BWXT
BWX Technologies, Inc.

October 8, 2021
21-054

ATTN: Document Control Desk
Director, Office of Nuclear Material Safety & Safeguards
U. S. Nuclear Regulatory Commission
Washington, DC 20555-0001

Reference: 1) License No. SNM-42, Docket 70-27

2) Letter dated June 11, 2021, BWXT (Freudenberger) to NRC (Doc. Control Desk) - Request to Amend License SNM-42, Chapter 5, Nuclear Criticality Safety

3) Letter dated September 10, 2021, NRC (Downs) to BWXT(Terry) - Request for Additional Information Regarding Proposed Changes to License Application Chapter 5, Nuclear Criticality Safety

Subject: Response to Request for Additional Information to Amend License SNM-42, Chapter 5, Nuclear Criticality Safety

Dear Sir or Madam:

In Reference 2, BWXT Nuclear Operations Group, Inc. - Lynchburg (BWXT NOG-L), requested approval for an amendment to Chapter 5 of the SNM-42 License Application in accordance with 10 CFR 70.34. Based on recent communication between Jeremy Munson (NRC) and Larry Wetzel (BWXT NOG-L), and a request for additional information (Reference 3), BWXT NOG-L is submitting additional information to clarify the Chapter 5 amendment request. Enclosure 1 provides a summary of the requested additional information with BWXT NOG-L's accompanying responses and additional changes made to Chapter 5.

The original amendment to Chapter 5, which was submitted in Reference 2, has been modified and is included as Enclosure 2 to this letter. Enclosure 2 contains the proposed revision of Chapter 5 of the SNM-42 License Application.

If you have questions or require additional information, please contact Chris Terry, Manager of Licensing and Safety Analysis, at ctterry@bwxt.com or 434-522-5202.

Sincerely,

Richard J. Freudenberger
Manager, Environment, Safety, Health and Safeguards
BWXT Nuclear Operations Group, Inc. – Lynchburg

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NMSS

Enclosures

cc: NRC, Region II
NRC, Resident Inspector
NRC, James Downs

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ENCLOSURE 1

Responses to RAI for Amendment to Chapter 5 of the SNM-42 License Application

NCS-1

Section 5.3 of NUREG-1520, "Standard Review Plan for Fuel Cycle Facilities License Applications" states that for a license amendment request the reviewer should review the portions of the license application affected by the change to ensure that the effectiveness of any license commitments have not been reduced, or that the licensee has provided an adequate justification that there is still adequate protection against the risk of accidental criticality.

Section 5.4.3.1.5 of NUREG-1520, "Standard Review Plan for Fuel Cycle Facilities License Applications" states that the reviewer should consider the licensee's commitments regarding the organization and administration of the NCS program to be acceptable if, in part, the licensee describes a program consistent with industry standards. Section 5.4.3.1.1 of NUREG-1520 further states that for licensees requesting to conduct activities to which an NRC-endorsed standard applies, the reviewer should verify that the licensee addresses the subjects covered by the standard.

Regulatory Guide (RG)-3.71, "[NCS] Standards for Nuclear Materials Outside Reactor Cores," endorses American National Standards Institute/American Nuclear Society (ANSI/ANS)-8.1-2014 (R2018), "[NCS] in Operations with Fissionable Materials Outside Reactors." Paragraph 4.1.4 of ANSI/ANS-8.1 states that for areas involving movement of fissionable material, postings that specify material identification and all limits on parameters subject to procedural control shall be maintained. However, Section 5.2 of the revised license application states that limits and controls are provided to operating areas via NCS postings or procedures, or both, which suggests that NCS postings may not be present in areas where limits and controls are otherwise defined in procedures.

a. State whether NCS postings will be used for all activities involving SNM. Explicitly state any activities in which NCS postings will not be used.

b. Clarify how NCS postings will be utilized consistent with Paragraph 4.1.4 of ANSI/ANS-8.1.

BWXT Response:

The current Chapter 5 states in Section 5.1.2 (emphasis added):

> Activities at the site involving special nuclear material are conducted according to limits and controls established by Nuclear Criticality Safety. **The administrative limits and controls are provided to the operating areas on Nuclear Criticality Safety postings or in operating procedures or both.** Engineered limits and controls are provided in operating and maintenance procedures as necessary.
>
> Nuclear Criticality Safety postings shall describe the administrative limits and controls for a particular area, operation, work station, or storage location as appropriate for providing workers a ready reference for verifying compliance and safe operation. Nuclear Criticality

NCS-1

Section 5.3 of NUREG-1520, "Standard Review Plan for Fuel Cycle Facilities License Applications" states that for a license amendment request the reviewer should review the portions of the license application affected by the change to ensure that the effectiveness of any license commitments have not been reduced, or that the licensee has provided an adequate justification that there is still adequate protection against the risk of accidental criticality.

Section 5.4.3.1.5 of NUREG-1520, "Standard Review Plan for Fuel Cycle Facilities License Applications" states that the reviewer should consider the licensee's commitments regarding the organization and administration of the NCS program to be acceptable if, in part, the licensee describes a program consistent with industry standards. Section 5.4.3.1.1 of NUREG-1520 further states that for licensees requesting to conduct activities to which an NRC-endorsed standard applies, the reviewer should verify that the licensee addresses the subjects covered by the standard.

Regulatory Guide (RG)-3.71, "[NCS] Standards for Nuclear Materials Outside Reactor Cores," endorses American National Standards Institute/American Nuclear Society (ANSI/ANS)-8.1-2014 (R2018), "[NCS] in Operations with Fissionable Materials Outside Reactors." Paragraph 4.1.4 of ANSI/ANS-8.1 states that for areas involving movement of fissionable material, postings that specify material identification and all limits on parameters subject to procedural control shall be maintained. However, Section 5.2 of the revised license application states that limits and controls are provided to operating areas via NCS postings or procedures, or both, which suggests that NCS postings may not be present in areas where limits and controls are otherwise defined in procedures.

a. State whether NCS postings will be used for all activities involving SNM. Explicitly state any activities in which NCS postings will not be used.

b. Clarify how NCS postings will be utilized consistent with Paragraph 4.1.4 of ANSI/ANS-8.1.

BWXT Response:

The current Chapter 5 states in Section 5.1.2 (emphasis added):

> Activities at the site involving special nuclear material are conducted according to limits and controls established by Nuclear Criticality Safety. **The administrative limits and controls are provided to the operating areas on Nuclear Criticality Safety postings or in operating procedures or both.** Engineered limits and controls are provided in operating and maintenance procedures as necessary.
>
> Nuclear Criticality Safety postings shall describe the administrative limits and controls for a particular area, operation, work station, or storage location as appropriate for providing workers a ready reference for verifying compliance and safe operation. Nuclear Criticality Safety limits and controls are posted according to procedural requirements and instructions maintained by Nuclear Criticality Safety.

Nuclear Criticality Safety postings will include the following information as a minimum:

- Type of material permitted.
- Form of material.
- Allowable quantity (number of containers, pieces, weight, or volume).
- Spacing of fuel units, if required.
- Restriction on the presence of moderators, if required.

The revised Chapter 5 states in Section 5.2 (emphasis added):

> Activities at the site involving special nuclear material are conducted according to the limits and controls established by Nuclear Criticality Safety. **The administrative limits and controls are provided to the operating areas on Nuclear Criticality Safety postings or in operating procedures or both.**
>
> Nuclear Criticality Safety postings describe the administrative limits and controls for a particular area, operation, work station, or storage location as appropriate to provide workers a ready reference for verifying compliance and safe operation.
>
> Nuclear Criticality Safety postings generally include the following information as a minimum:
>
> - Type of material permitted.
> - Form of material.
> - Allowable quantity (number of containers, pieces, weight, or volume).
> - Spacing of fuel units, if required.
> - Restriction on the presence of moderators, if required.

The statement of "The administrative limits and controls are provided to the operating areas on Nuclear Criticality Safety postings or in operating procedures or both" exists in both the current and revised versions of Chapter 5. There was no change to this statement.

The requested additional information regarding NCS postings is provided below:

a. *State whether NCS postings will be used for all activities involving SNM. Explicitly state any activities in which NCS postings will not be used.*

The only area which currently uses procedures and no postings is the Waste Treatment Facility. The mass of ^{235}U in the waste treatment process is tracked via an automated inventory system. The inventory system receives inputs from the combination of Low Level Liquid Waste samples and solution volumes. The outputs are Treatment Plant solids which are collected in 55 gallon drums and have a mass assigned based on NDA values. This process has been in place for at least 30 years.

Postings are used where appropriate and are supplemented by procedures in the rest of the BWXT NOG-L facility.

b. *Clarify how NCS postings will be utilized consistent with Paragraph 4.1.4 of ANSI/ANS-8.1.*

Section 4.1.4 of ANSI/ANS-8.1-2014 states:

> **4.1.4 Materials control**
> The movement of fissionable material shall be controlled. Appropriate material labeling and area posting shall be maintained specifying material identification and all limits on parameters subject to procedural control.

As discussed above, postings are used with the one exception noted. The use of procedures in place of postings is use where it provides a better fit consistent with the standard "Appropriate material labeling and area posting shall …"

The BWXT perspective is the intent of the standard is met. The objective of the standard is to ensure the operators have ready reference to the limits for their work evolution. This is generally met through postings and in rare cases only in procedures. The decision is based on which approach provides the greatest value to the operator.

NCS-2

Section 5.3 of NUREG-1520, "Standard Review Plan for Fuel Cycle Facilities License Applications" states that for a license amendment request the reviewer should review the portions of the license application affected by the change to ensure that the effectiveness of any license commitments have not been reduced, or that the licensee has provided an adequate justification that there is still adequate protection against the risk of accidental criticality.

Section 5.4.3.1.5 of NUREG-1520, "Standard Review Plan for Fuel Cycle Facilities License Applications" states that the reviewer should consider the licensee's commitments regarding the organization and administration of the NCS program to be acceptable if, in part, the licensee describes a program consistent with industry standards. Section 5.4.3.1.1 of NUREG-1520 further states that for licensees requesting to conduct activities to which an NRC-endorsed standard applies, the reviewer should verify that the licensee addresses the subjects covered by the standard.

Regulatory Guide (RG)-3.71, "[NCS] Standards for Nuclear Materials Outside Reactor Cores," endorses American National Standards Institute/American Nuclear Society (ANSI/ANS)-8.20-1991 (R2020), "[NCS] Training." Paragraph 2 of ANSI/ANS-8.20 states that the standard provides criteria for NCS training of personnel associated with operations outside reactors where a criticality risk exists. Paragraph 3 of ANSI/ANS-8.20-1991 (R2020) states that these personnel include, but are not limited to: (1) those who work with fissionable material and their supervisors, (2) operations support personnel, (3) design personnel, (4) maintenance personnel, (5) emergency response personnel, (6) managers and other administrative personnel, and (7) others who enter areas where fissionable material is processed, stored, or handled.

Section 5.5 of the revised license application states that all individuals are given NCS training prior to being granted unescorted access to restricted areas via general employee safety training.

However, the revised license application removes certain elements from the description of the licensee's general employee safety training such that the following elements are no longer included: (1) a discussion about the basic NCS controls with appropriate examples, (2) a discussion about NCS posting, and (3) a discussion about nuclear safety violations and their impact on the NCS program.

a. Describe how NCS training is consistent with ANSI/ANS-8.20 for personnel that do not receive specialized NCS training, including: operations support personnel, design personnel, maintenance personnel, emergency response personnel, managers and other administrative personnel, and others who enter areas where fissionable material is process, stored, or handled.

b. Explain how this requested change to the license application does not reduce the effectiveness of the NCS training program or provide a justification for this change.

BWXT Response:

BWXT's philosophy for General Employee Safety Training (GEST) is personnel should understand the necessary response to normal and abnormal conditions. The details of the cause of these conditions may distract personnel from this expected response. Using chemical safety as an example, personnel are trained not to mix chemical A with chemical B. They are trained on the consequences (toxic gas, exothermic reaction, etc.) and how to respond (evacuate, use a fire extinguisher, etc.) if the chemicals are mixed. The training does not discuss the details of the chemistry involved since this does not help prevent the accident or mitigate its consequences.

In line with BWXT's GEST philosophy, personnel who do not handle SNM do not need as much training on NCS as those who work with SNM. There is no obvious value to training an office worker to the level of a machinist or a chemical process operator. The office worker receiving GEST receives an appropriate level of NCS training.

To clarify this in the revised Chapter 5 a discussion of the training philosophy has been added to 5.5. This states:

> *The Nuclear Criticality Safety training philosophy utilizes a graded approach. All personnel receive General Employee Safety Training (GEST). This training provides a general overview of Nuclear Criticality Safety including instructions not to handle or relocate SNM without completing Specialized Nuclear Criticality Safety training and instructions on response to criticality accident alarms. The next level of training is Specialized Nuclear Criticality Safety training which is for personnel who will handle SNM. This training is described in more detail below.*

BWXT recognizes the value of ANSI/ANS standards and particularly the ANSI/ANS-8 series, but does not commit to strict compliance with ANSI/ANS-8.20-1991 (R2020) in the current or revised version of Chapter 5. There are items in the standard which are not relevant to employees who do not handle SNM in unclad or clad forms and some requirements are of limited value for those who do handle SNM in unclad or clad forms

While ANSI/ANS-8.20-1991 (R2020) Section 3 lists different groups of personnel who need to be trained, Section 6.1 states "The content of the training program shall be tailored to job responsibilities and shall support the conduct of the job." The BWXT philosophy of a graded approach tailors the training to the job task.

The subject of Section 7.1 of ANSI/ANS-8.20-1991 (R2020) is the Program Content for the NCS training of personnel. In the table below, the Section 7 requirements (shall) and recommendations (should) are listed along with BWXT's response based on the current training.

ANSI/ANS-8.20-1991 (R2020)	BWXT Response
7.1.1 The concept of a fission chain reaction **should** be discussed. The distinction **should** be made among families of chains in which fission rate decreases with time, those that are sustained with a constant fission rate, and those that have an exponential increase in the fission rate.	GEST: A discussion about the fission process and criticality is included. A discussion of the trajectory of the fission rate does not aid personnel in understanding their actions. They are trained that prompt evacuation will reduce their dose. Specialized Training: BWXT believes reviewing the types of fission chains is of little benefit, and it is more beneficial to explain that a criticality can reoccur.
7.1.2 The time history of supercritical excursions **should** be described for metal (fast neutron) systems and for moderated (slow neutron)'systems.	GEST: The details are not covered since it does not provide benefit to personnel that do not handle SNM. The training does discuss that a criticality can occur in a "blink of an eye" and the effects cannot be reversed. Specialized Training: BWXT believe the time history of different excursions does not help personnel. This is not included in training.

ANSI/ANS-8.20-1991 (R2020)	BWXT Response
7.1.2.1 The kinetic energy released during the fission burst **should** be compared to the equivalent energy measured in familiar events, for example, chemical explosions.	GEST: The training discusses that the lethal range is approximately 15 feet from the criticality. Specialized Training: Covered in GEST
7.1.2.2 A distinction **should** be made between the intensity of radiation that may appear essentially instantaneously, as from a spike yield, and that which may be expected to be associated with a continuing fission reaction. This information **should** be used to estimate the range of exposures that may be associated with process accidents.	GEST: This is not covered. The training emphasizes the importance of prompt evacuation to minimize the total dose. Specialized Training: BWXT believes information on the intensities does not help personnel's understanding. They are taught to evacuate promptly. The second "should" is an emergency preparedness aspect and not related to personnel training.
7.1.3 Health effects of criticality accidents **shall** be discussed.	GEST: While not specific to a criticality, the training discusses the prompt, delayed and teratogenic effects of radiation exposure. Specialized Training: The general discussion in GEST is adequate.
7.2.1 A description of neutron-induced fission, neutron capture, and neutron scattering and leakage **should** be included.	GEST: The training includes a discussion of the atom and the fission process. Specialized Training: The discussion of the fission process is adequate.
7.2.2 The influence of neutron energy on the fission probability **should** be discussed.	GEST: This not discussed. Specialized Training: The effects of moderation on the fission process are discussed.

ANSI/ANS-8.20-1991 (R2020)	BWXT Response
7.2.3 Neutron moderation **should** be explained as the mechanism that reduces the neutron energy. Several good neutron moderators **should** be identified.	GEST: This is not discussed. Specialized Training: The effects of moderation on the fission process are discussed.
7.2.4 Removal of neutrons from fissioning systems by neutron absorbers **should** be discussed.	GEST: This is not discussed. Specialized Training: The effects of neutron poisons on the fission process are discussed.
7.3.1 Selected criticality accidents **should** be described.	GEST: It is discussed that 22 process accident have happened in the world. Twenty-one of these were in solutions systems. These accidents resulted in 9 fatalities. Specialized Training: Selected accidents are discussed.
7.3.2 The causes of the selected criticality accidents and the means of their termination **should** be discussed.	GEST: This is not discussed. Specialized Training: The cause of the selected accidents are discussed. The mechanism for termination is not normally discussed.
7.4.1 Training **shall** be provided in the recognition of and in the response to criticality alarms in accordance with ANSI/ANS-8.3-1986	GEST: This is included. Specialized Training: This is covered in GEST.

ANSI/ANS-8.20-1991 (R2020)	BWXT Response
7.4.2 An example of the reduction in the received dose as a function of distance, time, and shielding **shall** be given to emphasize the need for prompt evacuation.	GEST: A numerical example is not given, the training emphasizes the need to evacuate promptly to minimize dose. Specialized Training: A numerical example is not given, the training emphasizes the need to evacuate promptly to minimize dose.
7.5.1 The effects and applications of the following factors that are relevant to criticality safety of operations in the facility **shall** be explained and illustrated: ...	GEST: A general discussion of controls is given. Examples include the limiting the mass of materials in a glovebox operation, maintaining minimum spacing during material transfers, and requiring small diameter columns for storing process solutions. Personnel are also informed that "Something as simple as moving a fuel cart can cause a violation". Specialized Training: In the specialized training, the controlled parameters are discussed in more detail than in GEST.
7.5.2 Single parameter limits appropriate to the facility **shall** be discussed.	GEST: These are not discussed. Specialized Training: The single parameter limits are rarely used because of the 10CFR70.61 requirement to assure criticality is highly unlikely. To provide personnel with limits which are not used in the facility is counter to good safety practice.

ANSI/ANS-8.20-1991 (R2020)	BWXT Response
7.5.3 The concept of nuclear criticality **shall** be illustrated by examples appropriate to the facility. The following are typical illustrations: (1) the change in critical mass of small pieces of fissionable material, such as lathe turnings or low enriched pellets, upon immersion in water or oil (2) the influence of nonfissionable materials and of geometry on nuclear criticality (3) factors affecting interaction among units.	<u>GEST:</u> This is not discussed. Personnel are instructed that they must have specialized NCS training before they are allowed to handle SNM. <u>Specialized Training:</u> The controlled parameters are discussed with basic information on how the parameter impacts criticality safety.
7.5.4 The concept of contingencies for checking the validity of criticality safety limits **shall** be discussed.	<u>GEST:</u> This is not discussed. <u>Specialized Training:</u> Contingency checking is not included in the training since BWXT's safety philosophy is the operators follow the posted limits and if they do not understand, they will stop and ask for clarification. The complex nature of the neutronics, bounding assumptions, and development of contingencies makes simple contingency checking counter to good safety practice.
7.6.1 The facility management's nuclear criticality safety policy **shall** be described.	<u>GEST:</u> The training states "management is committed to a strong safety culture …". Additionally, personnel are reminded they shall follow the procedures, postings and limits for their operations. <u>Specialized Training:</u> This is covered in GEST.

ANSI/ANS-8.20-1991 (R2020)	BWXT Response
7.6.2 The facility policy for the use of check lists, sign-off sheets, and documentation in the execution of procedures that are pertinent to criticality safety **shall** be explained.	GEST: Personnel are trained to follow procedures as written. Specialized Training: Personnel are trained to follow procedures as written.
7.6.3 Relevant procedures that pertain to criticality safety **shall** be discussed. Emphasis **shall** be given to criticality safety limits, controls, and emergency procedures.	GEST: Personnel are informed that general guidance on limits and controls can be found in the NCS Manuals. Specialized Training: Procedures and controls are covered as part of the on-the-job training.
7.6.4 The policy that relates to situations not covered by procedures and to situations in which the safety of the operation is in question **shall** be described.	GEST: Personnel are instructed to follow procedures. If they cannot, they are to stop and notify their management. Specialized Training: This is covered in GEST.
7.6.5 Employees **shall** be informed of their right to question any operations that they believe may not be safe.	GEST: Personnel are trained if they have questions or concerns regarding their operation, to contact their management and if they still have questions, to contact NCS. Specialized Training: This is covered in GEST.

While most of the requirements and recommendations of ANSI/ANS-8.20-1991 (R2020) are met, there are some aspects of the standard which BWXT does not believe are value added for our personnel.

As discussed above, the change does not reduce the effectiveness of the NCS training program.

NCS-3

Section 5.3 of NUREG-1520, "Standard Review Plan for Fuel Cycle Facilities License Applications" states that for a license amendment request the reviewer should review the portions of the license application affected by the change to ensure that the effectiveness of any license commitments is not reduced, or that the licensee has provided an adequate justification that there is still adequate protection against the risk of accidental criticality.

Section 5.1.4 of the current license application states that new operators will work alongside an experienced operator until the supervisor determines that the new operator understands the safety requirements well enough to perform the job alone. However, the revised license application removes this statement, which appears to be a nonconservative change.

a. Explain how this requested change to the license application does not reduce the effectiveness of the NCS training program or provide a justification for this change with respect to the continued protection against the risk of accidental criticality.

BWXT Response:

In the discussion of how on-the-job training ties with Specialized Nuclear Criticality Safety training, the following statement, which is a variation of what is in the current Chapter 5, was included in the revised Chapter 5.

> *In the on-the-job training process, a new operator will work with an experienced operator until the supervisor judges that the new operator understands the safety requirements well enough to perform the job alone.*

NCS-4

Section 5.3 of NUREG-1520, "Standard Review Plan for Fuel Cycle Facilities License Applications" states that for a license amendment request the reviewer should review the portions of the license application affected by the change to ensure that the effectiveness of any license commitments have not been reduced, or that the licensee has provided an adequate justification that there is still adequate protection against the risk of accidental criticality.

Section 5.4.3.1.7.2 of NUREG-1520, "Standard Review Plan for Fuel Cycle Facilities License Applications" states that the reviewer should consider the licensee's commitments with regard to criticality safety evaluations (CSEs) acceptable if, in part, the licensee commits to establishing NCS safety limits based on analyses assuming optimum or the most reactive credible values of parameters (e.g., the most reactive conditions physically possible or bounding values limited by regulatory requirements) unless specified controls are implemented to limit parameters to a particular range. If less than optimum values are used and corresponding controls are not identified, the basis will be justified in the CSE.

Section 5.2 of the revised license application states that the bounding assumptions for controlled parameters may take credit for physical properties and behaviors, experimental data, or historical operational data. Section 5.2 of the revised license application further states that historical

operational data may be used to establish the parameter range with appropriate consideration of the data applicability. Historical operational data provides useful information in establishing the values (or range of values) for normal conditions and certain upset conditions. However, it is not clear how historical operational data can be used to establish the most reactive credible values (or range of values).

a. Explain how historical operational data will be used to establish the most reactive credible values for parameters assumed to be less than optimum and not otherwise controlled.

BWXT Response:

In Section 5.2 of the revised Chapter 5,

> The bounding assumptions for controlled parameters may take credit for physical properties and behaviors, experimental data, or historical operational data. Experimental data or historical operational data may be used to establish the parameter range with appropriate consideration of the data applicability. Parameters that are not controlled shall be considered at their most reactive, credible values.

Was replaced with:

> *The bounding assumptions for controlled parameters are established based on engineering judgment and experience using physical properties and behaviors, experimental data, and/or historical operational data. When physical properties result in excessively conservative parameter bounds, experimental data and historical operating experience may be used to establish more realistic, but still conservative bounds. Parameters that are not controlled shall be considered at their most reactive, credible values.*

This revised wording clarifies how bounding assumptions are developed and how experimental data and historical operational data are used. In an NCS analysis, the assumptions must be documented. As such when experimental data or historical operational data is used, the analyst needs to justify its applicability and demonstrate that the bounding assumptions are conservative. As part of the analysis, the peer reviewer must also concur with the justification of the bounding assumptions. The NCS analysis process flows from the requirements of 10CFR70 and from the ANSI/ANS-8 series of standards as part of establishing a program to ensure the criticality safety of the facility. This program is implemented through internal procedures.

NCS-5

Section 5.3 of NUREG-1520, "Standard Review Plan for Fuel Cycle Facilities License Applications" states that for a license amendment request the reviewer should review the portions of the license application affected by the change to ensure that the effectiveness of any

license commitments have not been reduced, or that the licensee has provided an adequate justification that there is still adequate protection against the risk of accidental criticality.

Section 5.3 of NUREG-1520, "Standard Review Plan for Fuel Cycle Facilities License Applications" states, in part, that for a license amendment request the reviewer should review the relevant portions of the license application and criticality code validation report affected by the change, if applicable, to ensure that the effectiveness of any license commitments is not reduced, or that the licensee has provided an adequate justification that there is still adequate protection against the risk of accidental criticality.

Section 5.3.1 of the revised license application states that reverification of the computer code system will occur at least annually and after revision of the computer code system. However, it is not clear what is considered a component of the computer code system.

a. Clarify what is considered a component of the computer code system. State whether reverification will be performed after a change to hardware or operating system software.

BWXT Response:

The intent of the term "computer code system" is as defined in ANSI/ANS-8.24-2017, which is:

> A calculational method, computer hardware and software (e.g., operating system) that impacts the calculational results.

This has been clarified in the revised Chapter 5.

> *Reverification of the computer code system (as defined in ANSI/ANS-8.24-2017) will occur at least annually or after revision to the computer code system.*

The reverification is performed after changes to hardware or software which could impact the calculational results.

ENCLOSURE 2

Revision of SNM-42 License Application, Chapter 5 – Nuclear Criticality Safety

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SNM-42
CHAPTER 5
NUCLEAR CRITICALITY SAFETY

CHAPTER 5
NUCLEAR CRITICALITY SAFETY
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5.1 Nuclear Criticality Safety Program

NOG-L management has overall responsibility for the safety of all operations involving SNM. NOG-L management is committed to implementing a Nuclear Criticality Safety (NCS) program which incorporates the following objectives:

1. preventing an inadvertent nuclear criticality,
2. complying with the Double Contingency Principle as stated in ANSI/ANS-8.1-2014,
3. complying with the Process Analysis requirement of ANSI/ANS-8.1-2014,
4. complying with the NCS performance requirements of 10 CFR 70.61.

NOG-L management has established a Nuclear Criticality Safety program to implement these objectives. The program is led by the manager of Nuclear Criticality Safety who meets the requirements stated in Chapter 2. The Nuclear Criticality Safety manager has the overall authority and responsibility for the implementation of the Nuclear Criticality Safety program for the site. The Nuclear Criticality Safety manager is responsible for:

1. maintaining computational methods and practices,
2. determining the need for Nuclear Criticality Safety evaluations,
3. performing evaluations, and ensuring NCS controls are properly implemented,
4. maintaining Nuclear Criticality Safety inspection and audit programs,
5. training of the NCS staff to perform their duties,
6. overseeing of the Specialized Nuclear Criticality Safety Training Program and the NCS portion of the General Employee Safety Training

The NCS manager has the authority to terminate any operation deemed to be unsafe or contrary to license conditions or good safety practices.

The responsibilities of the Nuclear Criticality Safety manager do not relieve area management of their responsibility for ensuring that operations are conducted in compliance with Nuclear Criticality Safety requirements. Decisions of the Nuclear Criticality Safety manager are not to be compromised by direct pressures of time or production.

The NCS staff positions and minimum qualifications are provided in Chapter 2. NCS analyses shall be performed by a qualified NCS staff member and peer reviewed by an appropriately qualified NCS staff member. All NCS analyses shall be documented.

5.2 Nuclear Criticality Safety Control Philosophy

The risk of a criticality is minimized by controlling parameters within specified limits. There are twelve parameters of criticality control. These controlled parameters are defined as follows:

1. **Favorable Geometry Control** uses limiting dimensions of a piece of equipment or SNM arrangement to increasing neutron leakage.
2. **Spacing Control** decreases the neutron interaction by separating SNM.
3. **Volume Control** uses fixed volumes to limit the amount of SNM present and increase leakage.
4. **Fixed Neutron Absorber Control** uses a solid neutron absorber (poison) to reduce neutron multiplication.
5. **Piece Count Control** limits fuel mass and/or geometry by controlling the number of containers or components with known amounts of SNM and/or fixed geometries.
6. **Mass Control** limits the amount of SNM at a given location.
7. **Moderation Control** limits or excludes either interstitial (mixed with the SNM) or interspersed (between SNM units) moderating materials.
8. **Concentration Control** limits the mass of SNM per unit volume.
9. **Material Specification Control** is a control based on consideration of the physical or chemical composition of material (e.g. metal, nitrate) and may also include the shape and composition of other materials (e.g. ATR element).
10. **Uranium Enrichment Control** utilizes the inherent differences in critical attributes (critical dimensions, mass, etc.) of uranium at different enrichments of ^{235}U.
11. **Soluble Neutron Absorber Control** uses a neutron absorber in soluble form to increase neutron absorption in a system.
12. **Reflector Control** limits the reflection of neutrons to a SNM system from adjacent materials.

The bounding assumptions for controlled parameters are established based on engineering judgment and experience using physical properties and behaviors, experimental data, and/or historical operational data. When physical properties result in excessively conservative parameter bounds, experimental data and historical operational data may be used to establish more realistic, but still conservative bounding assumptions. Parameters that are not controlled shall be considered at their most reactive, credible values.

Three parameter limits are used in NCS analyses. These limits are defined below:

1. The **Safety Limit (SL)** is the value of the controlled parameter that will not be exceeded unless more than one unlikely, independent, and concurrent change in process conditions (contingency) has occurred.
2. The **Limiting Condition of Operation (LCO)** is the value of the controlled parameter that will not be exceeded unless a contingency has occurred.
3. The **Routine Operating Limit (ROL)** is the implementing value that is the same or more restrictive than the LCO and helps ensure that a violation of the LCO is unlikely.

The margins of subcriticality for the Safety Limit and the Limiting Condition of Operation are provided in Table 5.2. The Routine Operating Limit does not have an associated margin of subcriticality.

Items Relied On For Safety (IROFS) are defined and implemented to maintain each identified controlled parameter within its specified Limiting Condition of Operation, thereby ensuring the subcriticality of a system or process. The four types of controls, listed in order of preference, are defined as follows:

1. **Passive Engineered** controls use fixed design features or devices that take advantage of natural forces such as gravity, ambient pressure, etc. No human intervention is required except for maintenance and inspection.
2. **Active Engineered** controls use add-on, active hardware (e.g., electrical, mechanical, hydraulic, etc.) to sense parameters and automatically secure the system to a safe condition. No human intervention is required during operation.
3. **Enhanced Administrative** controls rely on human judgment, training, and personal responsibility for implementation and are augmented by warning devices (visual or audible) which require human action according to a procedure.
4. **Simple Administrative** controls rely on human judgment, training, and personal responsibility for implementation each time the control function is needed.

The availability and reliability of the IROFS established for criticality safety are assured through management measures which are described in Chapter 11. The characteristics of IROFS are described in Chapter 3.

Activities at the site involving special nuclear material are conducted according to the limits and controls established by Nuclear Criticality Safety. The administrative limits and controls are provided to the operating areas on Nuclear Criticality Safety postings or in operating procedures or both.

Nuclear Criticality Safety postings describe the administrative limits and controls for a particular area, operation, work station, or storage location as appropriate to provide workers a ready reference for verifying compliance and safe operation.

Nuclear Criticality Safety postings generally include the following information as a minimum:

- Type of material permitted.
- Form of material.
- Allowable quantity (number of containers, pieces, weight, or volume).
- Spacing of fuel units, if required.
- Restriction on the presence of moderators, if required.

5.3 Nuclear Criticality Safety Analysis Techniques

The safety of operations can be demonstrated using many different methods including

- subcritical values in standards endorsed in Regulatory Guide 3.71, Revision 3,
- subcritical or critical values, from widely accepted industry handbooks, experimental data, or peer-reviewed publications,
- use of industry-accepted hand-calculation methods subject to the limitations of those methods,
- and use of discrete ordinates and Monte Carlo computer codes to calculate the effective multiplication factor (k_{eff}).

Subcritical values stated in standards or handbooks may be used as stated in the standard or handbook. Use of these subcritical values is subject to the constraints specified in the standard or handbook.

Critical experiment data or critical data from handbooks and publications may be used with the application of appropriate safety factors. The limits derived from the critical values shall be no greater than:

- 90% of the critical dimension for cylinder diameters,
- 85% of the critical dimension for slab thicknesses,
- 75% of the critical spherical volume,
- 45% of the critical mass if double batching is credible,
- 75% of the critical mass if double batching is not credible,
- 45% of the minimum critical concentration.

The subcritical values derived from safety factors as described above do not have to meet the margins of subcriticality specified in Table 5.2.

Historically a method referred to as "Law of Substitution" (now called Substitution Methodology) has been used to account for interaction between different items. This methodology is described below since it is not commonly used in industry.

Substitution Methodology

The substitution methodology allows intermixing of different units without explicitly calculating the intermixed array. The methodology requires establishing the required horizontal edge-to-edge spacing necessary for each of the units in an infinite planar array under the worst credible level of interspersed moderation. The minimum allowed horizontal edge-to-edge spacing is 12 inches between fissile units, subject to the following:

- The unit must be modeled with any associated non-controlled parameters at the optimum, credible conditions.
- Reflective boundary conditions must be placed on the X & Y faces, no closer than 6 inches from the surface of the SNM unit (establishes minimum 12 inch edge-to-edge horizontal spacing requirement).
- The floor must be modeled as minimum 12-inch-thick concrete.
- A minimum of 1200 cm of air (or interspersed moderation) must be modeled above the floor, unless there is intervening material that could increase reactivity.
    - In this case, the more restrictive of the 1200 cm or the actual material and height is used.
    - If there are multiple levels above the unit,
        - the interaction of the levels must be addressed by explicit vertical modeling
          OR
        - the interaction must be bounded by use of a reflector such as thick concrete on the intervening face of the model.
- The normal (LCO) condition of the controlled parameters must meet the LCO k_{eff} limit, see Table 5.2.
- All credible interspersed moderation levels must be evaluated. This cannot result in a situation that exceeds the Safety Limit k_{eff} (see Table 5.2).
- The spacing between units is increased until the Safety Limit k_{eff} is met.

The process is repeated for other SNM units that will be intermixed. The required spacing between two different units is the larger of the two.

<u>Neutron Isolation</u>

A unit containing fuel may be considered isolated from another unit if the separation (edge-to-edge of fuel) is greater than the larger of the following distances:

a. Twelve feet, or

b. The greatest distance across an orthographic projection of either array on a plane perpendicular to a line joining their centers.

Isolation may also be demonstrated using other techniques.

5.3.1 Neutron Transport Computer Codes for Calculation of k_{eff}

When using computer codes to establish NCS limits, the controlled parameters are varied to determine the sensitivity of k_{eff} to changes in the controlled parameter. The amount the controlled parameters are varied is based on the contingency or contingencies under evaluation.

NCS calculations are performed using validated computer codes, techniques and cross section data sets. The computer codes are run on configuration-controlled software and hardware. All such analyses are reviewed by an independent qualified staff member.

Validation of computer codes and cross section sets is done per ANSI/ANS-8.24-2017. A computer code will be initially verified then validated. Reverification of the computer code system (as defined in ANSI/ANS-8.24-2017) will occur at least annually or after revision to the computer code system. The application of new computer codes or additional benchmark data will be reviewed and approved by a qualified NCS staff member.

5.3.1.1 Calculational Margin and Margin of Subcriticality

The calculational margin includes the allowances for the bias (k_{eff} minus the experimental k_{eff} value or the ratio of the calculational k_{eff} to the experimental k_{eff} minus 1) and the bias uncertainty as well as uncertainties associated with interpolation, extrapolation and trending. The bias uncertainty accounts for the uncertainties in benchmarks, the calculational models and the calculational method. An acceptable k_{eff} is determined by:

$$1 - \Delta k_{MoS} - \Delta k_{CM} \geq k_{calc(analysis)} + 2\,\sigma_{calc(analysis)}$$

$$(USL = 1 - \Delta k_{MoS} - \Delta k_{CM})$$

The preferred form is:

$$1 - \Delta k_{MoS} \geq k_{calc(analysis)} + 2\,\sigma_{calc(analysis)} + \Delta k_{CM}$$

where: Δk_{MoS} is the Margin of Subcriticality (MoS – listed in Table 5.2),
Δk_{CM} is the Calculational Margin,
$k_{calc(analysis)}$ is the calculated k_{eff} of a system being evaluated as part of Nuclear Criticality Safety analysis,
$\sigma_{calc(anlaysis)}$ is the uncertainty on that calculation.

Techniques for Establishing the Calculational Margin:

The Non-Parametric Method (NPM) is primarily applied when the underlying distribution of the data is not known or cannot be verified. The confidence level that a fraction of the population is above an observed value is:

$$\beta = 1 - \sum_{j=0}^{m-1} \frac{n!}{j!(n-j)!}(1-q)^j q^{n-j}$$

where:

q is the desired population fraction (0.95)

n is the number of benchmarks in the data set

m is the rank order indexing from the smallest sample to the largest (m=1 for the smallest sample, m=2 for the second smallest, etc.).

For the smallest value in the sample, the equation reduces to:

$$\beta = 1 - q^n = 1 - 0.95^n$$

If there are more than 58 benchmarks, a rank order (m) greater than 1 can be used provided the selected rank order yields a β equal to or greater than 0.95 which would assure at least a 95/95 confidence level.

Non-parametric methods are the preferred method to establish the calculational margin. The non-parametric approach used is based on the specified rank order calculated k_{eff} value. This method has three terms that define the calculational margin (Δk_{CM}).

$$\Delta k_{CM} = |bias| + \sigma_{calc} + \Delta k_{NPM}$$

where: bias = k_{calc}-k_{exp} , or k_{calc}/k_{exp} - 1

k_{calc} used is the specified rank order calculated k_{eff} of the benchmarks used for the validation,

k_{exp} is the reported experimental k_{eff} for the same configuration,

k_{NPM} is the margin accounting for the amount of experimental data.

Since no credit is taken for a positive bias, if the specified rank order calculated k_{eff} of the benchmarks is greater than the experimental value, the bias is set to zero and the equation becomes:

$$\Delta k_{CM} = 0 + \sigma_{calc} + \Delta k_{NPM} \text{ (for } k_{exp} \leq k_{calc})$$

The non-parametric margin (Δk_{NPM}) is based on the degree of confidence for 95% of the population and is shown below.

Table 5.1 Degree of Confidences and Non-Parametric Margin

Degree of Confidence for 95% of the population (β)	Number of Experiments (n)	Non-Parametric Margin (Δk_{NPM})
>0.9	n > 45	0.00
>0.8	32 < n < 44	0.01
>0.7	24 < n < 31	0.02
>0.6	18 < n < 23	0.03
>0.5	14 < n < 17	0.04
>0.4	10 < n < 13	0.05
<0.4	n < 10	Insufficient data

β - Percent confidence that a fraction of the population is above the lowest point.

Other statistical methods such as Lower Tolerance Band (95/95 or greater) or Lower Tolerance Limit (95/95 or greater) may be used if the data meets the assumptions of the methodology. When methods that employ trending are used, trends may indicate k_{eff} values greater than unity for some parameter ranges. In ranges where the trended k_{eff} value exceeds unity, additional margin shall be applied equal to the amount of the positive bias as a function of the trending parameter. For methods that use average values, it is possible to have average k_{eff}'s that exceed unity. In those cases, the additional margin shall be applied. The margin shall be the amount of the positive bias.

5.3.1.2 Validation Applicability:

The Validation Applicability includes:

1. Unclad fuel of different chemical forms in both solid and solution form,
2. Clad fuel components,
3. The full range of enrichments, H/X, and average energy, and
4. A large number of moderators and reflectors.

The Validation Applicability covers the operations existing in the facility.

If extensions to the Validation Applicability are required, the extensions will be consistent with the assumptions and limitations of the method used to establish the calculational margin or by application of additional margin, which must be justified.

5.3.1.3 Margin of Subcriticality:

The margin of subcriticality varies depending on the systems and the condition. Three categories for margins are:

1. Low-enriched systems contain uranium enriched ≤ 10 weight percent in ^{235}U,
2. High-enriched systems contain uranium enriched > 10 weight percent in ^{235}U, and
3. Systems involving welded clusters in which the welded cluster is the reactivity driver of the system, must meet the following:

   - Be fueled by high enriched uranium (>90 weight percent ^{235}U).
   - Have a thermal neutron spectrum when full flooded.
   - Be constructed of the same geometric style elements as those in the applicable critical experiments.
   - Any significant absorbers must have been included in the applicable critical experiments.
   - The workstations shall be in an area where clusters or subcomponents of clusters are handled.

A system is considered to be critical at the point when the k_{eff} value is 1. The Safety Limit and the Limiting Condition of Operation have k_{eff} which is lower than the critical value by the approved margin of subcriticality, also call the margin of subcriticality. The system k_{eff} limits and margin of subcriticality (Δk_{MoS}) for the three different categories are listed in table below.

Table 5.2 Margin of Subcriticality for LCO and SL

Type of System	**LCO and SL**	
	Δk_{MoS}	k_{eff}
Low-enriched systems	0.03	0.97
High-enriched systems	0.05	0.95
Systems involving welded clusters	0.025	0.975

5.4 Nuclear Criticality Safety Audits and Inspections

NCS audits and inspections are defined in Chapter 11.5.1.

5.5 Nuclear Criticality Safety Training

The Nuclear Criticality Safety training philosophy utilizes a graded approach. All personnel receive General Employee Safety Training (GEST). This training provides a general overview of Nuclear Criticality Safety including instructions not to handle or relocate SNM without completing Specialized Nuclear Criticality Safety training and instructions on response to criticality accident alarms. The next level of training is Specialized Nuclear Criticality Safety training which is for personnel who will handle SNM. This training is described in more detail below.

5.5.1 General Employee Safety Training

All individuals are given Nuclear Criticality Safety training prior to being granted unescorted access to the Restricted Areas as defined by 10 CFR 20. This includes, as a minimum, the following training:

- A discussion about the fission process and criticality.
- A brief history of criticality accidents.
- The effects and consequences of a criticality accident at this plant.
- The importance of an immediate evacuation in case of a criticality accident.

This training shall be developed with the technical oversight of Nuclear Criticality Safety. This training is repeated annually.

5.5.2 Specialized Criticality Safety Training

In addition to General Employee Safety Training, all employees who handle fissile materials are given specialized instruction annually. This program covers

- The general safety principles of handling fissile material,
- A discussion about the basic nuclear criticality safety controls used at NOG together with appropriate examples of the various controls,
- A discussion about the nuclear criticality safety postings including examples of specific criticality safety limits,
- A discussion about nuclear safety violations and the impact they have on the nuclear criticality safety program.

Specialized Nuclear Criticality Safety training shall be developed with the technical oversight of Nuclear Criticality Safety.

Specialized training is supplemented by on-the-job training and qualification of operators. This training specifically addresses the criticality safety limits contained in operating procedures and on postings for specific jobs. In the on-the-job training process, a new operator will work with an experienced operator until the supervisor judges that the new operator understands the safety requirements well enough to perform the job alone.

5.5.3 Evaluation of Training

The effectiveness of the Nuclear Criticality Safety training is judged by three methods.

First, written and/or oral tests are given to each individual who receives Specialized Nuclear Criticality Safety instruction; the test must be passed. Tests are not normally given following General Employee Safety Training.

Second, Nuclear Criticality Safety inspections of the entire plant reveal how well personnel understand the safety controls as demonstrated by of the number of Nuclear Criticality Safety violations found.

A third method of evaluating how well employees understand the safety requirements is the supervisor's close contact with the employee.

5.6 Criticality Accident Alarm System

The site shall maintain a criticality accident alarm system for each area in which 700 grams or more of ^{235}U is possessed, 450 grams or more of plutonium, or 450 grams or more of any combination thereof. This monitoring system shall be capable of energizing a clearly audible alarm signal if an inadvertent criticality occurs. The placement of the detectors shall be determined by calculation utilizing detection criteria described in 10 CFR 70.24(a)(1), and methodology described in Regulatory Guide 3.71, Nuclear Criticality Safety Standards for Fuels and Material Facilities, Revision 3, October 2018.

Whenever the criticality monitoring system is out of service, in storm-watch mode, or being tested or repaired, compensatory measures shall be in place to ensure evacuation if a criticality occurs. Compensatory measures shall be specified in facility procedures, and periods when the criticality monitoring system is out of service should be minimized to the extent practical.

5.7 LTC Specific Requirements

LTC Building B is limited to 40 units, excluding the hot cells, underwater storage, in-ground storage tubes and the examination of commercial fuel assemblies. Each unit shall be separated by a minimum of 8 inch edge-to-edge and 24 inches center-to-center.

The limits are listed below:

5.7.1 Mixed Uranium and Plutonium Limits at LTC

Fuel (other than fuel contained in irradiated fuel rods) containing or potentially containing uranium and plutonium will be handled based on units. Each unit will be limited to total fissile material based on the plutonium weight percentage as shown below:

$$\frac{^{233}U\,(g) + \,^{235}U\,(g)}{350} + \frac{^{239}Pu\,(g) + \,^{241}Pu\,(g)}{220} \leq 1$$

5.7.2 Hot Cells in Building B

The hot cells shall be limited to three units, as defined in 5.7.1, in Hot Cell No. 1, provided the units are separated by a minimum of 12 inch edge-to-edge and one unit in each of the other hot cells.

5.7.3 Storage Tubes Inside LTC Buildings

SNM in storage tubes shall be limited to the values specified in 5.7.1 for each tube. Storage tubes shall be spaced a minimum of 17 inch center-to-center (except for one pair of tubes which may be spaced a minimum of 16.5 inches), are approximately 5 inches in diameter, and are totally immersed in concrete.

5.7.4 Outside Storage at LTC

Outside storage consists of underground storage, shipments and the fenced outside storage area located adjacent to Building J.

SNM in storage tubes shall be limited to the values specified in 5.7.1 for each tube. Tubes shall be spaced 20 inch center-to-center, are approximately 5 inches in diameter, and are totally immersed in concrete.

5.7.5 Unirradiated Commercial (PWR and BWR) Fuel Assemblies at LTC

Unirradiated fuel assemblies will be received at a maximum of two at a time in a shipping container licensed for two assemblies, or one assembly in a shipping container licensed for one assembly. Unirradiated fuel assemblies may be handled and stored subject to the following conditions:

1. Unirradiated fuel assemblies may be stored in air in the Cask Handling Area (CHA) or in the Development Test Area.
2. Assemblies may be stored in their shipping container as received.
3. Assemblies may be stored a minimum of 21-inches apart surface-to-surface.
4. Assemblies may be stored under water in the CHA pool, Pool Test Facility pool, or Development Test Area pool in racks constructed to maintain a 1-foot minimum surface-to-surface separation between assemblies and any other SNM. Assemblies may be handled and dismantled under water subject to the same requirements of the irradiated fuel in the CHA Pool.
5. No more than four unirradiated assemblies may be kept at the LTC site at one time.
6. Only one unirradiated fuel assembly shall be dismantled or reassembled at a time in the Development Test Area. The dismantling operation shall meet the following:
   - Only one fuel rod may be removed from or inserted into the assembly at a time.
   - Only one fuel rod may be in transit to any location at a time.

   * The fuel assembly may be completely disassembled by withdrawing one fuel rod at a time from the assembly; during all stages of disassembly, the partially disassembled assembly shall be maintained within the confines of the assembly whether damaged or undamaged.
7. Associated with the dismantling operation, one storage position will be permitted for fuel rods removed from an assembly provided that:
   - The assembly and associated rod storage position shall be separated from each other and from any other fissile material by a minimum of 21 inches surface-to-surface.
   - The associated rod storage position shall be no larger in any dimension than the fuel assembly. There shall be one storage position for each fuel assembly to be dismantled. Rods may be stored or handled in a slab up to 4 inches thick provided the slab is separated from other fissile material by a minimum of 12 feet.
   - Only one fuel rod may be removed or inserted into the associated rod storage position at a time.

8. Fuel assemblies to be studied shall meet the following:

   - Each assembly shall be of the enriched PWR type with a 15 x 15, or 17 x 17 square pin lattice not greater than 8.6 inches on a side (further identified as Babcock & Wilcox Mark B or Mark C canless assemblies).
   - The maximum initial enrichment in an unirradiated fuel assembly shall not exceed 4.05 wt%.
   - Damaged fuel assemblies may be examined in air. Fuel assemblies which have been damaged can be examined in water if they maintain their 8.6 inch on a side dimension.

9. Other PWR or BWR fuel assemblies which do not meet the above listed requirements may be studied, provided:

   - The unirradiated, fully reflected fuel assembly (fueled with UO2 only) with all control rods removed is shown by an appropriate Nuclear Criticality Safety evaluation to be safe.
   - The fuel assembly is shown by an appropriate safety evaluation to be safe under specific conditions of disassembly.

10. BWR fuel assemblies may be received and studied provided:

    - They are evaluated pursuant to item 9 above, or
    - The BWR fuel assemblies have a maximum initial unirradiated enrichment of 4.05 wt% ^{235}U and have a cross sectional area not exceeding that of a 22.5 cm (8.85 in.) diameter cylinder.

11. After examination, fuel rods, including fuel rod segments may be placed in any available hole in a fuel assembly, including instrumented and control rod guide tube positions, i.e., 225 and 285 fuel rods in Mark B and Mark C assemblies, respectively. Fuel rod segments shall have their ends sealed, and shall be encapsulated in steel tubing with ends sealed, prior to insertion into an available hole in a fuel assembly

5.7.6 Irradiated Commercial (PWR and BWR) Fuel Assemblies at LTC

Irradiated fuel assemblies will be received at a maximum of two at a time in a shipping container licensed for two assemblies, or one assembly in a shipping container licensed for one assembly.

1. Irradiated fuel assemblies will be stored in the CHA pool which is limited to the following conditions:

   - A maximum of four fuel assemblies or portions thereof may be in the pool at a time.

- The assemblies shall be stored in racks constructed to maintain a 1-foot minimum surface-to-surface separation between assemblies and any other SNM in storage or transit. Each position in the assembly storage rack must limit contained fuel to a square not to exceed the dimensions of a fresh fuel assembly or to a cross sectional area not exceeding that of a 22.5 cm (8.85 in.) diameter cylinder.
- Partially dismantled assemblies will be stored in the assembly storage rack.
- Only one assembly may be in a designated work area of the pool at any one time. There shall be a minimum of 1-foot surface-to-surface separation between the assembly in the work area and any other fissile material.

2. Dismantling of irradiated fuel assemblies is permitted in the Pool under Hot Cell No. 1 provided:

   - Only one fuel rod at a time shall be removed from or inserted into the fuel assembly
   - A fuel assembly can be completely dismantled by withdrawing one fuel rod at a time from the assembly; during all stages of dismantlement, the partially dismantled assembly shall be maintained within the confines of a square not exceeding the dimensions of a fresh fuel assembly or to a cross sectional area not exceeding that of a 22.5 cm (8.85 in.) diameter cylinder.

3. Associated with the dismantling operation, one storage position will be permitted for fuel rods or components removed from the assembly provided that:

   - The assembly and associated rod storage position shall be separated from each other and from any other fissile material by a minimum of 1 foot surface-to-surface.
   - Fissile material and fuel rods or components in the associated storage positions shall be restricted to a square not exceeding the dimensions of a fresh fuel assembly or to a cross sectional area not exceeding that of a 22.5 cm (8.85 in.) diameter cylinder.
   - Only one fuel rod may be inserted or removed from the storage position at a time.
   - A maximum of 75 fuel rods shall be permitted in the rod storage position.

4. Fuel assemblies to be studied shall meet the following:

   - Each assembly shall be of the enriched PWR type with a 15 x 15, or 17 x 17 square pin lattice not greater than 8.6 inches on a side (further identified as Babcock & Wilcox Mark B or Mark C canless assemblies).
   - The maximum initial enrichment in an unirradiated fuel assembly shall not exceed 4.05 wt%.

5. Other PWR or BWR fuel assemblies which do not meet the above listed requirements may be studied, provided:

   - The unirradiated, fully reflected fuel assembly (fueled with UO2 only) with all control rods removed is shown by an appropriate Nuclear Criticality Safety to be safe.
   - The fuel assembly is shown by an appropriate Nuclear Criticality Safety evaluation to be safe under specific conditions of disassembly.

6. BWR fuel assemblies may be received and studied provided:

   - They are evaluated pursuant item 5 above, or
   - The BWR fuel assemblies have a maximum initial unirradiated enrichment of 4.05 wt% ^{235}U and have a cross sectional area not exceeding that of a 22.5 cm (8.85 in.) diameter cylinder.