Met-Ed GPU

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Middletown, Pennsylvania 17057

Writer's Direct Dial Number

June 1, 1981
LL2-81-0152

TMI Program Office
L. H. Barrett, Deputy Director
U.S. Nuclear Regulatory Commission
Middletown, PA 17057

Dear Sir:

Three Mile Island Nuclear Station, Unit 2 (TMI-2)
Operation License No. DPR-73
Docket No. 50-320
Submerged Demineralizer System

During discussions with you and members of your staff, we have been requested to provide the following additional information:

> "The licensee will provide written documentation for criticality concerns. The calculations will be based on actual geometry."

This letter is our response to your request.

Extract:

The SDS Prefilter, Final Filter and Demineralizer will not become locations for critical masses of UO_2/U235 to accummulate.

SDS Prefilter:

The SDS Prefilter consists of 45 cartridges manufactured by AMF-Cuno Division, Meriden, Connecticut. These 45 cartridges are arranged in 15 "candles", each of which consists of 3 cartridges. [1]Each of these cartridges is a 125 micron nominal rating bearing Part Number C78W8-3.

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This cartridge has been type tested for particulate loading (loading quantity when plugged) using material known as "AC Coarse", also called Arizona Road Dust by AC Cuno. The 125 micron nominal cartridge has been demonstrated to hold, at plugged condition, 350-400 grams of this material whose characteristics are as follows:

A unit volume of AC Coarse material has the following characteristics:[1]

12%	0-5 microns
12%	5-10 microns
14%	10-20 microns
23%	20-40 microns
30%	40-80 microns
9%	80-100 microns

The exact chemical composition of Arizona Road Dust is not precisely known. However, it is assumed to be a common silicate material with composition and density similar to brick, chalk, light concrete, dry earth, limestone, mica and sandstone. These materials have densities ranging from 1.4-2.7.[2] Assuming the lowest density, 1.4, and 45 cartridges with known holding capacity of 400 grams per cartridge, and ratioing the density of "Arizona Road Dust" to UO_2 (density = 10.1 gm/cc), the combined cartridge loading of (assumed) fuel fines would be:

$$45 \text{ cartridges} \times \frac{400 \text{ gm}}{\text{cartridge}} \times \frac{10.1 \text{ gm/cc } UO_2}{1.4 \text{ gm/cc "Dust"}} = 129857 \text{ gm of } UO_2$$

and the amount of fissile material held would be:

$$129857 \text{ gm } UO_2 \times \left(\frac{238}{238 + 32}\right) \frac{U}{UO_2} \times 2.95 \text{ w/o } \frac{U235}{U238} = 3377 \text{ gm of } U235$$

Analyses[3] performed by GPU, Parsippany on the Prefilter assumed a roughly uniform lattice based upon the geometry of the filter elements within the prefilter housing. From that analysis:

"The filter elements were represented as regulating cells by an inner ring of water, an annular ring of filter material, a ring of UO_2 deposit, and finally an outer ring of water. The filter element is ... annular and the center dimension was used for the central water region in the cell. The outer surface is ... ribbed and the outer dimension of the solid filter material is used as the outside of the filter material in the cell model. The material itself is represented simply as a hydrocarbon with a density of 1.0 gm/cm^3. The outer region is water. Cell diameter was picked so that the cell area ... is ... 1/15 of the area occupied by the 15 elements of the prefilter ... The assumed accumulation of fuel material was modeled as an annular ring of fuel density UO_2 extending outward from the cartridge element, displacing the outer moderator ... Cell calculations were performed for

> the filter elements with accumulations of UO_2 of 1/4, 1/2, 3/4, 1 and 1 1/4 inch thickness ... For each calculated point the calculated K_∞ and M^2 was used to determine the material buckling and radius of a critical sphere... A polynominal fit to these data was used to approximate the minimum critical mass and the thickness of buildup giving it.

Calculations in these analyses show that exact critical mass and buildup thickness, taking into account infinite reflector, are:

Radius	5.083 cm
Thickness	0.73 in
UO_2 Kg	344 Kg
U 235 Kg	10.2 Kg

The conclusion is that <u>all</u> 45 prefilter cartridges would each have to be laden with a 0.73 inch outside coating of UO_2 fines containing 2.95% U235 for a critical configuration to exist.

Based on the previously identified test results of the 125 micron Prefilter cartridges with AC Coarse material, and taking into consideration the density difference of this "Road Dust" to UO_2, the filter cartridges will be plugged when they are laden with approximately 0.264 inch of material. This condition will not create criticality.

<u>SDS Final Filter</u>

The SDS Final Filter consists of 90 cartridges manufactured by AMF-Cuno Division, Meriden, Connecticut. These 90 cartridges are arranged in 30 "candles", each of which consists of 3 cartridges.[1] Each cartridge has a 10 micron nominal rating and bears Part Number G78C8-3. This cartridge has been type tested for particulate loading (loading quantity when plugged) using material known as "AC Fine", also called Arizona Road Dust by AC Cuno. The 10 micron nominal cartridge has been demonstrated to hold, at plugging condition, 132 grams of this material whose characteristics are as follows:

A unit volume of AC Fine material has the following characteristics:[8]

86.9%	0-2 microns
11.1%	2-5 microns
1.7%	5-10 microns
0.33%	10-20 microns
0.05%	20-40 microns
0.006%	40-80 microns

Utilizing the same logic as employed on the Prefilter, the 90 cartridges of the Prefilter hold:

$$90 \text{ cartridges} \times \frac{132 \text{ gram}}{\text{cartridge}} \times \frac{10.1 \text{ gm/cc}}{1.4 \text{ gm/cc}} = 85706 \text{ gm of } UO_2$$

and the amount of fissile material held would be:

$$85706 \times \left(\frac{238}{238 + 32}\right) \frac{U}{UO_2} \times 2.95 \text{ w/o } \frac{U235}{U238} = 2229 \text{ gm of } U235$$

The analysis[3] performed by Parsippany on the Final filter showed:

> "...a similar exercise (as performed on the Prefilter) with the final filter tank and its 30 filter elements would have yielded about a 10% larger cell radius.... A second set of cells was defined with an approximate 15% larger cell radius to show the sensitivity of the results to cell pitch...."

The result of the calculation is that the larger radius requires more material for criticality - and, hence, the final filter is less loaded with "fines" or filtrites at full ΔP conditions than the prefilter at full ΔP conditions due to the lesser amount of material loaded at plugging. Consequently, its margin to "critical" loading is greater and it is less reactive. Criticality in the final filter is therefore not a problem.

<u>SDS Demineralizer</u>

The analyses[5] for criticality on the SDS Demineralizer shows that the most reactive case is one in which there is 30% UO_2 in the mixture of (homogeneous) UO_2 and water. (Zeolite within the demineralizer bed ignored). In this case, the 30% UO_2/water mixture yields a base critical sphere with about 179 Kg of UO_2 or (at 2.95 w/o) 5 Kg U235.

This material would have to be deposited in a sphere, homogeneously within the zeolite bed either as the result of deposition of fines getting through the 10 micron nominal final filter, or deposition of dissolved Uranium into the zeolite bed.

In either case, the zeolite media has, due to its own characteristics, approximately 30% Void[4]. That is, in one cubic foot of zeolite exchange media, approximately 30% is void. If all of the void were UO_2, and knowing the UO_2 has a density of 10.1, 179 Kg of UO_2 would occupy all of the "void" in 2.09 ft^3 of zeolite.

Calculating the radius of the sphere in which all zeolite voids are full of UO_2: 179 Kg of UO_2, at a density of 10.1, occupies a volume of

17723 cc, or 17.723 liters. Employing the zeolite's 30% void, the volume of zeolite which would contain this UO_2 would be $\frac{17.72}{.3}$ = 59.08 liters.

The most reactive geometry of this mixture of material is a sphere which would have a radius of:

$$V = \frac{4}{3} \pi r^3 \qquad r^3 = \frac{3V}{4\pi}$$

$$r = \sqrt[3]{\frac{3 \times 59{,}080 \text{ cm}^3}{4 \times \pi}} \qquad r = \sqrt[3]{14104} = 24.16 \text{ cm} = 9.5''$$

This "sphere" would be 70% zeolite (properties shown in Attachments 1 and 2) and 30% UO_2, leaving no room for water (moderator). Moderator material which would be available would be a) the water (12-20%) in the hydrated zeolite and b) the zeolite (assumed to be a poor moderator). Further, the assumption that the "fines" accummulate in a geometrical sphere is significantly conservative. The associated concurrent requirement of displacement of moderator (water) to permit the UO_2 to collect in a sphere ensures no criticality. Results of confirming analyses taking into consideration physical properties of mixtures of water, fuel and zeolite will be submitted to the NRC by June 15, 1981.

The anticipated conclusion is that the Demineralizer cannot become the location for a critical mass of UO_2 fines because the required geometry cannot exist concurrently with the moderator necessary for criticality.

Should you wish to discuss this matter further, please contact Mr. L. J. Lehman, Jr. of my staff.

Sincerely,

G K Hovey

G. K. HOVEY
Vice President
and Director TMI-2

GKH:LJL:dp
Attachment

cc: Dr. B. J. Snyder,
Program Director
-TMI Program Office

POOR ORIGINAL

ION EXCHANGE

LINDE Molecular Sieves

ion exchange bulletin

LINDE IONSIV IE-95 Ion Exchanger

DESCRIPTION

LINDE IONSIV IE-95 Ion Exchanger is an alkali metal alumino silicate primarily of the chabazite structure type supplied in the mixed ionic (Na^+, Mg^{++}, Ca^{++}) form.

CHEMICAL FORMULA

(Na_2O, MgO, CaO) . Al_2O_3 . 4-6 SiO_2 . H_2O

SHIPPING INFORMATION

LINDE IONSIV IE-95 Ion Exchanger is available in 20 X 50 mesh form. Samples may be obtained on request.

REGENERATION

Typically, regeneration may be accomplished by the use of NaCl solution of the regenerant fluid.

TYPICAL PROPERTIES

Particle Size	Mesh (20 X 50)
Pore Openings	3.7 X 4.2 Å and 2.6 Å
Bulk Density	
As shipped	40 lbs/cu.ft.
	640 kg/cu.m.
Hydrated, packed	46 lbs/cu.ft.
	740 kg/cu.m.
BS&D Density (hydrated)	38 lbs/cu.ft.
	610 kg/cu.m.
H_2O Content	
As shipped	1 – 10 wt.%
Hydrated	12 – 17 wt.%
Ion Exchange Capacity	2.0 – 2.5 meq/gm (anhydrous)

TYPICAL APPLICATION AREAS

LINDE IONSIV IE-95 Ion Exchanger products have been found to be effective for recovery and storage of radio-nuclides and for cation exchange from acid solutions.

ADDITIONAL INFORMATION

Bulletins discussing additional applications of LINDE Molecular Sieves are available. Call or write your nearest LINDE Molecular Sieve Sales Office.

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F-4091 87-0246 1M

POOR ORIGINAL

ION EXCHANGE

LINDE Molecular Sieves

ion exchange bulletin

LINDE IONSIV A-50 Ion Exchanger Series

DESCRIPTION

LINDE IONSIV A-50 Ion Exchanger Series are an alkali metal alumino-silicate of the Type A crystal structure supplied in the Na+ (sodium) form.

CHEMICAL FORMULA

$Na_2O . Al_2O_3 . 2 SiO_2 . 4.5 H_2O$

SHIPPING INFORMATION

LINDE IONSIV A-50 Ion Exchanger Series are available in powder and 20 X 50 mesh form. Samples may be obtained on request.

TYPICAL APPLICATION AREAS

The LINDE IONSIV A-50 Ion Exchanger Series products are generally highly effective cation exchangers for the removal of small ions from dilute solutions.

TYPICAL PROPERTIES

	A-50	A-51
Particle Size	Powder (1 to 10 µm)	Mesh (20 X 50)
Pore Openings	4.2 Å into α-cage 2.2 Å into β-cage	4.2 Å into α-cage 2.2 Å into β-cage
Bulk Density		
As shipped	26 lbs/cu.ft.—420 kg/cu.m.	42 lbs/cu.ft. 670 kg/cu.m.
Hydrated, packed		50 lbs/cu.ft. 800 kg/cu.m.
BS&D Density (Hydrated)		42 lbs/cu.ft. 670 kg/cu.m.
H_2O content	18—22 wt.%	As shipped 1—10 wt.% Hydrated 16—20 wt.%
Ion Exchange Capacity	6.5—7.0 meq/gm (anhydrous)	5.0—5.5 meq/gm (anhydrous)

REGENERATION

Typically, regeneration may be accomplished by the use of NaCl solution as the regenerant fluid.

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Attachment 3

References:

1. Telephone conversation, G. R. Skillman to Hal Fuller, AMF-Cuno, (203) 237-5541, 17 May 1981, 1300.

2. Table 1-110, Properties of Common Solid Materials, CRC Handbook of Tables for Applied Engineering Science.

3. Criticality Analyses for SDS Prefilter, SDS Final Filter, and SDS Demineralizer, conducted by GPU Parsippany, May 1981.

4. "Crystalline Molecular Sieves" my D. W. Breck, Union Carbide Corporation, Page 5, Table 1, Chabazite Group.