71-9292

Westinghouse

Westinghouse Electric Company
Nuclear Fuel
Columbia Fuel Site
P.O. Drawer R
Columbia, South Carolina 29250
USA

U. S. Nuclear Regulatory Commission		Direct tel:	(803) 647 3552
Attn: Mr. Jose Cuadrado		Direct fax:	(803) 695 4164
Project Manager		e-mail:	Kentna@westinghouse.com
Spent Fuels Project Officer			
Office of Nuclear Material Safety and Safeguards		Our ref:	UAM-NRC-05-009
Washington, DC 20555		Your Ref:	

Mr. Cuadrado: June 14, 2005

Subject: CERTIFICATE OF COMPLIANCE NO. 9292 FOR THE MODEL NO. PATRIOT PACKAGE: Follow-up Information Requested during Conference Call Held June 2, 2005 - DOCKET No. 71-9292; TAC No. L23770

Attached please find the information requested during the conference call between your staff and Westinghouse June 2, 2005. Certain pages of the Patriot SAR were revised as a result. These are enclosed as Revision 2 to the SAR.

Please direct any questions to the me at (803) 647-3552.

Sincerely,
WESTINGHOUSE ELECTRIC COMPANY, LLC

Norman A. Kent

Norman A. Kent
Manager Transport Licensing and Regulatory Compliance
Nuclear Material Supply

Enclosures:
1. Response to Follow-up Questions
2. Rev 2 Change pages to SAR

NMSS01

Enclosure 1: Response to Follow-up Questions

ITEM 1

Table 6A-12 on page 6A-34 of the SAR is missing case #25.

Westinghouse Response:

Case #25 was inadvertently omitted from the table. Revision 2 to the SAR will include the correct table. The table is given below.

Table 1: Benchmark Critical Experiments

Case #	Case Name		Case #	Case Name
1	bw1484-i.18332.out:		26	pnl-3314-116.1322.out:
2	bw1484-ii.358.out:		27	pnl-3314-119.19398.out:
3	bw1484-iii.24205.out:		28	pnl-3314-055.25658.out:
4	bw1484-iv.29886.out:		29	pnl-3314-070.2076.out:
5	bw1484-v.18468.out:		30	pnl-2615-008.25870.out:
6	bw1484-vi.501.out:		31	pnl-2615-004.2286.out:
7	bw1484-vii.24341.out:		32	pnl-2615-031.1792.out:
8	bw1484-viii.132.out:		33	Bw1645s1.1950.out:
9	bw1484-ix.24614.out:		34	Bw1645s2.19626.out:
10	bw1484-x.18725.out:		35	Bw1645t1.26073.out:
11	bw1484-xi.787.out:		36	Bw1645t2.19824.out:
12	bw1484-xii.981.out:		37	Bw1645t3.2556.out:
13	bw1484-xiii.24808.out:		38	Bw1645t4.26281.out:
14	bw1484-xiv.482.out:		39	Nsc71h1.2773.out:
15	bw1484-xv.1214.out:		40	Nsc71h2.20046.out:
16	bw1484-xvi.18974.out:		41	Nsc71h3.2295.out:
17	bw1484-xvii.1419.out:		42	Nsc71sq.26500.out:
18	bw1484-xviii.25026.out:		43	Nsc71w1.3026.out:
19	bw1484-xix.739.out:		44	Nsc71w2.26708.out:
20	bw1484-xx.25233.out:		45	BW1810A.2632.out:
21	bw1484-xxi.19182.out:		46	BW1810B.3288.out:
22	pnl-2438-020.1066.out:		47	Bw1810cr.20673.out:
23	pnl-2438-032.1655.out:		48	BW1810D.27507.out:
24	pnl-3314-002.1854.out:		49	BW1810E.3515.out:
25	pnl-3314-113.25440.out:			

ITEM 2

On page 6 of 13 in our RAI response (NMS-NRC-05-005) Westinghouse states,

> "The energy (ev) of the average lethargy causing fission for the PATRIOT package that results in a maximum keff over the range of interspersed moderation densities and moderator configurations is approximately 0.6 ev. Only six of the critical benchmark critical experiments have EALF that is greater than 0.5 ev, but the ***results show no significant trend in bias vs. energy. The largest bias results from a the correlation to the enrichment parameter***, and results in an upper safety limit of 0.9343 including a 0.05 arbitrary margin to ensure subcriticality."

Provide trend data to substantiate these statements.

Westinghouse Response:
The USLSTATS output for AEF and ENR are provided to address the items above. Further, the data are graphed as follows:

- USLs for 49 LWR-type fuel critical experiments, k_{eff} vs AEF (0.0 – 0.5 eV),
- USLs for 49 LWR-type fuel critical experiments, k_{eff} vs AEF (0.5 - 2.5 ev), and
- USLs for 49 LWR-type fuel critical experiments, k_{eff} vs enrichment

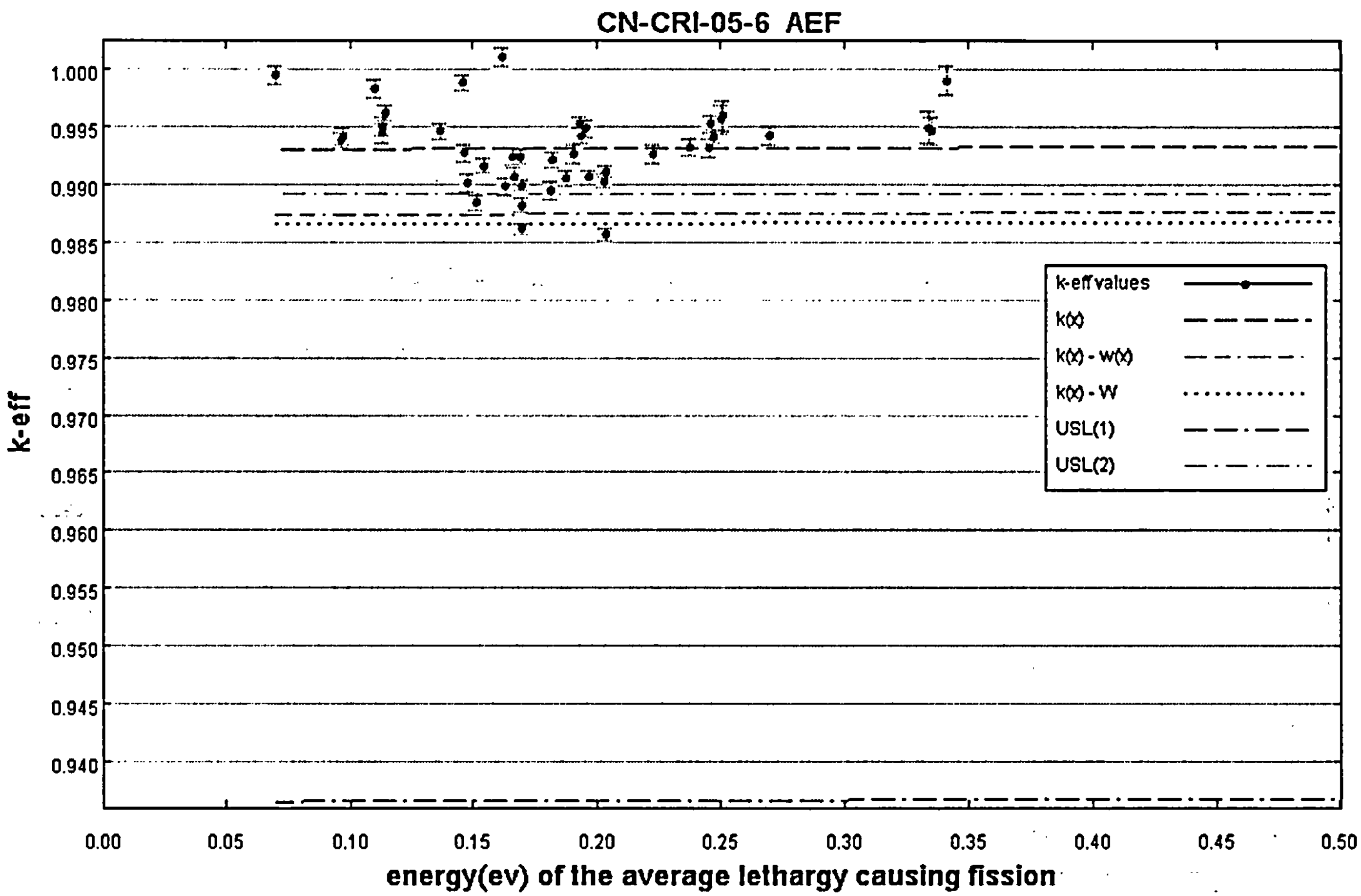

Figure 1 USLs for 49 LWR-type fuel critical experiments, k_{eff} vs AEF (0.0 – 0.5 eV)

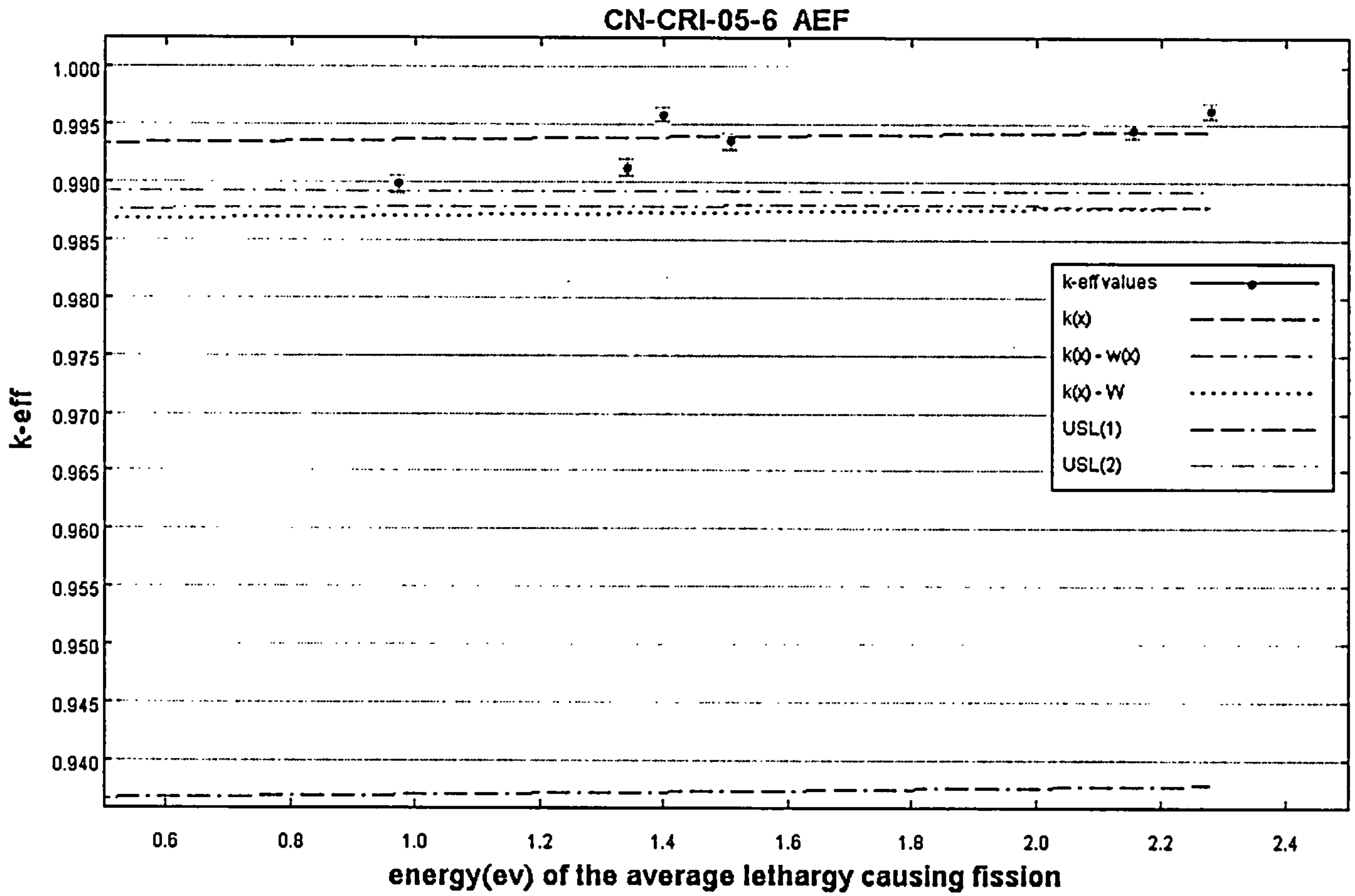

Figure 2-1 (cont) USLs for 49 LWR-type fuel critical experiments, k_{eff} vs AEF (0.5 - 2.5 ev)

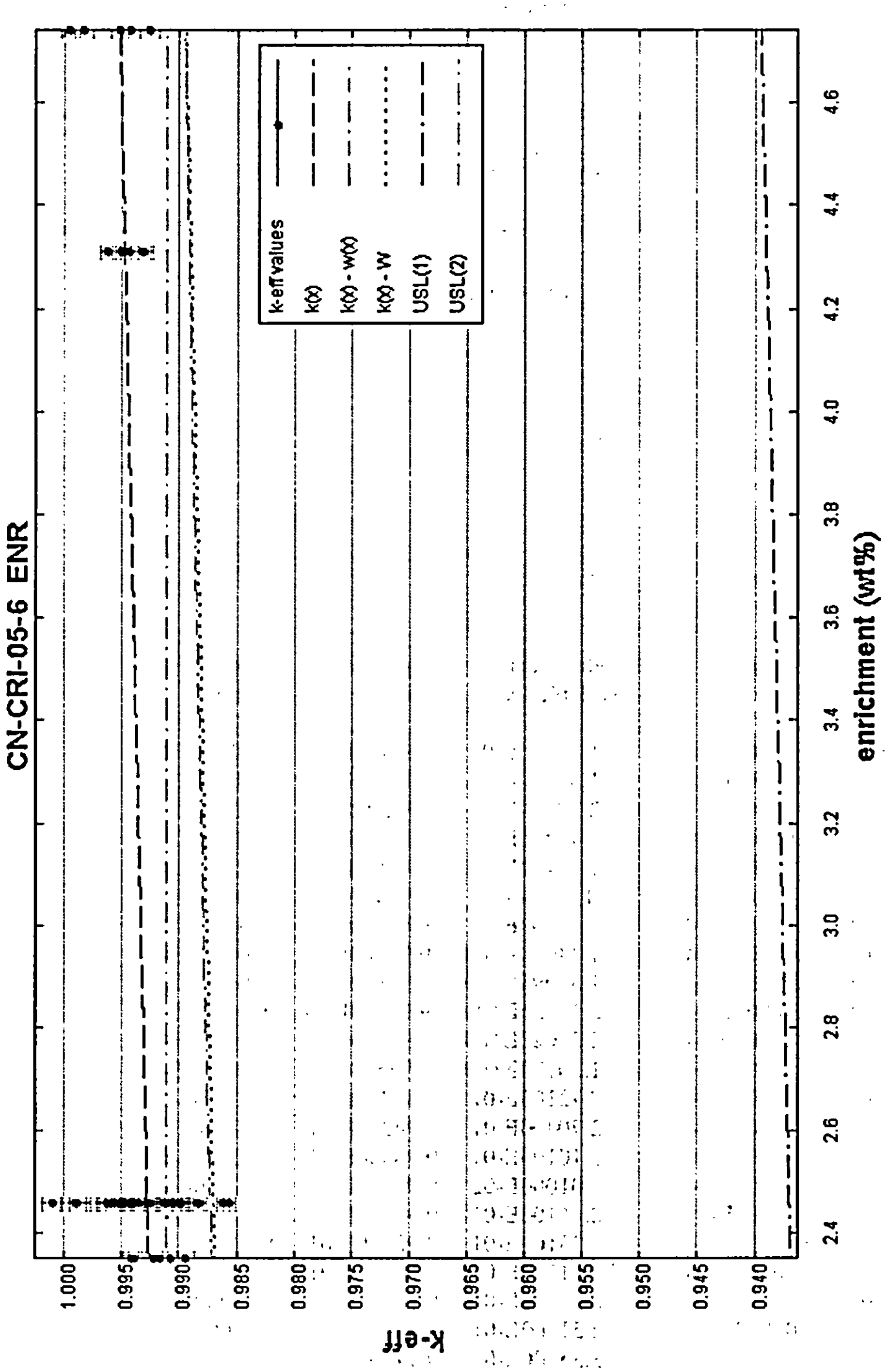

Figure 2 USLs for 49 LWR-type fuel critical experiments, k_{eff} vs enrichment

```
uslstats: a utility to calculate upper subcritical
          limits for criticality safety applications

****************************************************************************
                 Version 1.4, April 23, 2003
                Oak Ridge National Laboratory

****************************************************************************

   Input to statistical treatment from file:AEF

Title: CN-CRI-05-6  AEF

   Proportion of the population = .950
   Confidence of fit            = .950
   Confidence on proportion     = .950
   Number of observations       =   49
   Minimum value of closed band =    0.00
   Maximum value of closed band =    0.00
   Administrative margin        =    0.05
```

independent variable - x	dependent variable - y	deviation in y	independent variable - x	dependent variable - y	deviation in y
1.69400E-01	9.92400E-01	6.00000E-04	1.82000E-01	9.89400E-01	8.00000E-04
2.47800E-01	9.94100E-01	6.00000E-04	1.82300E-01	9.92100E-01	7.00000E-04
1.93800E-01	9.95300E-01	5.00000E-04	2.37900E-01	9.93200E-01	7.00000E-04
1.88300E-01	9.90500E-01	7.00000E-04	2.45400E-01	9.93100E-01	8.00000E-04
1.63800E-01	9.89800E-01	7.00000E-04	1.13400E-01	9.95000E-01	8.00000E-04
1.62400E-01	1.00100E+00	8.00000E-04	1.13000E-01	9.94400E-01	8.00000E-04
1.48100E-01	9.90100E-01	8.00000E-04	1.14200E-01	9.96200E-01	7.00000E-04
1.46500E-01	9.98800E-01	7.00000E-04	1.34020E+00	9.91200E-01	7.00000E-04
1.37300E-01	9.94600E-01	6.00000E-04	1.39990E+00	9.95800E-01	6.00000E-04
1.47200E-01	9.92700E-01	7.00000E-04	2.15550E+00	9.94400E-01	6.00000E-04
1.96300E-01	9.94800E-01	7.00000E-04	2.28020E+00	9.96200E-01	7.00000E-04
1.66700E-01	9.92400E-01	7.00000E-04	1.50730E+00	9.93500E-01	7.00000E-04
1.94200E-01	9.94200E-01	7.00000E-04	9.72100E-01	9.89800E-01	7.00000E-04
1.97100E-01	9.90600E-01	6.00000E-04	2.70400E-01	9.94200E-01	8.00000E-04
2.03800E-01	9.85600E-01	5.00000E-04	1.10100E-01	9.98300E-01	8.00000E-04
1.70400E-01	9.86100E-01	5.00000E-04	7.01000E-02	9.99500E-01	8.00000E-04
2.03200E-01	9.90300E-01	6.00000E-04	2.46100E-01	9.95200E-01	7.00000E-04
1.70200E-01	9.88200E-01	6.00000E-04	2.23100E-01	9.92600E-01	8.00000E-04
2.03900E-01	9.91100E-01	5.00000E-04	1.91200E-01	9.92600E-01	8.00000E-04
1.70400E-01	9.89900E-01	5.00000E-04	2.50800E-01	9.95600E-01	1.30000E-03
1.51700E-01	9.88400E-01	6.00000E-04	2.51400E-01	9.95900E-01	1.30000E-03
9.74000E-02	9.94100E-01	7.00000E-04	3.35500E-01	9.94600E-01	1.20000E-03
9.65000E-02	9.93800E-01	6.00000E-04	3.41400E-01	9.99000E-01	1.30000E-03
1.55100E-01	9.91600E-01	6.00000E-04	3.34000E-01	9.94900E-01	1.40000E-03
1.67100E-01	9.90700E-01	7.00000E-04			

```
chi =  5.5918 (upper bound = 9.49). The data tests normal.


      Output from statistical treatment

CN-CRI-05-6  AEF

 Number of data points (n)                          49
 Linear regression, k(X)                           0.9930 + ( 6.0837E-
04)*X
 Confidence on fit (1-gamma) [input]                95.0%
 Confidence on proportion (alpha) [input]           95.0%
 Proportion of population falling above
 lower tolerance interval (rho) [input]             95.0%
 Minimum value of X                                 7.0100E-02
 Maximum value of X                                 2.2802E+00
 Average value of X                                 3.6155E-01
 Average value of k                                  0.99322
 Minimum value of k                                  0.98560
 Variance of fit, s(k,X)^2                          1.0856E-05
 Within variance, s(w)^2                            5.9286E-07
 Pooled variance, s(p)^2                            1.1449E-05
 Pooled std. deviation, s(p)                        3.3837E-03
 C(alpha,rho)*s(p)                                  1.0845E-02
 student-t @ (n-2,1-gamma)                          1.67945E+00
 Confidence band width, W                           6.5412E-03
 Minimum margin of subcriticality, C*s(p)-W         4.3042E-03

 Upper subcritical limits: ( 7.01000E-02 <= X <=   2.2802    )
***** *********** *******

 USL Method 1 (Confidence Band with
 Administrative Margin)              USL1 = 0.9365 + ( 6.0837E-04)*X

 USL Method 2 (Single-Sided Uniform
 Width Closed Interval Approach)     USL2 = 0.9822 + ( 6.0837E-04)*X

 USLs Evaluated Over Range of Parameter X:
 **** ********* **** ***** ** ********* **
```

X:	7.01E-2	3.86E-1	7.02E-1	1.02E+0	1.33E+0	1.65E+0	1.96E+0	2.28E+0
USL-1:	0.9365	0.9367	0.9369	0.9371	0.9373	0.9375	0.9377	0.9378
USL-2:	0.9822	0.9824	0.9826	0.9828	0.9830	0.9832	0.9833	0.9835

```
****************************************************************************
                        Thus spake USLSTATS
                             Finis.
 Plot file written to: AEF.plt
```

```
uslstats: a utility to calculate upper subcritical
                        limits for criticality safety applications

****************************************************************************
                    Version 1.4, April 23, 2003
                   Oak Ridge National Laboratory

****************************************************************************

   Input to statistical treatment from file:ENR

Title: CN-CRI-05-6  ENR

   Proportion of the population = .950
   Confidence of fit            = .950
   Confidence on proportion     = .950
   Number of observations       =   49
   Minimum value of closed band =    0.00
   Maximum value of closed band =    0.00
   Administrative margin        =    0.05
```

independent variable - x	dependent variable - y	deviation in y	independent variable - x	dependent variable - y	deviation in y
2.46000E+00	9.92400E-01	6.00000E-04	2.35000E+00	9.89400E-01	8.00000E-04
2.46000E+00	9.94100E-01	6.00000E-04	2.35000E+00	9.92100E-01	7.00000E-04
2.46000E+00	9.95300E-01	5.00000E-04	4.31000E+00	9.93200E-01	7.00000E-04
2.46000E+00	9.90500E-01	7.00000E-04	4.31000E+00	9.93100E-01	8.00000E-04
2.46000E+00	9.89800E-01	7.00000E-04	4.31000E+00	9.95000E-01	8.00000E-04
2.46000E+00	1.00100E+00	8.00000E-04	4.31000E+00	9.94400E-01	8.00000E-04
2.46000E+00	9.90100E-01	8.00000E-04	4.31000E+00	9.96200E-01	7.00000E-04
2.46000E+00	9.98800E-01	7.00000E-04	2.46000E+00	9.91200E-01	7.00000E-04
2.46000E+00	9.94600E-01	6.00000E-04	2.46000E+00	9.95800E-01	6.00000E-04
2.46000E+00	9.92700E-01	7.00000E-04	2.46000E+00	9.94400E-01	6.00000E-04
2.46000E+00	9.94800E-01	7.00000E-04	2.46000E+00	9.96200E-01	7.00000E-04
2.46000E+00	9.92400E-01	7.00000E-04	2.46000E+00	9.93500E-01	7.00000E-04
2.46000E+00	9.94200E-01	7.00000E-04	2.46000E+00	9.89800E-01	7.00000E-04
2.46000E+00	9.90600E-01	6.00000E-04	4.74000E+00	9.94200E-01	8.00000E-04
2.46000E+00	9.85600E-01	5.00000E-04	4.74000E+00	9.98300E-01	8.00000E-04
2.46000E+00	9.86100E-01	5.00000E-04	4.74000E+00	9.99500E-01	8.00000E-04
2.46000E+00	9.90300E-01	6.00000E-04	4.74000E+00	9.95200E-01	7.00000E-04
2.46000E+00	9.88200E-01	6.00000E-04	4.74000E+00	9.92600E-01	8.00000E-04
2.46000E+00	9.91100E-01	5.00000E-04	4.74000E+00	9.92600E-01	8.00000E-04
2.46000E+00	9.89900E-01	5.00000E-04	2.46000E+00	9.95600E-01	1.30000E-03
2.46000E+00	9.88400E-01	6.00000E-04	2.46000E+00	9.95900E-01	1.30000E-03
2.35000E+00	9.94100E-01	7.00000E-04	2.46000E+00	9.94600E-01	1.20000E-03
2.35000E+00	9.93800E-01	6.00000E-04	2.46000E+00	9.99000E-01	1.30000E-03
2.35000E+00	9.91600E-01	6.00000E-04	2.46000E+00	9.94900E-01	1.40000E-03
2.35000E+00	9.90700E-01	7.00000E-04			

chi = 5.5918 (upper bound = 9.49). The data tests normal.

```
        Output from statistical treatment

   CN-CRI-05-6  ENR

    Number of data points (n)                        49
    Linear regression, k(X)                          0.9901 + ( 1.0818E-
03)*X
    Confidence on fit (1-gamma) [input]               95.0%
    Confidence on proportion (alpha) [input]          95.0%
    Proportion of population falling above
    lower tolerance interval (rho) [input]            95.0%
    Minimum value of X                               2.3500E+00
    Maximum value of X                               4.7400E+00
    Average value of X                               2.9145E+00
    Average value of k                                0.99322
    Minimum value of k                                0.98560
    Variance of fit, s(k,X)^2                        9.9990E-06
    Within variance, s(w)^2                          5.9286E-07
    Pooled variance, s(p)^2                          1.0592E-05
    Pooled std. deviation, s(p)                      3.2545E-03
    C(alpha,rho)*s(p)                                8.8529E-03
    student-t @ (n-2,1-gamma)                        1.67945E+00
    Confidence band width, W                         5.7522E-03
    Minimum margin of subcriticality, C*s(p)-W       3.1008E-03

    Upper subcritical limits: (  2.3500    <= X <=   4.7400    )
    ***** *********** *******

    USL Method 1 (Confidence Band with
    Administrative Margin)             USL1 = 0.9343 + ( 1.0818E-03)*X

    USL Method 2 (Single-Sided Uniform
    Width Closed Interval Approach)    USL2 = 0.9812 + ( 1.0818E-03)*X

    USLs Evaluated Over Range of Parameter X:
    **** ********* **** ***** ** ********* **
```

X:	2.35E+0	2.69E+0	3.03E+0	3.37E+0	3.72E+0	4.06E+0	4.40E+0	4.74E+0
USL-1:	0.9369	0.9372	0.9376	0.9380	0.9383	0.9387	0.9391	0.9394
USL-2:	0.9838	0.9841	0.9845	0.9849	0.9852	0.9856	0.9860	0.9863

```
*****************************************************************************
                         Thus spake USLSTATS
                             Finis.
        Plot file written to: ENR.plt
```

ITEM 3

Section 1.2.3 of the SAR inconsistently uses the terms gadolinia, gadolinium, and Gd_2O_3. revise the section using consistent and correct terminology.

Westinghouse Response:
Section 1.2.3 has been revised with correct and consistent terminology.

1.2.3 Contents of Packaging

Each shipping package holds a maximum of two BWR fuel rod assemblies. The unirradiated UO2 fuel rod assemblies are in a 10x10 square array having a fuel cross-sectional area of approximately 25 in^2. A fuel channel, which is a zirconium alloy box that contains the fuel rod bundles inside the reactor, may also be shipped as part of the bundle. Two assembly types may be transported in the package. They are described below.

The first assembly type, shown in figure 6.2, is made up of four sub-assemblies with 24 fuel rods in each subassembly. The 96 full length fuel rods have a nominal active length of 150 inches. Fuel pellets have a nominal outside diameter (O.D.) of 0.819 cm and are encapsulated in a zirconium alloy clad fuel tube. The cladding tube has a nominal thickness of 0.063 cm and a nominal outside diameter of .962 cm with end caps welded to each end. One of the following three paragraphs describe the enrichments of the fuel rods in the assembly:

a) The maximum U235 enrichment of the fuel rod assembly is 5.0% by weight; with a maximum average U235 enrichment within any axial zone of the assembly of 4.0% by weight. In addition, there are two (2) fuel rods per quadrant containing at least 2.5% by weight *gadolinia*.

b) The maximum U235 enrichment of the fuel rod assembly is 5.0% by weight; with a maximum average U235 enrichment within any axial zone of the assembly of 4.73% by weight. In addition, there are two (2) fuel rods per quadrant containing at least 5.3% by weight *gadolinia*.

c) The maximum U235 enrichment of the fuel rod assembly is 5.0% by weight; with a maximum average U235 enrichment within any axial zone of the assembly of 4.86% by weight. In addition, there are three (3) fuel rods per quadrant containing at least 2.4% by weight *gadolinia*.

The second assembly type, shown in figure 6A-4, is made up of four sub-assemblies with 24 rods in each sub-assembly. The assembly contains four-1/3 length rods and eight-2/3 length rods. The 1/3 length rods are located on the outside corners of the assembly. The eight-2/3 length rods, two per sub-assembly, are located on the geometric diagonal toward the center of the assembly. The three zones (upper, middle, and lower) of the assembly correspond to the fuel loading sets #4-#6 discussed in Section 6A.

The upper zone will have a minimum of eight Gadolinia-Urania rods each having a content of at least 4.0 wt% Gd_2O_3. The middle zone will have a minimum of ten Gadolinia-Urania rods each having a content of at least 4.0 wt% Gd_2O_3. The lower zone will have a minimum of twelve Gadolinia-Urania rods each having a content of at least 4.0 wt% Gd_2O_3.

Fuel pellets have a nominal outside diameter (O.D.) of 0.848 cm and are encapsulated in a zirconium alloy clad fuel tube. The cladding tube has a nominal thickness of 0.061 cm and a nominal outside diameter of .984 cm. The maximum U^{235} enrichment is 5.0 wt%.

ITEM 4

On page 10 of 13 of the RAI response letter, NMS-NAK-05-005, the paragraph describing the method for calculating the Gd_2O_3 specifies a minimum number of Gadolinia-Urania rods that is true for one of the fuel loading sets but not necessarity for all three. Revise the paragraph to eliminate the potential confusion. Note that this paragraph is also found in the SAR in Section 6A.4.

Westinghouse Response:

The paragraph in Section 6A.4 of the SAR has been revised to eliminate the potential confusion.

The Gadolinia pellet density depends on the Gd_2O_3 content. The composition for the Gadolinia-Urania pellet material is conservative for the purpose of the criticality evaluation, but bounds the specified range of Gadolinia-Urania pellet UO_2 and Gd_2O_3 contents. The actual range for Gadolinia-Urania pellet density is 10.57 to 10.43 g/cm^3 with a corresponding Gd_2O_3 content of 1.00 to 5.00 w/o. *The fuel assembly content specifies a minimum Gd_2O_3 content of 4.00 w/o and the Gadolinia-Urania density that is 10.43 g/cm3.* The Gadolinia-Urania material composition is specified in CSAS as a mixture of Uranium oxide (UO_2), Gadolinium (Gd), and Oxygen (O) that minimizes the Gadolinium content and maximizes the uranium oxide content. The UO_2 composition is specified as the theoretical UO_2, 10.96 g/cm^3. The Gd_2O_3 composition is specified using the standard composition for Gd and O with a density that is determined using the Gd_2O_3 density for 4.00 w/o adjusted to a minimum limit using the tolerance of a single pellet. Furthermore, the Gd density is reduced to 75 percent of this minimum limit to account for any other uncertainties in the Gadolinia-Urania fuel composition such as distribution and size of Gd_2O_3 particles.

ITEM 5

Please provide the wording to be included in the Certificate of Compliance that describes the contents. Specifically, information on the location of Gd_2O_3 rods and partial length rods must be included, as well as the minimum gadolinia loading.

Westinghouse Response:

Below please find the current CoC wording and the proposed new wording. Rather than refer to any sketch or paragraph in the SAR, it was decided to provide a verbal description of the three loading sets, exactly as was done for the original contents. Note also that while checking the wording of Section 6A, another typographical error was discovered on page 6A-6. Paragraph (b) of Section 6A.2.1.3 should read "24 per mini-bundle" and not "23 per mini-bundle." This is corrected in Revision 2.

Current CoC Contents Wording:

5.(b) Contents

(1) Type and form of material

The package is designed to hold two unirradiated BWR fuel assemblies, comprised of UO, fuel rods in a 10 x 10 square array. The fuel cross-sectional area is 25 square inches. Each assembly is made up of 96 full-length fuel rods having a maximum active fuel length of 150 inches. The fuel pellet diameter is 0.819 ± 0.002 cm, encapsulated in 0.063 cm zirconium alloy cladding. There is a 0.0085 cm gap between the pellets and the cladding. The maximum U-235 enrichment of any fuel rod is 5.0 weight percent. Each assembly contains water holes in the four center rod positions of the assembly. Three different fuel package loadings have the following specifications:

(i) Maximum average U-235 enrichment is 4.0 weight percent within any axial zone of the assembly; Maximum U-235 content is 3.25 weight percent of any gadolinia-urania rod or axial zone of gadolinia-urania fuel rod; Maximum number of fuel rods per assembly containing 5.0 weight percent U-235 enriched pellets is 36; maximum U-235 enrichment is 4.0 weight percent for all edge rods, and 3.5 weight percent for all corner rods; Each assembly must include at least eight fuel rods with a minimum gadolinia content of 2.5 weight percent in all axial regions with enriched pellets. The eight gadolinia rods are arranged with two rods in each quadrant of the fuel assembly. The two gadolinia rods within each quadrant must be symmetric about the geometric diagonal of the fuel assembly, and must not be in an edge or corner rod location. Other fuel rods containing gadolinia may be present.

(ii) Maximum average U-235 enrichment is 4.725 weight percent within any axial zone of the assembly; Maximum U-235 content is 4.275 weight percent of any gadolinia-urania rod or axial zone of gadolinia-urania fuel rod; Maximum number of fuel rods per assembly containing 5.0 weight percent U-235 enriched pellets is 52; maximum U-235 enrichment is 4.5 weight percent for all edge rods, and 4.0 weight percent for all corner rods; Each assembly must include at least eight fuel rods with a minimum gadolinia content of 5.3 weight percent in all axial regions with enriched pellets. The eight gadolinia rods are arranged with two rods in each quadrant of the fuel assembly. The two gadolinia rods within each quadrant must be symmetric about the geometric diagonal of the fuel assembly, and must not be in an edge or corner rod location. Other fuel rods containing gadolinia may be present.

(iii) Maximum average U-235 enrichment is 4.858 weight percent within any axial zone of the assembly; Maximum U-235 content is 4.2 weight percent of any gadolinia-urania rod or axial zone of any gadolinia-urania fuel rod; Maximum number of fuel rods per assembly containing 5.0 weight percent U-235 enriched pellets is 80; Maximum U-235 enrichment is 4.0 weight percent for all corner rods; Each assembly must include at least twelve fuel rods with a minimum gadolinia content of 2.4 weight percent in all axial regions with enriched pellets. The twelve gadolinia rods are arranged with three rods in each quadrant of the fuel assembly. The three gadolinia rods within each quadrant must be symmetric about the geometric diagonal of the fuel assembly, and must not be in an edge or corner rod location. Other fuel rods containing gadolinia may be present.

5. (b) (2) Maximum quantity of material per package

Two fuel assemblies. The total weight of contents not to exceed 1320 pounds.

(c) Transport Index for Criticality Control

Minimum transport index to be shown on label for nuclear criticality control: 1.0

Proposed CoC Contents Wording:

5.(b) Contents

The package is designed to hold two unirradiated BWR fuel assemblies, comprised of UO, fuel rods in a 10 x 10 square array. The fuel cross-sectional area is 25 square inches.

(1) Description of Assembly Type #1

Each assembly is made up of 96 full-length fuel rods having a maximum active fuel length of 150 inches. The fuel pellet diameter is 0.819 ± 0.002 cm, encapsulated in 0.063 cm zirconium alloy cladding. There is a 0.0085 cm gap between the pellets and the cladding. The maximum U-235 enrichment of any fuel rod is 5.0 weight percent. Each assembly contains water holes in the four center rod positions of the assembly. Three different fuel package loadings have the following specifications:

(i) Maximum average U-235 enrichment is 4.0 weight percent within any axial zone of the assembly; Maximum U-235 content is 3.25 weight percent of any gadolinia-urania rod or axial zone of gadolinia-urania fuel rod; Maximum number of fuel rods per assembly containing 5.0 weight percent U-235 enriched pellets is 36; maximum U-235 enrichment is 4.0 weight percent for all edge rods, and 3.5 weight percent for all corner rods; Each assembly must include at least eight fuel rods with a minimum gadolinia content of 2.5 weight percent in all axial regions with enriched pellets. The eight gadolinia rods are arranged with two rods in each quadrant of the fuel assembly. The two gadolinia rods within each quadrant must be symmetric about the geometric diagonal of the fuel assembly, and must not be in an edge or corner rod location. Other fuel rods containing gadolinia may be present.

(ii) Maximum average U-235 enrichment is 4.725 weight percent within any axial zone of the assembly; Maximum U-235 content is 4.275 weight percent of any gadolinia-urania rod or axial zone of gadolinia-urania fuel rod; Maximum number of fuel rods per assembly containing 5.0 weight percent U-235 enriched pellets is 52; maximum U-235 enrichment is 4.5 weight percent for all edge rods, and 4.0 weight percent for all corner rods; Each assembly must include at least eight fuel rods with a minimum gadolinia content of 5.3 weight percent in all axial regions with enriched pellets. The eight gadolinia rods are arranged with two rods in each quadrant of the fuel assembly. The two gadolinia rods within each quadrant must be symmetric about the geometric diagonal of the fuel assembly, and must not be in an edge or corner rod location. Other fuel rods containing gadolinia may be present.

(iii) Maximum average U-235 enrichment is 4.858 weight percent within any axial zone of the assembly; Maximum U-235 content is 4.2 weight percent of any gadolinia-urania rod or axial zone of any gadolinia-urania fuel rod; Maximum number of fuel rods per assembly containing 5.0 weight percent U-235 enriched pellets is 80; Maximum U-235 enrichment is 4.0 weight percent for all corner rods; Each assembly must include at least twelve fuel rods with a minimum gadolinia content of 2.4 weight percent in all axial regions with enriched pellets. The twelve gadolinia rods are arranged with three rods in each quadrant of the fuel assembly. The three gadolinia rods within each quadrant must be symmetric about the geometric diagonal of the fuel assembly, and must not be in an edge or corner rod location. Other fuel rods containing gadolinia may be present.

(2) *Description of Assembly Type #2*

Each assembly is made up of 96 fuel rods having a maximum active fuel length of 150 inches. Each assembly contains four-1/3 length rods and eight-2/3 length rods. The 1/3 length rods are located on the outside corners of the assembly. The eight-2/3 length rods, two per sub-assembly, are located on the geometric diagonal toward the center of the assembly. The fuel pellet diameter is 0.848 nominal, encapsulated in 0.061 cm nominal zirconium alloy cladding. There is a 0.0075 cm gap between the pellets and the cladding. The maximum U-235 enrichment of any fuel rod is 5.0 weight percent. Each assembly contains water holes in the four center rod positions of the assembly. Three different fuel package loadings have the following specifications:

(i) *Maximum U-235 enrichment of any rod is 5.0 weight percent; There shall be 84 rods, 21 per mini-bundle; There shall be a minimum of eight Gd2O3-UO2 rods per assembly, each having a Gadolinia content of at least 4.0 wt%. These eight Gd2O3-UO2 rods shall be placed two to a mini-bundle, arrayed symmetrically about the assembly. They shall not be placed on the periphery or the outer corner; There shall be 12 water holes, three in each mini-bundle. One water hole shall be on the outside corner and the other two shall be on the geometric diagonal towards center of the assembly. Other fuel rods containing gadolinia may be present.*

(ii) *Maximum U-235 enrichment of any rod is 5.0 weight percent; There shall be 92 rods, 23 per mini-bundle; There shall be a minimum of ten Gd2O3-UO2 rods per assembly, each having a Gadolinia content of at least 4.0 wt%. These ten Gd2O3-UO2 rods shall be shall be arrayed symmetrically about the assembly and along a major diagonal. They shall not be placed on the periphery or the outer corner; There shall be four water holes, one in each mini-bundle, on the outside corner. Other fuel rods containing gadolinia may be present.*

(iii) *Maximum U-235 enrichment of any rod is 5.0 weight percent; There shall be 96 rods, 24 per mini-bundle; There shall be a minimum of twelve Gd2O3-UO2 rods* *per assembly, each having a Gadolinia content of at least 4.0 wt%. These twelve Gd2O3-UO2 rods shall be shall be arrayed symmetrically about the assembly and along a major diagonal. They shall not be placed on the periphery or the outer corner. Other fuel rods containing gadolinia may be present.*

5. (b) (3) Maximum quantity of material per package

Two fuel assemblies. The total weight of contents not to exceed 1320 pounds.

(c) *Criticality Safety* Index *(CSI):* 1.0

Enclosure 2: Revision 2 Change Pages

Pages revised

- Page 1-2
- Page 6A-6
- Page 6A-9
- Page 6A-34

Westinghouse Electric Company, LLC
Columbia Fuel Fabrication Plant
Columbia, SC

Application for Certificate of Compliance for the Patriot BWR Fuel Shipping Package

NRC Certificate of Compliance

USA/9292/AF-85

Docket 71-9292

Initial Submittal: September 2004
Revision 1: April 2005
Revision 2: June 2005

Westinghouse Electric Company LLC
Nuclear Fuel
4350 Northern Pike
Monroeville, PA 15146

Westinghouse

Westinghouse Electric Company, LLC
Columbia Fuel Fabrication Plant
Columbia, SC

Application for Certificate of Compliance for the Patriot BWR Fuel Shipping Package

NRC Certificate of Compliance

USA/9292/AF-85

Docket 71-9292

Initial Submittal: September 2004
Revision 1: April 2005
Revision 2: June 2005

Westinghouse Electric Company LLC
Nuclear Fuel
4350 Northern Pike
Monroeville, PA 15146

Westinghouse

PATRIOT SAFETY ANALYSIS REPORT
LIST OF EFFECTIVE PAGES (cont.)

Page	Revision	Page	Revision	Page	Revision	Page	Revision
i	0	2-34	0	6-30	0	6A-6	2
ii	0			6-31	0	6A-7	1
		3-1	0	6-32	0	6A-8	1
1-1	0	3-2	0	6-33	0	6A-9	2
1-2	2	3-3	0	6-34	0	6A-10	0
1-3	1	3-4	0	6-35	0	6A-11	0
1A-1	0			6-36	0	6A-12	1
1B-1	0			6-37	0	6A-13	1
1B-2	0			6-38	0	6A-14	0
		4-1	0	6-39	0	6A-15	0
2-1	0			6-40	0	6A-16	0
2-2	0	5-1	0	6-41	0	6A-17	0
2-3	0			6-42	0	6A-18	0
2-4	0			6-43	0	6A-19	0
2-5	0	6-1	0	6-44	0	6A-20	0
2-6	0	6-2	0	6-45	0	6A-21	0
2-7	0	6-3	0	6-46	0	6A-22	0
2-8	0	6-4	0	6-47	0	6A-23	0
2-9	0	6-5	0	6-48	0	6A-24	1
2-10	0	6-6	0	6-49	0	6A-25	0
2-11	0	6-7	0	6-50	0	6A-26	0
2-12	0	6-8	0	6-51	0	6A-27	0
2-13	0	6-9	0	6-52	0	6A-28	0
2-14	0	6-10	0	6-53	0	6A-29	0
2-15	0	6-11	0	6-54	0	6A-30	0
2-16	0	6-12	0	6-55	0	6A-31	0
2-17	0	6-13	0	6-56	0	6A-32	0
2-18	0	6-14	0	6-57	0	6A-33	0
2-19	0	6-15	0	6-58	0	6A-34	2
2-20	0	6-16	0	6-59	0	6A-35	1
2-21	0	6-17	0	6-60	0		
2-22	0	6-18	0	6-61	0	7-1	0
2-23	0	6-19	0	6-62	0	7-2	0
2-24	0	6-20	0	6-63	0	7-3	0
2-25	0	6-21	0	6-64	0		
2-26	0	6-22	0	6-65	0	8-1	0
2-27	0	6-23	0	6-66	0	8-2	0
2-28	0	6-24	0	6-67	0	8-3	0
2-29	0	6-25	0				
2-30	0	6-26	0	6A-1	0		
2-31	0	6-27	0	6A-2	0		
2-32	0	6-28	0	6A-3	0		
2-33	0	6-29	0	6A-4	0		

1.0 GENERAL INFORMATION

1.1 Introduction

This application is submitted for approval of the Westinghouse Electric Company Nuclear Power, Inc. Boiling Water Reactor (BWR) new fuel rod assembly shipping package, designated as Model No. PATRIOT. The PATRIOT is based on the General Electric (GE) RA-series shipping package, including the RA-3 (Docket No. 71-4986), with some modifications. Differences between the PATRIOT and the GE RA-3 are intended to increase the structural integrity of the package and increase the package's ability to successfully complete the testing sequence described in 10CFR71. Further, criticality safety is assured through specific criticality analyses of the BWR fuel contents to be shipped. The package meets the applicable regulatory criteria of 10CFR71, with a Transport Index of 1 (i.e., TI = 50/52 = 0.9615 ≈ 1.0).

1.2 Package Description

1.2.1 Packaging

The PATRIOT shipping package is comprised of outer and inner packages. The outer package is constructed primarily of wood and serves as an overpack for the inner package. The inner package is a rectangular carbon steel box which sits inside the wooden outer package overpack. The maximum allowable gross weight of the complete package, which is equal to the test weight, is 2988 lbs. A detailed description of the inner and outer packages is provided in Sections 2.1.3 & 2.1.4. Drawings of the packages are provided in Appendix 1A.

1.2.2 Containment Boundary

The unirradiated fuel, in the form of uranium dioxide pellets, is encapsulated in sealed zirconium alloy tubes. These tubes are designed to withstand the operational conditions of a nuclear reactor. During transport in this package, the sealed tubes serve as the containment boundary for the fuel.

1.2.3 Contents of Packaging

Each shipping package holds a maximum of two BWR fuel rod assemblies. The unirradiated UO_2 fuel rod assemblies are in a 10 x 10 square array having a fuel cross-sectional area of approximately 25 in^2. A fuel channel, which is a zirconium alloy box that contains the fuel rod bundles inside the reactor, may also be shipped as part of the bundle. Two assembly types may be transported in the package. They are described below.

The first assembly type, shown in figure 6.2, is made up of four sub-assemblies with 24 fuel rods in each subassembly. The 96 full length fuel rods have a nominal active length of 150 inches. Fuel pellets have a nominal outside diameter (O.D.) of 0.819 cm and are encapsulated in a zirconium alloy clad fuel tube. The cladding tube has a nominal thickness of 0.063 cm and a nominal outside diameter of .962 cm with end caps welded to each end. One of the following three paragraphs describe the enrichments of the fuel rods in the assembly:

a) The maximum U^{235} enrichment of the fuel rod assembly is 5.0% by weight; with a maximum average U^{235} enrichment within any axial zone of the assembly of 4.0% by weight. In addition, there are two (2) fuel rods per quadrant containing at least 2.5% by weight *gadolinia*.

b) The maximum U^{235} enrichment of the fuel rod assembly is 5.0% by weight; with a maximum average U^{235} enrichment within any axial zone of the assembly of 4.73% by weight. In addition, there are two (2) fuel rods per quadrant containing at least 5.3% by weight *gadolinia*.

c) The maximum U^{235} enrichment of the fuel rod assembly is 5.0% by weight; with a maximum average U^{235} enrichment within any axial zone of the assembly of 4.86% by weight. In addition, there are three (3) fuel rods per quadrant containing at least 2.4% by weight *gadolinia*.

The second assembly type, shown in figure 6A-4, is made up of four sub-assemblies with 24 rods in each sub-assembly. The assembly contains four-1/3 length rods and eight-2/3 length rods. The 1/3 length rods are located on the outside corners of the assembly. The eight-2/3 length rods, two per sub-assembly, are located on the geometric diagonal toward the center of the assembly. The three zones (upper, middle, and lower) of the assembly correspond to the fuel loading sets #4-#6 discussed in Section 6A.

The upper zone will have a minimum of eight Gadolinia-Urania rods each having a content of at least 4.0 wt% Gd_2O_3. The middle zone will have a minimum of ten Gadolinia-Urania rods each having a content of at least 4.0 wt% Gd_2O_3. The lower zone will have a minimum of twelve Gadolinia-Urania rods each having a content of at least 4.0 wt% Gd_2O_3.

6A.2 FISSILE MATERIAL CONTENTS

The package will carry heterogeneous uranium compounds in the form of BWR fuel rods in a 10x10 fuel bundle. The uranium enrichment shall not be greater than 5.0 wt% ^{235}U. The uranium isotopic distribution considered in the models in this criticality safety analysis is shown in Table 6A-2.

Table 6A-2 Uranium Isotope Distribution

Isotope	Modeled Wt%
^{235}U	5.0
^{238}U	95.0

Figure 6.2 of Section 6 illustrates the geometry of the typical 10 x 10 BWR fuel assembly and pertinent component dimensions. During shipment for the fuel analyzed in this section, the fuel assembly channel and inter-module flow channels are present. The fuel assembly consists of four mini-bundles, each containing up to 24 rods.

6A.2.1 Individual Fuel Package Loading Criteria

Three distinct new fuel package loadings are defined according to maximum ^{235}U content, number and placement of UO_2 fuel rods, number of water holes, minimum number Gd_2O_3-UO_2 rods, and the ^{235}U / Gd_2O_3-UO_2 content of the Gadolinia-Urania rods. The criteria for each loading set is given below. Note that all analyses take credit for only 75% of the Gadolinia content specified.

6A.2.1.1 Fuel Package Loading Set 4

(a) The ^{235}U enrichment of any fuel rod shall not exceed 5.0 wt%.

(b) There shall be 84 rods, 21 per mini-bundle.

(c) There shall be a minimum of eight Gd_2O_3-UO_2 rods per assembly, each having a Gadolinia content of at least 4.0 wt%. These eight Gd_2O_3-UO_2 rods shall be placed two to a mini-bundle, arrayed symmetrically about the assembly. They shall not be placed on the periphery or the outer corner.

(d) There shall be 12 water holes, three in each mini-bundle. One water hole shall be on the outside corner and the other two shall be on the geometric diagonal towards center of the assembly.

(e) The fuel pellet diameter shall be 8.48 mm nominal

6A.2.1.2 Fuel Package Loading Set 5

(a) The 235U enrichment of any fuel rod shall not exceed 5.0 wt%.

(b) There shall be 92 rods, 23 per mini-bundle.

(c) There shall be a minimum of ten Gd_2O_3-UO_2 rods per assembly, each having a Gadolinia content of at least 4.0 wt%. These ten Gd_2O_3-UO_2 rods shall be shall be arrayed symmetrically about the assembly and along a major diagonal. They shall not be placed on the periphery or the outer corner.

(d) There shall be four water holes, one in each mini-bundle, on the outside corner.

(e) The fuel pellet diameter shall be 8.48 mm nominal.

6A.2.1.3 Fuel Package Loading Set 6

(a) The 235U enrichment of any fuel rod shall not exceed 5.0 wt%.

(b) There shall be 96 rods, 24 per mini-bundle.

(c) There shall be a minimum of 12 Gd_2O_3-UO_2 rods per assembly, each having a Gadolinia content of at least 4.0 wt%. These 12 Gd_2O_3-UO_2 rods shall be shall be arrayed symmetrically about the assembly. They shall not be placed on the periphery or the outer corner.

(d) The fuel pellet diameter shall be 8.48 mm nominal.

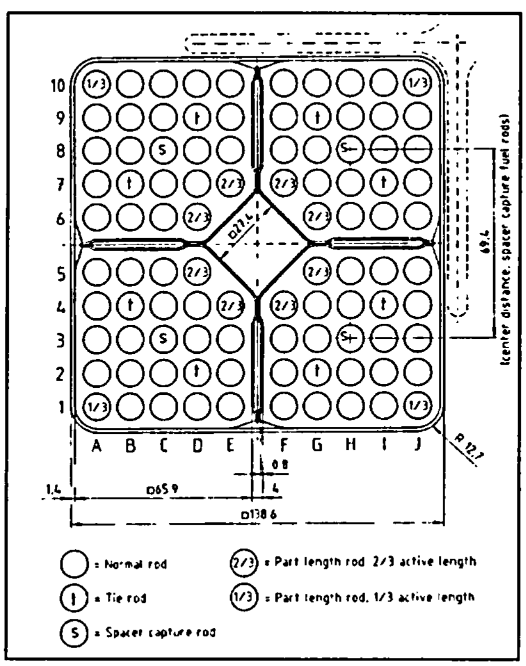

Figure 6A-4 Typical 10x10 Assembly Design

6A.4 MATERIAL PROPERTIES

The material properties of the packaging were not changed from Section 6. Note that the ethafoam and other packing material are not used in this analysis.

The Gadolinia pellet density depends on the Gd_2O_3 content. The composition for the Gadolinia-Urania pellet material is conservative for the purpose of the criticality evaluation, but bounds the specified range of Gadolinia-Urania pellet UO_2 and Gd_2O_3 contents. The actual range for Gadolinia-Urania pellet density is 10.57 to 10.43 g/cm^3 with a corresponding Gd_2O_3 content of 1.00 to 5.00 w/o. The fuel assembly content specifies a minimum Gd_2O_3 content of 4.00 w/o and the Gadolinia-Urania density that is 10.43 g/cm3. The Gadolinia-Urania material composition is specified in CSAS as a mixture of Uranium oxide (UO_2), Gadolinium (Gd), and Oxygen (O) that minimizes the Gadolinium content and maximizes the uranium oxide content. The UO_2 composition is specified as the theoretical UO_2, 10.96 g/cm^3. The Gd_2O_3 composition is specified using the standard composition for Gd and O with a density that is determined using the Gd_2O_3 density for 4.00 w/o adjusted to a minimum limit using the tolerance of a single pellet. Furthermore, the Gd density is reduced to 75 percent of this minimum limit to account for any other uncertainties in the Gadolinia-Urania fuel composition such as distribution and size of Gd_2O_3 particles.

6A.4.1 Computer Codes and Cross-Section Libraries

SCALE CSAS25 is used to perform the calculations of keff. The average energy of fission is in the intermediate energy range for evaluation of package arrays with fractional density water. The SCALE 238 group library is used instead of the SCALE 44 group library. Although any intermediate-energy problems are suspect because of the scarcity of critical experiments, this library performs better than any other library in SCALE. (Ref 4). The bias for the SCALE 238 group library is used in this calculation note.

6A.4.2 Demonstration of Maximum Reactivity

This analysis considers the accident transportation modes for fuel loading sets #4-#6, summarized in Table 6A-5. Fuel loading sets #4-#6 are to be transported as channeled fuel. The fuel lattice is conservatively assumed to have expanded uniformly to the inner surface of the channel for the hypothetical accident conditions. (It should be noted that drop tests performed in support of this safety analysis did not yield such results. See Section 2.) Because the fuel is shipped in channels, the plastic inserts are not included in the calculations. The ethafoam and rubber pads also are not considered because the moderating effect they would have is conservatively bounded by the variable water density calculations that were performed.

Determining maximum reactivity consisted of analyzing each loading set over the entire water density spectrum (0.08 g/cc to 1.0 g/cc) for each package configuration (i.e. placement of the assemblies in the basket), and flooding condition (full or partial). Calculations were made for the partial flooding condition for a right-side-up array and in inverted array. The inverted array means that alternating rows of packages were inverted to enable the fuel assemblies to face each other across a void. The water level for the partially flooded condition was conservatively set at the height of the fuel assemblies.

Table 6A-4 Accident Transportation Modes for Fuel Loading Sets #4-#6

Condition	Fuel Loading Set #4	Fuel Loading Set #5	Fuel Loading Set #6
Wooden outer container	Burned away	Burned away	Burned away
Inner container packing	Burned away	Burned away	Burned away
Fuel Channeled/Unchanneled	Channeled	Channeled	Channeled
Plastic inserts	No	No	No
Ethafoam / rubber pads	No	No	No
Carbon steel angle spacers	Yes	Yes	Yes
Water density	0.08 – 1.0 g/cc	0.08 – 1.0 g/cc	0.08 – 1.0 g/cc
Flooding Type	Fully Flooded Partially Flooded	Fully Flooded Partially Flooded	Fully Flooded Partially Flooded
Package Configurations	1 (Outside edge) 2 (Inside edge) 6 (Centered)	1 (Outside edge) 2 (Inside edge) 6 (Centered)	1 (Outside edge) 2 (Inside edge) 6 (Centered)
Partial Flooding Array Configurations	Right-Side-Up Inverted	Right-Side-Up Inverted	Right-Side-Up Inverted
Number Gd_2O_3-UO_2 Rods	8	10	12
Gd_2O_3-UO_2 Rod Config.	X	X & J	J
Gd_2O_3-UO_2 Loading	4.0%	4.0%	4.0%

Results are given in Tables 6A-6 through 6A-8, and plotted in Figures 6A-4 through 6A-6. Note that the curves in the graphs are presented as "eye guides" to enable the reader to discern the flow of the data for the partial and full flooded conditions.

Table 6A-11 Input Deck for Run # 6P-1-030 (cont'd)
END DATA END READ PLOT TTL=!XY PLOT OF RA3! PLT=YES PIC=MAT XUL=0 YUL=29 ZUL=50 XLR=50 YLR=0 ZLR=50 UAX=1 VAX=0 WAX=0 UDN=0 VDN=-1 WDN=0 NAX=600 SCR=YES LPI=8 END PLT1 END PLOT

Table 6A-12 Benchmark Criticality Experiments				
Case #	Case Name		Case #	Case Name
1	bw1484-i.18332.out:		26	pnl-3314-116.1322.out:
2	bw1484-ii.358.out:		27	pnl-3314-119.19398.out:
3	bw1484-iii.24205.out:		28	pnl-3314-055.25658.out:
4	bw1484-iv.29886.out:		29	pnl-3314-070.2076.out:
5	bw1484-v.18468.out:		30	pnl-2615-008.25870.out:
6	bw1484-vi.501.out:		31	pnl-2615-004.2286.out:
7	bw1484-vii.24341.out:		32	pnl-2615-031.1792.out:
8	bw1484-viii.132.out:		33	Bw1645s1.1950.out:
9	bw1484-ix.24614.out:		34	Bw1645s2.19626.out:
10	bw1484-x.18725.out:		35	Bw1645t1.26073.out:
11	bw1484-xi.787.out:		36	Bw1645t2.19824.out:
12	bw1484-xii.981.out:		37	Bw1645t3.2556.out:
13	bw1484-xiii.24808.out:		38	Bw1645t4.26281.out:
14	bw1484-xiv.482.out:		39	Nsc71h1.2773.out:
15	bw1484-xv.1214.out:		40	Nsc71h2.20046.out:
16	bw1484-xvi.18974.out:		41	Nsc71h3.2295.out:
17	bw1484-xvii.1419.out:		42	Nsc71sq.26500.out:
18	bw1484-xviii.25026.out:		43	Nsc71w1.3026.out:
19	bw1484-xix.739.out:		44	Nsc71w2.26708.out:
20	bw1484-xx.25233.out:		45	BW1810A.2632.out:
21	bw1484-xxi.19182.out:		46	BW1810B.3288.out:
22	pnl-2438-020.1066.out:		47	Bw1810cr.20673.out:
23	pnl-2438-032.1655.out:		48	BW1810D.27507.out:
24	pnl-3314-002.1854.out:		49	BW1810E.3515.out:
25	*pnl-3314-113.25440.out*			