71-9853
71-9191

Babcock & Wilcox
a McDermott company

Naval Nuclear Fuel Division
P. O. Box 785
Lynchburg, Virginia 24505-0785
(804) 522-6000

March 22, 1984

'84 MAR 30 A11:12

replaced by B&W app. dated 4/5/84
PDR
Return to 39655

DOCKETED USNRC APR 4 1984 NMSS MAIL SECTION DOCKET CLERK

U. S. Nuclear Regulatory Commission
Attn: C. E. MacDonald, Chief
Transportation Certification Branch
Division of Fuel Cycle & Material Safety, NMSS
Washington, D. C. 20555

Gentlemen:

The Babcock and Wilcox Company, Naval Nuclear Fuel Division is requesting a modification to shipping container USA/9853/B( )F, Certificate of Compliance Number 9853, per 10 CFR 71.31(b) and 71.13(b) to enable this package to be used for transporting R2 Materials Testing and Research Reactor elements.

The nuclear criticality safety of the R2 elements transported in the 9853 container is provided in the attached Babcock and Wilcox Company, Lynchburg Research Center letter from M. N. Baldwin to N. A. Regan, dated March 20, 1984; "Nuclear Safety Analysis of the Unirradiated Fuel Shipping Container for Shipment of R2 Elements".

Pending approval, please make the following changes to Certificate of Compliance No. 9853, dated January 13, 1984:

5 (b) Contents

(2) Maximum quantity of material per package

ORNL - BNL Container

Seven (7) fuel elements containing 370 grams U-235 per element with enrichment > 20 wt % U-235; or seven (7) uranium silicide U_3Si_2/Al fuel elements containing 500 grams U-235 per element with enrichment < 20 wt % U-235.

23513

C. E. MacDonald
U. S. Nuclear Regulatory Commission

and

References

LRC letter: "Nuclear Safety Analysis of the Unirradiated Fuel Shipping Container for Shipment of R2 Elements", M. N. Baldwin, dated March 20, 1984.

Your expeditious review and approval will be greatly appreciated.

Sincerely,

BABCOCK & WILCOX, NNFD

N. A. Regan
N. A. Regan
Nuclear Safety & Licensing Officer

NAR:mh

Attachment

cc: U. S. Department of Transportation
Attn: R. Rawl
Materials Transportation Bureau
Office of Hazardous Materials Regulation (OHMR)
Washington, D. C. 20590

Babcock & Wilcox
a McDermott company

Research and Development Division
Lynchburg Research Center
Lynchburg, Virginia 24505

To: N. A. REGAN, NNFD-31

From: M. N. BALDWIN, CHEMICAL & NUCLEAR ENGINEERING, LRC

cc: FM Alcorn
RW Carson, NNFD-31
RA Cordani, NNFD-3
AJ Koudelka
RH Lewis

Cust.

File No. or Ref.

Subj. NUCLEAR SAFETY ANALYSIS OF THE UNIRRADIATED FUEL SHIPPING CONTAINER FOR SHIPMENT OF R-2 ELEMENTS

Date: MARCH 20, 1984

The Analysis of the Unirradiated Fuel Shipping Container, designed by ORNL, is complete. The attached analysis shows that the container is suitable for shipping up to seven LEU, R-2 fuel elements with loadings not exceeding 500g U-235 per element. The attachment may be used as a basis for amending Certificate of Compliance #9853 to include the R-2 elements.

Q.A. Statement: I have reviewed this work including comparison to earlier work at ORNL and detail checks of current computer runs with the U_3Si_2/Al R2 fuel elements. I agree with the reported results and with the reported conclusion that the shipping containers can be safely used for the R2 elements and meet the requirements of 10 CFR 71.57.

F. M. Alcorn
F. M. Alcorn

M. N. Baldwin
M. N. Baldwin

I. Introduction

The Unirradiated Fuel Shipping Container, designed by Oak Ridge National Laboratory and licensed by NRC[1] for shipping specified types of unirradiated fuel elements, is examined herein from a Nuclear Criticality Safety point of view for its suitability for shipping R-2 fuel elements. The overall safety analysis of the container has been reported in reference 2.

The R-2 element is geometrically similar to an "MTR element" as is the HFBR elements assumed for the ORNL evacuations of the container, but incorporates U_3Si_2/Al as the core material. The fuel is proliferation resistant low enriched uranium (<20 wt% U-235), and each element may be loaded with up to 500g of U-235.[3,4] The element is illustrated in Figure 1. It is made up of 18 fuel plates, each loaded to 27.2 ± 0.5g of U-235. Total length including end adapters is 36-3/8 inch.

II. Method of Analysis

Our analysis follows that used by Thomas[5,6] in proving the criticality safety of HFBR element & ALRR converter element shipments: i.e., the KENO IV code and the Hansen-Roach cross-section sets were used, nine element positions are assumed per packages rather than the actual seven, the steel forming the inner basket was associated with each element in an identical manner, the nature of container damage was identical, and the geometric representation of the container was identical. In addition, our analysis incorporated the reduced density phenolic foam described in the re-evaluation of the ORR Shipping Package by Thomas.[7]

The validity of using the KENO IV code and Hansen-Roach cross-section set for LEU fuel (~20% enriched) was demonstrated by a calculation of the LEU

Critical Experiment which was conducted at the Ford Nuclear Reactor, University of Michigan in December, 1981. This calculation explicitly modeled each fuel plate and water gap as has been done in the present safety evaluation. This benchmark calculation gave a result that exceeded the measured value by a ΔK of 0.027 ± 0.007. Details of this calculation are reported in reference 8. Thomas[5] references the work of D. W. Mugnuson for validation of the code and cross-section sets used with borated-phenolic foam.

Results of Calculations

Results of the calculations are presented in Tables 1 and 2. Note that an infinite array of packages under normal conditions gives a very low Keff of less than 0.3. When the interior of the packages is flooded and no water is present between the packages to provide isolation, Keff reaches a maximum. In this latter case, Keff reaches 0.96 when nine elements per package are assumed loaded and the package is assumed damaged. When the number of elements is reduced to seven, by filling two element positions with water, Keff of an infinite array of packages is well below 0.9 for all postulated conditions.

Conclusions

Calculations show that up to seven LEU, R-2 fuel elements with loadings not exceeding 500g of U-235 per element, meet the requirements of a Fissile Class I package in transport, when loaded into the Unirradiated Fuel Shipping Container No. USA/9853/B( )F. Since a Fissile Class I package is more restrictive than a Fissile Class II or III (from a nuclear criticality safety viewpoint), the package evaluated is acceptable for all class shipments.

Table 1 Computed Keff for the Undamaged Package

Number of Packages	Condition	Keff ± σ: 9 elem/pkg	Keff ± σ: 7 elem/pkg	Arrangement of 7 Elements
Infinite array	No water preset	0.249 ± 0.003	-----	------------
Infinite array	Packages flooded, and water between packages	0.833 ± 0.008	-----	------------
Infinite array	Packages flooded, and no water between packages	0.914 ± 0.010	0.854 ± 0.009	EEW EEE EEW

Table 2 Computed Keff for the Damaged Package

Number of Packages	Condition	Keff ± σ: 9 elem/pkg	Keff ± σ: 7 elem/pkg	Arrangement of 7 Elements
Infinite array	Packages flooded, and water between packages	0.822 ± 0.010	-----	------------
Infinite array	Packages flooded, and no between packages	0.961 ± 0.009	0.844 ± 0.009	EEW EEE WEE
Infinite array	Packages flooded, and no between packages	------	0.854 ± 0.010	EEW EEE EEW

References

1. Certificate of Compliance No. 9853 dated January 13, 1984.

2. Safety Analysis Report for Packaging: The Unirradiated Fuel Shipping Container ORNL/ENG/TM-15, September 1979.

3. Statement of Work for Fabrication of LEU Silicide Fuel Elements To Be Irradiated In The R-2 Reactor, ANL Document No. A0004-1024-SA, Rev. 00, January 25, 1984.

4. Babcock & Wilcox NNFD Contract No. 31-109-38-6734 Supplemental Agreement No. 3.

5. Nuclear Criticality Safety Assessment of ORR, NBS, and HFBR Fuel Element Shipping Package, J. T. Thomas, ORNL/CSD/TM-77, January, 1979.

6. Union Carbide letter dated March 21, 1979 from J. T. Thomas to R. W. Knight.

7. Union Carbide letter dated September 10, 1979 from J. T. Thomas to J. H. Evans.

8. Babcock & Wilcox memo dated March 20, 1984 from M. N. Baldwin to F. M. Alcorn.

Appendix A

Data Input

MIXTURES AND NUMBER DENSITIES

1	-92504	2.39803-03	
1	92803	9.50083-03	FUEL MEAT
1	14100	7.92159-03	
1	13100	3.46789-02	
2	13100	6.02726-02	ALUMINUM
5	502	1.00000+00	WATER
7	13100	1.13837-02	END FITTINGS
7	502	0.81130+00	
10	200	1.00000+00	STAINLESS STEEL
11	100	1.00000+00	CARBON STEEL
13	6100	1.10880-03	
13	1101	1.39150-03	
13	8100	7.78390-04	
13	5100	8.88440-05	
13	14100	3.77890-05	BORATED PHENOLIC FOAM
13	11100	4.11060-06	
13	17100	5.84920-06	
13	13100	2.26010-06	
13	12100	2.48320-06	
13	20100	1.52160-05	
14	6100	2.72390-03	
14	1101	3.24120-03	
14	8100	1.75120-03	
14	5100	1.40660-04	
14	14100	5.98470-05	BORATED PHENOLIC FOAM
14	11100	6.50780-06	AND WOOD
14	17100	9.25890-06	
14	13100	3.57820-06	
14	12100	3.93130-06	
14	20100	2.40870-05	
15	6100	1.50995-03	
15	5100	7.79750-05	
15	14100	3.31750-05	
15	11100	3.60750-06	CHARRED BORATED PHENOLIC FOAM
15	13100	1.98350-06	
15	12100	2.17930-06	
15	20100	1.33530-05	

BOX TYPES

```
BOX TYPE  1
CUBOID   1  0. 32639+1  -0. 32639+1   0. 38000-1   -0. 38000-1
0. 29845+2      -0. 29845+2    16*0. 5
CUBOID   2  0. 33422+1  -0. 33422+1   0. 76000-1   -0. 76000-1
0. 31278+2      -0. 31278+2    16*0. 5
CUBOID   5  0. 33422+1  -0. 33422+1   0. 22250+0   -0. 22250+0
0. 31278+2      -0. 31278+2    16*0. 5
CUBOID   2  0. 37922+1  -0. 37922+1   0. 22250+0   -0. 22250+0
0. 31278+2      -0. 31278+2    16*0. 5
CUBOID   7  0. 37922+1  -0. 37922+1   0. 22250+0   -0. 22250+0
0. 46196+2      -0. 46196+2    16*0. 5
CUBOID   5  0. 39827+1  -0. 39827+1   0. 22250+0   -0. 22250+0
0. 88027+2      -0. 88027+2    16*0. 5
CUBOID  10  0. 40587+1  -0. 40587+1   0. 22250+0   -0. 22250+0
0. 88344+2      -0. 88344+2    16*0. 5


BOX TYPE  2
CUBOID   1  0. 32639+1  -0. 32639+1   0. 38000-1   -0. 38000-1
0. 29845+2      -0. 29845+2    16*0. 5
CUBOID   2  0. 33422+1  -0. 33422+1   0. 95000-1   -0. 95000-1
0. 34449+2      -0. 34449+2    16*0. 5
CUBOID   5  0. 33422+1  -0. 33422+1   0. 38200+0   -0. 24150+0
0. 34449+2      -0. 34449+2    16*0. 5
CUBOID   2  0. 37922+1  -0. 37922+1   0. 38200+0   -0. 24150+0
0. 34449+2      -0. 34449+2    16*0. 5
CUBOID   7  0. 37922+1  -0. 37922+1   0. 382000+0 -0. 24150+0
0. 46196+2      -0. 46196+2    16*0. 5
CUBOID   5  0. 39827+1  -0. 39827+1   0. 57250+0   -0. 24150+0
0. 88027+2      -0. 88027+2    16*0. 5
CUBOID  10  0. 40587+1  -0. 40587+1   0. 64870+0   -0. 24150+0
0. 88344+2      -0. 88344+2    16*0. 5


BOX TYPE  3
CUBOID   1  0. 32639+1  -0. 32639+1   0. 38000-1   -0. 38000-1
0. 29845+2      -0. 29845+2    16*0. 5
CUBOID   2  0. 33422+1  -0. 33422+1   0. 95000-1   -0. 95000-1
0. 34449+2      -0. 34449+2    16*0. 5
CUBOID   5  0. 33422+1  -0. 33422+1   0. 24150+0   -0. 38200+0
0. 34449+2      -0. 34449+2    16*0. 5
CUBOID   2  0. 37922+1  -0. 37922+1   0. 24150+0   -0. 38200+0
0. 34449+2      -0. 34449+2    16*0. 5
CUBOID   7  0. 37922+1  -0. 37922+1   0. 241500+0 -0. 38200+0
0. 46196+2      -0. 46196+2    16*0. 5
CUBOID   5  0. 39827+1  -0. 39827+1   0. 241500+0 -0. 57250+0
0. 88027+2      -0. 88027+2    16*0. 5
CUBOID  10  0. 40587+1  -0. 40587+1   0. 241500+0 -0. 64870+0
0. 88344+2      -0. 88344+2    16*0. 5
```

BOX TYPES (CONTINUED)

```
BOX TYPE  4
CUBOID   5  0. 40587+1  -0. 40587+1  0. 22250+0  -0. 22250+0
0. 88344+2      -0. 88344+2   16*0. 5
```

```
BOX TYPE  5
CUBOID   5  0. 40587+1  -0. 40587+1  0. 64870+0  -0. 24150+0
0. 88344+2      -0. 88344+2   16*0. 5
```

```
BOX TYPE  6
CUBOID   5  0. 40587+1  -0. 40587+1  0. 241500+0 -0. 64870+0
0. 88344+2      -0. 88344+2   16*0. 5
```

AN ELEMENT AND ITS ASSOCIATED MATRIX IS FORMED BY STACKING BOX TYPES ALONG THE Y DIRECTION IN THE ORDER 3 , SIXTEEN 1'S , 2.

AN ELEMENT POSITION WITH THE ELEMENT MISSING IS FORMED BY STACKING BOX TYPES ALONG THE Y DIRECTION IN THE ORDER 6 , SIXTEEN 4'S , & 5.

REFLECTOR GEOMERY FOR UNDAMAGED PACKAGES WITH WATER BETWEEN

```
CORE BDY  0 1. 21761+1  -1. 21761+1  1. 33506+1   -1. 33506+1
8. 8344+01       -8. 8344+01    16*0. 5
CYLINDER  13  3. 1000+01    8. 8344+01     -8. 8344+01   16*0. 5
CYLINDER  14  3. 1000+01    1. 03108+2     -1. 02944+2   16*0. 5
CYLINDER  11  3. 1320+01    1. 0343+02     -1. 0358+02   16*0. 5
CUBOID    5  3. 138+01 -3. 138+01 3. 138+01 -3. 138+01 1. 138+02 -1. 138+02
16*0. 5
```

REFLECTOR GEOMETRY FOR DAMAGED PACKAGES WITH WATER BETWEEN

```
CORE BDY  0 1. 21761+1  -1. 21761+1  1. 33506+1   -1. 33506+1
8. 8344+01       -8. 8344+01    16*0. 5
CYLINDER  13  2. 3380+01    8. 8344+01     -8. 8344+01   16*0. 5
CYLINDER  14  2. 3380+01    9. 5400+01     -9. 5400+01   16*0. 5
CYLINDER  15  3. 1000+01    1. 0311+02     -1. 0294+02   16*0. 5
CYLINDER  11  3. 1320+01    1. 0343+02     -1. 0358+02   16*0. 5
CUBOID    5  3. 138+01 -3. 138+01 3. 138+01 -3. 138+01 1. 138+02 -1. 138+02
16*0. 5
```

Appendix B

Keno Run Identifiers

Hash Code	Date	Keff ± σ
ACRAAXN	3-13-84	0.833 ± 0.008
ACRAAXK	3-13-84	0.822 ± 0.010
ACRAAYL	3-13-84	0.249 ± 0.003
ACRABKV	3-13-84	0.844 ± 0.009
ACRABKH	3-13-84	0.854 ± 0.010
ACRAAXO	3-13-84	0.914 ± 0.010
ACRAEBP	3-12-84	0.961 ± 0.009
ACRAAXP	3-14-84	0.854 ± 0.009

DOCKET NO. 71-9853

CONTROL NO. 23513

DATE OF DOC. 03/22/84

DATE RCVD. 03/30/84

FCUF ______ PDR ✓

FCAF ______ LPDR ______

WM ______ I&E REF. ✓

WMUR ______ SAFEGUARDS ______

FCTC ✓ OTHER ______

DESCRIPTION:

requesting a modification

04/06/84 INITIAL CEC