Enclosure 1

RAI Responses

NAC-LWT SAR, Revision 20B

NAC INTERNATIONAL

RESPONSES TO THE

UNITED STATES
NUCLEAR REGULATORY COMMISSION

REQUEST FOR ADDITIONAL INFORMATION

FOR REVIEW OF THE CERTIFICATE OF COMPLIANCE NO. 9225, NAC-LWT PACKAGE

TO INCORPORATE EFN RODS, BOOSTER RODS, AND MOLY TARGETS)

(EPID No. L-2020-LLA-0056, DOCKET NO. 71-9225)

August 2020

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TO
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STRUCTURAL EVALUATION

1-1 Clarify the size of the fillet weld used to join the plug cap to the NRU/NRX tube and provide supporting calculations.

Sheet 1 of Drawing 175 shows the plug cap (bill of materials [BOM] part 5) joined to the plug tube (BOM part 4) by a fillet weld of unspecified weld size. The plug cap weld is needed to maintain small fragments within the NRU/NRX caddy and will be subjected to loading during drop tests, vibration, etc., for normal conditions of transport (NCT) and hypothetical accident conditions (HAC). It appears that supporting calculations demonstrating the weld's ability to retain the plug cap during NCT and HAC have not been provided.

This information is needed to meet the requirements of 10 CFR 71.71(c)(5), 71.71(c)(7), 71.73(c)(1), and 71.73(c)(3).

<u>NAC International Response to RAI 1-1:</u>

The design drawing for the caddy plug contains both the weld and the geometry details. An excerpt of the design drawing is included in RAI Figure 1-1. The caddy plug consists of a caddy plug tube and a caddy plug cap, joined by the 0.05-inch fillet weld.

Structural evaluation for the caddy plug is performed for the caddy plug, including the 0.05-inch fillet weld, for normal and accident conditions of transport, as documented in Appendix H of NAC Calculation No. 65007700-2000. The calculated factor of safety for the weld is greater than 8 for the governing loading condition. The proprietary calculation is provided in Enclosure 3 of this response package.

To clarify the design, it should be noted that the caddy assembly, with or without the plug, is placed in the NRU/NRX basket tube. The caddy plug fits into the caddy assembly tube with minimal radial gap and is retained in the tube by the NRU/NRX basket lid which is placed on top of the basket/tube assembly. Note that the difference between the cavity length of the NRU/NRX basket assembly/tube and the length of the caddy assembly is 0.23-inch (nominal) and, therefore, the caddy plug (15-inch long) is retained in the caddy tube. Even without crediting the caddy plug, the fuel material will be constrained in the caddy cavity due to the small radial gap between the caddy and NRU/NRX basket tube and the small gap to the NRU/NRX basket lid at top of the caddy assembly.

RAI Figure 1-1 Caddy Plug on the following page.

[redacted]

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STRUCTURAL EVALUATION

1-2. Clarify how the plug assembly will remain attached to the NRU/NRX tube during NCT and HAC conditions and provide supporting calculations/details.

Sheet 1 of Drawing 175 depicts the plug (BOM part 6) which is assumed to be attached to the tube (BOM part 1) in an unknown fashion. The plug is needed to maintain small fragments of material when carrying EFN rods, moly targets, or booster rods within the NRU/NRX caddy. However, the diameter of the plug tube is unspecified (flag note 4) and it is unclear how the plug assembly will remain attached to a tube (which has an unspecified diameter) during NCT and HAC.

This information is needed to meet the requirements of 10 CFR 71.71(c)(5), 71.71(c)(7), 71.73(c)(1), and 71.73(c)(3).

<u>NAC International Response to RAI 1-2:</u>

As described in the response to RAI 1-1, the caddy plug is not attached to caddy assembly and does not require attachment. The caddy plug fits in the caddy tube with a 1.9-inch ID (reference) as shown on Sheet 1 of Drawing 175. The caddy plug is retained in the caddy tube by the NRU/NRX basket lid in the transport configuration. Based on the component dimensions it is not feasible for gross/significant amount of fuel material to exit the caddy tube geometry regardless of the presence of the caddy plug but the caddy plug will ensure that small fragments can be contained and not result in material difficult to remove after transport.

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STRUCTURAL EVALUATION

1-3 Clarify the basis for cladding damage limitations on EFN rods and how they will be measured and/or ensured when NRU/NRX caddies are carrying EFN rods.

Page 1-9 of the application states in part "...Therefore, there are no cladding damage limits except for full cask loads of EFN rods which require the equivalent of 30% clad (fueled surface area).". It appears that calculations supporting this value/assessment have not been provided, so it is unclear how the cladding will perform for NCT and HAC with these damage limits. In addition, it is unclear from this description if damage is limited to 30% of the cladding surface area or if only 30% of the cladding surface needs to be intact. In addition, it is unclear how this value will be ascertained, measured, or otherwise verified.

This information is needed to meet the requirements of 10 CFR 71.71(c)(5), 71.71(c)(7), 71.73(c)(1), and 71.73(c)(3).

NAC International Response to Structural Evaluation RAI 1-3:

Structural evaluations of the clad were not included as they are not considered critical to the performance of this package. The fuel type in question is a uranium aluminum alloy that is not subject to cracking/fracturing as a result of burnup that is typical of oxide fuel material, therefore the clad is not an integral requirement for assuring geometry of the fissile material. Clad material simply provides spacing and moderator displacement function in terms of the safety analysis. The clad is an extrusion clad aluminum that tightly adheres to the fuel core. Regardless, both criticality and shielding evaluations evaluate bounding conditions associated with the requested limit. Shielding evaluations do not credit the clad at all and assume collapse of the fuel region (the fuel rod core alloy) into the worst case (fully collapsed at top of tube) configuration. Criticality evaluations credit the minimum amount of clad specified (30% by volume). The bounding evaluation as discussed in SAR Section 6.7.6.3.2 was performed by reducing the clad thickness uniformly, in which case there would be a small layer of clad over the full fuel rod. As stated in SAR Section 6.7.6.3.2, this evaluation bounds missing clad (up to 70% removed or 30% remaining) over the rod surface area. The requirement that at least 30% of the fuel clad remains (by surface area) is therefore a significantly more restrictive requirement than that imposed by the provided safety analysis.

Assurance that this requirement is met, is up to the shipper or consignors to verify. This will be verified as any other CoC imposed limitations. The method by which this will be determined does not need to be specified within the license application.

Based on EFN fuel structure and integrity of an extrusion clad alloy fuel core, significantly more clad will be available on damaged fuel than 30%. The value provided is simply the lower bound supported by the safety analysis.

NAC INTERNATIONAL RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

MATERIALS EVALUATION

2-1. Provide information on temperature and radiation level inside the package resulting from the new contents of the package.

The applicant provided the heat loading and temperature effects in SAR Pages 195 – 196, without presenting any potential temperature changes resulting from the new contents. The information provided was from the previous SAR revision. The staff needs to confirm that temperature values are acceptable for the new contents. The temperature is important to assess the stability of seals, O-ring and aluminum. Similarly, the applicant did not provide any information on the change in radiation level(s) resulting from the new package contents. The staff needs the changes in radiation level(s) to assess the material stability of the seals and O-ring.

This information is needed to meet the requirements of 10 CFR 71.31.

<u>NAC International Response to Materials Evaluation RAI 2-1:</u>

The application thermal and radiation level evaluation rely on the previously approved NRU/NRX payloads being bounding in terms of both heat load, component temperatures, as well as radiation exposures. The fuel materials themselves are very similar to the NRU/NRX fuels (see Chapter 5 for detailed comparisons) and will be transported in the basket configuration licensed for the NRU/NRX materials. As stated in SAR Chapter 1, the maximum heat load produced by the proposed payload is 25% that of the NRU/NRX payloads in the same geometry. The heat load allowed per tube in the NRU/NRX configuration is 35.6W and 8W for the EFN rods (< 1 W for the remaining requested payloads). Shielding evaluations provided in SAR Chapter 5 demonstrate that dose fields produced by NRU/NRX payloads bound those of the amendment request under any of the evaluated conditions. This is expected given the similar fuel structure and reduced heat load.

It is not necessary to generate temperature or radiation field calculations when the as provided data demonstrates that the payloads being requested are bounded by those of the previously approved NRU/NRX payloads. In the context of component temperatures, the SER for the NRU/NRX payloads, issued by NRC February 28, 2013 (Revision 58) found that:

"Within this amendment, the maximum temperature inside the package for NRU/NRX fuels is 245°F. The maximum temperatures of the package components for the MTR contents (Condition 1, Table 3.4-6) bound the maximum temperatures for the package components for the NRU/NRX material contents. The staff finds the values that were calculated acceptable."

As the NRU/NRX payload was deemed acceptable, the lower heat load payloads requested in this amendment are bounded.

While the SER does not explicitly discuss the radiation impact on the seals, the significantly lower than design basis source, or even NRU/NRX source terms which in turn are significantly lower than system design basis sources, indicate that the requested payloads will not challenge the previously licensed configurations.

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SHIELDING EVALUATION

3-1. Explain what is meant by a limited amount of cladding integrity being credited for full basket loads of EFN rods, why this was done, and how this limitation could affect the shielding evaluation of the package since no radiation level (or dose rate) analysis was performed for this amendment. Also explain how limits on cladding and content integrity (or lack thereof) affect the physical distribution of all the proposed contents' sources within the package and how the shielding evaluation accounts for this physical distribution and changes to it.

SAR Page 1-9 states in part "...Therefore, there are no cladding damage limits except for full cask loads of EFN rods which require the equivalent of 30% clad (fueled surface area)." It is unclear what this statement means in terms of the physical condition of the contents (the rod integrity under normal and hypothetical accident conditions) and the physical distribution of the source within the package. It is also not clear how the shielding evaluations account for the potential source distributions for the allowed cladding damage for the EFN rods and the allowed damage or physical conditions of the other proposed contents.

This information is needed to meet the requirements of 10 CFR 71.47 and 71.51.

NAC International Response to Shielding Evaluation RAI 3-1:

No clad is required to be present to assure that dose rates of the requested payloads remain within safety limit(s). The clad requirement enters thru criticality control only. The NRC SER for the NRU/NRX payloads (Revision 58 of the NAC-LWT CoC) duplicates the discussion included in the SAR Section5.3.21 NRU/NRX evaluation and states.

"The NRU/NRX fuel, which is composed of a metal alloy, is not expected to fail during transport, and will not produce rubble. However, the applicant looked at a damaged fuel configuration that fully collapses the fuel in the basket tubes. Collapsed fuel was modeled at the nominal fuel density. The fuel meat alloy will not compact as a result of any transport condition. Also, collapsed models do not include fuel clad or end plug material."

The additional payloads requested in this amendment are simply dispositioned as containing less source and source density with similar fuel material in the same basket geometry. It should also be noted that the NRU-HEU fuel was not bounding for the NRU/NRX payloads (NRU-LEU are more than an order of magnitude higher), and the NRU/NRX payloads are not bounding for the NAC-LWT. These factors combine to demonstrate that the requested payloads do not provide a challenge to regulatory requirements or NAC-LWT performance.

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SHIELDING EVALUATION

3-2. Confirm whether the caddy plugs are always used with the proposed contents.

Based on the staff's understanding of the descriptions of the contents and the shielding evaluation, it would seem that the caddies should always be used with the proposed contents and that this should be specified in the package operations section of the application.

This information is needed to meet the requirements of 10 CFR 71.47, 71.51 and 71.87.

NAC International Response to Shielding Evaluation RAI 3-2:

As discussed in the Responses to RAI 1-1 and 1-2, there are minimal gaps (fraction of inch) between basket components (basket tube and lid) and the caddy that would not allow any significant reconfiguration of fuel materials. In particular, the bounding (NRU-HEU) shielding evaluations did not credit a caddy or caddy plug and therefore do not require the use of a caddy or caddy plug.

While the shielding evaluation does not require a caddy or caddy plug, the use of the plug was proposed when small fuel fragments/sections are loaded. Within the initial application, NAC did not propose a specific value associated with these pieces and referred to them as small fragments. As part of the RAI response, NAC is revising SAR Chapters 1 and 7 (Enclosure 5)of the application to require the use of the caddy plug when rods/targets or fragments/segments thereof are smaller than 6 inches in length. Additionally, the "Proposed CoC Changes" (Enclosure 2) are revised to reflect these changes.

Changes not associated with the RAI Response

Steps 18 and 20 of Submittal 20A were found to be duplicates, therefore, Step 20 has been deleted and the subsequent steps of SAR Section 7.1.15 have been renumbered.

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SHIELDING EVALUATION

3-3 Explain what is meant by no caddy being credited in the shielding evaluation. Confirm whether this means that none of its materials were credited and that its ability to retain the rods/contents within any set geometric volume was also not credited.

In Section 4.1 of the application, the applicant stated that no caddy was credited in the evaluation of bounding dose rates for the NRU-HEU contents. However, there are no details on how this evaluation was done.

This information is needed to meet the requirements of 10 CFR 71.47 and 71.51.

NAC International Response to Shielding Evaluation RAI 3-3:

No credit was applied to the caddy's ability to retain the rods/contents within any set geometry. No caddy material was included when compaction lengths were calculated for the Booster/EFN/Moly payload configurations (i.e., the basket tube cross section is used to calculated the minimum/bounding source height). This approach matches the NRU-HEU analysis. The NRU basket and lid structure assure retention of the fuel material within the tube, and thereby evaluated, geometry.

SAR Section 5.3.21 contains the evaluation detail on the NRU/NRX payloads. No caddy is discussed in this section and no caddy was included in the evaluation. Only the basket tubes were credited for containing fuel materials. As stated in SAR Section 5.3.21, the fuel material, without clad, was collapsed to form a source region closest to the minimum shielding region of the cask (top forging) allowed by the NRU/NRX basket lid. The requested payloads in this amendment were dispositioned against the NRU evaluation.

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CRITICALITY EVALUATION

4-1 Provide the maximum allowed U-235 enrichment for each of the proposed new contents.

The applicant provided specifications for the proposed new contents in Table 1-1 of the calculation package, "50055-5001 Rev. 0," however, the table only contains the minimum enrichment as "Enrichment(%) – Min". There is no maximum allowable enrichment limit for the proposed contents. Because enrichment is an imperative parameter for criticality safety of U-235 based fissile materials, all packages must include a maximum allowable U-235 enrichment for fissile material contents in accordance with the regulatory requirements of 10 CFR 71.55 (b) "Except as provided in paragraph (c) or (g) of this section, a package used for the shipment of fissile material must be so designed and constructed and its contents so limited that it would be subcritical..." The staff will revise the content specification table in CoC Condition 5.(b)(1)(xxii) to reflect the revised definition of the fissile material contents.

The staff needs this information in order to determine if the package with the proposed contents meets the regulatory requirements of 10 CFR 71.55.

NAC International Response to Criticality Evaluation RAI 4-1:

To assure that the proposed CoC conforms to the NAC-LWT SAR, Chapter 1 Table 1.2-18 and CoC Table 5.(b)(1)(xxii) are revised to add the maximum enrichment specified in SAR Table 6.7.6-10 of 94 wt% (^{235}U) for the requested new contents.

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CRITICALITY EVALUATION

4-2 Demonstrate that the keff of the NAC-LWT package with the mixed load of NRU/EFN (National Research University/Enriched Fast Neutron) rods and six Moly targets in the caddies is below the upper subcritical limit (USL).

Page 6.7.6-5 of the application states: "Previous analysis demonstrated that a cask loaded of NRU/EFN rods in caddies produces keff values above the USL when assuming unclad materials. The analysis also demonstrated that a configuration with the six interior basket tubes empty is significantly below the USL. Rather than leaving the interior locations empty the low fissile mass Moly targets are placed into the inner 6 tubes. With a fissile mass of the bounding Moly caddy (containing Double Length Moly targets) being <20% that of the NRU caddy, engineering judgement indicates that results will be below the USL." The staff's concern is that this engineering judgment may not be reliable because replacing the six empty tubes with highly enriched Moly targets will impact on the reactivity of the package in two key aspects: (1) increased quantity of fissile material and (2) removal of the neutron flux trap formed by the empty tubes. Criticality safety of the package with this proposed loading configuration is a concern because the package fully loaded with the NRU/EFN rods has been shown by the applicant to exceed the USL.

The staff needs this information to determine if the package with the proposed contents meets the regulatory requirements of 10 CFR 71.55(b), 71.55(d), and 71.55(e).

<u>NAC International Response to Criticality Evaluation RAI 4-2:</u>

In the text following the RAI, the Reviewer quoted an engineering judgment statement from page 6.7.6-5, SAR Section 6.7.6.3.4. NAC did perform the evaluation of the mixed payload and demonstrated that the mixed payload k_{eff} was well below the USL. The evaluation included various configurations of the Moly rods to obtain a maximum reactivity mixed payload configuration. The evaluation concluded that spreading out the Moly rods along the length of the tube/caddy to provide maximum interaction with the NRU/EFN rods resulted in increased reactivity versus the more compact configuration for only Moly rods. Results for this evaluation were summarized in SAR Table 6.7.6-6 as stated in SAR Section 6.7.6.3.4.

As the requested evaluation is already included in the SAR no calculation or SAR changes are required to address the NRC RAI

NAC INTERNATIONAL RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

CRITICALITY EVALUATION

4-3 Provide justification for the applicability of the selected critical experiments for code benchmarking or revise the code benchmarking to use critical experiments that are more appropriate for this application.

The applicant performed benchmarking analyses for the MCNP computer code used to perform criticality safety analyses. In Table 6.5.6-1 of the application, the applicant provided a list of the 169 critical experiments it selected for code benchmarking. The staff notes that of these selected critical experiments, 18 of them are rods with U-235 enrichment around 79% and arranged in various sizes of hexagonal arrays, 47 of them are rods with U-235 enrichment of around 79% and arranged in various sizes of square arrays, 97 are plates with 93% U-235 enrichment and arranged in various square arrays, six of them are rods with 17% U-235 enrichment and arranged in various hexagonal arrays, and one is a 360 plate array at 19.77% enrichment. Since the Booster rods, EFN rods, and Mo-99 targets are all at 91% enrichment, in solid rod shape, and they will form approximate hexagonal geometry arrays when loaded into the caddies, it is not clear if the majority of the selected critical experiments are applicable to this application, particularly those experiments with plate shape fuel in square arrays and those with low U 235 enrichment. As such, there is a concern that the bias and bias uncertainty determined using those selected critical experiments may be skewed and not appropriate for the criticality analysis for the package with the proposed contents.

The staff needs this information to determine if the package with the proposed contents meets the regulatory requirements of 10 CFR 71.55(b), 71.55(d), and 71.55(e).

<u>NAC International Response to Criticality Evaluation RAI 4-3:</u>

Critical benchmarks are discussed in detail within the NRC SER for the NRU/NRX payload addition. The same benchmarks are applicable to the EFN/Booster/Moly application as the fuel material is virtually identical and the basket and fuel geometry is identical to that approved in CoC 58 and discussed within the SER. The only change NAC made is to update the verification to a new version of MCNP. This does not change the relevance/applicability of the benchmark set. The relevant SER section is duplicated below.

6.6 Benchmark Evaluations
The applicant performs the criticality evaluations using the MCNP5 v1.60 three-dimensional Monte Carlo code and continuous energy cross sections. The applicant performed benchmarks with the same computer code and cross section set.

6.6.1 Experiments and Applicability
The applicant performed benchmark comparisons and determined a USL based on the guidance published in NUREG/CR-6361, "Criticality Benchmark Guide for Light-Water-Reactor Fuel in Transportation and Storage Packages." The staff found the use of this guidance acceptable. The applicant uses experiments from the International Handbook of Evaluated Criticality Safety Benchmark Experiments. The experiments are listed in Table 6.5.5-1 of the NAC-LWT SAR. The staff found that these are appropriately referenced. The staff verified that the following important design parameters for the NRU/NRX fuel in the NAC-LWT system were within the benchmark experiments cited by the applicant.

- Enrichment
- Type of fissile material
- Fuel rod pitch and diameter
- Energy of the Average Lethargy Causing Fission (EALCF)

The applicant analyzed 94% enriched fuel, while the maximum enrichment in the experiments was 93.2%. Per Table 6.5.5-5 of the application the USL was reduced to extend the applicability to lower enrichments. For the enrichment range from 17 to 93.2% the minimum USL is 0.928. The USL is slightly negatively correlated with enrichment and if extrapolated to 100% enrichment is 0.92781 which is bounded by the USL of 0.9270. Therefore, the staff has reasonable assurance that the USL of 0.9270 bounds the USL at this slightly increased enrichment of 94%. The staff verified that the selected critical experiments include uranium aluminum fuel with aluminum clad. The fuel rod pitch and diameter are within the range of selected benchmarking experiments. The range for EALCF for the experiments used in determining the bias is 0.05 eV to 0.4 eV with most experiments falling between 0.05 eV to 0.15 eV. The EALCF of the NRU/NRX criticality calculations is 0.123 eV.

6.6.2 Bias Determination
The applicant calculated a USL of 0.9270 using the USLSTATS code. The staff found this acceptable because this includes the biases and uncertainties of the model and computer code into a value that has a 95% confidence level such that any keff less than the USL is less than 0.95. The NAC-LWT SAR's previous benchmarking evaluation for high-enriched research reactor fuel was based on MCNP5 v1.30 using the same experiment base gave a USL of 0.9171. The change in USL comes from the applicant restricting the data used in determining the USL to EALCF energies up to 0.4 eV rather than 1.2 eV used in the benchmarking for MCNP v1.30. The staff found this acceptable for the NAC-LWT NRU/NRX application as the EALCF for this application is within this range.

NAC INTERNATIONAL RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

PACKAGE OPERATIONS EVALUATION

5-1 Pending resolution to RAI 4-2, revise step 21 of the operating procedures to either disallow mixed loading of the NRU/EFN rods and Moly targets in the same basket or to indicate that the Moly targets can only be loaded into the six interior locations of the fuel basket.

The applicant provided revised operating procedures for loading of the proposed new contents. In step 21, the applicant added a note stating: "EFN rods and Moly targets may be loaded in the same basket, but Booster rods shall not be loaded in the same basket as either EFN rods or Moly targets," however, this kind of mixed loading has not been analyzed to demonstrate it is safe to do so with respect to criticality safety (see RAI 4-2). Therefore, this operating procedure needs to be revised. If the response to RAI 4-2 cannot demonstrate it is safe to do so, the applicant should remove the note to Operating Procedure Step 21. If new analyses demonstrate that it is safe to allow mixed loading of EFN rods and Moly targets with six Moly targets in the interior locations of the fuel basket, the applicant needs to revise the operating procedures to clearly state that only six Moly targets can be loaded with EFN rods and the six Moly target rods must be loaded only in the interior locations of the fuel basket.

The staff needs this information to determine if the package with the proposed contents meets the regulatory requirements of 10 CFR 71.55(b), 71.55(d), 71.55(e), and 71.87.

<u>NAC International Response to Package Operations Evaluation RAI 5-1:</u>

NAC would like to clarify that the physical limit is six caddies with Moly targets, not six Moly targets. It should be further noted, as stated in the response to RAI 4-2, that the basket evaluation for 12 caddies with EFN rods in the basket exterior and 6 tubes with Moly caddies in the basket interior was performed and included in the application and shown to be safe.

The note being referred to is modified as part of the RAI response package to identify that, for a mixed loading of EFN rods and Moly targets, the EFN rods are limited to exterior basket positions. This is the limitation imposed by the criticality evaluation performed in support of this amendment.

While a specific evaluation for Moly targets in exterior locations of a mixed load was not performed, it is clear from the evaluation performed on the full basket, and the much larger EFN fissile mass, that less EFN rods in the basket periphery and more Moly targets will reduce system reactivity and be safe. The only required limit is therefore that EFN rods are limited to basket exterior (periphery) locations in a mixed load.

Enclosure 2

No. 71-9225 for NAC-LWT Cask

Proposed Changes for Revision 69 of Certificate of Compliance

Booster Rods, EFN Rods and Mo-99 ("Moly") Targets

Application

NAC-LWT SAR, Revision 20B

August 2020

CoC Sections (revised)

CoC Page 4 of 32

5.(a)(3)(ii) Drawings (continued)

LWT 315-40-175, Rev. 2 (Sheets 1 – 2) Caddy Assembly, NRU/NRX

CoC Page 27 of 33

5.(b)(2) Maximum quantity of material per package (continued)

(xx) For NRU/NRX fuel described in item 5.(b)(1)(xix):

Up to 18 undamaged or damaged NRU or NRX fuel assemblies (or the equivalent number of loose rods) may be loaded per NRU/NRX fuel basket in accordance with NAC Drawing Nos. LWT 315-40-172, LWT 315-40-173, LWT 315-40-174, and LWT 315-40-175. Package configuration to be in accordance with NAC Drawing No. LWT 315-40-170. The NRU/NRX Caddy Plug describe in drawing LWT 315-40-175, Assembly 98, is not required for NRU/NRX fuel shipments. Maximum decay heat not to exceed 0.64 kW per package.

CoC Sections (new)

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5.(b)(1) Type and form of material (continued)

(xxii) EFN Rods, Booster Rods, and Moly Targets (Short and Double Length)

Parameter	Short Moly	Double Length Moly	EFN	Boosters
Maximum Cask Heat Load (W)	101	101	144	4
Maximum Per Caddy Heat Load (W)	0.3	0.8	8	0.2
Payload Limit (lb/tube)	20			
# Rod/Targets (Equivalent)	20	36	36	16
Maximum ^{235}U per rod (g)	1.1	2.41	13	18.1
Minimum Cool Time (yr)	38	8	23	37
Maximum ^{235}U Depletion (%)	94.8	30.4	87.4	2.9
Maximum Initial Enrichment (wt% 235U)	94			

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5.(b)(2) Maximum quantity of material per package (continued)

(xxiii) For EFN Rods, Booster Rods, and Moly Targets (Short and Double Length), as described in Item 5.(b)(1)(xxii):

Up to eighteen (18) NRU/NRX caddies loaded with EFN rods, Booster rods, or Moly targets, may be loaded per NRU/NRX fuel basket in accordance with NAC Drawing Nos. LWT 315-40-172, LWT 315-40-173, LWT 315-40-174, and LWT 315-40-175. Package configuration to be in accordance with NAC Drawing No. LWT 315-40-170. Maximum heat loads not to exceed 144W for EFN rods (8 W per caddy), 101 W for EFN/Moly mixed basket (8W per caddy for EFN rods and 0.8 W per caddy for Moly targets), 4W for Booster rods (0.2 W per caddy).

NRU/NRX caddies are limited to 36 EFN rods, 16 Booster rods, 20 Short Moly Targets, or 36 double length Moly targets or the equivalent number in rod/target segments or fragments. All materials must be placed in a caddy. One single fuel type may be loaded into one NRU/NRX caddy. EFN and Moly targets may be loaded into a single package. Booster rod caddies may not be mixed with EFN rod or Moly target caddies in a single package. Undamaged and damaged material are permitted for transport. Only a limited amount of cladding integrity is credited for full basket loads of EFN rods. Therefore, there are no cladding damage limits except for full cask loads of EFN rods which require the equivalent of 30% clad (fueled surface area). Rods/targets or segments/fragments thereof smaller than 6 inches in length require the use of an NRU/NRX caddy plug. Larger rod segments are retained axially within the caddy by the NRU/NRX basket tube and basket lid structure.

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5.(c) Criticality Safety Index

For, EFN rods, Booster rods, and Moly targets described in 5.(b)(1)(xxii) and limited in 5.(b)(2) (xxviii)	100.0

Enclosure 3

No. 71-9225 for NAC-LWT Cask

List of Calculations

Booster Rods, EFN Rods and Mo-99 ("Moly") Targets Application

NAC-LWT SAR, Revision 20B

August 2020

List of Calculations, NAC-LWT SAR, Revision LWT-20B

Enclosure 2 Contents:

1. Calculation 65007700-2000, NRU-NRX Basket and Spacer Assemblies Structural Evaluation, Revision 4, (ONLY Appendix H)

CALCULATIONS WITHHELD IN THEIR ENTIRETY PER 10 CFR 2.390

Enclosure 4

No. 71-9225 for NAC-LWT Cask

List of SAR Changes

Booster Rods, EFN Rods and Mo-99 ("Moly") Targets Application

NAC-LWT SAR, Revision 20B

August 2020

List of SAR Changes, NAC-LWT SAR, Revision 20B

Chapter 1

- Page 1-5, revised fifth bullet on the page.
- Page 1-9, revised definition of "Damaged and Undamaged EFN rods, Booster Rods, or Moly Targets.
- Page 1.2-7, revised bullet number 23.
- Page 1.2-20, revised last paragraph on the page.
- Page 1.2-64, revised Table 1.2-18

Chapter 2

- No changes.

Chapter 3

- No changes.

Chapter 4

- No changes.

Chapter 5

- No changes.

Chapter 6

- No changes.

Chapter 7

- Page 7.1-67, revised Steps 18 and 19. Deleted Step 20 and renumbered all subsequent steps.
- Page 7.1-68, revised notes in the new step 20.
- Pages 7.1-69 thru 70, updated step numbers.

Chapter 8

- No changes.

Chapter 9

- No changes.

Enclosure 5

No. 71-9225 for NAC-LWT Cask

List of Effective Pages and SAR Changed Pages

Booster Rods, EFN Rods and Mo-99 ("Moly") Targets Application

NAC-LWT SAR, Revision 20B

August 2020

ED20200112

LIST OF EFFECTIVE PAGES

LIST OF EFFECTIVE PAGES (Continued)

LIST OF EFFECTIVE PAGES (Continued)

LIST OF EFFECTIVE PAGES (Continued)

Table 1.1-1 Terminology and Notation (cont'd)

- any combination of individual ANSTO basket modules containing either spiral fuel assemblies or MOATA plate bundles up to a total of 42 assemblies/bundles, including up to 7 degraded clad DIDO, spiral or MOATA elements/ bundles in DFCs placed in an ANSTO top basket module
- combination ANSTO-DIDO basket assembly (one ANSTO top module and five DIDO intermediate and base basket modules) containing up to 42 DIDO, spiral or MOATA elements/bundles with up to 7 degraded clad elements/bundles in the ANSTO top module in DFCs
- up to eight (8) SLOWPOKE Fuel Canisters each containing up to 100 undamaged and/or damaged SLOWPOKE fuel rods
- up to eighteen (18) NRU or NRX fuel assemblies. Fuel assemblies may be cropped. NRU fuel assemblies have the flow tube removed. NRX fuel assemblies/rods must be placed into the fuel rod caddy assembly as criticality analysis applied the fuel rod caddy as geometry constraints. Note, the use of the caddy plug is not required for NRU or NRX shipments. Each basket tube is limited to the equivalent content of one assembly. One single fuel type may be loaded into one NRU/NRX basket assembly. NRU or NRX undamaged and damaged fuel assemblies/rods will be loaded into an 18 tube basket.
- up to eighteen (18) NRU/NRX caddies loaded with EFN rods, Booster rods, or Moly targets. EFN rods, Booster rods, or Moly targets must be placed into the NRU/NRX caddy as criticality analysis applied the caddy as geometry constraints. There is one caddy per fuel tube. One single fuel type may be loaded into one NRU/NRX caddy. EFN and Moly targets may be loaded into a single package. Booster rods may not be mixed with EFN or Moly rods. Undamaged and damaged material is permitted for transport. Rods/targets or segments/fragments thereof smaller than 6 inches in length require the use of a caddy plug
- 4 HEUNL containers. Containers shall be empty or filled with HEUNL material, such that a minimum under filled cavity void of one gallon exists.
- One SLOWPOKE fuel core. The SLOWPOKE fuel core contains up to 298 undamaged SLOWPOKE fuel rods, the upper and lower plates, and center tube.
- up to 4,000 lbs of solid, irradiated and contaminated hardware, which may include fissile material less than a Type A quantity and meeting the exemptions of 10 CFR 71.15, paragraphs (a), (b) and (c). Total allowed mass includes the weight of spacers, shoring and dunnage.

Table 1.1-1 Terminology and Notation (cont'd)

Impact Limiters	Aluminum honeycomb energy absorbers located at the ends of the cask.
Intact LWR Fuel (Assembly or Rod)	Spent nuclear fuel that is not Damaged LWR Fuel, as defined herein. To be classified as intact, fuel must meet the criteria for both intact cladding and structural integrity. An intact fuel assembly can be handled using normal handling methods, and any missing fuel rods have been replaced by solid filler rods that displace a volume equal to, or greater than, that of the original fuel rod.
Damaged LWR Fuel (Assembly or Rod)	Spent nuclear fuel that includes any of the following conditions that result in either compromise of cladding confinement integrity or recognition of fuel assembly geometry. 1. The fuel contains known or suspected cladding defects greater than a pinhole leak or a hairline crack that have the potential for release of significant amounts of fuel particles. 2. The fuel assembly: i. is damaged in such a manner as to impair its structural integrity; ii. has missing or displaced structural components such as grid spacers; iii. is missing fuel pins that have not been replaced by filler rods that displace a volume equal to, or greater than, that of the original fuel rod; iv. cannot be handled using normal handling methods. 3. The fuel is no longer in the form of an intact fuel assembly and consists of, or contains, debris such as loose pellets, rod segments, etc.
Damaged Fuel (TRIGA)	TRIGA fuel (elements and cluster rods) with known or suspected clad breach (i.e., cladding defects that permit the release of gas from the interior of the rod and/or allow water intrusion into the clad to fuel gap while submerged).
Fuel Debris (TRIGA)	TRIGA damaged fuel that does not maintain its structural integrity, including fuel particles, fuel debris, and broken fuel rods.

Table 1.1-1 Terminology and Notation (cont'd)

Damaged NRU or NRX Fuel Assembly, Rod, or Rod Segments	Fuel assemblies, loose rods or rod segments that do not meet the structural or clad integrity requirements of the undamaged NRU or NRX fuel assembly are classified as damaged. Loose fuel rods defined as damaged, or rod segments, shall be loaded in the NRU/NRX caddy prior to placement into the NRU/NRX basket. Note, the use of the caddy plug is not required for NRU or NRX shipments. Damaged NRU assemblies may be loaded into the NRU/NRX basket tube without use of a caddy. Damaged NRX assemblies shall be loaded into the NRU/NRX basket tube with the use of a caddy. Note, the use of the caddy plug is not required for NRU or NRX shipments. NRU/NRX basket and basket lid, including screens, provide the gross material boundary for damaged fuel (i.e., gross material is retained in basket tube). Clad through-wall damage is limited to 5% of the fueled surface area. Clad removed (i.e., clad originally associated with the rod but no longer present) is limited to 2% of the fueled surface area. Clad through-wall damage without loss of cladding from the system may occur due to processes such as clad splitting. Fuel assemblies with exposed fuel material resulting from the cropping process are considered damaged but do not require use of a caddy (NRU only) provided loose, fuel containing, rod segments are not loaded into the same basket opening as a cropped assembly.
Damaged and Undamaged EFN Rods, Booster Rods, or Moly Targets	Rods/targets or rod/target segments/fragments must be loaded into NRU/NRX caddies. Only limited amount of cladding integrity is credited for full basket loads of EFN rods. Therefore, there are no cladding damage limits except for full cask loads of EFN rods which require the equivalent of 30% clad (fueled surface area). Rods/targets or segments/fragments thereof smaller than 6 inches in length require the use of the NRU/NRX caddy plug.
HEUNL Container	A stainless steel container for highly enriched uranyl nitrate liquid (HEUNL). The container is comprised of a welded lid, shell, bottom plate structure with lid penetrations for fill and drain operations. HEUNL is a solution containing uranyl nitrates, various other nitrates, and water.

Table 1.1-1 Terminology and Notation (cont'd)

Undamaged SLOWPOKE Fuel Rods in the	SLOWPOKE fuel rods that are structurally sound, but may have fuel core exposure due to corrosion or mechanical damaged of the clad
SLOWPOKE Fuel Core	SLOWPOKE fuel rods that are "Undamaged Aluminum-Based Fuel" therefore limiting through-clad corrosions and/or mechanical damage of the clad to 5% of the fuel surface area of the element.

21. Any combination of undamaged or damaged SLOWPOKE Fuel Rods contained in 5 x 5 or 4 x 4 rod insert assemblies loaded into screened aluminum Fuel Canisters (four rod insert assemblies per fuel canister) with a maximum of four (4) SLOWPOKE Canisters per MTR-28 top and upper intermediate basket module (maximum of eight canisters per NAC-LWT cask). Cell block spacers will be installed in the center three fuel cells for the loaded basket modules.
22. Maximum 18 NRU or NRX fuel assemblies or the equivalent number of loose rods. NRX assemblies or rods must be placed into a fuel rod caddy assembly for handling and geometry constraint. NRU fuel rods may be placed in a caddy. Note, the use of the caddy plug is not required for NRU or NRX shipments. Only a single fuel type (NRU or NRX) shall be loaded in a single NRU/NRX fuel basket assembly.
23. Maximum 18 NRU/NRX caddies containing EFN rods, Booster rods, or Moly targets. NRUX/NRX caddies are limited to 36 EFN rods, 16 Booster rods, 20 Short Moly Targets, or 36 double length Moly targets or the equivalent number in rod/target segments or fragments. Rods/targets or segments/fragments thereof smaller than 6 inches in length require the use of the caddy plug. All materials must be placed in a caddy and only a single type is permitted in a caddy. EFN rod and Moly targets caddies may be placed into the same package (EFN rods are limited to exterior basket tubes). Booster rod caddies may not be mixed with EFN rod or Moly target caddies in a single package.
24. Four HEUNL containers. Containers shall be empty or filled with HEUNL material such that a minimum under filled cavity void of one gallon exists.
25. One SLOWPOKE fuel core containing up to 298 undamaged SLOWPOKE fuel rods. The SLOWPOKE fuel core is packaged in the SLOWPOKE fuel core basket.

1.2.3.1 TRIGA Fuel and Basket Description

Two basic types of TRIGA fuel are to be transported in the NAC-LWT cask: TRIGA fuel elements and smaller fuel rods from TRIGA fuel cluster assemblies. TRIGA fuel elements are approximately 1-1/2 inches in diameter and are described in Section 1.2.3.1.1. TRIGA fuel cluster rods are smaller; approximately 1/2-inch in diameter and are also described in Section 1.2.3.1.1.

Up to 140 TRIGA fuel elements in the form of: a) standard fuel elements – either aluminum clad or stainless steel clad; b) instrumented fuel elements – similar to standard fuel elements (aluminum clad or stainless steel clad), but containing thermocouple instrumentation; and c) fuel follower control rod elements (aluminum or stainless steel clad) – poison rods with a fuel follower in a single tube may be shipped in the NAC-LWT cask. Up to 560 TRIGA fuel cluster rods may be shipped.

Up to six equivalent TRIGA fuel cluster rods may be loaded and transported in a sealed damaged fuel can (DFC). Up to the equivalent of two TRIGA damaged fuel elements and debris may be loaded and shipped in a sealed DFC. The TRIGA transport baskets and DFCs are described in Section 1.2.3.1.2.

1.2.3.1.1 TRIGA Fuel

TRIGA Fuel Elements

The characteristics of the design basis TRIGA fuel element are presented in Table 1.2-4 and in Table 1.2-1 for the poisoned basket and in Table 1.2-2 for the nonpoisoned basket.

The fuel material in a TRIGA fuel element is a solid, homogeneous mixture of uranium-zirconium hydride alloy, i.e., a metal alloy fuel. Both the aluminum-clad and the stainless steel-clad TRIGA fuel elements are approximately 1.5-inch diameter rods by approximately 30 inches long. The fuel follower control rod elements range in length from 45 inches to 66.5 inches and are cut, as required, to fit the basket length. Instrumented fuel elements are identical to standard fuel elements with the exception of thermocouples and wires and lead-out tubing. The lead-out tubing needs to be detached prior to shipment in order for the instrumented fuel elements to fit into the standard element height envelope. The aluminum-clad TRIGA fuel element and instrumented fuel element, the stainless steel-clad TRIGA fuel element and instrumented fuel element, and the standard fuel follower control rod element are shown in Figure 1.2.3-1 through Figure 1.2.3-5, respectively.

TRIGA Fuel Cluster Rods

The fuel material in TRIGA fuel cluster rods is a solid, homogeneous mixture of uranium-zirconium-erbium hydride alloy, i.e., a metal alloy fuel. Erbium is a burnable neutron poison that is used in the fuel to enhance the flux profile along the length of the fuel rod, and conservatively ignored in the nuclear evaluations. The rods have a nominal diameter of 0.54 inch and are approximately 31 inches long. The rod cladding is Incoloy 800 material and is 0.015-inch thick, minimum. Instrumented rods are identical to the standard rods, with the exception of thermocouples and wires. A diagram of the TRIGA fuel cluster rods, and the individual fuel pin (cluster rod) making up the cluster, is shown in Figure 1.2.3-6.

The active fuel region of a TRIGA fuel cluster rod is a maximum of 0.53 inch in diameter, 22.5 inches in length, and has an initial uranium enrichment of up to 95 percent for HEU material and 20percent for LEU material. A compression spring is utilized to fill the space in the plenum region of the rod, and top and bottom plugs are used to seal the fuel within the rod. The design-basis TRIGA fuel cluster rod characteristics are summarized in Table 1.2-3, Table 1.2-4, and Tables 5.1.1-1, 5.1.1-2, 6.2.6-1 and 6.2.6-2.

Axial fuel spacers, as shown on Drawing 315-40-085, may be used to axially position the TRIGA fuel elements, fuel inserts and DFCs. The axial spacers do not provide a safety function and are dunnage used to position the fuel elements to facilitate fuel handling. The total weight

physical, radiation protection and thermal characteristics of the SLOWPOKE fuel rods are listed in Table 1.2-14.

The SLOWPOKE canister is constructed primarily of aluminum. A limited quantity of stainless steel is located within the canister lid structure. The canister is designed to: a) minimize the dispersal of gross fuel particles that may escape from damaged fuel rod cladding and/or fuel debris (note that metallic fuel is not expected to release significant gross particulate even with severe clad damaged); b) facilitate retrieval of the contents from the transportation cask; and, c) confine damaged fuel and/or debris within a known volume to facilitate criticality control, maintain dose limits, and control thermal loads within the cask. SLOWPOKE fuel pieces and debris may be placed into an aluminum tube structure located within the canister. The aluminum tubes provide structural support for individual fuel rods/pieces during transport in the NAC-LWT but are not required within the analysis to maintain safety limits.

1.2.3.13 NRU/NRX Fuel Assemblies or Fuel Rods

NRU/NRX fuel assemblies and fuel rods are transported in the NAC-LWT in an 18 tube basket. The basket assembly is composed of 18 fuel tubes arranged in two concentric rings. The basket is spaced towards the top of the cask cavity by a bottom basket spacer.

NRX fuel assemblies or loose fuel rods must be loaded into a fuel rod caddy assembly. Loose NRU fuel rods may be loaded into a caddy. Note, the use of the caddy plug is not required for NRU or NRX shipments. Mixed loading of NRU and NRX assemblies in a basket is not permitted. NRX assemblies are composed of (7) fuel rods and the NRU assemblies are composed of (12) fuel rods.

NRU/NRX HEU fuel rods are composed of highly enriched (> 90 wt%) uranium-aluminum alloy fuel meat within aluminum cladding. NRU LEU fuel meat is composed of <20% wt% ^{235}U enriched material composed of uranium-aluminum-silicon. NRU and NRX rods have a fin structure attached to the clad. The NRX rods have spiral fins to retain rod spacing. NRU assemblies in addition to the fins have a set of spacer disks assuring that rod pitch is maintained. A sketch of both NRU and NRX fuel assemblies is provided in Figure 1.2.3-20. Key physical, radiation protection and thermal characteristics of the NRU and NRX fuel assemblies are listed in Table 1.2-15.

NRU/NRX fuel assemblies, loose rods, or rod segments that do not meet the structural or clad integrity requirements of the undamaged NRU or NRX fuel assembly are classified as damaged. Loose fuel rods defined as damaged, or rod segments, must be loaded in the NRU/NRX caddy prior to placement into the NRU/NRX basket. Damaged NRU assemblies may be loaded into the NRU/NRX basket tube without use of a caddy. Note, the use of the caddy plug is not required for NRU or NRX shipments. Damaged NRX assemblies shall be loaded into the NRU/NRX basket

tube with the use of a caddy. NRU/NRX basket and basket lid, including screens, provide the gross material boundary for damaged fuel (i.e., gross material is retained in basket tube). Clad through-wall damage is limited to 5% of the fueled surface area. Clad removed (i.e., clad originally associated with the rod but no longer present) is limited to 2% of the fueled surface area. Clad through-wall damage without loss of cladding from the system may occur due to processes such as clad splitting. Fuel assemblies with exposed fuel material resulting from the cropping process are considered damaged but do not require use of a caddy (NRU only) provided loose, fuel containing, rod segments are not loaded into the same basket opening as a cropped assembly. To address these definitions the "up to a fuel assembly" quantity of material is further evaluated. Analysis are also included to address loss of cladding (through-wall clad damage).

The NRU/NRX caddy is constructed of aluminum. The aluminum caddy provides geometry constraint to fuel rod movement. Due to the increased reactivity of NRX fuel relative to high enriched NRU fuel, only NRX criticality evaluations credited this constraint. Note, the use of the caddy plug is not required for NRU or NRX shipments.

1.2.3.14 EFN Rods, Booster Rods or Moly Targets (Short and Double Length)

EFN Rods, Booster Rods, and Moly Targets are transported in the NAC-LWT in an 18 tube basket (NRU/NRX basket) in NRU/NRX caddies. Short and Double Length Moly targets are simply referred to as Moly targets unless otherwise noted.

Mixed loading of EFN rod caddies and Moly target caddies is permitted. Booster rod caddies are not allowed for loading with EFN rod caddies or Moly target caddies. Each payload type may not be mixed in a caddy.

EFN Rods, Booster Rods, and Moly Targets are composed of highly enriched (> 90 wt%) uranium-aluminum alloy fuel meat within aluminum cladding. Rods/targets have a fin structure attached to the clad. The EFN rods and Booster Rods were a component of an assembly prior to disassembly. Moly targets were part of a rod with multiple targets axially connected. Sketches of payload type are provided in Figure 1.2.3-22. Key physical, radiation protection, and thermal characteristics of the are listed in Table 1.2-18.

A distinction between undamaged and damaged material is not required as all rods/targets were evaluated considering complete or majority loss of clad with the damaged evaluation bounding undamaged (no significant clad through damage) condition. Segments/fragments of the rods/targets are permitted for loading providing total equivalent quantity limits in Table 1.2-18 are maintained. Rods/targets or segments/fragments thereof smaller than 6 inches in length require the use of the caddy plug.

Table 1.2-17 SLOWPOKE Fuel Core

Parameter	Value
Maximum Cask Heat Load (W)	45
Payload Limit (lb)	15
Maximum Number of Rods per Core	298
Maximum Initial ^{235}U per rod (g)	2.83
Maximum Initial Enrichment (wt % ^{235}U)	95.3
Maximum Initial ^{235}U per core (g)	837
Minimum Initial Enrichment (wt% ^{235}U)	90
Minimum Cool Time	2 weeks
Maximum Core Average Depletion (%^{235}U)	2.1%

Notes:

1 Heat load limit established by thermal analysis.

2 Maximum number of rods per core, fissile material (^{235}U) initial mass per rod limit, and maximum initial enrichment established by criticality analysis.

3 Fissile material (^{235}U) initial mass per fuel core, minimum initial enrichment, depletion percentage, and cool time established by shielding analysis.

4 Payload weight limit established by structural analysis.

Table 1.2-18 EFN Rods, Booster Rods, and Moly Targets

Parameter	Short Moly	Double Length Moly	EFN	Boosters
Maximum Per Caddy Heat Load (W)	0.3	0.8	8	0.2
Payload Limit (lb/tube)	20			
# Rod/Targets (Equivalent)	20	36	36	16
Maximum ^{235}U per rod (g)	1.1	2.41	13	18.1
Minimum Cool Time (yr)	38	8	23	37
Maximum ^{235}U Depletion (%)	94.8	30.4	87.4	2.9
Maximum Initial Enrichment (wt% ^{235}U)	94			

Notes:

1.) Fissile material (^{235}U) mass limit established by criticality and shielding analysis.
2.) Cool time, burnup/depletion limit established by shielding analysis.
3.) Payload weight limit established by structural analysis and includes both fuel, caddy/caddy plug weight and dunnage.
4.) Depletion percentage may be generated on a per assembly basis for EFN rods and Booster rods and on a rod basis for the Moly Targets. Assemblies are disassembled into rods/rods segments prior to loading into caddy. Moly rods are disassembled into the component targets.

7. Remove the alternate vent and drain port covers. Store the alternate port covers to protect the seal surfaces. Visually inspect the vent valve quick-disconnect nipples and replace if necessary. Prior to installation, inspect the Viton® O-ring seals on the alternate port covers, and if any O-ring shows any damage, replace it.
8. Install the cask lifting yoke with the guides removed to a crane of sufficient capacity in accordance with the user facilities' heavy lifting program and engage the two lifting trunnions at the front end of the cask. Raise and rotate the cask to a vertical position on the rear cask supports, moving the crane and/or trailer, as required, to maintain the cask engaged in the rear cask supports. When the cask is vertical, lift the cask from the ISO container.
9. Move and place the cask on a base plate, if required, at the intended loading station. Connect the base plate to the cask's attachment points using chains and take up slack with the tensioners. Disengage the lifting yoke.
10. Visually inspect the neutron shield tank fill, drain, and level inspection plugs for signs of neutron shield fluid leakage. If leakage is detected or suspected, verify shield tank fluid level and correct, as required.
11. Loosen and remove all closure lid bolts. Prior to installation, inspect the lid bolts and replace any that are damaged.
12. Attach lid lifting slings, or equivalent lid removal fixture, to the closure lid. Remove the closure lid and set it on a support that is suitable for radiological control and for maintaining the cleanliness of the closure lid. Prior to installation, carefully inspect the Teflon O-ring seal in the underside of the closure lid. If the O-ring shows any damage, replace it. Remove the metallic O-ring from the groove and discard. Clean and visually inspect the groove and lid recess seating surfaces for cleanliness, damage, or degradation. If the groove and lid recess seating surfaces are acceptable, install a new metallic O-ring with an approved spare. Ensure the replacement O-rings are properly installed and seated.
13. Visually inspect the inner cavity for foreign material, free water, or damage. Note deficiencies and correct as required. Remove any shipping dunnage as necessary. Clean all accessible surfaces, including the lid sealing surface. Install, or verify the presence of the drain tube and drain alignment ring.
14. Verify the proper installation of, or install, the NRU/NRX bottom basket spacer.
15. Install the required dry transfer system components on the top of the cask.
16. Position the Dry Transfer System (DTS) components for fuel loading, as appropriate.
17. Identify the EFN, Moly, or Booster rods/targets to be loaded, and verify that they comply with the authorized content, heat load and quantity conditions of the CoC.
18. Load either undamaged and/or damaged EFN, Moly, or Booster rods/targets into fuel rod caddy assemblies.

    Note: Caddies with rods/targets or segments/fragments thereof smaller than 6 inches in length shall have caddy plugs installed.

19. Insert the caddy plug in the caddy after it has been loaded for all caddies loaded with rods/targets or segments/fragments thereof smaller than 6 inches in length.

20. Load the basket module with up to 18 fuel rod caddies of EFN, Moly, or Booster rods/targets.

    Note: EFN rods and Moly targets may be loaded in the same basket, but Booster rods shall not be loaded in the same basket as either EFN rods or Moly targets.

    Note: In a mixed loads EFN rods are limited to basket peripheral locations.

21. Perform an independent verification of the fuel selection and loading process.
22. Install the NRU/NRX basket lid assembly and torque bolts to 20 +/- 2 ft-lbs.
23. Load the shielded transfer cask with the loaded basket.
24. Place the transfer cask containing the basket onto the dry transfer system components positioned on the top of the cask.
25. Lower the loaded NRU/NRX fuel basket from the transfer cask into the NAC-LWT cask cavity.
26. Remove the transfer cask from the dry transfer system adapter.
27. Using the dry transfer system adapter components, install temporary shield plug. Remove shield ring/plug assembly through the dry transfer system adapter.
28. Install the closure lid onto the cask using the dry transfer system. Visually verify that the lid is properly seated.
29. Install lid bolts hand tight.
30. Remove dry transfer system components from the top of the cask.
31. Tighten all 12 closure lid bolts to 260 ± 20 ft-lbs in three passes using the torque sequence indicated on the closure lid.
32. Connect a gas supply line to the vent valve and the drain line to the drain valve.
33. Open the air, nitrogen, or helium gas supply valve and pressurize the cask cavity (< 30 psig) to force any residual water out the drain line. Continue to supply pressurized gas to the cask for a minimum of five minutes after the last residual free water discharges from the drain. Remove the drain and gas supply lines and attach a vacuum drying system (VDS) to the vent.

    Note: At the option of the user, the NAC-LWT cask can be placed in a horizontal position in the ISO at this point in the procedure in accordance with Step 43.

34. Connect the Vacuum Drying System (VDS) to the cask vent valve and evacuate the cask cavity by vacuum pump to less than or equal to 10 torr (13 mbar) and continue vacuum pumping for a minimum of 15 minutes.
35. At the end of the evacuation period, isolate the cask cavity from the vacuum pump and monitor the cask cavity pressure for a minimum of 10 minutes. If the pressure rise is less than 5 torr (6.7 mbar), the cavity is verified as dry of free water. If the pressure rise is greater than 5 torr (6.7 mbar), resume vacuum drying until the dryness verification results are satisfactory.
36. Backfill the cask cavity with helium to 0 psig (1 atmosphere, absolute), +1, -0 psi and disconnect the VDS from the vent valve.
37. Perform a helium leakage test of the closure lid containment O-ring using a Helium Mass Spectrometer Leak Detector (MSLD) in accordance with the requirements of SAR Section 8.1.3.1.

38. Install the vent and drain alternate port covers and torque the bolts to 100 ±10 inch-pounds.
39. If an alternate port cover containment O-ring seal was replaced, perform a helium leakage test on the affected port cover using a He MSLD in accordance with the requirements of SAR Section 8.1.3.2.2.
40. If the alternate port cover containment seal was inspected and accepted for reuse, perform an air pressure drop leakage test on the affected port cover as follows.
    a. Install a pressure test fixture to the port cover test port, including a calibrated pressure gauge with a minimum sensitivity of 0.25 psi.
    b. Pressurize the port cover seal annulus to 15 psig, +1, -0 psi.
    c. Isolate the gas supply and observe the pressure gauge for a minimum of five minutes.
    d. The acceptance criterion for the test is no measurable drop in pressure during the minimum test time. An acceptable test assures that the minimum assembly verification leakage test sensitivity is achieved.
41. Survey the cask surface for removable contamination and radiation dose rates. Decontaminate the cask, if required.

    Note: Removable contamination levels and radiation levels shall comply with 49 CFR 173.443 and 173.441, respectively.
42. Using the cask lifting yoke with guides removed, lift and position the cask in the rear cask supports on the ISO/trailer. Engage the trunnion pockets in the bottom end of the cask with the rotation trunnions. Lower the cask to rest on the front tie-down saddle, moving the crane, and/or trailer, as required.
43. Disengage the cask lifting yoke from the cask lifting trunnions and set it aside.
44. Install and attach the cask tie-down strap. Install the cask top and bottom impact limiters.
45. Install a TID to one of the top impact limiter ball lock pins. Record TID identification number on the loading/shipping documentation.
46. Install roof cross-members, if used and replace ISO container roof.
47. Complete a Health Physics survey on the external surfaces of the package and record the results. Complete dose rate measurements at the package surface, at 1 meter from the package surface, and at 2 meters from the vertical plane of the side of the transport vehicle. The maximum dose rate at 1 meter from the package is the transport index (TI). Ensure compliance with 10 CFR 71.87(i) and observe the following criteria.
    a. If the dose rate is less than 2 mSv/h (200 mrem/hr) at all accessible points on the external surface of the package, and the TI is less than 10, the package meets the requirements of 10 CFR 71.47 (a).
    b. If the dose rate is greater than 2 mSv/h (200 mrem/hr), but is less than 10 mSv/h (1000 mrem/hr) at any point on the external surface of the package, or the TI is greater than 10, the package must be shipped as "exclusive use" and meet the requirements of 10 CFR 71.47 (b), (c) and (d). If the dose rate and shipping requirements of 10 CFR 71.47 (b), (1), (2), (3) and (4) cannot be met, the package cannot be shipped.

c. If the dose rate is > 10 mSv/h (1000 mrem/hr) at any point on the external surface of the package, the package exceeds the limits of 10 CFR 71.47 and cannot be shipped.

46. Determine the appropriate Criticality Safety Index (CSI) assigned to the package contents in accordance with the CoC, and indicate the correct CSI on the Fissile Material label applied to the package per 49 CFR 172, Subpart E.

47. Complete the shipping documents, carrier instructions (as required), and apply appropriate placards and labels.

7.1.16 Procedure for Loading AECL SLOWPOKE Fuel Rod Contents Into the SLOWPOKE Fuel Canister

The following general procedures provide guidance for the loading of AECL SLOWPOKE fuel rod contents into individual fuel can inserts, which are then subsequently placed into a SLOWPOKE Fuel Canister. The Fuel Canister is subsequently loaded into a MTR-28 upper intermediate or top basket module for dry transferred into the NAC-LWT cask using the Dry Transfer System (DTS).

The SLOWPOKE Fuel Canister includes a welded fuel canister body into which four (4) 5 x 5 inserts (assembled of 0.40 inch nominal internal diameter insert tubes for intact SLOWPOKE Fuel Rods) and/or four (4) 4 x 4 inserts (assembled of 0.53 inch nominal internal diameter insert tubes for damaged SLOWPOKE Fuel Rods) are stacked to allow for the placement of up to 100 fuel rods in each SLOWPOKE Fuel Canister. The Fuel Canister is closed by a lockable, spring-loaded lid assembly, which incorporates a lid handle for loaded Fuel Canister handling. The lid assembly incorporates two lid latch bolts with lock washers and torque to 30 ± 5 in-lbs, which prevent inadvertent lid removal during shipment and handling. The SLOWPOKE Fuel Canister is provided with an aluminum bottom screened opening and two upper side aluminum screened openings to allow for the self-draining of the Fuel Canister if stored in water at the receiving facility prior to final processing. Each of the insert tubes is notched at the base of the tube to facilitate draining of each insert tube through the bottom screened opening. The screened openings and tight fitting lid retains fuel debris and minimizes the potential for release of fuel debris from the SLOWPOKE Fuel Canister to the NAC-LWT internal cavity.

The SLOWPOKE Fuel Canisters are visually inspected, load tested, and the welds examined following fabrication prior to acceptance for use. The AECL SLOWPOKE fuel rod contents shall be verified as meeting the quantity, decay heat and fissile content limits of the NRC Certificate of Compliance (CoC) prior to loading. The radioactive materials to be loaded in each SLOWPOKE Fuel Canister shall be identified and recorded as part of the packaging manifest for the cask shipment. Independent confirmation of the identification and location of the radioactive materials shall be made during the loading operations.