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Memorandum

TO : Donald A. Nussbaumer, Chief, Source and Special Nuclear Materials Branch, DML

DATE: January 23, 1967

FROM : Charles D. Luke, Chief
Criticality Branch, DML

Cd.L

SUBJECT: NUCLEAR MATERIALS AND EQUIPMENT CORPORATION (NUMEC), PWR LETTER, JANUARY 6, 1967, DOCKET NO. 70-135

REFERENCE: (1) Ltr, DAN to NUMEC, 12/16/66
(2) Memo, CDL to DAN, 12/7/66
(3) NUMEC Application, 1/4/67

DML:CB:GHB

NUMEC disagrees with our review and comments (Ref. 1 and 2) concerning the safety analysis for the PWR area. We offer the following comments:

1. In response to our first comment, NUMEC states that the fraction critical "extrapolation to 0.6 as proposed in our application... is indeed reasonable and conservative. Such analysis will be presented at a later date to justify use of larger individual units...." NUMEC contradicts this in the second paragraph by stating: "We agree with you that an individual unit having a fraction critical value of 0.6 when bare could be critical if fully reflected." NUMEC indicates full reflection is credible. We cannot agree, therefore, that the criterion of 0.6 is indeed reasonable and conservative.

   NUMEC states the intent is to use only the units in Table XII-1 and that each unit will meet the criteria of TID-7016, Rev. 1. We have no objection to the criteria in TID-7016, Rev. 1. We do not agree that the Table XII-1 units meet the criteria because NUMEC has not demonstrated H/X-density correspondence.

2. Concerning our second comment, NUMEC states: "This statement by you shows lack of understanding of the PWR process which is described on page XII-1 of the application wherein it is stated that the H/X U-235 density relationship applies to 'Fully enriched ceramic grade UO_2 powder...blended with customer specified ceramic grade powders, and pressed...into thin wafers.' Because of the stated presence of diluents in the pressed wafers, the normal void volume associated with lower density U-235 cannot be taken up by water and hence the density H/X relationship specified in the abscissa of Figure 1 of TID-7016, Rev. 1, for salts and slurries, does apply."

The diluent is not present in all operations for PWR wafer production, e.g., the UO_2 as received and initially handled is not diluted. Even where diluent is present, the minimum diluent volume fraction is not stated.

An example may best illustrate our disagreement concerning the H/X-density correspondence.

1. NUMEC stated density: $\rho \leq 2.87$ g U/cm^3.

2. For UO_2-H_2O at the stated density, H/U = 6.2 (Reference: L. C. Amos, HW-64421).

3. Because the uranium is fully enriched, H/U = H/U-235.

4. From Figure 1, TID-7016, Rev. 1, for an H/U-235 ratio of 6.2, the corresponding U-235 density (ρ_o) is about 1.7 g U-235/cm^3.

5. The mass limits of TID-7016, Rev. 1, should be reduced by the factor $(\rho_o/\rho)^N$, where N = 1.5 (Reference: Fig. 7, TID-7028.)

3. NUMEC contends that the homogenization process is conservative in determining the fraction critical of the storage array. NUMEC contends that array reactivity increases with additional units, but that fraction critical does not necessarily increase. We agree with NUMEC that reactivity of the array increases with the addition of units. We disagree with NUMEC concerning the fraction critical statement. Consider, for example, a bare critical array of N units. Each unit has a fraction critical value of 1/N. As each unit is added to the array, the fraction critical increases linearly by 1/N. The reactivity also increases, but not necessarily in a linear manner.

NUMEC has erred in changing the basis for the fraction critical calculation. For the single unit, the cell volume is considered to be the unit volume. As each unit is added to the array, the space between units is added to the cell volume. NUMEC then homogenized the several units and spaces in arriving at a fractional critical less than that of a single unit.

The NUMEC method does not ensure safety. For example, two critical units could be so spaced that a shape factor greater than 2 is calculated. Mathematically dividing the two critical masses by the

shape factor results in a subcritical array. However, from a physical standpoint, the two critical units represent a supercritical array. We realize NUMEC does not have critical units. We are demonstrating only that the homogenizing process is not conservative.

In summary, NUMEC should:

1. Correctly consider the H/X-density correspondence. NUMEC has stated that only the safe units from TID-7016, Rev. 1, will be used. The errors identified in our Comments 1 and 2 would be non-existent if NUMEC would correctly apply the H/X-density criterion. In the latest submission, NUMEC has stated that the 0.6 fraction critical criterion will not be used.

2. Correctly calculate the fraction critical for the intermediate storage array.

NUMEC has submitted (Ref. 3) a revised page XII-19 to eliminate a clerical error. This revision does not affect our comments in Ref. 2 or in this memorandum.