Each fuel plate in the fuel element is separated by a gap of 0.096 inches in the center of the fuel element. These gap thicknesses change in the outer three layers to 0.108 inches, 0.118 inches, and 0.100 inches, respectively. See Figure 6.3.1-1. The aluminum beyond the 2.25-inch width and the 22.75-inch length of the fuel meat is represented as either water or water mist in this model. The numerical results of this modeling may be seen in Table 6.3.1-1 under Box Type 1 or Box Type 2.

The basket is modeled as a 304 stainless steel structure that has walls which are 0.25 inches thick and contain ten holes that measure 3.18 inches square by 22.75 inches long. There are three holes in the upper and lower rows and four holes in the middle row sufficient to hold 10 fuel elements. See Figure 6.3.1-2. The numerical results of this modeling may be seen in Table 6.3.1-1, and the arrangement of all the boxes showing two baskets separated by 21.875 inches may be seen in the same table in between the END GEOMETRY and END KENO cards.

6.3.2 Package Regional Densities

The number densities for the materials used in this model may be seen in Tables 6.3.1-1 and 6.4-1 through 6.4-5. The number density used for the fuel meat was 0.00261362 atoms/barn-cm for U-235. A molecular weight of 235.043933 gram/gram-mole and an Avogadro's number of 6.025 E23 gram-atom/gram-mole were used in calculating this number density. Other materials in the fuel meat such as U-238, oxygen, silicone, etc., were not modeled. The number densities for the materials specified in Table 6.3.1-1 that are provided by the SCALE system for the 27GROUPNDF4 cross-section set are shown in Tables 6.4-1 through 6.4-5.

6.4 Criticality Calculations

The SCALE* System that is running on the Control Data Corporation 7600 Computer at General Electric's Nuclear Energy Business Operations was used for the k-effective calculations.

The 27GROUPNDF4 cross-section set and the KENO-IV criticality code in the SCALE system were used to perform these calculations. The results of these calculations may be seen in Figure 6.4-1 and in Tables 6.4-1 through 6.4-5.

In Figure 6.4-1, k-effective values are plotted as a function of mist density. These results show the peak k-effective to be less than 0.87 for the fully water-flooded accident condition, and less than 0.33 for the mist densities up to 0.1 grams H_2O/cc. Thirty-thousand neutron histories were run to obtain the 0.87 k-effective result. However, all of the mist density calculations were stopped by a 15-minute time limit. The smallest number of histories run was 25,500. More detailed numerical results of all of these calculations may be seen in Tables 6.4-1 through 6.4-5.

6.5 Critical Benchmark Experiments

In the discussion below, the benchmark experiments are presented first. This is followed by tables showing models of these experiments prepared as input to the SCALE system. Then the k-effective results using these models are presented, followed by the determination of biases required for each of the types of fissile material.

*Bucholz, J. A., "SCALE: A Modular Code System for Performing Standardized Computer Analyses for Licensing Evaluation", NUREG/CR-0200, ORNL/NUREG/CSD/2, Volume 1, Oak Ridge National Laboratory; July, 1980.

6.5.1 Benchmark Experiments and Applicability

Uranium with enrichments varying from 1.3 w/o to fully enriched and plutonium are the fissile materials that are considered in the validation of SCALE for this evaluation. The forms include fully enriched homogeneous uranium-water mixtures, low-enriched heterogeneous uranium dioxide-water mixtures, and homogeneous plutonium-water mixtures.

In Table 6.5.1-1 below, critical experiments suitable for validation are identified.

6.5.2 Details of the Benchmark Calculations

Models of TRX-1 and TRX-2 prepared as input to the SCALE system are shown in Tables 6.5.2-1 and 6.5.2-2, respectively. Models of ORNL-1 and ORNL-2 are shown in Table 6.5.2-3. Models of PNL-1 and PNL-2 are shown in Table 6.5.2-4. Models of the B&W UO_2 rod and MO_2 rod are shown in Table 6.5.2-5.

6.5.3 K-Effective Results of the Benchmark Calculations

K-effective results are presented for the ORNL, PNL, TRX, and B&W critical experiments in Table 6.5.3-1.

It is concluded that use of the SCALE System using the 27GROUPNDF4 cross-section set requires a negative 0.3 percent bias on the one sigma deviation for fully enriched uranium solutions and no bias for plutonium solutions; a negative bias of 2.3 percent on the mean value and 0.3 percent on the one sigma deviation for the multiplication factor must be applied for low-enriched, clumped uranium rods in water.

A bias of 2.3 percent on the mean value and 0.3 percent on the one sigma deviation is applied to the k-effective results in Figure 6.4-1 in this evaluation.

FIGURE 6.3.1-1

FUEL ELEMENT SCHEMATIC

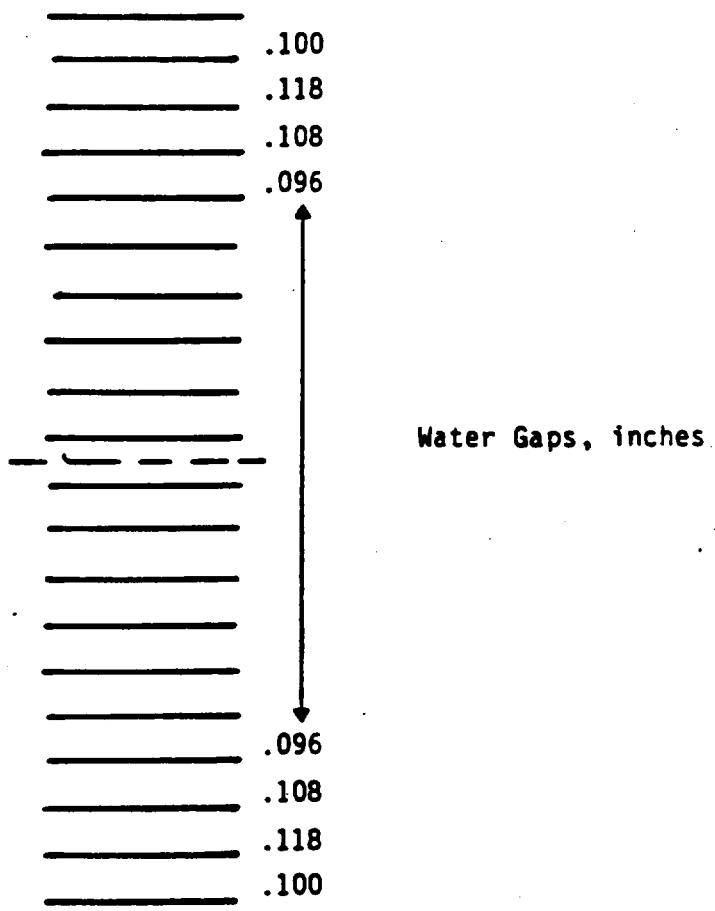
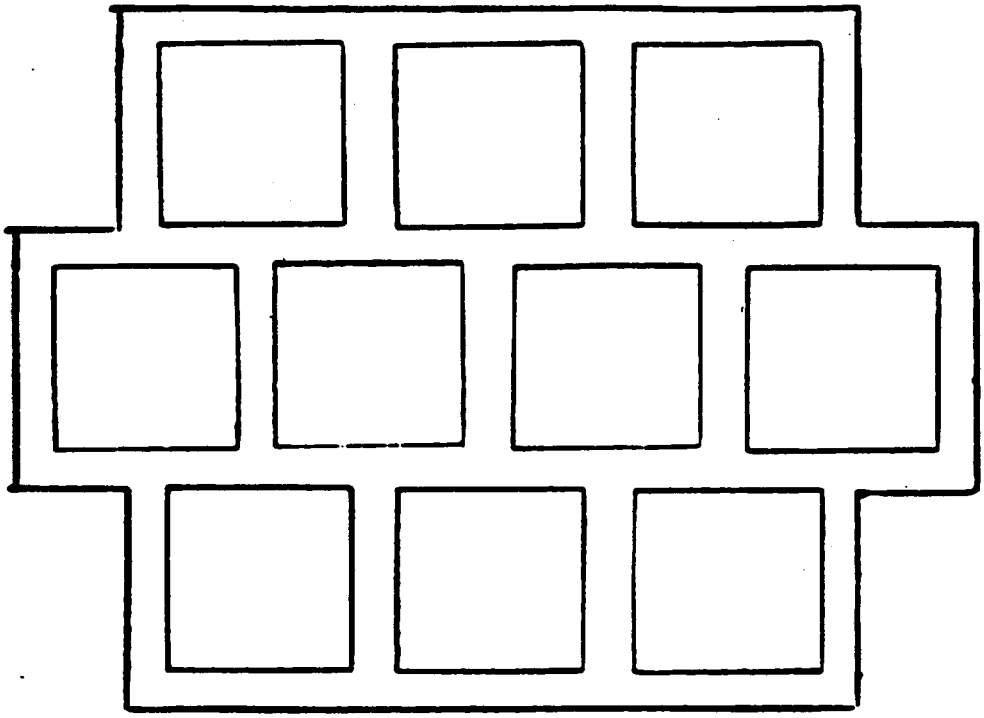


FIGURE 6.3.1-2

FUEL BASKET SCHEMATIC

Document 22



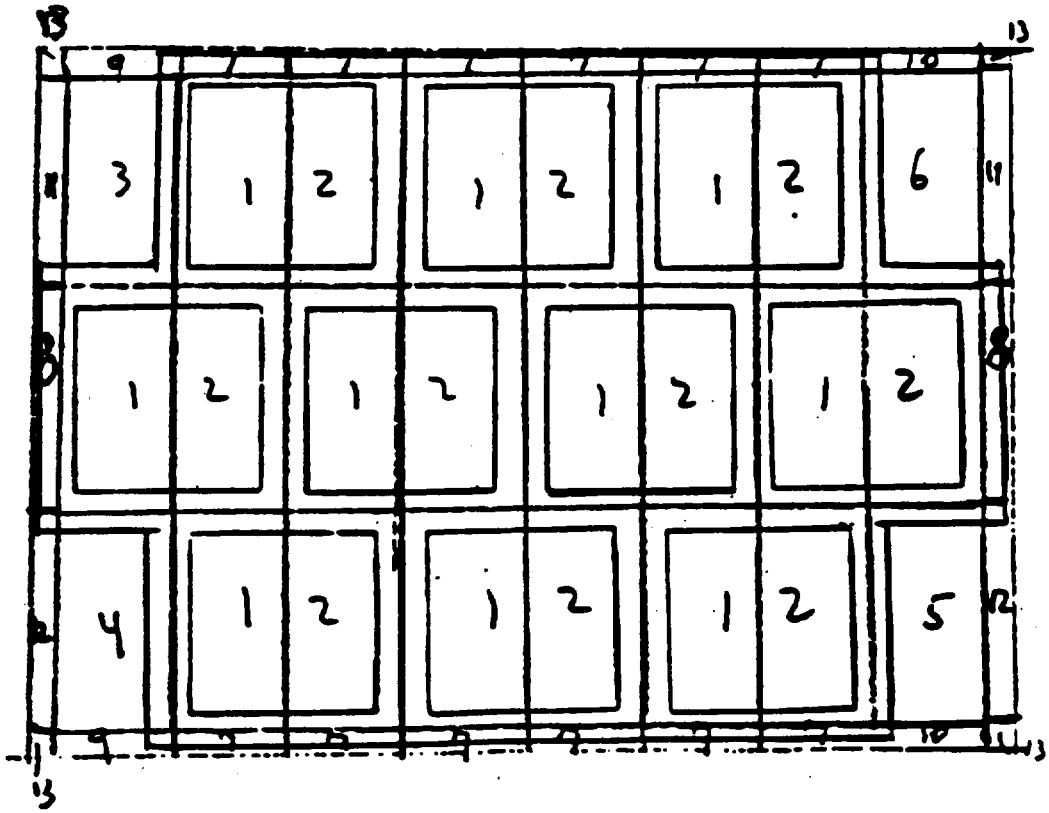


TABLE 6.3.1-1

```
KEFF BNL FUEL SHIPPING ARRAY  FWR 2 CONT SIDE-BY-SIDE
  GROUPNDF4  7  7  3  LATTICECELL  0  0
U-235  1 0. 2.61362-3 END
AL  2 1. END
H2O  3 8.8-5 END
AL  4 1. END
H2O  5 1. END
SS304  6 1. END
H2O  7 8.8-5 END
SYMMSLABCELL        0.37084 0.057912 1 3 0.127 2 END
KEFF BNL FUEL SHIPPING ARRAY  FWR 2 CONT SIDE-BY-SIDE
15.0 103 300 3 16 21 5 1 0
BOX TYPE     1
CUBOID  3   0. -2.857500   .121920  -.121920 28.892500 -28.892500 -0.5
CUBOID  2   0. -2.857500   .156464  -.156464 28.892500 -28.892500 -0.5
CUBOID  1   0. -2.857500   .214376  -.214376 28.892500 -28.892500 -0.5
CUBOID  2   0. -2.857500   .248920  -.248920 28.892500 -28.892500 -0.5
CUBOID  3   0. -2.857500   .492760  -.492760 28.892500 -28.892500 -0.5
CUBOID  2   0. -2.857500   .527304  -.527304 28.892500 -28.892500 -0.5
CUBOID  1   0. -2.857500   .585216  -.585216 28.892500 -28.892500 -0.5
CUBOID  2   0. -2.857500   .619760  -.619760 28.892500 -28.892500 -0.5
CUBOID  3   0. -2.857500   .863600  -.863600 28.892500 -28.892500 -0.5
CUBOID  2   0. -2.857500   .898144  -.898144 28.892500 -28.892500 -0.5
CUBOID  1   0. -2.857500   .956056  -.956056 28.892500 -28.892500 -0.5
CUBOID  2   0. -2.857500   .990600  -.990600 28.892500 -28.892500 -0.5
CUBOID  3   0. -2.857500  1.234440 -1.234440 28.892500 -28.892500 -0.5
CUBOID  2   0. -2.857500  1.268984 -1.268984 28.892500 -28.892500 -0.5
CUBOID  1   0. -2.857500  1.326896 -1.326896 28.892500 -28.892500 -0.5
CUBOID  2   0. -2.857500  1.361440 -1.361440 28.892500 -28.892500 -0.5
CUBOID  3   0. -2.857500  1.605280 -1.605280 28.892500 -28.892500 -0.5
CUBOID  2   0. -2.857500  1.639824 -1.639824 28.892500 -28.892500 -0.5
CUBOID  1   0. -2.857500  1.697736 -1.697736 28.892500 -28.892500 -0.5
CUBOID  2   0. -2.857500  1.732280 -1.732280 28.892500 -28.892500 -0.5
CUBOID  3   0. -2.857500  1.976120 -1.976120 28.892500 -28.892500 -0.5
CUBOID  2   0. -2.857500  2.010664 -2.010664 28.892500 -28.892500 -0.5
CUBOID  1   0. -2.857500  2.068576 -2.068576 28.892500 -28.892500 -0.5
CUBOID  2   0. -2.857500  2.103120 -2.103120 28.892500 -28.892500 -0.5
CUBOID  3   0. -2.857500  2.346960 -2.346960 28.892500 -28.892500 -0.5
CUBOID  2   0. -2.857500  2.381504 -2.381504 28.892500 -28.892500 -0.5
CUBOID  1   0. -2.857500  2.439416 -2.439416 28.892500 -28.892500 -0.5
CUBOID  2   0. -2.857500  2.473960 -2.473960 28.892500 -28.892500 -0.5
CUBOID  3   0. -2.857500  2.748280 -2.748280 28.892500 -28.892500 -0.5
CUBOID  2   0. -2.857500  2.782824 -2.782824 28.892500 -28.892500 -0.5
CUBOID  1   0. -2.857500  2.840736 -2.840736 28.892500 -28.892500 -0.5
CUBOID  2   0. -2.857500  2.875280 -2.875280 28.892500 -28.892500 -0.5
CUBOID  3   0. -2.857500  3.175000 -3.175000 28.892500 -28.892500 -0.5
CUBOID  2   0. -2.857500  3.209544 -3.209544 28.892500 -28.892500 -0.5
CUBOID  1   0. -2.857500  3.267456 -3.267456 28.892500 -28.892500 -0.5
CUBOID  2   0. -2.857500  3.302000 -3.302000 28.892500 -28.892500 -0.5
CUBOID  3   0. -2.857500  3.556000 -3.556000 28.892500 -28.892500 -0.5
CUBOID  2   0. -2.857500  3.683000 -3.683000 28.892500 -28.892500 -0.5
CUBOID    7    0.000   -4.039    4.039   -4.039   28.8925  -28.8925 -0.5
CUBOID    6    0.000   -4.356    4.356   -4.356   28.8925  -28.8925 -0.5
```

TABLE 6.3.1-1 (CONTINUED)

BOX TYPE	2							
BOID	3	2.857500	-0.	.121920	-.121920	28.892500	-28.892500	-0.5
BOID	2	2.857500	-0.	.156464	-.156464	28.892500	-28.892500	-0.5
CUBOID	1	2.857500	-0.	.214376	-.214376	28.892500	-28.892500	-0.5
CUBOID	2	2.857500	-0.	.248920	-.248920	28.892500	-28.892500	-0.5
CUBOID	3	2.857500	-0.	.492760	-.492760	28.892500	-28.892500	-0.5
CUBOID	2	2.857500	-0.	.527304	-.527304	28.892500	-28.892500	-0.5
CUBOID	1	2.857500	-0.	.585216	-.585216	28.892500	-28.892500	-0.5
CUBOID	2	2.857500	-0.	.619760	-.619760	28.892500	-28.892500	-0.5
CUBOID	3	2.857500	-0.	.863600	-.863600	28.892500	-28.892500	-0.5
CUBOID	2	2.857500	-0.	.898144	-.898144	28.892500	-28.892500	-0.5
CUBOID	1	2.857500	-0.	.956056	-.956056	28.892500	-28.892500	-0.5
CUBOID	2	2.857500	-0.	.990600	-.990600	28.892500	-28.892500	-0.5
CUBOID	3	2.857500	-0.	1.234440	-1.234440	28.892500	-28.892500	-0.5
CUBOID	2	2.857500	-0.	1.268984	-1.268984	28.892500	-28.892500	-0.5
CUBOID	1	2.857500	-0.	1.326896	-1.326896	28.892500	-28.892500	-0.5
CUBOID	2	2.857500	-0.	1.361440	-1.361440	28.892500	-28.892500	-0.5
CUBOID	3	2.857500	-0.	1.605280	-1.605280	28.892500	-28.892500	-0.5
CUBOID	2	2.857500	-0.	1.639824	-1.639824	28.892500	-28.892500	-0.5
CUBOID	1	2.857500	-0.	1.697736	-1.697736	28.892500	-28.892500	-0.5
CUBOID	2	2.857500	-0.	1.732280	-1.732280	28.892500	-28.892500	-0.5
CUBOID	3	2.857500	-0.	1.976120	-1.976120	28.892500	-28.892500	-0.5
CUBOID	2	2.857500	-0.	2.010664	-2.010664	28.892500	-28.892500	-0.5
CUBOID	1	2.857500	-0.	2.068576	-2.068576	28.892500	-28.892500	-0.5
CUBOID	2	2.857500	-0.	2.103120	-2.103120	28.892500	-28.892500	-0.5
CUBOID	3	2.857500	-0.	2.346960	-2.346960	28.892500	-28.892500	-0.5
BOID	2	2.857500	-0.	2.381504	-2.381504	28.892500	-28.892500	-0.5
BOID	1	2.857500	-0.	2.439416	-2.439416	28.892500	-28.892500	-0.5
CUBOID	2	2.857500	-0.	2.473960	-2.473960	28.892500	-28.892500	-0.5
CUBOID	3	2.857500	-0.	2.748280	-2.748280	28.892500	-28.892500	-0.5
CUBOID	2	2.857500	-0.	2.782824	-2.782824	28.892500	-28.892500	-0.5
CUBOID	1	2.857500	-0.	2.840736	-2.840736	28.892500	-28.892500	-0.5
CUBOID	2	2.857500	-0.	2.875280	-2.875280	28.892500	-28.892500	-0.5
CUBOID	3	2.857500	-0.	3.175000	-3.175000	28.892500	-28.892500	-0.5
CUBOID	2	2.857500	-0.	3.209544	-3.209544	28.892500	-28.892500	-0.5
CUBOID	1	2.857500	-0.	3.267456	-3.267456	28.892500	-28.892500	-0.5
CUBOID	2	2.857500	-0.	3.302000	-3.302000	28.892500	-28.892500	-0.5
CUBOID	3	2.857500	-0.	3.556000	-3.556000	28.892500	-28.892500	-0.5
CUBOID	2	2.857500	-0.	3.683000	-3.683000	28.892500	-28.892500	-0.5
CUBOID	7	4.039	-0.000	4.039	-4.039	28.8925	-28.8925	-0.5
CUBOID	6	4.356	-0.000	4.356	-4.356	28.8925	-28.8925	-0.5
BOX TYPE	3							
CUBOID	7	4.039	-0.000	4.356	-4.039	28.8925	-28.8925	-0.5
CUBOID	6	4.356	-0.000	4.356	-4.356	28.8925	-28.8925	-0.5
BOX TYPE	4							
CUBOID	7	4.039	-0.000	4.039	-4.356	28.8925	-28.8925	-0.5
CUBOID	6	4.356	-0.000	4.356	-4.356	28.8925	-28.8925	-0.5
BOX TYPE	5							
CUBOID	7	0.000	-4.039	4.039	-4.356	28.8925	-28.8925	-0.5
CUBOID	6	0.000	-4.356	4.356	-4.356	28.8925	-28.8925	-0.5
BOX TYPE	6							
BOID	7	0.000	-4.039	4.356	-4.039	28.8925	-28.8925	-0.5
BOID	6	0.000	-4.356	4.356	-4.356	28.8925	-28.8925	-0.5

TABLE 6.3.1-1 (CONTINUED)

```
BOX TYPE     7
 JBOID    6     0.000    -4.356     0.317    -0.000    28.8925   -28.8925 -0.5
BOX TYPE     8
CUBOID    6     0.000    -0.317     4.356    -4.356    28.8925   -28.8925 -0.5
BOX TYPE     9
CUBOID    7     4.039    -0.000     0.317    -0.000    28.8925   -28.8925 -0.5
CUBOID    6     4.356    -0.000     0.317    -0.000    28.8925   -28.8925 -0.5
BOX TYPE    10
CUBOID    7     0.000    -4.039     0.317    -0.000    28.8925   -28.8925 -0.5
CUBOID    6     0.000    -4.356     0.317    -0.000    28.8925   -28.8925 -0.5
BOX TYPE    11
CUBOID    7     0.000    -0.317     4.356    -4.039    28.8925   -28.8925 -0.5
CUBOID    6     0.000    -0.317     4.356    -4.356    28.8925   -28.8925 -0.5
BOX TYPE    12
CUBOID    7     0.000    -0.317     4.039    -4.356    28.8925   -28.8925 -0.5
CUBOID    6     0.000    -0.317     4.356    -4.356    28.8925   -28.8925 -0.5
BOX TYPE    13
CUBOID    7     0.317    -0.000     0.317    -0.000    28.8925   -28.8925 -0.5
BOX TYPE    14
CUBOID    7 27.78125    -27.78125     0.317    -0.000    28.8925   -28.8925 -0.5
BOX TYPE    15
CUBOID    7 27.78125    -27.78125     4.356    -4.356    28.8925   -28.8925 -0.5
BOX TYPE     16
CUBOID    7 27.78125    -27.78125     4.356    -4.356    28.8925   -28.8925 -0.5
ARRAY BDY     7 63.26325 -63.26325     13.385    -13.385 28.8925 -28.8925 -0.5
CUBOID    5  93.74325 -93.74325    43.865    -43.865 59.37250  -59.37250 -0.5
 ND GEOMETRY
      0 13  9  7  7  7  7  7  7 10 13 14 13  9  7  7  7  7  7  7 10 13
        11  3  1  2  1  2  1  2  6 11 15 11  3  1  2  1  2  1  2  6 11
         8  1  2  1  2  1  2  1  2  8 16  8  1  2  1  2  1  2  1  2  8
        12  4  1  2  1  2  1  2  5 12 15 12  4  1  2  1  2  1  2  5 12
        13  9  7  7  7  7  7  7 10 13 14 13  9  7  7  7  7  7  7 10 13  0
END KENO
```

TABLE 6.4-1

```
KEFF BNL FUEL SHIPPING ARRAY  FWR 2 CONT SIDE-BY-SIDE
27GROUPNDF4  7  7  3  LATTICECELL  0  0
U-235  1 0. 2.61362-3 END
AL  2 1. END
H2O  3 6.8-5 END
AL  4 1. END
H2O  5 1. END
SS304  6 1. END
H2O  7 8.8-5 END
SYMMSLABCELL      0.37084 0.057912 1 3 0.127 2 END
    MIXTURE  NUCLIDE   DENSITY      MIXTURE  NUCLIDE   DENSITY
       1     -92235   2.61362E-03      8     -92235   4.08154E-04
       2      13027   6.02383E-02      8      13027   1.12225E-02
       3       1001   5.87448E-06      8       1001   3.86267E-06
       3       8016   2.93724E-06      8       8016   1.93134E-06
       4          3   6.02383E-02
       5          5   6.67555E-02      5          8   3.33777E-02
       6      24304   1.74239E-02      6      25055   1.73634E-02
       6      26304   5.93526E-02      6      28304   7.72036E-02
       7          6   5.87448E-06      7          9   2.93724E-06
CROSS SECTIONS READ FROM TAPE
NUCLIDE =       1001   H 1269 F, 1002 T 218 GP 032475(2)
NUCLIDE =          5   H 1269 F, 1002 T 218 GP 032475(2)
NUCLIDE =          6   H 1269 F, 1002 T 218 GP 032475(2)
NUCLIDE =       8016   O-16 1276 218 GP 030476(7)
NUCLIDE =          8   O-16 1276 218 GP 030476(7)
NUCLIDE =          9   O-16 1276 218 GP 030476(7)
NUCLIDE =      13027   AL-27 1193 218 GP 040375(5)
NUCLIDE =          3   AL-27 1193 218 GP 040375(5)
NUCLIDE =      24304   CR 1191 WT SS-304(1/EST) P-3 293K SP=5+4(42375)
NUCLIDE =      25055   MN-55 1197 SIGP=5+4 NEWILACS 218NGP P-3 293K
NUCLIDE =      26304   FE 1192 WT SS-304(1/EST) P-3 293K SP=5+4(42375)
NUCLIDE =      28304   NI 1190 WT SS-304(1/EST) P-3 293K SP=5+4(42375)
NUCLIDE =      92235   U-235 1261 SIGP=5+4 NEWILACS 218NGP P-3 293K(3)
 GENERATIONS      AVERAGE                        67 PER CENT          95 PER CENT          99 PER CENT      NUMBER OF
   SKIPPED      K-EFFECTIVE      DEVIATION    CONFIDENCE INTERVAL  CONFIDENCE INTERVAL  CONFIDENCE INTERVAL  HISTORIES
      3          .26772   + OR -  .00301      .26470 TO  .27073    .26169 TO  .27374    .25868 TO  .27676     25500
                                 FREQUENCY FOR GENERATIONS    4 TO   88
 .1869 TO  .2100     *
 .2100 TO  .2331     ***
 .2331 TO  .2562     ************************
 .2562 TO  .2793     ******************************
 .2793 TO  .3024     ********************
 .3024 TO  .3255     ***
 .3255 TO  .3485     ****
```

TABLE 6.4-2

```
KEFF BNL FUEL SHIPPING ARRAY  FWR 2 CONT SIDE-BY-SIDE
276GROUPNDF4  7  7  3  LATTICECELL  0  0
U-235  1 0. 2.61362-3 END
AL  2 1. END
H2O  3 1.-3 END
AL  4 1. END
H2O  5 1. END
SS304  6 1. END
H2O  7 1.-3 END
SYMMSLABCELL      0.37084 0.057912 1 3 0.127 2 END
    MIXTURE  NUCLIDE   DENSITY      MIXTURE  NUCLIDE   DENSITY
       1     -92235   2.61362E-03      8     -92235   4.08154E-04
       2      13027   6.02383E-02      8      13027   1.12225E-02
       3       1001   6.67555E-05      8       1001   4.38940E-05
       3       8016   3.33777E-05      8       8016   2.19470E-05
       4          3   6.02383E-02
       5          5   6.67555E-02      5          8   3.33777E-02
       6      24304   1.74239E-02      6      25055   1.73634E-03
       6      26304   5.93526E-02      6      28304   7.72036E-03
       7          6   6.67555E-05      7          9   3.33777E-05
CROSS SECTIONS READ FROM TAPE
NUCLIDE =       1001   H 1269 F, 1002 T 218 GP 032475(2)
NUCLIDE =          5   H 1269 F, 1002 T 218 GP 032475(2)
NUCLIDE =          6   H 1269 F, 1002 T 218 GP 032475(2)
NUCLIDE =       8016   O-16 1276 218 GP 030476(7)
NUCLIDE =          8   O-16 1276 218 GP 030476(7)
NUCLIDE =          9   O-16 1276 218 GP 030476(7)
NUCLIDE =      13027   AL-27 1193 218 GP 040375(5)
NUCLIDE =          3   AL-27 1193 218 GP 040375(5)
NUCLIDE =      24304   CR 1191 WT SS-304(1/EST) P-3 293K SP=5+4(42375)
NUCLIDE =      25055   MN-55 1197 SIGP=5+4 NEWXLACS 218NGP P-3 293K
NUCLIDE =      26304   FE 1192 WT SS-304(1/EST) P-3 293K SP=5+4(42375)
NUCLIDE =      28304   NI 1190 WT SS-304(1/EST) P-3 293K SP=5+4(42375)
NUCLIDE =      92235   U-235 1261 SIGP=5+4 NEWXLACS 218NGP P-3 293K(3)
 GENERATIONS      AVERAGE                      67 PER CENT          95 PER CENT          99 PER CENT      NUMBER OF
   SKIPPED      K-EFFECTIVE      DEVIATION    CONFIDENCE INTERVAL  CONFIDENCE INTERVAL  CONFIDENCE INTERVAL  HISTORIES
      3          .27187   + OR -  .00299      .26888 TO  .27486    .26589 TO  .27786    .26290 TO  .28085     25500
                                 FREQUENCY FOR GENERATIONS    4 TO   88
 .1679 TO  .1910     *
 .1910 TO  .2141     *
 .2141 TO  .2372     ********
 .2372 TO  .2603     ****************
 .2603 TO  .2834     ******************************
 .2834 TO  .3065     **********************
 .3065 TO  .3296     ******
 .3296 TO  .3527     **
```

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TABLE 6.4-3

```
KEFF BNL FUEL SHIPPING ARRAY  FWR 2 CONT SIDE-BY-SIDE
27GROUPNDF4  7  7  3  LATTICECELL  0  0
U-235  1 0. 2.61362-3 END
AL  2 1. END
H2O  3 1.-2 END
AL  4 1. END
H2O  5 1. END
SS304  6 1. END
H2O  7 1.-2 END
SYMMSLABCELL      0.37084 0.05791 1 3 0.127 2 END
```

MIXTURE	NUCLIDE	DENSITY	MIXTURE	NUCLIDE	DENSITY
1	-92235	2.61362E-03	8	-92235	4.08154E-04
2	13027	6.02383E-02	8	13027	1.12225E-02
3	1001	6.67555E-04	8	1001	4.38940E-04
3	8016	3.33777E-04	8	8016	2.19470E-04
4	3	6.02383E-02			
5	5	6.67555E-02	5	8	3.33777E-02
6	24304	1.74239E-02	6	25055	1.73634E-03
6	26304	5.93526E-02	6	28304	7.72036E-03
7	6	6.67555E-04	7	9	3.33777E-04

```
CROSS SECTIONS READ FROM TAPE
NUCLIDE =      1001   H 1269 F, 1002 T 218 GP 032475(2)
NUCLIDE =         5   H 1269 F, 1002 T 218 GP 032475(2)
NUCLIDE =         6   H 1269 F, 1002 T 218 GP 032475(2)
NUCLIDE =      8016   O-16 1276 218 GP 030476(7)
NUCLIDE =         8   O-16 1276 218 GP 030476(7)
NUCLIDE =         9   O-16 1276 218 GP 030476(7)
NUCLIDE =     13027   AL-27 1193 218 GP 040375(5)
NUCLIDE =         3   AL-27 1193 218 GP 040375(5)
NUCLIDE =     24304   CR 1191 WT SS-304(1/EST) P-3 293K SP=5+4(42375)
NUCLIDE =     25055   MN-55 1197 SIGP=5+4 NEWILACS 218NGF P-3 293K
NUCLIDE =     26304   FE 1192 WT SS-304(1/EST) P-3 293K SP=5+4(42375)
NUCLIDE =     28304   NI 1190 WT SS-304(1/EST) P-3 293K SP=5+4(42375)
NUCLIDE =     92235   U-235 1261 SIGP=5+4 NEWILACS 218NGF P-3 293K(3)
```

GENERATIONS SKIPPED	AVERAGE K-EFFECTIVE	DEVIATION	67 PER CENT CONFIDENCE INTERVAL	95 PER CENT CONFIDENCE INTERVAL	99 PER CENT CONFIDENCE INTERVAL	NUMBER OF HISTORIES
3	.26963	+ OR - .00313	.26650 TO .27275	.26339 TO .27588	.26025 TO .27900	25500

FREQUENCY FOR GENERATIONS 4 TO 88

```
.1888 TO  .2119    **
.2119 TO  .2350    ********
.2350 TO  .2581    ****************
.2581 TO  .2812    ******************************
.2812 TO  .3043    ****************
.3043 TO  .3274    *********
.3274 TO  .3505    **
```

TABLE 6.4-4

```
KEFF BNL FUEL SHIPPING ARRAY  FWR 2 CONT SIDE-BY-SIDE
27GROUPNDF4  7  7  3  LATTICECELL  0  0
U-235  1 0. 2.61362-3 END
AL  2 1. END
H2O  3 1.-1 END
AL  4 1. END
H2O  5 1. END
SS304  6 1. END
H2O  7 1.-1 END
SYMMSLABCELL      0.37084 0.057912 1 3 0.127 2 END
    MIXTURE  NUCLIDE   DENSITY      MIXTURE  NUCLIDE   DENSITY
        1    -92235   2.61362E-03      8    -92235   4.08154E-04
        2     13027   6.02383E-02      8     13027   1.12225E-02
        3      1001   6.67555E-03      8      1001   4.38940E-03
        3      8016   3.33777E-03      8      8016   2.19470E-03
        4         3   6.02383E-02
        5         5   6.67555E-02      5         8   3.33777E-02
        6     24304   1.74239E-02      6     25055   1.73634E-03
        6     26304   5.93526E-02      6     28304   7.72036E-03
        7         6   6.67555E-03      7         9   3.33777E-03
CROSS SECTIONS READ FROM TAPE
NUCLIDE =      1001   H 1269 F, 1002 T 218 GP 032475(2)
NUCLIDE =         5   H 1269 F, 1002 T 218 GP 032475(2)
NUCLIDE =         6   H 1269 F, 1002 T 218 GP 032475(2)
NUCLIDE =      8016   O-16 1276 218 GP 030476(7)
NUCLIDE =         8   O-16 1276 218 GP 030476(7)
NUCLIDE =         9   O-16 1276 218 GP 030476(7)
NUCLIDE =     13027   AL-27 1193 218 GP 040375(5)
NUCLIDE =         3   AL-27 1193 218 GP 040375(5)
NUCLIDE =     24304   CR 1191 WT SS-304(1/EST) P-3 293K SP=5+4(42375)
NUCLIDE =     25055   MN-55 1197 SIGP=5+4 NEWXLACS 218NGF P-3 293K
NUCLIDE =     26304   FE 1192 WT SS-304(1/EST) P-3 293K SP=5+4(42375)
NUCLIDE =     28304   NI 1190 WT SS-304(1/EST) P-3 293K SP=5+4(42375)
NUCLIDE =     92235   U-235 1261 SIGP=5+4 NEWXLACS 218NGF P-3 293K(3)
 GENERATIONS      AVERAGE                    67 PER CENT          95 PER CENT          99 PER CENT      NUMBER OF
   SKIPPED      K-EFFECTIVE      DEVIATION   CONFIDENCE INTERVAL  CONFIDENCE INTERVAL  CONFIDENCE INTERVAL  HISTORIES
      3          .29635   + OR -  .00309     .29326 TO  .29944    .29017 TO  .30252    .28708 TO  .30561     26400
                              FREQUENCY FOR GENERATIONS    4 TO   91
 .2386 TO  .2617     ***********
 .2617 TO  .2848     **********************
 .2848 TO  .3079     ************************
 .3079 TO  .3310     **********************
 .3310 TO  .3541     *******
 .3541 TO  .3772     **
```

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TABLE 6.4-5

```
KEFF BWL FUEL SHIPPING ARRAY  FWR
27GROUPNDF4  7  7  3  LATTICECELL  0  0
U-235  1 0. 2.61362-3 END
AL  2 1. END
H2O  3 1. END
AL  4 1. END
H2O  5 1. END
SS304  6 1. END
H2O  7 1. END
SYMMSLABCELL      0.37084 0.057912 1 3 0.127 2 END
```

MIXTURE	NUCLIDE	DENSITY	MIXTURE	NUCLIDE	DENSITY
1	-92235	2.61362E-03	8	-92235	4.08154E-04
2	13027	6.02383E-02	8	13027	1.12225E-02
3	1001	6.67555E-02	8	1001	4.38940E-02
3	8016	3.33777E-02	8	8016	2.19470E-02
4	3	6.02383E-02			
5	5	6.67555E-02	5	8	3.33777E-02
6	24304	1.74239E-02	6	25055	1.73634E-03
6	26304	5.93526E-02	6	28304	7.72036E-03
7	6	6.67555E-02	7	9	3.33777E-02

```
CROSS SECTIONS READ FROM TAPE
NUCLIDE =      1001   H 1269 F, 1002 T 218 GP 032475(2)
NUCLIDE =         5   H 1269 F, 1002 T 218 GP 032475(2)
NUCLIDE =         6   H 1269 F, 1002 T 218 GP 032475(2)
NUCLIDE =      8016   O-16 1276 218 GP 030476(7)
NUCLIDE =         8   O-16 1276 218 GP 030476(7)
NUCLIDE =         9   O-16 1276 218 GP 030476(7)
NUCLIDE =     13027   AL-27 1193 218 GP 040375(5)
NUCLIDE =         3   AL-27 1193 218 GP 040375(5)
NUCLIDE =     24304   CR 1191 WT SS-304(1/EST) P-3 293K SP=5+4(42375)
NUCLIDE =     25055   MN-55 1197 SIGP=5+4 NEWILACS 218NGF P-3 293K
NUCLIDE =     26304   FE 1192 WT SS-304(1/EST) P-3 293K SP=5+4(42375)
NUCLIDE =     28304   NI 1190 WT SS-304(1/EST) P-3 293K SP=5+4(42375)
NUCLIDE =     92235   U-235 1261 SIGP=5+4 NEWILACS 218NGP P-3 293K(3)
```

GENERATIONS SKIPPED	AVERAGE K-EFFECTIVE	DEVIATION	67 PER CENT CONFIDENCE INTERVAL	95 PER CENT CONFIDENCE INTERVAL	99 PER CENT CONFIDENCE INTERVAL	NUMBER OF HISTORIES
3	.81978	+ OR - .00475	.81502 TO .82453	.81027 TO .82929	.80551 TO .83404	30000

```
                    FREQUENCY FOR GENERATIONS    4 TO  103
.6928 TO  .7159     **
.7159 TO  .7389     *******
.7389 TO  .7620     ***
.7620 TO  .7851     **********
.7851 TO  .8082     *************
.8082 TO  .8313     ********************
.8313 TO  .8544     ********************
.8544 TO  .8775     ****************
.8775 TO  .9006     ******
.9006 TO  .9237     **
.9237 TO  .9468     *
```

FIGURE [illegible] K-Effective [illegible] Sigma) [illegible] Water [illegible]
Model 2. Two Casks, Each Containing 3510 Grams U-235 Of Fully Enriched Uranium In Plate Fuel In Ten Fuel Elements In A 304 Stainless Steel Basket, Are In An Array Separated By 21.875" Edge-To-Edge Containing A Mist. There Is 12" Of Water Reflection Around The Array. The K-Effective Results Contain A Bias Of 0.3% In The 1 Sigma Value And 2.3% In The Mean Value.

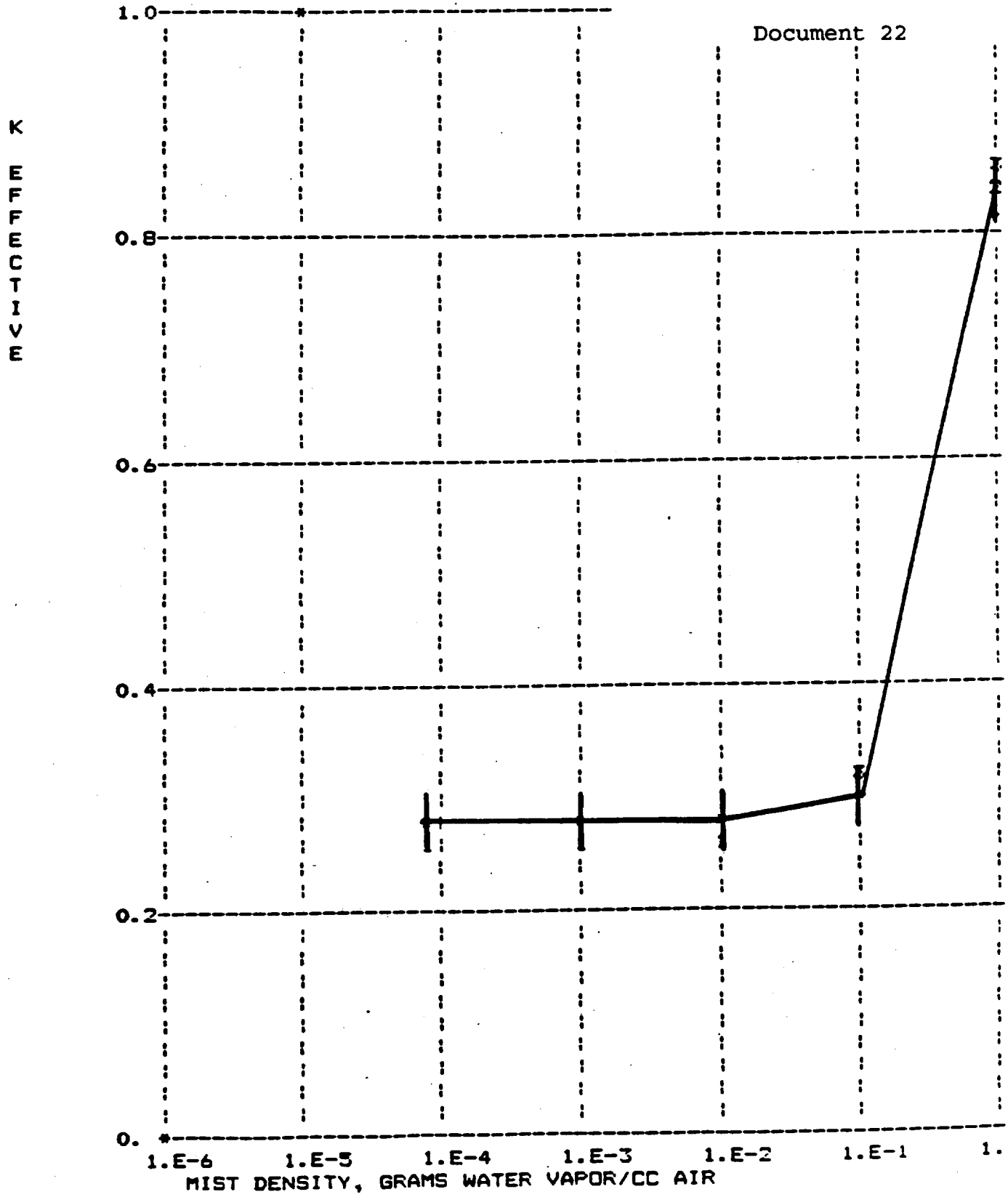

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TABLE 6.5.1-1

Critical Experiments for
Computational Tool Evaluation

Experiment Name	References
A. TRX-1 & TRX-2 Low-Enriched Uranium Rods in Water	A.1. J. Hardy, Jr., D. Klein and J. J. Volpe; "A Study of Physics Parameters In Several Water-Moderated Lattices of Slightly Enriched and Natural Uranium", WAPD-TM-931; March, 1970.
	A.2. J. Hardy, Jr., D. Klein and J. J. Volpe; Nucl. Sci. Eng. 40, 101 (1970). J. J. Volpe, J. Hardy, Jr., and D. Klein, Nucl. Sci. Eng. 40, 116 (1970).
	A.3. J. Hardy, Jr., D. Klein and R. Dannels; Nucl. Sci. Eng. 26, 462 (1966).
	A.4. J. R. Brown et al., "Kinetics and Buckling Measurements In Lattices of Slightly Enriched U or UO_2 Rods In H_2O", WAPD-176 (January, 1958).
	A.5. R. Sher and S. Fiarman, "Studies of Thermal Reactor Benchmark Data Interpretation: Experimental Corrections", EPRI NP-209; October, 1976.
B. ORNL 1-4 & ORNL 10 Fully Enriched Uranium Spherical Solutions	B.1. R. Gwin and D. W. Magnuson, "Eta of U-233 and U-235 for Critical Experiments", Nuc. Sci. Eng. 12, 364 (1962).
	B.2. A. Staub et al., "Analysis of A Set of Critical Homogeneous U-H_2O Spheres", Nuc. Sci. Eng. 34, 263 (1968).

TABLE 6.5.1-1
(Continued)

Experiment Name	References
C. PNL 1-5 Plutonium Spherical Solutions	C.1. R. C. Lloyd et al., "Criticality Studies With Plutonium Solutions", Nuc. Sci. Eng. 25, 165 (1966).
	C.2. L. E. Hansen and E. D. Clayton, "Theory-Experiment Tests Using ENDF/B Version II Cross-Section Data", Trans. Amer. Nuc. Soc. 15, 309 (June, 1972).
	C.3. F. E. Kruesi et al., "Critical Mass Studies of Plutonium-Nitrate Solution", HW-24514 (1952).
D. Babcock & Wilcox Small Lattice Facility Low-Enriched UO_2 Rods in Water	D.1. M. N. Baldwin et al., "Physics Verification Program - Part III", BAW-3647-6, Babcock & Wilcox, 1970.
MO_2 Rods in Water	D.2. G. T. Fairburn et al., "Pu Lattice Experiments In Uniform Test Lattice of UO_2-1.5% PuO_2 Fuel", BAW-1357, Babcock & Wilcox; August, 1970.

```
        TABLE 6.5.2-1  TRX-1
KEFF TRX-1 763 U METAL RODS 1.291W/D WAPD 176 JAN. 1958
27GROUPNDF4  7 10 4 LATTICECELL  0 0
U-235  1 0. 6.253-4 END
U-238  1 0. 0.047205 END
AL  2 0. 0.06025 END
H  3 0. 0.06676 END
O  3 0. 0.03338 END
H2O  4 8.8-5 END
H  5 0. 0.06676 END
O  5 0. 0.03338 END
FE  6 1. END
AL  7 0. 0.06025 END
TRIANGPITCH  1.806 0.983 1 3 1.1506 2 1.0084 4 END
KEFF TRX-1 763 U METAL RODS 1.291W/D WAPD 176 JAN. 1958
15.0 103 300 3 6 60 33 2 0
BOX TYPE  1
ZHEMICYL+X  7 0.5753 0. -15.24 -0.5
CUBOID  5 0.903 -0. 0.782 -0.782 0. -15.24 -0.5
CUBOID  500 0.903 -0. 0.782 -0.782 0. -76.20 -0.5
CUBOID  6 0.903 -0. 0.782 -0.782 5.08 -76.20 -0.5
BOX TYPE  2
ZHEMICYL-X  7 0.5753 0. -15.24 -0.5
CUBOID  5 0. -0.903 0.782 -0.782 0. -15.24 -0.5
CUBOID  500 0. -0.903 0.782 -0.782 0. -76.20 -0.5
CUBOID  6 0. -0.903 0.782 -0.782 5.08 -76.20 -0.5
BOX TYPE  3
ZHEMICYL+X  7 0.5753 20.32 -0. -0.5
CUBOID  5 0.903 -0. 0.782 -0.782 20.32 -0. -0.5
CUBOID  500 0.903 -0. 0.782 -0.782 81.28 -0. -0.5
CUBOID  6 0.903 -0. 0.782 -0.782 81.28 -1.27 -0.5
BOX TYPE  4
ZHEMICYL-X  7 0.5753 20.32 -0. -0.5
CUBOID  5 0. -0.903 0.782 -0.782 20.32 -0. -0.5
CUBOID  500 0. -0.903 0.782 -0.782 81.28 -0. -0.5
CUBOID  6 0. -0.903 0.782 -0.782 81.28 -1.27 -0.5
BOX TYPE  5
CUBOID  5 0.903 -0. 0.782 -0.782 0. -76.20 -0.5
CUBOID  6 0.903 -0. 0.782 -0.782 5.08 -76.20 -0.5
BOX TYPE  6
CUBOID  5 0.903 -0. 0.782 -0.782 81.28 -0. -0.5
CUBOID  6 0.903 -0. 0.782 -0.782 81.28 -1.27 -0.5
ARRAY BOY  5 27.090 -27.090 25.806 -25.806 81.915 -81.915 -0.5
CUBOID  5 57.090 -57.090 55.806 -55.806 81.915 -81.915 -0.5
```

TABLE 6.5.2-1 TRX-1 (CONTINUED)

```
NEFF TRX-1 763 U METAL RODS 1.291U/O WAPD 176 JAN. 1958
END GEOMETRY
 5  1 60 1  1 33 1 2 2 1 0 6  1 60 1  1 33 1 1 1 1 0 2 24 38 2  1 33 2 2 2 1 0
 1 25 39 2  1 33 2 2 2 1 0 2 17 43 2  2 32 2 2 2 1 0 1 18 44 2  2 32 2 2 2 1 0
 2 14 46 2  3 31 2 2 2 1 0 1 15 47 2  3 31 2 2 2 1 0 2 13 47 2  4 30 2 2 2 1 0
 1 14 48 2  4 30 2 2 2 1 0 2 12 48 2  5 29 2 2 2 1 0 1 13 49 2  5 29 2 2 2 1 0
 2  9 51 2  6 28 2 2 2 1 0 1 10 52 2  6 28 2 2 2 1 0 2  8 52 2  7 27 2 2 2 1 0
 1  9 53 2  7 27 2 2 2 1 0 2  7 53 2  8 26 2 2 2 1 0 1  8 54 2  8 26 2 2 2 1 0
 2  6 54 2  9 25 2 2 2 1 0 1  7 55 2  9 25 2 2 2 1 0 2  5 55 2 10 24 2 2 2 1 0
 1  6 56 2 10 24 2 2 2 1 0 2  4 56 2 11 23 2 2 2 1 0 1  5 57 2 11 23 2 2 2 1 0
 2  3 57 2 12 22 2 2 2 1 0 1  4 58 2 12 22 2 2 2 1 0 2  2 58 2 13 21 2 2 2 1 0
 1  3 59 2 13 21 2 2 2 1 0 2  1 59 2 16 18 2 2 2 1 0 1  2 60 2 16 18 2 2 2 1 0
 4 24 38 2  1 33 2 1 1 1 0 3 25 39 2  1 33 2 1 1 1 0 4 17 43 2  2 32 2 1 1 1 0
 3 18 44 2  2 32 2 1 1 1 0 4 14 46 2  3 31 2 1 1 1 0 3 15 47 2  3 31 2 1 1 1 0
 4 13 47 2  4 30 2 1 1 1 0 3 14 48 2  4 30 2 1 1 1 0 4 12 48 2  5 29 2 1 1 1 0
 3 13 49 2  5 29 2 1 1 1 0 4  9 51 2  6 28 2 1 1 1 0 3 10 52 2  6 28 2 1 1 1 0
 4  8 52 2  7 27 2 1 1 1 0 3  9 53 2  7 27 2 1 1 1 0 4  7 53 2  8 26 2 1 1 1 0
 3  8 54 2  8 26 2 1 1 1 0 4  6 54 2  9 25 2 1 1 1 0 3  7 55 2  9 25 2 1 1 1 0
 4  5 55 2 10 24 2 1 1 1 0 3  6 56 2 10 24 2 1 1 1 0 4  4 56 2 11 23 2 1 1 1 0
 3  5 57 2 11 23 2 1 1 1 0 4  3 57 2 12 22 2 1 1 1 0 3  4 58 2 12 22 2 1 1 1 0
 4  2 58 2 13 21 2 1 1 1 0 3  3 59 2 13 21 2 1 1 1 0 4  1 59 2 16 18 2 1 1 1 0
 3  2 60 2 16 18 2 1 1 1 9
END KENO
```

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```
KEFF TRX-2 577 U METAL RODS 1.291W/O WAPD 176 JAN. 1958
27GROUPNDF4  7 10 4 LATTICECELL  0 0
U-235  1 0. 6.253-4 END
U-238  1 0. 0.047205 END
AL  2 0. 0.06025 END
N  3 0. 0.06676 END
O  3 0. 0.03338 END
H2O  4 8.8-5 END
N  5 0. 0.06676 END
O  5 0. 0.03338 END
FE  6 1. END
AL  7 0. 0.06025 END
TRIANGPITCH  2.174 0.983 1 3 1.1506 2 1.0084 4 END
KEFF TRX-2 577 U METAL RODS 1.291W/O WAPD 176 JAN. 1958
15.0 103 300 3 6 52 29 2 0
BOX TYPE  1
ZHEMICYL+X  7 0.5753 0. -15.24 -0.5
CUBOID  5  1.087 -0. 0.941 -0.941 0. -15.24 -0.5
CUBOID  500 1.087 -0. 0.941 -0.941 0. -76.20 -0.5
CUBOID  6 1.087 -0. 0.941 -0.941 5.08 -76.20 -0.5
BOX TYPE  2
ZHEMICYL-X  7 0.5753 0. -15.24 -0.5
CUBOID  5  0. -1.087 0.941 -0.941 0. -15.24 -0.5
CUBOID  500 0. -1.087 0.941 -0.941 0. -76.20 -0.5
CUBOID  6 0. -1.087 0.941 -0.941 5.08 -76.20 -0.5
BOX TYPE  3
ZHEMICYL+X  7 0.5753 20.32 -0. -0.5
CUBOID  5  1.087 -0. 0.941 -0.941 20.32 -0. -0.5
CUBOID  500 1.087 -0. 0.941 -0.941 81.28 -0. -0.5
CUBOID  6 1.087 -0. 0.941 -0.941 81.28 -1.27 -0.5
BOX TYPE  4
ZHEMICYL-X  7 0.5753 20.32 -0. -0.5
CUBOID  5  0. -1.087 0.941 -0.941 20.32 -0. -0.5
CUBOID  500 0. -1.087 0.941 -0.941 81.28 -0. -0.5
CUBOID  6 0. -1.087 0.941 -0.941 81.28 -1.27 -0.5
BOX TYPE  5
CUBOID  5 1.087 -0. 0.941 -0.941 0. -76.20 -0.5
CUBOID  6 1.087 -0. 0.941 -0.941 5.08 -76.20 -0.5
BOX TYPE  6
CUBOID  5 1.087 -0. 0.941 -0.941 81.28 -0. -0.5
CUBOID  6 1.087 -0. 0.941 -0.941 81.28 -1.27 -0.5
ARRAY BOY  5 28.262 -28.262 27.289 -27.289 81.915 -81.915 -0.5
CUBOID  5 58.262 -58.262 57.289 -57.289 81.915 -81.915 -0.5
END GEOMETRY
 5  1 52 1  1 29 1 2 2 1 0 6  1 52 1  1 29 1 1 1 1 0 2 22 32 2  1 29 2 2 2 1 0
 1 23 33 2  1 29 2 2 2 1 0 2 15 37 2  2 28 2 2 2 1 0 1 16 38 2  2 28 2 2 2 1 0
 2 12 40 2  3 27 2 2 2 1 0 1 13 41 2  3 27 2 2 2 1 0 2 11 41 2  4 26 2 2 2 1 0
 1 12 42 2  4 26 2 2 2 1 0 2 10 42 2  5 25 2 2 2 1 0 1 11 43 2  5 25 2 2 2 1 0
 2  7 45 2  6 24 2 2 2 1 0 1  8 46 2  6 24 2 2 2 1 0 2  6 46 2  7 23 2 2 2 1 0
 1  7 47 2  7 23 2 2 2 1 0 2  5 47 2  8 22 2 2 2 1 0 1  6 48 2  8 22 2 2 2 1 0
 2  4 48 2  9 21 2 2 2 1 0 1  5 49 2  9 21 2 2 2 1 0 2  3 49 2 10 20 2 2 2 1 0
 1  4 50 2 10 20 2 2 2 1 0 2  2 50 2 11 19 2 2 2 1 0 1  3 51 2 11 19 2 2 2 1 0
 2  1 51 2 14 16 2 2 2 1 0 1  2 52 2 14 16 2 2 2 1 0 4 22 32 2  1 29 2 1 1 1 0
 3 23 33 2  1 29 2 1 1 1 0 4 15 37 2  2 28 2 1 1 1 0 3 16 38 2  2 28 2 1 1 1 0
 4 12 40 2  3 27 2 1 1 1 0 3 13 41 2  3 27 2 1 1 1 0 4 11 41 2  4 26 2 1 1 1 0
 3 12 42 2  4 26 2 1 1 1 0 4 10 42 2  5 25 2 1 1 1 0 3 11 43 2  5 25 2 1 1 1 0
 4  7 45 2  6 24 2 1 1 1 0 3  8 46 2  6 24 2 1 1 1 0 4  6 46 2  7 23 2 1 1 1 0
 3  7 47 2  7 23 2 1 1 1 0 4  5 47 2  8 22 2 1 1 1 0 3  6 48 2  8 22 2 1 1 1 0
 4  4 48 2  9 21 2 1 1 1 0 3  5 49 2  9 21 2 1 1 1 0 4  3 49 2 10 20 2 1 1 1 0
 3  4 50 2 10 20 2 1 1 1 0 4  2 50 2 11 19 2 1 1 1 0 3  3 51 2 11 19 2 1 1 1 0
 4  1 51 2 14 16 2 1 1 1 0 3  2 52 2 14 16 2 1 1 1 9
END XENO
```

TABLE 6.5.2-3 ORNL-1 & ORNL-2

```
KEFF ORNL-1 NSE 34 263-274 (1968P) SCALE MODEL
27GROUPNDF4  1 7 1 INFHOMMEDIUM  1 0
U-235  1 0. 4.8066-5 END
U-238  1 0. 2.807-6 END
U-234  1 0. 5.38-7 END
U-236  1 0. 1.38-7 END
H  1 0. 1.869-4 END
O  1 0. 0.033736 END
N  1 0. 0.066228 END
 ISN=12 IIM=40 ICM=70 IUS=1 END
KEFF ORNL-1 NSE 34 263-274 (1968P) SCALE MODEL
15.0 103 300 3 0 0 0 0 0
SPHERE  1 34.5948 -0.5
END GEOMETRY
END KENO
KEFF ORNL-2 NSE 34 263-274 (1968P) SCALE MODEL
27GROUPNDF4  1 8 1 INFHOMMEDIUM  1 0
U-235  1 0. 5.6205-5 END
U-238  1 0. 3.28-6 END
U-234  1 0. 6.31-7 END
U-236  1 0. 1.63-7 END
H  1 0. 2.129-4 END
O  1 0. 0.0338 END
N  1 0. 0.066148 END
B-10  1 0. 1.0284-6 END
 ISN=12 IIM=40 ICM=70 IUS=1 END
KEFF ORNL-2 NSE 34 263-274 (1968P) SCALE MODEL
15.0 103 300 3 0 0 0 0 0
SPHERE  1 34.5948 -0.5
END GEOMETRY
END KENO
```

TABLE 6.5.2-4 PNL-1 & PNL-2

```
KEFF PNL-1 NSE 25 165 (1966)
27GROUPNDF4  1 5 1 INFHOMMEDIUM  1 0
PU-239  1 0. 9.373-5 END
PU-240  1 0. 4.501-6 END
N  1 0. 6.216-4 END
O  1 0. 0.03456 END
N  1 0. 0.06563 END
 ISN=12 IIN=40 ICN=70 IUS=1 END
KEFF PNL-1 NSE 25 165 (1966)
15. 103 300 3 0 0 0 0 0
SPHERE  1 19.509 -0.5
END GEOMETRY
END KENO
KEFF PNL-2 NSE 25 165 (1966)
27GROUPNDF4  1 5 1 INFHOMMEDIUM  1 0
PU-239  1 0. 4.141-4 END
PU-240  1 0. 1.988-5 END
N  1 0. 4.720-3 END
O  1 0. 0.03977 END
N  1 0. 0.05416 END
 ISN=12 IIN=40 ICN=70 IUS=1 END
KEFF PNL-2 NSE 25 165 (1966)
15. 103 300 3 0 0 0 0 0
SPHERE  1 19.509 -0.5
END GEOMETRY
END KENO
```

TABLE 6.5.2-5 B&W UO2 & MO2 EXPERIMENTS

```
B&W UO2 EXP CELL  SCALE MODEL  ENDF8-IV LATTICE SELFSHLD
27GROUPNDF4  3 7 3  LATTICECELL    0 0
O      1  0.  4.472785-2  END
U-235  1  0.  5.570288-4  END
U-238  1  0.  2.180690-2  END
AL     2  0.  6.051481-2  END
H      3  0.  6.668320-2  END
B-10   3  0.  2.243000-5  END
O      3  0.  3.334160-2  END
SQUAREPITCH   1.6256 1.0434   1  3 1.2060 2 END
B&W UO2 EXP CELL  SCALE MODEL  ENDF8-IV LATTICE SELFSHLD
15.  103  300  3  4R1  1
6R1
CYLINDER  1  .521716  .8128  -.8128  -.5
CYLINDER  2  .603     .8128  -.8128  -.5
CUBOID    3  .8128  -.8128  .8128  -.8128  .8128  -.8128  -.5
END GEOMETRY
END KENO
```

```
B&W MUO2 EXPERIMENT  SCALE MODEL  LATTICECELL SELFSHIELDIN
27GROUPNDF4  3 12  3 LATTICECELL    0 0
O          1  0.  4.358350-2  END
U-235      1  0.  1.543510-4  END
U-238      1  0.  2.131198-2  END
PU-239     1  0.  2.646750-4  END
PU-240     1  0.  5.295900-5  END
PU-241     1  0.  5.271000-6  END
PU-242     1  0.  8.320000-7  END
AM-241     1  0.  1.616000-6  END
ZIRCALLOY  2  1.019225        END
H          3  0.  6.668320-2  END
B-10       3  0.  2.465000-5  END
O          3  0.  3.334160-2  END
SQUAREPITCH  1.89738  1.2751  1  3  1.4275  2  END
B&W MUO2 EXPERIMENT  SCALE MODEL LATTICE SLFSHLDING
10.  103  300  3  4R1  1
6R1
CYLINDER  1  .63754   .94869  -.94869                          -.5
CYLINDER  2  .71374   .94869  -.94869                          -.5
CUBOID    3  .94869  -.94869   .94869  -.94869  .94869  -.94869 -.5
END GEOMETRY
END KENO
```

TABLE 6.5.3-1

K-Effective Results
Computational Tool Evaluation

Name of Critical Experiment	Feature	SCALE Results K-eff ± 2 Sigma	SCALE Results No. of Neutron Histories
ORNL-1	Fully Enriched	1.0021 ± 0.0060	30,000
ORNL-2	U-235 Nitrate	0.9977 ± 0.0068	30,000
TRX-1	Low Enriched	0.9773 ± 0.0060	30,000
TRX-2	U-235 Rods	0.9820 ± 0.0060	30,000
PNL-1	Plutonium	1.0157 ± 0.0108	30,000
PNL-2	Nitrate (5Pu240)	1.0105 ± 0.0114	30,000
B&W	UO_2 Rod	0.9920*± 0.0046	30,000
B&W	MO_2 Rod	0.9972*± 0.0054	30,000

*k-infinity values

Document 22

GENERAL ELECTRIC

NUCLEAR ENERGY BUSINESS OPERATIONS
GENERAL ELECTRIC COMPANY • VALLECITOS NUCLEAR CENTER • PLEASANTON, CALIFORNIA 94566

August 7, 1985

Mr. C. E. MacDonald, Chief
Transportation Certification Branch
Office of Nuclear Material Safety & Safeguards
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Reference: Certificate of Compliance No. 5942
Docket No. 71-5942

Dear Mr. MacDonald:

Certificate of Compliance No. 5942 presently authorizes the shipment of 3,510 grams of U-235 in the form of MTR-type fuel elements in the Model 700 shipping container (Item 5.(b)2.(viii) of the Certificate). A stainless steel fuel shipping basket (GE Drawing No. 106D4150) is used.

General Electric hereby requests that the 3,510-gram U-235 limit be increased to 7,020 grams. The new configuration involves the use of the Model 700 cavity extension and two stainless steel baskets stacked one on top of the other. The new basket design is shown on GE Drawing No. 106D4150 enclosed. The design is exactly the same as the present basket except for its shortened length.

A criticality analysis for the requested fuel loading is attached. The format follows that of Regulatory Guide 7.9.

No change is requested in the maximum permitted heat loading. As the elements essentially fill the fuel spaces in the basket, there is no way for an element to slip from a space in the upper basket into the lower one, creating a "hot spot". The real effect of the requested loading is to increase the length of the allowed fuel elements.

A check for $150.00 is enclosed.

Sincerely,

G. E. Cunningham
Senior Licensing Engineer

/ca

Enclosures

CRITICALITY EVALUATION

A criticality evaluation of the General Electric 700 cask is given below. This cask has a cavity that is 15 inches in diameter by 54.75 inches long for holding material, including special nuclear material. The cask is of steel-encased, lead-shielded construction.

6.1 Conclusions

Compliance with 10CFR71.61 for Fissile Class III shipments is demonstrated below for one loading. This loading involves 20 MTR-type fuel elements in which 10 elements are inserted in each of two stainless steel baskets in a cask. The basket provides a fixed neutron poison for each fuel element. Each fuel element has 18 plates containing 19.5 grams U-235 of fully enriched uranium per plate. Each fuel element also contains two aluminum support plates. This gives 351 grams U-235 per fuel element and 7,020 grams U-235 per cask.

The contents of the cask during shipment are dry. After the accident described in 10CFR71.73, the contents of the cask are assumed to be wet. Also, for loading and unloading activities for which hot cells are not available, the loading and unloading may be accomplished under water. After an underwater loading is completed, for example, the lid is placed on the cask and the cask is removed from the water; then the water is drained from the cask.

In the discussion below, details of the package fuel loading are presented first. Then a description of the models used to calculate the k-effective values for the fuel loading is presented. This is followed by the criticality calculation discussion for each of the models. Finally, the criticality benchmark experiments section is presented.

6.2 Package Fuel Loading

The type, form, and maximum quantity of special nuclear material per package are: 7,020 grams U-235 provided the fuel is in the form of MTR-type fuel elements with each element containing no more than 351 grams U-235 and inserted in a spaced stainless steel fuel shipping basket described in GE Drawing No. 106D4150, Rev. 1. A shoring device to limit vertical motion of the fuel elements will be included.

The loading above qualifies as Fissile Class III under provisions of 10CFR71.61, and the maximum number of packages per shipment is one (1).

6.3 Model Specification

The model for normal conditions is two casks side-by-side and touching. A cask outside diameter of 36.875 inches is used in this evaluation. This diameter provides the minimum spacing between the fuel baskets in each cask. When the overpacks are installed on each of the casks, separation distance between the baskets is larger; so use of the 36.875-inch cask OD is conservative. Each cask contains two stainless steel fuel baskets, and each fuel basket contains 10 plate-type fuel elements. The available space inside the cask is filled with a water mist having a density of 8.8 E-5 grams H_2O/cc, representing a humid condition of saturated air at about 120°F and at atmospheric pressure. The 8.8 E-5 density is then changed to 0.1 and 1.0 grams H_2O/cc, and the k-effective values are calculated for each of these densities. This two-cask array is reflected on all sides by 12 inches of water.

The model for one cask under accident conditions involves twenty fuel elements loaded in two baskets in a cask that is fully flooded with water and reflected on all sides by 12 inches of water.

It is not clear whether two stainless steel baskets loaded with 20 plate-type fuel elements are more reactive outside of a cask or inside of a cask for the mist densities considered in this evaluation. Therefore, two models are prepared. Model A is prepared for two baskets loaded with 10 fuel elements in each basket where the baskets are located outside of a cask. Model B is prepared for two baskets containing 10 fuel elements each where the two baskets are located inside of a cask. Furthermore, Model A at a mist density of 8.8 E-5 grams H_2O/cc represents conditions such as loading of fuel elements into fuel baskets in a hot cell, where the baskets are not in a cask; Model B at this density represents a normal condition. Model A at a mist density of 1.0 grams H_2O/cc (full density water) represents the underwater loading of baskets with fuel where the baskets are outside of the cask; Model B at this density represents underwater loading of baskets with fuel where the baskets are inside the cask, and it represents the accident condition for this cask. More details of these models are given below.

6.3.1 Description of Calculational Models

In the discussion below, Model A is presented first followed by Model B. In each of the model presentations, the fuel modeling is presented first followed by the basket and/or cask modeling. Each of these models is prepared as input to the SCALE System using the 27GROUPNDF4 cross-section set and the KENO-IV criticality code to perform the k-effective calculations.

In Model A, each fuel plate in a fuel element and each fuel element in a basket is described in three dimensions discretely. Each fuel element contains 20 plates: 18 fuel plates are in the middle of the fuel element, and 2 aluminum plates are at the top and bottom of each fuel element, respectively. Each fuel plate contains fuel meat that is 2.25 inches wide, 0.0228 inches thick, and 22.75 inches long. Each fuel plate contains 19.5 grams U-235 in this fuel meat space. The fuel meat is clad with 0.0136 inches of aluminum such that the fuel plate thickness becomes 0.05 inches.

Each fuel plate in the fuel element is separated by a gap of 0.096 inches except in the outer three layers of the fuel element where these gap thicknesses are 0.108 inches, 0.118 inches, and 0.100 inches, respectively. See Figure 6.3.1-1. The numerical results of this modeling may be seen in Table 6.3.1-1 under Box Type 1 or Box Type 2.

The basket is modeled as a 304 stainless steel structure that has walls that are 0.25 inches thick and contain 10 holes that measure 3.18 inches square by 22.75 inches long. There are three holes in the upper and lower rows and four holes in the middle row sufficient to hold 10 fuel elements. See Figure 6.3.1-2. The numerical results of this modeling may be seen in Table 6.3.1-1.

The basket model shown in the bottom half of Figure 6.3.1-2 will not fit inside of a GE 700 series cask. Therefore, another technique is used to model a basket in the 700 series cask. This technique uses the fuel homogenization feature with the XSDRNPM code on the SCALE System. The cross-sections from XSDRNPM are captured on Tape 3 of the SCALE System. Then they are fed back into the SCALE System on Tape 4, and the generalized geometry option of the KENO-IV code that is available on the SCALE System is used to model the stainless steel basket. This basket then becomes one box type in a KENO-IV model and is combined with other box types to construct a model for the fuel inside two baskets that are inside a GE 700 series lead cask. This technique constitutes Model B for this evaluation and is described in more detail below.

Fuel homogenization is accomplished by two actions: the use of the SYMMSLABCELL card coupled with the use of material 500 to describe the fuel. See Table 6.3.1-2. The description of the fuel materials for the discrete fuel in Table 6.3.1-1 and for the homogenized fuel in Table 6.3.1-2 between the two title cards in each of these tables is identical, except for the addition of material number 8, Lead, in Table 6.3.1-2. Furthermore, the geometrical description occurring in the boxes for Box Types 3-13 in each of the tables also is identical.

For Box Type 1, however, all of the cards used to describe the fuel discretely in Table 6.3.1-1 are replaced by one card in Table 6.3.1-2, and the material number for this card is 500. The same thing occurs for Box Type 2 in the two tables. When the SCALE System encounters this input, the XSDRNPM code is then used to flux and volume weight the cross-sections for the 0.0228-inch thick fuel meat, the 0.0136-inch aluminum clad, and the 0.096-inch thick water between the plates, as specified on the SYMMSLABCELL card, into a homogeneous fuel material represented by material 500. The cross-sections for all of the materials modeled in Table 6.3.1-2 including the homogenized fuel material may be captured on magnetic tape (Tape No. 3 in the SCALE System) and used later in other calculations. Two issues about this fuel homogenization of concern in this evaluation are discussed below.

A water gap of 0.096 inches is used everywhere in the homogenized fuel model, whereas the water gap is 0.108 inches, 0.118 inches, and 0.100 inches in the outermost water gaps in the discrete fuel model. Since the fuel element is under-moderated, the reactivity of the homogenized fuel model may be a little bit lower than the reactivity of the discrete fuel model. However, in the homogenization process, leakage of neutrons from the ends of the fuel element is not accounted for due to the options used in the XSDRNPM calculation in this evaluation. This effect would cause the homogenized fuel model to be a little bit more reactive than the discrete fuel model. A comparison of the k-effective results from each of these fuel models is given later.

The generalized geometry option in the KENO-IV code on the SCALE System was used to construct a model of the stainless steel basket containing 10 homogenized fuel elements in a GE 700 lead cask. The listing of the generalized geometry input may be seen in Table 6.3.1-3. This geometry was checked with the Picture Code*. A plan

*Irving, D. C. and Morrison, G. W., "PICTURE: An Aid In De-Bugging Geom Input Data", ORNL-TM-2892; May 14, 1970.

view of a cask containing a basket and 10 fuel elements that represents the results from the generalized geometry description and the Picture Code may be seen in Figures 6.3.1-3A and -3B. Model B prepared as input to the KENO-IV code using the generalized geometry modeling may be seen in Table 6.3.1-4 for two casks touching and in Table 6.3.1-5 for one cask.

6.3.2 Package Regional Densities

The number densities for the materials used in Models A and B may be seen in Tables 6.3.1-1, -2, -4, -5, and 6.4-1 through 6.4-8. The number density used for the fuel meat was 0.00261362 atoms/barn-cm for U-235. A molecular weight of 235.043933 gram/gram-mole and an Avogadro's number of 6.025 E23 gram-atom/gram-mole were used in calculating this number density. Other materials in the fuel meat such as U-238, oxygen, silicone, etc., were not modeled. The number densities for the materials specified in Tables 6.3.1-1, -2, -4, and -5 that are provided by the SCALE System for the 27GROUPNDF4 cross-section set are shown in Tables 6.4-1 through 6.4-8.

6.4 Criticality Calculations

The results of eight k-effective calculations are presented in this section. The SCALE* System that is running on the Control Data Corporation 7600 Computer at General Electric's Nuclear Energy Business Operations was used for the k-effective calculations. The 27GROUPNDF4 cross-section set and the KENO-IV criticality code in the SCALE System were used. The results of these calculations may be seen in Tables 6.4-1 through 6.4-8 and in Figure 6.4-1. These results are discussed below.

*Bucholz, J. A., "SCALE" A Modeular Code System for Performing Standardized Computer Analyses for Licensing Evaluation", NUREG/CR-0200, ORNL/NUREG/CSD/2, Volume 1, Oak Ridge National Laboratory; July, 1980.

In Table 6.4-1, a k-effective result is given for Model A in which two baskets, each loaded with 10 plate-type fuel elements, are touching outside of a cask and the mist density is 8.8 E-5 grams H_2O/cc. This condition represents loading of the two baskets in a hot cell. The mist is in the available spaces inside the holes in the baskets (including between the fuel plates). The fuel plates are described discretely. Twelve-inch thick water reflector is used on all six sides around the baskets in this model. The peak k-effective is seen to be less than 0.32 for the result in Table 6.4-1. This peak k-effective contains a bias of 2.3 percent on the mean value, 0.3 percent on the one sigma value, and represents the peak k-effective at 2 sigma, rounded up. The bias is discussed in Section 6.5. 24,900 neutron histories were run to obtain this k-effective result. This bias is also applied to all other peak k-effective results described below.

In Tables 6.4-2 and 6.4-3, the results for two Model A k-effective calculations are given for a mist density of 1.0 grams H_2O/cc, or full water flooding. These models represent conditions for loading of two baskets under water. The results in Table 6.4-2 are for two baskets, each loaded with 10 plate-type fuel elements that are next to each other and touching. The results in Table 6.4-3 are for two baskets, each loaded with 10 plate-type fuel elements that are stacked one on top of the other. The fuel plates in each calculation are modeled discretely. A 12-inch thick water reflector is used on all six sides around these models. The k-effective results show the peak k-effective to be less than 0.96 for the model in Table 6.4-2 and to be less than 0.88 for the model in Table 6.4-3.

In Figure 6.4-1, k-effective values are plotted as a function of mist density for two GE 700 casks that are side by side and touching. Each cask contains two stainless steel baskets, and each basket is loaded with 10 fuel elements. The baskets are stacked one on top of the other. The homogenized fuel model is used to represent each fuel element, and a separate homogenization calculation was made for each mist density. The generalized geometry model was used to represent the fuel baskets. Underneath the bottom basket of fuel is lead that is

10.9375 inches thick, the same thickness as the lead on the side walls of the cask. Lead replaces structural steel in Model B. The vertical space above the fuel and upper basket in a cask is filled with mist until the 54.75-inch height is reached; the space above this height is filled with 10.9375 inches of lead. Full density water is used between the casks, and a 12-inch thick water reflector is used on all six sides for the model in Figure 6.4-1. Only one cask is used for a mist density of 1.0 grams H_2O/cc, representing the accident condition and an underwater loading condition. The peak k-effective is seen to be less than 0.93 for the fully water-flooded condition. Peak k-effectives are seen to be as low as 0.11 for the 8.8 E-5 grams H_2O/cc density and 0.38 for the 0.1 grams H_2O/cc density. K-effective calculations for mist densities between 8.8 E-5 grams H_2O/cc and 0.1 grams H_2O/cc were not run for the in-cask models because no significant peaking was found for similar models out of the cask and because the k-effective values are very low.

30,000 neutron histories were run to obtain the 0.93 k-effective result. However, both the mist density calculations were stopped by the 15-minute time limit, and the smallest number of histories run was 16,200 for the 8.8 E-5 grams H_2O/cc mist density. More detailed numerical results of these calculations may be seen in Tables 6.4-5 through 6.4-7.

It is not clear whether Model B is more reactive when the two baskets are sitting right on top of one another in a cask, or whether they are more reactive when they are separated by some amount of water, like 1 inch of water or 2 inches of water. Two calculations were run for these two models, one with 1-inch water separation and one with 2-inch water separation, but for only 8,100 neutron histories. One basket stacked immediately on top of the other basket with no separation was found to be the most reactive. However, it is not clear what the k-effective result would be if one basket containing 10 fuel elements were pushed against the lead at the top of the cask while the other basket containing 10 fuel elements were next to the lead at the bottom of the cask. This point is considered next.

In Table 6.4-8, k-effective results are given for Model B in which one basket containing 10 plate-type fuel elements is next to the lead at the top of the cask, and the other basket containing 10 plate-type fuel elements is next to the lead at the bottom of the cask. Full water flooding is present throughout the cask, and a 12-inch thick water reflector is used all around the cask. The results in Table 6.4-8 are seen to give a peak k-effective less than 0.88, compared to the k-effective result of 0.93 when the baskets are stacked on top of one another in Table 6.4-7. The 0.88 k-effective result is also plotted in Figure 6.4-1 for the mist density of 1.0 grams H_2O/cc.

K-effective results in Tables 6.4-3 and 6.4-4 may be used to compare Models A and B, respectively. In Model A (Table 6.4-3), two baskets each containing 10 plate-type fuel elements are stacked vertically outside a cask and the fuel elements are described discretely; in Model B (Table 6.4-4), two baskets each containing 10 plate-type fuel elements are stacked vertically inside a cask, but all of the lead is replaced by water. The results for Models A and B show the peak k-effective to be about 0.88 and to be nearly identical for both models.

6.5.1 Benchmark Experiments and Applicability

Uranium with enrichments varying from 1.3 w/o to fully enriched and plutonium are the fissile materials that are considered in the validation of SCALE for this evaluation. The forms include fully enriched homogeneous uranium-water mixtures, low-enriched heterogeneous uranium dioxide-water mixtures, and homogeneous plutonium-water mixtures.

In Table 6.5.1-1 below, critical experiments suitable for validation are identified.

6.5.2 Details of the Benchmark Calculations

Models of TRX-1 and TRX-2 prepared as input to the SCALE system are shown in Tables 6.5.2-1 and 6.5.2-2, respectively. Models of ORNL-1 and ORNL-2 are shown in Table 6.5.2-3. Models of PNL-1 and PNL-2 are shown in Table 6.5.2-4. Models of the B&W UO_2 rod and MO_2 rod are shown in Table 6.5.2-5.

6.5.3 K-Effective Results of the Benchmark Calculations

K-effective results are presented for the ORNL, PNL, TRX, and B&W critical experiments in Table 6.5.3-1.

It is concluded that use of the SCALE System using the 27GROUPNDF4 cross-section set requires a negative 0.3 percent bias on the one sigma deviation for fully enriched uranium solutions and no bias for plutonium solutions; a negative bias of 2.3 percent on the mean value and 0.3 percent on the one sigma deviation for the multiplication factor must be applied for low-enriched, clumped uranium rods in water.

A bias of 2.3 percent on the mean value and 0.3 percent on the one sigma deviation is applied to the k-effective results in Figure 6.4-1 in this evaluation.

FIGURE 6.3.1-1

FUEL ELEMENT SCHEMATIC

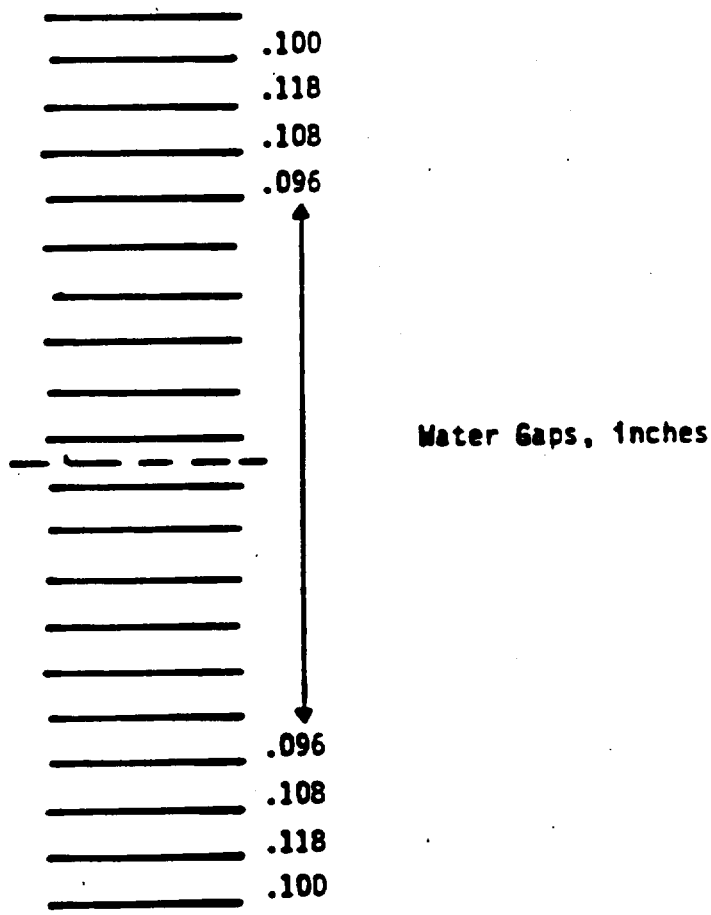
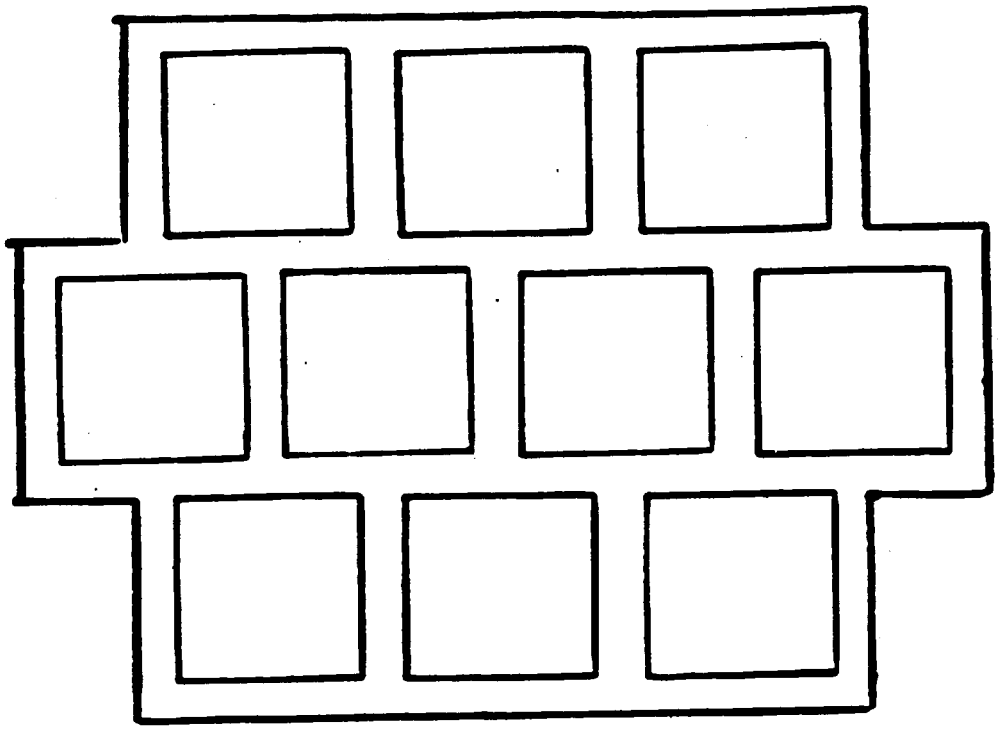


FIGURE 6.3.1-2

FUEL BASKET SCHEMATIC
FOR BASKET OUTSIDE OF CASK MODELS



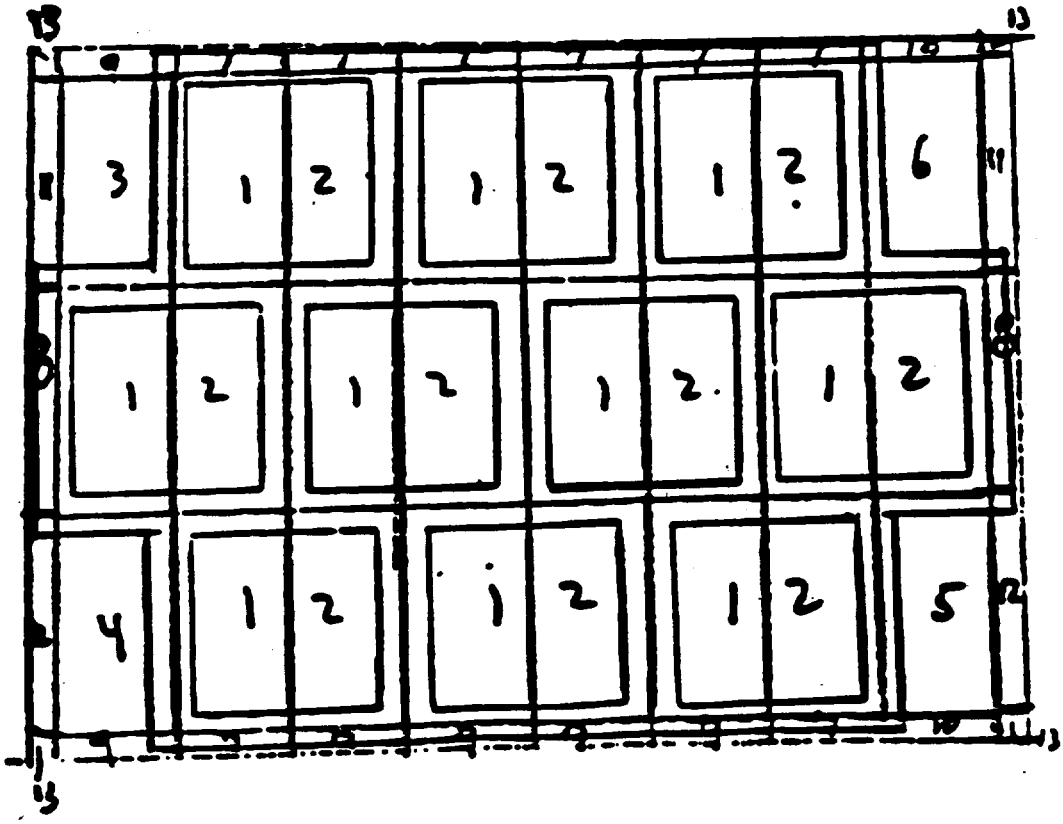


FIGURE 6.3.1-3A
PLAN VIEW OF CASK
PICTURE OF GENERALIZED GEOMETRY FOR KENO-IV
F=Fuel M=Mist S=Stainless Steel L=Lead W=Water

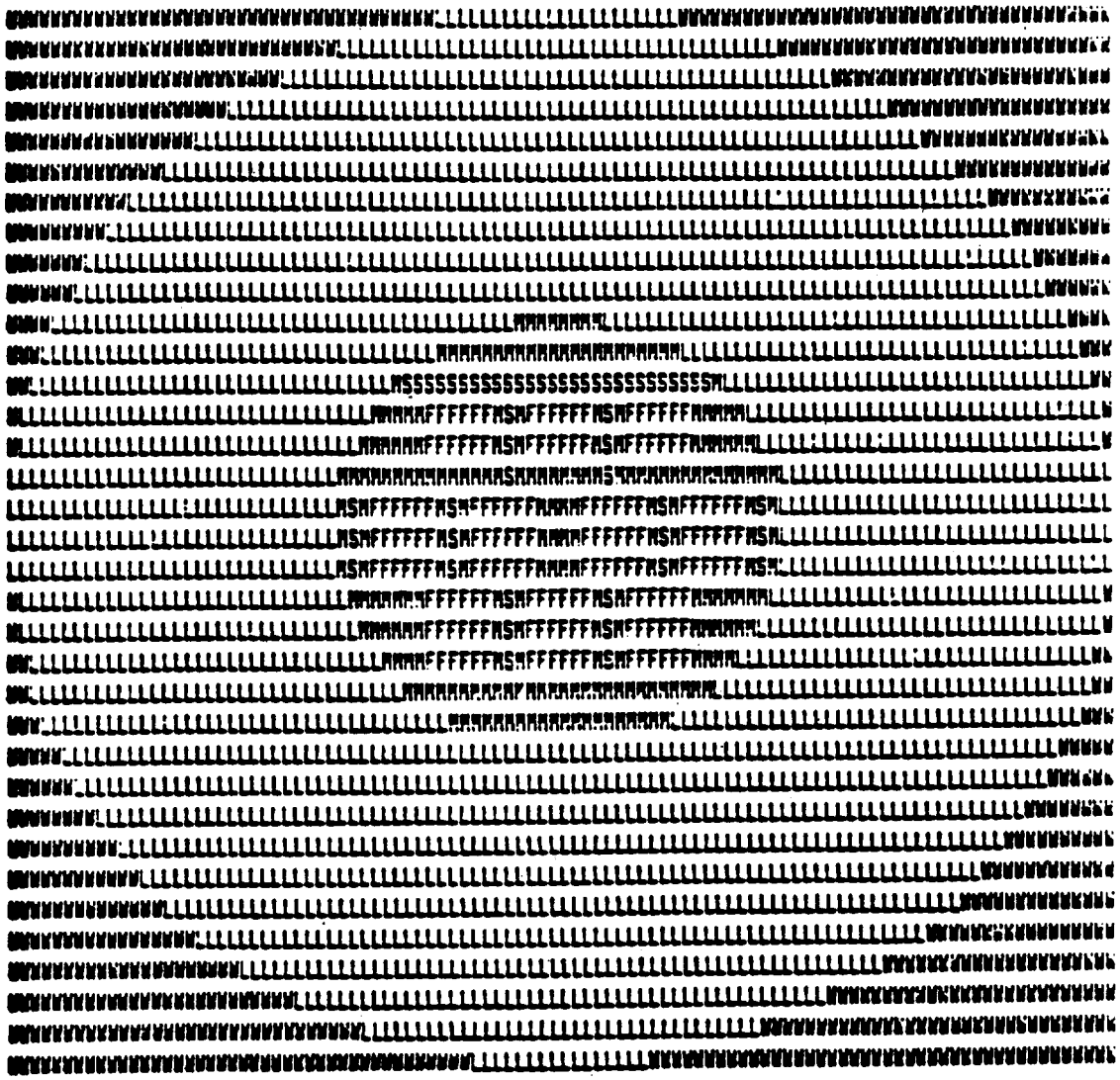
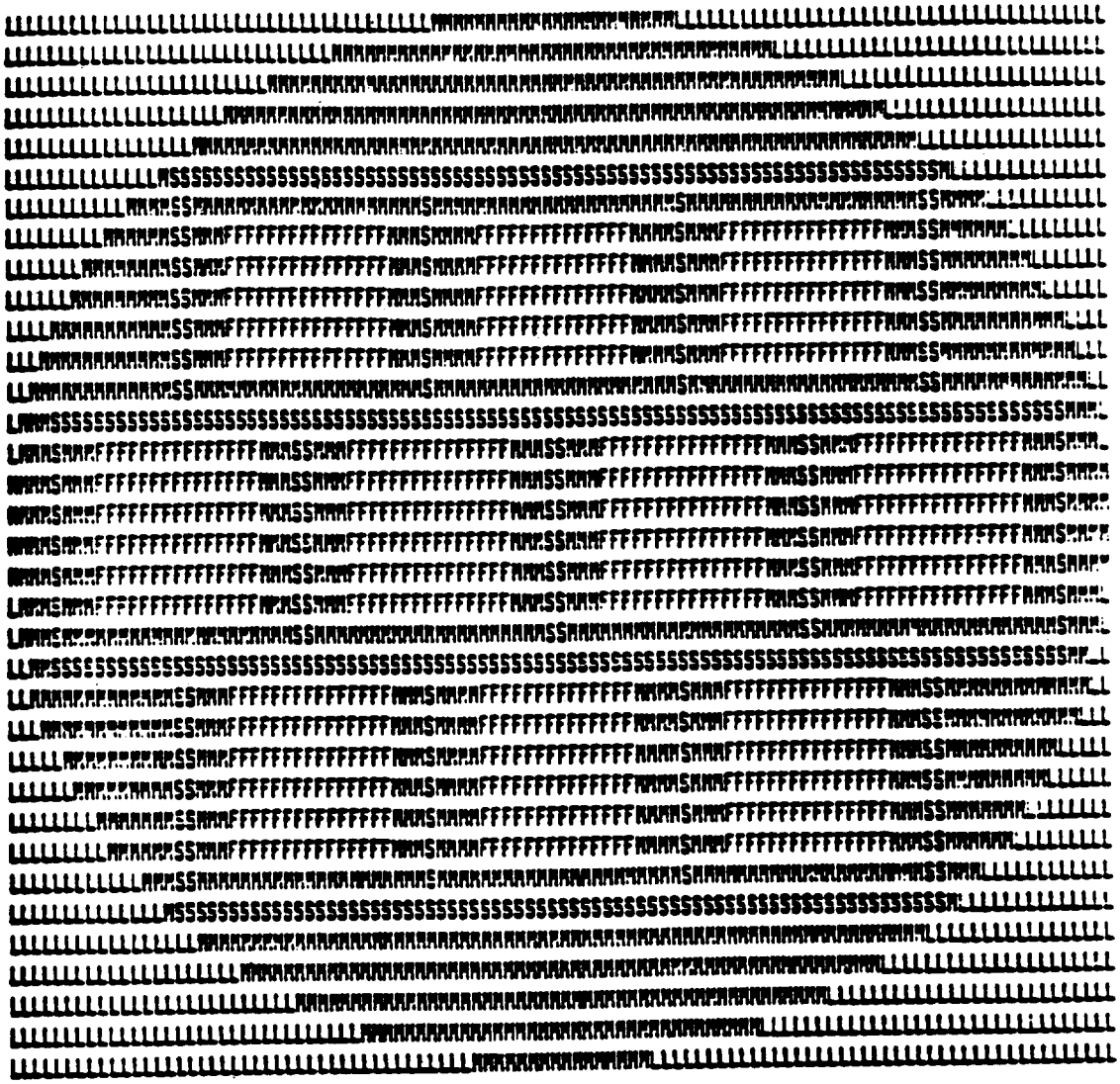


FIGURE 6.3.1-3B
ENLARGED PLAN VIEW OF CASK CONTENTS
PICTURE OF GENERALIZED GEOMETRY FOR KENO-IV
F=Fuel M=Mist S=Stainless Steel L=Lead W=Water



```
KEFF BNL FUEL SHIPPING ARRAY  FWR 2 BASKETS 21.875" SEP'N  MIST=8.8-5 GMS H2O
27GROUPNDF4  7  7  3  LATTICECELL  0  0
235  1 0. 2.61362-3 END
   2 1. END
    3 8.8-5 END
AL  4 1. END
H2O  5 1. END
SS304  6 1. END
H2O  7 8.8-5 END
SYMMSLABCELL        0.37084 0.057912 1 3 0.127 2 END
KEFF BNL FUEL SHIPPING ARRAY  FWR 2 BASKETS 21.875" SEP'N  MIST=8.8-5 GMS H2O.
15.0 103 300 3 16 21 5 1 0
BOX TYPE     1
CUBOID  3   0. -2.857500   .121920  -.121920 28.892500 -28.892500 -0.5
CUBOID  2   0. -2.857500   .156464  -.156464 28.892500 -28.892500 -0.5
CUBOID  1   0. -2.857500   .214376  -.214376 28.892500 -28.892500 -0.5
CUBOID  2   0. -2.857500   .248920  -.248920 28.892500 -28.892500 -0.5
CUBOID  3   0. -2.857500   .492760  -.492760 28.892500 -28.892500 -0.5
CUBOID  2   0. -2.857500   .527304  -.527304 28.892500 -28.892500 -0.5
CUBOID  1   0. -2.857500   .585216  -.585216 28.892500 -28.892500 -0.5
CUBOID  2   0. -2.857500   .619760  -.619760 28.892500 -28.892500 -0.5
CUBOID  3   0. -2.857500   .863600  -.863600 28.892500 -28.892500 -0.5
CUBOID  2   0. -2.857500   .898144  -.898144 28.892500 -28.892500 -0.5
CUBOID  1   0. -2.857500   .956056  -.956056 28.892500 -28.892500 -0.5
CUBOID  2   0. -2.857500   .990600  -.990600 28.892500 -28.892500 -0.5
CUBOID  3   0. -2.857500  1.234440 -1.234440 28.892500 -28.892500 -0.5
CUBOID  2   0. -2.857500  1.268984 -1.268984 28.892500 -28.892500 -0.5
CUBOID  1   0. -2.857500  1.326896 -1.326896 28.892500 -28.892500 -0.5
CUBOID  2   0. -2.857500  1.361440 -1.361440 28.892500 -28.892500 -0.5
CUBOID  3   0. -2.857500  1.605280 -1.605280 28.892500 -28.892500 -0.5
CUBOID  2   0. -2.857500  1.639824 -1.639824 28.892500 -28.892500 -0.5
CUBOID  1   0. -2.857500  1.697736 -1.697736 28.892500 -28.892500 -0.5
CUBOID  2   0. -2.857500  1.732280 -1.732280 28.892500 -28.892500 -0.5
CUBOID  3   0. -2.857500  1.976120 -1.976120 28.892500 -28.892500 -0.5
CUBOID  2   0. -2.857500  2.010664 -2.010664 28.892500 -28.892500 -0.5
CUBOID  1   0. -2.857500  2.068576 -2.068576 28.892500 -28.892500 -0.5
CUBOID  2   0. -2.857500  2.103120 -2.103120 28.892500 -28.892500 -0.5
CUBOID  3   0. -2.857500  2.346960 -2.346960 28.892500 -28.892500 -0.5
CUBOID  2   0. -2.857500  2.381504 -2.381504 28.892500 -28.892500 -0.5
CUBOID  1   0. -2.857500  2.439416 -2.439416 28.892500 -28.892500 -0.5
CUBOID  2   0. -2.857500  2.473960 -2.473960 28.892500 -28.892500 -0.5
CUBOID  3   0. -2.857500  2.748280 -2.748280 28.892500 -28.892500 -0.5
CUBOID  2   0. -2.857500  2.782824 -2.782824 28.892500 -28.892500 -0.5
CUBOID  1   0. -2.857500  2.840736 -2.840736 28.892500 -28.892500 -0.5
CUBOID  2   0. -2.857500  2.875280 -2.875280 28.892500 -28.892500 -0.5
CUBOID  3   0. -2.857500  3.175000 -3.175000 28.892500 -28.892500 -0.5
CUBOID  2   0. -2.857500  3.209544 -3.209544 28.892500 -28.892500 -0.5
CUBOID  1   0. -2.857500  3.267456 -3.267456 28.892500 -28.892500 -0.5
CUBOID  2   0. -2.857500  3.302000 -3.302000 28.892500 -28.892500 -0.5
CUBOID  3   0. -2.857500  3.556000 -3.556000 28.892500 -28.892500 -0.5
CUBOID  2   0. -2.857500  3.683000 -3.683000 28.892500 -28.892500 -0.5
CUBOID    7    0.000   -4.039    4.039   -4.039   28.8925   -28.8925 -0.5
CUBOID    6    0.000   -4.356    4.356   -4.356   28.8925   -28.8925 -0.5
```

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```
BOX TYPE     2
CUBOID  3   2.857500 -0.    .121920  -.121920 28.892500 -28.892500 -0.5
CUBOID  2   2.857500 -0.    .156464  -.156464 28.892500 -28.892500 -0.5
CUBOID  1   2.857500 -0.    .214376  -.214376 28.892500 -28.892500 -0.5
CUBOID  2   2.857500 -0.    .248920  -.248920 28.892500 -28.892500 -0.5
CUBOID  3   2.857500 -0.    .492760  -.492760 28.892500 -28.892500 -0.5
CUBOID  2   2.857500 -0.    .527304  -.527304 28.892500 -28.892500 -0.5
CUBOID  1   2.857500 -0.    .585216  -.585216 28.892500 -28.892500 -0.5
CUBOID  2   2.857500 -0.    .619760  -.619760 28.892500 -28.892500 -0.5
CUBOID  3   2.857500 -0.    .863600  -.863600 28.892500 -28.892500 -0.5
CUBOID  2   2.857500 -0.    .898144  -.898144 28.892500 -28.892500 -0.5
CUBOID  1   2.857500 -0.    .956056  -.956056 28.892500 -28.892500 -0.5
CUBOID  2   2.857500 -0.    .990600  -.990600 28.892500 -28.892500 -0.5
CUBOID  3   2.857500 -0.   1.234440 -1.234440 28.892500 -28.892500 -0.5
CUBOID  2   2.857500 -0.   1.268984 -1.268984 28.892500 -28.892500 -0.5
CUBOID  1   2.857500 -0.   1.326896 -1.326896 28.892500 -28.892500 -0.5
CUBOID  2   2.857500 -0.   1.361440 -1.361440 28.892500 -28.892500 -0.5
CUBOID  3   2.857500 -0.   1.605280 -1.605280 28.892500 -28.892500 -0.5
CUBOID  2   2.857500 -0.   1.639824 -1.639824 28.892500 -28.892500 -0.5
CUBOID  1   2.857500 -0.   1.697736 -1.697736 28.892500 -28.892500 -0.5
CUBOID  2   2.857500 -0.   1.732280 -1.732280 28.892500 -28.892500 -0.5
CUBOID  3   2.857500 -0.   1.976120 -1.976120 28.892500 -28.892500 -0.5
CUBOID  2   2.857500 -0.   2.010664 -2.010664 28.892500 -28.892500 -0.5
CUBOID  1   2.857500 -0.   2.068576 -2.068576 28.892500 -28.892500 -0.5
CUBOID  2   2.857500 -0.   2.103120 -2.103120 28.892500 -28.892500 -0.5
CUBOID  3   2.857500 -0.   2.346960 -2.346960 28.892500 -28.892500 -0.5
CUBOID  2   2.857500 -0.   2.381504 -2.381504 28.892500 -28.892500 -0.5
CUBOID  1   2.857500 -0.   2.439416 -2.439416 28.892500 -28.892500 -0.5
CUBOID  2   2.857500 -0.   2.473960 -2.473960 28.892500 -28.892500 -0.5
CUBOID  3   2.857500 -0.   2.748280 -2.748280 28.892500 -28.892500 -0.5
CUBOID  2   2.857500 -0.   2.782824 -2.782824 28.892500 -28.892500 -0.5
CUBOID  1   2.857500 -0.   2.840736 -2.840736 28.892500 -28.892500 -0.5
CUBOID  2   2.857500 -0.   2.875280 -2.875280 28.892500 -28.892500 -0.5
CUBOID  3   2.857500 -0.   3.175000 -3.175000 28.892500 -28.892500 -0.5
CUBOID  2   2.857500 -0.   3.209544 -3.209544 28.892500 -28.892500 -0.5
CUBOID  1   2.857500 -0.   3.267456 -3.267456 28.892500 -28.892500 -0.5
CUBOID  2   2.857500 -0.   3.302000 -3.302000 28.892500 -28.892500 -0.5
CUBOID  3   2.857500 -0.   3.556000 -3.556000 28.892500 -28.892500 -0.5
CUBOID  2   2.857500 -0.   3.683000 -3.683000 28.892500 -28.892500 -0.5
CUBOID    7     4.039    -0.000     4.039    -4.039    28.8925   -28.8925 -0.5
CUBOID    6     4.356    -0.000     4.356    -4.356    28.8925   -28.8925 -0.5
BOX TYPE     3
CUBOID    7     4.039    -0.000     4.356    -4.039    28.8925   -28.8925 -0.5
CUBOID    6     4.356    -0.000     4.356    -4.356    28.8925   -28.8925 -0.5
BOX TYPE     4
CUBOID    7     4.039    -0.000     4.039    -4.356    28.8925   -28.8925 -0.5
CUBOID    6     4.356    -0.000     4.356    -4.356    28.8925   -28.8925 -0.5
BOX TYPE     5
CUBOID    7     0.000    -4.039     4.039    -4.356    28.8925   -28.8925 -0.5
CUBOID    6     0.000    -4.356     4.356    -4.356    28.8925   -28.8925 -0.5
BOX TYPE     6
CUBOID    7     0.000    -4.039     4.356    -4.039    28.8925   -28.8925 -0.5
CUBOID    6     0.000    -4.356     4.356    -4.356    28.8925   -28.8925 -0.5
```

TABLE 6.3.1-1 (CONTINUED)

```
BOX TYPE     7
CUBOID    6    0.000    -4.356    0.317    -0.000    28.8925   -28.8925 -0.5
BOX TYPE     8
CUBOID    6    0.000    -0.317    4.356    -4.356    28.8925   -28.8925 -0.5
BOX TYPE     9
CUBOID    7    4.039    -0.000    0.317    -0.000    28.8925   -28.8925 -0.5
CUBOID    6    4.356    -0.000    0.317    -0.000    28.8925   -28.8925 -0.5
BOX TYPE    10
CUBOID    7    0.000    -4.039    0.317    -0.000    28.8925   -28.8925 -0.5
CUBOID    6    0.000    -4.356    0.317    -0.000    28.8925   -28.8925 -0.5
BOX TYPE    11
CUBOID    7    0.000    -0.317    4.356    -4.039    28.8925   -28.8925 -0.5
CUBOID    6    0.000    -0.317    4.356    -4.356    28.8925   -28.8925 -0.5
BOX TYPE    12
CUBOID    7    0.000    -0.317    4.039    -4.356    28.8925   -28.8925 -0.5
CUBOID    6    0.000    -0.317    4.356    -4.356    28.8925   -28.8925 -0.5
BOX TYPE    13
CUBOID    7    0.317    -0.000    0.317    -0.000    28.8925   -28.8925 -0.5
BOX TYPE    14
CUBOID    7 27.78125   -27.78125    0.317    -0.000    28.8925   -28.8925 -0.5
BOX TYPE    15
CUBOID    7 27.78125   -27.78125    4.356    -4.356    28.8925   -28.8925 -0.5
BOX TYPE    16
CUBOID    7 27.78125   -27.78125    4.356    -4.356    28.8925   -28.8925 -0.5
ARRAY BDY    7 63.26325 -63.26325    13.385    -13.385 28.8925 -28.8925 -0.5
CUBOID    5  93.74325 -93.74325    43.865    -43.865 59.37250  -59.37250 -0.5
END GEOMETRY
      0 13  9  7  7  7  7  7  7 10 13 14 13  9  7  7  7  7  7  7 10 13
        11  3  1  2  1  2  1  2  6 11 15 11  3  1  2  1  2  1  2  6 11
         8  1  2  1  2  1  2  1  2  8 16  8  1  2  1  2  1  2  1  2  8
        12  4  1  2  1  2  1  2  5 12 15 12  4  1  2  1  2  1  2  5 12
        13  9  7  7  7  7  7  7 10 13 14 13  9  7  7  7  7  7  7 10 13  0
END KENO
```

```
KEFF BNL FUEL SHIPPING ARRAY  FWR HOMOGENIZED FUEL MIST = 1.0 GMS H2O/CC
27GROUPNDF4  8  8  3  LATTICECELL  0  0
U-235  1 0. 2.61362-3 END
AL  2 1. END
H2O  3 1. END
AL  4 1. END
H2O  5 1. END
SS304  6 1. END
H2O  7 1. END
PB  8 1. END
SYMMSLABCELL        0.37084 0.057912 1 3 0.127 2 END
KEFF BNL FUEL SHIPPING ARRAY  FWR HOMOGENIZED FUEL MIST = 1.0 GMS H2O/CC
15.0 103 300 3 13 10 5 1 0
BOX TYPE     1
CUBOID  500    0. -2.857500  3.21564 -3.21564 28.892500 -28.892500 -0.5
CUBOID    7    0.000    -4.039    4.039    -4.039    28.8925   -28.8925 -0.5
CUBOID    6    0.000    -4.356    4.356    -4.356    28.8925   -28.8925 -0.5
BOX TYPE     2
CUBOID  500    2.857500 -0.  3.21564 -3.21564 28.892500 -28.892500 -0.5
CUBOID    7    4.039    -0.000    4.039    -4.039    28.8925   -28.8925 -0.5
CUBOID    6    4.356    -0.000    4.356    -4.356    28.8925   -28.8925 -0.5
BOX TYPE     3
CUBOID    7    4.039    -0.000    4.356    -4.039    28.8925   -28.8925 -0.5
CUBOID    6    4.356    -0.000    4.356    -4.356    28.8925   -28.8925 -0.5
BOX TYPE     4
CUBOID    7    4.039    -0.000    4.039    -4.356    28.8925   -28.8925 -0.5
CUBOID    6    4.356    -0.000    4.356    -4.356    28.8925   -28.8925 -0.5
BOX TYPE     5
CUBOID    7    0.000    -4.039    4.039    -4.356    28.8925   -28.8925 -0.5
CUBOID    6    0.000    -4.356    4.356    -4.356    28.8925   -28.8925 -0.5
BOX TYPE     6
CUBOID    7    0.000    -4.039    4.356    -4.039    28.8925   -28.8925 -0.5
CUBOID    6    0.000    -4.356    4.356    -4.356    28.8925   -28.8925 -0.5
BOX TYPE     7
CUBOID    6    0.000    -4.356    0.317    -0.000    28.8925   -28.8925 -0.5
BOX TYPE     8
CUBOID    6    0.000    -0.317    4.356    -4.356    28.8925   -28.8925 -0.5
BOX TYPE     9
CUBOID    7    4.039    -0.000    0.317    -0.000    28.8925   -28.8925 -0.5
CUBOID    6    4.356    -0.000    0.317    -0.000    28.8925   -28.8925 -0.5
BOX TYPE    10
CUBOID    7    0.000    -4.039    0.317    -0.000    28.8925   -28.8925 -0.5
CUBOID    6    0.000    -4.356    0.317    -0.000    28.8925   -28.8925 -0.5
BOX TYPE    11
CUBOID    7    0.000    -0.317    4.356    -4.039    28.8925   -28.8925 -0.5
CUBOID    6    0.000    -0.317    4.356    -4.356    28.8925   -28.8925 -0.5
BOX TYPE    12
CUBOID    7    0.000    -0.317    4.039    -4.356    28.8925   -28.8925 -0.5
CUBOID    6    0.000    -0.317    4.356    -4.356    28.8925   -28.8925 -0.5
BOX TYPE    13
CUBOID    7    0.317    -0.000    0.317    -0.000    28.8925   -28.8925 -0.5
ARRAY BDY    7 17.741 -17.741    13.385   -13.385 28.8925 -28.8925 -0.5
CUBOID  5  48.221 -48.221 43.865 -43.865 59.3725 -59.3725 -0.5
END GEOMETRY
      0 13  9  7  7  7  7  7  7 10 13
        11  3  1  2  1  2  1  2  6 11
         8  1  2  1  2  1  2  1  2  8
        12  4  1  2  1  2  1  2  5 12
        13  9  7  7  7  7  7  7 10 13 0
END KENO
```

TABLE 6.3.1-3
STEEL BASKET MODEL FOR
KENO GENERALIZED GEOMETRY

```
ZONE1 XENDS -46.83125,  46.83125
ZONE1 YENDS -46.83125, -13.38580,  -4.67360,   4.67360,  13.38580,
  46.83125
ZONE1 ZENDS -28.89250,  28.89250
ZONE      1     1     1
BLOK1 XENDS -46.83125,  46.83125
BLOK1 YENDS -46.83125, -13.38580
BLOK1 ZENDS -28.89250,  28.89250
BLOCK     1     1     1
MEDIA            2,     4,     5
SURFACES         1,     2
SECTOR -1  0
SECTOR  1 -1
SECTOR  0  1
ZONE      1     2     1
BLOK1 XENDS -46.83125, -13.38580, -12.75080, -11.56970,  -5.85470,
  -4.67360,  -4.03860,  -2.85750,   2.85750,   4.03860,   4.67360,
   5.85470,  11.56970,  12.75080,  13.38580,  46.83125
BLOK1 YENDS -13.38580, -12.75000, -11.92784,  -5.49656,  -4.67360
BLOK1 ZENDS -28.89250,  28.89250
BLOCK     1     1     1
MEDIA            2,     4,     5
SURFACES         1,     2
SECTOR -1  0
SECTOR  1 -1
SECTOR  0  1
BLOCK     1     2     1
MEDIA            2,     4,     5
SURFACES         1,     2
SECTOR -1  0
SECTOR  1 -1
SECTOR  0  1
BLOCK     1     3     1
MEDIA            2,     4,     5
SURFACES         1,     2
SECTOR -1  0
SECTOR  1 -1
SECTOR  0  1
BLOCK     1     4     1
MEDIA            2,     4,     5
SURFACES         1,     2
SECTOR -1  0
SECTOR  1 -1
SECTOR  0  1
BLOCK    15     1     1
MEDIA            2,     4,     5
SURFACES         1,     2
SECTOR -1  0
SECTOR  1 -1
SECTOR  0  1
BLOCK    15     2     1
MEDIA            2,     4,     5
SURFACES         1,     2
```

TABLE 6.3.1-3
STEEL BASKET MODEL FOR
KENO GENERALIZED GEOMETRY

```
SECTOR -1  0
SECTOR  1 -1
SECTOR  0  1
BLOCK    15    3    1
MEDIA           2,    4,    5
SURFACES        1,    2
SECTOR -1  0
SECTOR  1 -1
SECTOR  0  1
BLOCK    15    4    1
MEDIA           2,    4,    5
SURFACES        1,    2
SECTOR -1  0
SECTOR  1 -1
SECTOR  0  1
BLOCK     2    1    1
MEDIA           3
BLOCK     2    2    1
MEDIA           3
BLOCK     2    3    1
MEDIA           3
BLOCK     2    4    1
MEDIA           3
BLOCK     6    1    1
MEDIA           3
BLOCK     6    2    1
MEDIA           3
BLOCK     6    3    1
MEDIA           3
BLOCK     6    4    1
MEDIA           3
BLOCK    10    1    1
MEDIA           3
BLOCK    10    2    1
MEDIA           3
BLOCK    10    3    1
MEDIA           3
BLOCK    10    4    1
MEDIA           3
BLOCK    14    1    1
MEDIA           3
BLOCK    14    2    1
MEDIA           3
BLOCK    14    3    1
MEDIA           3
BLOCK    14    4    1
MEDIA           3
BLOCK     3    1    1
MEDIA           3
BLOCK     3    2    1
MEDIA           2
BLOCK     3    3    1
MEDIA           2
```

TABLE 6.3.1-3
STEEL BASKET MODEL FOR
KENO GENERALIZED GEOMETRY

```
BLOCK    3    4    1
MEDIA         2
BLOCK    5    1    1
MEDIA         3
BLOCK    5    2    1
MEDIA         2
BLOCK    5    3    1
MEDIA         2
BLOCK    5    4    1
MEDIA         2
BLOCK    7    1    1
MEDIA         3
BLOCK    7    2    1
MEDIA         2
BLOCK    7    3    1
MEDIA         2
BLOCK    7    4    1
MEDIA         2
BLOCK    9    1    1
MEDIA         3
BLOCK    9    2    1
MEDIA         2
BLOCK    9    3    1
MEDIA         2
BLOCK    9    4    1
MEDIA         2
BLOCK   11    1    1
MEDIA         3
BLOCK   11    2    1
MEDIA         2
BLOCK   11    3    1
MEDIA         2
BLOCK   11    4    1
MEDIA         2
BLOCK   13    1    1
MEDIA         3
BLOCK   13    2    1
MEDIA         2
BLOCK   13    3    1
MEDIA         2
BLOCK   13    4    1
MEDIA         2
BLOCK    4    1    1
MEDIA         3
BLOCK    4    2    1
MEDIA         2
BLOCK    4    3    1
MEDIA         1
BLOCK    4    4    1
MEDIA         2
BLOCK    8    1    1
MEDIA         3
BLOCK    8    2    1
```

TABLE 6.3.1-3
STEEL BASKET MODEL FOR
KENO GENERALIZED GEOMETRY

```
MEDIA          2
BLOCK     8    3    1
MEDIA          1
BLOCK     8    4    1
MEDIA          2
BLOCK    12    1    1
MEDIA          3
BLOCK    12    2    1
MEDIA          2
BLOCK    12    3    1
MEDIA          1
BLOCK    12    4    1
MEDIA          2
ZONE      1    5    1
BLOK1 XENDS -46.83125,  46.83125
BLOK1 YENDS  13.38580,  46.83125
BLOK1 ZENDS -28.89250,  28.89250
BLOCK     1    1    1
MEDIA          2,    4,    5
SURFACES       1,    2
SECTOR -1  0
SECTOR  1 -1
SECTOR  0  1
ZONE      1    4    1
BLOK1 XENDS -46.83125, -13.38580, -12.75080, -11.56970,  -5.85470,
  -4.67360,  -4.03860,  -2.85750,   2.85750,   4.03860,   4.67360,
   5.85470,  11.56970,  12.75080,  13.38580,  46.83125
BLOK1 YENDS   4.67360,   5.49656,  11.92784,  12.75080,  13.38580
BLOK1 ZENDS -28.89250,  28.89250
BLOCK     1    1    1
MEDIA          2,    4,    5
SURFACES       1,    2
SECTOR -1  0
SECTOR  1 -1
SECTOR  0  1
BLOCK     1    2    1
MEDIA          2,    4,    5
SURFACES       1,    2
SECTOR -1  0
SECTOR  1 -1
SECTOR  0  1
BLOCK     1    3    1
MEDIA          2,    4,    5
SURFACES       1,    2
SECTOR -1  0
SECTOR  1 -1
SECTOR  0  1
BLOCK     1    4    1
MEDIA          2,    4,    5
SURFACES       1,    2
SECTOR -1  0
SECTOR  1 -1
SECTOR  0  1
```

TABLE 6.3.1-3
STEEL BASKET MODEL FOR
KENO GENERALIZED GEOMETRY

```
BLOCK    15    1    1
MEDIA           2,    4,    5
SURFACES        1,    2
SECTOR -1  0
SECTOR  1 -1
SECTOR  0  1
BLOCK    15    2    1
MEDIA           2,    4,    5
SURFACES        1,    2
SECTOR -1  0
SECTOR  1 -1
SECTOR  0  1
BLOCK    15    3    1
MEDIA           2,    4,    5
SURFACES        1,    2
SECTOR -1  0
SECTOR  1 -1
SECTOR  0  1
BLOCK    15    4    1
MEDIA           2,    4,    5
SURFACES        1,    2
SECTOR -1  0
SECTOR  1 -1
SECTOR  0  1
BLOCK     2    1    1
MEDIA           3
BLOCK     2    2    1
MEDIA           3
BLOCK     2    3    1
MEDIA           3
BLOCK     2    4    1
MEDIA           3
BLOCK     6    1    1
MEDIA           3
BLOCK     6    2    1
MEDIA           3
BLOCK     6    3    1
MEDIA           3
BLOCK     6    4    1
MEDIA           3
BLOCK    10    1    1
MEDIA           3
BLOCK    10    2    1
MEDIA           3
BLOCK    10    3    1
MEDIA           3
BLOCK    10    4    1
MEDIA           3
BLOCK    14    1    1
MEDIA           3
BLOCK    14    2    1
MEDIA           3
BLOCK    14    3    1
```

TABLE 6.3.1-3
STEEL BASKET MODEL FOR
KENO GENERALIZED GEOMETRY

```
MEDIA          3
BLOCK   14     4     1
MEDIA          3
BLOCK    3     1     1
MEDIA          2
BLOCK    3     2     1
MEDIA          2
BLOCK    3     3     1
MEDIA          2
BLOCK    3     4     1
MEDIA          3
BLOCK    5     1     1
MEDIA          2
BLOCK    5     2     1
MEDIA          2
BLOCK    5     3     1
MEDIA          2
BLOCK    5     4     1
MEDIA          3
BLOCK    7     1     1
MEDIA          2
BLOCK    7     2     1
MEDIA          2
BLOCK    7     3     1
MEDIA          2
BLOCK    7     4     1
MEDIA          3
BLOCK    9     1     1
MEDIA          2
BLOCK    9     2     1
MEDIA          2
BLOCK    9     3     1
MEDIA          2
BLOCK    9     4     1
MEDIA          3
BLOCK   11     1     1
MEDIA          2
BLOCK   11     2     1
MEDIA          2
BLOCK   11     3     1
MEDIA          2
BLOCK   11     4     1
MEDIA          3
BLOCK   13     1     1
MEDIA          2
BLOCK   13     2     1
MEDIA          2
BLOCK   13     3     1
MEDIA          2
BLOCK   13     4     1
MEDIA          3
BLOCK    4     1     1
MEDIA          2
```

TABLE 6.3.1-3
STEEL BASKET MODEL FOR
KENO GENERALIZED GEOMETRY

```
BLOCK      4     2     1
MEDIA            1
BLOCK      4     3     1
MEDIA            2
BLOCK      4     4     1
MEDIA            3
BLOCK      8     1     1
MEDIA            2
BLOCK      8     2     1
MEDIA            1
BLOCK      8     3     1
MEDIA            2
BLOCK      8     4     1
MEDIA            3
BLOCK     12     1     1
MEDIA            2
BLOCK     12     2     1
MEDIA            1
BLOCK     12     3     1
MEDIA            2
BLOCK     12     4     1
MEDIA            3
ZONE       1     3     1
BLOK1 XENDS -46.83125, -17.74190, -17.10690, -15.92580, -10.21080,
  -9.02970,  -8.39470,  -7.21360,  -1.49860,  -0.31750,   0.31750,
   1.49860,   7.21360,   8.39470,   9.02970,  10.21080,  15.92580,
  17.10690,  17.74190,  46.83125
BLOK1 YENDS  -4.67360,  -4.03860,  -3.21564,   3.21564,   4.03860,
   4.67360
BLOK1 ZENDS -28.89250,  28.89250
BLOCK      1     1     1
MEDIA            2,    4,    5
SURFACES         1,    2
SECTOR -1  0
SECTOR  1 -1
SECTOR  0  1
BLOCK      1     2     1
MEDIA            2,    4,    5
SURFACES         1,    2
SECTOR -1  0
SECTOR  1 -1
SECTOR  0  1
BLOCK      1     3     1
MEDIA            2,    4,    5
SURFACES         1,    2
SECTOR -1  0
SECTOR  1 -1
SECTOR  0  1
BLOCK      1     4     1
MEDIA            2,    4,    5
SURFACES         1,    2
SECTOR -1  0
SECTOR  1 -1
```

TABLE 6.3.1-3
STEEL BASKET MODEL FOR
KENO GENERALIZED GEOMETRY

```
SECTOR  0  1
BLOCK     1     5     1
MEDIA            2,    4,    5
SURFACES         1,    2
SECTOR -1  0
SECTOR  1 -1
SECTOR  0  1
BLOCK    19     1     1
MEDIA            2,    4,    5
SURFACES         1,    2
SECTOR -1  0
SECTOR  1 -1
SECTOR  0  1
BLOCK    19     2     1
MEDIA            2,    4,    5
SURFACES         1,    2
SECTOR -1  0
SECTOR  1 -1
SECTOR  0  1
BLOCK    19     3     1
MEDIA            2,    4,    5
SURFACES         1,    2
SECTOR -1  0
SECTOR  1 -1
SECTOR  0  1
BLOCK    19     4     1
MEDIA            2,    4,    5
SURFACES         1,    2
SECTOR -1  0
SECTOR  1 -1
SECTOR  0  1
BLOCK    19     5     1
MEDIA            2,    4,    5
SURFACES         1,    2
SECTOR -1  0
SECTOR  1 -1
SECTOR  0  1
BLOCK     2     1     1
MEDIA            3
BLOCK     2     2     1
MEDIA            3
BLOCK     2     3     1
MEDIA            3
BLOCK     2     4     1
MEDIA            3
BLOCK     2     5     1
MEDIA            3
BLOCK     6     1     1
MEDIA            3
BLOCK     6     2     1
MEDIA            3
BLOCK     6     3     1
MEDIA            3
```

TABLE 6.3.1-3
STEEL BASKET MODEL FOR
KENO GENERALIZED GEOMETRY

```
BLOCK    6    4    1
MEDIA         3
BLOCK    6    5    1
MEDIA         3
BLOCK   10    1    1
MEDIA         3
BLOCK   10    2    1
MEDIA         3
BLOCK   10    3    1
MEDIA         3
BLOCK   10    4    1
MEDIA         3
BLOCK   10    5    1
MEDIA         3
BLOCK   14    1    1
MEDIA         3
BLOCK   14    2    1
MEDIA         3
BLOCK   14    3    1
MEDIA         3
BLOCK   14    4    1
MEDIA         3
BLOCK   14    5    1
MEDIA         3
BLOCK   18    1    1
MEDIA         3
BLOCK   18    2    1
MEDIA         3
BLOCK   18    3    1
MEDIA         3
BLOCK   18    4    1
MEDIA         3
BLOCK   18    5    1
MEDIA         3
BLOCK    3    1    1
MEDIA         3
BLOCK    3    2    1
MEDIA         2
BLOCK    3    3    1
MEDIA         2
BLOCK    3    4    1
MEDIA         2
BLOCK    3    5    1
MEDIA         3
BLOCK    5    1    1
MEDIA         3
BLOCK    5    2    1
MEDIA         2
BLOCK    5    3    1
MEDIA         2
BLOCK    5    4    1
MEDIA         2
BLOCK    5    5    1
```

TABLE 6.3.1-3
STEEL BASKET MODEL FOR
KENO GENERALIZED GEOMETRY

```
MEDIA          3
BLOCK    7     1     1
MEDIA          3
BLOCK    7     2     1
MEDIA          2
BLOCK    7     3     1
MEDIA          2
BLOCK    7     4     1
MEDIA          2
BLOCK    7     5     1
MEDIA          3
BLOCK    9     1     1
MEDIA          3
BLOCK    9     2     1
MEDIA          2
BLOCK    9     3     1
MEDIA          2
BLOCK    9     4     1
MEDIA          2
BLOCK    9     5     1
MEDIA          3
BLOCK   11     1     1
MEDIA          3
BLOCK   11     2     1
MEDIA          2
BLOCK   11     3     1
MEDIA          2
BLOCK   11     4     1
MEDIA          2
BLOCK   11     5     1
MEDIA          3
BLOCK   13     1     1
MEDIA          3
BLOCK   13     2     1
MEDIA          2
BLOCK   13     3     1
MEDIA          2
BLOCK   13     4     1
MEDIA          2
BLOCK   13     5     1
MEDIA          3
BLOCK   15     1     1
MEDIA          3
BLOCK   15     2     1
MEDIA          2
BLOCK   15     3     1
MEDIA          2
BLOCK   15     4     1
MEDIA          2
BLOCK   15     5     1
MEDIA          3
BLOCK   17     1     1
MEDIA          3
```

TABLE 6.3.1-3
STEEL BASKET MODEL FOR
KENO GENERALIZED GEOMETRY

```
BLOCK    17    2    1
MEDIA           2
BLOCK    17    3    1
MEDIA           2
BLOCK    17    4    1
MEDIA           2
BLOCK    17    5    1
MEDIA           3
BLOCK     4    1    1
MEDIA           3
BLOCK     4    2    1
MEDIA           2
BLOCK     4    3    1
MEDIA           1
BLOCK     4    4    1
MEDIA           2
BLOCK     4    5    1
MEDIA           3
BLOCK     8    1    1
MEDIA           3
BLOCK     8    2    1
MEDIA           2
BLOCK     8    3    1
MEDIA           1
BLOCK     8    4    1
MEDIA           2
BLOCK     8    5    1
MEDIA           3
BLOCK    12    1    1
MEDIA           3
BLOCK    12    2    1
MEDIA           2
BLOCK    12    3    1
MEDIA           1
BLOCK    12    4    1
MEDIA           2
BLOCK    12    5    1
MEDIA           3
BLOCK    16    1    1
MEDIA           3
BLOCK    16    2    1
MEDIA           2
BLOCK    16    3    1
MEDIA           1
BLOCK    16    4    1
MEDIA           2
BLOCK    16    5    1
MEDIA           3
   2
1.0      XSQ   1.0      YSQ   -362.9025      $
1.0      XSQ   1.0      YSQ   -2193.166      $
END KENO
```

TABLE 6.3.1-4
KENO GENERALIZED GEOMETRY INPUT

```
EFF BNL FUEL SHIPPING ARRAY FWR HOMOGENIZED FUEL GENERAL GEOM 8.8-5 2 CSK 29
5. 103 300 3 27 27 14 9 18 13 3 2 1 5 -14 0 0 2000 00 6 1 1 0 0 104 00 0 0
 -92235 2.613620-3 2 13027 6.023834-2 3 1001 5.874480-6 3 8016 2.937240-6
 3 6.023834-2 5 5 6.675546-2 5 8 3.337773-2
 24304 1.742388-2 6 25055 1.736342-3 6 26304 5.935260-2 6 28304 7.720361-3
 6 5.874480-6 7 9 2.937240-6 8 82000 3.298823-2
 -92235 4.081544-4 9 13027 1.122249-2 9 1001 3.862672-6 9 8016 1.931336-6
BOX TYPE 1
GENERAL 9 6*0.0 27*0.5
GENERAL 7 6*0.0 27*0.5
GENERAL 6 6*0.0 27*0.5
GENERAL 8 6*0.0 27*0.5
GENERAL 5 6*0.0 27*0.5
CUBOID 5 46.84000 -46.84000 46.84000 -46.84000 28.9000 -28.9000 27*0.5
BOX TYPE 2
CYLINDER 8 46.83125 27.78125 -0. 27*0.5
CUBOID 5 46.84 -46.84 46.84 -46.84 27.78125 -0. 27*0.5
BOX TYPE 3
CYLINDER 7 19.05 11.74 -11.74 27*0.5
CYLINDER 8 46.84 11.74 -11.74 27*0.5
CUBOID 5 46.84 -46.84 46.84 -46.84 11.74 -11.74 27*0.5
CORE BDY 5 93.68 -93.68 46.84 -46.84 97.32125 -97.32125 27*0.5
 BID 5 124.16 -124.16 77.32 -77.32 127.80125 -127.80125 27*0.5
 . 2 1 1 1 1 1 5 1 0 1 1 2 1 1 1 1 2 3 1 0 3 1 2 1 1 1 1 4 4 1 9
GENERALIZED GEOMETRY GOES HERE
15 1 1 2 -8.7122 -8.7122 0. 30 1 1 2 0. -8.7122 0. 45 1 1 2 8.7122 8.7122 0.
60 1 1 2 -13.0683 0. 0. 75 1 1 2 -4.3561 0. 0. 90 1 1 2 4.3561 0. 0.
105 1 1 2 13.0683 0. 0. 120 1 1 2 -8.7122 8.7122 0. 135 1 1 2 0. 8.7122 0.
150 1 1 2 8.7122 8.7122 0.
165 2 1 2 -8.7122 -8.7122 0. 180 2 1 2 0. -8.7122 0. 195 2 1 2 8.7122 8.7122 0
210 2 1 2 -13.0683 0. 0. 225 2 1 2 -4.3561 0. 0. 240 2 1 2 4.3561 0. 0.
255 2 1 2 13.0683 0. 0. 270 2 1 2 -8.7122 8.7122 0. 285 2 1 2 0. 8.7122 0.
300 2 1 2 8.7122 8.7122 0.
END KENO
```

TABLE 6.3.1-5
KENO GENERALIZED GEOMETRY INPUT

```
IFF BNL FUEL SHIPPING ARRAY FWR HOMOGENIZED FUEL GENERAL GEOM 1. 1 CSR 2ST
3. 103 300 3 27 27 20 12 24 13 3 1 1 5 -20 0 0 2000 00 6 1 1 0 0 104 00 0 0
-92235 2.613620-3 2 13027 6.023834-2 3 1001 6.675546-2 3 8016 3.337773-2
3 6.023834-2 5 5 6.675546-2 5 11 3.337773-2
24304 1.742389-2 6 25055 1.736342-3 6 26304 5.935260-2 6 28304 7.720731-3
6 5.874480-6 7 12 2.937240-6 8 82000 3.298823-2
7 6.675546-5 9 13 3.337773-5 10 8 6.675546-4 10 14 3.337773-4
1 9 6.675546-3 11 15 3.337773-3
2 -92235 4.081544-4 12 13027 1.122249-2 12 1001 4.389400-2 12 8016 2.194700-2
DX TYPE 1
ENERAL 12 6*0.0 27*0.5
ENERAL 5 6*0.0 27*0.5
ENERAL 6 6*0.0 27*0.5
ENERAL 8 6*0.0 27*0.5
ENERAL 5 6*0.0 27*0.5
UBOID 5 46.84000 -46.84000 46.84000 -46.84000 28.9000 -28.9000 27*0.5
DX TYPE 2
YLINDER 8 46.87125 27.78125 -0. 27*0.5
UBOID 5 46.84 -46.84 46.84 -46.84 27.78125 -0. 27*0.5
DX TYPE 3
YLINDER 5 19.05 11.74 -11.74 27*0.5
YLINDER 8 46.84 11.74 -11.74 27*0.5
UBOID 5 46.84 -46.84 46.84 -46.84 11.74 -11.74 27*0.5
BDY 5 46.84 -46.84 46.84 -46.84 97.32125 -97.32125 27*0.5
.ID 5 77.32 -77.32 77.32 -77.32 127.80125 -127.80125 27*0.5
2 1 1 1 1 1 1 1 5 1 0 1 1 1 1 1 1 1 2 3 1 0 3 1 1 1 1 1 1 4 4 1 9
ENERALIZED GEOMETRY GOES HERE
0 1 1 2 -8.7122 -8.7122 0. 60 1 1 2 0. -8.7122 0. 90 1 1 2 8.7122 8.7122 0.
20 1 1 2 -13.0683 0. 0. 150 1 1 2 -4.3561 0. 0. 180 1 1 2 4.3561 0. 0.
10 1 1 2 13.0683 0. 0. 240 1 1 2 -8.7122 8.7122 0. 270 1 1 2 0. 8.7122 0.
00 1 1 2 8.7122 8.7122 0.
ND KENO
```

TABLE 6.4-1

```
L.F BNL FUEL SHIPPING ARRAY  FWR 2 BASKETS TOUCHING MST=6.8-5 DISCRETE FUEL
    MIXTURE  NUCLIDE   DENSITY     MIXTURE  NUCLIDE   DENSITY
        1    -92235   2.61362E-03     9     -92235   4.08154E-04
        2     13027   6.02332E-02     9      13027   1.12225E-02
        3      1001   5.87448E-06     9       1001   3.86267E-06
        3      8016   2.93724E-06     9       8016   1.93134E-06
        4         3   6.02383E-02
        5         5   6.67555E-02     5          8   3.33777E-02
        6     24304   1.74239E-02     6      25055   1.73634E-03
        6     26304   5.93526E-02     6      28304   7.72036E-03
        7         6   5.87448E-06     7          9   2.93724E-06
        8     82000   3.29882E-02
:ROSS SECTIONS READ FROM TAPE
'UCLIDE =       1001   H 1269 F, 1002 T 218 GP 032475(2)
:UCLIDE =          5   H 1269 F, 1002 T 218 GP 032475(2)
'UCLIDE =          6   H 1269 F, 1002 T 218 GP 032475(2)
'UCLIDE =       8016   O-16 1276 218 GP 030476(7)
:UCLIDE =          8   O-16 1276 218 GP 030476(7)
:UCLIDE =          9   O-16 1276 218 GP 030476(7)
:UCLIDE =      13027   AL-27 1193 218 GP 040375(5)
:UCLIDE =          3   AL-27 1193 218 GP 040375(5)
:UCLIDE =      24304   CR 1191 WT SS-304(1/EST) P-3 293K SP=5+4(42375)
:UCLIDE =      25055   MN-55 1197 SIGP=5+4 NEWXLACS 218NGP P-3 293K
:UCLIDE =      26304   FE 1192 WT SS-304(1/EST) P-3 293K SP=5+4(42375)
   IDE =      28304   NI 1190 WT SS-304(1/EST) P-3 293K SP=5+4(42375)
 _LIDE =      82000   PB   1288 218NGP 042375 P-3 293K
:UCLIDE =      92235   U-235 1261 SIGP=5+4 NEWXLACS 218NGP P-3 293K(3
.C. OF INITIAL
GENERATIONS      AVERAGE                          NUMBER OF
  SKIPPED      K-EFFECTIVE       DEVIATION       HISTORIES
     3           .30094    + OR -   .00319        24900
 FREQUENCY FOR GENERATIONS     4 TO    86
.1970 TO  .2201      *
.2201 TO  .2432      **
.2432 TO  .2663      *******
.2663 TO  .2894      ********************
.2894 TO  .3125      *********************
.3125 TO  .3356      ************************
.3356 TO  .3587      ********
.3587 TO  .3818      *
```

TABLE 6.4-2

```
EFF BNL FUEL SHIPPING ARRAY  FWR 2 BASKETS TOUCHING MST=1. DISCRETE FUEL
7GROUPNDF4  8  8  3  LATTICECELL  0  0
-235  1 0. 2.61362-3 END
_  2 1. END
CD  3 1. END
_  4 1. END
CD  5 1. END
S304  6 1. END
CD  7 1. END
B  8 1. END
YMMSLABCELL        0.37084 0.057912 1 3 0.127 2 END
IXTURE NUCLIDE   DENSITY     MIXTURE NUCLIDE   DENSITY
 1      -92235  2.613620E-03   9      -92235  4.081544E-04
 2       13027  6.023834E-02   9       13027  1.122249E-02
 3        1001  6.675546E-02   9        1001  4.389400E-02
 3        8016  3.337773E-02   9        8016  2.194700E-02
 4           3  6.023834E-02
 5           5  6.675546E-02   5           8  3.337773E-02
 7           6  6.675546E-02   7           9  3.337773E-02
 6       24304  1.742388E-02   6       25055  1.736342E-03
 6       26304  5.935260E-02   6       28304  7.720361E-03
 8       82000  3.298823E-02
ROSS SECTIONS READ FROM TAPE
'  IDE =        1001   H 1269 F, 1002 T 218 GP 032475(2)
  .IDE =           5   H 1269 F, 1002 T 218 GP 032475(2)
UCLIDE =           6   H 1269 F, 1002 T 218 GP 032475(2)
UCLIDE =        8016   O-16 1276 218 GP 030476(7)
UCLIDE =           8   O-16 1276 218 GP 030476(7)
UCLIDE =           9   O-16 1276 218 GP 030476(7)
UCLIDE =       13027   AL-27 1193 218 GP 040375(5)
UCLIDE =           3   AL-27 1193 218 GP 040375(5)
UCLIDE =       24304   CR 1191 WT SS-304(1/EST) P-3 293K SF=5-4(42375)
UCLIDE =       25055   MN-55 1197 SIGP=5+4 NEWXLACS 218NGP P-3 293K
UCLIDE =       26304   FE 1192 WT SS-304(1/EST) P-3 293K SF=5+4(42375)
UCLIDE =       28304   NI 1190 WT SS-304(1/EST) P-3 293K SF=5+4(42375)
UCLIDE =       82000   PB   1288 218NGP 042375 P-3 293K
UCLIDE =       92235   U-235 1261 SIGP=5+4 NEWXLACS 218NGP P-3 293K(3)
EFF BNL FUEL SHIPPING ARRAY  FWR 2 CONT SIDE-BY-SIDE MST=1.
O. OF INITIAL
GENERATIONS       AVERAGE                          NUMBER OF
  SKIPPED       K-EFFECTIVE       DEVIATION        HISTORIES
     3            .91561    + OR -   .00479         30000
 FREQUENCY FOR GENERATIONS     4 TO  103
.8117 TO  .8348      *****
.8348 TO  .8579      **********
.8579 TO  .8810      **************
.8810 TO  .9041      *******
.9041 TO  .9272      ******************
  72 TO  .9502       ************************
  02 TO  .9733       ***************
.9733 TO  .9964      *******
.9964 TO 1.0195      **
.0195 TO 1.0426      *
```

TABLE 6.4-3

```
    BNL FUEL SHIPPING ARRAY  FWR 2 BASKETS DOUBLE-STACK MST=1. DISCRETE FUEL
'GROUPNDF4  8  8  3  LATTICECELL  0  0
-235  1 0. 2.61362-3 END
.  2 1. END
:0  3 1. END
.  4 1. END
:0  5 1. END
:304  6 1. END
:0  7 1. END
:  8 1. END
/MMSLABCELL        0.37084 0.057912 1 3 0.127 2 END
IXTURE NUCLIDE   DENSITY     MIXTURE NUCLIDE   DENSITY
 1      -92235  2.613620E-03   9      -92235  4.081544E-04
 2       13027  6.023834E-02   9       13027  1.122249E-02
 3        1001  6.675546E-02   9        1001  4.389400E-02
 3        8016  3.337773E-02   9        8016  2.194700E-02
 4           3  6.023834E-02
 5           5  6.675546E-02   5           8  3.337773E-02
 6       24304  1.742388E-02   6       25055  1.736342E-03
 6       26304  5.935260E-02   6       28304  7.720361E-03
 7           6  6.675546E-02   7           9  3.337773E-02
 8       82000  3.298223E-02
ROSS SECTIONS READ FROM TAPE
JCLIDE =        1001   H 1269 F, 1002 T 218 GP 032475(2)
 IDE =             5   H 1269 F, 1002 T 218 GP 032475(2)
 IDE =             6   H 1269 F, 1002 T 218 GP 032475(2)
JCLIDE =        8016   O-16 1276 218 GP 030476(7)
JCLIDE =           8   O-16 1276 218 GP 030476(7)
JCLIDE =           9   O-16 1276 218 GP 030476(7)
JCLIDE =       13027   AL-27 1193 218 GP 040375(5)
JCLIDE =           3   AL-27 1193 218 GP 040375(5)
JCLIDE =       24304   CR 1191 WT SS-304(1/EST) P-3 293K SP=5+4(42375)
JCLIDE =       25055   MN-55 1197 SIGP=5+4 NEWXLACS 218NGP P-3 293K
JCLIDE =       26304   FE 1192 WT SS-304(1/EST) P-3 293K SP=5+4(42375)
JCLIDE =       28304   NI 1190 WT SS-304(1/EST) P-3 293K SP=5+4(42375)
JCLIDE =       82000   PB   1288 218NGP 042375 P-3 293K
JCLIDE =       92235   U-235 1261 SIGP=5+4 NEWXLACS 218NGP P-3 293K(3)
EFF BNL FUEL SHIPPING ARRAY  FWR DOUBLE STACK MST=1.
O. OF INITIAL
GENERATIONS       AVERAGE                          NUMBER OF
  SKIPPED       K-EFFECTIVE       DEVIATION        HISTORIES
     3            .84505    + OR -   .00499         30000
 FREQUENCY FOR GENERATIONS    4 TO  103
.7411 TO  .7642      ******
.7642 TO  .7873      ***
.7873 TO  .8104      ********************
.8104 TO  .8335      ***********
.8335 TO  .8566      ******************
.8566 TO  .8797      ***************
 97 TO  .9028        **************
   28 TO  .9259      ******
.9259 TO  .9490      *
.9490 TO  .9721      **
.9721 TO  .9952
.9952 TO 1.0183      *
```

TABLE 6.4-4

```
EFF BNL FUEL WATER FOR LEAD FWR HOMOGENIZED FUEL GENERAL GEOM 1. 2 CSI 2ST.
    MIXTURE  NUCLIDE   DENSITY     MIXTURE  NUCLIDE   DENSITY
       1     -92235   2.61362E-03    12     -92235   4.08154E-04
       2      13027   6.02383E-02    12      13027   1.12225E-02
       3       1001   6.67555E-02    12       1001   4.38940E-02
       3       8016   3.33777E-02    12       8016   2.19470E-02
       4          3   6.02383E-02
       5          5   6.67555E-02     5         11   3.33777E-02
       6      24304   1.74239E-02     6      25055   1.73634E-03
       6      26304   5.93526E-02     6      28304   7.72036E-03
       7          6   5.8744EE-06     7         12   2.93724E-06
       8      82000   3.29882E-02
       9          7   6.67555E-05     9         13   3.33777E-05
      10          8   6.67535E-04    10         14   3.33777E-04
      11          9   6.67555E-03    11         15   3.33777E-03
CROSS SECTIONS READ FROM TAPE
NUCLIDE =       1001   H 1269 F, 1002 T 218 GP 032475(2)
NUCLIDE =          5   H 1269 F, 1002 T 218 GP 032475(2)
NUCLIDE =          6   H 1269 F, 1002 T 218 GP 032475(2)
NUCLIDE =          7   H 1269 F, 1002 T 218 GP 032475(2)
NUCLIDE =          8   H 1269 F, 1002 T 218 GP 032475(2)
NUCLIDE =          9   H 1269 F, 1002 T 218 GP 032475(2)
NUCLIDE =       8016   O-16 1276 218 GP 030476(7)
    IDE =         11   O-16 1276 218 GP 030476(7)
   _IDE =         12   O-16 1276 218 GP 030476(7)
NUCLIDE =         13   O-16 1276 218 GP 030476(7)
NUCLIDE =         14   O-16 1276 218 GP 030476(7)
NUCLIDE =         15   O-16 1276 218 GP 030476(7)
NUCLIDE =      13027   AL-27 1193 218 GP 040375(5)
NUCLIDE =          3   AL-27 1193 218 GP 040375(5)
NUCLIDE =      24304   CR 1191 WT SS-304(1/EST) P-3 293K SP=5+4(42375)
NUCLIDE =      25055   MN-55 1197 SIGP=5+4 NEWXLACS 218NGP P-3 293K
NUCLIDE =      26304   FE 1192 WT SS-304(1/EST) P-3 293K SP=5+4(42375)
NUCLIDE =      28304   NI 1190 WT SS-304(1/EST) P-3 293K SP=5+4(42375)
NUCLIDE =      82000   PB   1288 218NGP 042375 P-3 293K
NUCLIDE =      92235   U-235 1261 SIGP=5+4 NEWXLACS 218NGP P-3 293K(3)
NO. OF INITIAL
 GENERATIONS      AVERAGE                          NUMBER OF
   SKIPPED      K-EFFECTIVE        DEVIATION      HISTORIES
      3           .84533   + OR -   .00569         30000
  FREQUENCY FOR GENERATIONS     4 TO  103
 .7183 TO  .7414      ****
 .7414 TO  .7645      *****
 .7645 TO  .7876      ********
 .7876 TO  .8107      **********
 .8107 TO  .8338      ***********
 .8338 TO  .8569      ***************************
 .8569 TO  .8800      *********
    00 TO  .9031      ********
   031 TO  .9262      *******
 .9262 TO  .9493      ******
 .9493 TO  .9723      *****
```

TABLE 6.4-5

```
:FF BNL FUEL SHIPPING ARRAY FWR HOMOGENIZED FUEL GENERAL GEOM 8.8-5 2 CSI  2ST
   MIXTURE  NUCLIDE   DENSITY     MIXTURE  NUCLIDE   DENSITY
       1    -92235   2.61362E-03     9    -92235   4.08154E-04
       2     13027   6.02383E-02     9     13027   1.12225E-02
       3      1001   5.87448E-06     9      1001   3.86267E-06
       3      8016   2.93724E-06     9      8016   1.93134E-06
       4         3   6.02383E-02
       5         5   6.67555E-02     5         8   3.33777E-02
       6     24304   1.74239E-02     6     25055   1.73634E-03
       6     26304   5.93526E-02     6     28304   7.72036E-03
       7         6   5.87446E-06     7         9   2.93724E-06
       8     82000   3.29882E-02
:OSS SECTIONS READ FROM TAPE
JCLIDE =      1001   H 1269 F, 1002 T 218 GP 032475(2)
JCLIDE =         5   H 1269 F, 1002 T 218 GP 032475(2)
JCLIDE =         6   H 1269 F, 1002 T 218 GP 032475(2)
JCLIDE =      8016   O-16 1276 218 GP 030476(7)
JCLIDE =         8   O-16 1276 218 GP 030476(7)
JCLIDE =         9   O-16 1276 218 GP 030476(7)
JCLIDE =     13027   AL-27 1193 218 GP 040375(5)
JCLIDE =         3   AL-27 1193 218 GP 040375(5)
JCLIDE =     24304   CR 1191 WT SS-304(1/EST) P-3 293K SP=5+4(42375)
JCLIDE =     25055   MN-55 1197 SIGP=5+4 NEWXLACS 218NGP P-3 293K
   IDE =     26304   FE 1192 WT SS-304(1/EST) P-3 293K SP=5+4(42375)
  IDE =      28304   NI 1190 WT SS-304(1/EST) P-3 293K SP=5+4(42375)
JCLIDE =     82000   PB   1288 218NGP 042375 P-3 293K
JCLIDE =     92235   U-235 1261 SIGP=5+4 NEWXLACS 218NGP P-3 293K(3)
). OF INITIAL
GENERATIONS      AVERAGE                          NUMBER OF
  SKIPPED      K-EFFECTIVE       DEVIATION       HISTORIES
     3           .09697    + OR -   .00173         13900
 FREQUENCY FOR GENERATIONS     4 TO    49
.0623 TO  .0854      *********
.0854 TO  .1085      ******************************
.1085 TO  .1316      *******
```

TABLE 6.4-6

```
EFF BNL FUEL SHIFFING ARRAY FWR HOMOGENIZED FUEL GENERAL GEOM 0.1 2 CS  CST
    MIXTURE  NUCLIDE   DENSITY     MIXTURE  NUCLIDE   DENSITY
        1    -92235   2.61362E-03     9     -92235   4.08154E-04
        2     13027   6.02383E-02     9      13027   1.12225E-02
        3      1001   6.67555E-03     9       1001   4.38940E-03
        3      8016   3.33777E-03     9       8016   2.19470E-03
        4         3   6.02383E-02
        5         5   6.67555E-02     5          8   3.33777E-02
        6     24304   1.74239E-02     6      25055   1.73634E-03
        6     26304   5.93526E-02     6      28304   7.72036E-03
        7         6   6.67555E-03     7          9   3.33777E-03
        8     82000   3.29862E-02
ROSS SECTIONS READ FROM TAPE
UCLIDE =       1001   H 1269 F, 1002 T 218 GP 032475(2)
UCLIDE =          5   H 1269 F, 1002 T 218 GP 032475(2)
UCLIDE =          6   H 1269 F, 1002 T 218 GP 032475(2)
UCLIDE =       8016   O-16 1276 218 GP 030476(7)
UCLIDE =          8   O-16 1276 218 GP 030476(7)
UCLIDE =          9   O-16 1276 218 GP 030476(7)
UCLIDE =      13027   AL-27 1193 218 GP 040375(5)
UCLIDE =          3   AL-27 1193 218 GP 040375(5)
UCLIDE =      24304   CR 1191 WT SS-304(1/EST) P-3 293K SF=5+4(42375)
UCLIDE =      25055   MN-55 1197 SIGP=5+4 NEWXLACS 218NGP P-3 293K
   IDE =      26304   FE 1192 WT SS-304(1/EST) P-3 293K SF=5+4(42375)
  IDE =       28304   NI 1190 WT SS-304(1/EST) P-3 293K SF=5+4(42375)
UCLIDE =      82000   PB   1288 218NGP 042375 P-3 293K
UCLIDE =      92235   U-235 1261 SIGP=5+4 NEWXLACS 218NGP P-3 293K(3
O. OF INITIAL
GENERATIONS       AVERAGE                          NUMBER OF
  SKIPPED       K-EFFECTIVE       DEVIATION       HISTORIES
     3            .35831    + OR -   .00412        17400
                                FREQUENCY FOR GENERATIONS     4 TO    61

.2775 TO  .3006      *
.3006 TO  .3237      ****
.3237 TO  .3468      ******************
.3468 TO  .3699      ****************
.3699 TO  .3930      **************
.3930 TO  .4160      *
.4160 TO  .4391      **
.4391 TO  .4622      **
```

TABLE 6.4-7

```
EFF BNL FUEL SHIPPING ARRAY FWR HOMOGENIZED FUEL GENERAL GEOM 1. 1 CSK 293K
    MIXTURE  NUCLIDE   DENSITY     MIXTURE  NUCLIDE   DENSITY
       1     -92235   2.61362E-03    12     -92235   4.08154E-04
       2      13027   6.02383E-02    12      13027   1.12225E-02
       3       1001   6.67555E-02    12       1001   4.38940E-02
       3       8016   3.33777E-02    12       8016   2.19470E-02
       4          3   6.02383E-02
       5          5   6.67555E-02     5         11   3.33777E-02
       6      24304   1.74239E-02     6      25055   1.73634E-03
       6      26304   5.93526E-02     6      28304   7.72036E-03
       7          6   5.87448E-06     7         12   2.93724E-06
       8      82000   3.29882E-02
       9          7   6.67555E-05     9         13   3.33777E-05
      10          8   6.67555E-04    10         14   3.33777E-04
      11          9   6.67555E-03    11         15   3.33777E-03
CROSS SECTIONS READ FROM TAPE
NUCLIDE =       1001   H 1269 F, 1002 T 218 GP 032475(2)
NUCLIDE =          5   H 1269 F, 1002 T 218 GP 032475(2)
NUCLIDE =          6   H 1269 F, 1002 T 218 GP 032475(2)
NUCLIDE =          7   H 1269 F, 1002 T 218 GP 032475(2)
NUCLIDE =          8   H 1269 F, 1002 T 218 GP 032475(2)
NUCLIDE =          9   H 1269 F, 1002 T 218 GP 032475(2)
NUCLIDE =       8016   O-16 1276 218 GP 030476(7)
NUCLIDE =         11   O-16 1276 218 GP 030476(7)
NUCLIDE =         12   O-16 1276 218 GP 030476(7)
NUCLIDE =         13   O-16 1276 218 GP 030476(7)
NUCLIDE =         14   O-16 1276 218 GP 030476(7)
NUCLIDE =         15   O-16 1276 218 GP 030476(7)
NUCLIDE =      13027   AL-27 1193 218 GP 040375(5)
NUCLIDE =          3   AL-27 1193 218 GP 040375(5)
NUCLIDE =      24304   CR 1191 WT SS-304(1/EST) P-3 293K SP=5+4(42375)
NUCLIDE =      25055   MN-55 1197 SIGP=5+4 NEWXLACS 218NGP P-3 293K
NUCLIDE =      26304   FE 1192 WT SS-304(1/EST) P-3 293K SP=5+4(42375)
NUCLIDE =      28304   NI 1190 WT SS-304(1/EST) P-3 293K SP=5+4(42375)
NUCLIDE =      82000   PB   1288 218NGP 042375 P-3 293K
NUCLIDE =      92235   U-235 1261 SIGP=5+4 NEWXLACS 218NGP P-3 293K(3)
NO. OF INITIAL
 GENERATIONS      AVERAGE                          NUMBER OF
   SKIPPED      K-EFFECTIVE       DEVIATION       HISTORIES
     3            .88725    + OR -   .00446         30000
  FREQUENCY FOR GENERATIONS     4 TO  103
 .7602 TO  .7833      *
 .7833 TO  .8064      ****
 .8064 TO  .8295      ****
 .8295 TO  .8526      **************
 .8526 TO  .8757      ***************
 .8757 TO  .8988      **********************
 .8988 TO  .9219      ******************
  9219 TO  .9450      ***********
   450 TO  .9681      *******
 .9681 TO  .9912      ***
```

TABLE 6.4-8

```
:FF BNL FUEL SHIPPING FT-B FWR HOMOGENIZED FUEL GENERAL GEOM 1. 1 CS' 2S'K
:E FUEL STACK AGAINST UPPER LEAD AND ONE FUEL STACK AGAINST LOWER LEAD
    MIXTURE  NUCLIDE   DENSITY     MIXTURE  NUCLIDE   DENSITY
       1     -92235   2.61362E-03    12     -92235   4.08154E-04
       2      13027   6.02383E-02    12      13027   1.12225E-02
       3       1001   6.67555E-02    12       1001   4.38940E-02
       3       8016   3.33777E-02    12       8016   2.19470E-02
       4          3   6.02383E-02
       5          5   6.67555E-02     5         11   3.33777E-02
       6      24304   1.74239E-02     6      25055   1.73634E-03
       6      26304   5.93526E-02     6      28304   7.72036E-03
       7          6   5.87448E-06     7         12   2.93724E-06
       8      82000   3.29882E-02
       9          7   6.67555E-05     9         13   3.33777E-05
      10          8   6.67555E-04    10         14   3.33777E-04
      11          9   6.67555E-03    11         15   3.33777E-03
ROSS SECTIONS READ FROM TAPE
UCLIDE =       1001   H 1269 F, 1002 T 218 GP 032475(2)
UCLIDE =          5   H 1269 F, 1002 T 218 GP 032475(2)
UCLIDE =          6   H 1269 F, 1002 T 218 GP 032475(2)
UCLIDE =          7   H 1269 F, 1002 T 218 GP 032475(2)
UCLIDE =          8   H 1269 F, 1002 T 218 GP 032475(2)
UCLIDE =          9   H 1269 F, 1002 T 218 GP 032475(2)
   IDE =       8016   O-16 1276 218 GP 030476(7)
  _IDE =         11   O-16 1276 218 GP 030476(7)
UCLIDE =         12   O-16 1276 218 GP 030476(7)
UCLIDE =         13   O-16 1276 218 GP 030476(7)
UCLIDE =         14   O-16 1276 218 GP 030476(7)
UCLIDE =         15   O-16 1276 218 GP 030476(7)
UCLIDE =      13027   AL-27 1193 218 GP 040375(5)
UCLIDE =          3   AL-27 1193 218 GP 040375(5)
UCLIDE =      24304   CR 1191 WT SS-304(1/EST) P-3 293K SP=5+4(42375
UCLIDE =      25055   MN-55 1197 SIGP=5+4 NEWXLACS 218NGP P-3 293K
UCLIDE =      26304   FE 1192 WT SS-304(1/EST) P-3 293K SP=5+4(42375)
UCLIDE =      28304   NI 1190 WT SS-304(1/EST) P-3 293K SP=5+4(42375)
UCLIDE =      82000   PB   1288 218NGP 042375 P-3 293K
UCLIDE =      92235   U-235 1261 SIGP=5+4 NEWXLACS 218NGP P-3 293K(3)
O. OF INITIAL
GENERATIONS      AVERAGE                          NUMBER OF
  SKIPPED      K-EFFECTIVE       DEVIATION       HISTORIES
     3           .84483   + OR -   .00429          30000
 FREQUENCY FOR GENERATIONS     4 TO  103
.7409 TO  .7640      ***
.7640 TO  .7871      *****
.7871 TO  .8102      ***************
.8102 TO  .8333      ******************
.8333 TO  .8564      ************************
.8564 TO  .8795      ****************
   '95 TO  .9026     ****************
  J26 TO  .9257      *****
.9257 TO  .9488
.9488 TO  .9718      **
```

IGURE 6.4-1: K-Effective (±2 Sigma) Vs. Water Mist Density For odel B. Two Casks Each Contain 7020 Grams U-235 Of Fully Enriched ranium In Plate Fuel Form In Twenty Fuel Elements In A 304 Stainless teel Basket And Are Touching In An Array. The Mist Is Inside The Cask. here Is 12" Of Water Reflection Between The Casks And Around The Array.
* K-Effective Results Contain A Bias Of 0.3% In The 1 Sigma Value And In The Mean Value. Water Is Between The Plates Here.

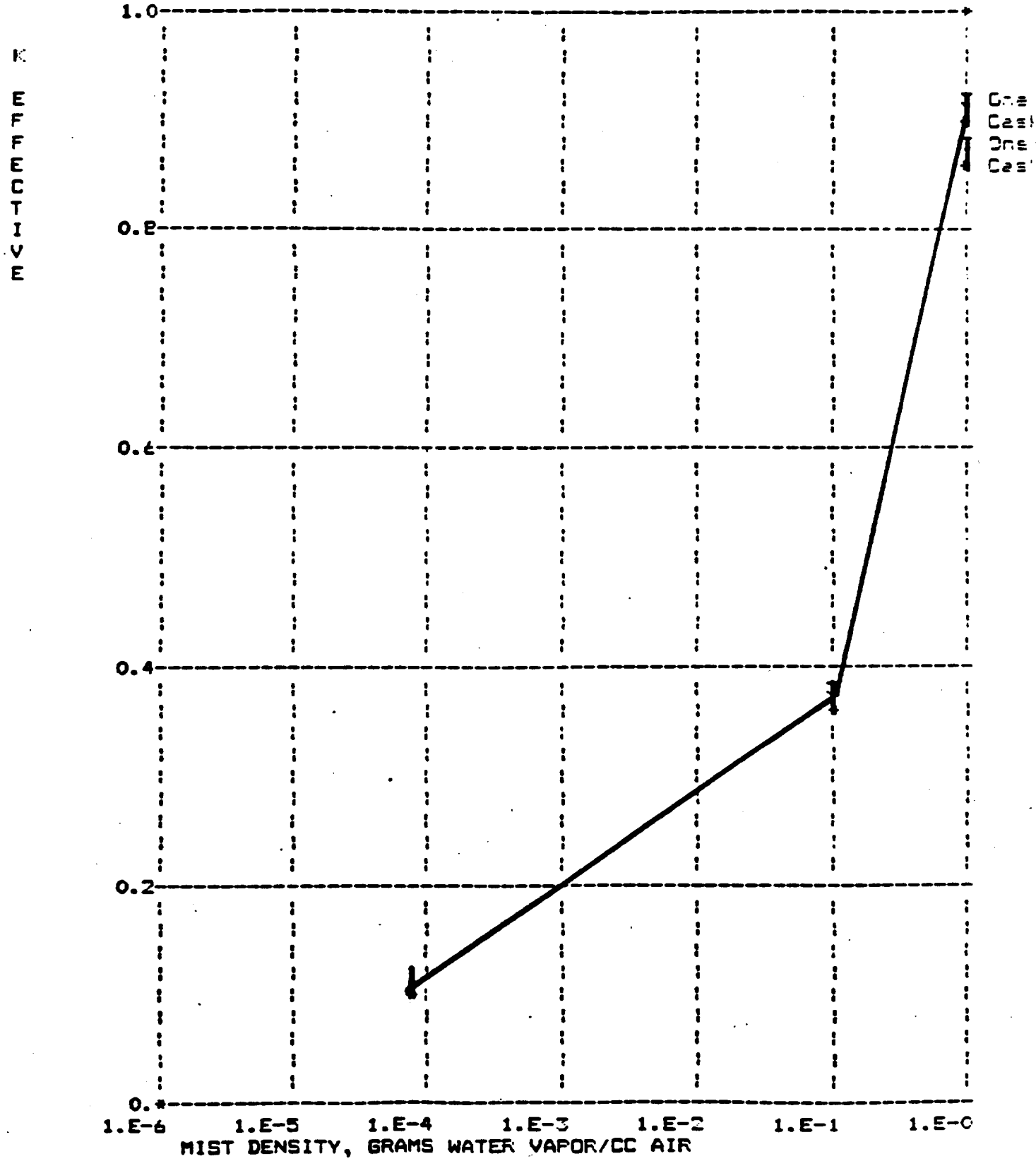

TABLE 6.5.1-1

Critical Experiments for Computational Tool Evaluation

Experiment Name	References
A. TRX-1 & TRX-2 Low-Enriched Uranium Rods in Water	A.1. J. Hardy, Jr., D. Klein and J. J. Volpe; "A Study of Physics Parameters In Several Water-Moderated Lattices of Slightly Enriched and Natural Uranium", WAPD-TM-931; March, 1970.
	A.2. J. Hardy, Jr., D. Klein and J. J. Volpe; Nucl. Sci. Eng. 40, 101 (1970). J. J. Volpe, J. Hardy, Jr., and D. Klein, Nucl. Sci. Eng. 40, 116 (1970).
	A.3. J. Hardy, Jr., D. Klein and R. Dannels; Nucl. Sci. Eng. 26, 462 (1966).
	A.4. J. R. Brown et al., "Kinetics and Buckling Measurements In Lattices of Slightly Enriched U or UO_2 Rods In H_2O", WAPD-176 (January, 1958).
	A.5. R. Sher and S. Fiarman, "Studies of Thermal Reactor Benchmark Data Interpretation: Experimental Corrections", EPRI NP-209; October, 1976.
B. ORNL 1-4 & ORNL 10 Fully Enriched Uranium Spherical Solutions	B.1. R. Gwin and D. W. Magnuson, "Eta of U-233 and U-235 for Critical Experiments", Nuc. Sci. Eng. 12, 364 (1962).
	B.2. A. Staub et al., "Analysis of A Set of Critical Homogeneous U-H_2O Spheres", Nuc. Sci. Eng. 34, 263 (1968).

TABLE 6.5.1-1
(Continued)

Experiment Name	References
C. PNL 1-5 Plutonium Spherical Solutions	C.1. R. C. Lloyd et al., "Criticality Studies With Plutonium Solutions", Nuc. Sci. Eng. 25, 165 (1966).
	C.2. L. E. Hansen and E. D. Clayton, "Theory-Experiment Tests Using ENDF/B Version II Cross-Section Data", Trans. Amer. Nuc. Soc. 15, 309 (June, 1972).
	C.3. F. E. Kruesi et al., "Critical Mass Studies of Plutonium-Nitrate Solution", HW-24514 (1952).
D. Babcock & Wilcox Small Lattice Facility Low-Enriched UO_2 Rods in Water	D.1. M. N. Baldwin et al., "Physics Verification Program - Part III", BAW-3647-6, Babcock & Wilcox, 1970.
MO_2 Rods in Water	D.2. G. T. Fairburn et al., "Pu Lattice Experiments In Uniform Test Lattice of UO_2-1.5% PuO_2 Fuel", BAW-1357, Babcock & Wilcox; August, 1970.

TABLE 6.5.2-1 TRX-1

```
NEFF TRX-1 763 U METAL RODS 1.291U/O WAPD 176 JAN. 1958
SYMMGROUPMOD4  7 10 4 LATTICECELL  0 0
U-235  1 0. 6.253-4 END
U-238  1 0. 0.047205 END
AL  2 0. 0.06025 END
H  3 0. 0.06676 END
O  3 0. 0.03338 END
H2O  4 0.0-5 END
H  5 0. 0.06676 END
O  5 0. 0.03338 END
FE  6 1. END
AL  7 0. 0.06025 END
TRIANGPITCH  1.806 0.983 1 3 1.1506 2 1.0084 4 END
NEFF TRX-1 763 U METAL RODS 1.291U/O WAPD 176 JAN. 1958
15.0 103 300 3 6 60 33 2 0
BOX TYPE  1
ZONECYL4X  7 0.5753 0. -15.24 -0.5
CUBOID  5 0.903 -0. 0.782 -0.782 0. -15.24 -0.5
CUBOID  500 0.903 -0. 0.782 -0.782 0. -76.20 -0.5
CUBOID  6 0.903 -0. 0.782 -0.782 5.08 -76.20 -0.5
BOX TYPE  2
ZONECYL-X  7 0.5753 0. -15.24 -0.5
CUBOID  5 0. -0.903 0.782 -0.782 0. -15.24 -0.5
CUBOID  500 0. -0.903 0.782 -0.782 0. -76.20 -0.5
CUBOID  6 0. -0.903 0.782 -0.782 5.08 -76.20 -0.5
BOX TYPE  3
ZONECYL4X  7 0.5753 20.32 -0. -0.5
CUBOID  5 0.903 -0. 0.782 -0.782 20.32 -0. -0.5
CUBOID  500 0.903 -0. 0.782 -0.782 81.28 -0. -0.5
CUBOID  6 0.903 -0. 0.782 -0.782 81.28 -1.27 -0.5
BOX TYPE  4
ZONECYL-X  7 0.5753 20.32 -0. -0.5
CUBOID  5 0. -0.903 0.782 -0.782 20.32 -0. -0.5
CUBOID  500 0. -0.903 0.782 -0.782 81.28 -0. -0.5
CUBOID  6 0. -0.903 0.782 -0.782 81.28 -1.27 -0.5
BOX TYPE  5
CUBOID  5 0.903 -0. 0.782 -0.782 0. -76.20 -0.5
CUBOID  6 0.903 -0. 0.782 -0.782 5.08 -76.20 -0.5
BOX TYPE  6
CUBOID  5 0.903 -0. 0.782 -0.782 81.28 -0. -0.5
CUBOID  6 0.903 -0. 0.782 -0.782 81.28 -1.27 -0.5
ARRAY BOY  5 27.090 -27.090 25.806 -25.806 81.915 -81.915 -0.5
CUBOID  5 57.090 -57.090 55.806 -55.806 81.915 -81.915 -0.5
```

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TABLE 6.5.2-1 TRX-1 (CONTINUED)

```
DEFF TRX-1 763 W METAL RODS 1.291W/D WAPD 176 JAN. 1958
BEG GEOMETRY
 5  1 60 1  1 33 1 2 2 1 0 6  1 60 1  1 33 1 1 1 1 0 2 24 38 2  1 33 2 2 2 1 0
 1 25 39 2  1 33 2 2 2 1 0 2 17 43 2  2 32 2 2 2 1 0 1 18 44 2  2 32 2 2 2 1 0
 2 14 46 2  3 31 2 2 2 1 0 1 15 47 2  3 31 2 2 2 1 0 2 13 47 2  4 30 2 2 2 1 0
 1 14 48 2  4 30 2 2 2 1 0 2 12 48 2  5 29 2 2 2 1 0 1 13 49 2  5 29 2 2 2 1 0
 2  9 51 2  6 28 2 2 2 1 0 1 10 52 2  6 28 2 2 2 1 0 2  8 52 2  7 27 2 2 2 1 0
 1  9 53 2  7 27 2 2 2 1 0 2  7 53 2  8 26 2 2 2 1 0 1  8 54 2  8 26 2 2 2 1 0
 2  6 54 2  9 25 2 2 2 1 0 1  7 55 2  9 25 2 2 2 1 0 2  5 55 2 10 24 2 2 2 1 0
 1  6 56 2 10 24 2 2 2 1 0 2  4 56 2 11 23 2 2 2 1 0 1  5 57 2 11 23 2 2 2 1 0
 2  3 57 2 12 22 2 2 2 1 0 1  4 58 2 12 22 2 2 2 1 0 2  2 58 2 13 21 2 2 2 1 0
 1  3 59 2 13 21 2 2 2 1 0 2  1 59 2 14 18 2 2 2 1 0 1  2 60 2 14 18 2 2 2 1 0
 4 24 38 2  1 33 2 1 1 1 0 3 25 39 2  1 33 2 1 1 1 0 4 17 43 2  2 32 2 1 1 1 0
 3 18 44 2  2 32 2 1 1 1 0 4 14 44 2  3 31 2 1 1 1 0 3 15 47 2  3 31 2 1 1 1 0
 4 13 47 2  4 30 2 1 1 1 0 3 14 48 2  4 30 2 1 1 1 0 4 12 48 2  5 29 2 1 1 1 0
 3 13 49 2  5 29 2 1 1 1 0 4  9 51 2  6 28 2 1 1 1 0 3 10 52 2  6 28 2 1 1 1 0
 4  8 52 2  7 27 2 1 1 1 0 3  9 53 2  7 27 2 1 1 1 0 4  7 53 2  8 26 2 1 1 1 0
 3  8 54 2  8 26 2 1 1 1 0 4  6 54 2  9 25 2 1 1 1 0 3  7 55 2  9 25 2 1 1 1 0
 4  5 55 2 10 24 2 1 1 1 0 3  6 56 2 10 24 2 1 1 1 0 4  4 56 2 11 23 2 1 1 1 0
 3  5 57 2 11 23 2 1 1 1 0 4  3 57 2 12 22 2 1 1 1 0 3  4 58 2 12 22 2 1 1 1 0
 4  2 58 2 13 21 2 1 1 1 0 3  3 59 2 13 21 2 1 1 1 0 4  1 59 2 14 18 2 1 1 1 0
 3  2 60 2 14 18 2 1 1 1 9
END KENO
```

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TABLE 6.5.2-2 TRX-2

```
NEFF TRX-2 577 U METAL RODS 1.291U/D WAPD 176 JAN. 1958
27GROUPKDF4  7 10 4 LATTICECELL  0 0
U-235  1 0. 6.253-4 END
U-238  1 0. 0.047205 END
AL  2 0. 0.06025 END
N  3 0. 0.06676 END
O  3 0. 0.03338 END
H2O  4 0.0-5 END
N  5 0. 0.06676 END
O  5 0. 0.03338 END
FE  6 1. END
AL  7 0. 0.06025 END
TRIANGPITCH  2.174 0.983 1 3 1.1504 2 1.0084 4 END
NEFF TRX-2 577 U METAL RODS 1.291U/D WAPD 176 JAN. 1958
35.0 103 300 3 6 32 29 2 0
BOX TYPE  1
ZHEMICYL+X  7 0.5753 0. -15.24 -0.5
CUBOID  5  1.087 -0. 0.941 -0.941 0. -15.24 -0.5
CUBOID  300 1.087 -0. 0.941 -0.941 0. -76.20 -0.5
CUBOID  6 1.087 -0. 0.941 -0.941 5.08 -76.20 -0.5
BOX TYPE  2
ZHEMICYL-X  7 0.5753 0. -15.24 -0.5
CUBOID  5  0. -1.087 0.941 -0.941 0. -15.24 -0.5
CUBOID  300 0. -1.087 0.941 -0.941 0. -76.20 -0.5
CUBOID  6 0. -1.087 0.941 -0.941 5.08 -76.20 -0.5
BOX TYPE  3
ZHEMICYL+X  7 0.5753 20.32 -0. -0.5
CUBOID  5  1.087 -0. 0.941 -0.941 20.32 -0. -0.5
CUBOID  300 1.087 -0. 0.941 -0.941 81.28 -0. -0.5
CUBOID  6 1.087 -0. 0.941 -0.941 81.28 -1.27 -0.5
BOX TYPE  4
ZHEMICYL-X  7 0.5753 20.32 -0. -0.5
CUBOID  5  0. -1.087 0.941 -0.941 20.32 -0. -0.5
CUBOID  300 0. -1.087 0.941 -0.941 81.28 -0. -0.5
CUBOID  6 0. -1.087 0.941 -0.941 81.28 -1.27 -0.5
BOX TYPE  5
CUBOID  5 1.087 -0. 0.941 -0.941 0. -76.20 -0.5
CUBOID  6 1.087 -0. 0.941 -0.941 5.08 -76.20 -0.5
BOX TYPE  6
CUBOID  5 1.087 -0. 0.941 -0.941 81.28 -0. -0.5
CUBOID  6 1.087 -0. 0.941 -0.941 81.28 -1.27 -0.5
ARRAY BOY  5 28.262 -28.262 27.289 -27.289 81.915 -81.915 -0.5
CUBOID  5 58.262 -88.262 57.289 -87.289 81.915 -81.915 -0.5
END GEOMETRY
5  1 32 1  1 29 1 2 2 1 0 6  1 32 1  1 29 1 1 1 1 0 2 22 32 2  1 29 2 2 2 1 0
1 23 33 2  1 29 2 2 2 1 0 2 15 37 2  2 28 2 2 2 1 0 1 16 38 2  2 28 2 2 2 1 0
2 12 40 2  3 27 2 2 2 1 0 1 13 41 2  3 27 2 2 2 1 0 2 11 41 2  4 26 2 2 2 1 0
1 12 42 2  4 26 2 2 2 1 0 2 10 42 2  5 25 2 2 2 1 0 1 11 43 2  5 25 2 2 2 1 0
2  7 45 2  6 24 2 2 2 1 0 1  8 46 2  6 24 2 2 2 1 0 2  6 46 2  7 23 2 2 2 1 0
1  7 47 2  7 23 2 2 2 1 0 2  5 47 2  8 22 2 2 2 1 0 1  6 48 2  8 22 2 2 2 1 0
2  4 48 2  9 21 2 2 2 1 0 1  5 49 2  9 21 2 2 2 1 0 2  3 49 2 10 20 2 2 2 1 0
1  4 50 2 10 20 2 2 2 1 0 2  2 50 2 11 19 2 2 2 1 0 1  3 51 2 11 19 2 2 2 1 0
2  1 51 2 14 16 2 2 2 1 0 1  2 52 2 14 16 2 2 2 1 0 4 22 32 2  1 29 2 1 1 1 0
3 23 33 2  1 29 2 1 1 1 0 4 15 37 2  2 28 2 1 1 1 0 3 16 38 2  2 28 2 1 1 1 0
4 12 40 2  3 27 2 1 1 1 0 3 13 41 2  3 27 2 1 1 1 0 4 11 41 2  4 26 2 1 1 1 0
3 12 42 2  4 26 2 1 1 1 0 4 10 42 2  5 25 2 1 1 1 0 3 11 43 2  5 25 2 1 1 1 0
4  7 45 2  6 24 2 1 1 1 0 3  8 46 2  6 24 2 1 1 1 0 4  6 46 2  7 23 2 1 1 1 0
3  7 47 2  7 23 2 1 1 1 0 4  5 47 2  8 22 2 1 1 1 0 3  6 48 2  8 22 2 1 1 1 0
4  4 48 2  9 21 2 1 1 1 0 3  5 49 2  9 21 2 1 1 1 0 4  3 49 2 10 20 2 1 1 1 0
3  4 50 2 10 20 2 1 1 1 0 4  2 50 2 11 19 2 1 1 1 0 3  3 51 2 11 19 2 1 1 1 0
1  1 [illegible]
```

TABLE 6.5.2-3 DRUL-1 & DRUL-2

```
NEFT DRUL-1 NSE 34 263-274 (1968P) SCALE MODEL
27BROUPNDF4  1 7 1 INFHOMMEDIUM  1 0
U-235  1 0. 4.8066-5 END
U-238  1 0. 2.807-6 END
U-234  1 0. 5.38-7 END
U-236  1 0. 1.28-7 END
H  1 0. 1.869-4 END
O  1 0. 0.033736 END
N  1 0. 0.066228 END
 IBM=12 IIN=40 ICM=70 IUS=1 END
NEFT DRUL-1 NSE 34 263-274 (1968P) SCALE MODEL
15.0 103 300 3 0 0 0 0 0
SPHERE  1 34.5948 -0.5
END GEOMETRY
END KENO
NEFT DRUL-2 NSE 34 263-274 (1968P) SCALE MODEL
27BROUPNDF4  1 0 1 INFHOMMEDIUM  1 0
U-235  1 0. 5.6205-5 END
U-238  1 0. 3.28-6 END
U-234  1 0. 6.31-7 END
U-236  1 0. 1.43-7 END
H  1 0. 2.129-4 END
O  1 0. 0.0338 END
N  1 0. 0.066148 END
B-10  1 0. 1.0286-6 END
 IBM=12 IIN=40 ICM=70 IUS=1 END
NEFT DRUL-2 NSE 34 263-274 (1968P) SCALE MODEL
15.0 103 300 3 0 0 0 0 0
SPHERE  1 34.5948 -0.5
END GEOMETRY
END KENO
```

TABLE 6.5.2-4 PNL-1 & PNL-2

```
NEFF PNL-1 NSE 25 165 (1966)
ZVBROUPNDF4  1 S 1 INFNONMEDIUM  1 0
PU-239  1 0. 9.373-5 END
PU-240  1 0. 4.501-6 END
H  1 0. 6.216-4 END
B  1 0. 0.03456 END
N  1 0. 0.06563 END
 IBN=12 IIN=40 ICN=70 IUS=1 END
NEFF PNL-1 NSE 25 165 (1966)
SS. 103 300 3 0 0 0 0 0
SPHERE  1 19.509 -0.5
END GEOMETRY
END KENO
NEFF PNL-2 NSE 25 165 (1966)
ZVBROUPNDF4  1 S 1 INFNONMEDIUM  1 0
PU-239  1 0. 4.141-4 END
PU-240  1 0. 1.980-5 END
H  1 0. 4.720-3 END
B  1 0. 0.03977 END
N  1 0. 0.05416 END
 IBN=12 IIN=40 ICN=70 IUS=1 END
NEFF PNL-2 NSE 25 165 (1966)
SS. 103 300 3 0 0 0 0 0
SPHERE  1 19.509 -0.5
END GEOMETRY
END KENO
```

TABLE 6.5.2-5 B&W UO2 & MOX EXPERIMENTS

```
B&W UO2 EXP CELL  SCALE MODEL  ENDF/B-IV LATTICE SELFSHLD
27GROUPNDF4  3 7 3  LATTICECELL    0 0
O       1  0.  4.472785-2  END
U-235   1  0.  5.570280-4  END
U-238   1  0.  2.180690-2  END
AL      2  0.  6.051481-2  END
N       3  0.  6.668320-2  END
B-10    3  0.  2.243000-5  END
O       3  0.  3.334160-2  END
SQUAREPITCH  1.6256 1.0434  1  3 1.2060 2 END
B&W UO2 EXP CELL  SCALE MODEL  ENDF/B-IV LATTICE SELFSHLD
25.  103  300  3  GR1  1
GR1
CYLINDER 1  .521716  .8128  -.8128  -.5
CYLINDER 2  .603     .8128  -.8128  -.5
CUBOID   3  .8128  -.8128  .8128  -.8128  .8128  -.8128  -.5
END GEOMETRY
END KENO
```

```
B&W MOX EXPERIMENT  SCALE MODEL  LATTICECELL SELFSHIELDING
27GROUPNDF4  3 12  3 LATTICECELL    0 0
O          1  0.  4.258150-2  END
U-235      1  0.  1.541510-4  END
U-238      1  0.  2.131198-2  END
PU-239     1  0.  2.646750-4  END
PU-240     1  0.  5.275900-5  END
PU-241     1  0.  5.271000-6  END
PU-242     1  0.  8.320000-7  END
AM-241     1  0.  1.616000-6  END
ZIRCALLOY  2  1.019225        END
N          3  0.  6.668320-2  END
B-10       3  0.  2.465000-5  END
O          3  0.  3.334160-2  END
SQUAREPITCH  1.8738  1.2751  1  3  1.4275  2  END
B&W MOX EXPERIMENT  SCALE MODEL LATTICE SLFSHLDING
30.  103  300  3  GR1  1
GR1
CYLINDER 1  .63754   .94869  -.94869                          -.5
CYLINDER 2  .71374   .94869  -.94869                          -.5
CUBOID   3  .94869  -.94869   .94869  -.94869  .94869  -.94869 -.5
END GEOMETRY
END KENO
```

TABLE 6.5.3-1

K-Effective Results
Computational Tool Evaluation

Name of Critical Experiment	Feature	SCALE Results K-eff ± 2 Sigma	SCALE Results No. of Neutron Histories
ORNL-1	Fully Enriched	1.0021 ± 0.0060	30,000
ORNL-2	U-235 Nitrate	0.9977 ± 0.0068	30,000
TRX-1	Low Enriched	0.9773 ± 0.0060	30,000
TRX-2	U-235 Rods	0.9820 ± 0.0060	30,000
PNL-1	Plutonium	1.0157 ± 0.0108	30,000
PNL-2	Nitrate (5Pu240)	1.0105 ± 0.0114	30,000
B&W	UO_2 Rod	0.9920*± 0.0046	30,000
B&W	MO_2 Rod	0.9972*± 0.0054	30,000

*k-infinity values

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GENERAL ELECTRIC

NUCLEAR ENERGY BUSINESS OPERATIONS
GENERAL ELECTRIC COMPANY • VALLECITOS NUCLEAR CENTER • PLEASANTON, CALIFORNIA 94566

September 16, 1985

Mr. C. E. MacDonald, Chief
Transportation Certification Branch
Office of Nuclear Material Safety and Safeguards
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

References: 1) Certificate of Compliance No. 5942, Docket 71-5942.
2) Application for Amendment; June 5, 1985.
3) Application for Amendment; August 7, 1985.
4) Letter, C. E. MacDonald to G. E. Cunningham; September 4, 1985.

Dear Mr. MacDonald:

This letter is in response to the questions contained in your letter of September 4, 1985 (Ref. 4).

Separation will be provided by placing a 0.188-inch-thick 304 stainless steel plate between the two baskets. Holes are provided in the plate to facilitate draining after underwater cask loading. The plate is shown on Drawing No. 218B6061 enclosed as Attachment A.

The difference in k-effective between the 10-element case (Ref. 2) and the 20-element case (Ref. 3) is explained by the fact that a bias was applied in the former and a more accurate model was used in the latter. The model used in the 10-element case was overly conservative. A comparison of the two models and a summary of the input/output of the SCALE calculation for the 10-element case are included as Attachment B. The full computer run is included as Attachment C.

Sincerely,

G. E. Cunningham

G. E. Cunningham
Senior Licensing Engineer
(415) 862-2211, Ext. 4330

/ca

Attachments

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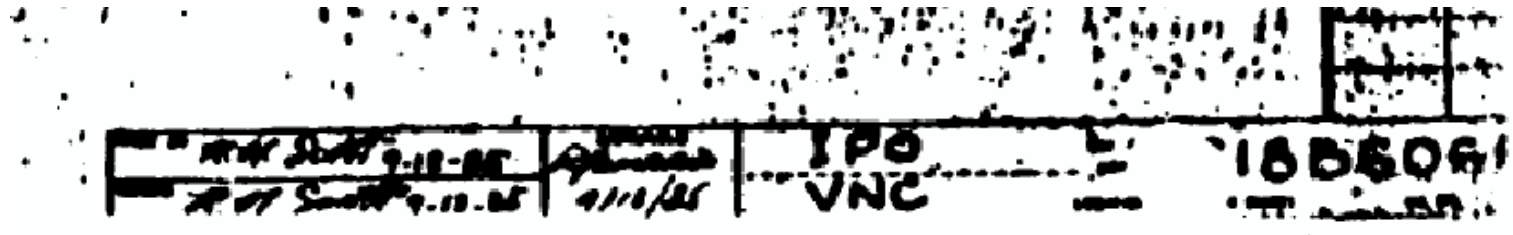
Attachment A

Drawing No. 218B6061

FIGURE WITHHELD UNDER 10 CFR 2.390



Attachment B

Criticality Evaluation

CRITICALITY EVALUATION

GENERAL ELECTRIC COMPANY
MODEL NO. 700 CASK, DOCKET NO. 71-5942

INTRODUCTION

In the General Electric submittal letter of June 5, 1985, k-effective results were presented for a model that contained 10.9375 inches of lead closely surrounding the sides and bottom of a stainless steel basket containing 10 MTR-type fuel assemblies. The calculated k-effective value was 0.92363 ± 0.00740. The details of this close lead model giving this k-effective result are described below. A comparison of this result with a normal lead model used in the August 7, 1985, submittal giving a calculated k-effective of 0.88725 ± 0.00446 (Table 6.4-7 for 20 MTR-type assemblies for the August 7, 1985, submittal) also is provided.

COMPARISON

The k-effective result for the close lead model presented below is 0.90286 ± 0.00470. The k-effective result for the normal lead model is 0.88725 ± 0.00446. When a bias of 2.3% is applied to the mean value and 0.3% is applied to the one sigma value, these k-effective results become 0.92363 ± 0.00741 for the close lead model and 0.90766 ± 0.00712 for the normal lead model.

The close lead model does not represent the placement of the stainless steel basket containing the 10 MTR-type fuel elements in a GE 700 cask very well. For example, the lead is too close to the stainless steel basket along the top, bottom, and sides of the basket in this model. Furthermore, at the corners of the cask cavity, water appears in locations where there should be lead (see Figure 3). Therefore, the normal lead model better represents the accident condition for this shipment.

MODEL SPECIFICATION

The close lead model was for one cask under accident conditions and involved ten MTR-type fuel elements loaded in a basket that was fully flooded. Each MTR-type fuel element contained no more than 351 grams U-235 and was inserted in a spaced stainless steel fuel shipping basket described in GE Drawing No. 106D4150. The fuel element and basket assembly was further modeled to be inside a General Electric 700 cask. This cask has a cavity that is 15 inches in diameter by 40 inches long for holding the assembly. The cask is of steel-encased, lead-shielded construction. A cask OD of 36.875 inches and a cask ID of 15 inches were used to give a lead thickness of 10.9375 inches surrounding the sides of the basket. A lead thickness of 10.9375 inches also was used underneath the basket. Lead was used to replace the steel encasement.

DESCRIPTION OF CALCULATIONAL MODEL

In this calculation, each fuel plate in a fuel element and each fuel element in a basket was described in three dimensions discretely. The model was prepared as input to the SCALE System using the 27GROUPNDF4 cross-section set and the KENO-IV criticality code for performing the k-effective calculations. The fuel element modeling is described first. Then the modeling of the basket surrounded by lead is presented.

Each fuel element contained 20 plates: 18 fuel plates were in the middle of the fuel element, and 2 aluminum plates were at the top and bottom of each fuel element, respectively. Each fuel plate contained fuel meat that was 2.25 inches wide, 0.0228 inches thick, and 22.75 inches long. Each fuel plate contained 19.5 grams U-235 in this fuel meat space. The fuel meat was clad with 0.0136 inches of aluminum such that the fuel plate thickness became 0.05 inches.

Each fuel plate in the fuel element was separated by a gap of 0.096 inches in the center of the fuel element. These gap thicknesses changed in the outer three layers to 0.108 inches, 0.118 inches, and 0.100 inches, respectively. See Figure 1. The aluminum beyond the 2.25-inch width and the 22.75-inch length of the fuel meat was represented as water in this model. The numerical results of this modeling may be seen in Table 1 under Box Type 1 or Box Type 2.

The basket was modeled as a 304 stainless steel structure that had walls which were 0.25 inches thick and contained 10 holes that measured 3.18 inches square by 22.75 inches long. There were three holes in the upper and lower rows and four holes in the middle row sufficient to hold the 10 fuel elements. See Figure 2. The numerical results of this modeling may be seen in Table 1 under Box Type 1 and Box Type 2.

A slab of lead 10.9375 inches thick was then used to surround the basket on the top, bottom, sides, and underneath the basket. A 12-inch-thick layer of water was then used to surround the lead on the top, bottom, sides, and underneath portion of this assembly and on top of the basket in this model.

A plan view of this model may be seen in Figure 3. The Picture Code* was used with the generalized geometry option commands in the KENO-IV code on the SCALE System to construct Figure 3 for this model. Figure 3 shows that this model does not represent the placement of the stainless steel basket containing the 10 MTR-type fuel elements in a GE 700 cask very well. For example, the lead is too close to the stainless steel basket along the top, bottom and sides of the basket in this model. Furthermore, at the corners of the cask cavity, water appears in the locations where there should be lead. However, at the time this model was prepared, the generalized geometry input was not available.

*Irving, D. C. and Morrison, G. W., "PICTURE: An Aid In De-Bugging Geom Input Data", ORNL-TM-2892; May 14, 1970.

PACKAGE REGIONAL DENSITIES

The number densities for the materials used in this model may be seen in Table 2. The number density used for the fuel meat was 0.00261362 atom/barn-cm for U-235. A molecular weight of 235.043933 gram/gram-mole and Avogadro's number of 6.025E23 gram-atom/gram-mole were used in calculating this number density. Other materials in the fuel meat such as U-238, oxygen, silicon, etc., were not modeled. The number densities for the materials specified in Table 1 that are provided by the SCALE System for the 27GROUPNDF4 cross-section set are shown in Table 2.

CRITICALITY CALCULATIONS

The SCALE* System that is running on the Control Data Corporation 7600 computer at General Electric's Nuclear Energy Business Operations was used for the k-effective calculations. The 27GROUPNDF4 cross-section set and the KENO-IV criticality code in the SCALE System were used to perform these calculations. The k-effective result shown in Table 2 is 0.90286 ± 0.00470. A bias of 2.3% on the mean value and 0.3% on the 1 sigma deviation is applied here due to the comparison of k-effective results from the SCALE System and the 27GROUPNDF4 cross-section set with critical benchmark experiments. The k-effective result then becomes 0.9236 ± 0.0074. The bias is applied as follows: 0.90286 * 1.023 = 0.92363; .003 * .90286 + .00470 = .00741. The critical benchmark experiment discussion is contained in the June 5, 1985, letter.

*Bucholz, J. A., "SCALE: A Modular Code System for Performing Standardized Computer Analyses for Licensing Evaluation", NUREG/CR-0200, ORNL/NUREG/CSD/2, Volume 1, Oak Ridge National Laboratory; July, 1980.

FIGURE 1

FUEL ELEMENT SCHEMATIC

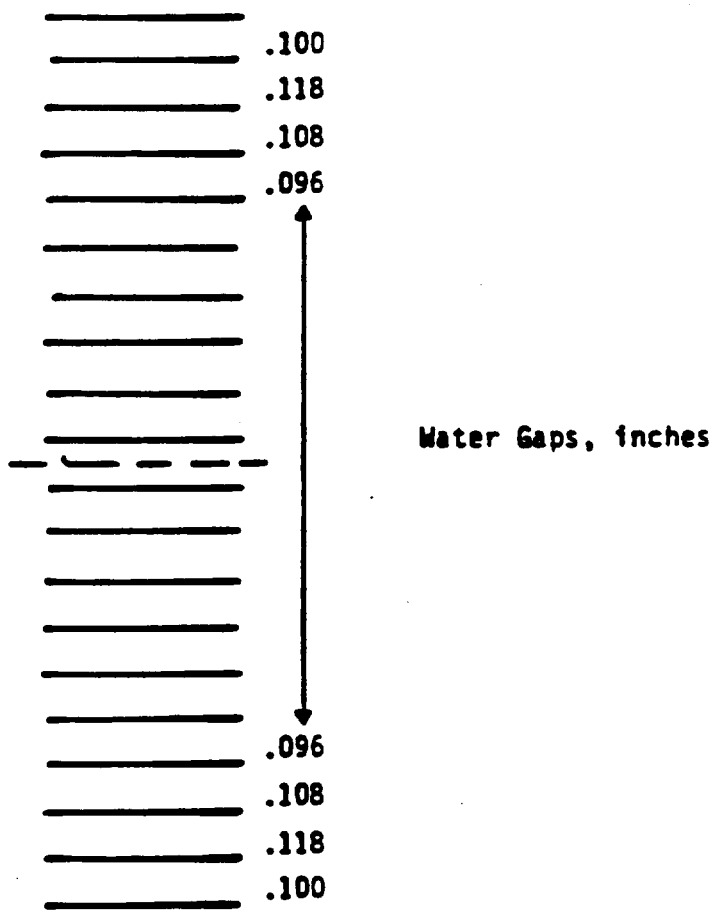
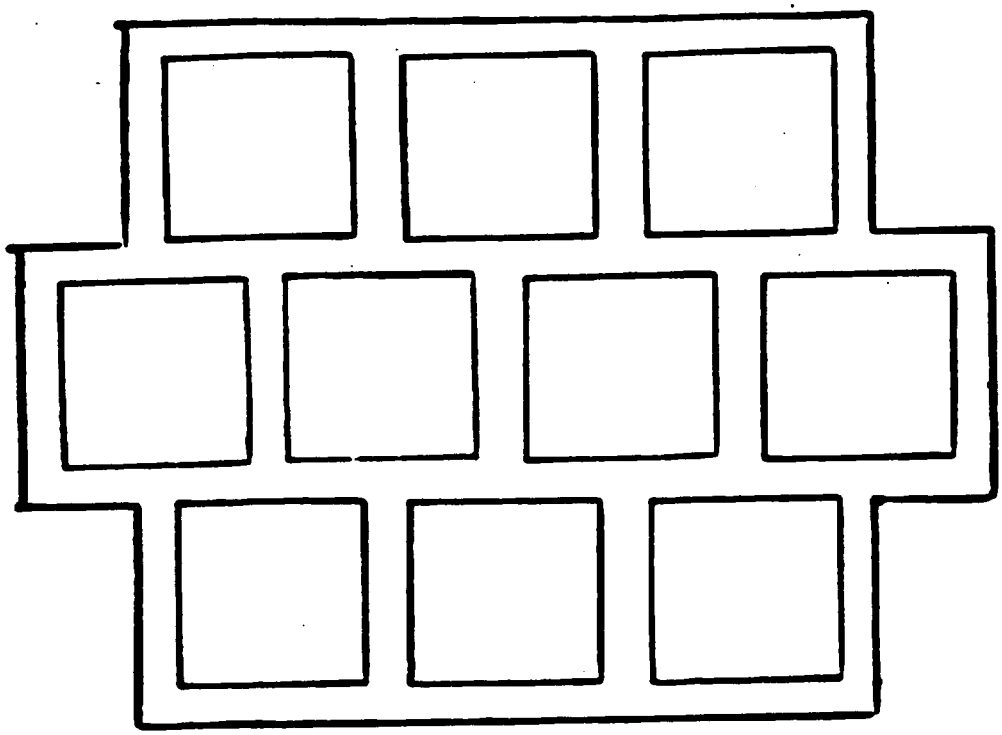


FIGURE 2

FUEL BASKET SCHEMATIC



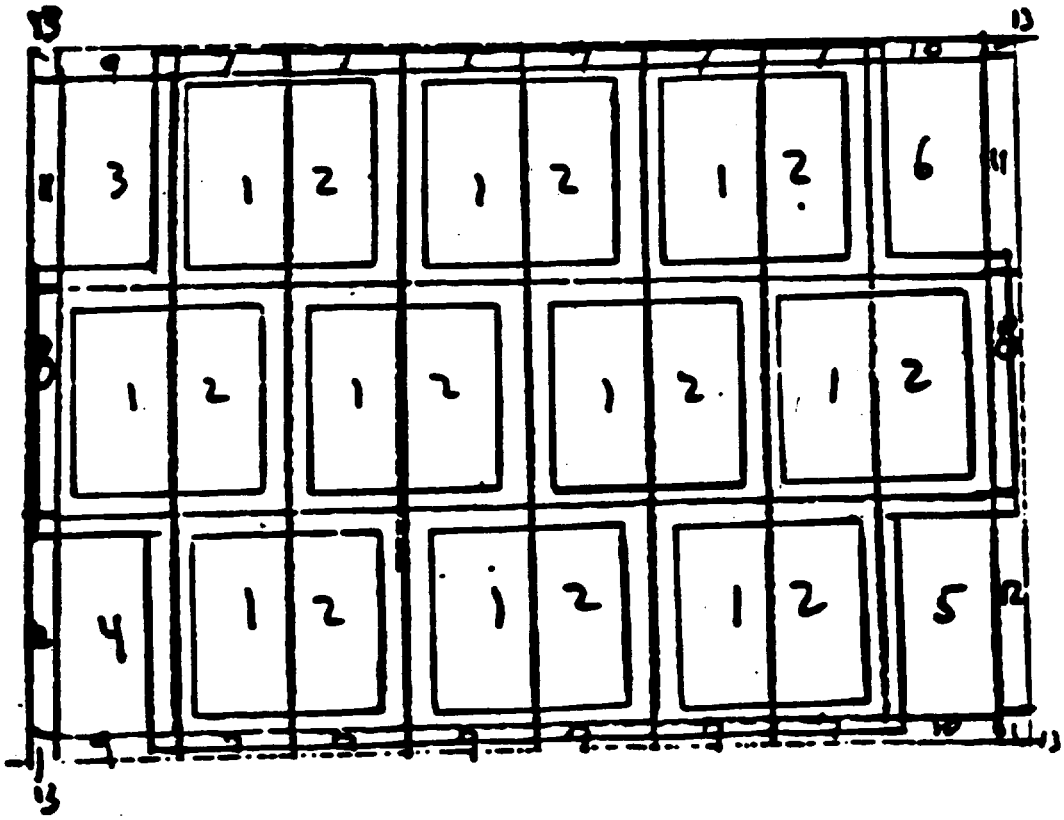


FIGURE 3
ENLARGED PLAN VIEW OF MODEL CONTENTS
PICTURE OF GENERALIZED GEOMETRY FOR KENO-IV
F=Fuel L=Lead S=Stainless Steel W=Water

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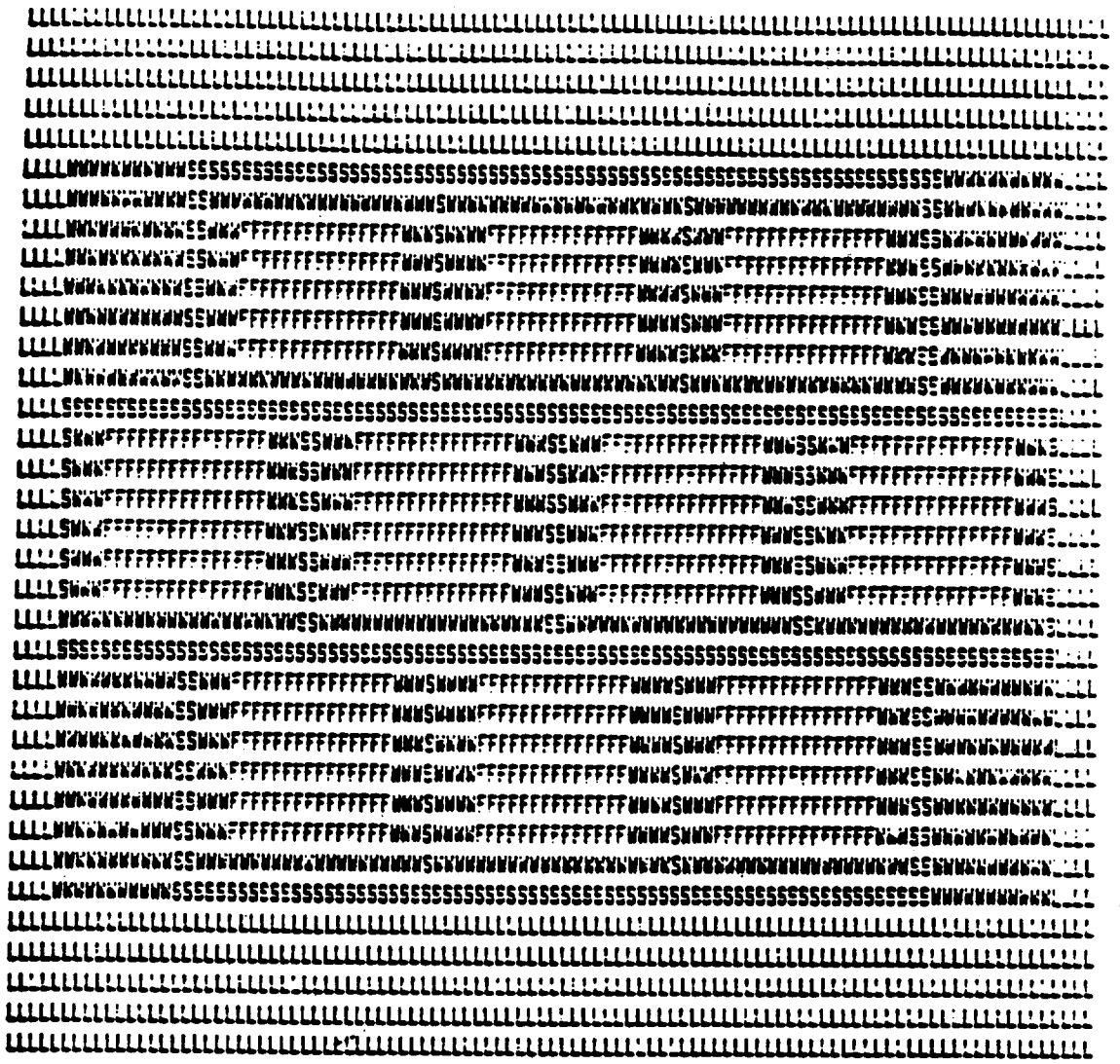

6.14.5 OWR Fuel Criticality Analysis

6.1. Discussion and Results

Fissile Class I mass limits were determined for OWR fuel elements in the BMI-1 shipping cask. Up to 24 OWR fuel elements each containing up to 240 grams of U^{235} in the basket (BMI drawing BCL-000-500) will remain subcritical during normal and credible abnormal shipping conditions. An infinite array of BMI casks, each loaded with 24 OWR fuel elements, is subcritical (k_{eff} = 0.837), and a Transport Index (TI) = 0 may be assigned to each shipment.

Subcriticality is maintained with the use of the aforementioned basket(s). These baskets contain neutron poison in the form of Boral plates built into the basket. To ensure the presence of the Boral, the maintenance procedures as outlined in Revision H of the Safety Analysis Report for The Model BMI-1 Shipping Cask must be performed prior to each use.

6.2. Package Fuel Loading

A series of criticality evaluations were made of the BMI-1 cask using the KENO V.a[1] computer code. The analyses were made for the exclusive shipment of irradiated OWR fuel elements.

Up to 24 OWR fuel elements each containing up to 240 grams of U^{235} in the basket (BMI drawing BCL-000-500) may be shipped in the BMI-1 cask.

6.3. Calculational Model

The fissile material was assumed to be contained in the fuel plates of each assembly. Figures 6.1 and 6.2 are representations of OWR fuel assemblies. The calculational model was based on the fueled region with average dimensions of 24.5 in. x 2.457 in. x 0.02 in. The average plate dimensions used were 24.625 in. x 2.797 in. x 0.05 in. The U^{235} modeled was taken to be 100% U^{235} [U(100)].

The configurational model of the modified BMI-1 cask used for the criticality analyses is shown in Figures 6.3 and 6.4 of Rev. H of the SARP.

Calculational models are described in Table 6.1 with atom densities for the several materials used listed in Table 6.2.

For calculational simplicity, it was desired to perform analyses with the fuel as homogenized within the cross sectional volume of the assembly. A calculation (Table 1, case 1) was performed to verify that this modeling assumption was valid. The results of this calculation were compared to a heterogeneous model (Table 1, case 2) where mass and volumes were

conserved. The results indicate that the homogenized fuel region is the more conservative (greater multiplication factor) of the two conditions, and, therefore, was used throughout the remainder of the calculations. The Boral loaded plates of the basket were modeled according to the BMI-1 Poison Plate drawing (number unreadable). Only the Boral and stainless steel were used during the calculations in the cavity of the cask. Credit was not taken for absorptive characteristics of other material(s) of which the basket is constructed.

A series of calculations (Cases 21-30) were performed to determine the sensitivity of multiplication factor versus percentage of boron present in the boral plates of the basket insert. The amount of boron present was reduced to 75% of the design level. For the several cases executed, it can be seen that the shipping cask will be subcritical during normal and hypothetical accident conditions of transport. However, as indicated in Section 6.1, "*Subcriticality is maintained with the use of the aforementioned basket(s). These baskets contain neutron poison in the form of Boral plates built into the basket. To ensure the presence of the Boral, the maintenance procedures as outlined in Revision H of the Safety Analysis Report for The Model BMI-1 Shipping Cask must be performed prior to each use*".

Table 6.1 Description of Calculational Models

Case	k_{eff}*	Description
1	0.060	Single fuel element with homogenized fuel region, flooded but not externally reflected.
2	0.053	Single fuel element with discrete fuel plates, flooded but not externally reflected..
3	0.035	Twenty-four fuel elements were modeled as dry, i.e., without water in the channels of the assembly, in a single bare cask, i.e., no external reflecting material (water).
4	0.051	Same as Case 3, except that the cask was externally reflected with 24-inches of full density water.
5	0.796	Same as Case 3 except water was added to the channels in each assembly. The remainder of the cask cavity was filled with full density water.
6	0.797	Same as Case 5 except that the cask was externally reflected with 24-inches of full density water.
7	1.063	Same as Case 3 except that the boral poison plates were replaced with full density water.
8	0.107	Same as Case 3 except 27 casks are in a 3 x 3 x 3 close-packed (touching), bare cubic array.
9	0.804	Same as Case 8 except water was added to the channels in each assembly. The remainder of the cask cavity was filled with full density water. Interstitial spaces between casks were filled with full density water.
10	0.820	Same as Case 5, except 27 casks are in a 3 x 3 x 3 bare cubic array.
11	0.805	Same as Case 10 but interstitial spaces between casks were filled with full density water.
12	0.805	Same as Case 11 but reflector material was water at 0.75 of full density.
13	0.817	Same as Case 12 but reflector material was water at 0.001 of full density.
14	0.806	Same as Case 13 but reflector material was water at 0.5 of full density.
15	0.804	Same as Case 14 but reflector material was water at 0.25 of full density.
16	0.805	Same as Case 15 but reflector material was water at 0.1 of full density.
17	0.287	Same as Case 3 but configured as an infinite array.
18	0.075	Same as Case 3 but configured as an infinite array with interstitial spaces between casks filled with full density water.
19	0.840	Same as Case 5 but configured as an infinite array without water in interstitial spaces between casks.
20	0.807	Same as Case 5 but configured as an infinite array with interstitial spaces between casks filled with full density water.

Table 6.1 Description of Calculational Models (Continued)

Case	k_{eff}*	Description
21	0.035	24 OWR fuel elements in a single, dry and bare cask; 75% of boron present in boral plates. (Same as Case 3 except for boron content).
22	0.801	24 OWR fuel elements in a cask with water added to the channels in each assembly; no external reflection; 75% of boron present in boral plates. (Same as Case 5 except for boron content.)
23	0.816	Same as Case 22 except that the cask was externally reflected with 24-inches of full density water.
24	0.855	Same as Case 19, except that 75% of boron present in boral plates.
25	0.813	Same as Case 20, except that 75% of boron present in boral plates.
26	0.303	Same as Case 17 except 75% of boron present in boral plates.
27	0.830	Same as Case 10 except 75% of boron present in borall plates.
28	0.875	Same as case 13 except 75% of boron present in boral plates.
29	0.813	Same as Case 28 except interstitial and thick water reflection at full density.
30	0.816	Same as Case 9 except 75% of boron present in boral plates.
		* All statistical standard deviations (σ) $\leq$ 0.004

Table 6.2. Material Atom Densities

Material	Isotope or Element	Atom Density, at/barn-cm
Fuel Assembly (wet)	U^{235}(100)	0.000183
	Al	0.0178
	H	0.047
	O	0.02358
Fuel Assembly (Dry)	U^{235}(100)	0.000183
	Al	0.0178
Aluminum	Al	0.0603
Lead	Pb	0.0332
Boral	B(nat)	0.03862
	C	0.00964
	Al	0.0367
Stainless Steel		Standard Mixture = 200 provided by KENO V.a
Water		Standard Mixture = 502 provided by KENO V.a

6.4. Criticality Calculations

The following subsections discuss the calculational methods and results of the multiplication factor analyses. These results confirm the cask loading limits provided in Section 6.1.

6.4.1. Calculational Method

KENO V.a[1] is a Monte Carlo criticality program used to calculate the multiplication factor (k_{eff}) of a three-dimensional system. The code employed the Hansen-Roach[2] 16-group cross sections. The calculations were completed when 50,000 neutron histories were completed. This number of histories was sufficient to give standard deviations of less than 0.005 for all cases. The first few generations (3) of each calculation were excluded in the computation of the mean.

The 16-group cross sections selected for the fissile isotope U^{235} were determined from the standard recipe (reproduced below from the original reference) which would determine the potential scattering cross section, σ_p. The notation specifies a scattering cross section per absorber atom for the mixture:[2]

$$\sigma_p = \Sigma\, \sigma_s \text{ (moderator) / N (atomic density of absorber atoms)}$$

Moderators considered have atomic weights less than or equal to 16.

6.4.2 Criticality Analyses Results

For the cases described in Table 6.1, calculational results are provided in therein.

From these results it can be seen that for all normal and credible abnormal conditions, up to 24-OWR fuel elements can be safely shipped in the BMI-1 shipping cask. Case 7, an exception to the above statement, results in a critical condition because the Boral poison plates were excluded from the model. This points to the need for the shipper to verify the presence of the Boral in the basket prior to each loading for shipment.

Complete computer input and output for all cases are maintained on-file.

6.5. Code Benchmarking and Validation

Although only KENO V.a was used for the analyses, four computer codes and two cross section sets were employed in the validation and benchmarking analyses in order to obtain results by different methods but with the same cross sections (three of the four). Two of the codes, MCNP[3] and KENO are Monte Carlo programs while the other two, ONEDANT[4] and TWODANT[5] are discrete ordinate transport programs based on the S_n method. Most of the analyses were performed with the Hansen-Roach 16-group cross sections while the runs made with MCNP

employed the continuous energy set, ENDF/B-V.

Table 6.4 lists the experimental, critical benchmarks and the calculated multiplication factors which provide the basis for establishing the computational bias. Benchmark experiments represent systems where both fast and thermal absorptions (fissions) dominate since the modeled package conditions also span these two conditions.

Complete computer input and output for all cases are maintained on file. Based on the fact that the differences between calculated and measured critical systems does not exceed 2% and is generally less than 1%, it was concluded that calculated multiplications factors not exceeding 0.97 were subcritical.

Table 6.3. Calculational Results of Benchmark Critical Experiments.

Case	k_{eff}	Code	Description
1.a	0.996	ONEDANT	Lady Godiva; bare;u(93); metal sphere (ref 8)
1.b	0.993	KENO	Lady Godiva; bare;u(93); metal sphere (ref 8)
1.c	0.997	MCNP	Lady Godiva; bare;u(93); metal sphere (ref 8)
2.a	1.005	ONEDANT	Jezebel; bare; pu(6); metal sphere (ref 8)
2.b	1.001*	KENO	Jezebel; bare; pu(6); metal sphere (ref 8)
2.c	1.004*	MCNP	Jezebel; bare; pu(6); metal sphere (ref 8)
3	1.001	ONEDANT	Flattop; U(93); metal sphere; reflected by U(.7) (ref 8)
4	0.996	ONEDANT	Flattop; U(53); metal sphere; reflected by U(.7) (ref 13)
5	0.994	ONEDANT	U(97); metal sphere in water (ref 6)
6	0.995	ONEDANT	Pu(5) metal sphere in water (ref 9)
7.a	0.994	TWODANT	Pu(3) solution at 109g/l, 9" cylinder (ref 10)
7.b	0.992*	KENO	Pu(3) solution at 109g/l, 9" cylinder (ref 10)
7.c	0.995*	MCNP	Pu(3) solution at 109g/l, 9" cylinder (ref 10)
8	0.996	TWODANT	Pu(3) solution at 109g/l, 12" cylinder (ref 10)
9	0.999	TWODANT	Pu(3) solution at 55g/l, 12" cylinder (ref 10)
10	1.002	TWODANT	Pu(3) solution at 49g/l, 12" cylinder (ref 10)
11	1.006	TWODANT	Pu(3) solution at 47g/l, 12" cylinder (ref 10)
12	0.992	TWODANT	Pu(3) solution at 39g/l, 12" cylinder (ref 10)
13	1.006	TWODANT	Pu(3) solution at 33g/l, 12" cylinder (ref 10)
14	1.000	TWODANT	Pu(1.5 solution) at 26g/l, 12" cylinder (ref 10)
15	0.004	TWODANT	Pu(1.5 solution) at 44.7g/l, 30cm cylinder (ref 11)
16	0.989	TWODANT	Pu(5 solution) at 38.0g/l, 13" cylinder (ref 11)
17	1.007	TWODANT	U93) solution at 54.9g/l, 33cm cylinder (ref 7)
18	0.999	TWODANT	U(93) solution at 137g/l, 33cm cylinder (ref 7)
19	1.001	TWODANT	U(93) solution at 357g/l, 33cm cylinder (ref 7)
20.a	1.008	TWODANT	U(93) solution at 144g/l, 28cm cylinder (ref 7)
20.b	1.009*	KENO	U(93) solution at 144g/l, 28cm cylinder (ref 7)
20.c	1.003*	MCNP	U(93) solution at 144g/l, 28cm cylinder (ref 7)
21	1.006	TWODANT	U(93) solution at 144g/l, 33cm cylinder (ref 12)
			*All Monte Carlo runs converged to $1\sigma \leq 0.003$.

6.5 References

1. L. M. Petrie & N. F. Landers," KENO V.a: An Improved Monte Carlo Criticality Program with Supergrouping," NUREG/CR-200, Volume 2, Section F11, ORNL/NUREG/CSD-2/V1/R2, 1984.

2. G. E. Hansen & W. H. Roach, "Six and Sixteen Group Cross Sections for Fast and Intermediate Critical Assemblies," Los Alamos National Laboratory report, LAMS-2543, November 1959.

3. J. F. Briesmeister, Ed., "MCNP - A General Monte Carlo Code for Neutron and Photon Transport, Version 3A," Los Alamos National Laboratory report LA-7396-M, Rev. 2, Manual, September 1986.

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11. J. G. Walford and A. F. Thomas, "The Equipment and Methods Used in British Criticality Laboratories," in Criticality Control in Chemical and Metallurgical Plant, Karlsruhe Symposium, 1961 (Organization for Economic Cooperation and Development, European Nuclear Energy

Agency, paris, 1961), pp. 553-558.

12. B. G. Dubovski, A. V. Kamaev, V. V. Orlov, G. M. Vladykov, V. N. Gurin, F. M. Kuznetsov, V. P. Kochergin, I. P. Markelov, G. A. Popov, and V. J. Sviridenko, "The Critical Parameters of Aqueous Solutions of $UO_2(NO_3)_2$ and Nuclear Safety," in Proceedings of the Third International Conference on the peaceful Uses Of Atomic Energy, Geneva, 1964 (United Nations, New York, 1965) Vol. 13, pp. 254-263.

FIGURE WITHHELD UNDER 10 CFR 2.390

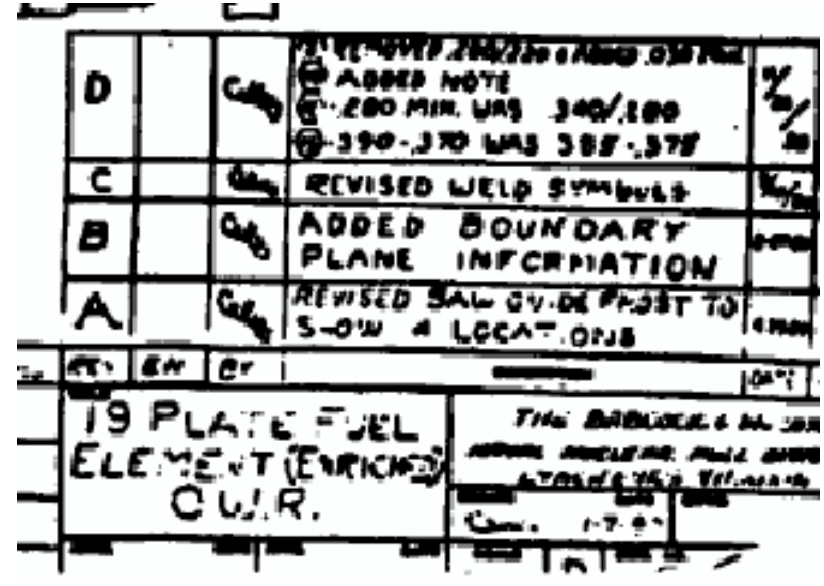

FIGURE WITHHELD UNDER 10 CFR 2.390

REVISIONS

ZN.	RN	DESCRIPTION	DATE	APPROVED
	A	REFERENCE EDGE. NOTE ADDED	3/20/81	
	B	[illegible]	7/21/83	Lewis

FIGURE WITHHELD UNDER 10 CFR 2.390

Figure 6.3. Elevation Cross-section of BMI Shipping Cask

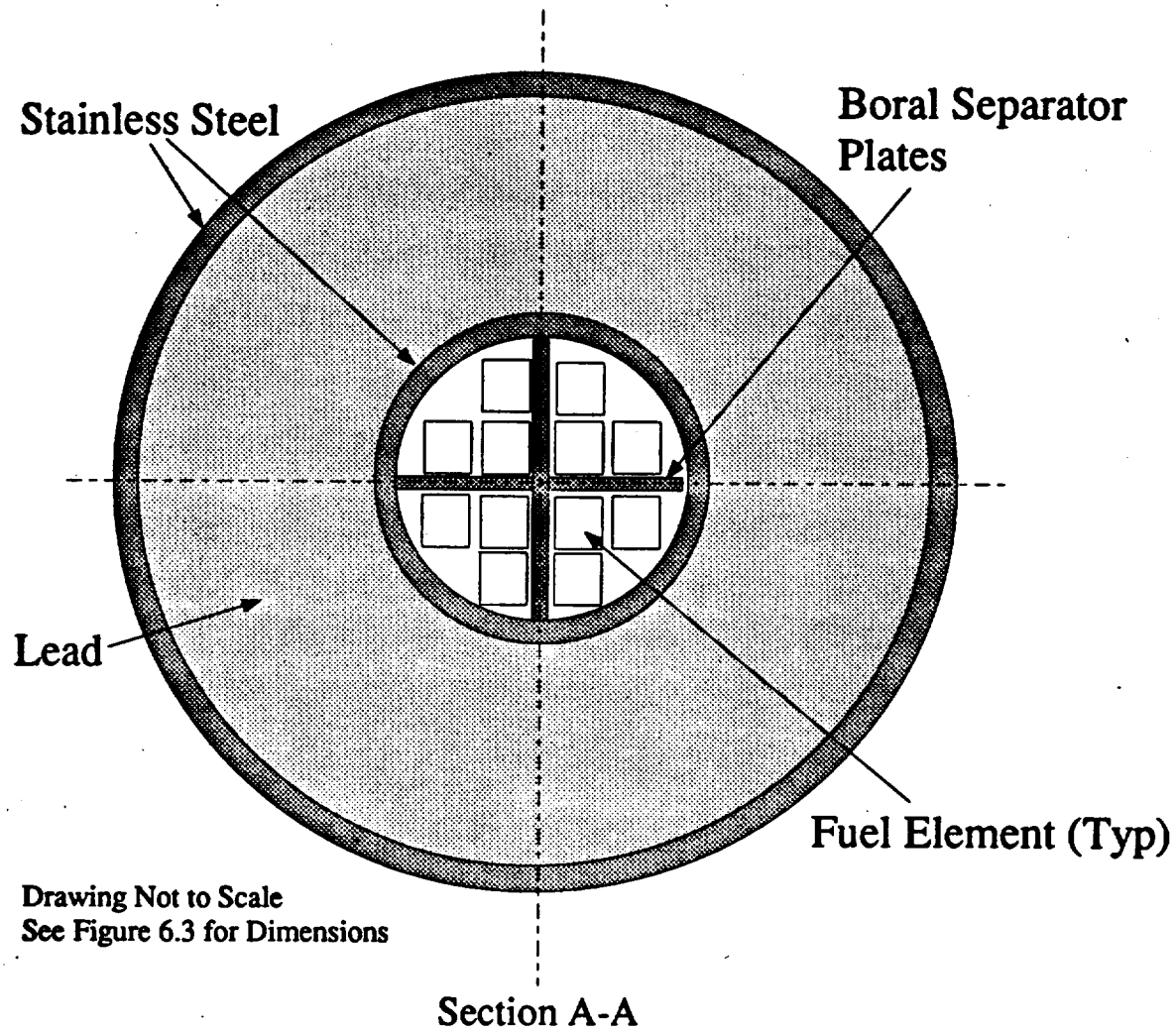

Figure 6.4. Plan Cross-section of BMI Shipping Cask

Document 30

6.14.6 NBSR Fuel Criticality Analysis

The NBSR fuel criticality analysis is based upon an earlier analysis performed for the NBSR stainless steel divider in the GE-700 Cask (Certificate No. 5942, Docket No. 71-5942). A copy of the Certificate is included in this section. Following the certificate are the original criticality evaluation and a copy of comparative criticality calculations showing that "crushed NBSR fuel elements are significantly more subcritical than whole elements."

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ATTACHMENT A

Copy of Certificate of Compliance No. 5942

NRC FORM 618
10 CFR 71

U.S. NUCLEAR REGULATORY COMMISSION

CERTIFICATE OF COMPLIANCE
FOR RADIOACTIVE MATERIALS PACKAGES

a. CERTIFICATE NUMBER	b. REVISION NUMBER	c. PACKAGE IDENTIFICATION NUMBER	d. PAGE NUMBER	e. TOTAL NUMBER PAGES
5942	14	USA/5942/B( )F	1	5

PREAMBLE

a. This certificate is issued to certify that the packaging and contents described in Item 5 below, meets the applicable safety standards set forth in Title 10, Code of Federal Regulations, Part 71, "Packaging and Transportation of Radioactive Material."

b. This certificate does not relieve the consignor from compliance with any requirement of the regulations of the U.S. Department of Transportation or other applicable regulatory agencies, including the government of any country through or into which the package will be transported.

3. THIS CERTIFICATE IS ISSUED ON THE BASIS OF A SAFETY ANALYSIS REPORT OF THE PACKAGE DESIGN OR APPLICATION

a. ISSUED TO (Name and Address)

General Electric Company
Vallecitos Nuclear Center
Pleasanton, CA 94566

b. TITLE AND IDENTIFICATION OF REPORT OR APPLICATION:

General Electric Company application dated dated May 30, 1985, as supplemented.

c. DOCKET NUMBER 71-5942

4. CONDITIONS

This certificate is conditional upon fulfilling the requirements of 10 CFR Part 71, as applicable, and the conditions specified below.

5.

(a) Packaging

(1) Model No.: 700

(2) Description

A steel encased lead shielded shipping cask enclosed by a double-walled protective jacket of the same shape with a rectangular baseplate. The cask is a double-walled steel circular cylinder, 37-inch-diameter by 65-inch high with a central cavity 15-inch-diameter by 40-inch high. Approximately 10.25 inches of lead surround the central cavity. The cask is equipped with a cavity drain line, pressure relief valve set at 100 psig, and lifting device. Closure is accomplished by a silicone rubber gasketed and bolted steel lead filled plug. The maximum gross weight of the package (contents, cask assembly, protective jacket and base) is 35,500 pounds.

The cask may be modified with a 14-inch high cavity extension with an additional silicone rubber gasket. The modified cask is 79 inches high. The maximum gross weight of the package (contents, modified cask assembly, protective jacket and base) is 40,000 pounds.

(3) Drawings

The packaging is constructed in accordance with the following General Electric Company Drawing Nos.: 129D4768, Rev. 3; 129D4769, Rev. 4; and 129D4770, Rev. 6.

Lifting and/or tie-down devices which are a structural part of the package must be in accordance with the above drawings.

U.S. NUCLEAR REGULATORY COMMISSION

5. (b) Contents

(1) Type and form of material

(i) Byproduct, source, and special nuclear material as solid oxide or metal in the form of fuel rods, or plates, fuel assemblies, or meeting the requirements of special form radioactive material.

(ii) Co-60 metal contained within sealed liner and sleeve described in Neutron Products, Inc. Drawing Nos. 240139, Sheets 1 through 3, Revision No. F and 240138, Revision No. -.

(2) Maximum quantity of material per package

Not to exceed 700 pounds (including shoring), and

(i) 740 gm U-235, provided that the maximum U-235 enrichment does not exceed 6 weight percent; or

(ii) 1,200 gm U-235, provided that the fuel material is in the form of MTR-type fuel elements with a minimum active fuel length of 23 inches; or

(iii) 220 gm fissile material; or

(iv) 1,650 gm U-235, provided that the maximum U-235 enrichment does not exceed 3.5 weight percent and the fuel material is in the form of 88 rods loaded with 0.376-inch-diameter pellets with a minimum active fuel length of 31 inches; or

(v) those values presented in Figure 1.20, Weight Limits for Model 700 Shipping Container, of Exhibit A to this application, applicable to fuel material in the form of rods with a minimum pellet diameter of 0.40 inch; or

(vi) 5,100 gm U-235, provided the fuel is in the form of ETR-type fuel elements (GETR Fuel) with each element containing no more than 510 gm U-235 and inserted in the spaced stainless steel fuel shipping basket described in GE Drawing No. 106D4150, Rev. 0.; or

(vii) 6,200 gm U-235, provided the fuel is in the form of MURR TRTR type elements containing not more than 775 gm U-235 per element; loaded and spaced in the stainless steel fuel shipping basket as described in MURR Drawing No. 1228, Sheets 1 thru 5, Revision 0. Fuel elements shall have at least 150 days cooling time since last reactor operation; or

(viii) 3,510 gm U-235 provided the fuel is in the form of MTR-type fuel elements with each element containing no more than 351 gm U-235 and inserted in a spaced stainless steel fuel shipping basket described in GE Drawing No. 106D4150, Rev. 1 for GETR fuel. A shoring device to limit vertical motion of the fuel elements must be included; or

5. (b) (2) (continued)

(ix) 7,020 gm U-235 provided the fuel is in the form of MTR-type fuel elements with each element containing no more than 351 gm U-235 inserted in a spaced stainless steel fuel shipping basket described in GE Drawing No. 106D4150, Rev. 1, for 24-inch length fuel. Each shipment must contain 20 fuel elements in 2 fuel baskets with the spacer plate shown on GE Drawing No. 218B6061, Rev. 0, located between the baskets. A shipment may contain less than 20 elements provided each absent element is replaced by an aluminum or steel spacer in the form of an open-ended pipe with a minimum outer diameter of 2.5 inches and a minimum wall thickness of 0.125 inches. The space must be of sufficient length to replace the absent fuel element;or

(x) 7,000 gm U-235 provided the fuel is in the form of MTR-type fuel sections with each section containing no more than 175 gm U-235 inserted into the stainless steel Cask Divider (fuel shipping basket) shown in General Electric Company Drawing No. 183C8253, Rev. 1. When a shipment contains less than the maximum number (40) of fuel sections, empty fuel section basket spaces must be provided with an aluminum or steel spacer in the form of an open-ended pipe with a minimum outer diameter of 2.5 inches and a minimum wall thickness of 0.125 inches. The spacer must be of sufficient length to replace the absent fuel sections; or

(xi) 6,300 gms U-235 provided the fuel is in the form of MTR-type fuel elements or sections with each fuel element or section having an average linear density of no more than 43 gms U-235 per inch of length. Each fuel element or section is inserted into the stainless steel cask divider shown in General Electric Company Drawing No. 183C8257, Rev. 0. When a shipment contains less than the maximum number of fuel elements and fuel sections, empty fuel basket spaces must be provided with an aluminum or steel spacer in the form of an open-ended pipe with a minimum outer diameter of 2.5 inches and a minimum wall thickness of 0.125 inches. The spacer must be of sufficient length to replace the absent fuel assembly and sections.

STATE OF NUCLEAR REGULATORY COMMISSION

5. (b) (3) Maximum quantity of radioactive decay heat per package

(i) 6,500 watts for dry shipments, or

(ii) 1,500 watts for wet shipments, provided that the cavity shall contain at least a 1,000 cu in air void (at standard temperature and pressure) at the time of delivery to a carrier for transport.

(c) Fissile Class III

Maximum number of packages per shipment 2

6. The liner required for Co-60 metal which does not meet the requirement for special form radioactive material, must be dried, leak tested, and back-filled with an inert gas in accordance with Enclosure 2, Rev. 2 to Neutron Products, Inc. letter dated February 28, 1986.

7. Shoring must be provided to minimize movement of contents during accident conditions of transport.

8. Prior to each shipment (except for contents meeting the requirements of special form radioactive material), the package must be leak tested by a method capable of determining that a leakage of 10^{-3} atm cm^3/s at standard temperature and pressure is not exceeded.

9. Prior to each shipment the silicone rubber hid gasket(s) must be inspected. This gasket(s) must be replaced if inspection shows any defects or every 12 months, whichever occurs first. Cavity drain line must be sealed with appropriate sealant applied to threads of pipe plug.

10. The applicant must confirm annually that the pressure relief valve is operable at 100 psig.

11. When needed, sufficient antifreeze in the cask must be used to prevent damage of any component of the package due to freezing.

12. Fabrication of additional packagings is not authorized.

13. The package authorized by this certificate is hereby approved for use under the general license provisions of 10 CFR §71.12.

14. Expiration date: July 31, 1990.

REFERENCES

General Electric application dated May 30, 1985.

General Electric supplements dated: June 5 and 7, August 7, and September 16, 1985; February 28, May 8, July 11, August 15, and November 26, 1986; and December 13, 1988 and April 15, 1989.

University of Missouri letter dated March 20, 1980.

Appendix 6-A regarding University of Missouri's quality assurance program is not considered part of this application.

Neutron Products, Inc. supplements dated: November 11, 1985; and February 28, March 11 and 31, April 1 and 10, 1986.

FOR THE U.S. NUCLEAR REGULATORY COMMISSION

Charles E. Macbonald, Chief
Transportation Certification Branch
Division of Fuel Cycle and
Material Safety, NMSS

Date: APR 18 1989

UNITED STATES NUCLEAR REGULATORY COMMISSION

CRITICALITY EVALUATION

A criticality evaluation of the General Electric 700 cask containing 40 National Bureau of Standards (NBS) fuel sections prepared for reprocessing is given below. This cask has a cavity that is 15 inches in diameter by 54.75 inches long for holding material, including special nuclear material. The cask is of steel-encased lead-shielded construction.

6.1 Conclusions

Compliance with 10CFR71.61 for Fissile Class III shipments is demonstrated below for one loading. This loading involves 40 MTR-type fuel sections cut for reprocessing and inserted in a stainless steel basket in the cask cavity. The basket provides a fixed neutron poison for the fuel sections. Each fuel section has 17 plates originally containing 10.294 grams U-235 of fully enriched uranium per plate. This gives 175 grams U-235 per fuel section and 7,000 grams U-235 per cask, without consideration of U-235 burnup.

Although the actual shipment will be made dry, the contents of the cask were assumed to be wet, as after the accident described in 10CFR71.73 the contents of the cask would be wet, and the loading and unloading activities for this shipment were assumed to be made under water.

In the discussion below, details of the package fuel loading are presented first. Then, a description of the models used to calculate the k-effective values for the fuel loading is presented. This is followed by the criticality calculation discussion for each of the models. Finally, the criticality benchmark experiments section is presented.

6.2 Package Fuel Loading

The type, form, and maximum quantity of special nuclear material per package are: 7,000 grams U-235 provided the fuel is in the form of MTR-type fuel sections with each section containing no more than 175 grams U-235 as described in NBS Drawing No. E-04-039, Revision 3 (attached) and inserted in a spaced

ainless steel fuel shipping basket described in GE Drawing No. SK-86-1 (Figure 6.3.1-2). The loading above qualifies as Fissile Class III under provisions of 10CFR71.61, and the maximum number of packages per shipment is one (1).

6.3 Model Specification

The model for normal conditions is two casks side by side, touching, and reflected on all sides by 12 inches of water. A cask outside diameter of 36.875 inches is used in this evaluation. This diameter provides the minimum spacing between the casks. When overpacks are installed on each of the casks, the separation distance between the casks is larger; so use of the 36.875-inch cask OD is conservative. Each cask contains a stainless steel fuel basket, and each fuel basket contains 40 plate-type fuel sections. The available space inside the cask is filled with water.

6.3.1 Description of Calculational Models

In the discussion below, the fuel modeling is presented first followed by the basket and cask modeling. Each of these models is prepared as input to the SCALE* System using the 27GROUPNDF4 cross-section set and the KENO-IV criticality code to perform the k-effective calculations.

Each fuel section contains 19 plates: 17 plates are in the middle of the fuel section and an aluminum end plate is at each outer end of each fuel section, respectively. Each fuel plate contains fuel meat that is 2.415 inches wide, 0.020 inches thick, and 10.90625 inches long. Each fuel plate contains 10.294 grams U-235 in this fuel meat space. The fuel meat is clad with 0.015 inches of aluminum such that the fuel plate thickness becomes 0.05 inches.

Each fuel plate is separated by a gap of 0.116 inches. Each aluminum end plate is 0.065 inches thick. The aluminum side plates are 0.188 inches thick, 3.265 inches high, 10.90625 inches long, and provide an overall width to the fuel

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Bucholz, J. A., "SCALE, A Modular Code System for Performing Standardized Computer Analyses for Licensing Evaluation", NUREG/CR-0200, ORNL/NUREG/CSD/2, Volume 1, Oak Ridge National Laboratory; July, 1980.

section of 3 inches. This leaves a space of 0.1045 inches between each aluminum side plate and the fuel meat, which is assumed to be filled with water. There is also a space of 1.15625 inches on the top end and the bottom end of each fuel section that is assumed to be water. See Figure 6.3.1-1. The numerical results of this modeling also may be seen in Table 6.3.1-5 on page 72.

The basket is modeled as a 304 stainless steel structure that has 10 locations to contain the fuel sections. A plan view of the basket is shown in Figure 6.3.1-2. The 304 stainless steel plates in this basket are 0.1875 inches thick, except for the three plates in the center of the basket which are 0.25 inches thick. The fuel basket extends the entire length of the cask cavity, and four fuel sections from Figure 6.3.1-1 (NBS Drawing No. E-04-039, Revision 3) are stacked on top of each other in each hole, giving a cask load of 40 fuel sections. The GE 700 cask is modeled radially as having a cavity of 15 inches in diameter, and then a radial thickness of 0.25 inches of 304 stainless steel, and then a radial thickness of 10.3125 inches of lead, and then a radial thickness of 0.375 inches of carbon steel; this gives an outside cask diameter of 36.875 inches. The bottom of the cask also is modeled as having a 0.25-inch thick plate of 304 stainless steel, a 10.3125-inch thick lead space, and a 0.375-inch thick carbon steel plate on the bottom. The top of the cask is modeled to be the same as the bottom of the cask except that the 0.375-inch thick plate on the top of the cask is modeled as 304 stainless steel rather than carbon steel.

A model of this fuel section-basket-cask arrangement is prepared as input to the criticality codes on the SCALE System using a fuel homogenization feature with the XSDRNPM code and a generalized geometry option available on the KENO-IV code. This model is described below.

Input to obtain homogenized fuel cross sections on a tape is shown in Table 6.3.1-1. Fuel homogenization is accomplished by two actions: the use of the SYMMSLABCELL card coupled with the use of material 500 to describe the fuel in Box Type 1 or Box Type 2. When the SCALE System encounters this input, the XSDRNPM code is then used to flux and volume weight the cross sections for the

0.020-inch thick meat, the 0.015-inch thick aluminum clad, and the 0.116-inch thick water between the plates, as specified on the SYMMSLABCELL card (in centimeters), into a homogeneous fuel material represented by material 500. The cross sections for all of the materials modeled in Table 6.3.1-1, including the homogenized fuel material, are captured on a magnetic tape (Tape No. 3 in the SCALE System) and may be used later in other calculations.

Input for two GE 700 casks that are side by side is shown in Table 6.3.1-2. This input uses the free-standing KENO-IV code on the SCALE System and the generalized geometry option available on that KENO-IV code. Cross section information reflecting the input shown in Table 6.3.1-1 was written on Tape No. 18643, and this tape is read in on Tape No. 4 in the two-cask model as shown in Table 6.3.1-2. Each cask contains a NBS stainless steel basket, and each basket contains 40 NBS fuel sections for reprocessing. All of the voids inside the cask are filled with water, and the two-cask array is reflected on all sides by 12 inches of water. The input in Table 6.3.1-2 also contains information for the starting of some neutrons in each column of fuel that exists in the two-cask array.

The fuel section-basket-cask arrangement is modeled with generalized geometry input, and this input may be seen in Table 6.3.1-3. This input may be checked with the Picture Code*.

A plan view of a cask containing a basket and 40 fuel sections that represents the results from the generalized geometry description and the Picture Code may be seen in Figures 6.3.1-3A through -3F. Figures 6.3.1-3A through -3C show the fueled portion of the model, and each enlargement shows more details of this model. Figures 6.3.1-3D through -3F show the details of the nonfueled portion of the model immediately above or below each fueled section vertically, where the stainless steel basket extends through the model but the aluminum and fuel are replaced by water.

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*Irving, D. C. and Morrison, G. W., "PICTURE: An Aid In De-Bugging Geom Input Data", ORNL-TM-2892; May 14, 1970.

In the generalized geometry model discussed thus far, the fuel sections are positioned in a basket such that they are as close to one another as they can be. It is not clear whether this case is more reactive, or one in which the outer fuel sections are pushed out as close as they can be to the lead in the cask. Therefore, some of the generalized geometry input in Table 6.3.1-3 was changed, and the results are shown in Figures 6.3.1-4A through -4C. The alterations made to the generalized geometry input are shown in Table 6.3.1-4.

Since the calculations made to validate the criticality codes on the SCALE System using the 27GROUPNDF4 cross-section set did not use homogenized fuel or generalized geometry, two additional models are required. In Table 6.3.1-5, a model for a 2x2 array of single NBS fuel sections prepared for reprocessing is shown in which the fuel, clad, and water gap details in the fuel section are modeled discretely. The space between the fuel plates and the space on the top and the bottom of each fuel section are filled with water, and the 2x2 array is reflected on all sides by 12 inches of water.

In Table 6.3.1-6, the same model is prepared as input to the free-standing KENO-IV code on the SCALE System using a generalized geometry description for the fuel meat-clad-water gap in each fuel section and using cross sections prepared by the fuel homogenization process.

6.3.2 Package Regional Densities

The number densities for the materials used in this analysis may be seen in Tables 6.3.1-1 and 6.3.1-2. The number density used for the fuel meat was 0.00305685 atom/barn-cm for U-235. This corresponds to a mass of 175 grams U-235 for each NBS fuel section prepared for reprocessing. A molecular weight of 235.043933 gram/gram-mole and an Avogadro's number of 6.025 E23 gram-atom/gram-mole were used in calculating this number density. Other materials in the fuel meat, such as U-238, silicon, etc., were not modeled. The number densities for the materials specified in Tables 6.3.1-1 and 6.3.1-2 that are provided by the SCALE System for the 27GROUPNDF4 cross-section set are shown in Tables 6.4-1 through 6.4-4.

6.4 Criticality Calculations

The results of four k-effective calculations are presented in this section. The SCALE System that is running on the Control Data Corporation 7600 Computer at General Electric's Nuclear Energy Business Operations was used for the k-effective calculations. The 27GROUPNDF4 cross-section set for the KENO-IV criticality code in the SCALE System was used. The results of these calculations may be seen in Tables 6.4-1 through 6.4-4. These results are discussed below.

In Table 6.4-1, a k-effective result is given for two casks side by side, each loaded with 40 NBS fuel sections prepared for reprocessing with the sections in each basket pushed as close to each other as possible. This condition represents the worst condition possible for this evaluation. These results give a mean k-effective of 0.892 and a one sigma value of 0.00460 for 30,000 neutron histories. However, when a bias of 2.3 percent is applied to the mean value and 0.3 percent is applied to the one sigma value, the peak k-effective at 2 sigma, rounded up, becomes 0.928 for 30,000 neutron histories. The bias is discussed is Section 6.5. This bias also is applied to all other k-effective results described below.

In Table 6.4-2, k-effective results are given for a similar model to those in Table 6.4-1, but with four of the fuel sections in each basket pushed out as closely as possible to the lead in the cask. These results give a mean value of 0.834, a one sigma value of 0.00538, or a peak value of 0.869 for 30,000 neutron histories when the biases are applied.

In Tables 6.4-3 and 6.4-4, the k-effective results for the 2x2 array for the discrete fuel section modeling and for the generalized geometry homogenized fuel section modeling are given, respectively. These results show the peak k-effective to be 0.7259 for the discrete fuel section modeling and 0.7242 for the homogenized fuel section modeling, giving a difference of 0.0017 in k-effective. These results are nearly identical.

6.5.1 Benchmark Experiments and Applicability

Uranium with enrichments varying from 1.3 w/o to fully enriched and plutonium are the fissile materials that are considered in the validation of SCALE for this evaluation. The forms include fully enriched homogeneous uranium-water mixtures, low-enriched heterogeneous uranium dioxide-water mixtures, and homogeneous plutonium-water mixtures.

In Table 6.5.1-1 below, critical experiments suitable for validation are identified.

6.5.2 Details of the Benchmark Calculations

Models of TRX-1 and TRX-2 prepared as input to the SCALE System are shown in Tables 6.5.2-1 and 6.5.2-2, respectively. Models of ORNL-1 and ORNL-2 are shown in Table 6.5.2-3. Models of PNL-1 and PNL-2 are shown in Table 6.5.2-4. Models of the B&W UO_2 rod and MO_2 rod are shown in Table 6.5.2-5.

6.5.3 K-Effective Results of the Benchmark Calculations

K-effective results are presented for the ORNL, PNL, TRX, and B&W critical experiments in Table 6.5.3-1.

It is concluded that use of the SCALE System using the 27GROUPNDF4 cross-section set requires a negative 0.3 percent bias on the one sigma deviation for fully enriched uranium solutions and no bias for plutonium solutions; a negative bias of 2.3 percent on the mean value and 0.3 percent on the one sigma deviation for the multiplication factor must be applied for low-enriched, clumped uranium rods in water.

FIGURE WITHHELD UNDER 10 CFR 2.390

FIGURE WITHHELD UNDER 10 CFR 2.390

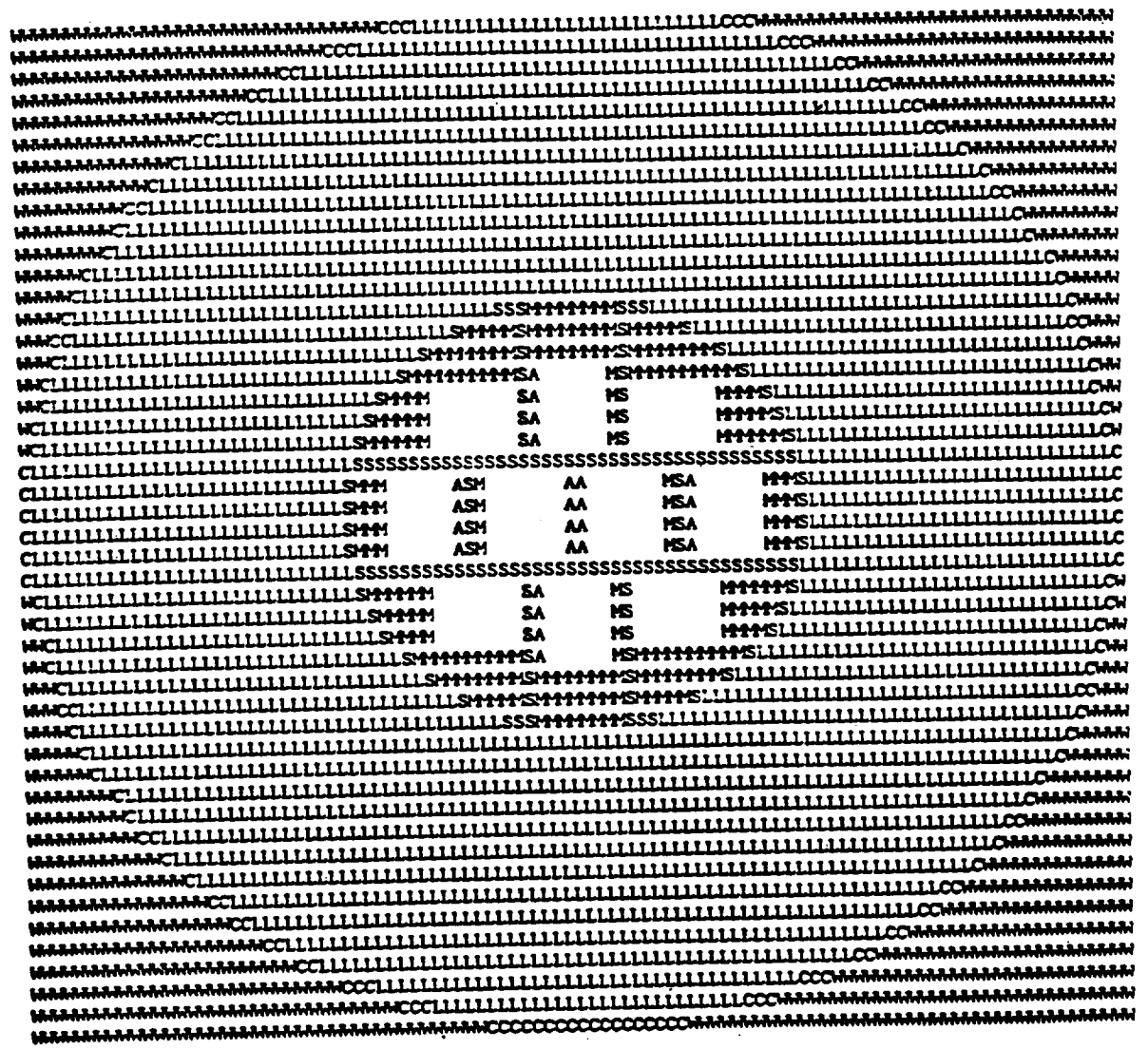
Figure 6.3.1-2

Shipping Basket

FIGURE 6.3.1-3A
TOTAL CASK

X -0.4700E 02 0.4700E 02
Y 0.4700E 02 -0.4700E 02
Z 0. 0.

NU= 48 NV= 100 DELU= 0.1958E 01 DELV= 0.9400E 00

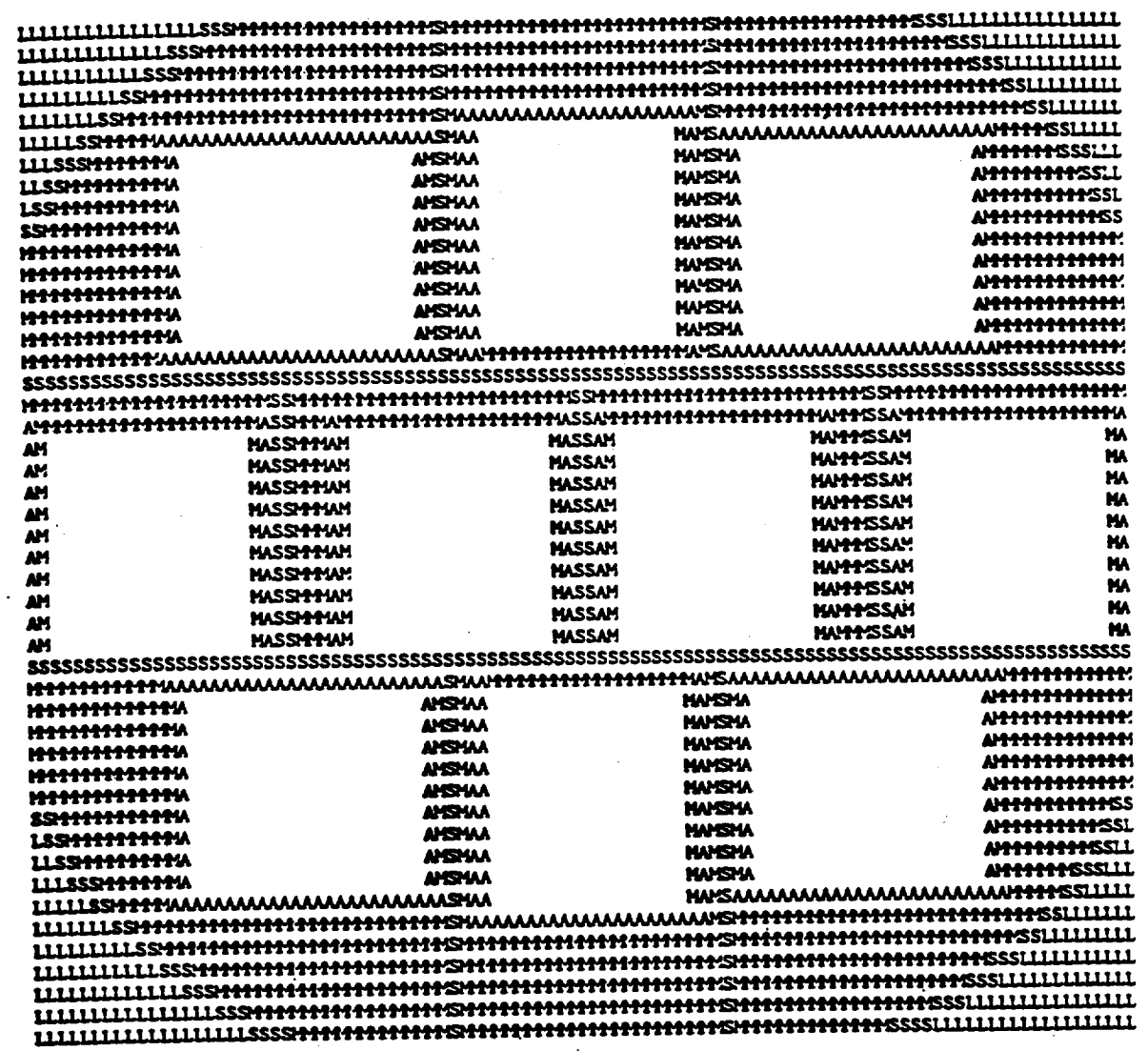


FUEL = · · WATER IN CASK = M 304SS = S ALUMINUM = A LEAD = L CARBON STEEL = C WATER OUTSIDE CASK = W

FIGURE 6.3.1-3B
CENTRAL CASK

X -0.1700E 02 0.1700E 02
Y 0.1700E 02 -0.1700E 02
Z 0. 0.

NU= 48 NV= 100 DELU= 0.7083E 00 DELV= 0.3400E 00

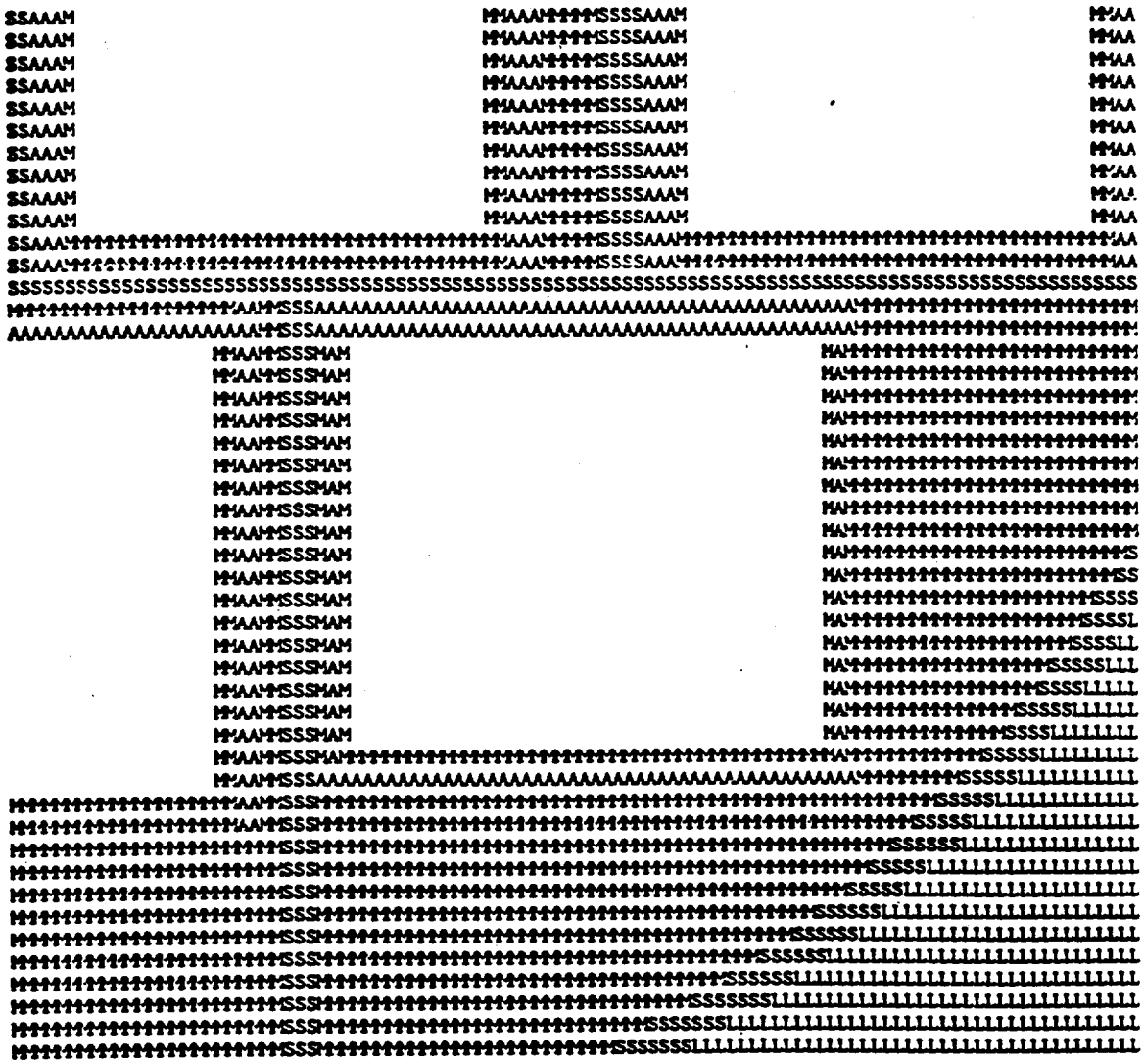


FUEL = ' ' WATER IN CASK = M 304SS = S ALUMINUM = A LEAD = L CARBON STEEL = C WATER OUTSIDE CASK = W

FIGURE 6.3.1-3C
CENTRAL CASK LOWER RIGHT CORNER

X 0. 0.1700E 02
Y 0. -0.1700E 02
Z 0. 0.

NU= 48 NV= 100 DELU= 0.3542E 00 DELV= 0.1700E 00

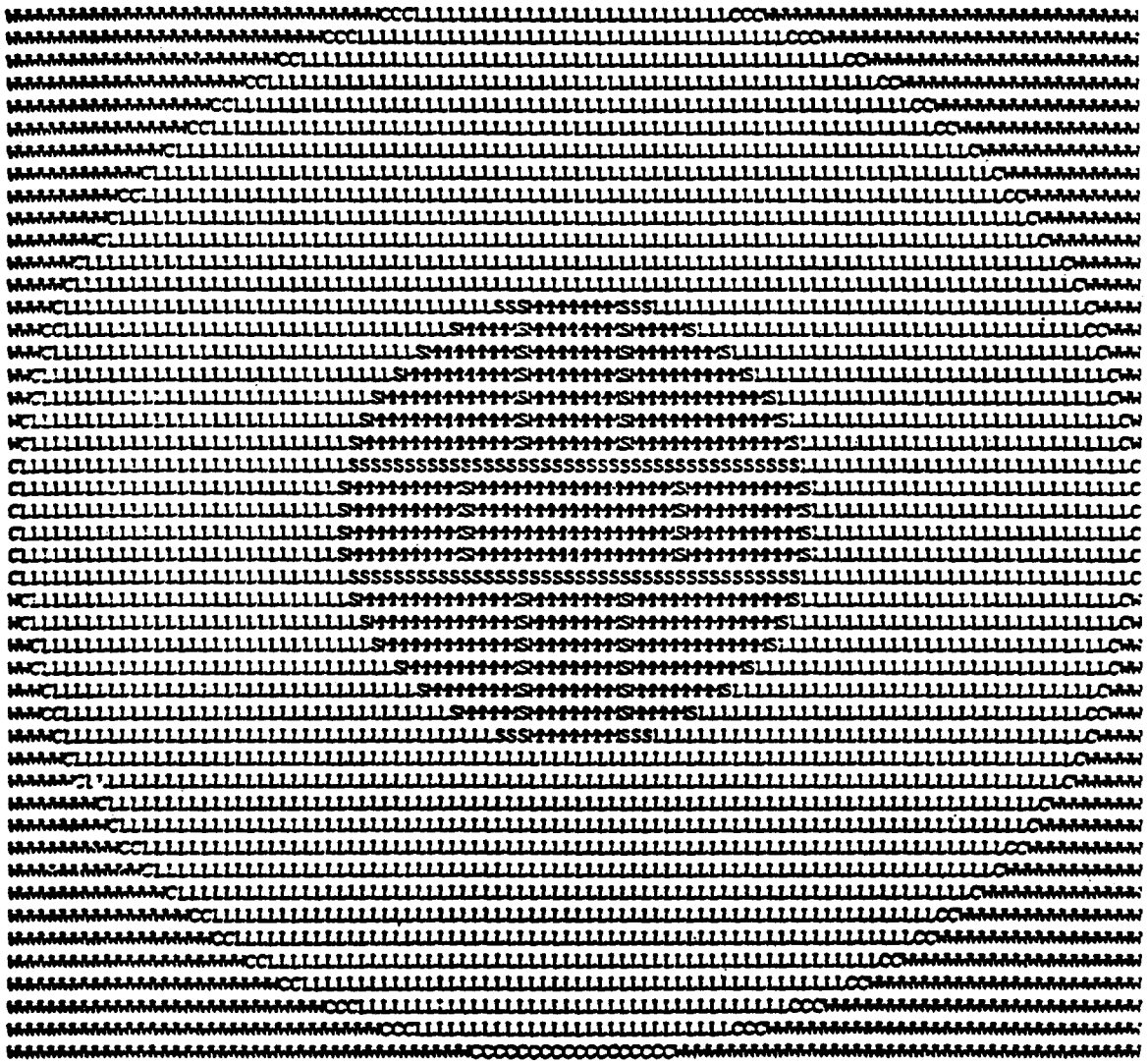


FUEL = ' ' WATER IN CASK = M 304SS = S ALUMINUM = A LEAD = L CARBON STEEL = C WATER OUTSIDE CASK = W

FIGURE 6.3.1-3D
TOTAL CASK BELOW OR ABOVE FUEL ELEMENT

X	-0.4700E 02	0.4700E 02
Y	0.4700E 02	-0.4700E 02
Z	-0.1600E 02	-0.1600E 02

NU= 48 NV= 100 DELU= 0.1958E 01 DELV= 0.9400E 00

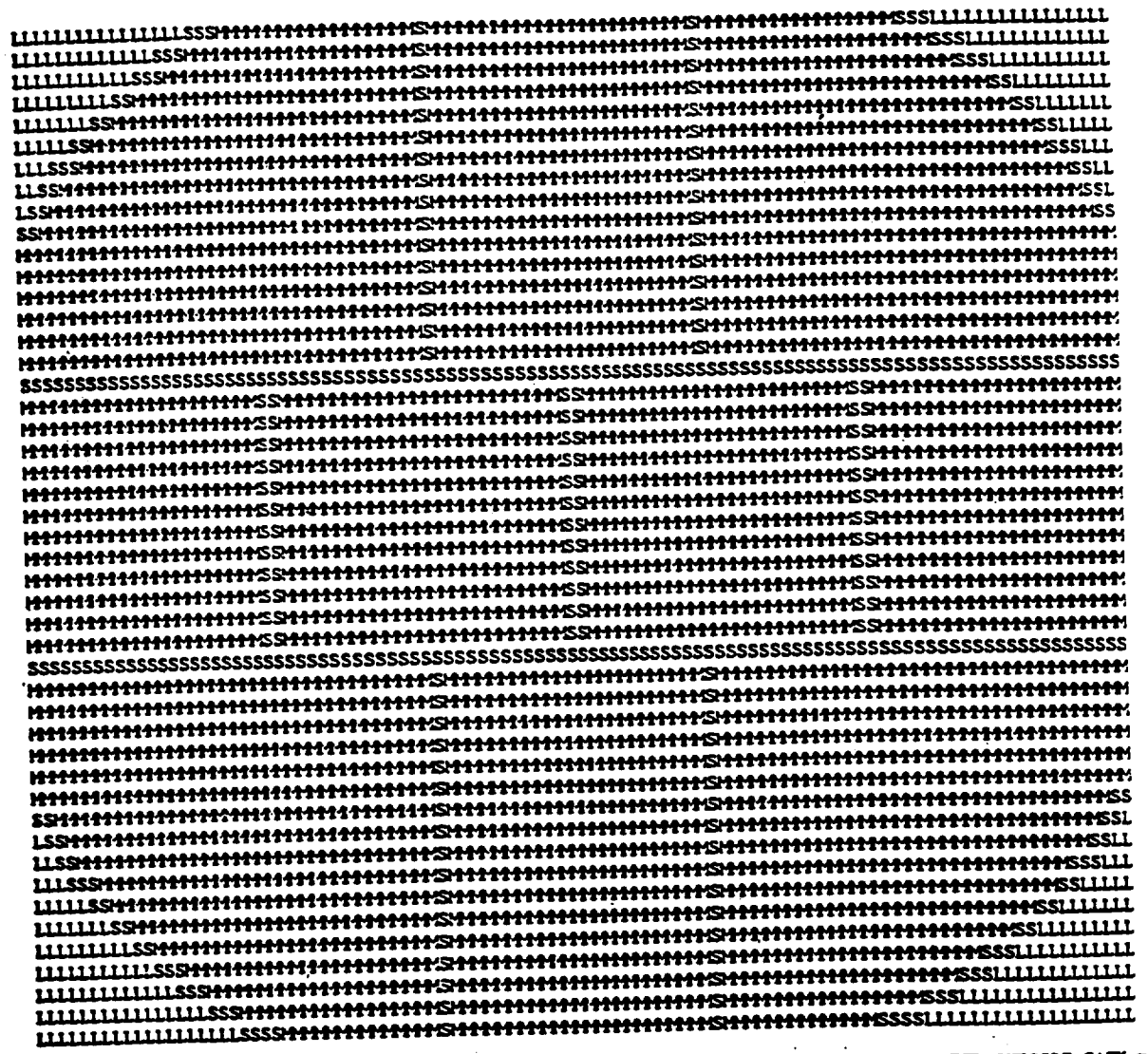


FUEL = ' ' WATER IN CASK = M 304SS = S ALUMINUM = A LEAD = L CARBON STEEL = C WATER OUTSIDE CASK = W

FIGURE 6.3.1-3E
CENTRAL CASK BELOW OR ABOVE FUEL ELEMENT

X	-0.1700E 02	0.1700E 02
Y	0.1700E 02	-0.1700E 02
Z	-0.1600E 02	-0.1600E 02

NU= 48 NV= 100 DELU= 0.7083E 00 DELV= 0.3400E 00



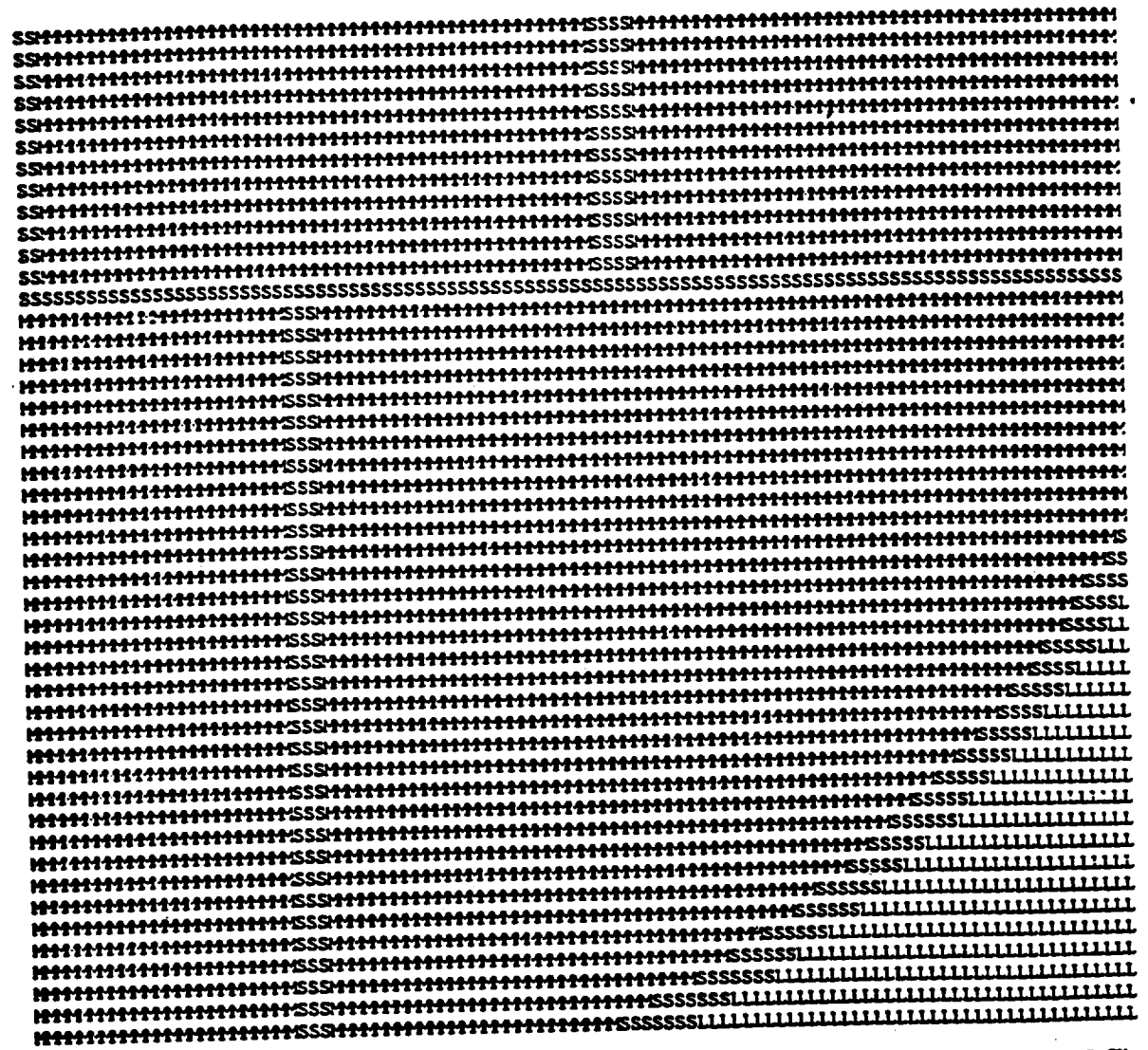
FUEL = · · WATER IN CASK = M 304SS = S ALUMINUM = A LEAD = L CARBON STEEL = C WATER OUTSIDE CASK = W

FIGURE 6.3.1-3F

CENTRAL CASK LOWER RIGHT CORNER BELOW OR ABOVE FUEL ELEMENT

X	0.	0.1700E 02
Y	0.	-0.1700E 02
Z	-0.1600E 02	-0.1600E 02

NU= 48 NV= 100 DELU= 0.3542E 00 DELV= 0.1700E 00

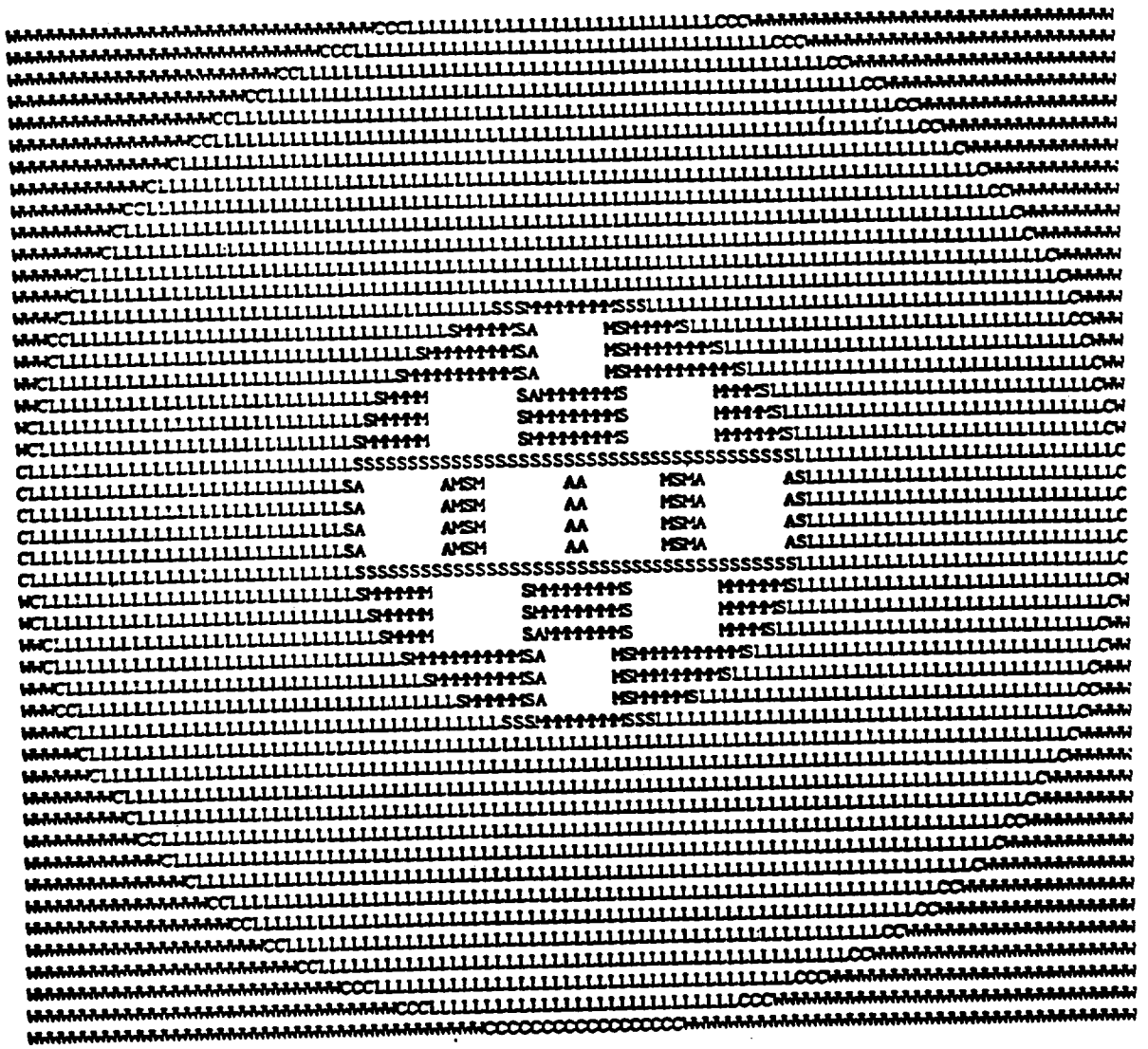


FUEL = · · WATER IN CASK = M 304SS = S ALUMINUM = A LEAD = L CARBON STEEL = C WATER OUTSIDE CASK = W

FIGURE 6.3.1-4A
TOTAL CASK FUEL OUT TO LEAD

X -0.4700E 02 0.4700E 02
Y 0.4700E 02 -0.4700E 02
Z 0. 0.

NU= 46 NV= 100 DELU= 0.1958E 01 DELV= 0.9400E 00



FUEL = · · WATER IN CASK = M 304SS = S ALUMINUM = A LEAD = L CARBON STEEL = C WATER OUTSIDE CASK = W

FIGURE 6.3.1-4B

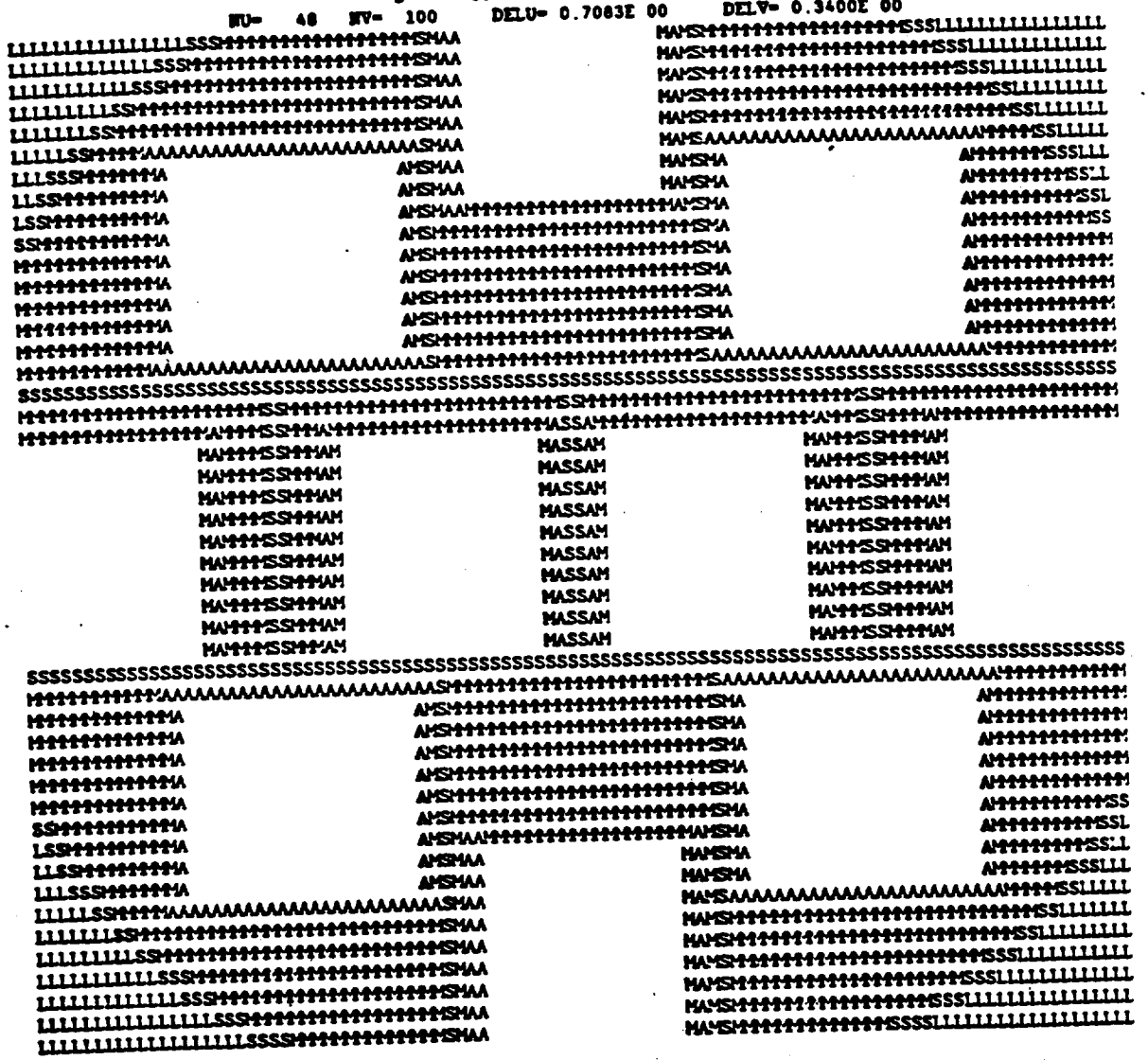
CENTRAL CASK FUEL OUT OT LEAD

X -0.1700E 02 0.1700E 02

Y 0.1700E 02 -0.1700E 02

Z 0. 0.

NU= 48 NV= 100 DELU= 0.7083E 00 DELV= 0.3400E 00



FUEL = ' ' WATER IN CASK = M 304SS = S ALUMINUM = A LEAD = L CARBON STEEL = C WATER OUTSIDE CASK = W

FIGURE 6.3.1-4C

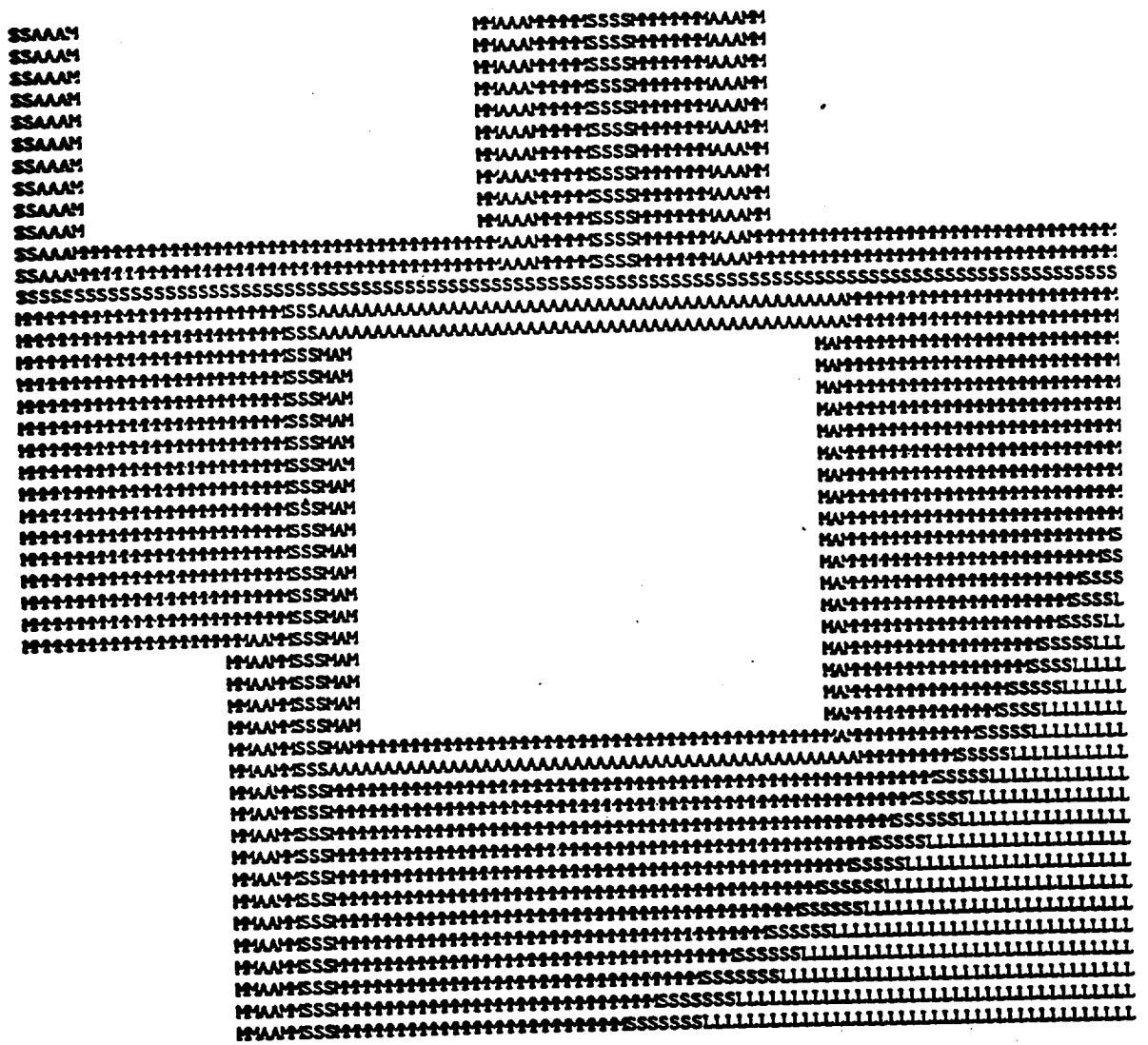
CENTRAL CASK LOWER RIGHT CORNER FUEL OUT TO LEAD

X 0. 0.1700E 02

Y 0. -0.1700E 02

Z 0. 0.

NU= 48 NV= 100 DELU= 0.3542E 00 DELV= 0.1700E 00



FUEL = · · WATER IN CASK = M 304SS = S ALUMINUM = A LEAD = L CARBON STEEL = C WATER OUTSIDE CASK = W

TABLE 6.3.1-1

KEFF NBS FUEL MODEL TO GET HOMOGENIZED FUEL CROSS-SECTION TAPE

```
$$ASIS,ROUT(BL),T(:,8,16),KEYW(WRL)
$:IDENT:VXXX,WRL,VVV18,X4447
$:USERID:FS9911$XXX
$:NEED:P1
$:SELECT:CDCJOB
JOBNM,STMFZ,SN,T176.
CHARGE.
STAGE,TAPE3,PE,POST,RP=730.
ATTACH(LLOYD,PROCLIB,ID=SCALE)
LIBRARY(LLOYD)
SCALE,CSAS2.
EXIT.
***EOS
KEFF NBS FUEL MODEL TO GET HOMOGENIZED FUEL CROSS-SECTION TAPE
27GROUPNDF4  9  9  3  LATTICECELL  0  0
U-235  1 0. 0.003056845 END
AL  2 1. END
H2O  3 1. END
AL  4 1. END
H2O  5 8.8-5 END
SS304  6 1. END
H2O  7 1. END
PB  8 1. END
CARBONSTEEL  9 1. END
SYMMSLABCELL      0.42164 0.0508 1 3 0.127 2 END
KEFF NBS FUEL MODEL TO GET HOMOGENIZED FUEL CROSS-SECTION TAPE
5.0 5 300 3 2 2 1 4 0
BOX TYPE    1
CUBOID  500 3.0670  -3.0670   3.70628  -3.70628  13.8510 -13.8510 -0.5
CUBOID  7   3.0670  -3.0670   3.8605  -3.8605  13.8510 -13.8510 -0.5
CUBOID  4   3.8100  -3.8100   3.9875  -3.9875  13.8510 -13.8510 -0.5
CUBOID  7   3.8100  -3.8100   4.4082  -4.1466  16.7880 -17.0260 -0.5
CUBOID  5   4.28625  -4.28625   4.4082  -4.7933  16.7880 -17.0260 -0.5
CUBOID  6   4.52438  -4.52438   4.6463  -5.0314  16.7880 -17.0260 -0.5
BOX TYPE    2
CUBOID  500 3.0670  -3.0670   3.70628  -3.70628  13.8510 -13.8510 -0.5
CUBOID  7   3.0670  -3.0670   3.8605  -3.8605  13.8510 -13.8510 -0.5
CUBOID  4   3.8100  -3.8100   3.9875  -3.9875  13.8510 -13.8510 -0.5
CUBOID  7   3.8100  -3.8100   4.4082  -4.1466  16.7880 -17.0260 -0.5
CUBOID  5   4.28625  -4.28625   4.4082  -4.7933  16.7880 -17.0260 -0.5
CUBOID  9   4.52438  -4.52438   4.6463  -5.0314  16.7880 -17.0260 -0.5
ARRAY BDY  5 9.04876 -9.04876 9.6777 -0. 135.256 -0. -0.5
CUBOID  8 11.58876 -11.58876 12.2177 -2.54 137.796 -2.54 -0.5
CUBOID  6 42.06876 -42.06876 42.6977 -33.02 168.276 -33.02 -0.5
END GEOMETRY
1 1 2 1 1 1 1 1 4 1 0 2 2 2 1 1 1 1 1 4 1 9
END KENO
***EOI
$:ENDJOB
```

TABLE 6.3.1-2
TWO CASK MODEL INPUT

```
$$ASIS,ROUT(BL),T(:,8,16),KEYWORD(WRL)
$:IDENT:VXXX,WRL,VVV18,X4447
$:USERID:FS9911$XXX
$:NEED:P1
$:SELECT:CDCJOB
JOBNM,STMFZ,SN,T4444.
CHARGE.
STAGE,TAPE4,PE,PRE,VSN=018643.
ATTACH(LLOYD,PROCLIB,ID=SCALE)
LIBRARY(LLOYD)
KENO.
EXIT.
***EOS
KEFF NBS FUEL SHPNG ARRY FWR HOMO FUEL GEN GEOM 1. 2 CSK
15. 103 300 3 27 27 16 10 20 19 3 2 1 6 -16 0 0 2000 00 6 1 1 0 0 104 00 0 0
         1    -92235   3.05685E-03    10    -92235   3.68295E-04
         2     13027   6.02383E-02    10     13027   1.08864E-02
         3      1001   6.67555E-02    10      1001   4.66484E-02
         3      8016   3.33777E-02    10      8016   2.33242E-02
         4         3   6.02383E-02
         5         5   5.87448E-06     5         8   2.93724E-06
         6     24304   1.74239E-02     6     25055   1.73634E-03
         6     26304   5.93526E-02     6     28304   7.72036E-03
         7         6   6.67555E-02     7         9   3.33777E-02
         8     82000   3.29882E-02
         9      6012   3.92145E-03     9     26000   8.34952E-02
BOX TYPE  1
GENERAL  10 6*0.0 27*0.5
GENERAL  7 6*0.0 27*0.5
GENERAL  6 6*0.0 27*0.5
GENERAL  7 6*0.0 27*0.5
GENERAL  8 6*0.0 27*0.5
GENERAL  9 6*0.0 27*0.5
GENERAL  4 6*0.0 27*0.5
CUBOID  7 46.84000 -46.84000 46.84000 -46.84000 16.7900 -16.7900 27*0.5
BOX TYPE  2
CYLINDER  8 45.87875 26.19375 -0. 27*0.5
CYLINDER  9 46.83125 26.19375 -0. 27*0.5
CYLINDER  6 46.83125 27.14625 -0.635 27*0.5
CUBOID  7 46.84000 -46.84000 46.84000 -46.84000 27.14625 -0.635 27*0.5
BOX TYPE  3
CYLINDER  8 45.87875 26.19375 -0. 27*0.5
CYLINDER  9 46.83125 26.19375 -0. 27*0.5
CYLINDER  6 46.83125 26.82875 -0. 27*0.5
CYLINDER  9 46.83125 26.82875 -0.9525 27*0.5
CUBOID  7 46.84000 -46.84000 46.84000 -46.84000 26.82875 -0.9525 27*0.5
CORE BDY  7 93.68 -93.68 46.84 -46.84 94.94125 -94.94125 27*0.5
CUBOID  7 124.16 -124.16 77.32 -77.32 125.42125 -125.42125 27*0.5
1 1 2 1 1 1 1 1 6 1 0 2 1 2 1 1 1 1 1 1 1 0 3 1 2 1 1 1 1 6 6 1 9
GENERALIZED GEOMETRY GOES HERE
15 1 1 3 -8.65 -8.9 0. 30 1 1 3 0. -9.22 0. 45 1 1 3 8.65 -8.9 0.
60 2 1 3 -8.65 -8.9 0. 75 2 1 3 0. -9.22 0. 90 2 1 3 8.65 -8.9 0.
105 1 1 3 -13.33 0. 0. 120 1 1 3 -4.5 0. 0. 135 1 1 3 4.5 0. 0.
150 2 1 3 -13.33 0. 0. 165 2 1 3 -4.5 0. 0. 180 2 1 3 4.5 0. 0.
195 1 1 3  13.33 0. 0. 210 2 1 3  13.33 0. 0.
225 1 1 3 -8.65 8.9 0. 240 1 1 3 0. 9.22 0. 255 1 1 3 8.65 8.9 0.
270 2 1 3 -8.65 8.9 0. 240 2 1 3 0. 9.22 0. 300 2 1 3 8.65 8.9 0.
END KENO
***EOI
$:ENDJOB
```

TABLE 6.3.1-3
STEEL BASKET MODEL FOR
KENO GENERALIZED GEOMETRY

```
   2
ZONE1 XENDS -46.83125,  -4.52438,   4.52438,  46.83125
ZONE1 YENDS -46.83125,  -5.08000,   5.08000,  46.83125
ZONE1 ZENDS -16.78788, -13.85100,  13.85100,  16.78788
ZONE      1    1    2
BLOK1 XENDS -46.83125, -12.81749, -12.57111, -12.40601, -12.25869,
  -5.09081,  -4.94349,  -4.77839,  -4.52439, -4.52438
BLOK1 YENDS -46.83125, -12.70000, -12.22248, -11.95705,  -5.82295,
  -5.55752,  -5.08100,  -5.08000
BLOK1 ZENDS -13.85100,  13.85100
BLOCK     1    1    1
MEDIA           2,    3,    5,    6,    4
SURFACES        1,    2,    3,    4
SECTOR -1  0  0  0
SECTOR  1 -1  0  0
SECTOR  0  1 -1  0
SECTOR  0  0  1 -1
SECTOR  0  0  0  1
BLOCK     2    1    1
MEDIA           2,    3,    5,    6,    4
SURFACES        1,    2,    3,    4
SECTOR -1  0  0  0
SECTOR  1 -1  0  0
SECTOR  0  1 -1  0
SECTOR  0  0  1 -1
SECTOR  0  0  0  1
BLOCK     3    1    1
MEDIA           2,    3,    5,    6,    4
SURFACES        1,    2,    3,    4
SECTOR -1  0  0  0
SECTOR  1 -1  0  0
SECTOR  0  1 -1  0
SECTOR  0  0  1 -1
SECTOR  0  0  0  1
BLOCK     4    1    1
MEDIA           2,    3,    5,    6,    4
SURFACES        1,    2,    3,    4
SECTOR -1  0  0  0
SECTOR  1 -1  0  0
SECTOR  0  1 -1  0
SECTOR  0  0  1 -1
SECTOR  0  0  0  1
BLOCK     5    1    1
MEDIA           2,    3,    5,    6,    4
SURFACES        1,    2,    3,    4
SECTOR -1  0  0  0
SECTOR  1 -1  0  0
SECTOR  0  1 -1  0
SECTOR  0  0  1 -1
SECTOR  0  0  0  1
BLOCK     6    1    1
MEDIA           2,    3,    5,    6,    4
SURFACES        1,    2,    3,    4
SECTOR -1  0  0  0
SECTOR  1 -1  0  0
SECTOR  0  1 -1  0
```

TABLE 6.3.1-3 (Cont-2/50)
STEEL BASKET MODEL FOR
KENO GENERALIZED GEOMETRY

```
SECTOR  0  0  1 -1
SECTOR  0  0  0  1
BLOCK     7    1    1
MEDIA          2,   3,   5,   6,   4
SURFACES       1,   2,   3,   4
SECTOR -1  0  0  0
SECTOR  1 -1  0  0
SECTOR  0  1 -1  0
SECTOR  0  0  1 -1
SECTOR  0  0  0  1
BLOCK     8    1    1
MEDIA          2,   3,   5,   6,   4
SURFACES       1,   2,   3,   4
SECTOR -1  0  0  0
SECTOR  1 -1  0  0
SECTOR  0  1 -1  0
SECTOR  0  0  1 -1
SECTOR  0  0  0  1
BLOCK     9    1    1
MEDIA          2,   3,   5,   6,   4
SURFACES       1,   2,   3,   4
SECTOR -1  0  0  0
SECTOR  1 -1  0  0
SECTOR  0  1 -1  0
SECTOR  0  0  1 -1
SECTOR  0  0  0  1
BLOCK     1    2    1
MEDIA          2,   3,   5,   6,   4
SURFACES       1,   2,   3,   4
SECTOR -1  0  0  0
SECTOR  1 -1  0  0
SECTOR  0  1 -1  0
SECTOR  0  0  1 -1
SECTOR  0  0  0  1
BLOCK     2    2    1
MEDIA          7
BLOCK     3    2    1
MEDIA          7
BLOCK     4    2    1
MEDIA          7
BLOCK     5    2    1
MEDIA          7
BLOCK     6    2    1
MEDIA          7
BLOCK     7    2    1
MEDIA          7
BLOCK     8    2    1
MEDIA          7
BLOCK     9    2    1
MEDIA          7
BLOCK     1    3    1
MEDIA          2,   3,   5,   6,   4
SURFACES       1,   2,   3,   4
SECTOR -1  0  0  0
SECTOR  1 -1  0  0
SECTOR  0  1 -1  0
```

TABLE 6.3.1-3 (Cont-3/50)
STEEL BASKET MODEL FOR
KENO GENERALIZED GEOMETRY

```
SECTOR  0  0  1 -1
SECTOR  0  0  0  1
BLOCK     2    3    1
MEDIA            2
BLOCK     3    3    1
MEDIA            7
BLOCK     4    3    1
MEDIA            2
BLOCK     5    3    1
MEDIA            2
BLOCK     6    3    1
MEDIA            2
BLOCK     7    3    1
MEDIA            7
BLOCK     8    3    1
MEDIA            2
BLOCK     9    3    1
MEDIA            2
BLOCK     1    4    1
MEDIA            2,   3,   5,   6,   4
SURFACES         1,   2,   3,   4
SECTOR -1  0  0  0
SECTOR  1 -1  0  0
SECTOR  0  1 -1  0
SECTOR  0  0  1 -1
SECTOR  0  0  0  1
BLOCK     2    4    1
MEDIA            2
BLOCK     3    4    1
MEDIA            7
BLOCK     4    4    1
MEDIA            2
BLOCK     5    4    1
MEDIA            1
BLOCK     6    4    1
MEDIA            2
BLOCK     7    4    1
MEDIA            7
BLOCK     8    4    1
MEDIA            2
BLOCK     9    4    1
MEDIA            2
BLOCK     1    5    1
MEDIA            2,   3,   5,   6,   4
SURFACES         1,   2,   3,   4
SECTOR -1  0  0  0
SECTOR  1 -1  0  0
SECTOR  0  1 -1  0
SECTOR  0  0  1 -1
SECTOR  0  0  0  1
BLOCK     2    5    1
MEDIA            2
BLOCK     3    5    1
MEDIA            7
BLOCK     4    5    1
MEDIA
```

TABLE 6.3.1-3 (Cont-4/50)
STEEL BASKET MODEL FOR
KENO GENERALIZED GEOMETRY


```
BLOCK     5    5    1
MEDIA           2
BLOCK     6    5    1
MEDIA           2
BLOCK     7    5    1
MEDIA           7
BLOCK     8    5    1
MEDIA           2
BLOCK     9    5    1
MEDIA           2
BLOCK     1    6    1
MEDIA           2,   3,   5,   6,   4
SURFACES        1,   2,   3,   4
SECTOR -1  0  0  0
SECTOR  1 -1  0  0
SECTOR  0  1 -1  0
SECTOR  0  0  1 -1
SECTOR  0  0  0  1
BLOCK     2    6    1
MEDIA           7
BLOCK     3    6    1
MEDIA           7
BLOCK     4    6    1
MEDIA           7
BLOCK     5    6    1
MEDIA           7
BLOCK     6    6    1
MEDIA           7
BLOCK     7    6    1
MEDIA           7
BLOCK     8    6    1
MEDIA           7
BLOCK     9    6    1
MEDIA           7
BLOCK     1    7    1
MEDIA           2,   3,   5,   6,   4
SURFACES        1,   2,   3,   4
SECTOR -1  0  0  0
SECTOR  1 -1  0  0
SECTOR  0  1 -1  0
SECTOR  0  0  1 -1
SECTOR  0  0  0  1
BLOCK     2    7    1
MEDIA           2
BLOCK     3    7    1
MEDIA           2
BLOCK     4    7    1
MEDIA           2
BLOCK     5    7    1
MEDIA           2
BLOCK     6    7    1
MEDIA           2
BLOCK     7    7    1
MEDIA           2
BLOCK     8    7    1
MEDIA           2
```

TABLE 6.3.1-3 (Cont-5/50)
STEEL BASKET MODEL FOR
KENO GENERALIZED GEOMETRY

```
BLOCK     9    7    1
MEDIA          2
ZONE      3    1    2
BLOK1 XENDS   4.52438,   4.52439,   4.77839,   4.94349,   5.09081,
  12.25869,  12.40601,  12.57111,  12.81749,  46.83125
BLOK1 YENDS -46.83125, -12.70000, -12.22248, -11.95705,  -5.82295,
  -5.55752,  -5.08100,  -5.08000
BLOK1 ZENDS -13.85100,  13.85100
BLOCK     1    1    1
MEDIA          2,    3,    5,    6,    4
SURFACES       1,    2,    3,    4
SECTOR -1  0  0  0
SECTOR  1 -1  0  0
SECTOR  0  1 -1  0
SECTOR  0  0  1 -1
SECTOR  0  0  0  1
BLOCK     2    1    1
MEDIA          2,    3,    5,    6,    4
SURFACES       1,    2,    3,    4
SECTOR -1  0  0  0
SECTOR  1 -1  0  0
SECTOR  0  1 -1  0
SECTOR  0  0  1 -1
SECTOR  0  0  0  1
BLOCK     3    1    1
MEDIA          2,    3,    5,    6,    4
SURFACES       1,    2,    3,    4
SECTOR -1  0  0  0
SECTOR  1 -1  0  0
SECTOR  0  1 -1  0
SECTOR  0  0  1 -1
SECTOR  0  0  0  1
BLOCK     4    1    1
MEDIA          2,    3,    5,    6,    4
SURFACES       1,    2,    3,    4
SECTOR -1  0  0  0
SECTOR  1 -1  0  0
SECTOR  0  1 -1  0
SECTOR  0  0  1 -1
SECTOR  0  0  0  1
BLOCK     5    1    1
MEDIA          2,    3,    5,    6,    4
SURFACES       1,    2,    3,    4
SECTOR -1  0  0  0
SECTOR  1 -1  0  0
SECTOR  0  1 -1  0
SECTOR  0  0  1 -1
SECTOR  0  0  0  1
BLOCK     6    1    1
MEDIA          2,    3,    5,    6,    4
SURFACES       1,    2,    3,    4
SECTOR -1  0  0  0
SECTOR  1 -1  0  0
SECTOR  0  1 -1  0
SECTOR  0  0  1 -1
SECTOR  0  0  0  1
```

TABLE 6.3.1-3 (Cont-6/50)
STEEL BASKET MODEL FOR
KENO GENERALIZED GEOMETRY

```
BLOCK     7    1    1
MEDIA            2,    3,    5,    6,    4
SURFACES         1,    2,    3,    4
SECTOR -1  0  0  0
SECTOR  1 -1  0  0
SECTOR  0  1 -1  0
SECTOR  0  0  1 -1
SECTOR  0  0  0  1
BLOCK     8    1    1
MEDIA            2,    3,    5,    6,    4
SURFACES         1,    2,    3,    4
SECTOR -1  0  0  0
SECTOR  1 -1  0  0
SECTOR  0  1 -1  0
SECTOR  0  0  1 -1
SECTOR  0  0  0  1
BLOCK     9    1    1
MEDIA            2,    3,    5,    6,    4
SURFACES         1,    2,    3,    4
SECTOR -1  0  0  0
SECTOR  1 -1  0  0
SECTOR  0  1 -1  0
SECTOR  0  0  1 -1
SECTOR  0  0  0  1
BLOCK     9    2    1
MEDIA            2,    3,    5,    6,    4
SURFACES         1,    2,    3,    4
SECTOR -1  0  0  0
SECTOR  1 -1  0  0
SECTOR  0  1 -1  0
SECTOR  0  0  1 -1
SECTOR  0  0  0  1
BLOCK     8    2    1
MEDIA            7
BLOCK     7    2    1
MEDIA            7
BLOCK     6    2    1
MEDIA            7
BLOCK     5    2    1
MEDIA            7
BLOCK     4    2    1
MEDIA            7
BLOCK     3    2    1
MEDIA            7
BLOCK     2    2    1
MEDIA            7
BLOCK     1    2    1
MEDIA            7
BLOCK     9    3    1
MEDIA            2,    3,    5,    6,    4
SURFACES         1,    2,    3,    4
SECTOR -1  0  0  0
SECTOR  1 -1  0  0
SECTOR  0  1 -1  0
SECTOR  0  0  1 -1
SECTOR  0  0  0  1
```

TABLE 6.3.1-3 (Cont-7/50)
STEEL BASKET MODEL FOR
KENO GENERALIZED GEOMETRY

```
BLOCK     8    3    1
MEDIA           2
BLOCK     7    3    1
MEDIA           7
BLOCK     6    3    1
MEDIA           2
BLOCK     5    3    1
MEDIA           2
BLOCK     4    3    1
MEDIA           2
BLOCK     3    3    1
MEDIA           7
BLOCK     2    3    1
MEDIA           2
BLOCK     1    3    1
MEDIA           2
BLOCK     9    4    1
MEDIA           2,   3,   5,   6,   4
SURFACES        1,   2,   3,   4
SECTOR -1  0  0  0
SECTOR  1 -1  0  0
SECTOR  0  1 -1  0
SECTOR  0  0  1 -1
SECTOR  0  0  0  1
BLOCK     8    4    1
MEDIA           2
BLOCK     7    4    1
MEDIA           7
BLOCK     6    4    1
MEDIA           2
BLOCK     5    4    1
MEDIA           1
BLOCK     4    4    1
MEDIA           2
BLOCK     3    4    1
MEDIA           7
BLOCK     2    4    1
MEDIA           2
BLOCK     1    4    1
MEDIA           2
BLOCK     9    5    1
MEDIA           2,   3,   5,   6,   4
SURFACES        1,   2,   3,   4
SECTOR -1  0  0  0
SECTOR  1 -1  0  0
SECTOR  0  1 -1  0
SECTOR  0  0  1 -1
SECTOR  0  0  0  1
BLOCK     8    5    1
MEDIA           2
BLOCK     7    5    1
MEDIA           7
BLOCK     6    5    1
MEDIA           2
BLOCK     5    5    1
MEDIA           2
```

TABLE 6.3.1-3 (Cont-8/50)
STEEL BASKET MODEL FOR
KENO GENERALIZED GEOMETRY


```
BLOCK     4    5    1
MEDIA           2
BLOCK     3    5    1
MEDIA           7
BLOCK     2    5    1
MEDIA           2
BLOCK     1    5    1
MEDIA           2
BLOCK     9    6    1
MEDIA           2,   3,   5,   6,   4
SURFACES        1,   2,   3,   4
SECTOR -1  0  0  0
SECTOR  1 -1  0  0
SECTOR  0  1 -1  0
SECTOR  0  0  1 -1
SECTOR  0  0  0  1
BLOCK     8    6    1
MEDIA           7
BLOCK     7    6    1
MEDIA           7
BLOCK     6    6    1
MEDIA           7
BLOCK     5    6    1
MEDIA           7
BLOCK     4    6    1
MEDIA           7
BLOCK     3    6    1
MEDIA           7
BLOCK     2    6    1
MEDIA           7
BLOCK     1    6    1
MEDIA           7
BLOCK     9    7    1
MEDIA           2,   3,   5,   6,   4
SURFACES        1,   2,   3,   4
SECTOR -1  0  0  0
SECTOR  1 -1  0  0
SECTOR  0  1 -1  0
SECTOR  0  0  1 -1
SECTOR  0  0  0  1
BLOCK     8    7    1
MEDIA           2
BLOCK     7    7    1
MEDIA           2
BLOCK     6    7    1
MEDIA           2
BLOCK     5    7    1
MEDIA           2
BLOCK     4    7    1
MEDIA           2
BLOCK     3    7    1
MEDIA           2
BLOCK     2    7    1
MEDIA           2
BLOCK     1    7    1
MEDIA           2
```

TABLE 6.3.1-3 (Cont-9/50)
STEEL BASKET MODEL FOR
KENO GENERALIZED GEOMETRY

```
ZONE      1    3    2
BLOK1 XENDS -46.83125, -12.81749, -12.57111, -12.40601, -12.25869,
  -5.09081,  -4.94349,  -4.77839,  -4.52439,  -4.52438
BLOK1 YENDS   5.08000,   5.08100,   5.55752,   5.82295,  11.95705,
  12.22248,  12.70000,  46.83125
BLOK1 ZENDS -13.85100,  13.85100
BLOCK     1    7    1
MEDIA           2,    3,    5,    6,    4
SURFACES        1,    2,    3,    4
SECTOR -1  0  0  0
SECTOR  1 -1  0  0
SECTOR  0  1 -1  0
SECTOR  0  0  1 -1
SECTOR  0  0  0  1
BLOCK     2    7    1
MEDIA           2,    3,    5,    6,    4
SURFACES        1,    2,    3,    4
SECTOR -1  0  0  0
SECTOR  1 -1  0  0
SECTOR  0  1 -1  0
SECTOR  0  0  1 -1
SECTOR  0  0  0  1
BLOCK     3    7    1
MEDIA           2,    3,    5,    6,    4
SURFACES        1,    2,    3,    4
SECTOR -1  0  0  0
SECTOR  1 -1  0  0
SECTOR  0  1 -1  0
SECTOR  0  0  1 -1
SECTOR  0  0  0  1
BLOCK     4    7    1
MEDIA           2,    3,    5,    6,    4
SURFACES        1,    2,    3,    4
SECTOR -1  0  0  0
SECTOR  1 -1  0  0
SECTOR  0  1 -1  0
SECTOR  0  0  1 -1
SECTOR  0  0  0  1
BLOCK     5    7    1
MEDIA           2,    3,    5,    6,    4
SURFACES        1,    2,    3,    4
SECTOR -1  0  0  0
SECTOR  1 -1  0  0
SECTOR  0  1 -1  0
SECTOR  0  0  1 -1
SECTOR  0  0  0  1
BLOCK     6    7    1
MEDIA           2,    3,    5,    6,    4
SURFACES        1,    2,    3,    4
SECTOR -1  0  0  0
SECTOR  1 -1  0  0
SECTOR  0  1 -1  0
SECTOR  0  0  1 -1
SECTOR  0  0  0  1
BLOCK     7    7    1
MEDIA           2,    3,    5,    6,    4
```

TABLE 6.3.1-3 (Cont-10/50)
STEEL BASKET MODEL FOR
KENO GENERALIZED GEOMETRY

```
SURFACES        1,    2,    3,    4
SECTOR -1  0  0  0
SECTOR  1 -1  0  0
SECTOR  0  1 -1  0
SECTOR  0  0  1 -1
SECTOR  0  0  0  1
BLOCK     8    7    1
MEDIA           2,    3,    5,    6,    4
SURFACES        1,    2,    3,    4
SECTOR -1  0  0  0
SECTOR  1 -1  0  0
SECTOR  0  1 -1  0
SECTOR  0  0  1 -1
SECTOR  0  0  0  1
BLOCK     9    7    1
MEDIA           2,    3,    5,    6,    4
SURFACES        1,    2,    3,    4
SECTOR -1  0  0  0
SECTOR  1 -1  0  0
SECTOR  0  1 -1  0
SECTOR  0  0  1 -1
SECTOR  0  0  0  1
BLOCK     1    6    1
MEDIA           2,    3,    5,    6,    4
SURFACES        1,    2,    3,    4
SECTOR -1  0  0  0
SECTOR  1 -1  0  0
SECTOR  0  1 -1  0
SECTOR  0  0  1 -1
SECTOR  0  0  0  1
BLOCK     2    6    1
MEDIA           7
BLOCK     3    6    1
MEDIA           7
BLOCK     4    6    1
MEDIA           7
BLOCK     5    6    1
MEDIA           7
BLOCK     6    6    1
MEDIA           7
BLOCK     7    6    1
MEDIA           7
BLOCK     8    6    1
MEDIA           7
BLOCK     9    6    1
MEDIA           7
BLOCK     1    5    1
MEDIA           2,    3,    5,    6,    4
SURFACES        1,    2,    3,    4
SECTOR -1  0  0  0
SECTOR  1 -1  0  0
SECTOR  0  1 -1  0
SECTOR  0  0  1 -1
SECTOR  0  0  0  1
BLOCK     2    5    1
MEDIA           2
```

TABLE 6.3.1-3 (Cont-11/50)
STEEL BASKET MODEL FOR
KENO GENERALIZED GEOMETRY

```
BLOCK     3    5    1
MEDIA          7
BLOCK     4    5    1
MEDIA          2
BLOCK     5    5    1
MEDIA          2
BLOCK     6    5    1
MEDIA          2
BLOCK     7    5    1
MEDIA          7
BLOCK     8    5    1
MEDIA          2
BLOCK     9    5    1
MEDIA          2
BLOCK     1    4    1
MEDIA          2,   3,   5,   6,   4
SURFACES       1,   2,   3,   4
SECTOR -1  0  0  0
SECTOR  1 -1  0  0
SECTOR  0  1 -1  0
SECTOR  0  0  1 -1
SECTOR  0  0  0  1
BLOCK     2    4    1
MEDIA          2
BLOCK     3    4    1
MEDIA          7
BLOCK     4    4    1
MEDIA          2
BLOCK     5    4    1
MEDIA          1
BLOCK     6    4    1
MEDIA          2
BLOCK     7    4    1
MEDIA          7
BLOCK     8    4    1
MEDIA          2
BLOCK     9    4    1
MEDIA          2
BLOCK     1    3    1
MEDIA          2,   3,   5,   6,   4
SURFACES       1,   2,   3,   4
SECTOR -1  0  0  0
SECTOR  1 -1  0  0
SECTOR  0  1 -1  0
SECTOR  0  0  1 -1
SECTOR  0  0  0  1
BLOCK     2    3    1
MEDIA          2
BLOCK     3    3    1
MEDIA          7
BLOCK     4    3    1
MEDIA          2
BLOCK     5    3    1
MEDIA          2
BLOCK     6    3    1
MEDIA          2
```

TABLE 6.3.1-3 (Cont-12/50)
STEEL BASKET MODEL FOR
KENO GENERALIZED GEOMETRY

```
BLOCK     7    3    1
MEDIA           7
BLOCK     8    3    1
MEDIA           2
BLOCK     9    3    1
MEDIA           2
BLOCK     1    2    1
MEDIA           2,   3,   5,   6,   4
SURFACES        1,   2,   3,   4
SECTOR -1  0  0  0
SECTOR  1 -1  0  0
SECTOR  0  1 -1  0
SECTOR  0  0  1 -1
SECTOR  0  0  0  1
BLOCK     2    2    1
MEDIA           7
BLOCK     3    2    1
MEDIA           7
BLOCK     4    2    1
MEDIA           7
BLOCK     5    2    1
MEDIA           7
BLOCK     6    2    1
MEDIA           7
BLOCK     7    2    1
MEDIA           7
BLOCK     8    2    1
MEDIA           7
BLOCK     9    2    1
MEDIA           7
BLOCK     1    1    1
MEDIA           2,   3,   5,   6,   4
SURFACES        1,   2,   3,   4
SECTOR -1  0  0  0
SECTOR  1 -1  0  0
SECTOR  0  1 -1  0
SECTOR  0  0  1 -1
SECTOR  0  0  0  1
BLOCK     2    1    1
MEDIA           2
BLOCK     3    1    1
MEDIA           2
BLOCK     4    1    1
MEDIA           2
BLOCK     5    1    1
MEDIA           2
BLOCK     6    1    1
MEDIA           2
BLOCK     7    1    1
MEDIA           2
BLOCK     8    1    1
MEDIA           2
BLOCK     9    1    1
MEDIA           2
ZONE      3    3    2
BLOK1 XENDS   4.52438,   4.52439.   4.77839.   4.94349,   5.09081,
```