NIST

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February 14, 1992

Mr. Charles E. MacDonald
Chief, Transportation Branch
Division of Safeguards and Transportation
United States Nuclear Regulatory Commission
Washington, D.C. 20555

Reference: Docket Number 71-9246

Dear Mr. MacDonald:

Enclosed please find the additional requested information pertaining to criticality (10CFR71.61), and package integrity 10CFR71.55. Revised drawings of the container (Revision 2) are attached. This reflects the removal of the lifting and tie-down eyelets from the package design. There are no tie-down or lifting devices which are a structural part of the package in this final design.

Sincerely,

J. Michael Rowe
Chief, Reactor Radiation Division

Enclosure

N101 .1

NIST "ST" SERIES SHIPPING CONTAINER TESTING FOR NORMAL CONDITIONS OF TRANSPORT

The "ST" series Fissile Material Package is designed to transport a single NBSR fuel element in compliance with 49CFR173 and 10CFR71. This package was tested to demonstrate its integrity for normal conditions of transport.

The tested package is identical to those that will be used for transport. Prior to the sequence of tests, the package was loaded with a dummy element. The dummy element is identical to a fueled element except for the absence of the fueled portion of the internal plates. All tests required by 10CFR71.71 were performed in sequence as outlined below. Photographs were taken to document the physical conditions of the test.

Water Test: The sprinklers were arranged so that all sides of the package are wetted. The simulated rainfall via sprinklers was measured and exceeded 2" per hour. A post test time delay to allow "soak in" was not required since this is a metal container. Following the test, the package was examined for any deterioration or evidence of water entering the container. No water entered the container.

Free Drop Test: The package was dropped from a height of 4 feet onto a poured concrete pad. Because of the geometry of this package this test was repeated such that

(1) the first drop was on the closed, welded end,
(2) the second drop was on the end with the removable plate, and
(3) the third drop was with the package horizontal.

Prior to the 4' free drop test the package was dropped from a height of one foot on each corner of each end (four drops per end). The package was examined for any damage that could affect its integrity. No damage was found.

Penetration Test: A 6kg, 3.2cm diameter bar was dropped so as to impact the center of the package from a height of 1 meter. The package was resting on an unyielding surface, positioned horizontally as it would be during a shipment. Because the bar must impact a curved surface of the package, care was taken that the impact was not glancing.

The test bar was examined for any deformity at the impact point; none was found. The package was examined for any damage that could affect its integrity. No damage was observed.

Compression Test: This test was applied in the geometry in which the package normally is positioned during shipment, that is with the longitudinal axis of the package horizontal and each end resting on an unyielding surface (concrete). The projected area of the package (5-1/2" diameter pipe, 70" long) is 2500cm^2. This requires the greater of (1) 1300 kg/m^2 x 0.25 m^2 = 325 kg (715 lbs.), or (2) 5 x 55lbs. = 275 lbs. Hence 325kg was placed along the length of the package by placing three layers of lead bricks, each layer consisting of eight bricks (11.9 kg/brick), plus four additional bricks for a total of 28 bricks (333kg) on top of the package. This provided the uniform compression loading on two sides as required by 10CFR71.71. The load remained in place for 24 hours.

Upon completion of this test, the package was examined for any damage that could affect its integrity. No damage was observed.

Upon completion of the test sequence, the package was opened. The dummy element was examined for any damage that would indicate a possible failure of the package containment effectiveness. The interior of the package was examined for any damage that could affect its integrity. Other than chipped paint on the exterior of the package no effects of the testing were observed on the package. The dummy fuel element also showed no effects from the testing. It was not distorted or marred in any way. The package clearly met all the performance requirements of 10CFR71.57(d).

NIST "ST" SERIES SHIPPING CONTAINER SUBCRITICAL ANALYSIS (10CFR71.61)

Criteria: Twice this number of packages would be subcritical.

The attached report of a criticality analysis by the fabricator of the NBSR fuel, Babcock and Wilcox, demonstrates that up to seven undamaged NBSR fuel elements, arranged in any undamaged configuration, would be subcritical for any moderation and reflection geometry. No credit is taken for the poison effect of the steel in the package, nor for the spacing between packages.

Criteria: This number of packages would be subcritical if stacked together in any arrangement with optimal reflection and moderation.

Two (2) packages contain no more than 720 grams. Criticality cannot be achieved under any condition since this is less than the smallest mass of ^{235}U required to achieve criticality.

N 3-1

Babcock & Wilcox
a McDermott company

Naval Nuclear Fuel Division

To	A. J. Koudelka - NNFD-15A		
From	M. N. Baldwin - NNFD-15A	File No. or Ref.	MNB91-04
Subj.	FOUR NBSR ELEMENTS IN INFINITE SEA OF WATER	Date	1/31/91

REFERENCE 1: MEMO FROM J. W. HARWELL TO B. O. KIDD TITLED "NUCLEAR CRITICALITY SAFETY EVALUATION OF RIFLE RACKS IN THE RTRFE AREA TO INCLUDE ADDITIONAL ELEMENT TYPES," MARCH 28, 1989.

As you requested in response to a request from the National Institute of Standards and Technology, I have determined the upper limit of K-eff for four fully flooded NBSR fuel elements arranged 2x2 on a uniform square pitch in an infinite sea of water. The evaluation shows that the maximum K-eff value does not exceed 0.734.

For this evaluation, the basic NBSR element employed in Reference 1, and modeled in KENO Va was used. Each standard NBSR element was modeled explicitly to contain 17 fuel plates in the top and bottom fueled region, making a total of 34 fuel plates. The 2.436-Inch by 11.37-Inch by 0.020- Inch fueled portion of each plate is uniformly loaded with a matrix of 93% enriched UO_2 and aluminum to give a total plate loading of 10.294 Grams U-235. Clad thickness is 0.01525 Inches and water gap spacing is 0.116 Inches. A 6.00 Inch long water-filled center section separates the top and bottom fueled regions of the element. Total U-235 loading for the element is 350 grams.

The computer code KENO Va and the 16-group Master Library from Scale-3 processed thru BONAMI were used for the calculations. This was accomplished through the use of the Scale-3 control module CSAS25. Scale-3 is a modular code system for performing standardized computer analyses for licensing evaluations. It was prepared for the U. S. Nuclear Regulatory Commission by Oak Ridge National Laboratory. The CSAS25 control module has been benchmarked against numerous known-critical systems by Babcock & Wilcox Company (B&W) in addition to many other organizations. Since B&W benchmark and validation work shows that this control module (with various option restrictions which B&W imposes on criticality safety calculations) never underestimates the actual K-eff value of a system by more than 2%, and since a statistical uncertainty is always associated with a KENO Va calculation, a bias value of 0.02 plus two-sigma is always added to the calculated value when criticality safety is the consideration.

Five calculations, representing variations in the element spacing were made. The results presented in Table 1 include the two-sigma uncertainty and the 0.02 bias. K-eff is at a maximum when the element separation is about 0.5 Cm.

Although this evaluation uses the same calculational techniques, codes, bias value and cross-section library as would an internal criticality safety evaluation, and although the writer is confident that the K-eff quoted is conservative for safety considerations, and although it has been independently reviewed by another criticality safety engineer who has included his QA statement; this memo does not address many items that would be required by our evaluation procedures (such as review of required procedures, double contingency evaluation, posting requirements, etc.). This memo is not intended to constitute a criticality safety evaluation as defined by our procedures, and must not be subject to audit as a criticality safety evaluation. It is rather, what our customer requested: a determination of the upper limit of K-eff for four fully flooded NBSR fuel elements arranged 2x2 on a uniform square pitch in an infinite sea of water.

M. N. Baldwin

M. N. Baldwin

QA Statement:

I have reviewed these calculations and concur with the model, the codes used, the calculational techniques, the cross-section library, the results and conclusions. I further concur that this evaluation is not and is not intended to be a criticality safety evaluation as defined by NNFD procedures.

J. W. Harwell

J. W. Harwell

cc: FM Alcorn, NNFD-15A
JJ Bazley, NNFD-15A
AB Croft, NNFD-15A
RL Dunham, NNFD-15A
JW Harwell, NNFD-15A
BO Kidd, NNFD-15A
TD Lee, NNFD-35
RB Park, NNFD-15A
LL Wetzel, NNFD-15A

TABLE 1 - RESULTS OF CSAS25 RUNS - FOUR NBS ELEMENTS ON SQUARE PITCH IN AN INFINITE SEA OF WATER

RUN ID	ELEMENT SEPARATION	UPPER LIMIT* OF K-EFF
NBSG	0.0 CM.	0.708
NBSH	0.5 CM.	0.734
NBSI	1.0 CM.	0.726
NBSJ	3.0 CM.	0.590
NBSK	30.0 CM.	0.412

* calc. K-eff + two-sigma + 0.02

N.3-1

Babcock & Wilcox
a McDermott company

Naval Nuclear Fuel Division

To	A. J. Koudelka, NNFD-46		
From	M. N. Baldwin, NNFD-46	File No. or Ref.	MNB91-08
Subj.	SEVEN NBSR ELEMENTS IN INFINITE SEA OF WATER	Date	APRIL 26, 1991

Reference 1: MEMO FROM M N BALDWIN TO A J KOUDELKA TITLED "FOUR NBSR ELEMENTS IN INFINITE SEA OF WATER", JANUARY 31, 1991.

Reference 2: MEMO FROM J W HARWELL TO B O KIDD TITLED "NUCLEAR CRITICALITY SAFETY EVALUATION OF RIFLE RACKS IN THE RTRFE AREA TO INCLUDE ADDITIONAL ELEMENT TYPES", MARCH 28, 1989.

In response to a request to you from the National Institute of Standards and Technology, I determined and reported in Reference 1, the upper limit of K-eff for four fully flooded NBSR fuel elements arranged in their most reactive configuration in an infinite sea of water. The evaluation showed that the maximum K-eff value for four elements does not exceed 0.734.

Recently, a second request was received from the National Institute of Standards and Technology for the upper limit on K-eff for seven fully flooded and reflected elements. This second evaluation shows that the maximum K-eff value for seven elements does not exceed 0.881.

The methods used are basically the same as previously reported, but descriptions are repeated herein for the convience of the reader.

For this evaluation, the basic NBSR element employed in Reference 2, and modeled in KENO Va was used. Each standard NBSR element was modeled explicitly to contain 17 fuel plates in the top and bottom fueled region, making a total of 34 fuel plates. The 2.436-inch by 11.37-inch by 0.020-inch fueled portion of each plate is uniformly loaded with a matrix of 93% enriched UO2 and aluminum to give a total plate loading of 10.294 Gm U-235. Clad thickness is 0.01525 inches and water gap spacing is 0.116 inches. A 6.00 inch long water-filled center section separates the top and bottom fueled regions of the element. Total U-235 loading for the element is 350 grams.

UNCLASSIFIED
Arne J. Olsen 5/7/91
Classifier Date

The computer code KENO Va and the 16-group Master Library from Scale-3 processed through BONAMI were used for the calculations. This was accomplished through the use of the Scale-3 control module CSAS25. Scale-3 is a modular code system for performing standardized computer analyses for licensing evaluations. It was prepared for the U. S. Nuclear Regulatory Commission by Oak Ridge National Laboratory. The CSAS25 control module has been benchmarked against numerous known-critical systems by Babcock & Wilcox Company (B&W) in addition to many other organizations. Since B&W benchmark and validation work shows that this control module (with various option restrictions which B&W imposes on criticality safety calculations) never underestimates the actual K-eff value of a system by more than 2%, and since a statistical uncertainty is always associated with a KENO Va calculation, a bias value of 0.02 plus two-sigma is always added to the calculated value when criticality safety is the consideration.

Five calculations, representing variations in the element spacing were made. The results presented in Table 1 include the two-sigma uncertainty and the 0.02 bias.

Although this evaluation uses the same calculational techniques, codes, bias value and cross-section library as would an internal criticality safety evaluation, and although the writer is confident that the K-eff quoted is conservative for safety considerations, and although it has been independently reviewed by another criticality safety engineer who has included his QA statement; this memo does not address many items that would be required by our evaluation procedures (such as review of required procedures, double contingency evaluation, posting requirements, etc.). This memo is not intended to constitute a criticality safety evaluation as defined by our procedures, and must not be subject to audit as a criticality safety evaluation. It is rather, what our customer requested: a determination of the upper limit of k-eff for seven fully flooded NBSR fuel elements in an infinite sea of water.

M. N. Baldwin

M. N. BALDWIN

QA statement:

I have reviewed these calculations and concur with the model, the codes used, the calculational techniques, the cross-section library, the results and conclusions. I further concur that this evaluation is not and is not intended to be a criticality safety evaluation as defined by NNFD procedures.

J. W. Harwell

J. W. Harwell

TABLE 1 - RESULTS OF CSAS25 RUNS -
SEVEN NBS ELEMENTS IN AN INFINITE SEA OF WATER

RUN ID	ELEMENT SEPARATION	UPPER LIMIT OF K-EFF *
NBSB	0.0 CM.	0.849
NBSC	0.5 CM.	0.876
NBSD	1.0 CM.	0.881
NBSEE	1.5 CM	0.874
NBSFF	2.0 CM	0.859

* calc. K-eff + two-sigma + 0.02

FIGURE WITHHELD UNDER 10 CFR 2.390

NATIONAL INSTITUTE OF STANDARDS & TECHNOLOGY
GAITHERSBURG, MARYLAND

SHIPPING CONTAINER MODEL ST SERIES

NBSR FUEL ELEMENT

JACK STURROCK

JOHN NICKLAS

ALL DIMENSIONS IN FEET AND INCHES

SCALE: DO NOT SCALE

D-04-048

FIGURE WITHHELD UNDER 10 CFR 2.390

NATIONAL INSTITUTE OF STANDARDS & TECHNOLOGY GAITHERSBURG, MARYLAND 20899	
SHIPPING CONTAINER MODEL ST SERIES	
FOR NBSR FUEL ELEMENT	
JACK STURROCK [illegible]	JACK STURROCK [illegible]
MAHESH SUTHAR 2-7-92	JOHN NICHLAS 2-7-92
ALL DIMENSIONS IN FEET AND INCHES	SCALE: DO NOT SCALE
	D-04-048