UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555

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DOCKET NO: 70-1201

LICENSEE: B&W Fuel Company (BWFC)
Commercial Nuclear Fuel Plant (CNFP)
Lynchburg, Virginia

SUBJECT: SAFETY EVALUATION REPORT, LICENSE AMENDMENT APPLICATION DATED MAY 15, 1992, AND SUPPLEMENT DATED SEPTEMBER 2, 1992, RE PROCESSING URANIUM ENRICHED UP TO 5.1 WEIGHT PERCENT IN THE $^{235}U$ ISOTOPE

## BACKGROUND

CNFP is currently authorized to process uranium enriched up to 4.1 weight percent in the $^{235}U$ isotope. On July 2, 1991, B&W submitted an amendment application to increase the $^{235}U$ enrichment to 5.1 weight percent. By letter dated August 26, 1991, CNFP provided figures absent from the July submittal. Following a site visit and discussions on September 12-13, 1991, the NRC requested additional information by letter dated September 26, 1991. By letter dated May 15, 1992 (CNFP cover letter was mistakenly dated May 15, 1991) CNFP submitted a revised application to address the staff comments. The May 15, 1992, application supersedes all previous submittals. After discussions with staff, CNFP provided by letter dated September 2, 1992, supplemental information to support its application.

## DISCUSSION

Under the existing license, CNFP receives uranium dioxide ($UO_2$) pellets, encapsulates the pellets into fuel rods, and clusters the rods into fuel assemblies. With the proposed amendment, the process and management activities will not change. The technical criteria and controls for nuclear criticality safety (NCS) controls will change as a result of the enrichment increase. In addition, calculational methods for determining technical criteria have been changed. This discussion addresses these changes.

CNFP has conducted an NCS analysis for operations in the following process areas: fuel pellet handling and storage, fuel rod processing and storage, and fuel assembly processing and storage. This discussion describes these process areas and the specific NCS controls and limits for the areas.

### Technical Criteria

The basis for nuclear criticality safety has been changed. Allowing the maximum $^{235}U$ enrichment to increase to 5.1 weight percent (w/o) requires revision of certain technical criteria for nuclear criticality safety. Revised technical criteria have been established in Section 4.2 of the license amendment application.

Section 4.2 has been revised to provide allowable sizes for units enriched up to 5.1 w/o $^{235}U$. In particular, Section 4.2.3.2 has been modified to establish new values for safe individual units (SIUs) at 5.1 w/o. The current values are applicable to 4.1 w/o and include a volume of 14 liters, a cylinder diameter of 9 5/8 inches, a mass of 850 grams, and a slab height of 4 inches. For processing 5.1 w/o, the variables defining safe units shall be further restricted to a volume of 12 liters, a cylinder diameter of 8 inches, and a mass of 700 grams of $^{235}U$. The slab height will remain at 4 inches, but additional separation criteria will be imposed as discussed below.

Currently, enrichments up to 4.1 w/o can be stored in 4-inch infinite slabs. Handling and storage of both pellets and rods shall continue to use slab height as an NCS control. However, for heterogeneous systems with enrichments above 4.1 w/o, the infinite slab can no longer be assumed since the subcritical limit for slab height, together with the appropriate safety factor, is less than 4 inches for an enrichment of 5.1 w/o. Also, the k-effective value as calculated with KENO exceeds 0.95, the established criterion for a safe unit, if the most reactive heterogeneous geometry is assumed (i.e., optimum pellet diameter and maximum theoretical density). As a result, the licensee plans to establish a finite size slab for NCS control. A width restriction of 25 inches will define the finite size slab. This restriction will be implemented for pellets only.

Interaction among finite slabs and with other units is controlled by spacing criteria. The 4-inch thick, 25-inch wide finite slabs of fuel pellets will be spaced a minimum of 1 foot apart horizontally. The size of the 4-inch slab remains unlimited for enrichments up to 4.1 w/o, and no spacing is necessary.

Clad fuel rods with enrichments up to 5.1 w/o will not be restricted to a finite size slab. Calculations were made for 5.1 w/o zircalloy cladded fuel rods in a 4-inch thick infinite slab configuration. The calculated value of k-effective did not exceed 0.95 at any degree of moderation. The width limitation and horizontal spacing criteria are not necessary for the cladded fuel.

In Section 4.2.3.1, the licensee has established criteria for reflectors more effective than water. Reflecting material better than concrete is not allowed in any of the fuel processing areas. For optimum moderation, the margin of subcriticality did not meet the established criteria for a safe unit if the finite slab is reflected by concrete. Thus, NCS controls include a minimum separation distance of 1 foot between the finite slab and concrete floor. This separation criterion applies to both unclad pellets and clad rods.

Spacing criteria include a minimum spacing of 1 foot between individual finite slabs containing pellets with enrichments greater than 4.1 w/o and a requirement that all slabs be a minimum of 1 foot above any concrete floor. Adherence to the new SIUs, together with these spacing criteria, ensures subcriticality for 5.1 w/o.

Moderation Control

CNFP permits the use of a fire hose in the event of a fire. Improper fire fighting poses a nuclear criticality safety concern. Fissile material is present in amounts and configurations that could be made critical upon geometric rearrangement and addition of water. For example, water streams from a fire hose could displace pellets from corrugated trays in the vault area. Nuclear criticality safety controls require pellets to be maintained in a finite slab and to be 1 foot from concrete reflection. The possibility exists for a water stream to redirect pellets into a non-favorable geometry that is moderated and reflected to a degree that is not safe.

Although management approval is required to use hydrogenous fire fighting agents, the specific fire fighting methods and training thereof have not been established. To prevent a water stream from redirecting loose pellets into a non-favorable geometry that is optimally moderated, fire fighters should be trained in fire fighting methods. Methods might include preventing solid streams of water while permitting water fogs. Hose fog nozzles can produce a water fog without geometric rearrangement.

Management responsible for approving fire fighting techniques should be aware of the NCS implications associated with fire fighting. Training is required to ensure a single contingency does not initiate criticality during fire fighting. As stated in Section 7 of the Radiological Contingency Plan and Section 6.2 of the license, CNFP uses a fire brigade which is trained annually on fire fighting techniques and on the nuclear safety considerations involved with fire fighting. However, the proper fire fighting methods have not been prescribed in the Radiological Contingency Plan. To ensure nuclear criticality safety during fire fighting, the staff recommends the following license condition:

> Within 60 days of the date of this amendment, the licensee shall revise the Radiological Contingency Plan to prescribe fire fighting methods that prevent displacement or rearrangement of fissile material into a critical configuration and to identify the training program that ensures implementation of the methods.

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## Pellet Handling and Storage

A conveyor transfers boxes containing fuel pellets, received in approved shipping containers, from the pellet receipt area to the pellet storage vault. Pellets are stored within the vault until they are loaded into rods at the pellet processing tables.

NCS of the pellet storage vault is still maintained by using geometric slab limits combined with separation distances and using neutron poisons. No changes are made to the materials of construction or the neutron poison used. Activities shall continue to be controlled so that no accumulation shall be positioned above or below any other fuel accumulation. Only the single slab height shall be permitted on any one shelf. Also, the vault shall remain separated from other SNM and processing areas by an 8-inch thick concrete wall.

For enrichments up to 5.1 w/o, nuclear safety is based on a 4-inch thick finite slab with a 25-inch width, which must be separated 1 foot from concrete. Pellets shall be handled and stored within the slab criteria specified for size and spacing in Sections 4.2.3.2 and 4.2.2, respectively. Equipment used for processing pellets includes the conveyor, vault, hooded tables, pellet downdraft table, and transport carts. All equipment is either designed less than 25 inches in width or accompanied with a red line that indicates the allowable 25-inch width space. The conveyor, vault shelves, and transport cart are all less than 25 inches in width. Pellets are stacked 4-inches high within corrugated trays on the processing tables. The 4-inch height limitation is also marked in the hoods.

Specifications of the fuel pellet storage vault have been changed. In addition to the slab requirements, the vault geometry is limited by the separation criteria outlined in Section 4.2.4.2. These separation criteria include a vertical spacing between shelves, which remains at 16 inches, and a horizontal spacing between tiers, which has been changed from 36 inches to 119 inches. With this safe spacing, k-effective of the vault does not exceed 0.95 for all degrees of interspersed moderation and fully flooded boxes.

## Fuel Rod Processing and Storage

Fuel rod processing operations include welding, leak testing, cleaning, visual and dimensional inspection, and may involve conditions in which rods are immersed partially or wholly in liquids. To account for optimum moderation, calculations involved different size fuel rods and different spacings between rods under flooding conditions. The k-effective for the fuel rod types did not exceed 0.95 at any degree of moderation while limited to the 4-inch slab height.

Individual accumulations shall continue to be limited to the 4-inch slab height. To maintain the 4-inch slab, fuel rod transfer carts have 4-inch channels with side rails to contain the fuel. In addition, as before, no SNM accumulation shall be positioned above or below any other SNM accumulation. Fuel rod storage shelves shall continue to be labelled to instruct workers that fuel cannot be above or below another accumulation.

New criteria require fuel rods to be handled and stored with a minimum spacing of 1 foot from concrete as outlined in Section 4.2.3.2. Pallets and carts shall be used to maintain the 1-foot distance from the floor.

<u>Fuel Assembly Processing and Storage</u>

Fuel rods are transported to the fuel assembly room and loaded into assemblies. Fuel assembly processing consists of loading fuel rods into an assembly, dismantling assemblies, performing fabrication steps such as alignment and welding, and fuel inspections. Fuel rods shall be assembled into bundles within a closed area under moderation control. NCS controls include moderation and spacing.

NCS relies on the separation criteria and moderation control specified in Section 4.2.4.5. The separation between fuel bundle assembly stations remains 4 feet. With the exception of the additional criteria limiting the amount of 1-gallon containers to a volume totaling 20 gallons and limiting the use of polyethylene to one sheet per fuel rod channel, criteria for moderation control remain unchanged.

The current spacing requirements for enrichments less than 4.1 w/o have not changed. The newly established spacing requirement of 42 inches center-to-center is required for enrichments greater than 4.1 w/o and up to 5.1 w/o. Fuel assemblies are stored vertically in arrays using the following two spacing criteria: (1) fuel assemblies stored in linear arrays shall have a minimum 21-inch center-to-center spacing between assemblies with enrichments below 4.1 w/o, and (2) a minimum of 42-inch center-to-center spacing between assemblies with enrichments above 4.1 w/o and up to 5.1 w/o. A minimum 36-inch center-to-center spacing shall continue to be maintained between the nearest assemblies adjacent storage arrays.

Assembly racks are constructed to meet the spacing criteria for 4.1 w/o. Changes have been proposed for storing the 5.1 w/o fuel in a conservative storage arrangement. For enrichments greater than 4.1 w/o, every other storage space will be used. There is a dedicated storage rack modified by the removal of every other base plate resulting in a 42-inch center-to-center spacing. Fuel assemblies shall be stored in racks meeting the spacing criteria outlined in Section 4.2.4.6. Completed assemblies are stored in permanent fixtures. The spacing requirements are maintained by the design of the fuel assembly racks.

Enrichment segregation will be administratively controlled. Appropriate material labeling and area postings shall continue to be maintained specifying material identification and all limits on parameters that are subjected to procedural control.

Miscellaneous Operations

Within Section 4.2.4.9, the mass limit of 850 grams of $^{235}U$ for 4.1 w/o has been changed to 700 grams for 5.1 w/o.

Calculational Methods

NCS of individual units is based on either a calculation of k-effective or approved literature data. NCS of arrays is determined by calculation of k-effective. CNFP uses KENO-IV through the SCALE computer code package for calculations of k-effective. Safe units do not exceed 0.87 under normal conditions and 0.95 under assumed accident conditions, considering both calculational uncertainty and bias. Since the surface density model and solid angle technique will no longer be used to calculate neutron interaction between arrays, all references to these models or techniques existing in the license have been omitted.

Since calculational methods are based solely on KENO-IV computer calculations, the staff has evaluated CNFP's validation program. In response to staff inquiries, CNFP has revised Section 4.2.3.3 to include cross-section sets, range of applicability, and bias in the description of calculational methods.

A bias has been determined for criticality safety calculations used in safety evaluations by validating the method against benchmark critical experiments when applicable data are available. As part of CNFP's validation program, the NCS group documents the biases in the NCS benchmark notebook. Benchmarks were chosen to show the applicability of the biases to the materials and geometries modeled in the evaluations. The bias has been applied to the k-effective calculations before determining safety limits and margins.

In accordance with ANS\ANSI 8.1, CNFP establishes biases by correlating experimental and computational results. The biases attributable to calculational error are used to give adjusted critical values of calculated parameters. The adjustment is used where closely pertinent experimental data exists and is supported convincingly in the required written report of validation. Also, the areas of applicability are determined by provided examples of independent studies that have been performed to demonstrate the reliability of the codes and cross sections and by defining the various classes of critical systems for which the calculations are intended.

CNFP determined an optimum moderation condition by performing lattice cell calculations. Within these calculations, the following parameters varied: pellet size, pitch, and volume fraction of fuel and water. Although only pellet calculations were performed, the optimum moderation levels are used for cladded fuel rods as well as fuel pellets in boxes. NRC staff has performed independent calculations and has no objection to this practice.

Radiation Safety

The existing radiation protection program, as described in the license, will be applicable and extended to cover the proposed activities with uranium enriched up to 5.1 w/o. The staff has determined that CNFP's current program is adequate to protect the health and safety of the workers and public.

CONCLUSION/RECOMMENDATION

The licensee commits to the following:

- The variables defining safe units shall be a volume of 12 liters, a cylinder diameter of 8 inches, a mass of 700 grams of $^{235}U$, and a slab height of 4 inches.

- Pellets shall be handled and stored in a finite slab limited to 4 inches in height and 25 inches in width and shall be separated from any other slab or fuel accumulation by a minimum of 1-foot horizontal spacing.

- Accumulations of pellets or fuel rods shall be handled and stored at least 1 foot above concrete floors.

- In the pellet storage vault, the horizontal spacing between tiers within a cubicle shall be 119 inches.

- Fuel assemblies in linear arrays will have a minimum 42 inches center-to-center spacing for enrichments above 4.1 w/o.

The application identifies and discusses the criteria to be applied to NCS controls and describes the methods used to ensure a subcriticality in operations with and storage of fissile materials under normal and predictable abnormal operating conditions. The staff concludes that CNFP can process uranium enriched up to 5.1 weight percent in the $^{235}U$ isotope subject to the license requirements. The staff recommends approval of the application.

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In the next safety demonstration update, Table 5 should be included in Section 15.2.6.2, and the technical basis for the moderation limits (i.e., 20 gallons and 1 sheet of polyethylene) should be further described in Section 15.2.5.

The Region II Principal Inspector has no objection to this proposed action.

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