B&W FUEL COMPANY

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July 31, 1995

Charles J. Haughney, Chief
Transportation Branch
Division of Safeguards
and Transportation, NMSS
United States Nuclear Regulatory
Commission
Mail 6H3
11555 Rockville Pike
Rockville, MD 20852

Dear Mr. Haughney:

REFERENCE: Docket 71-6206, USA/6206/AF

B&W Fuel Company (BWFC) requests to increase the enrichment for fresh fuel assemblies shipped in the above licensed container. The criticality evaluation is provided as Attachment I. Other minor changes are indicated with a side bar.

Six copies of the entire SAR have been provided and serve also as a consolidated application for renewal. If you should have any questions regarding this amendment, please feel free to call me at (804) 832-5202.

Sincerely,

B&W FUEL COMPANY
Commercial Nuclear Fuel Plant

Kathryn S. Knapp

Kathryn S. Knapp
Manager, Safety & Licensing

NF01 1/3

Ltr. Encl.

Change: LA 4 0

ATTACHMENT I

Purpose:

To transmit the enrichment limits associated with different assemblies for the Model-B shipping container. The data in this transmittal will be used to revise the Model-B Certificate of Compliance.

Results:

The Model-B shipping container was evaluated with the Mk-B9/B10 15x15 (Design 1), MK-B10F 15x15 (Design 2), Mk-B11 15x15 (Design 3), Mk-BW 17x17 (Design 4), Mk-C 17x17 (Design 5), and the Mk-BW 15x15 (proposed VEPCO design - Design 6) fuel assembly types with 97.5% T.D. fuel. Two assemblies were loaded in the Model-B cask. The enrichment limit was 4.98 wt% U^{235} for the Mk-B11 (Design 3) and 5.05 wt% U^{235} for all other assembly types under accident conditions. Higher enrichments could have been accommodated in some cases but are limited by the current license for CNFP (5.1 wt% U^{235}) and environmental impact studies which prohibit enrichments above 5.00 wt% U^{235}. Note that the stainless-steel Connecticut Yankee assembly has been eliminated in this analysis. Appendix A contains a listing of a sample CSAS25 and KENO-IV input deck. The deck provided represents the limiting Mk-B11 case for 4.98% and B-10F for 5.05%. Results are summarized in greater detail within.

Conditions of Analysis

The analysis defined by this transmittal was based on the SCALE 4.2 27 group cross-section library. The 27 group cross-section library does not contain the U^{235} self-shielding cross-section errors as in the 123 group cross-section library. The cross-section error previously noted could result in increased values of K-maximum for low-density moderator cases. To ensure the trend of K-maximum decreased with decreasing moderator conditions as in the original analysis, a limited set of interspersed moderator or misted cases were run for two limiting assembly types.

The KENO-IV bias was defined using the SCALE 4.2 27 group cross-section library and was used in this analysis. Further discussion of the KENO-IV bias is contained in this transmittal.

Fuel rod and pellet tolerances were chosen to maximize K-effective and provide conservative fuel enrichment estimates. For the fuel rod, guide tube, and instrument tube cladding the outer diameter was minimized and the inner diameter maximized. This method often reduced the cladding thickness to values less than allowed by the cladding tolerance. However, a decreased cladding thickness reduces neutron absorption and increases the moderator volume in the assembly. Both effects maximize K-effective. The fuel rod was assumed to be solid UO_2 and no credit was taken for dish or chamfer factors. The fuel column in all cases was assumed to be the maximum length of 144 inches. The theoretical density was assumed to be a maximum of 97.5% theoretical density for all pellets in the assembly. The pellet radius was maximized by adding 0.0007 inches to the diameter according to the fuel pellet specifications. The previous discussed fuel pellet tolerances add approximately 2 KgU to the assembly and ensure conservatism.

Procedure

The CSAS25 module was used to generate the heterogeneous 27 group cross-section library for the assembly types examined. CSAS25 was used (BONAMI-S, NITAWL-II, KENOVa) to provide computation and confirmation of number densities through the KENOVa code. The KENO-IV code was used to calculate K-effective (and K-maximum). KENO-IV calculations were run with 2000 neutrons/generation, 850 generations, with the first three generations skipped (847 active neutron generations). Sample CSAS25 and KENO-IV input decks are provided.

The fuel assembly types evaluated in this analysis were the Mk-B9/B10 15x15 (Design 1), Mk-B10F 15x15 (Design 2), Mk-B11 15x15 (Design 3), Mk-BW 17x17 (Design 4), Mk-C 17x17 (Design 5), and the Mk-BW 15x15 (a proposed VEPCO design that does not currently exist - Design 6). Note that the Mk-B9 15x15 has the same fuel rod, guide tube, and instrument tube specifications as the Mk-B10 15x15. Therefore, the MK-B9 15x15 analysis applies to the MK-B10 15x15 design. The maximum theoretical density of the Mk-B10F (97.5% T.D.) was applied to the Mk-B9 and the Mk-B10 for conservatism. To ensure flexibility in the application of the license, the different assembly types are also referred to by a design number.

The maximum K-effective (K-maximum) was determined by applying the bias and standard deviation on the bias using the expected sample mean methodology and is described in detail in this transmittal. The bias determined for the 27 group cross-section library in Reference 23 is +0.01159 $\pm$0.00347 (1.763σ). For interspersed moderator or mist cases the conservative SAR KENO-IV bias of 0.02 was applied with a 2σ uncertainty since no critical benchmarks are available for low-density moderator cases.

Results

The results of the evaluation of the Model-B shipping container are shown in Table 5.1. The results indicate that the Mk-B11 fuel assembly is the most reactive for fresh fuel conditions. The maximum enrichment allowed for the Mk-B11 under accident conditions is 4.98 wt% U^{235}. All other assembly types had excess margin for enrichments at 5.05 wt% U^{235}. The maximum allowed U^{235} loading in KgU/Assembly for the Model-B shipping container is shown in Table 5.2.

The limiting accident configuration is a fully flooded configuration with 100% dense moderator. To verify that misted conditions were not more limiting than fully dense moderator conditions, several misted cases were evaluated for the Mk-B11 and

Mk-B10F fuel assembly designs. The Mk-B11 was chosen since it is the most reactive assembly under fully flooded conditions and the Mk-B10F was evaluated because it had the largest pellet diameter. These results are shown in Table 5.3 and verify that misted conditions are not limiting relative to the fully flooded cask with 100% dense moderator.

The Mk-B11 results indicate that K-effective decreases as the moderator density decreases with no apparent reactivity spike at lower moderator densities. The Mk-B10F assembly was evaluated at a typical 5% mist condition and has 0.0772 Δk margin to the fully flooded condition for this assembly. The Mk-B10F is the most reactive assembly for misted conditions while the Mk-B11 is most reactive for fully flooded conditions. Therefore, the limiting accident case with the 27 group cross-section library remains the fully flooded case as defined by the original SAR analysis (Reference 26) with the Mk-B11 fuel assembly design. Note that for low-density misted cases a KENO-IV bias of 2% (0.02 Δk) with a 2σ uncertainty on the base case was maintained as in the original Reference 26 SAR. The larger conservative bias was applied to the low-density misted cases since no critical benchmark information is available for these moderator conditions.

Table 5.1. Enrichment Limits for Different Assembly Types - Model B Shipping Container Flooded 100% Dense Moderator
(2000 Neutrons/Generation; 847 Active Generations; 1,694,000 Neutron Histories)

Enrich/ %T.D.	Assm. Type	Base K-effective (1σ Unc)	Maximum K-effective
5.05/ 97.5%	Mk-B11 15x15	0.93731 (0.00060)	0.95253
5.00/ 97.5%	Mk-B11 15x15	0.93616 (0.00056)	0.95136
4.95/ 97.5%	Mk-B11 15x15	0.93279 (0.00058)	0.94800
4.98/ 97.5%	Mk-B11 15x15	0.93473 (0.00059)	0.94994
5.05/ 97.5%	Mk-B10F 15x15	0.92827 (0.00058)	0.94348
5.05/ 97.5%	Mk-B9/ B10 [A]	0.92613 (0.00060)	0.94135 [A]
5.05/ 97.5%	Mk-C 17x17	0.92704 (0.00060)	0.94226
5.05/ 97.5%	Mk-BW 15x15	0.92763 (0.00060)	0.94285
5.05/ 97.5%	Mk-BW 17x17	0.92334 (0.00058)	0.93855

The maximum K-effective is calculated as $K_{MAX} = K_{BASE} + BIAS + [(UNC_{BASE})^2 + (UNC_{BIAS})^2]^{1/2}$, where the UNC factors are 1.763σ values and the BIAS = 0.01159 $\pm$ 0.00347 (1.763σ).

[A] This case was run at 97.5% T.D. and is conservative since the maximum density allowed by the pellet specification is 96.5% T.D.

Table 5.2. Maximum Allowed KgU^{235}/Assm By Assembly Type

Assembly Type	Design Type	Max Enrich wt% U^{235}	Max KgU^{235}/Assm
Mk-B9/Mk-B10 15x15	1	5.05	25.1978
Mk-B10F 15x15	2	5.05	25.6758
Mk-B11 15x15	3	4.98	23.7220
Mk-BW 17x17	4	5.05	24.3108
Mk-C 17x17	5	5.05	24.6126
Mk-BW 15x15	6	5.05	24.2355

Table 5.3. K-Max For Misted Conditions - Model B Shipping Container
(2000 Neutrons/Generation; 847 Active Generations; 1,694,000 Neutron Histories)

Enrich/ %T.D.	Assm Type/ Mist Density	Base K-effective (1σ Unc)	Maximum K-effective
4.98/ 97.5%	Mk-B11 / 0%	0.49649 (0.00029)	0.51707
4.98/ 97.5%	Mk-B11 / 4%	0.81557 (0.00042)	0.83641
4.98/ 97.5%	Mk-B11 / 5%	0.83744 (0.00044)	0.85832
4.98/ 97.5%	Mk-B11 / 6%	0.84949 (0.00045)	0.87039
4.98/ 97.5%	Mk-B11 / 10%	0.85317 (0.00048)	0.87413
5.05/ 97.5%	MK-B10F / 5%	0.84537 (0.00045)	0.86627

The maximum K-effective is calculated as $K_{MAX} = K_{BASE} + BIAS + UNC_{Base}$, where the UNC factor is a 2σ value and the BIAS = 0.02 for misted cases only.

Conclusions

The results of this analysis indicate that a maximum as-built enrichment of 4.98 wt% U^{235} applies to the Mk-B11 15x15 (Design 3) fuel assembly while an enrichment limit of 5.05 wt% U^{235} applies to all other assembly types (Designs 1, 2, 4, 5, and 6). These results are based on the 27 group cross-section library with the expected sample mean bias determined from evaluation of the 21 LRC critical configurations.

APPENDIX A

Sample CSAS25 Input: BONAMI-S/NITAWL-II/KENOVa

```
=csas25
27 gp mod b cask b11 4.98 wt% bonami-nitawlii cross-sections
27groupndf4           latticecell
uo2        1   0.975 305 92235 4.98 92238 95.02  end
zircalloy  2   1.0 305  end
h2o        3   1.0 305  end
zircalloy  4   1.0 305  end
h2o        5   1.0 305  end
zircalloy  6   1.0 305  end
h2o        7   1.0 305  end
h2o        8   1.0 305  end
b-10       9   0 8.997402e-04 305  end
b-11       9   0 4.007059e-03 305  end
c         9   0 1.177700e-04 305  end
mn         9   0 1.476300e-03 305  end
si        9   0 1.091300e-03 305  end
cr        9   0 1.682200e-02 305  end
ni        9   0 1.099100e-02 305  end
fe        9   0 5.392700e-02 305  end
c         10   0 3.925900e-04 305  end
mn         10   0 3.433200e-04 305  end
fe        10   0 8.401100e-02 305  end
b-10       11   0 1.498852e-02 305  end
b-11       11   0 6.675248e-02 305  end
c         11   0 2.724700e-02 305  end
h         12   0 4.182000e-02 305  end
b-10       12   0 6.636382e-05 305  end
b-11       12   0 2.955561e-04 305  end
c         12   0 3.346000e-02 305  end
h         13   0 7.913400e-02 305  end
c         13   0 3.956700e-02 305  end
end comp
squarepitch 1.44272 0.919988 1  3  1.05156 2  .93980 0  end
kenova 0.3622 pellet sq pitch 4.98wt%
read parm tme=4800 tba=3 gen=20 npg=2000 run=yes plt=no end parm
read geom
unit  1
com=!4.98 wt% 0.3622 pellet!
cylinder   1  1    0.459994 0.0 -10.0
cylinder   0  1    0.469900 0.0 -10.0
cylinder   2  1    0.525780 0.0 -10.0
cuboid     3  1  0.721360 -0.721360 0.721360 -0.721360 0.0 -10.0
end geom
read bnds  +xb=reflect -xb=reflect  +yb=reflect -yb=reflect  +zb=reflect
 -zb=reflect  end bnds
end data
end
```

Sample KENO-IV case for the MK-B11

```
MODB-b11 pellet 0.975 den, 4.98 WT% dia +0.0007"
  4000  850 2000 3  27  27  34 13 34  37 8  16  16  1  -34
   1  0  2000  00  1  0  0  0  0 00  00  0  0
 -1.0 -1.0 -1.0 -1.0  0.0 0.0
       1     -92235    1.20186E-03
       1      92238    2.26421E-02
       1       8016    4.76879E-02
       2      40302    4.25156E-02
       3     308016    3.33757E-02
       3       1001    6.67514E-02
       4     440302    4.25156E-02
       5     508016    3.33757E-02
       5     501001    6.67514E-02
       6     640302    4.25156E-02
       7     708016    3.33757E-02
       7     701001    6.67514E-02
       8     808016    3.33757E-02
       8     801001    6.67514E-02
       9       5010    8.99740E-04
       9       5011    4.00706E-03
       9       6012    1.17770E-04
       9      25055    1.47630E-03
       9      14000    1.09130E-03
       9      24000    1.68220E-02
       9      28000    1.09910E-02
       9      26000    5.39270E-02
      10    1026000    8.40110E-02
      10    1006012    3.92590E-04
      10    1025055    3.43320E-04
      11    1105010    1.49885E-02
      11    1105011    6.67525E-02
      11    1106012    2.72470E-02
      12    1201001    4.18200E-02
      12    1205010    6.63638E-05
      12    1205011    2.95556E-04
      12    1206012    3.34600E-02
      13    1306012    3.95670E-02
      13    1301001    7.91340E-02
BOX TYPE   1
CYLINDER   1  0.459994                        365.76  0.0  123z
CYLINDER   0  0.46990                         365.76  0.0  123z
CYLINDER   4  0.525780                        365.76  0.0  123z
CUBOID     3  0.721360 -0.721360  0.721360 -0.721360 365.76  0.0  123z
BOX TYPE   2
CYLINDER   3  0.635000                        365.76  0.0  123z
CYLINDER   4  0.670560                        365.76  0.0  123z
CUBOID     3  0.721360 -0.721360  0.721360 -0.721360 365.76  0.0  123z
BOX TYPE   3
CYLINDER   3  0.562610                        365.76  0.0  123z
CYLINDER   4  0.623570                        365.76  0.0  123z
CUBOID     3  0.721360 -0.721360  0.721360 -0.721360 365.76  0.0  123z
BOX TYPE   4
CUBOID     8  2.936875    0.0    1.442720    0.0    365.76  0.0  123z
```

```
CUBOID    9 3.413125    0.0   1.442720   0.0   365.76 0.0 123z
CUBOID   12 3.571875    0.0   1.442720   0.0   365.76 0.0 123z
CUBOID   13 3.592195    0.0   1.442720   0.0   365.76 0.0 123z
BOX TYPE  5
CUBOID   11 0.793750    0.0   1.442720   0.0   365.76 0.0 123z
CUBOID    8 2.936875    0.0   1.442720   0.0   365.76 0.0 123z
CUBOID    9 3.413125    0.0   1.442720   0.0   365.76 0.0 123z
BOX TYPE  6
CUBOID    8 3.592195    0.0   1.611376   0.0   365.76 0.0 123z
CUBOID    8 3.592195    0.0   3.043682   0.0   365.76 0.0 123z
CUBOID   10 3.592195    0.0   3.519932   0.0   365.76 0.0 123z
CUBOID    8 3.592195    0.0   3.678682   0.0   365.76 0.0 123z
CUBOID    8 3.592195    0.0   3.699002   0.0   365.76 0.0 123z
BOX TYPE  7
CUBOID    8 1.442720    0.0   1.611376   0.0   365.76 0.0 123z
CUBOID    8 1.442720    0.0   3.043682   0.0   365.76 0.0 123z
CUBOID   10 1.442720    0.0   3.519932   0.0   365.76 0.0 123z
CUBOID   12 1.442720    0.0   3.678682   0.0   365.76 0.0 123z
CUBOID   13 1.442720    0.0   3.699002   0.0   365.76 0.0 123z
BOX TYPE  8
CUBOID    8 1.442720    0.0   1.611376   0.0   365.76 0.0 123z
CUBOID    8 1.442720    0.0   3.043682   0.0   365.76 0.0 123z
CUBOID   10 1.442720    0.0   3.519932   0.0   365.76 0.0 123z
CUBOID   12 1.442720    0.0   3.678682   0.0   365.76 0.0 123z
CUBOID   13 1.442720    0.0   3.699002   0.0   365.76 0.0 123z
CORE BDY  0 25.232995   0.0  25.339800   0.0   365.76 0.0 123z
CUBOID   13 25.253315   0.0  25.360122   0.0   365.76 0.0 123z
CUBOID    8 34.794825   0.0  33.81070 -18.93240  365.76 0.0 123z
CUBOID   10 35.023425   0.0  34.03930 -19.16100  365.76 0.0 123z
CUBOID    8 35.023425   0.0  34.03930 -19.16100  386.08 -20.32 123z
 1 2 16 1  2 16  1  1 1 1  0
 2 7 11 4  4 14 10  1 1 1  0
 2 5 13 8  5 13  8  1 1 1  0
 2 4 14 10 7 11  4  1 1 1  0
 2 7 11 4  7 11  4  1 1 1  0
 3 9  9 1  9  9  1  1 1 1  0
 4 1  1 1  2 16  1  1 1 1  0
 6 1  1 1  1  1  1  1 1 1  0
 7 2 16 1  1  1  1  1 1 1  0
 8 5 13 1  1  1  1  1 1 1  1
END KENO
/EOR
```

Sample KENO-IV case for the Mk-B10F

```
MODB-b10f pellet 0.975 den, 5.05 WT% dia +0.0007"
  4000  850 2000 3  27  27  34 13 34  37 8  16  16  1  -34
   1  0  2000  00  1  0  0  0  0 00  00  0  0
 -1.0 -1.0 -1.0 -1.0  0.0 0.0
       1     -92235     1.21875E-03
       1      92238     2.26254E-02
       1       8016    4.76883E-02
       2      40302     4.25156E-02
       3     308016     3.33757E-02
       3       1001    6.67514E-02
       4     440302     4.25156E-02
       5     508016     3.33757E-02
       5     501001     6.67514E-02
       6     640302     4.25156E-02
       7     708016     3.33757E-02
       7     701001     6.67514E-02
       8     808016     3.33757E-02
       8     801001     6.67514E-02
       9       5010    8.99740E-04
       9       5011    4.00706E-03
       9       6012    1.17770E-04
       9      25055     1.47630E-03
       9      14000     1.09130E-03
       9      24000     1.68220E-02
       9      28000     1.09910E-02
       9      26000     5.39270E-02
      10     1026000     8.40110E-02
      10     1006012     3.92590E-04
      10     1025055     3.43320E-04
      11     1105010     1.49885E-02
      11     1105011     6.67525E-02
      11     1106012     2.72470E-02
      12     1201001     4.18200E-02
      12     1205010     6.63638E-05
      12     1205011     2.95556E-04
      12     1206012     3.34600E-02
      13     1306012     3.95670E-02
      13     1301001     7.91340E-02
BOX TYPE  1
CYLINDER   1  0.475234                        365.76  0.0  123z
CYLINDER   0  0.485140                        365.76  0.0  123z
CYLINDER   4  0.543560                        365.76  0.0  123z
CUBOID     3  0.721360 -0.721360  0.721360 -0.721360 365.76  0.0  123z
BOX TYPE  2
CYLINDER   3  0.635000                        365.76  0.0  123z
CYLINDER   4  0.670560                        365.76  0.0  123z
CUBOID     3  0.721360 -0.721360  0.721360 -0.721360 365.76  0.0  123z
BOX TYPE  3
CYLINDER   3  0.562610                        365.76  0.0  123z
CYLINDER   4  0.623570                        365.76  0.0  123z
CUBOID     3  0.721360 -0.721360  0.721360 -0.721360 365.76  0.0  123z
BOX TYPE  4
CUBOID     8  2.936875    0.0    1.442720    0.0    365.76  0.0  123z
```

```
CUBOID     9  3.413125    0.0   1.442720   0.0    365.76  0.0  123z
CUBOID    12  3.571875    0.0   1.442720   0.0    365.76  0.0  123z
CUBOID    13  3.592195    0.0   1.442720   0.0    365.76  0.0  123z
BOX TYPE   5
CUBOID    11  0.793750    0.0   1.442720   0.0    365.76  0.0  123z
CUBOID     8  2.936875    0.0   1.442720   0.0    365.76  0.0  123z
CUBOID     9  3.413125    0.0   1.442720   0.0    365.76  0.0  123z
BOX TYPE   6
CUBOID     8  3.592195    0.0   1.611376   0.0    365.76  0.0  123z
CUBOID     8  3.592195    0.0   3.043682   0.0    365.76  0.0  123z
CUBOID    10  3.592195    0.0   3.519932   0.0    365.76  0.0  123z
CUBOID     8  3.592195    0.0   3.678682   0.0    365.76  0.0  123z
CUBOID     8  3.592195    0.0   3.699002   0.0    365.76  0.0  123z
BOX TYPE   7
CUBOID     8  1.442720    0.0   1.611376   0.0    365.76  0.0  123z
CUBOID     8  1.442720    0.0   3.043682   0.0    365.76  0.0  123z
CUBOID    10  1.442720    0.0   3.519932   0.0    365.76  0.0  123z
CUBOID    12  1.442720    0.0   3.678682   0.0    365.76  0.0  123z
CUBOID    13  1.442720    0.0   3.699002   0.0    365.76  0.0  123z
BOX TYPE   8
CUBOID     8  1.442720    0.0   1.611376   0.0    365.76  0.0  123z
CUBOID     8  1.442720    0.0   3.043682   0.0    365.76  0.0  123z
CUBOID    10  1.442720    0.0   3.519932   0.0    365.76  0.0  123z
CUBOID    12  1.442720    0.0   3.678682   0.0    365.76  0.0  123z
CUBOID    13  1.442720    0.0   3.699002   0.0    365.76  0.0  123z
CORE BDY   0 25.232995    0.0   25.339800   0.0    365.76  0.0  123z
CUBOID    13 25.253315    0.0   25.360122   0.0    365.76  0.0  123z
CUBOID     8 34.794825    0.0   33.81070  -18.93240   365.76  0.0  123z
CUBOID    10 35.023425    0.0   34.03930  -19.16100   365.76  0.0  123z
CUBOID     8 35.023425    0.0   34.03930  -19.16100   386.08 -20.32 123z
 1  2 16 1  2 16  1  1 1 1  0
 2  7 11 4  4 14 10  1 1 1  0
 2  5 13 8  5 13  8  1 1 1  0
 2  4 14 10 7 11  4  1 1 1  0
 2  7 11 4  7 11  4  1 1 1  0
 3  9  9 1  9  9  1  1 1 1  0
 4  1  1 1  2 16  1  1 1 1  0
 6  1  1 1  1  1  1  1 1 1  0
 7  2 16 1  1  1  1  1 1 1  0
 8  5 13 1  1  1  1  1 1 1  1
END KENO
/EOR
```