PDR 70-1257

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March 12, 1980

Mr. W. T. Crow, Section Leader
Uranium Process Licensing Branch
Division of Fuel Cycle & Material Safety
U.S. Nuclear Regulatory Commission
Washington, D. C. 20555

License No. SNM-1227
Docket No. 70-1257

Dear Mr. Crow:

SUBJECT: NRC Comments & Questions on License Amendment Application No. 18

References: Letter, Robert L. Stevenson (NRC) to H. Paul Estey (ENC), dated January 24, 1980
Letter, H. Paul Estey (ENC) to W.T. Crow (NRC), dated February 22, 1980.
Verbal discussion in NRC Silver Spring Office on February 27, 1980 between W. T. Croww, R. L. Stevenson (both NRC) and H. P. Estey (ENC).
Telephone conversation on February 29, 1980 between R. L. Stevenson (NRC) and R. H. Schutt, J. W. Green and H. P. Estey (all ENC).

Exxon Nuclear Company, Inc. hereby submits its revised response to question no. 8 of the comments and questions raised by your staff on the subject license amendment application, as transmitted by your letter of January 24, 1980.

In addition to the revised response to question 8, the following changes to the license ammendment application are included to more fully describe the operation of ion exchange system and the basis for the assumptions used in the analysis:

- The Maximum Credible Accident Condition is now reported as the Theoretical Limit on Reactivity for the ion exchange column.

- Paragraph 4.6.13.4.1(a) is expanded to more fully describe the operation of the process waste stream and the controls on the ion exchange system to prevent exceeding the limits of concentration control.

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Respective pages of the License Amendment Application have been appropriately amended in accordance with this response, and seven copies of the amended pages are enclosed. Also, one copy has been sent to Region V IE.

Sincerely,

H. Paul Estey, Manager
Licensing and Compliance
Operating Facilities

Enclosures

cc: Mr. W. J. Cooley (USNRC Region V IE)

Revised Response To
Comment Number 8 on
License Amendment Application No. 18
(Application Dated November 19, 1979)
Exxon Nuclear Company, Inc.; License No. SNM-1227; Docket No. 70-1257

8. Page II-4.78, para. (c)

Question (a)

What is the basis for assuming a zero resin loading when the interstices were assumed filled with ADU for the calculation reported here?

Response

It was originally assumed that resin loading was a surface phenomenon with the cations being loaded on the resin surface which would proportionately decrease the interstitial void volume. Further investigations indicate some of the material loaded on the resin is absorbed in the resin and does not decrease the interstitial void volume. Since it is difficult to quantify the percent decrease in interstitial void volume with resin loading it will be assumed that the resin loading plus the interstitial void volume will represent the theoretical limit on uranium content in the column.

Paragraph 4.6.13.3(c) of the application is rewritten using the sum of the manufacturers maximum resin loading value and the interstitial void volume for the theoretical limit on uranium content in the resin bed.

Question (b)

The values quoted for normal resin unloading appear to be small compared to the uncertainty in, and possible impact of, resin bed

void volume. Are there no measurements of resin bed void volume that would be directly applicable to the situation analyzed?

Response

Three alternate methods are available for determining the resin bed void volume:

1) Manufacturers report void volumes 30-40 percent;

2) Manufacturers give a bulk density and particle density with the relationship, $\rho b = \rho p(1-\varepsilon)$ where ρb = bulk density, ρp = particle density and ε = void fraction;

   For the resins to be utilized, the bulk density is 42 lbs/ft^3 (0.67 kg/ℓ), and the particle density (or Sp. G.) is approximately 1.09, representing a 38 percent void volume.

3) Volumetric Measurement
   Laboratory measurements yield an average of 39.3 percent void volume. There appears to be good correlation for a void volume of 40 percent.

   Based on the above information paragraph 4.6.13.3(c) of the application has been rewritten using 40 percent as the resin bed void volume.

Question (c)

Why was it assumed that ADU would not fill the unpacked section?

Response

Administrative controls and the nature of the process preclude effluents containing greater than 300 ppm uranium from entering

the ion exchange column. At this concentration any undissolved particles that do enter the column would be filtered out in the resin bed void spaces. Any appreciable accumulation of solids accumulated in the resin would cause a pressure differential across the column stopping flow to the column.

Paragraph 4.6.13.4(a) of the application is rewritten to include a description of the process controls used to prevent effluents containing greater than 300 ppm uranium from entering the column or allowing a column being operated after breakthrough.

ATTACHMENT

SUMMARY OF CHANGES IN DOCUMENT NO. JN-2

Page No.	Section No.	Change
II-4.76	II-4.6.13.2	The description and nomenclature of the cases to be analyzed have been modified to more accurately describe what the cases analyzed represent.
II-4.76	II-4.6.13.2(a)	Changed resin loading value from 0.6 kgs/ft^3 to 1.27 kgs/ft^3 to correspond to the value given in paragraph 4.6.13.3(a).
II-4.77	II-4.6.13.2(c)	Nomenclature changed from "Maximum Credible Accident Condition" to "Theoretical Limit on Reactivity", and the assumed uranium loading is changed to the sum of the uranium in the loaded resin bed and the uranium in the interstitical void volume.
II-4.77	II-4.6.13.2(d)	Eliminated section. Since it would be impossible to achieve the conditions stated in section 4.6.13.2(c), the elution of that case is superfluous.
II-4.77	II-4.6.13.3(a)	The manufactuer's maximum resin loading value of 45 gmU/ℓ is used for comparison to the safe concentration; the use of 50 gmU/ℓ was an unnecessary conservatism.
II-4.77a	----	Eliminated page.
II-4.78 & II-4.79	II-4.6.13.3(c)	Section rewritten to reflect change in nomenclature, detailed description of void volume, and different density used for calculation.
II-4.79	II-4.6.13.3(d)	Eliminated section. Since it would be impossible to achieve the conditions stated in Section 4.6.13.3(c), the elution of that case is superfluous.
II-4.80, II-4.81 & II-4.82	II-4.6.13.4.1(a)	Expanded paragraph and included description of administrative controls on ion exchange system.
II-4.82	II-4.6.13.4.2	Changed "maximum credible" to "theoretical limit on reactivity", and restructured the last sentence of this paragraph.
II-4.82	II-4.6.13.4.3	Relocation of Material, only.
II-4.83	Table II-4.9	Changed page number, only.

4.6.13 Conversion Process Liquid Effluent Ion Exchange Treatment Systems

4.6.13.1 System Description

Effluents from the polishing centrifuges are collected in the quarantine tanks located in the tank gallery, where samples are withdrawn to check the uranium content both visually and with an on-line uranium monitor. If the effluent contains greater than 300 ppm uranium, it will be recycled. If it contains 300 ppm uranium or less, the effluent will be pumped through a set of prefilters and then through ion exchange columns for further uranium removal. A turbidity meter in the feed line to the ion exchange system will alarm and stop the flow to the columns at a point representing 300 ppm uranium. Each ion exchange system consists of three 20 inch diameter by 10 feet long cylindrical tanks, each approximately half full of resin. The effluent will pass through two tanks in series and then be discharged through the SNM Accountability Measurement Station to the Process Chemical Waste Storage Lagoon System. The effluent from the first ion exchange column passes through an on-line uranium monitor to detect saturation of the ion exchange resin. When the ion exchange resin becomes saturated to a point where uranium begins to leak through (breakthrough), the column is taken off line for regeneration. The resin is regenerated by first eluting the uranium off the resin with less than 2N nitric acid, then the resin is reconditioned with aqueous ammonia. The uranium rich eluate will be stored in eluate storage tanks located in the ion exchange regeneration tank gallery.

4.6.13.2 Assumptions for Analysis

The analysis considers the *normal operation of the ion exchange columns and a theoretical limit on reactivity for a column:*

(a) Normal Operating Condition (Loaded Column)

The bottom half of the column contains resin loaded with uranium to a bulk density of approximately *1.27* kgs/ft^3. The top half of the column contains effluent at the maximum permissible release limit (300 ppm U).

(b) Elution of Normal Operating Condition

The total content of the column accumulates in the most reactive geometry considering the maximum uranium concentration for 2N nitric acid and the geometry of the column.

(c) *Theoretical Limit On Reactivity*

The bottom half of the ion exchange column contains the loaded resin bed packed with ADU in the interstitial *void* volume of the resin bed. The upper half of the column contains effluent at the maximum permissible release limit (300 ppm U).

(*)

4.6.13.3 Evaluation

(a) Normal Operating Condition for a Loaded Column

The normal operating condition will assume that the resin is loaded to the maximum resin loading value which is calculated in the following manner:

$$\text{grams/liter} = \text{equivalent/liter} \times \frac{\text{Atomic Weight}}{\text{Valence}}$$

Total Chelating/Cation Exchange Capacity: 5.3 meg/g(dry)
Moisture Content: 68 percent (nominal)
Shipping Weight (sodium form) = 42 lbs/ft^3 = 0.67 kg/ℓ
Resin dry weight: 0.67 kg/ℓ x 0.32 = 214 g/ℓ

5.3 meg/g x 214 g/ℓ = 1134.2 meg/ℓ = 1.134 eq/ℓ

$$1.134 \text{ eq/ℓ} \times \frac{238}{6} = 45 \text{ gm/ℓ}$$

(*)

Minimum critical and safe uranium concentrations for a twenty inch diameter *column*:

Minimum Critical Concentration = 27.7 kgs U/ft
= 12.7 kgs/ft^3
= 448 gm U/ℓ

Safe Concentration (50% of Critical) = 224 gm U/ℓ

The maximum operating concentration of *45* gm U/ℓ is less than 50% of the safe concentration (224 gm U/ℓ).

(b) Elution of Normal Operating Condition

The elution of the ion exchange resin with a maximum of 2N nitric acid may concentrate the uranium to a maximum of 159 gms U/ℓ according to the following equations. The 159 gms U/ℓ in the eluant is less than the minimum safe concentration (224 gms U/ℓ) for a twenty inch column.

$$6\ HNO_3 + (NH_4)_2\ U_2O_7 \rightarrow 2\ UO_2(NO_3)_2 \cdot 6H_2O + 2NH_4NO_3 + 3H_2O$$

Maximum HNO_3 Concentration = 2 Molar (Normal)

2M HNO_3 → 2/3M UNH

GMW of UNH = 502.18

Max. UNH Concentration = 2/3 x 502.18 = 335 gms/ℓ

Max. U Concentration = 2/3 x 238 = 159 gms/ℓ

(c) *Theoretical Limit on Reactivity

During the normal operation of a column the resin will not reach the uranium concentration stated in (a), but will be at a lesser concentration with most of the loading taking place in the upper section of the resin bed. At breakthrough the bottom section of the column will be only partially loaded. The upper section of the resin bed may also contain minute quantities of undissolved ADU that have been filtered out by the resin bed. Administration controls assure that the column will not be operated beyond the breakthrough point, or if the interstational void volumes begin to be filled, but no physical limit (such as geometry) exists. The theoretical limit on reactivity demonstrates that the ion exchange column containing ion exchange resin and ADU at maximum theoretical density is sub-critical.

This case assumes a twenty-inch inside diameter by infinitely long cylinder filled with ADU and ion exchange resin.

The void volume of the resin bed can be determined by the following three alternate methods:

1) Manufacturers report void volumes of 30-40 percent;*

*2) Manufacturers give a bulk density and particle density with the relationship, $\rho b = \rho p(1-\epsilon)$ where ρb = bulk density, ρp = particle density and ϵ = void fraction; For the resins to be utilized, the bulk density is 42 lbs/ft^3 (0.67 kg/ℓ), and the particle density (or Sp. G.) is approximately 1.09, representing 38 percent void volume.

3) Volumetric Measurement
Laboratory measurements yield and average of 39.3 percent void volume.*

ENDF/B-III cross sections for ADU were generated at * a density resp: esentative of the maximum void volume (40 percent) plus the loaded density (45 gm/ℓ) of the resin. The resin was represented as water.

Maximum ADU density = 0.85 gm U/cm^3
ADU balk density in resin bed = 0.34 gm U/cm^3
Density of ADU loaded on resin = 0.045 gm U/cm^3
Density of ADU = 0.385 gm U/cm^3*

The reactivity of a twenty-inch inside diameter by infinitely long cylinder, fully reflected by water, was calculated using the HFN computer code. The results are as follows:

k_{eff} = *0.915* Full Water Reflection

The top half of the column containing effluents at a maximum concentration of 300 ppm U is accounted for by the assumption of an infinitely long column.

(*)

From the above data and calculations, it is concluded that the ion exchange columns are critically safe based on concentration control.

4.6.13.4 Compliance with Criteria

The results of the evaluation indicate that all of the criteria specified in Section I-5.2.2, "Technical Practices", of this Document have been satisfied, specifically:

4.6.13.4.1 Double Contingency

The double contingency principle requires that there must be at least two unlikely, independent and concurrent changes in process conditions before a nuclear criticality accident is possible. The contingency categories are 1) concentration control, and 2) enrichment control. These are discussed below:

(a) Concentration Control

Laboratory analyses of both Line 1 and Line 2 *indicate a yearly average uranium concentration in the ADU conversion process effluents of 89 ppm and 55 ppm respectively, which will be the feed concentrations for the ion exchange waste treatment system.* Laboratory and large scale testing indicate * the nomially expected uranium loading factor for the types of ion exchange resin used to be 0.6 kgs/ft^3, with the maximum experienced in large scale testing to be 1.0 kgs/ft^3. The concentrations are below the manufacture's value of 1.27 kgs/ft^3 used for the normal operating condition.* In addition to the normal process conditions, which are conservative compared to the (*) conditions analyzed, *the following* system of positive interlocks, alarms and sample points has been included in the system so that there are a minimum of two controls in series to prevent the process from exceeding the conditions analyzed:

*(1) Quarantine Tank Sample

Quarantined process wastes are sampled and analyzed for uranium concentration prior to release to the ion exchange system. The samples are both visually inspected and measured in the uranium monitor system for uranium concentration. If ADU is visually present, or if the uranium monitor indicates greater than 300 ppm uranium, the quarantine tank contents are recycled through the process centrifuges.*

*(2) Differential Pressure Interlocks on Prefilter

Two filters are operated alternately upstream from the ion exchange columns. Differential pressure instrumentation across these filters will alarm and automatically switch the flow to the alternate filter upon detection of high filter pressure drops. The plugged filter is then backwashed with nitric acid, rinsed, and placed in standby. Should both filters blind, the feed is by-passed to the Lagoon System.

(3) Turbidity Measurement on Ion Exchange Column Feed

A turbidity monitor is located between the prefilters and the ion exchange columns to monitor suspended solids (ADU). If the turbidity monitor detects a turbidity representing greater than 300 ppm uranium, it alarms and by-passes the feed to the Lagoon System.

(4) Online Uranium Monitor on Column Discharge

The online uranium monitor continuously measures the uranium concentration of the "roughing", or first, column. The control set point is ten percent of breakthrough. At breakthrough, the uranium monitor alarms, indicating regeneration is required.

(5) Differential Pressure Drop Across Ion Exchange Column

The pressure drop across the ion exchange columns is monitored, and a high ΔP, which represents blinding in the resin bed, causes the flow to that particular column to be stopped, and sounds an alarm.

(6) Nitric Acid Concentration Control

Two controls assure that nitric acid eluant concentration is less than 2N nitric: 1) dilute nitric is made up in a 1000 gallon dilute nitric tank and the normality is verified by laboratory analysis; and 2) specific

gravity instrumentation is interlocked to the main dilute nitric acid feed makeup tank valve such that detection of >2N nitric acid in the dilute nitric acid closes the valve.*

Table II-4.9 *demonstrates that for each limit on the operation of the ion exchange system there is a minimum of two administrative controls to* prevent the limit from being exceeded.

In addition to the controls on the system outlined above, the normal loading cycle time is approximately thirty hours, which would allow sufficient time to detect any instrumentation failures or changes in process conditions that would adversely affect the safety of the system.

(b) Enrichment Control

An independent verification of UF_6 assay is required before UF_6 cylinders can be connected to process piping. An undetected enrichment error would thus require failure to make two independent assay measurements, the supplier's (DOE) measurement and a measurement at an independent laboratory.

4.6.13.4.2 Geometry Control

This criteria requires, where practical, that criticality safety be provided by geometrical design rather than administrative controls. The ion-exchange system does not depend specifically on geometry control to assure criticality safety although the maximum safe concentration and *theoretical limit on reactivity are calculated for a twenty inch diameter cylinder.*

4.6.13.4.3 Critical Value

The analysis covers the range of enrichments up to and including 5% U-235; for all enrichments in the range, the ion-exchange system is safe. Data are established from approved sources (see Reference Section I-5.2). Calculations are based on approved methods listed in Section I-5.2.2.4.

TABLE II-4.9

MAXIMUM OPERATING PARAMETERS AND CONTROL METHODS

	High Uranium Content (>300 ppm U) to Ion Exchange Column	Continued Use of Column After It is Loaded (>1.0 kg/ft^3)	Use of Greater Than 2N Nitric Acid in the Elution Cycle
Normal Process Conditions	X	X	X
Quarantine Tank Sample (Visual and U Monitor)	X		
ΔP Alarm Interlock of Pre-filters, Bypasses & IX Columns	X		
Turbidity Measurement on IX Column Inlet	X		
Online Uranium Monitor of Column Discharge		X	
ΔP Alarm Across IX Column		X	
Periodic Lab Analysis (Sampled on Makeup)			X
Online Specific Gravity Loop			X

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