SUMMARY OF CHANGES FOR XN-52, Rev. 1

Page No.	Section No.	Change Summary
7-2	Table 7-I	Single package k_{eff} for Type AA fuel changed to $< 0.900 \pm .008$.
12-10	12.2.4	Value of k_∞ modified for the higher Type AA fuel enrichment.
12-13	12.3.4	Fully flooded and reflected package reactivity for Type AA fuel changed from 0.886 ± .008 to 0.900 ± .008.
12-18	12.4.1.3	The reactivity of Type AA fuel under normal transport conditions with optimum interspersed moderation was changed from < 0.905 to < 0.913.
12-25	12.4.3.4	Calculated reactivity for damaged package arrays containing Type AA fuel was changed from 0.886 ± .008 to 0.900 ± .008.
12-43	Table 12-XVI	Type AA fuel enrichment was changed from 3.3 to 3.5 wt.% 235-U.
12-44	Table 12-XVII	Summary of calculated reactivities changed to include new values for Type AA fuel.

GUIDE FOR INCLUSION OF REVISED PAGES

OF XN-52, REVISION 1

1. Replace the old page 7-2 with the new page 7-2 dated April 1980.
2. Replace the old pages 12-10, 13, 18 and 25 with the new pages 12-10, 13, 18 and 25 dated April 1980.
3. Replace the old pages 12-43 and 44 with the new pages 12-43 and 44 dated April 1980.

TABLE 7-1

INDIVIDUAL PACKAGE REACTIVITIES

XN I.D.	Single Package k_{eff}*
I	< 0.84
II	< 0.74
III	< 0.634 ± .013
IV	< 0.765 ± .009
V	< 0.762 ± .011
VI	< 0.557 ± .012
Generically	< 0.97
Characterized (UO_2)	
AA	< 0.900 ± .008

* See discussion presented in Section 12 for details regarding the evaluations.

12.2.4 XN Type AA Fuel Elements

For the XN Type AA fuel element the value of k_∞ was computed assuming full water moderation, using the CCELL code. The calculation assumed a fuel element averaged fuel-rod-cell and resulted in a value of k_∞ of 1.434.

12.3 Single Package Evaluation

12.3.1 XN Type I and II Fuel Elements

The Model 51032-1 package will contain two XN Type I fuel elements. The Model 51032-1 packaging was designed to accommodate four such fuel elements, but current needs require that no more than two be loaded per package. The two Type I (short) fuel elements will be secured at opposite ends of the strongback and on opposite sides of the separator blocks. In order to simplify calculations, the two fuel elements are assumed to be secured at the same end of the strongback with a separation distance equal to the width (6 inches) of the separator blocks (the actual separation distance will be approximately 12 inches). Complete water moderation ($k_\infty = 1.34$) and full water reflection are also assumed. The isolation provided by the water assumed to be between the fuel elements is ignored.

Based on the above information and assumptions, k_{eff} of a single Model 51032-1 package containing two XN Type I fuel elements was calculated to be less than 0.84.

In these and all subsequent cases evaluating generically characterized fuel elements, unless otherwise noted, the fuel material was UO_2 at 95 percent of theoretical density; the clad was 0.020 inch thick zirconium; and the diametrical gas gap was 0.010 inch. For all KENO-II calculations, water cross sections and steel epithermal cross sections were averaged by the GAMTEC-II code, and the steel thermal group self-shielded cross sections were calculated using the BRT-1 (Battelle-Revised THERMOS-1) code.

The results of KENO-II Monte Carlo calculations based on the geometrical arrangement shown in Figure 12.5 are summarized in Table 12-VII.

12.3.4 XN Type AA Fuel Elements

For the XN-Type AA fuel element described in Section 2, the reactivity of a single package is less than that computed for the fully flooded infinite array of damaged packages. The reasons for such a decrease are two-fold:

1) No fissile material will be interacting with the single package; and

2) Two sides of each fuel element will be separated from the water reflector by the 1/4 inch steel strongback rather than one side as assumed in the fully flooded array of damaged packages (see Figure 12.6 for geometrical details).

As a consequence, the reactivity of a single package when fully flooded and reflected by water is less than 0.900 ± .008 which was computed for the damaged package array.

The results of these calculations are given in Table 12-XI. These data show that the maximum reactivity occurs when there is approximately 0.6 inches of water between adjacent packages. (Note that there is no ethafoam included around the fuel elements thereby resulting in optimum conditions occurring when moderation is included external to the packages.)

As for Part A above, applying the criterion that $k_{eff} + 3\sigma \leq 0.97$, it is demonstrated that Type B fuel elements packaged in Model 51032-1 or -1a containers meet the requirements for normal conditions of transport as Fissile Class I packages.

12.4.1.3 XN Type AA Fuel Elements

Under normal conditions of transport, XN Type AA fuel elements (see Table 12-XII) contained within undamaged Model 51032-1a packaging can be considered to be unmoderated. The packaging method for XN-Type AA fuel elements does not include the use of ethafoam (low density expanded polyethylene) pads around the fuel element or any materials interspersed within the fuel elements. To simplify the Monte Carlo calculations, conservative assumptions were made regarding the geometry of an array of such undamaged packages. The assumed geometric configuration is shown in Figure 12.9.

With optimum interspersed moderation (0.55 inch) between the packages, the reactivity of an infinite array of Model 51032-1a packages containing XN Type AA fuel elements was computed to be < 0.913 at the 95% statistical confidence level. This value was computed using the KENO-IV computer code with 123 group cross section data obtained from the NITAWL/XSDRNPM codes as described in Section 12.1.3.2.

used to derive Fissile Class I and III package limits based on the reactivity of infinite arrays of damaged packages. Limiting fuel element characteristics are summarized in Table 12-XVI.

12.4.3.4 XN Type AA Fuel Elements

The assumed geometric arrangement of damaged fuel elements in the nuclear safety calculations is shown in Figure 12.6. As for the generic fuel elements, the effect of the containment vessel walls and portions of the steel strongback have been conservatively ignored and both the minimum vertical and horizontal separations are assumed to occur simultaneously.

The reactivity calculated for an infinite array of fuel element packages in this assumed configuration is 0.900 ± .008. This value was computed using the KENO-IV computer code with 123 group cross section data obtained as summarized in Section 12.1.3.2.

12.4.3.5 Shipments of Individual Rods

Analyses presented in Section 12 demonstrate compliance of various generic UO_2 fuel types under a variety of limits which are not dependent on the method of confining the fuel rod arrangement. Since optimum interspersed moderation is assumed for all Class I shipments, and full moderation with water is assumed for all Class III shipments, the results of these evaluations are not affected by minor additions of materials between adjacent fuel elements. Consequently, it is requested that generic packaging limitations derived in Section 12 be applied to permit

TABLE 12-XVI

SUMMARY OF MODEL 51032-1 AND -1a PACKAGING LIMITS

XN Fuel Type	Average Nominal Enrichment (wt.% 235-U)	UO$_2$ Pellet Diameter (inches)	Fuel Element Water-to-Fuel Volume Ratio	Polyethylene Shipping Shims Included In Fuel Element	Effective Water Density of Contained Shipping Shims (g/cm^3)	Fissile Class	Fuel Element Size (inches)
A	≤ 3.5	≤ 0.50	≤ 2.1	Yes	≤ 0.2	I	≤ 5.20
B	≤ 3.5	≤ 0.50	$1.3 \leq V_w/V_f \leq 2.1$	No	Not Applicable	I	≤ 8.55
C	≤ 4.0	≤ 0.50	≤ 1.8	Yes	Not Limited	III	≤ 8.60
D	≤ 4.0	≤ 0.50	≤ 2.1	Yes	Not Limited	III	≤ 8.48
E	≤ 4.0	≤ 0.40	≤ 2.3	Yes	Not Limited	III	≤ 8.40
F	≤ 5.0	≤ 0.50	≤ 2.1	Yes	Not Limited	III	≤ 8.00
AA	≤ 3.5	0.3565	0 563 inch square pitch	No	Not Applicable	I	≤ 9.[illegible]

TABLE 12-XVII

SUMMARY OF COMPUTED REACTIVITIES FOR XN FUEL TYPES

Fuel Type	Fissile Class	Single Package Reactivity	Reference Section	Undamaged Package Array Reactivity	Reference Section	Damaged Package Array Reactivity	Reference Section
I	III	< 0.84	12.3.1	Not Computed	12.4.2.1	< 0.84	12.4.3.1
II	III	< 0.75	12.3.1	0.803 ± .009	12.4.2.2	0.803 ± .009	12.4.3.1
III	I	< 0.659	12.3.2	< 0.955 ± .005	12.4.1.1	0.634 ± .013	12.4.3.2
IV	I	< 0.783	12.3.2	0.955 ± .005	12.4.1.1	0.765 ± .009	12.4.3.2
V	III	< 0.784	12.3.2	0.530 ± .014	12.4.2.3	0.762 ± .011	12.4.3.2
VI	I	< 0.581	12.3.2	0.733 ± .006	12.4.1.1	0.557 ± .012	12.4.3.2
A	I	< 0.858 ± .007	12.3.3 & Table 12-XV	0.948 ± .004	12.4.1.2(A)	< 0.858 ± .007	12.4.3.3
B	I	0.930 ± .008	12.3.3 & Table 12-XV	0.950 ± .005	12.4.1.2(B)	0.930 ± .008	12.4.3.3
C	III	0.936 ± .008	12.3.3 & Table 12-XV	< 0.947 ± .008	12.4.2.4	< 0.936 ± .008	12.4.3.3
D	III	< 0.938 ± .008	12.3.3 & Table 12-XV	< 0.947 ± .008	12.4.2.4	0.938 ± .008	12.4.3.3
E	III	< 0.938 ± .008	12.3.3. & Table 12-XV	< 0.947 ± .008	12.4.2.4	0.942 ± .009	12.4.3.3
F	III	< 0.940 ± .009	12.3.3 & Table 12-XV	< 0.932 ± .009	12.4.2.4	0.940 ± .009	12.4.3.3
AA	I	< 0.900 ± .008	12.3.4	< 0.913	12.4.1.3	0.900 ± .008	12.4.3.4