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sufficient to offset the increase in reactivity, within statistical uncertainty, due to the presence of CCs.

The maximum k_{eff} for each class of fuel assembly and the corresponding dry k_{eff} (normal condition for storage) is shown in Table P.6-27. KENO model plots of the worst cases for each fuel assembly class are shown in Figure P.6-13 through Figure P.6-23.

D. Determination of the Most Reactive Damaged Fuel Configuration

There are several mechanisms by which a fuel rod may be breached. These mechanisms may occur while the fuel is loaded in the reactor core, in the spent fuel pool, during *transfer*, while in temporary dry storage, and while in permanent dry storage. In addition, the type and extent of fuel rod breach can be broken down into several categories. For this calculation, the method by which the fuel rod is breached is not as important as the extent of the resultant damage. The worst case gross damage resulting from a cask-drop accident is assumed to be either a single-ended or double-ended rod shear with moderator intrusion. The bent or bowed fuel rod cases assume that the fuel is intact but not in its nominal fuel rod pitch. It is possible that the fuel rods may be crushed inwards or bowed outwards to a certain degree. Therefore, this will be evaluated by varying the fuel rod pitch from a minimum pitch (based on clad OD) to a maximum based on the fuel compartment tube size for each fuel assembly class. All pitch variations assume a uniform rod pitch throughout the entire fuel matrix.

The single-ended fuel rod shear cases assume that a fuel rod shears in one place and is displaced to a new location. The fuel pellets are assumed to remain in the fuel rod. This case will be evaluated by displacing one row of rods from the base fuel assembly matrix at small increments towards the side of the fuel compartment tube. The base fuel assembly matrix will be at nominal pitch and positioned in the "inward" position within the 24PTH-DSC to maximize the separation distance between the fuel array and the sheared row of fuel rods. A smaller rod pitch for the base fuel assembly matrix was not chosen because it has been shown from the pitch cases that decreasing the rod pitch decreases reactivity. Increasing the base fuel assembly rod pitch will increase reactivity, however, the resulting model is similar to and is bounded by the rod pitch varying cases presented above and therefore will not be duplicated here. The single shear cases are analyzed for all fuel assembly classes.

The double-ended fuel rod shear cases assume that the fuel rod shears in two places and the intact fuel rod piece is separated from the parent fuel rod. Three resulting conditions are exhibited by the occurrence of a double-ended rod shear. These are, the fuel rod piece can remain in place, it can be displaced in the same plane, or it can be displaced to a different plane. The "remain in place" situation results in no deviation from the base fuel assembly matrix, and is therefore considered trivial and will not be evaluated separately. The fuel rod piece displaced in the same plane is equivalent to the single-ended rod shear case discussed above and will not be reevaluated in these cases. The fuel rod piece displaced in a different plane results in two possibilities: an added rod or a removed rod. As in the single-ended shear cases, the base fuel assembly matrix will be positioned in the "inward" position of the 24PTH-DSC to allow room for a row of displaced fuel rods. One row of fuel rods of different lengths will be removed from a section of the assembly and added to another to determine if the system exhibits any trends. The nominal rod pitch is used for the base fuel matrix just as in the single-ended shear rod cases.

Due to the size of the B&W 15x15 fuel assembly relative to the fuel compartment tube, the double-ended rod shear case will not be analyzed since the minimum size of the postulated 15x16 fuel assembly exceeds the fuel compartment tube size. However, all the other fuel assembly classes are analyzed for the double-ended shear configuration.

The first step is to determine the most reactive damaged fuel assembly geometry. This was completed using limiting fixed poison loading, soluble boron concentration and assembly enrichment for the various fuel assembly classes. The limiting parameters used for this study are shown in Table P.6-28 and are based on selecting the highest permissible initial enrichment of 5.00 w/o U-235 for all fuel assembly classes. All 24 assembly locations were filled with damaged fuel assemblies. The intent of these calculations is to determine the most reactive geometry, not to meet the USL. The following is a breakdown of runs made in this analysis:

- Optimum Rod Pitch Study (for fuel assemblies and rod storage baskets) including enough missing fuel rods in an assembly to demonstrate that the worst case fuel geometry has been determined.
- Single-ended Shear Study.
- Double-ended Shear Study.
- Shifting of fuel assemblies beyond (6 inches above) the poison sheet height.

The canister/cask model for this evaluation differs from the actual design in the following ways:

- The boron 10 content is 10% lower than the minimum required in the B-Al poison plates and 25% lower than the minimum required in the Boral® plates,
- The neutron shield and the neutron shield jackaet (outer skin) of the cask are conservatively replaced with water between the casks, and
- The worst case material conditions, as determined in the previous Section above, are modeled.
- The "egg-crate" section length is modeled as 23.23 inches long (21.48" basket section + 1.75" steel insert plate). The actual design for the 24PTH-S has an "egg-crate" section length of 23.145 inches (20.77" basket section + 2.375" steel insert plate).

With the selection of the most reactive damaged fuel assembly geometry, the next set of analyses determined the maximum k_{eff} for various damaged fuel assembly loading configurations in the NUHOMS® 24PTH-DSC. The most reactive damaged fuel assembly geometry for each fuel assembly class thus determined will be bounding on all other damaged fuel geometries for the corresponding fuel assembly classes. Cases are then run to determine soluble boron loading for selected initial U235 enrichments for loading up to12 damaged fuel assemblies around the outside assembly locations. Cases are analyzed for all the configurations described in Table P.6-4.

All changes on this page are AMD 13

D.1 Effect of Rod Pitch and Number of Fuel Rods

The first set of damaged fuel analyses involved a study on the effect of the fuel rod pitch on system reactivity. KENO models with rod pitches ranging from a minimum corresponding to the clad OD to a maximum limited by the fuel compartment tube size are developed for each fuel assembly class. The results of the rod pitch study are shown in Table P.6-29. These results indicate that for nearly all the fuel assembly classes, the largest pitch (limited by the fuel compartment tube size) resulted in the most reactive configuration.

Once the most reactive pitch was determined, a series of calculations were performed that added or subtracted fuel rods from the base assembly to ensure that the limiting fuel assembly geometry was determined. The removal of fuel rods was restricted to those in the interior locations of the fuel assembly lattices to ensure that neutron communication is maintained. The selection of the rod loading patterns is aimed at maximizing the reactivity and those that are investigated are representative. All combinations of fuel rod positions are not investigated here for the sheer enormity of the task. It is expected that the reactivities of other cases (not investigated) with the same number of rods but with different loading patterns are within statistical uncertainty. Due to the presence of soluble boron in the moderator, it is expected that the maximum reactivity would occur when empty rod locations are replaced by fuel rods. These calculations are repeated for all classes of fuel assemblies at the optimum pitch value and the optimum moderator density. However, for the most reactive configuration, the moderator density is varied to determine the maximum value of k_{eff}. These results are shown in Table P.6-30. The results indicate that the most reactive configuration occurs when the fuel rods are at an optimum pitch with all the empty locations (guide tube and instrument tube) are replaced with fuel rods.

D.2 Single Ended Shear Study

The next sets of analyses performed are for the Single-ended rod shear studies. The Single-ended Rod Shear Study depicts the fuel assembly with its last row of rods torn away from the rest of the assembly. The displacement of the sheared row of rods varies radially from fuel assembly up to a maximum that is governed by the fuel assembly width and the fuel compartment tube size. To model this in KENO, the base case was slightly modified. First, the inward arrangement of fuel assemblies was modeled using only 4 units in KENO -- 201, 204, 211 and 214 instead of 24 units (one for each assembly position). Also, for a given fuel lattice, the fuel assemblies are modeled as a XX by (XX-1) array where XX corresponds to the fuel assembly class. For example, the B&W 15x15 fuel assembly is modeled as a 15x14 array. Unit 200 is a XX by 1 array comprising of the single sheared row of rods. The units 201, 204, 211 and 214, therefore comprise of two arrays, the array describing the truncated fuel assembly and the sheared row of fuel rods. The displaced row of rod array is then shifted (separation distance is "d") towards the top or bottom end of the fuel compartment tube (or away from the fuel assembly). The amount of fuel remains the same, i.e. no new fuel is added to the system. Nominal rod pitch for all of the fuel assembly classes is used for the base XX by (XX-1) fuel assembly. In the cask drop accident scenarios, even though highly unlikely the fuel assembly is assumed to be crushed as a result of the drop and therefore it may cause local decreases in the rod pitch of the assembly. However, the rod pitch studies outlined above show that a decrease in the fuel rod pitch results in a decrease in system reactivity, therefore for the single-ended rod

shear study runs, rod pitch is modeled at nominal value. The study is repeated for all fuel assembly classes and at varying moderator density for important separation distances.

At minimum shear distance, the results of this evaluation are compared to those given in Table P.6-29 to determine whether two different KENO models of the same geometry result in statistically insignificant differences. An example model plot of a single ended shear configuration with WE 14x14 fuel assembly is shown in Figure P.6-20. The results of this evaluation are shown in Table P.6-31. The results indicate that the differences in KENO models are statistically insignificant and that there exists an optimum shear row separation distance for each class of fuel assembly where the reactivity is highest.

D.3 Double Ended Shear Study

The three Double-ended Rod Shear cases model a row (XX by 1 array) of dislocated rods severed at different sections axially and then displacing to other sections of the DSC in order to define a conservative bounding condition for fuel rod location subsequent to a double-ended rod shear. To model this in KENO, the base case was accordingly modified. First, the inward arrangement of fuel assemblies was modeled using only 4 units in KENO -- 201, 204, 211 and 214 instead of 24 units (one for each assembly position). A new KENO unit, UNIT 11 forms one axial section of the basket that models the un-sheared fuel assemblies. The sheared fuel assemblies depleted by one row of fuel rods are modeled as a XX by (XX-1) array where XX corresponds to the fuel assembly class. The corresponding KENO units for the fuel assembly positions are 301, 304, 311 and 314. The unit 12 forms the axial section of the basket that models this depleted array of fuel assemblies. The fuel assemblies that contain the sheared-migrated row of fuel rods are modeled as a XX by (XX+1) array where XX corresponds to the fuel assembly class. The corresponding KENO units for the fuel assembly positions are 401, 404, 411 and 414. The unit 13 forms the axial section of the basket that models this depleted array of fuel assemblies. Depending on the fraction of double shear, the array 11 (an axial array of units 11, 12 and 13) is constructed to calculate the reactivity effect. Due to the height of a single axial segment (23.23"), the total axial height of the model for these studies is 139.38" (23.23*6). However, periodic axial boundary conditions are applied making the model essentially infinite. The same rod pitch assumptions made for the Single-ended Shear runs also apply here. Basically three types of double ended shear studies are evaluated. The first is a (1/2) shear where the sheared row breaks into two equal sections resulting in one-half of the fuel assembly that is defined by a rod array containing an extra row of fuel rods while the other half that is defined by an array depleted by one row of fuel rods. The second is a (1/3) shear where the sheared row breaks into two unequal sections measuring a third of the fuel assembly length and two-thirds of the fuel assembly length respectively. Therefore, the fuel assembly can be defined by three equal axial sections, one with a regular array of fuel rods, one with an extra row of fuel rods and the other with a depleted row of fuel rods. The same mechanism can be extended to other shear ratios but the effect on reactivity is expected to reduce with reduction in the shear ratio. The (1/4) shear is also analyzed in this study. Due to the size of the B&W 15x15 fuel assembly relative to the fuel compartment tube internal dimension, a double ended shear break is not credible. Therefore, this study is performed for all classes of fuel assemblies except the B&W 15x15 class. The internal moderator density is varied to determine the k_{eff} at optimum density.

All changes on this page are AMD 13

At the no-shear simulation, the results of this evaluation are compared to those given in Table P.6-29 to determine whether two different KENO models of the same geometry result in statistically insignificant differences. An example plot of a double ended shear configuration with CE 16x16 fuel assembly is shown in Figure P.6-21. *A sample input file for the CE 15x15 assembly with double shear is provided in Section P.6.6.2.* The results of this evaluation for CE fuel assemblies are shown Table P.6-32. Results of the Double-ended rod shear study show that the movement of one exterior row of 1/2 of the fuel assembly length is the most reactive.

D.4 Shifting of Fuel Beyond Fixed Poison

This study analyzes the effect of shifting of loose rods beyond the height of the poison plates. The calculational model assumes that a six-inch axial section of the entire fuel assembly shifts beyond the poison plates. This assumption conservatively bounds all the cases associated with the shifting of loose rods like sliding of a single rod, sliding of a row of single sheared rods etc. To model this in KENO, the base case was accordingly modified. First, the inward arrangement of fuel assemblies was modeled using only 4 units in KENO -- 201, 204, 211 and 214 instead of 24 units (one for each assembly position). A new KENO unit, UNIT 11 forms one axial section of the basket that models the fuel assemblies covered with poison. A six-inch axial section of the fuel assemblies containing the uncovered fuel assemblies are modeled with the KENO units 301, 304, 311 and 314. The unit 12 forms the axial section of the basket that models this uncovered section of fuel assemblies. Finally, the array 11 (an axial array of units 11 and 12) is constructed to calculate the reactivity effect. Periodic axial boundary conditions are utilized to make this model essentially infinite in length. This study is performed for all fuel assembly classes with varying moderator density.

The results of this evaluation are shown in Table P.6-33.

E. Most Reactive Damaged Configuration and Dancoff Factors

The fuel-loading configuration of the canister/cask affects the reactivity of the package. Several series of analyses performed in the previous section evaluated the various damaged assembly configurations. A comparison of the maximum k_{eff} due to the various damaged assembly configurations is shown in Table P.6-34. The most reactive damaged assembly configuration is based on the one with optimum pitch with the empty locations replaced with fuel rods. This configuration is the design basis configuration for all fuel assembly classes. This configuration will be utilized to determine the k_{eff} of the NUHOMS® 24PTH DSC containing damaged fuel assemblies.

For the configurations with both intact and damaged fuel assemblies loaded in a single DSC, modifications in the KENO input files are necessary to represent both the fuel lattices accurately. The fuel lattice data for the damaged fuel assemblies are provided through the "more data" card while those for the intact fuel assemblies are provided through the usual "squarepitch" card. This is due to the limitation of KENO to handle only one "squarepitch" card. The "more data" card requires the input of a Dancoff factor that represents the resonance absorption details in the damaged fuel lattice. The dancoff factor for the damaged fuel is obtained from a previously run KENO output containing a single fuel type. The Dancoff factor varies with moderator density

and to some extent with soluble boron concentration. Therefore, in order to utilize two fuel types in the same KENO model, the Dancoff factors for the various conditions listed in Table *P.6-35* are obtained from separate KENO calculations. The results for the Dancoff factor KENO outputs that are required to be input to the final calculations are shown in Table P.6-35. For the dry computer cases (moderator density = 0.01%), a conservative Dancoff factor of 0.99999 is used.

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F. Determination of the Damaged Fuel Loading Configuration for each Fuel Class

The most reactive damaged fuel configuration as determined above is with the fuel assembly defined by the fuel rods at optimum pitch and the empty guide tube and instrument tube locations replaced with fuel rods. The following analysis uses this configuration for the damaged fuel assemblies to determine the maximum allowed initial enrichment as a function of poison plate loading and soluble boron concentration for each assembly class. The design basis damaged assembly and the most reactive intact assembly type (from Table P.6-3) for each assembly class is used for each evaluation. Only the fuel assembly type, the number of damaged fuel assemblies per DSC and the fixed and soluble poison loading is changed for each model. In addition, for each case the internal moderator density is varied to determine the peak reactivity for the specific configuration. For these analyses, the moderator in the cask-canister annulus is treated as internal moderator except that it is not borated water (density of the water in the annulus changes with that of the borated water). The maximum initial enrichment for each assembly class as a function of soluble boron concentration and poison plate loading is documented in Table P.6-4.

The canister/cask model for this evaluation differs from the actual design in the following ways:

- the boron 10 content in the poison plates is 10% lower than the minimum required,
- the neutron shield and the neutron shield jackaet (outer skin) of the cask are conservatively replaced with water between the casks, and
- the worst case material conditions, as determined Section P.6.4.2 for intact fuel, are modeled.
- The "egg-crate" section length is modeled as 23.23 inches long (21.48" basket section + 1.75" steel insert plate). The actual design for the 24PTH-S has an "egg-crate" section length of 23.145 inches (20.77" basket section + 2.375" steel insert plate).

The soluble boron concentration credited in this analysis is varied from 2100 ppm to a maximum of 2750 ppm. The maximum analyzed initial enrichment is 5.0 wt. % U-235. The DSC is loaded with a maximum of 12 damaged fuel assemblies at the outermost positions. A sample input file is included in Section P.6.6.2.

Table P.6-28
Key Parameters Utilized in the Damaged/*Failed* Assembly Calculations

Fuel Assembly Class	Enrichment (Wt. % U-235)	Basket Type	Minimum Soluble Boron (ppm boron)
B&W 15x15	5.00	1C or 2C	2700
CE 14x14	5.00	1B or 2B	2400
CE 15x15	5.00	1C or 2C	2600
CE 16x16	5.00	1B or 2B	2500
WE 14x14	5.00	1B or 2B	2400
WE 15x15	5.00	1C or 2C	2500
WE 17x17	5.00	1C or 2C	2600

All changes on this page are AMD 13

Table P.6-29
Rod Pitch Study Results

Model Description	k_{KENO}	1σ	k_{eff}
B&W 15x15 Fuel Assembly, Enrichment = 5.00 wt. %, Soluble Boron = 2700 ppm, Type 1C or 2C Basket			
Pitch = 0.4300", IMD=60%	0.6749	0.0010	0.6769
Pitch = 0.4300", IMD=80%	0.6843	0.0010	0.6863
Pitch = 0.4300", IMD=100%	0.7073	0.0011	0.7095
Pitch = 0.4500", IMD=60%	0.7212	0.0011	0.7234
Pitch = 0.4500", IMD=80%	0.7375	0.0010	0.7395
Pitch = 0.4500", IMD=100%	0.7584	0.0009	0.7602
Pitch = 0.4750", IMD=60%	0.7763	0.0010	0.7783
Pitch = 0.4750", IMD=80%	0.7975	0.0012	0.7999
Pitch = 0.4750", IMD=100%	0.8102	0.0011	0.8124
Pitch = 0.5000", IMD=60%	0.8288	0.0011	0.8310
Pitch = 0.5000", IMD=80%	0.8470	0.0012	0.8494
Pitch = 0.5000", IMD=100%	0.8571	0.0010	0.8591
Pitch = 0.5250", IMD=60%	0.8723	0.0009	0.8741
Pitch = 0.5250", IMD=80%	0.8903	0.0009	0.8921
Pitch = 0.5250", IMD=100%	0.8911	0.0011	0.8933
Pitch = 0.5500", IMD=60%	0.9007	0.0010	0.9027
Pitch = 0.5500", IMD=80%	0.9211	0.0009	0.9229
Pitch = 0.5500", IMD=100%	0.9194	0.0010	0.9214
Pitch = 0.5680", IMD=60%	0.9156	0.0010	0.9176
Pitch = 0.5680", IMD=80%	0.9327	0.0009	0.9345
Pitch = 0.5680", IMD=100%	0.9283	0.0010	0.9303
Pitch = 0.5750", IMD=60%	0.9210	0.0010	0.9230
Pitch = 0.5750", IMD=70%	0.9309	0.0009	0.9327
Pitch = 0.5750", IMD=80%	0.9366	0.0010	0.9386
Pitch = 0.5750", IMD=90%	0.9356	0.0009	0.9374
Pitch = 0.5750", IMD=100%	0.9298	0.0010	0.9318
Pitch = 0.5950", IMD=60%	0.9256	0.0010	0.9276
Pitch = 0.5950", IMD=70%	0.9369	0.0010	0.9389
Pitch = 0.5950", IMD=80%	**0.9390**	**0.0010**	**0.9410**
Pitch = 0.5950", IMD=90%	0.9338	0.0008	0.9354
Pitch = 0.5950", IMD=100%	0.9258	0.0009	0.9276

Table P.6-29
Rod Pitch Study Results
(Continued)

Model Description	k_{KENO}	1σ	k_{eff}
CE 14x14 Fuel Assembly, Enrichment = 5.00 wt. %, Soluble Boron = 2400 ppm, Type 1B or 2B Basket			
Pitch = 0.4600", IMD=80%	0.6713	0.0009	0.6731
Pitch = 0.4600", IMD=80%	0.7202	0.0011	0.7224
Pitch = 0.5000", IMD=80%	0.8037	0.0011	0.8059
Pitch = 0.5400", IMD=80%	0.8677	0.0012	0.8701
Pitch = 0.5800", IMD=80%	0.9145	0.0009	0.9163
Pitch = 0.6200", IMD=50%	0.9244	0.0010	0.9264
Pitch = 0.6200", IMD=60%	**0.9387**	**0.0008**	**0.9403**
Pitch = 0.6200", IMD=70%	0.9360	0.0010	0.9380
Pitch = 0.6200", IMD=80%	0.9349	0.0009	0.9367
Pitch = 0.6200", IMD=90%	0.9236	0.0010	0.9256
Pitch = 0.6200", IMD=100%	0.9135	0.0010	0.9155
Pitch = 0.6260", IMD=50%	0.9277	0.0010	0.9297
Pitch = 0.6260", IMD=60%	0.9366	0.0010	0.9386
Pitch = 0.6260", IMD=70%	0.9374	0.0009	0.9392
Pitch = 0.6260", IMD=80%	0.9326	0.0008	0.9342
Pitch = 0.6260", IMD=90%	0.9222	0.0009	0.9240
Pitch = 0.6260", IMD=100%	0.9090	0.0010	0.9110
Pitch = 0.6400", IMD=50%	0.9300	0.0009	0.9318
Pitch = 0.6400", IMD=60%	0.9381	0.0009	0.9399
Pitch = 0.6400", IMD=70%	0.9375	0.0009	0.9393
Pitch = 0.6400", IMD=80%	0.9301	0.0009	0.9319
Pitch = 0.6400", IMD=90%	0.9165	0.0009	0.9183
Pitch = 0.6400", IMD=100%	0.9021	0.0008	0.9037
CE 15x15 Fuel Assembly, Enrichment = 5.00 wt. %, Soluble Boron = 2600 ppm, Type 1C or 2C Basket			
Pitch = 0.4180", IMD=60%	0.6399	0.0010	0.6419
Pitch = 0.4180", IMD=80%	0.6476	0.0009	0.6494
Pitch = 0.4180", IMD=100%	0.6640	0.0011	0.6662
Pitch = 0.4500", IMD=60%	0.7162	0.0010	0.7182
Pitch = 0.4500", IMD=80%	0.7325	0.0011	0.7347
Pitch = 0.4500", IMD=100%	0.7523	0.0010	0.7543
Pitch = 0.4750", IMD=60%	0.7725	0.0009	0.7743
Pitch = 0.4750", IMD=80%	0.7910	0.0010	0.7930
Pitch = 0.4750", IMD=100%	0.8094	0.0012	0.8118

Table P.6-29
Rod Pitch Study Results
(Continued)

Model Description	k_{KENO}	1σ	k_{eff}
CE 15x15 Fuel Assembly, Enrichment = 5.00 wt. %, Soluble Boron = 2600 ppm, Type 1C or 2C Basket			
Pitch = 0.5000", IMD=60%	0.8227	0.0010	0.8247
Pitch = 0.5000", IMD=80%	0.8424	0.0011	0.8446
Pitch = 0.5000", IMD=100%	0.8552	0.0010	0.8572
Pitch = 0.5250", IMD=60%	0.8640	0.0011	0.8662
Pitch = 0.5250", IMD=80%	0.8876	0.0011	0.8898
Pitch = 0.5250", IMD=100%	0.8946	0.0010	0.8966
Pitch = 0.5500", IMD=60%	0.8971	0.0009	0.8989
Pitch = 0.5500", IMD=80%	0.9169	0.0010	0.9189
Pitch = 0.5500", IMD=100%	0.9212	0.0011	0.9234
Pitch = 0.5750", IMD=60%	0.9169	0.0009	0.9187
Pitch = 0.5750", IMD=70%	0.9302	0.0010	0.9322
Pitch = 0.5750", IMD=80%	0.9361	0.0009	0.9379
Pitch = 0.5750", IMD=90%	0.9369	0.0009	0.9387
Pitch = 0.5750", IMD=100%	0.9332	0.0010	0.9352
Pitch = 0.5750", IMD=60%	0.9259	0.0011	0.9281
Pitch = 0.5750", IMD=70%	0.9372	0.0011	0.9394
Pitch = 0.5750", IMD=80%	**0.9391**	**0.0009**	**0.9409**
Pitch = 0.5750", IMD=90%	0.9369	0.0010	0.9389
Pitch = 0.5750", IMD=100%	0.9311	0.0011	0.9333
CE 16x16 Fuel Assembly, Enrichment = 5.00 wt. %, Soluble Boron = 2500 ppm, Type 1B or 2B Basket			
Pitch = 0.3820", IMD=80%	0.6680	0.0009	0.6698
Pitch = 0.4200", IMD=80%	0.7672	0.0012	0.7696
Pitch = 0.4600", IMD=80%	0.8486	0.0013	0.8512
Pitch = 0.5060", IMD=80%	0.9155	0.0010	0.9175
Pitch = 0.5400", IMD=50%	0.9249	0.0009	0.9267
Pitch = 0.5400", IMD=60%	0.9375	0.0009	0.9393
Pitch = 0.5400", IMD=70%	0.9391	0.0009	0.9409
Pitch = 0.5400", IMD=80%	0.9363	0.0008	0.9379
Pitch = 0.5400", IMD=90%	0.9279	0.0008	0.9295
Pitch = 0.5400", IMD=100%	0.9169	0.0008	0.9185
Pitch = 0.5478", IMD=50%	0.9265	0.0009	0.9283
Pitch = 0.5478", IMD=60%	0.9373	0.0009	0.9391
Pitch = 0.5478", IMD=70%	**0.9404**	**0.0009**	**0.9422**

Table P.6-29
Rod Pitch Study Results
(Continued)

Model Description	k_{KENO}	1σ	k_{eff}
CE 16x16 Fuel Assembly, Enrichment = 5.00 wt. %, Soluble Boron = 2500 ppm, Type 1B or 2B Basket			
Pitch = 0.5478", IMD=80%	0.9355	0.0011	0.9377
Pitch = 0.5478", IMD=90%	0.9257	0.0008	0.9273
Pitch = 0.5478", IMD=100%	0.9147	0.0009	0.9165
Pitch = 0.5580", IMD=50%	0.9285	0.0010	0.9305
Pitch = 0.5580", IMD=60%	0.9384	0.0008	0.9400
Pitch = 0.5580", IMD=70%	0.9389	0.0010	0.9409
Pitch = 0.5580", IMD=80%	0.9332	0.0009	0.9350
Pitch = 0.5580", IMD=90%	0.9221	0.0008	0.9237
Pitch = 0.5580", IMD=100%	0.9080	0.0010	0.9100
WE 14x14 Fuel Assembly, Enrichment = 5.00 wt. %, Soluble Boron = 2400 ppm, Type 1B or 2B Basket			
Pitch = 0.4220", IMD=80%	0.6674	0.0011	0.6696
Pitch = 0.4600", IMD=80%	0.7539	0.0010	0.7559
Pitch = 0.5000", IMD=80%	0.8273	0.0012	0.8297
Pitch = 0.5400", IMD=80%	0.8841	0.0011	0.8863
Pitch = 0.5560", IMD=80%	0.9015	0.0009	0.9033
Pitch = 0.5800", IMD=80%	0.9240	0.0010	0.9260
Pitch = 0.6200", IMD=50%	0.9306	0.0009	0.9324
Pitch = 0.6200", IMD=60%	0.9420	0.0010	0.9440
Pitch = 0.6200", IMD=70%	0.9428	0.0010	0.9448
Pitch = 0.6200", IMD=80%	0.9363	0.0009	0.9381
Pitch = 0.6200", IMD=90%	0.9258	0.0009	0.9276
Pitch = 0.6200", IMD=100%	0.9112	0.0010	0.9132
Pitch = 0.6260", IMD=50%	0.9341	0.0009	0.9359
Pitch = 0.6260", IMD=60%	0.9415	0.0009	0.9433
Pitch = 0.6260", IMD=70%	0.9421	0.0011	0.9443
Pitch = 0.6260", IMD=80%	0.9357	0.0009	0.9375
Pitch = 0.6260", IMD=90%	0.9269	0.0009	0.9287
Pitch = 0.6260", IMD=100%	0.9104	0.0009	0.9122
Pitch = 0.6400", IMD=50%	0.9356	0.0009	0.9374
Pitch = 0.6400", IMD=60%	**0.9434**	**0.0009**	**0.9452**
Pitch = 0.6400", IMD=70%	0.9419	0.0010	0.9439
Pitch = 0.6400", IMD=80%	0.9321	0.0010	0.9341
Pitch = 0.6400", IMD=90%	0.9194	0.0009	0.9212
Pitch = 0.6400", IMD=100%	0.9020	0.0010	0.9040

Table P.6-29
Rod Pitch Study Results
(Continued)

Model Description	k_{KENO}	1σ	k_{eff}
WE 15x15 Fuel Assembly, Enrichment = 5.00 wt. %, Soluble Boron = 2500 ppm, Type 1C or 2C Basket			
Pitch = 0.4220", IMD=60%	0.6699	0.0011	0.6721
Pitch = 0.4220", IMD=80%	0.6845	0.0010	0.6865
Pitch = 0.4220", IMD=100%	0.7089	0.0010	0.7109
Pitch = 0.4500", IMD=60%	0.7361	0.0009	0.7379
Pitch = 0.4500", IMD=80%	0.7532	0.0010	0.7552
Pitch = 0.4500", IMD=100%	0.7770	0.0012	0.7794
Pitch = 0.4750", IMD=60%	0.7888	0.0010	0.7908
Pitch = 0.4750", IMD=80%	0.8080	0.0011	0.8102
Pitch = 0.4750", IMD=100%	0.8271	0.0010	0.8291
Pitch = 0.5000", IMD=60%	0.8370	0.0009	0.8388
Pitch = 0.5000", IMD=80%	0.8592	0.0011	0.8614
Pitch = 0.5000", IMD=100%	0.8662	0.0010	0.8682
Pitch = 0.5250", IMD=60%	0.8766	0.0009	0.8784
Pitch = 0.5250", IMD=80%	0.8966	0.0011	0.8988
Pitch = 0.5250", IMD=100%	0.8984	0.0010	0.9004
Pitch = 0.5500", IMD=60%	0.9068	0.0011	0.9090
Pitch = 0.5500", IMD=80%	0.9236	0.0009	0.9254
Pitch = 0.5500", IMD=100%	0.9206	0.0010	0.9226
Pitch = 0.5630", IMD=60%	0.9167	0.0009	0.9185
Pitch = 0.5630", IMD=80%	0.9332	0.0009	0.9350
Pitch = 0.5630", IMD=100%	0.9263	0.0011	0.9285
Pitch = 0.5750", IMD=60%	0.9228	0.0010	0.9248
Pitch = 0.5750", IMD=70%	0.9335	0.0009	0.9353
Pitch = 0.5750", IMD=80%	0.9376	0.0009	0.9394
Pitch = 0.5750", IMD=90%	0.9343	0.0009	0.9361
Pitch = 0.5750", IMD=100%	0.9275	0.0010	0.9295
Pitch = 0.5950", IMD=60%	0.9268	0.0010	0.9288
Pitch = 0.5950", IMD=70%	0.9350	0.0008	0.9366
Pitch = 0.5950", IMD=80%	**0.9379**	**0.0010**	**0.9399**
Pitch = 0.5950", IMD=90%	0.9308	0.0011	0.9330
Pitch = 0.5950", IMD=100%	0.9210	0.0008	0.9226
Pitch = 0.5959", IMD=60%	0.9308	0.0009	0.9326
Pitch = 0.5959", IMD=70%	0.9370	0.0009	0.9388
Pitch = 0.5959", IMD=80%	0.9367	0.0009	0.9385
Pitch = 0.5959", IMD=90%	0.9310	0.0009	0.9328
Pitch = 0.5959", IMD=100%	0.9232	0.0008	0.9248

Table P.6-29
Rod Pitch Study Results
(Concluded)

Model Description	k_{KENO}	1σ	k_{eff}
WE 17x17 Fuel Assembly, Enrichment = 5.00 wt. %, Soluble Boron 2600 = ppm, Type 1C or 2C Basket			
Pitch = 0.3740", IMD=60%	0.6675	0.0010	0.6695
Pitch = 0.3740", IMD=80%	0.6792	0.0011	0.6814
Pitch = 0.3740", IMD=100%	0.7034	0.0013	0.7060
Pitch = 0.4000", IMD=60%	0.7357	0.0010	0.7377
Pitch = 0.4000", IMD=80%	0.7550	0.0011	0.7572
Pitch = 0.4000", IMD=100%	0.7757	0.0013	0.7783
Pitch = 0.4250", IMD=60%	0.7975	0.0009	0.7993
Pitch = 0.4250", IMD=80%	0.8184	0.0011	0.8206
Pitch = 0.4250", IMD=100%	0.8317	0.0013	0.8343
Pitch = 0.4500", IMD=60%	0.8502	0.0011	0.8524
Pitch = 0.4500", IMD=80%	0.8709	0.0010	0.8729
Pitch = 0.4500", IMD=100%	0.8746	0.0011	0.8768
Pitch = 0.4750", IMD=60%	0.8911	0.0010	0.8931
Pitch = 0.4750", IMD=80%	0.9106	0.0012	0.9130
Pitch = 0.4750", IMD=100%	0.9108	0.0010	0.9128
Pitch = 0.4960", IMD=60%	0.9135	0.0012	0.9159
Pitch = 0.4960", IMD=80%	0.9323	0.0008	0.9339
Pitch = 0.4960", IMD=100%	0.9285	0.0009	0.9303
Pitch = 0.5100", IMD=60%	0.9205	0.0009	0.9223
Pitch = 0.5100", IMD=70%	0.9311	0.0010	0.9331
Pitch = 0.5100", IMD=80%	0.9370	0.0010	0.9390
Pitch = 0.5100", IMD=90%	0.9354	0.0010	0.9374
Pitch = 0.5100", IMD=100%	0.9300	0.0010	0.9320
Pitch = 0.5400", IMD=60%	0.9264	0.0010	0.9284
Pitch = 0.5240", IMD=70%	0.9363	0.0009	0.9381
Pitch = 0.5240", IMD=80%	**0.9380**	**0.0010**	**0.9400**
Pitch = 0.5240", IMD=90%	0.9334	0.0009	0.9352
Pitch = 0.5240", IMD=100%	0.9256	0.0009	0.9274

Table P.6-30
Optimum Rod Pitch with Addition and Deletion of Rods

Model Description	k_{KENO}	1σ	k_{eff}
B&W 15x15 Fuel Assembly, Enrichment = 5.00 wt. %, Soluble Boron = 2700 ppm, Type 1C or 2C Basket, pitch = 0.5950"			
Add 00 Rods, IMD=80%	0.9390	0.0010	0.9410
Add 01 Rods, IMD=80%	0.9374	0.0009	0.9392
Add 04 Rods, IMD=80%	0.9428	0.0009	0.9446
Add 05 Rods, IMD=80%	0.9455	0.0011	0.9477
Add 09 Rods, IMD=80%	0.9493	0.0010	0.9513
Add 13 Rods, IMD=80%	0.9554	0.0009	0.9572
Add 17 Rods, IMD=50%	0.9094	0.0010	0.9114
Add 17 Rods, IMD=60%	0.9347	0.0009	0.9365
Add 17 Rods, IMD=70%	0.9502	0.0011	0.9524
Add 17 Rods, IMD=80%	0.9585	0.0011	0.9607
Add 17 Rods, IMD=90%	**0.9611**	**0.0008**	**0.9627**
Add 17 Rods, IMD=100%	0.9584	0.0009	0.9602
Remove 02 Rods, IMD=80%	0.9334	0.0008	0.9350
Remove 04 Rods, IMD=80%	0.9314	0.0009	0.9332
Remove 08 Rods, IMD=80%	0.9262	0.0008	0.9278
Remove 12 Rods, IMD=80%	0.9194	0.0008	0.9210
Remove 16 Rods, IMD=80%	0.9129	0.0009	0.9147
Remove 20 Rods, IMD=80%	0.9074	0.0009	0.9092
Remove 24 Rods, IMD=80%	0.8987	0.0009	0.9005
CE 14x14 Fuel Assembly, Enrichment = 5.00 wt. %, Soluble Boron = 2400 ppm, Type 1B or 2B Basket, pitch = 0.6200"			
Add 00 Rods, IMD=60%	0.9387	0.0008	0.9403
Add 04 Rods, IMD=60%	0.9414	0.0010	0.9434
Add 08 Rods, IMD=60%	0.9468	0.0010	0.9488
Add 12 Rods, IMD=60%	0.9559	0.0011	0.9581
Add 16 Rods, IMD=60%	0.9588	0.0010	0.9608
Add 20 Rods, IMD=50%	0.9358	0.0010	0.9378
Add 20 Rods, IMD=60%	0.9600	0.0009	0.9618
Add 20 Rods, IMD=70%	0.9732	0.0009	0.9750
Add 20 Rods, IMD=80%	0.9768	0.0012	0.9792
Add 20 Rods, IMD=90%	**0.9790**	**0.0010**	**0.9810**
Add 20 Rods, IMD=100%	0.9748	0.0008	0.9764
Remove 02 Rods, IMD=60%	0.9346	0.0008	0.9362
Remove 04 Rods, IMD=60%	0.9316	0.0009	0.9334
Remove 08 Rods, IMD=60%	0.9246	0.0011	0.9268
Remove 12 Rods, IMD=60%	0.9188	0.0010	0.9208
Remove 16 Rods, IMD=60%	0.9163	0.0009	0.9181
Remove 20 Rods, IMD=60%	0.9085	0.0009	0.9103
Remove 24 Rods, IMD=60%	0.8995	0.0010	0.9015

Table P.6-30
Optimum Rod Pitch with Addition and Deletion of Rods
(Continued)

Model Description	**k_{KENO}**	**1σ**	**k_{eff}**
CE 15x15 Fuel Assembly, Enrichment = 5.00 wt. %, Soluble Boron = 2600 ppm Type 1C or 2C Basket, pitch = 0.5750"			
Add 00 Rods, IMD=60%	0.9391	0.0009	0.9409
Add 01 Rods, IMD=60%	0.9428	0.0009	0.9446
Add 05 Rods, IMD=60%	0.9466	0.0008	0.9482
Add 09 Rods, IMD=50%	0.9120	0.0010	0.9140
Add 09 Rods, IMD=60%	0.9354	0.0009	0.9372
Add 09 Rods, IMD=70%	0.9466	0.0010	0.9486
Add 09 Rods, IMD=80%	**0.9540**	**0.0009**	**0.9558**
Add 09 Rods, IMD=90%	0.9529	0.0009	0.9547
Add 09 Rods, IMD=100%	0.9490	0.0010	0.9510
Remove 02 Rods, IMD=80%	0.9388	0.0009	0.9406
Remove 04 Rods, IMD=80%	0.9336	0.0008	0.9352
Remove 08 Rods, IMD=80%	0.9281	0.0010	0.9301
Remove 12 Rods, IMD=80%	0.9228	0.0009	0.9246
Remove 16 Rods, IMD=80%	0.9169	0.0009	0.9187
Remove 20 Rods, IMD=80%	0.9099	0.0011	0.9121
Remove 24 Rods, IMD=80%	0.9035	0.0009	0.9053
CE 16x16 Fuel Assembly, Enrichment = 5.00 wt. % Soluble Boron = 2500 ppm Type 1B or 2B Basket, pitch = 0.5478"			
Add 00 Rods, IMD=70%	0.9404	0.0009	0.9422
Add 04 Rods, IMD=70%	0.9454	0.0009	0.9472
Add 08 Rods, IMD=70%	0.9525	0.0010	0.9545
Add 12 Rods, IMD=70%	0.9583	0.0010	0.9603
Add 16 Rods, IMD=70%	0.9639	0.0010	0.9659
Add 20 Rods, IMD=50%	0.9368	0.0009	0.9386
Add 20 Rods, IMD=60%	0.9549	0.0009	0.9567
Add 20 Rods, IMD=70%	0.9654	0.0009	0.9672
Add 20 Rods, IMD=80%	0.9687	0.0009	0.9705
Add 20 Rods, IMD=90%	0.9688	0.0009	0.9706
Add 20 Rods, IMD=100%	0.9622	0.0010	0.9642
Remove 02 Rods, IMD=70%	0.9370	0.0009	0.9388
Remove 04 Rods, IMD=70%	0.9363	0.0009	0.9381
Remove 08 Rods, IMD=70%	0.9310	0.0009	0.9328
Remove 12 Rods, IMD=70%	0.9245	0.0009	0.9263
Remove 16 Rods, IMD=70%	0.9187	0.0010	0.9207
Remove 20 Rods, IMD=70%	0.9141	0.0008	0.9157
Remove 24 Rods, IMD=70%	0.9057	0.0010	0.9077

Table P.6-30
Optimum Rod Pitch with Addition and Deletion of Rods
(Continued)

Model Description	k_{KENO}	1σ	k_{eff}
WE 14x14 Fuel Assembly, Enrichment = 5.00 wt. %, Soluble Boron = 2400 ppm, Type 1B or 2B Basket, pitch = 0.6400"			
Add 00 Rods, IMD=60%	0.9434	0.0009	0.9452
Add 01 Rods, IMD=60%	0.9447	0.0009	0.9465
Add 05 Rods, IMD=60%	0.9502	0.0009	0.9520
Add 09 Rods, IMD=60%	0.9540	0.0010	0.9560
Add 13 Rods, IMD=80%	0.9566	0.0010	0.9586
Add 17 Rods, IMD=50%	0.9498	0.0010	0.9518
Add 17 Rods, IMD=60%	0.9648	0.0011	0.9670
Add 17 Rods, IMD=70%	**0.9703**	**0.0010**	**0.9723**
Add 17 Rods, IMD=80%	0.9668	0.0010	0.9688
Add 17 Rods, IMD=90%	0.9599	0.0010	0.9619
Add 17 Rods, IMD=100%	0.9508	0.0009	0.9526
Remove 02 Rods, IMD=60%	0.9400	0.0010	0.9420
Remove 04 Rods, IMD=60%	0.9372	0.0011	0.9394
Remove 08 Rods, IMD=60%	0.9293	0.0008	0.9309
Remove 12 Rods, IMD=60%	0.9217	0.0009	0.9235
Remove 16 Rods, IMD=60%	0.9170	0.0010	0.9190
Remove 20 Rods, IMD=60%	0.9074	0.0010	0.9094
WE 15x15 Fuel Assembly, Enrichment = 5.00 wt. %, Soluble Boron = 2500 ppm, Type 1C or 2C Basket, pitch = 0.5950"			
Add 00 Rods, IMD=80%	0.9379	0.0010	0.9399
Add 01 Rods, IMD=80%	0.9384	0.0009	0.9402
Add 04 Rods, IMD=80%	0.9426	0.0009	0.9444
Add 05 Rods, IMD=80%	0.9463	0.0009	0.9481
Add 09 Rods, IMD=80%	0.9486	0.0008	0.9502
Add 13 Rods, IMD=80%	0.9534	0.0010	0.9554
Add 17 Rods, IMD=80%	0.9597	0.0009	0.9615
Add 21 Rods, IMD=50%	0.9145	0.0010	0.9165
Add 21 Rods, IMD=60%	0.9403	0.0010	0.9423
Add 21 Rods, IMD=70%	0.9561	0.0010	0.9581
Add 21 Rods, IMD=80%	0.9636	0.0010	0.9656
Add 21 Rods, IMD=90%	**0.9659**	**0.0010**	**0.9679**
Add 21 Rods, IMD=100%	0.9648	0.0010	0.9668
Remove 02 Rods, IMD=80%	0.9341	0.0008	0.9357
Remove 04 Rods, IMD=80%	0.9314	0.0009	0.9332
Remove 08 Rods, IMD=80%	0.9235	0.0009	0.9253
Remove 12 Rods, IMD=80%	0.9157	0.0009	0.9175
Remove 16 Rods, IMD=80%	0.9107	0.0009	0.9125
Remove 20 Rods, IMD=80%	0.9107	0.0009	0.9125
Remove 24 Rods, IMD=80%	0.8959	0.0009	0.8977

Table P.6-30
Optimum Rod Pitch with Addition and Deletion of Rods
(Concluded)

Model Description	k_{KENO}	1σ	k_{eff}
WE 17x17 Fuel Assembly, Enrichment = 5.00 wt. %, Soluble Boron = 2600 ppm, Type 1C or 2C Basket, pitch = 0.5240"			
Add 00 Rods, IMD=80%	0.9380	0.0010	0.9400
Add 01 Rods, IMD=80%	0.9383	0.0009	0.9401
Add 04 Rods, IMD=80%	0.9402	0.0010	0.9422
Add 05 Rods, IMD=80%	0.9426	0.0009	0.9444
Add 09 Rods, IMD=80%	0.9466	0.0009	0.9484
Add 13 Rods, IMD=80%	0.9500	0.0009	0.9518
Add 17 Rods, IMD=80%	0.9531	0.0009	0.9549
Add 21 Rods, IMD=80%	0.9551	0.0010	0.9571
Add 25 Rods, IMD=50%	0.9100	0.0010	0.9120
Add 25 Rods, IMD=60%	0.9328	0.0010	0.9348
Add 25 Rods, IMD=70%	0.9516	0.0009	0.9534
Add 25 Rods, IMD=80%	0.9612	0.0010	0.9632
Add 25 Rods, IMD=90%	**0.9644**	**0.0011**	**0.9666**
Add 25 Rods, IMD=100%	0.9625	0.0009	0.9643
Remove 02 Rods, IMD=80%	0.9343	0.0009	0.9361
Remove 04 Rods, IMD=80%	0.9326	0.0009	0.9344
Remove 08 Rods, IMD=80%	0.9281	0.0009	0.9299
Remove 12 Rods, IMD=80%	0.9251	0.0010	0.9271
Remove 16 Rods, IMD=80%	0.9181	0.0011	0.9203
Remove 20 Rods, IMD=80%	0.9150	0.0009	0.9168
Remove 24 Rods, IMD=80%	0.9087	0.0008	0.9103
Remove 28 Rods, IMD=80%	0.9045	0.0008	0.9061

Table P.6-31
Single Ended Shear Evaluation Results

Model Description	k_{KENO}	1σ	k_{eff}
B&W 15x15 Fuel Assembly, Enrichment = 5.00 wt. %, Soluble Boron = 2700 ppm, Type 1C or 2C Basket			
Base KENO Model, IMD 80%	0.9327	0.0009	0.9345
SS Model, d=0.00", IMD 80%	0.9338	0.0009	0.9356
d=0.20", IMD=80%	0.9340	0.0009	0.9358
d=0.30", IMD=60%	0.9165	0.0010	0.9185
d=0.30", IMD=70%	0.9289	0.0009	0.9307
d=0.30", IMD=80%	0.9352	0.0008	0.9368
d=0.30", IMD=90%	0.9337	0.0010	0.9357
d=0.40", IMD=60%	0.9194	0.0008	0.9210
d=0.40", IMD=70%	0.9291	0.0011	0.9313
d=0.40", IMD=80%	0.9354	0.0010	0.9374
d=0.40", IMD=90%	0.9329	0.0010	0.9349
d=0.50", IMD=60%	0.9172	0.0010	0.9192
d=0.50", IMD=70%	0.9316	0.0010	0.9336
d=0.50", IMD=80%	0.9345	0.0009	0.9363
d=0.50", IMD=90%	0.9339	0.0011	0.9361
d=0.622", IMD=60%	0.9167	0.0011	0.9189
d=0.622", IMD=70%	0.9293	0.0009	0.9311
d=0.622", IMD=80%	0.9353	0.0010	0.9373
d=0.622", IMD=90%	0.9341	0.0011	0.9363
CE 14x14 Fuel Assembly, Enrichment = 5.00 wt. %, Soluble Boron = 2400 ppm, Type 1B or 2B Basket			
Base KENO Model, IMD 80%	0.9145	0.0009	0.9163
SS Model, d=0.00", IMD 80%	0.9167	0.0010	0.9187
d=0.20", IMD=80%	0.9190	0.0009	0.9208
d=0.40", IMD=60%	0.9155	0.0010	0.9175
d=0.40", IMD=70%	0.9219	0.0011	0.9241
d=0.40", IMD=80%	0.9219	0.0010	0.9239
d=0.40", IMD=90%	0.9161	0.0012	0.9185
d=0.80", IMD=60%	0.9181	0.0009	0.9199
d=0.80", IMD=70%	0.9238	0.0009	0.9256
d=0.80", IMD=80%	0.9221	0.0009	0.9239
d=0.80", IMD=90%	0.9166	0.0009	0.9184
d=1.20", IMD 60%	0.9192	0.0009	0.9210
d=1.20", IMD 70%	0.9244	0.0009	0.9262
d=1.20", IMD=80%	0.9214	0.0010	0.9234
d=1.30", IMD=90%	0.9144	0.0008	0.9160
d=1.50", IMD=80%	0.9208	0.0011	0.9230
d=1.638", IMD=80%	0.9189	0.0010	0.9209

Table P.6-31
Single Ended Shear Evaluation Results
(Continued)

Model Description	k_{KENO}	1σ	k_{eff}
CE 15x15 Fuel Assembly, Enrichment = 5.00 wt. %, Soluble Boron = 2600 ppm, Type 1C or 2C Basket			
Base KENO Model, IMD 80%	0.9169	0.0010	0.9189
SS Model, d=0.00", IMD 80%	0.9178	0.0010	0.9198
d=0.20", IMD=80%	0.9209	0.0011	0.9231
d=0.40", IMD=60%	0.8986	0.0010	0.9006
d=0.40", IMD=70%	0.9131	0.0011	0.9153
d=0.40", IMD=80%	0.9226	0.0009	0.9244
d=0.40", IMD=90%	0.9239	0.0009	0.9257
d=0.70", IMD=60%	0.9011	0.0010	0.9031
d=0.70", IMD=70%	0.9155	0.0010	0.9175
d=0.70", IMD=80%	0.9221	0.0011	0.9243
d=0.70", IMD=90%	0.9249	0.0009	0.9267
d=1.00", IMD 60%	0.9026	0.0010	0.9046
d=1.00", IMD 70%	0.9159	0.0010	0.9179
d=1.00", IMD=80%	0.9233	0.0011	0.9255
d=1.00", IMD=90%	0.9242	0.0009	0.9260
d=1.308", IMD=80%	0.9207	0.0010	0.9227
CE 16x16 Fuel Assembly, Enrichment = 5.00 wt. %, Soluble Boron = 2500 ppm, Type 1B or 2B Basket			
Base KENO Model, IMD 80%	0.9155	0.0010	0.9175
SS Model, d=0.00", IMD 80%	0.9178	0.0009	0.9196
d=0.20", IMD=80%	0.9187	0.0009	0.9205
d=0.40", IMD=60%	0.9161	0.0009	0.9179
d=0.40", IMD=70%	0.9210	0.0009	0.9228
d=0.40", IMD=80%	0.9216	0.0009	0.9234
d=0.40", IMD=90%	0.9165	0.0010	0.9185
d=0.80", IMD=60%	0.9171	0.0009	0.9189
d=0.80", IMD=70%	0.9225	0.0009	0.9243
d=0.80", IMD=80%	0.9220	0.0009	0.9238
d=0.80", IMD=90%	0.9173	0.0010	0.9193
d=1.20", IMD 60%	0.9185	0.0009	0.9203
d=1.20", IMD 70%	0.9242	0.0010	0.9262
d=1.20", IMD=80%	0.9233	0.0009	0.9251
d=1.20", IMD=90%	0.9162	0.0010	0.9182
d=1.50", IMD=80%	0.9198	0.0009	0.9216
d=1.699", IMD=80%	0.9184	0.0010	0.9204

Table P.6-31
Single Ended Shear Evaluation Results
(Continued)

Model Description	k_{KENO}	1σ	k_{eff}
WE 14x14 Fuel Assembly, Enrichment = 5.00 wt. %, Soluble Boron = 2400 ppm, Type 1B or 2B Basket			
Base KENO Model, IMD 80%	0.9015	0.0009	0.9033
SS Model, d=0.00", IMD 80%	0.9010	0.0012	0.9034
d=0.20", IMD=80%	0.9048	0.0012	0.9072
d=0.40", IMD=80%	0.9078	0.0010	0.9098
d=0.60", IMD=80%	0.9094	0.0009	0.9112
d=1.00", IMD=60%	0.9081	0.0011	0.9103
d=1.00", IMD=70%	0.9132	0.0011	0.9154
d=1.00", IMD=80%	0.9115	0.0011	0.9137
d=1.00", IMD=90%	0.9067	0.0009	0.9085
d=1.50", IMD 60%	0.9080	0.0010	0.9100
d=1.50", IMD 70%	0.9139	0.0011	0.9161
d=1.50", IMD=80%	0.9124	0.0010	0.9144
d=1.50", IMD=90%	0.9060	0.0008	0.9076
d=2.00", IMD=80%	0.9093	0.0009	0.9111
d=2.492", IMD=80%	0.9032	0.0010	0.9052
WE 15x15 Fuel Assembly, Enrichment = 5.00 wt. %, Soluble Boron = 2500 ppm, Type 1C or 2C Basket			
Base KENO Model, IMD 80%	0.9332	0.0009	0.9350
SS Model, d=0.00", IMD 80%	0.9318	0.0011	0.9340
d=0.20", IMD=80%	0.9336	0.0010	0.9356
d=0.30", IMD=80%	0.9339	0.0010	0.9359
d=0.50", IMD=60%	0.9203	0.0010	0.9223
d=0.50", IMD=70%	0.9312	0.0010	0.9332
d=0.50", IMD=80%	0.9346	0.0009	0.9364
d=0.50", IMD=90%	0.9342	0.0010	0.9362
d=0.70", IMD 60%	0.9189	0.0009	0.9207
d=0.70", IMD 70%	0.9293	0.0011	0.9315
d=0.70", IMD=80%	0.9347	0.0009	0.9365
d=0.70", IMD=90%	0.9325	0.0010	0.9345
d=0.813", IMD 60%	0.9170	0.0010	0.9190
d=0.813", IMD 70%	0.9286	0.0010	0.9306
d=0.813", IMD=80%	0.9357	0.0008	0.9373
d=0.813", IMD=90%	0.9332	0.0010	0.9352

Table P.6-31
Single Ended Shear Evaluation Results
(Concluded)

Model Description	k_{KENO}	1σ	k_{eff}
WE 17x17 Fuel Assembly, Enrichment = 5.00 wt. %, Soluble Boron = 2600 ppm, Type 1C or 2C Basket			
Base KENO Model, IMD 80%	0.9323	0.0008	0.9339
SS Model, d=0.00", IMD 80%	0.9314	0.0009	0.9332
d=0.20", IMD=80%	0.9321	0.0010	0.9341
d=0.30", IMD=80%	0.9317	0.0009	0.9335
d=0.50", IMD=60%	0.9147	0.0010	0.9167
d=0.50", IMD=70%	0.9278	0.0010	0.9298
d=0.50", IMD=80%	0.9334	0.0011	0.9356
d=0.50", IMD=90%	0.9314	0.0010	0.9334
d=0.70", IMD 60%	0.9157	0.0010	0.9177
d=0.70", IMD 70%	0.9262	0.0010	0.9282
d=0.70", IMD=80%	0.9346	0.0009	0.9364
d=0.70", IMD=90%	0.9327	0.0010	0.9347
d=0.846", IMD 60%	0.9144	0.0011	0.9166
d=0.846", IMD 70%	0.9288	0.0010	0.9308
d=0.846", IMD=80%	0.9329	0.0010	0.9349
d=0.846", IMD=90%	0.9318	0.0009	0.9336

Table P.6-32
Double Ended Shear Break Evaluation Results

Model Description	k_{KENO}	1σ	k_{eff}
CE 14x14 Fuel Assembly, Enrichment = 5.00 wt. %, Soluble Boron = 2400 ppm, Type 1B or 2B Basket			
Base KENO Model, IMD 80%	0.9145	0.0009	0.9163
DS Model, No Shear, IMD 80%	0.9139	0.0011	0.9161
1/2 Shear, IMD=60%	0.9218	0.0010	0.9238
1/2 Shear, IMD=70%	0.9288	0.0011	0.9310
1/2 Shear, IMD=80%	0.9285	0.0011	0.9307
1/2 Shear, IMD=90%	0.9270	0.0012	0.9294
1/2 Shear, IMD=100%	0.9146	0.0012	0.9170
1/3 Shear, IMD=80%	0.9250	0.0011	0.9272
1/4 Shear, IMD=80%	0.9207	0.0012	0.9231
CE 15x15 Fuel Assembly, Enrichment = 5.00 wt. %, Soluble Boron = 2600 ppm, Type 1C or 2C Basket			
Base KENO Model, IMD 80%	0.9169	0.0010	0.9189
DS Model, No Shear, IMD 80%	0.9179	0.0009	0.9197
1/2 Shear, IMD=60%	0.9028	0.0009	0.9046
1/2 Shear, IMD=70%	0.9186	0.0010	0.9206
1/2 Shear, IMD=80%	0.9291	0.0010	0.9311
1/2 Shear, IMD=90%	0.9340	0.0012	0.9364
1/2 Shear, IMD=100%	0.9340	0.0011	0.9362
1/3 Shear, IMD=80%	0.9272	0.0012	0.9296
1/4 Shear, IMD=80%	0.9222	0.0010	0.9242
CE 16x16 Fuel Assembly, Enrichment = 5.00 wt. %, Soluble Boron = 2500 ppm, Type 1B or 2B Basket			
Base KENO Model, IMD 80%	0.9155	0.0010	0.9175
DS Model, No Shear, IMD 80%	0.9162	0.0010	0.9182
1/2 Shear, IMD=60%	0.9190	0.0009	0.9208
1/2 Shear, IMD=70%	0.9278	0.0009	0.9296
1/2 Shear, IMD=80%	0.9283	0.0010	0.9303
1/2 Shear, IMD=90%	0.9251	0.0011	0.9273
1/2 Shear, IMD=100%	0.9189	0.0011	0.9211
1/3 Shear, IMD=80%	0.9267	0.0008	0.9283
1/4 Shear, IMD=80%	0.9191	0.0010	0.9211

Table P.6-32
Double Ended Shear Break Evaluation Results
(Concluded)

Model Description	k_{KENO}	1σ	k_{eff}
WE 14x14 Fuel Assembly, Enrichment = 5.00 wt. %, Soluble Boron = 2400 ppm, Type 1B or 2B Basket			
Base KENO Model, IMD 80%	0.9015	0.0009	0.9033
DS Model, No Shear, IMD 80%	0.9019	0.0010	0.9039
1/2 Shear, IMD=60%	0.9112	0.0011	0.9134
1/2 Shear, IMD=70%	0.9165	0.0010	0.9185
1/2 Shear, IMD=80%	0.9166	0.0011	0.9188
1/2 Shear, IMD=90%	0.9186	0.0011	0.9208
1/2 Shear, IMD=100%	0.9114	0.0012	0.9138
1/3 Shear, IMD=80%	0.9147	0.0010	0.9167
1/4 Shear, IMD=80%	0.9088	0.0013	0.9114
WE 15x15 Fuel Assembly, Enrichment = 5.00 wt. %, Soluble Boron = 2500 ppm, Type 1C or 2C Basket			
Base KENO Model, IMD 80%	0.9332	0.0009	0.9350
DS Model, No Shear, IMD 80%	0.9319	0.0009	0.9337
1/2 Shear, IMD=60%	0.9185	0.0010	0.9205
1/2 Shear, IMD=70%	0.9330	0.0011	0.9352
1/2 Shear, IMD=80%	0.9393	0.0010	0.9413
1/2 Shear, IMD=90%	0.9375	0.0011	0.9397
1/2 Shear, IMD=100%	0.9364	0.0010	0.9384
1/3 Shear, IMD=80%	0.9379	0.0010	0.9399
1/4 Shear, IMD=80%	0.9351	0.0011	0.9373
WE 17x17 Fuel Assembly, Enrichment = 5.00 wt. %, Soluble Boron = 2600 ppm, Type 1C or 2C Basket			
Base KENO Model, IMD 80%	0.9323	0.0008	0.9339
DS Model, No Shear, IMD 80%	0.9311	0.0010	0.9331
1/2 Shear, IMD=60%	0.9172	0.0010	0.9192
1/2 Shear, IMD=70%	0.9295	0.0010	0.9315
1/2 Shear, IMD=80%	0.9360	0.0012	0.9384
1/2 Shear, IMD=90%	0.9387	0.0010	0.9407
1/2 Shear, IMD=100%	0.9351	0.0011	0.9373
1/3 Shear, IMD=80%	0.9331	0.0013	0.9357
1/4 Shear, IMD=80%	0.9329	0.0010	0.9349

All changes on this page are AMD 13

Table P.6-33
Evaluation of Shifting of Fuel Rods beyond Poison *(Damaged Fuel)*

Model Description	k_{KENO}	1σ	k_{eff}
B&W 15x15 Fuel Assembly, Enrichment = 5.00 wt. %, Soluble Boron = 2700 ppm, Type 1C or 2C Basket			
6" Shift, IMD=60%	0.9309	0.0010	0.9329
6" Shift, IMD=70%	0.9403	0.0010	0.9423
6" Shift, IMD=80%	**0.9471**	**0.0009**	**0.9489**
6" Shift, IMD=90%	0.9461	0.0010	0.9481
6" Shift, IMD=100%	0.9402	0.0009	0.9420
CE 14x14 Fuel Assembly, Enrichment = 5.00 wt. %, Soluble Boron = 2400 ppm, Type 1B or 2B Basket			
6" Shift, IMD=60%	0.9214	0.0009	0.9232
6" Shift, IMD=70%	0.9242	0.0009	0.9260
6" Shift, IMD=80%	**0.9249**	**0.0010**	**0.9269**
6" Shift, IMD=90%	0.9171	0.0009	0.9189
6" Shift, IMD=100%	0.9050	0.0010	0.9070
CE 15x15 Fuel Assembly, Enrichment = 5.00 wt. %, Soluble Boron = 2600 ppm, Type 1C or 2C Basket			
6" Shift, IMD=60%	0.9151	0.0011	0.9173
6" Shift, IMD=70%	0.9257	0.0011	0.9279
6" Shift, IMD=80%	0.9310	0.0011	0.9332
6" Shift, IMD=90%	**0.9328**	**0.0014**	**0.9356**
6" Shift, IMD=100%	0.9316	0.0011	0.9338
CE 16x16 Fuel Assembly, Enrichment = 5.00 wt. %, Soluble Boron = 2500 ppm, Type 1B or 2B Basket			
6" Shift, IMD=60%	0.9211	0.0010	0.9231
6" Shift, IMD=70%	**0.9254**	**0.0010**	**0.9274**
6" Shift, IMD=80%	0.9240	0.0009	0.9258
6" Shift, IMD=90%	0.9171	0.0012	0.9195
6" Shift, IMD=100%	0.9110	0.0010	0.9130
WE 14x14 Fuel Assembly, Enrichment = 5.00 wt. %, Soluble Boron = 2400 ppm, Type 1B or 2B Basket			
6" Shift, IMD=60%	0.9078	0.0011	0.9100
6" Shift, IMD=70%	**0.9108**	**0.0011**	**0.9130**
6" Shift, IMD=80%	0.9103	0.0010	0.9123
6" Shift, IMD=90%	0.9051	0.0009	0.9069
6" Shift, IMD=100%	0.8979	0.0013	0.9005
WE 15x15 Fuel Assembly, Enrichment = 5.00 wt. %, Soluble Boron = 2500 ppm, Type 1C or 2C Basket			
6" Shift, IMD=60%	0.9301	0.0012	0.9325
6" Shift, IMD=70%	0.9437	0.0009	0.9455
6" Shift, IMD=80%	**0.9450**	**0.0009**	**0.9468**
6" Shift, IMD=90%	0.9428	0.0010	0.9448
6" Shift, IMD=100%	0.9365	0.0011	0.9387
WE 17x17 Fuel Assembly, Enrichment = 5.00 wt. %, Soluble Boron = 2600 ppm, Type 1C or 2C Basket			
6" Shift, IMD=60%	0.9265	0.0012	0.9289
6" Shift, IMD=70%	0.9402	0.0011	0.9424
6" Shift, IMD=80%	**0.9414**	**0.0010**	**0.9434**
6" Shift, IMD=90%	0.9411	0.0010	0.9431
6" Shift, IMD=100%	0.9367	0.0009	0.9385

Table P.6-34
Comparison of Various Damaged Assembly Configurations

Model Description	k_{KENO}	1σ	k_{eff}
B&W 15x15 Fuel Assembly, Enrichment = 5.00 wt. %, Soluble Boron = 2700 ppm, Type 1C or 2C Basket			
Optimum Pitch	0.9390	0.0010	0.9410
Add 17 Rods	**0.9611**	**0.0008**	**0.9627**
Single Shear	0.9354	0.0010	0.9374
Double Shear	-NA-	-NA-	-NA-
6" Shift	0.9471	0.0009	0.9489
CE 14x14 Fuel Assembly, Enrichment = 5.00 wt. %, Soluble Boron = 2400 ppm, Type 1B or 2B Basket			
Optimum Pitch	0.9387	0.0008	0.9403
Add 20 Rods	**0.9790**	**0.0010**	**0.9810**
Single Shear	0.9244	0.0009	0.9262
Double Shear	0.9288	0.0011	0.9310
6" Shift	0.9249	0.0010	0.9269
CE 15x15 Fuel Assembly, Enrichment = 5.00 wt. %, Soluble Boron 2600 ppm, Type 1C or 2C Basket			
Optimum Pitch	0.9391	0.0009	0.9409
Add 09 Rods	**0.9540**	**0.0009**	**0.9558**
Single Shear	0.9249	0.0009	0.9267
Double Shear	0.9340	0.0012	0.9364
6" Shift	0.9328	0.0014	0.9356
CE 16x16 Fuel Assembly, Enrichment = 5.00 wt. %, Soluble Boron = 2500 ppm, Type 1B or 2B Basket			
Optimum Pitch	0.9404	0.0009	0.9422
Add 20 Rods	**0.9688**	**0.0009**	**0.9706**
Single Shear	0.9242	0.0010	0.9262
Double Shear	0.9283	0.0010	0.9303
6" Shift	0.9254	0.0010	0.9274
WE 14x14 Fuel Assembly, Enrichment = 5.00 wt. %, Soluble Boron = 2400 ppm, Type 1B or 2B Basket			
Optimum Pitch	0.9434	0.0009	0.9452
Add 17 Rods	**0.9703**	**0.0010**	**0.9723**
Single Shear	0.9139	0.0011	0.9161
Double Shear	0.9186	0.0011	0.9208
6" Shift	0.9108	0.0011	0.9130
WE 15x15 Fuel Assembly, Enrichment = 5.00 wt. %, Soluble Boron = 2500 ppm, Type 1C or 2C Basket			
Optimum Pitch	0.9379	0.0010	0.9399
Add 21 Rods	**0.9659**	**0.0010**	**0.9679**
Single Shear	0.9357	0.0008	0.9373
Double Shear	0.9393	0.0010	0.9413
6" Shift	0.9450	0.0009	0.9468
WE 17x17 Fuel Assembly, Enrichment = 5.00 wt. %, Soluble Boron = 2600 ppm, Type 1C or 2C Basket			
Optimum Pitch	0.9380	0.0010	0.9400
Add 25 Rods	**0.9644**	**0.0011**	**0.9666**
Single Shear	0.9346	0.0009	0.9364
Double Shear	0.9387	0.0010	0.9407
6" Shift	0.9414	0.0010	0.9434