5 pgs

Docket: 70-36 (M)
Project: S-8

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UNITED NUCLEAR (MALLINCKRODT) LICENSE SNM-33, SHIPPING CONTAINER FOR 20% ENRICHED UF_4 (APPLICATION DATED 8/16/62) AND FOR ≤ 20% ENRICHED U_3O_8 (APPLICATION DATED 10/15/62), DOCKET 70-36

United Nuclear requests extension of their License SNM-33 to include a shipping container for 20% enriched UF_4 and U_3O_8 enriched up to 20% having maximum tap densities of 1.5 grams/cc.

The container consists of a 6.12" I.D. 'Schedule 40' steel pipe centered in a standard 55-gallon drum birdcage formed by welding three such drums end to end. For a maximum of seven containers per shipment a total solid angle of 3.2 steradians will not be exceeded. We are in agreement with United Nuclear's analysis that the k_{eff} for a 6.12" diameter cylinder does not exceed 0.5 at an H/X of approximately 90 for the 20% enriched material, and consequently, a total solid angle of 3.2 steradians with the containers in a close packed hexagonal array, is safe. Commingling will be avoided through carrier certification.

In conclusion, we recommend approval of the applications, subject to Mr. Christian Beck's structural integrity evaluation. In this regard it is of course necessary that the evaluation criteria of 10 CFR 70 (71), as proposed, be invoked.

Attachments:
1. Ltr fm UNC dtd 8/16/62
2. Ltr fm UNC dtd 10/15/62

cc - filed in "SNM Foreign Unirradiated" - CFB

DLR:MS:CEB
CDLuke/vj
10/26/62

B-108

S-8
70-36
Mallinckrodt

Subject: United Nuclear Corp – SNM-33, Shipping Container for 20% enriched UF_4 (dtd. 8/16/62) and for ≤20% enriched U_3O_8 (dtd 10/15/62). Docket 70-36

Container: 6" diam. sched 40 steel pipe (8¼' long) centered in a 3 (55 gal.) drum structure

Array: 7 container shipments resulting in Ω_{ST} = 3.2 (close-packed hexagonal array)

Calculation Check:

Ref: DP-532 (Table IV.16)

$$\frac{3.77 \text{ moles}}{l}\left(\frac{307.5\,g}{mole}\right) = 1160\,g\,\frac{UO_2F_2}{l}$$ corresponds to k_∞ = 1.84 for 30% enriched UO_2F_2

U = 237.5 g
O_2 = 32 g
F_2 = 38 g
= 307.5 g

1500 g $\frac{UF_4}{l}$ = UF_4 present

∴ k_∞ ≥ 1.84 would certainly be conservative for 20% enriched UF_4

U. Nuc. assumed k_∞ = 2.05

ρ_{bulk} = 1.5 g/cc
ρ_{theo} = 6.7 g/cc

$\frac{H}{U}$ = 18

$\frac{H}{X} = 18 \times \frac{100}{20} = 90$

U_3O_8 = 8.39 g/cc

$$\left(\frac{H}{X}\right)_{wt} = \frac{1-\frac{1.5}{8.39}}{9}\left(\frac{235}{(1.5)(.847)(20)}\right) = \frac{.861(235)}{(9)(25.4)} = \frac{202}{228} = .89$$

Callihan's Data: < 20% enriched U_3O_8

4.9% ⟶ D_c(unrefl) = 47 cm @ H/X = 320

2% ⟶ D_c(unrefl.) = 54 cm @ H/X = 450

United Nuclear
Mallinckrodt
Proj 5-8
Doc 70-36

Appl 8/16/62

Proposes shipment of 20% enr UF_4 having a bulk tap density of 1.5 g/cc

Assume $\rho_0 = 10$ g/cc crystal density

For UF_4 $c = 0.76$

$$\left(H/X\right)_{wet} = \frac{1 - \rho/\rho_0}{9} \times \frac{235}{\rho \times c \times e}$$

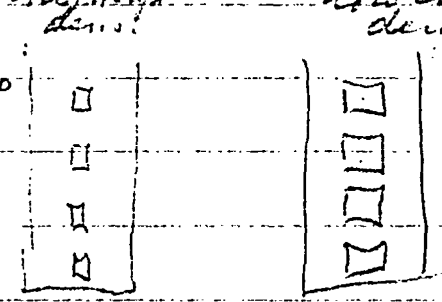
$$= \frac{1 - \frac{1.5}{10}}{9} \times \frac{235}{1.5 \times 0.76 \times 0.20} = 97.2$$

(.85)

Assume $\rho_0 = 6.7$ Crystal Density

$$\left(H/X\right)_{wet} = \frac{1 - \frac{1.5}{6.7}}{9} \times \frac{235}{1.5 \times 0.76 \times 0.20} = 89 \text{ or } U_3O_8$$

($1 - .224$ = .776; U_3O_8 (8.39); (.847) U_3O_8)



Higher cryst density comp. ρ_0 the more water, the higher H/X for a given bulk ρ

$\ell = 15.4$ cm

$$Vol = .785\,(15.4\text{ cm})^2\,(248\text{ cm})$$

$$Vol = 46{,}300\text{ cc}$$

98% 245 cm

$$\text{tap } \rho = 1.5\text{ g/cc}$$

$$\therefore\ 69{,}500\text{ g } UF_4$$

Fuel = 20% enriched UF_4

tot kg UF_4 = 69.5 kg

tot kg U = 53 kg

" U_{235} = 10.6 kg

$$N_{25} = \frac{(10{,}600\text{ g }U_{25})\left(\frac{6.02\times10^{23}\text{ atoms}}{235\text{ g }U_{25}}\right)}{46{,}300\text{ cc}} = \frac{272}{46{,}300\text{ cc}} = .000587\times10^{24}\text{ atoms/cc}$$

$$\frac{N_{28}}{N_{25}} = \frac{100-20}{20} = \frac{80}{20} = 4$$

? tot vol. H_2O

$$\rho_{\text{crystal }UF_4} = 6.7\text{ g/cc}$$

$$\left(\frac{H}{X}\right)_{wet} = \frac{1-\frac{1.5}{6.7}}{9}\times\frac{235}{1.5\times.76\times.20} = 89$$

$$\therefore\ \frac{H_2O}{U_{235}} = 44.5$$

$$g\,H_2O = 43.5\ g\,U_{235}$$
$$= (43.5)(10{,}600)$$
$$= 470{,}000\ g\,H_2O = 470{,}000\text{ cc }H_2O$$

$$\frac{N_{H_2O}}{N_{25}} = \frac{\frac{470\text{ kg }H_2O}{18\text{ kg }H_2O/mol}}{\frac{10.6\text{ kg }U}{235\text{ kg }U}} \qquad \frac{N_{H_2O}}{N_{25}} = \frac{26.1}{.045} = 580$$

$$\Sigma_a^{tot} = N_{25}\left[\sigma_{25} + \frac{N_{28}}{N_{25}}\sigma_{28} + \frac{N_{H_2O}}{N_{25}}\sigma_{H_2O}\right]$$

$$= .000587\times10^{24}\text{ atoms/cc}\ \left[637 + 4\,(2.8) + 580\,(0.66)\right]\times10^{-24}\text{ cm}^2$$

11.2   383 / 650 / 11.2 / 1044.2

$$= (.000587)(1044.2)$$

$$= 0.615\text{ cm}^{-1}$$

The σ_a of F is < 10 mb ∴ neglect effect in Σ_a^{tot} calc.

corrected
$\Sigma_a^{tot} = \frac{.615}{1.13} = 0.545\ cm^{-1}$

Let D = 0.162 cm.

$L^2 = \frac{D}{\Sigma_a^*} = \frac{0.162\ cm}{0.545\ cm^{-1}} = .3\ cm^2$

$f = \frac{\Sigma_{25}}{\Sigma_a\ tot} = \frac{N_{25}\sigma_{25}}{\Sigma_a\ tot} = \frac{(.000587 \times 10^{24}\ atoms/cc)(650 \times 10^{-24}\ cm^2)}{0.615\ cm^{-1}}$

$f = \frac{.382}{.615} = .622$

Let $\tau = 33\ cm^2$

Buckling: $B_g^2 = \left(\frac{2.405}{7.2+3cm}\right)^2 = .054\ cm^{-2}$

$\eta = 2.05$; $p\epsilon = 1.0$

$k_{eff} = \frac{\eta f}{(1+L^2 B_g^2)(1+\tau B_g^2)} = \frac{(2.05)(0.622)}{[1+(.3)(.054)][1+(33)(.054)]}$

(1.0162)(2.8) (2.78)

$= \frac{1.27}{2.8} = .454$