams. The periphery of the plate contains four accurately machined and located alignment keyways, equally spaced at 90° intervals, which engage the core barrel alignment keys. The reactor vessel closure head flange is slotted to engage the upper ends of the alignment keys in the core barrel. This system of keys and slots provides an accurate means of aligning the core with the closure head. The grid structure aligns and supports the upper end of the CEA shrouds.

The CEA shrouds extend from the fuel assembly alignment plate to an Elevation about 3' above the support plate. There are 45 single-type shrouds. These consist of cylindrical upper sections welded to integral bottom sections, which are shaped to provide flow passages for the coolant passing through the alignment plate while shrouding the CEAs from cross flow. Also, there are 20 dual-type shrouds which, in configuration, consist of two single-type shrouds connected by a rectangular section shaped to accommodate the dual CEAs. The bottoms of the shrouds are bolted to the fuel assembly alignment plate. At the UGS support plate, the single shrouds are connected to the plate by spanner nuts which permit axial adjustment. The spanner nuts are tightened to the proper torque and lock-welded. The dual shrouds are welded to the upper plate.

The fuel assembly alignment plate is designed to align the upper ends of the fuel assemblies and the lower ends of the CEA shrouds, as well as support the CEA shrouds. Precision machined and located holes in the fuel assembly alignment plate align the fuel assemblies (Figure 3.3-6). The fuel assembly alignment plate also has four equally spaced slots on its outer edge which engage with Stellite hard-faced pins protruding from the core shroud to limit lateral motion of the UGS assembly during operation. The alignment plate load and the weight of a fuel assembly produce a net downward force to counteract upward hydraulic forces for normal operating conditions and all DBEs. The fuel assembly alignment plate would capture the core and limit upward movement in the event of an accident.

A holddown ring acts as a shim between the reactor vessel flange and the UGS. It resists axial upward movement of the UGS assembly. This arrangement accommodates axial differential thermal expansion between the core barrel flange, UGS flange, the reactor vessel flange mating surface and head flange recess. The UGS also supports the incore instrumentation guide tubes. The tubes are conduits which protect the incore instrumentation and guide them during removal and insertion operations.

## 3.3.4 CONTROL ELEMENT DRIVE MECHANISM

### 3.3.4.1 Design

The CEDM is of the magnetic jack-type drive. Each CEDM is capable of withdrawing, inserting, holding, or tripping the CEA from any point within its 137" stroke (Figure 3.3-15). The design of the CEDM is identical to that for Maine Yankee (Reference 2).

The CEDM drives the CEA within the reactor core and indicates the position of the CEA with respect to the core. The speed at which the CEA is inserted or withdrawn from the core is consistent with the reactivity change requirements during reactor operation. For conditions that require a rapid shutdown of the reactor, the CEDM coils are deenergized, allowing the CEA and the extension shaft to drop into the core by gravity. The reactivity is reduced during such a drop at a rate sufficient to control the core under any operating transient or accident condition.

The CEA is decelerated at the end of the drop by the buffer section of the CEA guide tubes.

Originally, 65 CEDMs (61 CEDMs on the replacement reactor vessel closure head) were mounted on flanged nozzles on top of the reactor vessel closure head. Eight CEDMs were nonscrammable and were connected to the PLCEAs which have been removed (4 spare CEDMs are installed in the replacement reactor vessel closure head). Each CEDM extension shaft is connected to a CEA by a locked coupling. The weight of the CEAs and CEDMs is carried by the vessel head.

The CEDM is designed to handle dual or single CEAs. The total stroke of the drive is 137". The maximum withdrawing speed of CEDMs is 30" per minute for single CEAs and 20" per minute for dual CEAs. The maximum allowed time from receiving a trip signal to the essentially fully inserted position of the CEA is specified in the Technical Specifications.

a. CEDM Pressure Housing

   Each CEDM housing is attached to the reactor vessel head nozzle by means of a threaded joint and seal welded. It need not be removed since all servicing of the CEDM is performed from the top of the CEDM housing. This opening is closed by means of a threaded cap and omega seal weld.

   The CEDM upper housing design and fabrication conforms to the requirements of the ASME B&PV Code, Section III, for Class 1 appurtenances for the replacement reactor vessel closure head). The housing is designed for steady state conditions as well as all anticipated pressure and thermal transients.

b. Magnetic Jack Assembly

   The magnetic jack motor assembly fits into the CEDM housing through an opening in the top of the housing. This integral unit carries the motor tube, lift and hold pawls, and magnets. Electrical coils positioned around the CEDM housing supply the drive power. The CEDMs are cooled by forced air which maintains CEDM coil temperature below 350°F. Loss of cooling air will not prevent the CEDM from releasing the CEAs when a reactor trip is initiated. A description of the air circulation system is presented in Chapter 9.

The upper housing cap is threaded into the CEDM housing and seal welded after the CEDM motor assembly is inserted. This cap supports the position indication housing which encloses the CEDM extension shaft.

The lifting operation consists of a series of magnetically-operated step movements. Two sets of mechanical latches engage a notched drive shaft. To prevent excessive latch wear, a means has been provided to unload the latches during the engaging and disengaging operations.

The magnetic force is obtained from large DC magnet coils mounted on the outside of the motor tube. Power for the electromagnets is obtained from two separate supplies. A control programmer actuates the stepping cycle and positions the CEA by a forward or reverse stepping sequence. The CEA is held stationary by energizing one coil at a reduced current while all other coils are deenergized. The CEAs are tripped upon interruption of electrical power to all coils.

c. Position Indication

Three separate means are provided for transmitting CEA position indication.

The first method utilizes the electrical pulses from the magnetic coil power programmer. The second method utilizes reed switches and a voltage divider network mounted on the CEDM to provide an output voltage proportional to CEA position. The third method utilizes three pairs of reed switches spaced at discrete locations within a position transmitter assembly. A permanent magnet built into the drive shaft actuates the reed switches one at a time as it passes by them. CEA position instrumentation is discussed in detail in Chapter 7.

d. Control Element Assembly Disconnect

The CEA connects to the drive shaft extension with an internal collet-type coupling at its lower end. Coupling is performed before the vessel head is installed. In order to disengage the CEA from the drive shaft extension, a tool is attached to the top end of the drive shaft when the reactor vessel head (along with all the CEDMs) has been removed.

By pulling up on the spring-loaded operating rod in the center of the drive shaft, a tapered plunger is withdrawn from the center of the collet-type gripper causing it to collapse due to axial pressure from the CEA, thus permitting removal of the coupler from the CEA. Releasing the operating rod plunger after the coupler has been withdrawn from the CEA expands the coupler to a diameter that prevents recoupling to the CEA. At this point, the drive shaft buffer is resting on the positive stop in the CEA shroud. The drive shafts, uncoupled from the CEAs, are removed along with the UGS (when the UGS is removed from the vessel).

### 3.3.5 REFERENCES

1. Deleted
2. Maine Yankee Final Safety Report, Docket No. 50-309
3. Letter from A.E. Scherer (CE) to C.O. Thomas (NRC), "CEA Guide Tube Wear Sleeve Modification," LD-84-043, August 3, 1984

4. CENPD-404-P-A, “Implementation of ZIRLO Cladding Material in CE Nuclear Power Fuel Assembly Designs,” November 2001
5. BAW-10240P-A, Revision 0, “Incorporation of M5 Properties in Framatome ANP Approved Methods,” May 2004
6. BAW-10227P-A, Revision 01, “Evaluation of Advanced Cladding and Structural Material (M5) in PWR Reactor Fuel,” June 2003
7. CA10415, Revision 0, "A summary of the Method and Results for Qualification of the Core Shroud Tie Rods at Calvert Cliffs Units 1 and 2"
8. ECP-18-000534, Revision 0, "Design Analysis for Continued Operation of Units 1 and 2, Beyond One Cycle due to Failed Core Shroud Tie Rods'
9. ECP-19-000592, Revision 0, "The Use of Inert Rods at Calvert Cliffs Nuclear Power Plant (CCNPP)"

## TABLE 3.3-1

## UNIT 1 BATCH-RELATED DATA

| BATCH DESIGNATION | INITIAL ASSEMBLY AVERAGE ENRICHMENT wt% U-235 | NUMBER OF $B_4C$ SHIMS PER ASSEMBLY | INITIAL SHIM LOADING wt% $B_4C$ | AVERAGE WEIGHT OF URANIUM PER ASSEMBLY Kg U | FUEL RODS PER ASSEMBLY |
|---|---|---|---|---|---|
| 1A | 2.05 | 0 | --- | 395 | 176 |
| 1B | 2.45 | 12 | 2.9 | 368 | 164 |
| 1C | 2.99 | 0 | --- | 395 | 176 |
| 1C+ | 2.99 | 12 | 1.1 | 369 | 164 |
| 1C. | 2.99 | 12 | .68 | 368 | 164 |
| 1D | 3.03 | 0 | --- | 388 | 176 |
| 1D/ | 2.73 | 0 | --- | 388 | 176 |
| 1E | 3.03 | 0 | --- | 388 | 176 |
| 1E/ | 2.73 | 0 | --- | 387 | 176 |
| 1F | 3.03 | 0 | --- | 389 | 176 |
| 1F/ | 2.73 | 0 | --- | 389 | 176 |
| 1G | 3.65 | 0 | --- | 388 | 176 |
| 1G/ | 3.03 | 8 | 3.03 | 371 | 168 |
| 1H | 4.00 | 0 | --- | 389 | 176 |
| 1H/ | 3.55 | 8 | 3.03 | 372 | 168 |
| 1J | 4.05 | 0 | --- | 389 | 176 |
| 1J* | 3.40 | 0 | --- | 389 | 176 |
| 1K | 4.05 | 0 | --- | 389 | 176 |
| 1K* | 3.40 | 0 | --- | 388 | 176 |
| 1L | 4.05 | 0 | --- | 388 | 176 |
| 1L* | 3.40 | 0 | --- | 388 | 176 |
| 1M | 4.08 | 0 | --- | 393 | 176 |
| 1M* | 4.08 | 12 | 4.09 | 365 | 164 |
| 1MX | 3.85 | 0 | --- | 377 | 176 |
| 1N | 4.20 | 0 | --- | 393 | 176 |
| 1NX | 4.20 | 4 | 4.04 | 383 | 172 |
| 1N/ | 4.20 | 8 | 4.04 | 373 | 168 |

Batch 1MX is Advanced Nuclear Fuel (ANF) demonstration fuel with 12 $Gd_2O_3$ (10 wt%) fuel bearing (natural uranium) poison rods per assembly.

## TABLE 3.3-1

## UNIT 1 BATCH-RELATED DATA

| BATCH DESIGNATION | INITIAL ASSEMBLY AVERAGE ENRICHMENT wt% U-235 | NUMBER OF ERBIUM SHIMS PER ASSEMBLY | INITIAL SHIM LOADING wt% $Er_2O_3$ | AVERAGE WEIGHT OF URANIUM PER ASSEMBLY Kg U | FUEL RODS PER ASSEMBLY |
|---|---|---|---|---|---|
| 1P0 | 4.30 | 0 | 0.0 | 392 | 176 |
| 1P1 | 4.30 | 20 | 2.0 | 392 | 176 |
| 1P2 | 4.30 | 44 | 2.0 | 391 | 176 |
| 1P3 | 4.30 | 60 | 2.0 | 390 | 176 |
| 1R0 | 4.48 | 20 | 2.00 | 391 | 176 |
| 1R1 | 4.48 | 44 | 2.00 | 391 | 176 |
| 1R2 | 4.48 | 68 | 2.00 | 390 | 176 |
| 1RT | 4.00 (VAP) | 44 | 1.75 | 408 | 176 |
| 1S0 | 4.30 | 0 | 0.0 | 393 | 176 |
| 1S1 | 4.30 | 20 | 2.0 | 393 | 176 |
| 1S2 | 4.30 | 44 | 2.0 | 392 | 176 |
| 1S3 | 4.30 | 68 | 2.0 | 391 | 176 |
| 1T0 | 4.28 (VAP) | 0 | 0.0 | 408 | 176 |
| 1T1 | 4.28 (VAP) | 20 | 1.75 | 408 | 176 |
| 1T2 | 4.28 (VAP) | 44 | 1.75 | 407 | 176 |
| 1V0 | 4.25 (VAP) | 0 | 0.0 | 410 | 176 |
| 1V1 | 4.25 (VAP) | 44 | 1.75 | 408 | 176 |
| 1V2 | 4.25 (VAP) | 60 | 1.75 | 407 | 176 |
| 1W0 | 4.25 (VAP) | 0 | 0.00 | 409 | 176 |
| 1W1 | 4.25 (VAP) | 20 | 2.00 | 409 | 176 |
| 1W2 | 4.25 (VAP) | 44 | 2.00 | 407 | 176 |
| 1W3 | 4.25 (VAP) | 60 | 2.00 | 406 | 176 |
| 1W4 | 4.25 (VAP) | 60 | 2.00 | 406 | 176 |

## TABLE 3.3-1

## UNIT 1 BATCH-RELATED DATA

| BATCH DESIGNATION | INITIAL ENRICHMENTS wt% U-235 | NUMBER OF $ZrB_2$ SHIMS PER ASSEMBLY | INITIAL SHIM LOADING (mg-B-10/ inch) | AVERAGE WEIGHT OF URANIUM PER ASSEMBLY Kg U | FUEL RODS PER ASSEMBLY |
|---|---|---|---|---|---|
| 1X1 | 2.6/4.0/4.5 (VAP) | 44 | 3.29 | 407 | 176 |
| 1X2 | 2.6/4.0/4.5 (VAP) | 52 | 3.29 | 407 | 176 |
| 1X3 | 2.6/4.0/4.5 (VAP) | 64 | 3.29 | 406 | 176 |
| 1X4 | 2.6/4.0/4.5 (VAP) | 76 | 3.29 | 406 | 176 |
| 1X5 | 2.6/4.0/4.5 (VAP) | 96 | 3.29 | 405 | 176 |
| 1X7 | 2.0 (VAP) | 0 | 0 | 409 | 176 |
| 1Z1 | 4.95/4.65/2.60 (VAP) | 0 | 0 | 409 | 176 |
| 1Z2 | 4.95/4.65/2.60 (VAP) | 28 | 3.29 | 408 | 176 |
| 1Z3 | 4.95/4.65/2.60 (VAP) | 44 | 3.29 | 407 | 176 |
| 1Z4 | 4.95/4.65/4.00/2.60 (VAP) | 64 | 3.29 | 406 | 176 |
| 1Z5 | 4.95/4.65/4.00/2.60 (VAP) | 76 | 3.29 | 406 | 176 |
| 1Z6 | 4.95/4.65/4.00/2.60 (VAP) | 96 | 3.29 | 405 | 176 |
| AA1 | 4.95/4.00/2.60 (VAP) | 28 | 3.29 | 407 | 176 |
| AA2 | 4.95/4.00/2.60 (VAP) | 52 | 3.29 | 406 | 176 |
| AA3 | 4.95/4.55/4.00/2.60 (VAP) | 64 | 3.29 | 406 | 176 |
| AA4 | 4.95/4.55/4.00/2.60 (VAP) | 76 | 3.29 | 405 | 176 |
| AA5 | 4.95/4.55/4.00/2.60 (VAP) | 96 | 3.29 | 404 | 176 |
| 2X7 | 2.00 (VAP) | 0 | 0 | 409 | 176 |

VAP Value Added Pellet

Batch 2X7 assemblies were purchased as spare assemblies for Unit 2 Cycle 18. They were not used for U2C18; hence they are being employed for U1C20.

## TABLE 3.3-1

## UNIT 1 BATCH-RELATED DATA

| BATCH DESIGNATION | INITIAL ENRICHMENTS wt% U-235 | NUMBER OF $Gd_2O_3$ RODS PER ASSEMBLY | INITIAL $Gd_2O_3$ LOADING wt% | AVERAGE WEIGHT OF URANIUM PER ASSEMBLY Kg U | FUEL RODS PER ASSEMBLY |
|---|---|---|---|---|---|
| AB1 | 4.60/4.00/2.00<br>(3.60/2.60) | 4/12 | 4/8 | 407 | 176 |
| AB2 | 4.60/4.00/2.00<br>(3.60/3.20) | 4/12 | 4/6 | 408 | 176 |
| AB3 | 4.60/4.00/2.00<br>(3.60) | 12 | 4 | 409 | 176 |

| BATCH DESIGNATION | INITIAL ENRICHMENTS wt% U-235 | NUMBER OF $Gd_2O_3$ RODS PER ASSEMBLY | INITIAL $Gd_2O_3$ LOADING wt% | AVERAGE WEIGHT OF URANIUM PER ASSEMBLY Kg U | FUEL RODS PER ASSEMBLY |
|---|---|---|---|---|---|
| AC1 | 4.87/4.20/2.00<br>(3.60/2.80) | 4/12 | 4/8 | 407 | 176 |
| AC2 | 4.87/4.20/2.00<br>(3.20) | 12 | 6 | 408 | 176 |
| AC3 | 4.87/4.20/2.00<br>(3.60) | 8 | 4 | 409 | 176 |

| BATCH DESIGNATION | INITIAL ENRICHMENTS wt% U-235 | NUMBER OF $Gd_2O_3$ RODS PER ASSEMBLY | INITIAL $Gd_2O_3$ LOADING wt% | AVERAGE WEIGHT OF URANIUM PER ASSEMBLY Kg U | FUEL RODS PER ASSEMBLY |
|---|---|---|---|---|---|
| AD1 | 4.90/4.30/2.00<br>(3.60/2.50) | 4/12 | 4/8 | 407 | 176 |
| AD2 | 4.90/4.30/2.00<br>(3.60/3.20) | 4/12 | 4/6 | 408 | 176 |
| AD3 | 4.90/4.30/2.00<br>(3.60) | 12 | 4 | 409 | 176 |
| AD4 | 4.90/4.30/2.00<br>(3.60/3.20) | 4/4 | 4/6 | 409 | 176 |

## TABLE 3.3-1

## UNIT 1 BATCH-RELATED DATA

| BATCH DESIGNATION | INITIAL ENRICHMENTS wt% U-235 | NUMBER OF $Gd_2O_3$ RODS PER ASSEMBLY | INITIAL $Gd_2O_3$ LOADING wt% | AVERAGE WEIGHT OF URANIUM PER ASSEMBLY Kg U | FUEL RODS PER ASSEMBLY |
|---|---|---|---|---|---|
| AE1 | 4.85/4.25/1.60<br>(4.25/3.40) | 8/12 | 2/6 | 408 | 176 |
| AE2 | 4.85/4.25/1.60<br>(3.60/3.40) | 8/8 | 4/6 | 408 | 176 |
| AE3 | 4.85/4.25/1.60<br>(3.60) | 12 | 4 | 409 | 176 |
| AE4 | 4.85/4.25/1.60<br>(3.40) | 8 | 6 | 409 | 176 |
| AE5 | 4.85/4.25/1.60<br>(3.60) | 8 | 4 | 409 | 176 |

## TABLE 3.3-1

## UNIT 1 BATCH-RELATED DATA

| BATCH DESIGNATION | INITIAL ENRICHMENTS wt% U-235 | NUMBER OF $Gd_2O_3$ RODS PER ASSEMBLY | INITIAL $Gd_2O_3$ LOADING wt% | AVERAGE WEIGHT OF URANIUM PER ASSEMBLY Kg U | FUEL RODS PER ASSEMBLY |
|---|---|---|---|---|---|
| AF1 | 4.92 / 4.31 / 1.60<br>( 4.31 / 3.40 ) | 8 / 12 | 2.0 / 6.0 | 408 | 176 |
| AF2 | 4.92 / 4.31 / 1.60<br>( 3.40 ) | 16 | 6.0 | 408 | 176 |
| AF3 | 4.92 / 4.31 / 1.60<br>( 3.80 / 3.40 ) | 4 / 12 | 4.0 / 6.0 | 408 | 176 |
| AF4 | 4.92 / 4.31 / 1.60<br>( 3.80 ) | 12 | 4.0 | 409 | 176 |
| AF5 | 4.92 / 4.31 / 1.60<br>( 2.95 ) | 8 | 4.0 | 410 | 176 |
| AF6 | 2.95 / 1.30<br>( 2.95 ) | 8 | 4.0 | 410 | 176 |
| AF7[a] | 2.00 / 1.60 | 0 | 0 | 392 | 168 |

# TABLE 3.3-1

## UNIT 1 BATCH-RELATED DATA

### UNIT 1 CYCLE 1

| ASSEMBLY BATCH | NUMBER OF ASSEMBLIES | TOTAL SHIMS | TOTAL FUEL RODS |
|---|---|---|---|
| 1A | 69 | 0 | 12,144 |
| 1B | 80 | 960 | 13,108 |
| 1C | 40 | 0 | 7,040 |
| 1C+ | 16 | 192 | 2,624 |
| 1C. | 12 | 144 | 1,968 |
| TOTALS | 217 | 1,296 | 36,896 |

In Cycle 1, Batch B included three test assemblies. Each contains four SS rods as well as twelve poison rods.

### UNIT 1 CYCLE 2

| ASSEMBLY BATCH | NUMBER OF ASSEMBLIES | TOTAL SHIMS | TOTAL FUEL RODS |
|---|---|---|---|
| 1B | 77 | 924 | 12,620 |
| 1C | 40 | 0 | 7,040 |
| 1C+ | 16 | 192 | 2,624 |
| 1C. | 12 | 144 | 1,968 |
| 1D | 48 | 0 | 8,448 |
| 1D/ | 24 | 0 | 4,224 |
| TOTALS | 217 | 1,260 | 36,924 |

In Cycle 2, Batch B included two test assemblies. Each contains four SS rods as well as twelve poison rods.

### UNIT 1 CYCLE 3

| ASSEMBLY BATCH | NUMBER OF ASSEMBLIES | TOTAL SHIMS | TOTAL FUEL RODS |
|---|---|---|---|
| 1A | 40 | 0 | 7,040 |
| 1B | 1 | 12 | 160 |
| 1C | 32 | 0 | 5,632 |
| 1D | 48 | 0 | 8,448 |
| 1D/ | 24 | 0 | 4,224 |
| 1E | 48 | 0 | 8,448 |
| 1E/ | 24 | 0 | 4,224 |
| TOTALS | 217 | 12 | 38,176 |

In Cycle 3, Batch B is a test assembly. In addition to the twelve poison rods, it contains four SS rods.

## TABLE 3.3-1

## UNIT 1 BATCH-RELATED DATA

### UNIT 1 CYCLE 4

| ASSEMBLY BATCH | NUMBER OF ASSEMBLIES | TOTAL SHIMS | TOTAL FUEL RODS |
|---|---|---|---|
| 1B* | 1 | 12 | 160 |
| 1D | 48 | 0 | 8,488 |
| 1D/ | 24 | 0 | 4,224 |
| 1E | 48 | 0 | 8,448 |
| 1E/ | 24 | 0 | 4,224 |
| 1F | 48 | 0 | 8,448 |
| 1F/ | 24 | 0 | 4,224 |
| TOTALS | 217 | 12 | 38,176 |

* This is the test assembly. In addition to the twelve poison rods, it contains four SS rods, one in each corner.

### UNIT 1 CYCLE 5

| ASSEMBLY BATCH | NUMBER OF ASSEMBLIES | TOTAL SHIMS | TOTAL FUEL RODS |
|---|---|---|---|
| 1D | 1 | 0 | 175 |
| 1E | 48 | 0 | 8,448 |
| 1E/ | 4 | 0 | 704 |
| 1F | 48 | 0 | 8,448 |
| 1F/ | 24 | 0 | 4,224 |
| 1G | 40 | 0 | 7,040 |
| 1G/ | 52 | 416 | 8,736 |
| TOTALS | 217 | 416 | 37,775 |

In Cycle 5, the Batch 1D fuel assembly contains one SS rod.

### UNIT 1 CYCLE 6

| ASSEMBLY BATCH | NUMBER OF ASSEMBLIES | TOTAL SHIMS | TOTAL FUEL RODS |
|---|---|---|---|
| 1D | 1 | 0 | 176 |
| 2D | 8 | 0 | 1,408 |
| 1F | 44 | 0 | 7,743 |
| 1G | 40 | 0 | 7,040 |
| 1G/ | 52 | 416 | 8,736 |
| 1H | 40 | 0 | 7,040 |
| 1H/ | 32 | 256 | 5,376 |
| TOTALS | 217 | 672 | 37,519 |

Batch F includes one test assembly (SCOUT) that contains an SS rod.

# TABLE 3.3-1

## UNIT 1 BATCH-RELATED DATA

### UNIT 1 CYCLE 7

| ASSEMBLY BATCH | NUMBER OF ASSEMBLIES | TOTAL SHIMS | TOTAL FUEL RODS |
|---|---|---|---|
| 2B | 12 | 144 | 1,968 |
| 2D/ | 12 | 0 | 2,112 |
| 1E/ | 12 | 0 | 2,112 |
| 1F | 5 | 0 | 877 |
| 1G | 40 | 0 | 7,038 |
| 1H | 40 | 0 | 7,040 |
| 1H/ | 32 | 256 | 5,376 |
| 1J | 48 | 0 | 8,448 |
| 1J* | 16 | 0 | 2,816 |
| TOTALS | 217 | 400 | 37,787 |

Batch F includes one test assembly (SCOUT) that contains three SS rods.

Batch G includes four test assemblies (PROTOTYPE) that contains two stainless steel rods.

### UNIT 1 CYCLE 8

| ASSEMBLY BATCH | NUMBER OF ASSEMBLIES | NON-FUEL RODS | TOTAL FUEL RODS |
|---|---|---|---|
| 2E | 4 | 0 | 704 |
| 1F | 1 | 3 | 173 |
| 1G | 4 | 3 | 701 |
| 1H/ | 32 | 256 | 5,376 |
| 1H | 40 | 0 | 7,040 |
| 1J* | 16 | 0 | 2,816 |
| 1J | 48 | 0 | 8,448 |
| 1K* | 24 | 0 | 4,224 |
| 1K | 48 | 0 | 8,448 |
| TOTALS | 217 | 262 | 37,930 |

The Batch F assembly is a test assembly (SCOUT) that contains three stainless steel rods.

The four Batch G test assemblies (PROTOTYPE) contain three SS rods.

## TABLE 3.3-1

## UNIT 1 BATCH-RELATED DATA

### UNIT 1 CYCLE 9

| ASSEMBLY BATCH | NUMBER OF ASSEMBLIES | NON-FUEL RODS | TOTAL FUEL RODS |
|---|---|---|---|
| 2E | 24 | 0 | 4,224 |
| 1G | 4 | 2 | 702 |
| 1H | 1 | 0 | 176 |
| 1J* | 16 | 0 | 2,816 |
| 1J | 48 | 2 | 8,446 |
| 1K* | 24 | 2 | 4,222 |
| 1K | 48 | 2 | 8,446 |
| 1L* | 12 | 0 | 2,112 |
| 1L | 40 | 0 | 7,040 |
| TOTALS | 217 | 8 | 38,184 |

All non-fuel rods in Cycle 9 contain SS.

In Batch 1G, one test assembly (PROTOTYPE) contains two SS rods. Prior to Cycle 9, one SS rod was replaced with a test rod from SCOUT.

Batch 1J includes one assembly with two stainless rods.

Batch 1K includes two assemblies with a total of two stainless rods.

Batch 1K* includes two assemblies with a total of two stainless rods.

### UNIT 1 CYCLE 10

| ASSEMBLY BATCH | NUMBER OF ASSEMBLIES | NON-FUEL RODS | TOTAL FUEL RODS |
|---|---|---|---|
| 1K | 48 | 2 | 8,446 |
| 1K* | 21 | 2 | 3,694 |
| 1L | 40 | 2 | 7,038 |
| 1L* | 12 | 2 | 2,110 |
| 1M | 16 | 0 | 2,816 |
| 1M* | 76 | 912 | 12,464 |
| 1MX | 4 | 0 | 704 |
| TOTALS | 217 | 920 | 37,272 |

Batch 1L includes one assembly with two SS rods.

Batch 1L* includes two assemblies with a total of two SS rods.

Batch 1MX is ANF demonstration fuel with 12 $Gd_2O_3$ (10 wt%) fuel bearing (natural uranium) poison rods per assembly.

Batches 1K and 1K* have four assemblies with one SS rod in each.

## TABLE 3.3-1

## UNIT 1 BATCH-RELATED DATA

### UNIT 1 CYCLE 11

| ASSEMBLY BATCH | NUMBER OF ASSEMBLIES | NON-FUEL RODS | TOTAL FUEL RODS |
|---|---|---|---|
| 1K* | 1 | 0 | 176 |
| 1L | 36 | 3 | 6,333 |
| 1M | 16 | 2 | 2,814 |
| 1M* | 76 | 923 | 12,453 |
| 1MX | 4 | 0 | 704 |
| 1N | 12 | 0 | 2,112 |
| 1NX | 20 | 80 | 3,440 |
| 1N/ | 52 | 416 | 8,736 |
| TOTALS | 217 | 1,424 | 36,768 |

Batch 1L includes two assemblies with a total of three SS rods.

Batch 1M includes one assembly with a total of two SS rods.

Batch 1M* includes five assemblies with a total of eleven SS rods.

Batch 1MX is ANF demonstration fuel with 12 $Gd_2O_3$ (10 wt%) fuel bearing (natural uranium) poison rods per assembly.

### UNIT 1 CYCLE 12

| ASSEMBLY BATCH | NUMBER OF ASSEMBLIES | NON-FUEL RODS | TOTAL FUEL RODS |
|---|---|---|---|
| 1K* | 1 | 0 | 176 |
| 1L | 4 | 1 | 703 |
| 1M | 16 | 2 | 2,814 |
| 1M* | 20 | 245 | 3,275 |
| 1MX | 4 | 0 | 704 |
| 1N | 12 | 0 | 2,112 |
| 1NX | 20 | 80 | 3,440 |
| 1N/ | 52 | 416 | 8,736 |
| 1P0 | 16 | 0 | 2,816 |
| 1P1 | 12 | 0 | 2,112 |
| 1P2 | 8 | 0 | 1,408 |
| 1P3 | 52 | 0 | 9,152 |
| TOTALS | 217 | 744 | 37,448 |

Batch 1L includes one assembly with a total of one SS rod.

Batch 1M includes one assembly with a total of two SS rods.

Batch 1M* includes one assembly with a total of five SS rods.

Batch 1MX is ANF demonstration fuel with 12 $Gd_2O_3$ (10 wt%) fuel bearing (natural uranium) poison rods per assembly.

# TABLE 3.3-1

## UNIT 1 BATCH-RELATED DATA

### UNIT 1 CYCLE 13

| ASSEMBLY BATCH | NUMBER OF ASSEMBLIES | NON-FUEL RODS | TOTAL FUEL RODS |
|---|---|---|---|
| 2J* | 1 | 0 | 176 |
| 1N | 8 | 0 | 1,408 |
| 1NX | 16 | 64 | 2,752 |
| 1N/ | 16 | 128 | 2,688 |
| 1P0 | 16 | 0 | 2,816 |
| 1P1 | 12 | 0 | 2,112 |
| 1P2 | 8 | 0 | 1,408 |
| 1P3 | 52 | 0 | 9,152 |
| 1R0 | 24 | 0 | 4,224 |
| 1R1 | 28 | 0 | 4,928 |
| 1R2 | 32 | 0 | 5,632 |
| 1RT | 4 | 0 | 704 |
| TOTALS | 217 | 192 | 38,000 |

### UNIT 1 CYCLE 14

| ASSEMBLY BATCH | NUMBER OF ASSEMBLIES | NON-FUEL RODS | TOTAL FUEL RODS |
|---|---|---|---|
| 2J* | 5 | 0 | 880 |
| 1M* | 4 | 48 | 656 |
| 1P0 | 16 | 0 | 2,816 |
| 1P1 | 12 | 0 | 2,112 |
| 1P2 | 8 | 0 | 1,408 |
| 1R0 | 24 | 0 | 4,224 |
| 1R1 | 28 | 0 | 4,928 |
| 1R2 | 32 | 0 | 5,632 |
| 1RT | 4 | 0 | 704 |
| 1S0 | 24 | 0 | 4,224 |
| 1S1 | 4 | 0 | 704 |
| 1S2 | 40 | 0 | 7,040 |
| 1S3 | 16 | 0 | 2,816 |
| TOTALS | 217 | 48 | 38,144 |

# TABLE 3.3-1

## UNIT 1 BATCH-RELATED DATA

### UNIT 1 CYCLE 15

| ASSEMBLY BATCH | NUMBER OF ASSEMBLIES | NON-FUEL RODS | TOTAL FUEL RODS |
|---|---|---|---|
| 1L* | 4 | 0 | 704 |
| 1NX | 4 | 16 | 688 |
| 1RT | 2 | 2 | 350 |
| 1R2 | 6 | 1 | 1,055 |
| 1R0 | 24 | 0 | 4,224 |
| 1S3 | 16 | 0 | 2,816 |
| 1S2 | 40 | 0 | 7,040 |
| 1S1 | 4 | 0 | 704 |
| 1S0 | 24 | 0 | 4,224 |
| 1T2 | 60 | 0 | 10,560 |
| 1T1 | 4 | 0 | 704 |
| 1T0 | 28 | 0 | 4,928 |
| 2J* | 1 | 0 | 176 |
| TOTALS | 217 | 19 | 38,173 |

Assembly 1RT1 has 2 stainless steel rods.

Assembly 1R222 has 1 stainless steel rod.

### UNIT 1 CYCLE 16

| ASSEMBLY BATCH | NUMBER OF ASSEMBLIES | NON-FUEL RODS | TOTAL FUEL RODS |
|---|---|---|---|
| 1V0 | 24 | 0 | 4,224 |
| 1V1 | 48 | 0 | 8,448 |
| 1V2 | 24 | 0 | 4,224 |
| 1T0 | 28 | 0 | 4,928 |
| 1T1 | 4 | 0 | 704 |
| 1T2 | 60 | 0 | 10,560 |
| 1S0 | 20 | 0 | 3,520 |
| 1S1 | 4 | 0 | 704 |
| 1S2 | 4 | 0 | 704 |
| 2J* | 1 | 0 | 176 |
| TOTALS | 217 | 0 | 38,192 |

## TABLE 3.3-1

## UNIT 1 BATCH-RELATED DATA

### UNIT 1 CYCLE 17

| ASSEMBLY BATCH | NUMBER OF ASSEMBLIES | NON-FUEL RODS | TOTAL FUEL RODS |
|---|---|---|---|
| 1W0 | 20 | 0 | 3,520 |
| 1W1 | 12 | 0 | 2,112 |
| 1W2 | 36 | 0 | 6,336 |
| 1W3 | 16 | 0 | 2,816 |
| 1W4 | 4 | 0 | 704 |
| | | | |
| 1V0 | 24 | 0 | 4,224 |
| 1V1 | 48 | 0 | 8,448 |
| 1V2 | 24 | 0 | 4,224 |
| | | | |
| 1T0 | 20 | 0 | 3,520 |
| 1T1 | 4 | 0 | 704 |
| 1T2 | 8 | 0 | 1,408 |
| | | | |
| 1L* | 1 | 0 | 176 |
| TOTALS | 217 | 0 | 38,192 |

### UNIT 1 CYCLE 18

| ASSEMBLY BATCH | NUMBER OF ASSEMBLIES | NON-FUEL RODS | TOTAL FUEL RODS |
|---|---|---|---|
| X1 | 32 | 0 | 5,632 |
| X2 | 8 | 0 | 1,408 |
| X3 | 12 | 0 | 2,112 |
| X4 | 24 | 0 | 4,224 |
| X5 | 20 | 0 | 3,520 |
| X7 | 1 | 0 | 176 |
| | | | |
| W0 | 20 | 0 | 3,520 |
| W1 | 12 | 0 | 2,112 |
| W2 | 36 | 4 | 6,332 |
| W3 | 16 | 0 | 2,816 |
| W4 | 4 | 0 | 704 |
| | | | |
| V0 | 16 | 0 | 2,816 |
| V1 | 16 | 0 | 2,816 |
| TOTALS | 217 | 4 | 38,188 |

Batch W2 includes three assemblies with a total of four stainless rods.

# TABLE 3.3-1

## UNIT 1 BATCH-RELATED DATA

### UNIT 1 CYCLE 19

| ASSEMBLY BATCH | NUMBER OF ASSEMBLIES | NON-FUEL RODS | TOTAL FUEL RODS |
|---|---|---|---|
| 1Z1 | 4 | 0 | 704 |
| 1Z2 | 8 | 0 | 1,408 |
| 1Z3 | 12 | 0 | 2,112 |
| 1Z4 | 24 | 0 | 4,224 |
| 1Z5 | 40 | 0 | 7,040 |
| 1Z6 | 8 | 0 | 1,408 |
| 1X1 | 32 | 1 | 5,631 |
| 1X2 | 8 | 0 | 1,408 |
| 1X3 | 12 | 0 | 2,112 |
| 1X4 | 20 | 0 | 3,520 |
| 1X5 | 20 | 0 | 3,520 |
| 1W0 | 8 | 0 | 1,408 |
| 1W1 | 8 | 0 | 1,408 |
| 1W2 | 8 | 0 | 1,408 |
| 2V4 | 1 | 0 | 176 |
| 2TF | 2 | 0 | 352 |
| 2TW | 2 | 0 | 352 |
| TOTALS | 217 | 1 | 38,191 |

### UNIT 1 CYCLE 20

| ASSEMBLY BATCH | NUMBER OF ASSEMBLIES | NON-FUEL RODS | TOTAL FUEL RODS |
|---|---|---|---|
| AA1 | 12 | 0 | 2,112 |
| AA2 | 8 | 0 | 1,408 |
| AA3 | 12 | 0 | 2,112 |
| AA4 | 36 | 0 | 6,336 |
| AA5 | 20 | 0 | 3,520 |
| 2X7 | 4 | 0 | 704 |
| 1Z1 | 4 | 0 | 704 |
| 1Z2 | 8 | 0 | 1,408 |
| 1Z3 | 12 | 0 | 2,112 |
| 1Z4 | 24 | 0 | 4,224 |
| 1Z5 | 40 | 0 | 7,040 |
| 1Z6 | 8 | 0 | 1,408 |
| 1X1 | 24 | 0 | 4,224 |
| 1W0 | 4 | 0 | 704 |
| 2V4 | 1 | 0 | 176 |
| TOTALS | 217 | 0 | 38,192 |

## TABLE 3.3-1

## UNIT 1 BATCH-RELATED DATA

### UNIT 1 CYCLE 21

| ASSEMBLY BATCH | NUMBER OF ASSEMBLIES | NON-FUEL RODS | TOTAL FUEL RODS |
|---|---|---|---|
| AB1 | 48 | 0 | 8,448 |
| AB2 | 16 | 0 | 2,816 |
| AB3 | 32 | 0 | 5,632 |
| AA1 | 12 | 0 | 2,112 |
| AA2 | 8 | 0 | 1,408 |
| AA3 | 12 | 0 | 2,112 |
| AA4 | 36 | 0 | 6,336 |
| AA5 | 20 | 0 | 3,520 |
| 2X7 | 4 | 0 | 704 |
| 1Z1 | 4 | 0 | 704 |
| 1Z2 | 8 | 0 | 1,408 |
| 1Z3 | 4 | 0 | 704 |
| 1Z4 | 4 | 0 | 704 |
| 1X4 | 1 | 0 | 176 |
| 1W1 | 4 | 0 | 704 |
| 1W2 | 4 | 0 | 704 |
| TOTALS | 217 | 0 | 38,192 |

### UNIT 1 CYCLE 22

| ASSEMBLY BATCH | NUMBER OF ASSEMBLIES | NON-FUEL RODS | TOTAL FUEL RODS |
|---|---|---|---|
| AC1 | 56 | 0 | 9,856 |
| AC2 | 16 | 0 | 2,816 |
| AC3 | 24 | 0 | 4,224 |
| AB1 | 48 | 0 | 8,448 |
| AB2 | 16 | 0 | 2,816 |
| AB3 | 32 | 0 | 5,632 |
| AA1 | 12 | 0 | 2,112 |
| AA2 | 8 | 0 | 1,408 |
| 2X1 | 4 | 0 | 704 |
| 1X1 | 1 | 0 | 176 |
| TOTALS | 217 | 0 | 38,192 |

### UNIT 1 CYCLE 23

| ASSEMBLY BATCH | NUMBER OF ASSEMBLIES | NON-FUEL RODS | TOTAL FUEL RODS |
|---|---|---|---|
| AD1 | 36 | 0 | 6336 |
| AD2 | 20 | 0 | 3520 |
| AD3 | 16 | 0 | 2816 |
| AD4 | 24 | 0 | 4224 |
| AC1 | 56 | 0 | 9856 |
| AC2 | 16 | 0 | 2816 |
| AC3 | 24 | 0 | 4224 |
| AB3 | 24 | 0 | 4224 |
| BA5 | 1 | 0 | 176 |
| TOTALS | **217** | **0** | 38192 |

## TABLE 3.3-1

## UNIT 1 BATCH-RELATED DATA

### UNIT 1 CYCLE 24

| ASSEMBLY BATCH | NUMBER OF ASSEMBLIES | NON-FUEL RODS | TOTAL FUEL RODS |
|---|---|---|---|
| AE1 | 40 | 0 | 7040 |
| AE2 | 16 | 0 | 2816 |
| AE3 | 20 | 0 | 3520 |
| AE4 | 8 | 0 | 1408 |
| AE5 | 12 | 0 | 2112 |
| AD1 | 36 | 0 | 6336 |
| AD2 | 20 | 0 | 3520 |
| AD3 | 16 | 0 | 2816 |
| AD4 | 24 | 0 | 4224 |
| AC3 | 24 | 0 | 4224 |
| BA5 | 1 | 0 | 176 |
| TOTALS | 217 | 0 | 38,192 |

### UNIT 1 CYCLE 25

| ASSEMBLY BATCH | NUMBER OF ASSEMBLIES | NON-FUEL RODS | TOTAL FUEL RODS |
|---|---|---|---|
| AF1 | 32 | 0 | 5632 |
| AF2 | 4 | 0 | 704 |
| AF3 | 20 | 0 | 3520 |
| AF4 | 20 | 0 | 3520 |
| AF5 | 20 | 0 | 3520 |
| AF6 | 1 | 32 | 176 |
| AF7[a] | 4 | 0 | 672 |
| AE1 | 28 | 0 | 4928 |
| AE2 | 12 | 0 | 2112 |
| AE3 | 20 | 0 | 3520 |
| AE4 | 8 | 0 | 1408 |
| AE5 | 12 | 0 | 2112 |
| AD4 | 22 | 0 | 3872 |
| AB1 | 5 | 0 | 880 |
| BB4 | 3 | 0 | 528 |
| BB5[b] | 4 | 32 | 672 |
| BA6 | 2 | 0 | 352 |
| TOTALS | 217 | 64 | 38128 |

[a] Batch AF7 includes four asymmetric fresh assemblies (AF701-AF704) with eight inert rods each

[b] Batch BB5 includes four reconstituted assemblies with eight inert rods each.

## TABLE 3.3-1

## UNIT 1 BATCH-RELATED DATA

| PARAMETER | BATCHES | | | | | | |
|---|---|---|---|---|---|---|---|
| | A | B | C | D | E | F | G |
| Active Length, inches | 136.7 | 136.7 | 136.7 | 136.7 | 136.7 | 136.7 | 136.7 |
| Pellet Diameter, inches | .3795 | .3795 | .3795 | .3765 | .3765 | .3765 | .3765 |
| Pellet Length, inches | .650 | .650 | .650 | .450 | .450 | .450 | .450 |
| Pellet Density, g/cc | 10.193 | 10.193 | 10.193 | 10.385 | 10.385 | 10.385 | 10.385 |
| Stack Height Density, g/cc | 10.054 | 10.054 | 10.054 | 10.018 | 10.046 | 10.046 | 10.046 |
| Clad ID, inches | .3880 | .3880 | .3880 | .3840 | .3840 | .3840 | .3840 |
| Clad OD, inches | .440 | .440 | .440 | .440 | .440 | .440 | .440 |
| Clad Thickness, inches | .026 | .026 | .026 | .028 | .028 | .028 | .028 |
| Diametral Gap, inches | .0085 | .0085 | .0085 | .0075 | .0075 | .0075 | .0075 |

| PARAMETER | BATCHES | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | H | J | K | L | M | MX(a) | N | P |
| Active Length, inches | 136.7 | 136.7 | 136.7 | 136.7 | 136.7 | 136.7 | 136.7 | 136.7 |
| Pellet Diameter, inches | .3765 | .3765 | .3765 | .3765 | .3765 | .3700 | .3765 | .3765 |
| Pellet Length, inches | .450 | .450 | .450 | .450 | .450 | .425 | .450 | .450 |
| Pellet Density, g/cc | 10.385 | 10.385 | 10.385 | 10.385 | 10.385 | 10.302 | 10.439 | 10.439 |
| Stack Height Density, g/cc | 10.046 | 10.046 | 10.046 | 10.046 | 10.046 | 10.180(b) | 10.100 | 10.100 |
| Clad ID, inches | .3840 | .3840 | .3840 | .3840 | .3840 | .378 | .3840 | .3840 |
| Clad OD, inches | .440 | .440 | .4400 | .440 | .440 | .440 | .440 | .440 |
| Clad Thickness, inches | .028 | .028 | .0280 | .028 | .028 | .031 | .028 | .028 |
| Diametral Gap, inches | .0075 | .0075 | .0075 | .0075 | .0075 | .008 | .0075 | .0075 |

# TABLE 3.3-1

## UNIT 1 BATCH-RELATED DATA

| PARAMETER | R | RT | S | T | V | W | X |
|---|---|---|---|---|---|---|---|
| Active Length, inches | 136.7 | 136.7 | 136.7 | 136.7 | 136.7 | 136.7 | 136.7 |
| Pellet Diameter, inches | .3765 | .3810 | .3765 | .3810 | .3810 | .3810 | .3810 |
| Pellet Length, inches | .450 | .456 | .450 | .456 | .456 | .456 | .456 |
| Pellet Density, g/cc | 10.439 | 10.467 | 10.439 | 10.467 | 10.467 | 10.467 | 10.467 |
| Stack Height Density, g/cc | 10.12 | 10.31 | 10.17 | 10.31 | 10.31 | 10.31 | Regular 10.32<br>Annular 7.82 |
| Clad ID, inches | .3840 | .3880 | .3840 | .3880 | .3880 | .3880 | .3880 |
| Clad OD, inches | .440 | .440 | .440 | .440 | .440 | .440 | .440 |
| Clad Thickness, inches | .028 | .026 | .028 | .026 | .026 | .026 | .026 |
| Diametral Gap, inches | .0075 | .0070 | .0075 | .0070 | .0070 | .0070 | .0070 |

| PARAMETER | Z | AA | AB | AC |
|---|---|---|---|---|
| Active Length, inches | 136.7 | 136.7 | 136.7 | 136.7 |
| Pellet Diameter, inches | .3810 | .3810 | 0.3805 | 0.3805 |
| Pellet Length, inches | .456 | .456 | 0.476 (Central)<br>0.545 (Blanket) | 0.476 (Central)<br>0.545 (Blanket) |
| Pellet Density, g/cc | 10.467 | 10.467 | 10.5216 | 10.5216 |
| Stack Height Density, g/cc | Regular 10.32<br>Annular 7.82 | Regular 10.32<br>Annular 7.82 | 10.3743 ($UO_2$)<br>10.2277 (4 wt% $Gd_2O_3$)<br>10.1565 (6 wt% $Gd_2O_3$)<br>10.0867 (8 wt% $Gd_2O_3$)<br>10.3953 (Blanket) | 10.3743 ($UO_2$)<br>10.2277 (4 wt% $Gd_2O_3$)<br>10.1565 (6 wt% $Gd_2O_3$)<br>10.0867 (8 wt% $Gd_2O_3$)<br>10.3953 (Blanket) |
| Clad ID, inches | .3880 | .3880 | 0.387 | 0.387 |
| Clad OD, inches | .440 | .440 | 0.440 | 0.440 |
| Clad Thickness, inches | .026 | .026 | 0.0265 | 0.0265 |
| Diametral Gap, inches | .0070 | .0070 | 0.0065 | 0.0065 |

## TABLE 3.3-1

## UNIT 1 BATCH-RELATED DATA

| PARAMETER | BATCHES | | |
|---|---|---|---|
| | AD | AE | AF |
| Active Length, inches | 136.7 | 136.7 | 136.7 |
| Pellet Diameter, inches | 0.3805 | 0.3805 | 0.3805 |
| Pellet Length, inches | 0.476 (Central)<br>0.545 (Blanket) | 0.476 (Central)<br>0.545 (Blanket) | 0.476 (Central)<br>0.545 (Blanket) |
| Pellet Density, g/cc | 10.5216 | 10.5216 | 10.5216 |
| Stack Height Density, g/cc | 10.3743 ($UO_2$)<br>10.2277 (4 wt% $Gd_2O_3$)<br>10.1565 (6 wt% $Gd_2O_3$)<br>10.0867 (8 wt% $Gd_2O_3$)<br>10.3953 (Blanket) | 10.3743 ($UO_2$)<br>10.3003 (2 wt% $Gd_2O_3$)<br>10.2277 (4 wt% $Gd_2O_3$)<br>10.1565 (6 wt% $Gd_2O_3$)<br>10.3953 (Blanket) | 10.3743 ($UO_2$)<br>10.3003 (2% $Gd_2O_3$)<br>10.2277 (4% $Gd_2O_3$)<br>10.1565 (6% $Gd_2O_3$)<br>10.3953 (Blanket) |
| Clad ID, inches | 0.387 | 0.387 | 0.387 |
| Clad OD, inches | 0.440 | 0.440 | 0.440 |
| Clad Thickness, inches | 0.0265 | 0.0265 | 0.0265 |
| Diametral Gap, inches | 0.0065 | 0.0065 | 0.0065 |

---

(a) ANF Demonstration Assemblies.

(b) Pellet envelope includes both $UO_2$ and $Gd_2O_3$.

## TABLE 3.3-2

## UNIT 2 BATCH-RELATED DATA

| BATCH DESIGNATION | INITIAL ASSEMBLY AVERAGE ENRICHMENT wt% U-235 | NUMBER OF $B_4C$ SHIMS PER ASSEMBLY | INITIAL SHIM LOADING wt% $B_4C$ | AVERAGE WEIGHT OF URANIUM PER ASSEMBLY Kg U | FUEL RODS PER ASSEMBLY |
|---|---|---|---|---|---|
| 2A | 2.05 | 0 | --- | 396 | 176 |
| 2B | 2.45 | 12 | 2.9 | 370 | 164 |
| 2C | 2.99 | 0 | --- | 397 | 176 |
| 2C+ | 2.99 | 12 | 1.1 | 369 | 164 |
| 2C. | 2.99 | 12 | .7 | 369 | 164 |
| 2D | 3.03 | 0 | --- | 388 | 176 |
| 2D/ | 2.73 | 0 | --- | 388 | 176 |
| 2E | 3.03 | 0 | --- | 389 | 176 |
| 2E/ | 2.73 | 0 | --- | 389 | 176 |
| 2F | 3.65 | 0 | --- | 390 | 176 |
| 2F/ | 3.03 | 8 | 3.03 | 371 | 168 |
| 2G | 4.00 | 0 | --- | 389 | 176 |
| 2G/ | 3.55 | 8 | 3.03 | 372 | 168 |
| 2H | 4.05 | 0 | --- | 389 | 176 |
| 2H* | 3.40 | 0 | --- | 388 | 176 |
| 2J | 4.05 | 0 | --- | 390 | 176 |
| 2J* | 3.40 | 0 | --- | 390 | 176 |
| 2K | 4.08 | 0 | --- | 390 | 176 |
| 2K* | 4.08 | 12 | 4.09 | 362 | 164 |
| 2K/ | 4.08 | 8 | 4.09 | 372 | 168 |
| 2L | 4.30 | 0 | --- | 389 | 176 |
| 2LX | 4.30 | 4 | 4.09 | 380 | 172 |
| 2L/ | 4.30 | 8 | 4.09 | 371 | 168 |
| 2L* | 4.30 | 12 | 4.09 | 363 | 164 |
| 2LE | 3.81 | 0 | --- | 389 | 176 |
| 2M | 4.00 | 0 | --- | 392 | 176 |
| 2M1 | 4.00 | 4 | 4.09 | 384 | 172 |
| 2M2 | 4.00 | 8 | 4.09 | 375 | 168 |
| 2M3 | 4.00 | 12 | 4.09 | 366 | 164 |

## TABLE 3.3-2

## UNIT 2 BATCH-RELATED DATA

| BATCH DESIGNATION | INITIAL ASSEMBLY AVERAGE ENRICHMENT wt% U-235 | NUMBER OF ERBIUM SHIMS PER ASSEMBLY | INITIAL SHIM LOADING wt% $Er_2O_3$ | AVERAGE WEIGHT OF URANIUM PER ASSEMBLY Kg U | FUEL RODS PER ASSEMBLY |
|---|---|---|---|---|---|
| 2N0 | 4.48 | 0 | 0 | 392 | 176 |
| 2N2 | 4.48 | 20 | 1.75 | 392 | 176 |
| 2N4 | 4.48 | 44 | 1.75 | 390 | 176 |
| 2N6 | 4.48 | 68 | 1.75 | 389 | 176 |
| 2NT | 4.00 | 44 | 1.75 | 408 | 176 |
| 2P0 | 4.48 | 0 | 0 | 393 | 176 |
| 2P1 | 4.48 | 20 | 2.00 | 393 | 176 |
| 2P2 | 4.48 | 44 | 2.00 | 391 | 176 |
| 2R0 | 4.48 | 0 | 0 | 393 | 176 |
| 2R1 | 4.48 | 20 | 1.75 | 392 | 176 |
| 2R2 | 4.48 | 44 | 1.75 | 391 | 176 |
| 2R3 | 4.48 | 68 | 1.75 | 390 | 176 |
| 2S0 | 4.28 (VAP) | 0 | 0 | 410 | 176 |
| 2S1 | 4.28 (VAP) | 20 | 1.75 | 408 | 176 |
| 2S2 | 4.28 (VAP) | 44 | 1.75 | 408 | 176 |
| 2S3 | 4.28 (VAP) | 68 | 1.75 | 407 | 176 |
| 2T0 | 4.25 (VAP) | 0 | 0 | 410 | 176 |
| 2TF | 4.26 (FANP) | 0 | 0 | 412 | 176 |
| 2TW | 4.25 (VAP) | 0 | 0 | 409 | 176 |
| 2T1 | 4.25 (VAP) | 20 | 2.0 | 409 | 176 |
| 2T2 | 4.25 (VAP) | 44 | 2.0 | 408 | 176 |
| 2T3 | 4.25 (VAP | 68 | 2.0 | 407 | 176 |

FANP – Framatome Advanced Nuclear Power (AREVA)

| BATCH DESIGNATION | INITIAL ENRICHMENTS wt% U-235 | NUMBER OF $ZrB_2$ SHIMS PER ASSEMBLY | INITIAL SHIM LOADING (mg-B-10/ inch) | AVERAGE WEIGHT OF URANIUM PER ASSEMBLY Kg U | FUEL RODS PER ASSEMBLY |
|---|---|---|---|---|---|
| 2V0 | 2.6/4.1/4.6 (VAP) | 0 | 0 | 411 | 176 |
| 2V1 | 2.6/4.1/4.6 (VAP) | 44 | 3.35 | 408 | 176 |
| 2V2 | 2.6/4.1/4.6 (VAP) | 52 | 3.35 | 407 | 176 |
| 2V3 | 2.6/4.1/4.6 (VAP) | 64 | 3.35 | 406 | 176 |
| 2V4 | 2.6/4.1/4.6 (VAP) | 76 | 3.35 | 405 | 176 |
| 2V5 | 2.6/4.1/4.6 (VAP) | 96 | 3.35 | 404 | 176 |

## TABLE 3.3-2

## UNIT 2 BATCH-RELATED DATA

| BATCH DESIGNATION | INITIAL ENRICHMENTS wt% U-235 | NUMBER OF $ZrB_2$ SHIMS PER ASSEMBLY | INITIAL SHIM LOADING (mg-B-10/ inch) | AVERAGE WEIGHT OF URANIUM PER ASSEMBLY Kg U | FUEL RODS PER ASSEMBLY |
|---|---|---|---|---|---|
| 2W1 | 2.6/4.50/4.95 (VAP) | 28 | 3.29 | 408 | 176 |
| 2W2 | 2.6/4.50/4.95 (VAP) | 64 | 3.29 | 406 | 176 |
| 2W3 | 2.6/3.95/4.50/ 4.95 (VAP) | 52 | 3.29 | 407 | 176 |
| 2W4 | 2.6/3.95/4.50/ 4.95 (VAP) | 64 | 3.29 | 406 | 176 |
| 2W5 | 2.6/3.95/4.50/ 4.95 (VAP) | 76 | 3.29 | 406 | 176 |
| 2W6 | 2.6/3.95/4.50/ 4.95 (VAP) | 96 | 3.29 | 405 | 176 |
| 2X1 | 4.60/4.20/2.60 (VAP) | 28 | 3.29 | 409 | 176 |
| 2X2 | 4.60/4.20/2.60 (VAP) | 52 | 3.29 | 408 | 176 |
| 2X3 | 4.95/4.60/4.20/ 2.60 (VAP) | 64 | 3.29 | 407 | 176 |
| 2X4 | 4.95/4.60/4.20/ 2.60 (VAP) | 76 | 3.29 | 407 | 176 |
| 2X5 | 4.95/4.60/4.20/ 2.60 (VAP) | 96 | 3.29 | 406 | 176 |
| 2X6 | 4.20/4.00/2.60 (VAP) | 64 | 3.29 | 408 | 176 |

| BATCH DESIGNATION | INITIAL ENRICHMENTS wt% U-235 | NUMBER OF $Gd_2O_3$ RODS PER ASSEMBLY | INITIAL $Gd_2O_3$ LOADING wt% | AVERAGE WEIGHT OF URANIUM PER ASSEMBLY Kg U | FUEL RODS PER ASSEMBLY |
|---|---|---|---|---|---|
| 2Z1 | 4.88/4.34/2.00 | 0 | N/A | 410 | 176 |
| 2Z2 | 4.88/4.34/2.00 (4.40) | 4 | 2 | 410 | 176 |
| 2Z3 | 4.88/4.34/2.00 (4.40/3.42) | 4/12 | 2/6 | 408 | 176 |
| 2Z4 | 4.88/4.34/2.00 (2.93) | 16 | 8 | 407 | 176 |
| 2Z5 | 4.88/4.34/2.00 (2.93) | 12 | 8 | 408 | 176 |

## TABLE 3.3-2

## UNIT 2 BATCH-RELATED DATA

| BATCH DESIGNATION | INITIAL ENRICHMENTS wt% U-235 | NUMBER OF $Gd_2O_3$ RODS PER ASSEMBLY | INITIAL $Gd_2O_3$ LOADING wt% | AVERAGE WEIGHT OF URANIUM PER ASSEMBLY Kg U | FUEL RODS PER ASSEMBLY |
|---|---|---|---|---|---|
| BA1 | 4.60/4.00/2.00 | 0 | N/A | 410 | 176 |
| BA2 | 4.60/4.00/2.00<br>(3.60) | 4 | 4 | 410 | 176 |
| BA3 | 4.60/4.00/2.00<br>(4.00/3.60) | 4/12 | 2/4 | 409 | 176 |
| BA4 | 4.60/4.00/2.00<br>(3.60/3.20) | 4/12 | 4/6 | 408 | 176 |
| BA5 | 4.60/4.00/2.00<br>(4.00/3.20) | 8/12 | 2/6 | 408 | 176 |
| BA6 | 4.15/3.60/2.00<br>(3.20/2.40) | 4/8 | 4/8 | 408 | 176 |
| BA7 | 4.15/3.60/2.00<br>(3.20/2.60) | 4/12 | 4/6 | 408 | 176 |

| BATCH DESIGNATION | INITIAL ENRICHMENTS wt% U-235 | NUMBER OF $Gd_2O_3$ RODS PER ASSEMBLY | INITIAL $Gd_2O_3$ LOADING wt% | AVERAGE WEIGHT OF URANIUM PER ASSEMBLY Kg U | FUEL RODS PER ASSEMBLY |
|---|---|---|---|---|---|
| BB1 | 4.92/4.32/2.00<br>(3.60) | 8 | 4 | 409 | 176 |
| BB2 | 4.92/4.32/2.00<br>(4.40/2.95) | 4/4 | 2/6 | 409 | 176 |
| BB3 | 4.92/4.32/2.00<br>(3.60/2.95) | 4/8 | 4/6 | 408 | 176 |
| BB4 | 4.92/4.32/2.00<br>(3.60/2.95) | 4/12 | 4/8 | 407 | 176 |
| BB5 | 4.92/4.32/2.00<br>(4.40/2.95) | 8/12 | 2/8 | 407 | 176 |

## TABLE 3.3-2

## UNIT 2 BATCH-RELATED DATA

| BATCH DESIGNATION | INITIAL ENRICHMENTS wt% U-235 | NUMBER OF $Gd_2O_3$ RODS PER ASSEMBLY | INITIAL $Gd_2O_3$ LOADING wt% | AVERAGE WEIGHT OF URANIUM PER ASSEMBLY Kg U | FUEL RODS PER ASSEMBLY |
|---|---|---|---|---|---|
| BC1 | 4.90/4.30/1.60<br>(3.60) | 8 | 4 | 409 | 176 |
| BC2 | 4.90/4.30/1.60<br>(3.60/3.20) | 4/4 | 4/6 | 409 | 176 |
| BC3 | 4.90/4.30/1.60<br>(3.60/3.20) | 4/8 | 4/6 | 408 | 176 |
| BC4 | 4.90/4.30/1.60<br>(3.60/2.90) | 4/12 | 4/8 | 407 | 176 |
| BC5 | 4.90/4.30/1.60<br>(3.60/2.90) | 4/12 | 6/8 | 407 | 176 |

| BATCH DESIGNATION | INITIAL ENRICHMENTS wt% U-235 | NUMBER OF $Gd_2O_3$ RODS PER ASSEMBLY | INITIAL $Gd_2O_3$ LOADING wt% | AVERAGE WEIGHT OF URANIUM PER ASSEMBLY Kg U | FUEL RODS PER ASSEMBLY |
|---|---|---|---|---|---|
| BD1 | 4.91/4.33/1.60<br>(3.60/2.95) | 4/12 | 5.0/7.0 | 408 | 176 |
| BD2 | 4.91/4.30/1.60<br>(4.33/2.95) | 8/12 | 2.0/6.0 | 408 | 176 |
| BD3 | 4.91/4.33/1.60<br>(3.60) | 12 | 4.0 | 409 | 176 |
| BD4 | 4.91/4.33/1.60<br>(3.60) | 8 | 5.0 | 409 | 176 |
| BD5 | 2.95/1.60<br>(2.95) | 4 | 7.0 | 409 | 176 |

## TABLE 3.3-2

## UNIT 2 BATCH-RELATED DATA

| BATCH DESIGNATION | INITIAL ENRICHMENTS wt% U-235 | NUMBER OF $Gd_2O_3$ RODS PER ASSEMBLY | INITIAL $Gd_2O_3$ LOADING wt% | AVERAGE WEIGHT OF URANIUM PER ASSEMBLY Kg U | FUEL RODS PER ASSEMBLY |
|---|---|---|---|---|---|
| BE1 | 4.87 / 4.27 / 1.60<br>( 2.90 ) | 16 | 8.0 | 407 | 176 |
| BE2 | 4.87 / 4.27 / 1.60<br>( 4.27 / 2.90 ) | 8 / 12 | 2.0 / 8.0 | 407 | 176 |
| BE3 | 4.87 / 4.27 / 1.60<br>( 3.20 / 2.90 ) | 8 / 4 | 6.0 / 8.0 | 408 | 176 |
| BE4 | 4.87 / 4.27 / 1.60<br>( 3.20 ) | 12 | 6.0 | 408 | 176 |
| BE5 | 4.87 / 4.27 / 1.60<br>( 4.27 ) | 12 | 2.0 | 409 | 176 |
| BE6 | 4.87 / 4.27 / 1.60<br>( 4.27 ) | 12 | 2.0 | 410 | 176 |
| BE7[a] | 4.87 / 4.27 / 1.60<br>( 4.27 / 2.90 ) | 8 / 12 | 2.0 / 8.0 | 405 | 175 |

[a] Batch BE7 includes eight asymmetric fresh assemblies (BE701-BE108) with one insert rod each

# TABLE 3.3-2

## UNIT 2 BATCH-RELATED DATA

### UNIT 2 CYCLE 1

| ASSEMBLY BATCH | NUMBER OF ASSEMBLIES | TOTAL SHIMS | TOTAL FUEL RODS |
|---|---|---|---|
| 2A | 69 | 0 | 12,144 |
| 2B | 80 | 960 | 13,120 |
| 2C | 40 | 0 | 7,040 |
| 2C+ | 16 | 192 | 2,624 |
| 2C. | 12 | 144 | 1,968 |
| TOTALS | 217 | 1,296 | 36,896 |

### UNIT 2 CYCLE 2

| ASSEMBLY BATCH | NUMBER OF ASSEMBLIES | TOTAL SHIMS | TOTAL FUEL RODS |
|---|---|---|---|
| 2B | 65 | 780 | 10,660 |
| 2C | 40 | 0 | 7,040 |
| 2C+ | 16 | 192 | 2,624 |
| 2C. | 12 | 144 | 1,968 |
| 2D | 48 | 0 | 8,448 |
| 2D/ | 36 | 0 | 6,336 |
| TOTALS | 217 | 1,116 | 37,076 |

### UNIT 2 CYCLE 3

| ASSEMBLY BATCH | NUMBER OF ASSEMBLIES | TOTAL SHIMS | TOTAL FUEL RODS |
|---|---|---|---|
| 2B | 1 | 12 | 164 |
| 2C | 40 | 0 | 7,040 |
| 2C+ | 16 | 192 | 2,624 |
| 2C. | 12 | 144 | 1,968 |
| 2D | 48 | 0 | 8,448 |
| 2D/ | 36 | 0 | 6,336 |
| 2E | 48 | 0 | 8,448 |
| 2E/ | 16 | 0 | 2,816 |
| TOTALS | 217 | 348 | 37,844 |

### UNIT 2 CYCLE 4

| ASSEMBLY BATCH | NUMBER OF ASSEMBLIES | TOTAL SHIMS | TOTAL FUEL RODS |
|---|---|---|---|
| 2D | 25 | 0 | 4,400 |
| 2E | 48 | 0 | 8,448 |
| 2E/ | 16 | 0 | 2,816 |
| 2F | 40 | 0 | 7,040 |
| 2F/ | 88 | 704 | 14,784 |
| TOTALS | 217 | 704 | 37,488 |

# TABLE 3.3-2

## UNIT 2 BATCH-RELATED DATA

### UNIT 2 CYCLE 5

| ASSEMBLY BATCH | NUMBER OF ASSEMBLIES | TOTAL SHIMS | TOTAL FUEL RODS |
|---|---|---|---|
| 2D | 13 | 0 | 2,288 |
| 2F | 40 | 0 | 7,040 |
| 2F/ | 88 | 704 | 14,784 |
| 2G | 48 | 0 | 8,448 |
| 2G/ | 28 | 224 | 4,704 |
| TOTALS | 217 | 928 | 37,264 |

### UNIT 2 CYCLE 6

| ASSEMBLY BATCH | NUMBER OF ASSEMBLIES | TOTAL SHIMS | TOTAL FUEL RODS |
|---|---|---|---|
| 1E/ | 8 | 0 | 1,408 |
| 2D/ | 20 | 0 | 3,520 |
| 2D | 1 | 0 | 176 |
| 2F | 40 | 0 | 7,040 |
| 2G | 48 | 0 | 8,448 |
| 2G/ | 28 | 224 | 4,704 |
| 2H | 48 | 0 | 8,448 |
| 2H* | 24 | 0 | 4,224 |
| TOTALS | 217 | 224 | 37,968 |

### UNIT 2 CYCLE 7

| ASSEMBLY BATCH | NUMBER OF ASSEMBLIES | TOTAL SHIMS | TOTAL FUEL RODS |
|---|---|---|---|
| 2D | 1 | 0 | 176 |
| 2E | 8 | 0 | 1,408 |
| 2G | 48 | 0 | 8,448 |
| 2G/ | 28 | 224 | 4,704 |
| 2H | 48 | 0 | 8,448 |
| 2H* | 24 | 0 | 4,224 |
| 2J | 40 | 0 | 7,040 |
| 2J* | 20 | 0 | 3,520 |
| TOTALS | 217 | 224 | 37,968 |

## TABLE 3.3-2

## UNIT 2 BATCH-RELATED DATA

### UNIT 2 CYCLE 8

| ASSEMBLY BATCH | NUMBER OF ASSEMBLIES | NON-FUEL RODS | TOTAL FUEL RODS |
|---|---|---|---|
| 2H* | 21 | 1 | 3,695 |
| 2H | 48 | 7 | 8,441 |
| 2J* | 20 | 0 | 3,520 |
| 2J | 40 | 1 | 7,039 |
| 2K/ | 44 | 352 | 7,392 |
| 2K* | 28 | 336 | 4,592 |
| 2K | 16 | 0 | 2,816 |
| TOTALS | 217 | 697 | 37,495 |

Batch 2H* includes one assembly with one SS rod.

Batch 2H includes three assemblies with a total of seven SS rods.

Batch 2J includes one assembly with one SS rod.

### UNIT 2 CYCLE 9

| ASSEMBLY BATCH | NUMBER OF ASSEMBLIES | NON-FUEL RODS | TOTAL FUEL RODS |
|---|---|---|---|
| 2L | 16 | 0 | 2,816 |
| 2LX | 20 | 80 | 3,440 |
| 2L/ | 24 | 192 | 4,032 |
| 2L* | 28 | 336 | 4,592 |
| 2LE | 4 | 0 | 704 |
| 2K | 16 | 0 | 2,816 |
| 2K/ | 44 | 355 | 7,389 |
| 2K* | 28 | 339 | 4,589 |
| 2J | 36 | 1 | 6,335 |
| 2H* | 1 | 0 | 176 |
| TOTALS | 217 | 1,303 | 36,889 |

Batch 2K/ includes two assemblies with a total of three SS rods.

Batch 2K* includes one assembly with three SS rods.

Batch 2J includes one assembly with one SS rod.

## TABLE 3.3-2

## UNIT 2 BATCH-RELATED DATA

## UNIT 2 CYCLE 10

| ASSEMBLY BATCH | NUMBER OF ASSEMBLIES | NON-FUEL RODS | TOTAL FUEL RODS |
|---|---|---|---|
| 2M | 12 | 0 | 2,112 |
| 2M1 | 16 | 64 | 2,752 |
| 2M2 | 20 | 160 | 3,360 |
| 2M3 | 40 | 480 | 6,560 |
| 2L[a] | 16 | 0 | 2,816 |
| 2LX[a] | 20 | 80 | 3,440 |
| 2L/[a] | 24 | 192 | 4,032 |
| 2L*[a] | 28 | 336 | 4,592 |
| 2LE[a,b] | 4 | 0 | 704 |
| 2K[a] | 16 | 0 | 2,808[f] |
| 2K/[a] | 16 | 128 | 2,688 |
| 2J*[c] | 4 | 0 | 704 |
| 2H*[d] | 1 | 0 | 174[e] |
| TOTALS | 217 | 1,440 | 36,742 |

---

[a] Carried over from Unit 2, Cycle 9.

[b] Erbium demonstration assembly.

[c] Reinserted, discharged at End of Unit 2, Cycle 8.

[d] Reinserted, discharged at End of Unit 2, Cycle 7.

[e] The center assembly contains two SS replacement rods.

[f] Eight fuel rods were replaced by SS replacement rods in Batch 2K during the Cycle 9 to Cycle 10 refueling outage.

## TABLE 3.3-2

## UNIT 2 BATCH-RELATED DATA

### UNIT 2 CYCLE 11

| ASSEMBLY BATCH | NUMBER OF ASSEMBLIES | NON-FUEL RODS | TOTAL FUEL RODS |
|---|---|---|---|
| N0 | 12 | 0 | 2,112 |
| N2 | 8 | 0 | 1,408 |
| N4 | 16 | 0 | 2,816 |
| N6 | 48 | 0 | 8,448 |
| NT | 4 | 0 | 704 |
| M | 12 | 0 | 2,112 |
| M1 | 16 | 64 | 2,752 |
| M2 | 20 | 160 | 3,360 |
| M3 | 40 | 480 | 6,560 |
| L | 16 | 0 | 2,816 |
| LX | 12 | 48 | 2,064 |
| LT | 4 | 0 | 704 |
| J | 4 | 0 | 704 |
| L | 4 | 0 | 704 |
| J*[a] | 1 | 2 | 174 |
| TOTALS | 217 | 754 | 37,438 |

---

[a] Batch J* includes one assembly with a total of two SS rods.

### UNIT 2 CYCLE 12

| ASSEMBLY BATCH | NUMBER OF ASSEMBLIES | NON-FUEL RODS | TOTAL FUEL RODS |
|---|---|---|---|
| P0 | 24 | 0 | 4,224 |
| P1 | 8 | 0 | 1,408 |
| P2 | 60 | 0 | 10,560 |
| N0 | 12 | 0 | 2,112 |
| N2 | 8 | 0 | 1,408 |
| N4 | 16 | 0 | 2,186 |
| N6 | 48 | 0 | 8,448 |
| NT | 4 | 0 | 704 |
| M | 12 | 0 | 2,112 |
| M1 | 16 | 64 | 2,752 |
| N | 4 | 0 | 704 |
| M* | 4 | 48 | 656 |
| K1 | 1 | 0 | 176 |
| TOTALS | 217 | 112 | 38,080 |

## TABLE 3.3-2

## UNIT 2 BATCH-RELATED DATA

### UNIT 2 CYCLE 13

| ASSEMBLY BATCH | NUMBER OF ASSEMBLIES | NON-FUEL RODS | TOTAL FUEL RODS |
|---|---|---|---|
| R0 | 8 | 0 | 1,408 |
| R1 | 12 | 0 | 2,112 |
| R2 | 32 | 0 | 5,632 |
| R3 | 40 | 0 | 7,040 |
| P0 | 24 | 0 | 4,224 |
| P1 | 8 | 0 | 1,408 |
| P2 | 60 | 0 | 10,560 |
| N0 | 12 | 0 | 2,112 |
| N2 | 8 | 0 | 1,408 |
| N4 | 4 | 0 | 704 |
| K* | 4 | 48 | 656 |
| J* | 5 | 0 | 880 |
| TOTALS | 217 | 48 | 38,144 |

### UNIT 2 CYCLE 14

| ASSEMBLY BATCH | NUMBER OF ASSEMBLIES | NON-FUEL RODS | TOTAL FUEL RODS |
|---|---|---|---|
| 2S0 | 8 | 0 | 1,408 |
| 2S1 | 24 | 0 | 4,224 |
| 2S2 | 24 | 0 | 4,224 |
| 2S3 | 36 | 0 | 6,336 |
| 2R0 | 8 | 0 | 1,408 |
| 2R1 | 12 | 0 | 2,113 |
| 2R2 | 32 | 0 | 5,632 |
| 2R3 | 40 | 0 | 7,040 |
| 2P0 | 23 | 0 | 4,048 |
| 2P1 | 8 | 0 | 1,408 |
| 1L* | 1 | 0 | 176 |
| 1RT | 1 | 0 | 176 |
| TOTALS | 217 | 0 | 38,192 |

# TABLE 3.3-2

## UNIT 2 BATCH-RELATED DATA

### UNIT 2 CYCLE 15

| ASSEMBLY BATCH | NUMBER OF ASSEMBLIES | NON-FUEL RODS | TOTAL FUEL RODS |
|---|---|---|---|
| T0 | 20 | 0 | 3,520 |
| T1 | 4 | 0 | 704 |
| T2 | 40 | 0 | 7,040 |
| T3 | 20 | 0 | 3,520 |
| TF | 4 | 0 | 704 |
| TW | 4 | 0 | 704 |
| S0 | 8 | 0 | 1,408 |
| S1 | 24 | 0 | 4,224 |
| S2 | 24 | 0 | 4,224 |
| S3 | 36 | 0 | 6,336 |
| R0 | 8 | 0 | 1,408 |
| R1 | 12 | 0 | 2,112 |
| R2 | 12 | 0 | 2,112 |
| J* | 1 | 0 | 176 |
| TOTALS | 217 | 0 | 38,192 |

### UNIT 2 CYCLE 16

| ASSEMBLY BATCH | NUMBER OF ASSEMBLIES | NON-FUEL RODS | TOTAL FUEL RODS |
|---|---|---|---|
| 2V0 | 12 | 0 | 2,112 |
| 2V1 | 28 | 0 | 4,928 |
| 2V2 | 4 | 0 | 704 |
| 2V3 | 16 | 0 | 2,816 |
| 2V4 | 12 | 0 | 2,112 |
| 2V5 | 20 | 0 | 3,520 |
| 2T0 | 20 | 0 | 3,520 |
| 2T1 | 4 | 0 | 704 |
| 2T2 | 40 | 0 | 7,040 |
| 2T3 | 20 | 0 | 3,520 |
| 2TF | 4 | 0 | 704 |
| 2TW | 4 | 0 | 704 |
| 2S0 | 8 | 0 | 1,408 |
| 2S1 | 24 | 0 | 4,224 |
| 1L* | 1 | 0 | 176 |
| TOTALS | 217 | 0 | 38,192 |

## TABLE 3.3-2

## UNIT 2 BATCH-RELATED DATA

### UNIT 2 CYCLE 17

| ASSEMBLY BATCH | NUMBER OF ASSEMBLIES | NON-FUEL RODS | TOTAL FUEL RODS |
|---|---|---|---|
| W1 | 20 | 0 | 3,520 |
| W2 | 4 | 0 | 704 |
| W3 | 8 | 0 | 1,408 |
| W4 | 12 | 0 | 2,112 |
| W5 | 36 | 0 | 6,336 |
| W6 | 16 | 0 | 2,816 |
| V0 | 12 | 0 | 2,112 |
| V1 | 28 | 0 | 4,928 |
| V2 | 4 | 0 | 704 |
| V3 | 16 | 0 | 2,816 |
| V4 | 9 | 0 | 1,584 |
| V5 | 20 | 0 | 3,520 |
| 1V0 | 2 | 0 | 352 |
| 1V1 | 2 | 0 | 352 |
| T0 | 12 | 0 | 2,112 |
| T2 | 8 | 0 | 1,408 |
| T3 | 6 | 0 | 1,056 |
| TW | 2 | 0 | 352 |
| TOTALS | 217 | 0 | 38,192 |

### UNIT 2 CYCLE 18

| ASSEMBLY BATCH | NUMBER OF ASSEMBLIES | NON-FUEL RODS | TOTAL FUEL RODS |
|---|---|---|---|
| 2X1 | 12 | 0 | 2,112 |
| 2X2 | 12 | 0 | 2,112 |
| 2X3 | 28 | 0 | 4,928 |
| 2X4 | 8 | 0 | 1,408 |
| 2X5 | 32 | 0 | 5,632 |
| 2X6 | 4 | 0 | 704 |
| 2W1 | 20 | 0 | 3,520 |
| 2W2 | 4 | 0 | 704 |
| 2W3 | 8 | 0 | 1,408 |
| 2W4 | 12 | 0 | 2,112 |
| 2W5 | 35 | 0 | 6,160 |
| 2W6 | 16 | 0 | 2,816 |
| 2V0 | 11 | 0 | 1,936 |
| 2V1 | 13 | 0 | 2,288 |
| 1X4 | 1 | 0 | 176 |
| 1X7 | 1 | 0 | 176 |
| TOTALS | 217 | 0 | 38,192 |

# TABLE 3.3-2

## UNIT 2 BATCH-RELATED DATA

### UNIT 2 CYCLE 19

| ASSEMBLY BATCH | NUMBER OF ASSEMBLIES | NON-FUEL RODS | TOTAL FUEL RODS |
|---|---|---|---|
| 2Z1 | 8 | 0 | 1,408 |
| 2Z2 | 12 | 0 | 2,112 |
| 2Z3 | 28 | 0 | 4,928 |
| 2Z4 | 44 | 0 | 7,744 |
| 2Z5 | 4 | 0 | 704 |
| | | 0 | |
| 2X1 | 12 | | 2,112 |
| 2X2 | 12 | 0 | 2,112 |
| 2X3 | 28 | 0 | 4,928 |
| 2X4 | 8 | 0 | 1,408 |
| 2X5 | 32 | 0 | 5,632 |
| 2X6 | 4 | 0 | 704 |
| 2W1 | 12 | 0 | 2,112 |
| 2W2 | 4 | 0 | 704 |
| 2W4 | 7 | 0 | 1,232 |
| 2V1 | 1 | 0 | 176 |
| 2V4 | 1 | 0 | 176 |
| TOTALS | 217 | 0 | 38,192 |

### UNIT 2 CYCLE 20

| ASSEMBLY BATCH | NUMBER OF ASSEMBLIES | NON-FUEL RODS | TOTAL FUEL RODS |
|---|---|---|---|
| BA1 | 12 | 0 | 2,112 |
| BA2 | 8 | 0 | 1,408 |
| BA3 | 32 | 0 | 5,632 |
| BA4 | 12 | 0 | 2,112 |
| BA5 | 20 | 0 | 3,520 |
| BA6 | 4 | 0 | 704 |
| BA7 | 12 | 0 | 2,112 |
| 2Z1 | 8 | 0 | 1,408 |
| 2Z2 | 12 | 0 | 2,112 |
| 2Z3 | 24 | 0 | 4,224 |
| 2Z4 | 44 | 0 | 7,744 |
| 2Z5 | 4 | 0 | 704 |
| 2X1 | 8 | 0 | 1,408 |
| 2X2 | 8 | 0 | 1,408 |
| 2X3 | 8 | 0 | 1,408 |
| 1X1 | 1 | 0 | 176 |
| TOTALS | 217 | 0 | 38,192 |

## TABLE 3.3-2

## UNIT 2 BATCH-RELATED DATA

### UNIT 2 CYCLE 21

| ASSEMBLY BATCH | NUMBER OF ASSEMBLIES | NON-FUEL RODS | TOTAL FUEL RODS |
|---|---|---|---|
| BB1 | 12 | 0 | 2,112 |
| BB2 | 8 | 0 | 1,408 |
| BB3 | 20 | 0 | 3,520 |
| BB4 | 28 | 0 | 4,928 |
| BB5 | 28 | 0 | 4,928 |
| BA1 | 12 | 0 | 2,112 |
| BA2 | 8 | 0 | 1,408 |
| BA3 | 32 | 0 | 5,632 |
| BA4 | 12 | 0 | 2,112 |
| BA5 | 17 | 0 | 2,992 |
| BA6 | 4 | 0 | 704 |
| BA7 | 12 | 0 | 2,112 |
| 2Z1 | 8 | 0 | 1,408 |
| 2Z2 | 8 | 0 | 1,408 |
| 2Z3 | 8 | 0 | 1,408 |
| TOTALS | 217 | 0 | 38,192 |

### UNIT 2 CYCLE 22

| ASSEMBLY BATCH | NUMBER OF ASSEMBLIES | NON-FUEL RODS | TOTAL FUEL RODS |
|---|---|---|---|
| BC1 | 12 | 0 | 2,112 |
| BC2 | 8 | 0 | 1,408 |
| BC3 | 20 | 0 | 3,520 |
| BC4 | 20 | 0 | 3,520 |
| BC5 | 36 | 0 | 6,336 |
| BB1 | 12 | 0 | 2,112 |
| BB2 | 8 | 0 | 1,408 |
| BB3 | 20 | 0 | 3,520 |
| BB4 | 28 | 0 | 4,928 |
| BB5 | 24 | 0 | 4,224 |
| BA1 | 12 | 0 | 2,112 |
| BA2 | 8 | 0 | 1,408 |
| BA3 | 4 | 0 | 704 |
| BA5 | 1 | 0 | 176 |
| 2Z3 | 4 | 0 | 704 |
| TOTALS | 217 | 0 | 38,192 |

## UNIT 2 CYCLE 23

| ASSEMBLY BATCH | NUMBER OF ASSEMBLIES | NON-FUEL RODS | TOTAL FUEL RODS |
|---|---|---|---|
| BD1 | 28 | 0 | 4928 |
| BD2 | 28 | 0 | 4928 |
| BD3 | 20 | 0 | 3520 |
| BD4 | 20 | 0 | 3520 |
| BD5 | 1 | 0 | 176 |
| BC1 | 12 | 0 | 2112 |
| BC2 | 8 | 0 | 1408 |
| BC3 | 20 | 0 | 3520 |
| BC4 | 20 | 0 | 3520 |
| BC5 | 36 | 0 | 6336 |
| BB1 | 4 | 0 | 704 |
| BA4 | 4 | 0 | 704 |
| BA7 | 2 | 0 | 352 |
| ZZ4 | 14 | 0 | 2464 |
| TOTALS | 217 | 0 | 38,192 |

## UNIT 2 CYCLE 24

| ASSEMBLY BATCH | NUMBER OF ASSEMBLIES | NON-FUEL RODS | TOTAL FUEL RODS |
|---|---|---|---|
| BE1 | 28 | 0 | 4928 |
| BE2 | 20 | 0 | 3520 |
| BE3 | 16 | 0 | 2816 |
| BE4 | 8 | 0 | 1408 |
| BE5 | 15 | 0 | 2640 |
| BE6 | 1 | 0 | 176 |
| BE7[a] | 8 | 8 | 1400 |
| BD1 | 20 | 0 | 3520 |
| BD2 | 28 | 0 | 4928 |
| BD3 | 20 | 0 | 3520 |
| BD4 | 20 | 0 | 3520 |
| BD5 | 1 | 0 | 176 |
| BC2 | 4 | 0 | 704 |
| BB1 | 8 | 0 | 1408 |
| BB5 | 4 | 0 | 704 |
| AE1[b] | 8 | 64 | 1344 |
| AC1 | 6 | 0 | 1056 |
| AB1 | 2 | 0 | 352 |
| TOTALS | 217 | 72 | 38120 |

# TABLE 3.3-2

## UNIT 2 BATCH-RELATED DATA

| **PARAMETER** | **BATCHES** | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | **A** | **B** | **C** | **D** | **E** | **F** | **G** | **H** |
| Active Length, inches | 136.7 | 136.7 | 136.7 | 136.7 | 136.7 | 136.7 | 136.7 | 136.7 |
| Pellet Diameter, inches | .3805 | .3805 | .3805 | .3765 | .3765 | .3765 | .3765 | .3765 |
| Pellet Length, inches | .450 | .450 | .450 | .450 | .450 | .450 | .450 | .450 |
| Pellet Density, g/cc | 10.412 | 10.412 | 10.412 | 10.385 | 10.385 | 10.385 | 10.385 | 10.385 |
| Stack Height Density, g/cc | 10.039 | 10.043 | 10.039 | 10.046 | 10.046 | 10.046 | 10.046 | 10.046 |
| Clad ID, inches | .3880 | .3880 | .3880 | .3840 | .3840 | .3840 | .3840 | .3840 |
| Clad OD, inches | .440 | .440 | .440 | .440 | .440 | .440 | .440 | .440 |
| Clad Thickness, inches | .026 | .026 | .026 | .028 | .028 | .028 | .028 | .028 |
| Diametral Gap, inches | .0075 | .0075 | .0075 | .0075 | .0075 | .0075 | .0075 | .0075 |

| **PARAMETER** | **BATCHES** | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | **J** | **K** | **L** | **M** | **N** | **NT** | **P** | **R** |
| Active Length, inches | 136.7 | 136.7 | 136.7 | 136.7 | 136.7 | 136.7 | 136.7 | 136.7 |
| Pellet Diameter, inches | .3765 | .3765 | .3765 | .3765 | .3765 | .3810 | .3765 | .3765 |
| Pellet Length, inches | .450 | .450 | .450 | .450 | .450 | .456 | .450 | .450 |
| Pellet Density, g/cc | 10.385 | 10.385 | 10.385 | 10.439 | 10.439 | 10.467 | 10.439 | 10.439 |
| Stack Height Density, g/cc | 10.046 | 10.046 | 10.046 | 10.100 | 10.12 | 10.31 | 10.12 | 10.12 |
| Clad ID, inches | .3840 | .3840 | .3840 | .3840 | .384 | .388 | .384 | .384 |
| Clad OD, inches | .440 | .440 | .440 | .440 | .440 | .440 | .440 | .440 |
| Clad Thickness, inches | .028 | .028 | .028 | .028 | .028 | .026 | .028 | .028 |
| Diametral Gap, inches | .0075 | .0075 | .0075 | .0075 | .0075 | .0070 | .0075 | .0075 |

## TABLE 3.3-2

## UNIT 2 BATCH-RELATED DATA

| **PARAMETER** | **BATCHES** | | | | |
|---|---|---|---|---|---|
| | **S** | **T(Westinghouse)** | **T(FANP)** | **V** | **W** |
| Active Length, inches | 136.7 | 136.7 | 136.7 | 136.7 | 136.7 |
| Pellet Diameter, inches | .3810 | .3810 | .3805 | .3810 | .3810 |
| Pellet Length, inches | .456 | .456 | .435 | .456 | .456 |
| Pellet Density, g/cc | 10.467 | 10.467 | 10.522 | 10.467 | 10.467 |
| Stack Height Density, g/cc | 10.31 | 10.31 | 10.39 | Regular 10.32<br>Annular 7.82 | Regular 10.32<br>Annular 7.82 |
| Clad ID, inches | .3880 | .3880 | .3870 | .3880 | .3880 |
| Clad OD, inches | .440 | .440 | .440 | .440 | .440 |
| Clad Thickness, inches | .026 | .026 | .0265 | .026 | .026 |
| Diametral Gap, inches | .0070 | .0070 | .0065 | .0070 | .0070 |

| **PARAMETER** | **BATCHES** | | | |
|---|---|---|---|---|
| | **X** | **Z** | **BA** | **BB** |
| Active Length, inches | 136.7 | 136.7 | 136.7 | 136.7 |
| Pellet Diameter, inches | .3810 | 0.3805 | 0.3805 | 0.3805 |
| Pellet Length, inches | .456 | 0.476 (Central)<br>0.545 (Blanket) | 0.476 (Central)<br>0.545 (Blanket) | 0.476 (Central)<br>0.545 (Blanket) |
| Pellet Density, g/cc | 10.467 | 10.5216 | 10.5216 | 10.5216 |
| Stack Height Density, g/cc | Regular 10.32<br>Annular 7.82 | 10.3743 ($UO_2$)<br>10.3003 (2 wt% $Gd_2O_3$)<br>10.1565 (6 wt% $Gd_2O_3$)<br>10.0867 (8 wt% $Gd_2O_3$)<br>10.3953 (Blanket) | 10.3743 ($UO_2$)<br>10.3003 (2 wt% $Gd_2O_3$)<br>10.2277 (4 wt% $Gd_2O_3$)<br>10.1565 (6 wt% $Gd_2O_3$)<br>10.0867 (8 wt% $Gd_2O_3$) | 10.3743 ($UO_2$)<br>10.3003 (2 wt% $Gd_2O_3$)<br>10.2277 (4 wt% $Gd_2O_3$)<br>10.1565 (6 wt% $Gd_2O_3$)<br>10.0867 (8 wt% $Gd_2O_3$) |

## TABLE 3.3-2

## UNIT 2 BATCH-RELATED DATA

| | | | | |
|---|---|---|---|---|
| | | | 10.3953 (Blanket) | 10.3953 (Blanket) |
| Clad ID, inches | .3880 | 0.3870 | 0.3870 | 0.3870 |
| Clad OD, inches | .440 | 0.440 | 0.440 | 0.440 |
| Clad Thickness, inches | .026 | 0.0265 | 0.0265 | 0.0265 |
| Diametral Gap, inches | .0070 | 0.0065 | 0.0065 | 0.0065 |

| **PARAMETER** | | **BATCHES** | |
|---|---|---|---|
| | **BC** | **BD** | **BE** |
| Active Length, inches | 136.7 | 136.7 | 136.7 |
| Pellet Diameter, inches | 0.3805 | 0.3805 | 0.3805 |
| Pellet Length, inches | 0.476 (Central)<br>0.545 (Blanket) | 0.476 (Central)<br>0.545 (Blanket) | 0.476 (Central)<br>0.545 (Blanket) |
| Pellet Density, g/cc | 10.5216 | 10.5216 | 10.5216 |
| Stack Height Density, g/cc | 10.3743 ($UO_2$) | 10.3743 ($UO_2$) | 10.3743 ($UO_2$) |
| | | 10.3003 (2% $Gd_2O_3$) | 10.3003 (2% $Gd_2O_3$) |
| | 10.2277 (4 wt% $Gd_2O_3$) | 10.2277 (4% $Gd_2O_3$) | 10.1565 (6% $Gd_2O_3$) |
| | 10.1565 (6 wt% $Gd_2O_3$) | 10.1920 (5% $Gd_2O_3$) | 10.0867 (8% $Gd_2O_3$) |
| | 10.0867 (8 wt% $Gd_2O_3$) | 10.1565 (6% $Gd_2O_3$) | |
| | | 10.1215 (7% $Gd_2O_3$) | |
| | 10.3953 (Blanket) | 10.3953 (Blanket) | 10.3953 (Blanket) |
| Clad ID, inches | 0.387 | 0.387 | 0.387 |
| Clad OD, inches | 0.440 | 0.440 | 0.440 |
| Clad Thickness, inches | 0.0265 | 0.0265 | 0.0265 |
| Diametral Gap, inches | 0.0065 | 0.0065 | 0.0065 |

[1] Note that the density of the chromium-doped pellets for the LTA (batch BE6) differs from the standard $UO_2$ pellets of batch BE. Pellet densities from chromium- doped pellets are considered proprietary and shall not be reported in the UFSAR.

## TABLE 3.3-3

## BURNABLE POISON ROD DATA

## UNITS 1 AND 2

| BATCH | B,C+,C. | 1G/,1H/ 2F/,2G/ | 2K/,2K*,1NX, 1N/,1M*,2L*, 2L/,2LX | 1MX | 2LE | 2M | 1P | 2N | 2NT | 2P |
|---|---|---|---|---|---|---|---|---|---|---|
| Active Length | 122.7 | 122.7 | 122.7 | 122.7 | 115.7 | 115.7 | 108.7 | 112.7 | 112.7 | 112.2 |
| Pellet Diameter | .376 | .362 | .362 | .370 | .3765 | .362 | .3765 | .3765 | .3810 | .3765 |
| Clad ID | .388 | .384 | .384 | .378 | .384 | .384 | .384 | .384 | .388 | .384 |
| Clad OD | .440 | .440 | .440 | .440 | .440 | .440 | .440 | .440 | .440 | .440 |
| Clad Thickness, inches | .026 | .028 | .028 | .031 | .028 | .028 | .028 | .028 | .026 | .028 |
| Diametral Gap, inches | .012 | .022 | .022 | .008 | .0075 | .022 | .0075 | .0075 | .0070 | .0075 |

| BATCH | 1R | 1RT | 2R | 1S | 1T | 2S | 1V | 2T | 1W | 2V |
|---|---|---|---|---|---|---|---|---|---|---|
| Active Length | 114.2 | 114.2 | 112.7 | 114.2 | 112.2 | 112.7 | 112.2 | 112.2 | 114.2 | 114.7 |
| Pellet Diameter | .3765 | .3810 | .3765 | .3765 | .3810 | .3810 | .3810 | .3810 | .3810 | .3810 |
| Clad ID | .384 | .388 | .384 | .384 | .388 | .388 | .388 | .388 | .3880 | .388 |
| Clad OD | .440 | .440 | .440 | .440 | .440 | .440 | .440 | .440 | .440 | .440 |
| Clad Thickness, inches | .028 | .026 | .028 | .028 | .026 | .026 | .026 | .026 | .026 | .026 |
| Diametral Gap, inches | .0075 | .0070 | .0075 | .0075 | .0070 | .007 | .007 | .007 | .0070 | .0070 |

| BATCH | 1X | 2W | 1Z | 2X | AA | 2Z | AB | BA | AC |
|---|---|---|---|---|---|---|---|---|---|
| Active Length | 116.7 | 116.7 | 116.7 | 116.7 | 116.7 | 112.7 | 112.7 | 112.7 | 112.7 |
| Pellet Diameter | .3810 | .3810 | .3810 | .3810 | .3810 | 0.3805 | 0.3805 | 0.3805 | 0.3805 |
| Clad ID | .388 | .388 | .388 | .388 | .388 | 0.3870 | 0.387 | 0.387 | 0.387 |
| Clad OD | .440 | .440 | .440 | .440 | .440 | 0.440 | 0.440 | 0.440 | 0.440 |
| Clad Thickness, inches | .026 | .026 | .026 | .026 | .026 | 0.0265 | 0.0265 | 0.0265 | 0.0265 |
| Diametral Gap, inches | .0070 | .0070 | .0070 | .0070 | .0070 | 0.0065 | 0.0065 | 0.0065 | 0.0065 |

# TABLE 3.3-3

# BURNABLE POISON ROD DATA

# UNITS 1 AND 2

| BATCH | BB | AD | BC | AE | BD | AF | BE |
|---|---|---|---|---|---|---|---|
| Active Length, inches | 112.7 | 112.7 | 112.7 | 112.7 | 112.7 | 112.7 | 112.7 |
| Pellet Diameter, inches | 0.3805 | 0.3805 | 0.3805 | 0.3805 | 0.3805 | 0.3805 | 0.3805 |
| Clad ID, inches | 0.387 | 0.387 | 0.387 | 0.387 | 0.387 | 0.387 | 0.387 |
| Clad OD, inches | 0.440 | 0.440 | 0.440 | 0.440 | 0.440 | 0.440 | 0.440 |
| Clad Thickness, inches | 0.0265 | 0.0265 | 0.0265 | 0.0265 | 0.0265 | 0.0265 | 0.0265 |
| Diametral Gap, inches | 0.0065 | 0.0065 | 0.0065 | 0.0065 | 0.0065 | 0.0065 | 0.0065 |

All dimensions in inches.

Batch 1 MX is ANF demonstration fuel with 12 $Gd_2O_3$ (10 wt%) fuel bearing (natural uranium) poison rods per assembly.

Batch 2LE is Erbium bearing demonstration fuel with 44 $Er_2O_3$ (0.9 wt%) fuel bearing (3.40 wt% U-235) rods per assembly.

## TABLE 3.3-4

## CONTROL ELEMENT ASSEMBLY DATA

## UNITS 1 AND 2

## All Dimensions are Nominal and are in inches

| **CEA TYPE** | **FLCEA8**<br>**Non-reconstitutable** | **FLCEA7**<br>**Non-reconstitutable** | **FLCEA10**<br>**Non-reconstitutable** | **FLCEA9**<br>**Non-reconstitutable** |
|---|---|---|---|---|
| Number | 76(1) | 1(2) | 76(1) | 1(2) |
| Clad Thickness | 0.040 | 0.040 | 0.040 | 0.040 |
| Clad OD | 0.948 | 0.948 | 0.948 | 0.948 |
| Diametral Gap B4C/UAIC/LAIC/USS/LSS | .008(3) | .008(3) | .008/.012/.017/NA/NA | .008/.012/.017/.118/.012 |
| Corner Element Pitch | 4.64 | 4.64 | 4.64 | 4.64 |
| Pellet Type | B4C/AIC | AL2O3/SS/B4C/AIC | B4C/UAIC/LAIC | B4C/UAIC/LAIC/USS/LSS |
| Pellet Diameter | 0.86/0.86 | 0.85/0.86/0.86/0.86 | 0.86/0.856/0.851 | 0.86/0.856/0.851/0.75/0.856 |

---

Note (1) up to 76 FLCEA1, FLCEA2, FLCEA8 or FLCEA10
Note (2) up to 1 of FLCEA7 or FLCEA9
Note (3) diametral gap is .008 regardless of pellet type
AIC: Ag-In-Cd (Silver-Indium-Cadmium)
UAIC: Upper AIC
LAIC: Lower AIC
SS: Stainless Steel
USS: Upper SS
LSS: Lower SS

# TABLE 3.3-4

# CONTROL ELEMENT ASSEMBLY DATA

# UNITS 1 AND 2

## GUIDE TUBE FLUX SUPPRESSOR DATA

## UNIT 1 (CYCLES 11 AND 12)

| PARAMETER | GTFS |
|---|---|
| Number | 24(U1) |
| Clad Thickness | .040 |
| Clad OD | .948 |
| Diametral Gap | .008 |
| Pellet Type | $Al_2O_3/B_4C$ |
| Pellet Diameter | .85/.86 |

---

NOTE: All dimensions in inches except where noted.

# TABLE 3.3-5

# CORE RELATED DATA

# UNIT 1 AND UNIT 2

**CORE ARRANGEMENT**

| | |
|---|---|
| Number of Fuel Assemblies in Core, Total | 217 |
| Number of CEAs | 77 |
| Total Number of Fuel Rods and Non-Fuel Rods | 38,192 |
| CEA Pitch, min, inches | 11.57 |
| Spacing Between Fuel Assemblies, Fuel Rod Surface to Surface, inches | .20 |
| Spacing, Outer Fuel Rod Surface to Core Shroud, inches | .204 |
| Hydraulic Diameter, Nominal Channel, feet | .044 |
| Total Flow Area (Excluding Guide Tubes), $ft^2$ | 53.5 |
| Total Core Cross-section Area, $ft^2$ | 101.1 |
| Core Equivalent Diameter, inches | 136 |
| Core Circumscribed Diameter, inches | 143.3 |
| Core Volume, $ft^3$ | 1151 |