AREVA

Ref: AFS–14–0105

April 1, 2014

ATTN: Document Control Desk
Director, Spent Fuel Project Office
Office of Nuclear Material Safety and Safeguards
U. S. Nuclear Regulatory Commission
Washington, DC 20555–0001

SUBJECT: BRR Package Amendment Request, Docket No. 71–9341, SAR Revision 7

AREVA Federal Services LLC (AFS) hereby submits Revision 7 of the Safety Analysis Report for the BRR Package, Docket No. 71–9341. This revision is in response to the request for additional information made by the NRC and dated February 19, 2014.

The RAI states, "Verify that use of the nitrogen gas as the backfill-and-dry gas, after 8 hours of air drying, will not increase the fuel temperature above the 400 °F limit." AFS confirms that the maximum temperature of the governing (highest decay heat) fuel will approach 400 °F at approximately 8 hours in air or nitrogen, and will exceed it thereafter. The package users inform AFS that the total elapsed time between draining of the water and the backfill with helium (which would maintain a steady state maximum temperature below 400 °F) needs to be longer than 8 hours. Since using helium during vacuum drying may saturate the containment O–ring seals and prevent a successful assembly verification leakage rate test, it is necessary to allow the maximum fuel temperature to exceed 400 °F. The enclosed revision to the BRR Package SAR includes a justification for allowing the maximum temperature of the fuel to exceed 400 °F for the vacuum drying operation. The justification is summarized below.

The fuel temperature limit of 400 °F was initially chosen as a conservative limit for all fuel handling and shipping for two reasons: a) 400 °F is the highest temperature given for the 6061 aluminum fuel material yield data in Table Y-1 of the ASME B&PV Code, Section II, Part D, and b) the steady-state fuel temperature under helium gas is below 400 °F. However, there is no practical reason why the maximum fuel temperature cannot increase above this limit during the vacuum drying operation. Thermal analysis of the maximum decay heat fuel shows that the maximum steady state temperature of the fuel under air or nitrogen is 480 °F. This temperature is well below the acceptable limit for aluminum plate fuel as stated in Section 2.1 of Appendix 14.1 of NUREG-1537: "NRC finds 530 °C (986 °F) an acceptable fuel and cladding temperature limit…" This temperature is much higher than the maximum temperature of the fuel in the cask during drying. Conservatively, AFS has chosen the slightly lower limit of 500 °C (932 °F) for all fuel, based on the limit given for aluminum-clad TRIGA fuel stated in the same reference. More detail is provided in Section 3.2.2, *Technical Specifications of Components*, of the SAR.

Section 3.3.3, *Cask Draining and Vacuum Drying Operations*, has been revised, and a new section, Section 3.3.4, *Cask Cavity Backfill with Helium Gas*, has been added to document the cool down transient once the drying is complete and the cask is backfilled with helium. The maximum fuel temperature reaches the steady-state, NCT hot case temperature in about three hours after helium backfill. Thus, the maximum NCT hot case temperature of the fuel during transport will be unchanged from prior revisions of the SAR, and no changes to the thermal or structural analyses are necessary. Section 7.1.2.1, *Wet Loading*, and Section 7.1.2.2, *Dry Loading*, have been revised to remove the time limit for the drying operation under air or nitrogen and to permit more options for the vacuum drying detail procedure.

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Since the slight elevation of the maximum fuel temperature only occurs during vacuum drying operations, and does not create any structural or nucleonic change to the fuel, there is no effect on the shielding or criticality analyses in the SAR.

Two other changes have been made to Revision 7 of the SAR:

1. The revision letters (for MURR and MITR fuel) and the revision number (for ATR fuel) have been removed from their respective drawing numbers in the reference listing on page 3.5-2. This is justified since the information used to construct the fuel thermal models is not affected by any specific fuel drawing revisions.
2. The operating procedure has been revised to include the steps that must be taken at the MIT reactor for handling the cask between the transport conveyance and the facility. MIT needs to remove the pallet and package from the transport trailer and move it to the facility using a fork lift truck, whereas MURR uses a crane and does not remove the pallet from the trailer. Previously, the procedure had omitted the operating steps needed by MIT. These changes are made in Section 7.1.1, 7.1.2.1, and 7.1.3.

Included with this letter is one paper copy of the revised pages and one CD-R containing the entire SAR, Revision 7, in the PDF file "BRRC SAR, Complete, Rev. 7.pdf" (13,112 kb, 559 pages). The CD is contained within an envelope labeled, "BRR Package, Docket 71–9341 Electronic Copy of Document". Included below are the delete-insert instructions for updating paper copies of Revision 6 of the SAR to Revision 7.

AFS appreciates the NRC's timely response to this matter. To facilitate near-term shipping schedules, it is requested that Revision 3 of the Certificate of Compliance be issued by April 25, 2014.

Should you have any questions regarding this submittal, please contact me at (253) 552–1321 or via E–mail (phil.noss@areva.com).

Very Truly Yours,
AREVA Federal Services LLC

Phil Noss

Phil Noss
Licensing Manager

cc: Jose Cuadrado, NRC (including two paper copies and one CD)

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Delete and Insert Instructions for
Updating BRRC Safety Analysis Report
Docket Number 71–9341

SAR Section	Delete Rev. 6	Insert Rev. 7
Cover and Spine	Cover Page and Spine	Cover Page and Spine
Table of Contents	Pages i to v	Pages i to v
Section 3.2	Page 3.2-4	Page 3.2-4
Section 3.3	Pages 3.3-4 to 3.3-18	Pages 3.3-4 to 3.3-21
Section 3.5	Pages 3.5-2 & 3.5-3	Pages 3.5-2 & 3.5-3
Section 7.1	Pages 7.1-1 to 7.1-6	Pages 7.1-1 to 7.1-6

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BEA Research Reactor Package

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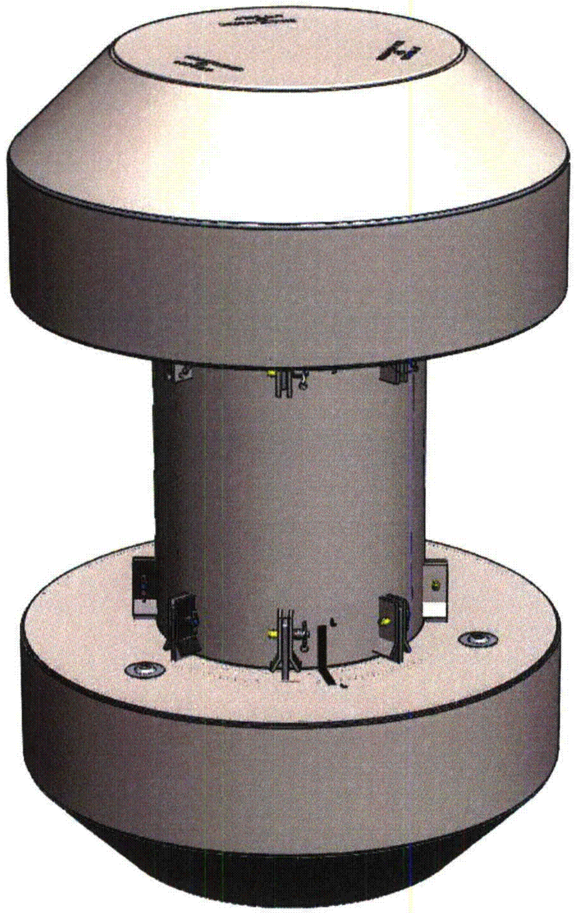
BEA Research Reactor Package



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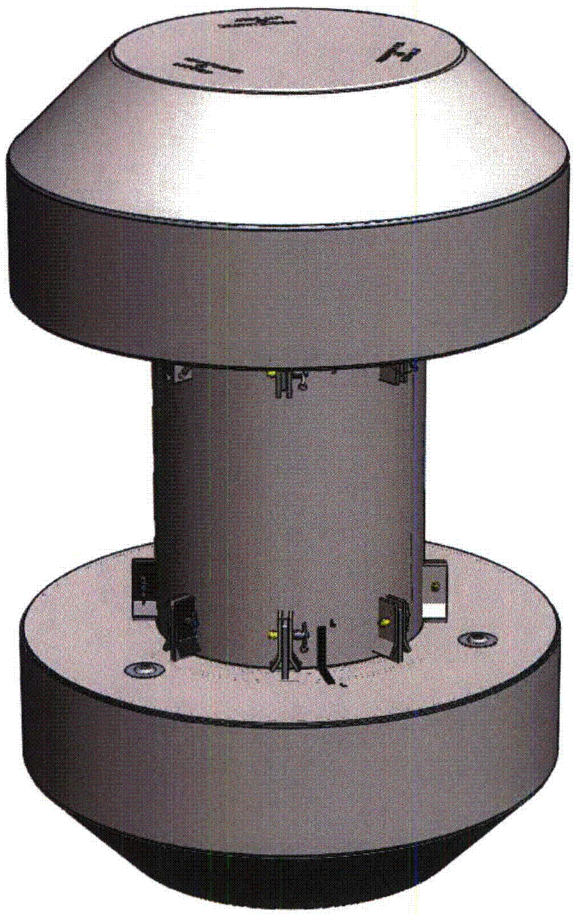
BEA Research Reactor Package



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Aluminum has a melting point of approximately 1,100 °F [6]; however for strength purposes the normal operational temperature is limited to 400°F based on structural strength considerations for aluminum [3]. The limit under HAC conditions is 1,100°F.

The allowable temperatures for the irradiated test and research reactor fuel elements under any condition of operation within the reactor facility are established by the NRC [34, 35] as follows (see Section 2.1 of Appendix 14.1 of [34]):

1) for stainless steel clad TRIGA fuel
    - for a cladding temperature at or less than 500 °C (932 °F), the peak fuel temperature shall be at or less than 1150 °C (2102 °F),
    - for a cladding temperature greater than 500 °C (932 °F), the peak fuel temperature shall be at or less than 950 °C (1742 °F),
2) for aluminum-clad TRIGA fuel, a peak fuel temperature should not exceed 500 °C (932 °F),
3) for highly enriched uranium (HEU) and uranium-silicide low-enriched uranium (LEU) aluminum clad fuel, a peak cladding and fuel temperature shall be at or less than 530 °C (986 °F).

Of the potential fuel payloads, only the TRIGA fuel uses both stainless steel and aluminum cladding. For simplicity, this evaluation conservatively uses the lower bounding permissible cladding temperature limit of 932 °F (500 °C) to cover both stainless steel and aluminum clad fuel. This temperature limit is applicable to cask draining and vacuum drying operations only. All other operations and transport conditions assume a permissible peak cladding and fuel temperature at or less than 400 °F.

The minimum allowable service temperature for all BRR package components is below -40 °F.

225 °F. Combining this temperature with the average fuel basket temperature of 293 °F yields a predicted bulk average backfill gas temperature of 259 °F.

Assuming the backfill gas has an initial temperature of 70 °F at the time of filling and that a fill pressure of one atmosphere is used, the predicted maximum operating pressure within the cask cavity for the transport of the MURR payload can be estimated via:

$$\text{Cavity Pressure} = 14.7\text{psia}\frac{(259^o\text{F} + 460^o\text{F})}{(70^o\text{F} + 460^o\text{F})} - 14.7\text{ psia}$$

$$\text{Cavity Pressure} = 5.2\text{ psig}$$

The equivalent peak bulk average fill gas temperatures for the MITR-II, ATR, and TRIGA baskets are 254, 164, and 174 °F, respectively. As such, the associated peak cask cavity pressures under NCT conditions are 5.1, 2.6, and 2.9 psig, respectively. Based on these NCT pressures, the maximum normal operating pressure (MNOP) within the cask cavity is set at a bounding level of 10 psig.

3.3.3 Cask Draining and Vacuum Drying Operations

An evaluation of the vacuum drying operation was conducted to ensure that the component temperatures will remain within their acceptable temperature limits. The vacuum drying operations consist of the following general steps:

1) the cask body with the appropriate fuel basket, but without the impact limiters, bottom drain plug, cask lid, and cask shield plug is lowered into the reactor pool and secured in the facility fuel loading station,
2) the fuel elements to be transported are placed in the fuel basket within the cask,
3) the shield plug is placed into the cask,
4) the loaded cask is lifted above the pool while spraying the exposed portions with clean demineralized water,
5) the enclosed water is drained from the cask's cavity and the cask is placed in the facility work area. Optionally, the cavity may be drained after securing the cask body in the facility work area. Following draining, the cask cavity is prepared for vacuum drying by flowing pressurized air (or nitrogen) through the cask cavity,
6) following the draining and decon operations, the drain port plug and the cask lid are installed. The vent port tool is installed and vacuum drying is initiated.
7) the minimum pressure achieved under vacuum drying is 1 to 3 torr.

The transient evaluation of these operations used a modified version of the NCT thermal model described in Appendix 3.5.3, *Analytical Thermal Model*. The modifications made for this evaluation consisted of assuming air as the backfill gas during draining and vacuum drying operations and disconnecting the thermal connections between the cask end surfaces and the impact limiters to simulate a bare cask within the reactor facility. The effect of being submerged in the reactor pool is addressed by assuming all cask components are at equilibrium with a maximum assumed pool water temperature of 80 °F at the start of the cask draining operation.

At time = 0, the loaded cask is assumed to be lifted from the pool, the water drained and the cask cavity filled with air or nitrogen. The transient draining and vacuum drying simulation incorporates several conservative assumptions, including:

- while cask draining will require several hours to complete, this safety evaluation conservatively assumes it is completed instantaneously in order to bound the minimum time required to reach steady-state conditions.
- the analysis conservatively ignores the latent heat cooling associated with the evaporation of the residual water on the surfaces of the fuel, basket, and cask,
- the increased thermal conductivity provided by moist air over the dry air conductivity assumed by the thermal modeling is conservatively ignored,
- the cooling effect created by the optional use of a continuous air or nitrogen gas purge during the draining process is conservatively ignored.
- the ambient conditions in the facility work area are conservatively assumed to be 100 °F without insolation.

The transient analysis is conducted for a period of 8 hours followed by a steady-state evaluation to illustrate the heat up rate and establish the peak temperatures that would occur if the helium backfill is not established. The MURR fuel element payload is selected as a basis for the vacuum drying evaluation since its decay heat loading bounds the other authorized payloads.

The thermal analysis of vacuum drying assumes that the thermal conductivity of the gas filling the voids of the packaging and the payload remain unchanged from its base value at atmospheric pressure conditions for vacuum pressures of 1 torr or greater. There are two states that define the process by which heat is transferred by a gas [32]:

> **viscous state**, in which the totality of molecules is responsible for the heat transfer. The viscous state occurs as long as the pressure is higher than the range in which the molecular state occurs. Within the viscous state the thermal conductivity of a gas is independent of pressure.
>
> **molecular state**, heat conductivity in the molecular state is when the gas pressure is so low that the molecular mean free path is about equal or greater than the distance between the plates. The thermal conductivity of the gas is no longer characterized by the viscous state for conductivity and therefore the conductivity is dependent on pressure. The heat transfer process under these conditions is called free molecular conduction.

The pressure at which the molecular mean free path is equal to the minimum distance between the surfaces within the packaging is determined below for air as the fill gas. Per [33], the mean free path of the fill gas molecules is computed via:

$$L = \frac{k \times T}{\pi \times \sqrt{2} \times P \times d^2}$$

where:

$k = 1.380658 \times 10^{-23}$ J/K, the Boltzmann constant
P = pressure in Pa
T = temperature in K
d = molecule diameter, in m

At the lowest practical vacuum pressure of 1 torr (133 Pa) used for vacuum drying and a conservatively high gas temperature of 480 °F (522K) based on the hottest fuel element (as determined from the steady-state analysis), the mean free path for air with a molecule diameter of about 3×10^{-10} m (based on oxygen, [33]) is:

$$L = \frac{1.380658\times10^{-23}\times522}{\pi\times\sqrt{2}\times133\times(3\times10^{-10})^2}$$

$$L = 1.36 \times 10^{-4} \text{ m} = 0.005 \text{ inches}$$

Since this mean free path is much smaller than the smallest significant gap in the model (i.e., the gap between fuel plates), the gas heat transfer everywhere within the model can be characterized as being in the viscous state and independent of the gas pressure.

Figure 3.3-9 illustrates the predicted package heat up following removal from the fuel pool. The illustrated thermal transient shows that approximately 10 hours is required (based on extrapolation of the transient trend) before the peak fuel plate temperature reaches 400°F. The computed peak fuel plate temperature under steady-state conditions of 480°F will require a total of approximately 17 hours to achieve. Table 3.3-5 provides a listing of the peak temperatures achieved by the cask and payload components for steady-state conditions. Since the peak fuel plate temperature of 480°F is well below the 932°F limit established in Section 3.2.2, *Technical Specifications of Components*, for this condition, indefinite operation under either air (or nitrogen gas) filled conditions or vacuum drying is permissible for in-facility operations.

3.3.4 Cask Cavity Backfill with Helium Gas

Once fuel drying is complete, the cask cavity is backfilled with helium to a pressure of slightly greater than atmospheric pressure, i.e., +1, -0 psig. An evaluation of the cool down transient following the helium gas backfill operation was conducted to establish the time required to lower the component temperatures from the peak level under vacuum drying conditions to at or below their associated temperature limits for transport conditions. The transient evaluation uses the same thermal model described above for the cask draining and vacuum drying evaluation. The only exception is that helium gas at one atmosphere is assumed for the gas filling the cask cavity. The initial component temperatures assumed for the start of the helium gas backfill transient are taken from those calculated for steady-state conditions with an air backfill (see Table 3.3-5). The ambient conditions in the facility work area remain the same at 100 °F without insolation. The transient analysis is conducted for a period of 4 hours to illustrate the cool down rate following the introduction of helium gas to the cask cavity.

Figure 3.3-10 illustrates the cool down transient after helium backfill assuming an initial temperature distribution of steady-state operations with an air or nitrogen atmosphere in the cask cavity. As seen from the figure, less than one hour is required to lower the peak fuel plate temperature to below 400°F. Approximately three hours are required to lower the fuel and cask component temperatures to those reported in Section 3.3.1.1, *Maximum Temperatures*, for the *NCT Hot* condition. Given that final leak testing and cask closure will take much longer than three hours, the temperature of the package and payload will be at or near those computed for the *NCT Hot without Solar* condition well before transport begins. Thus, no changes to the thermal or structural analyses for transport are necessary as a result of the elevated fuel cladding temperature potentially achieved under vacuum drying operations.

In conclusion, the results presented above demonstrate that steady-state operations under cask draining and vacuum drying conditions are permissible without exceeding the maximum allowable component temperature limits. The one hour time period following helium gas backfill required to reduce the peak fuel plate temperature below 400°F is so short compared with the time to complete preparation of the cask for transport that no specific tracking of the elapsed time will be required. Once filled with the helium gas, the package temperatures are bounded by those presented in Section 3.3.1.1, *Maximum Temperatures*, for NCT conditions.

Table 3.3-1 – NCT Temperatures for BRR Packaging with MURR Fuel

Component	Temperature (°F) ①		
	NCT Hot ④	NCT Hot without Solar	Max. Allowable
MURR Fuel Plate	350	331	400
MURR Side Plate	348	329	400
MURR Fuel Basket	334	315	800
Inner Shell	237	216	800
Lead	233	213	620
Outer Shell	216	195	800
Thermal Shield	185	182	800
Lower End Structure	205	184	800
Upper End Structure	220	200	800
Shield Plug	225	205	620 ②
Cask Lid	216	197	800
Closure/Vent Port Elastomeric Seals	216	197	250
Drain Port Elastomeric Seal	202	181	250
Upper Impact Limiter			
- Max. Foam	215	196	300
- Avg. Foam	146	132	300
- Shell	215	196	250 ③
Lower Impact Limiter			
- Max. Foam	200	179	300
- Avg. Foam	142	127	300
- Shell	200	179	250 ③
Max. Accessible Surface	-	185 ⑤	185
Cask Cavity Bulk Gas	259	239	N/A

Notes: ① Results assume a payload of eight (8) MURR fuel elements dissipating 158 W each and helium as the backfill gas.
② Temperature criterion based on melting point of the enclosed lead shielding.
③ Temperature criterion based on long term temperature limit for shell coating.
④ Results conservatively based on an earlier design for the cask and impact limiter attachment lugs. See Appendix 3.5.3 for a description of the design change and the conservative impact of ignoring the design change for NCT Hot modeling.
⑤ Maximum temperature occurs at the root of the upper cask impact limiter attachment lugs.

Table 3.3-2 – NCT Hot Temperatures for BRR Packaging with MITR-II Fuel

Component ①	Temperature (°F)	
	8 Elements @ 150 W Each④	Max. Allowable
MITR-II Fuel Plate	348	400
MITR-II Side Plate	347	400
MITR-II Fuel Basket	331	800
Inner Shell	237	800
Lead	234	620
Outer Shell	216	800
Thermal Shield	185	800
Lower End Structure	197	800
Upper End Structure	222	800
Shield Plug	230	620 ②
Cask Lid	218	800
Closure/Vent Port Elastomeric Seals	217	250
Drain Port Elastomeric Seal	194	250
Upper Impact Limiter		
- Max. Foam	217	300
- Avg. Foam	147	300
- Shell	217	250 ③
Lower Impact Limiter		
- Max. Foam	192	300
- Avg. Foam	140	300
- Shell	192	250 ③
Cask Cavity Bulk Gas	254	N/A

Notes: ① Results assume a payload of eight (8) MITR-II fuel elements dissipating 150 W each and helium as the backfill gas.

② Temperature criterion based on melting point of the enclosed lead shielding.

③ Temperature criterion based on long term temperature limit for shell coating.

④ Results conservatively based on an earlier design for the cask and impact limiter attachment lugs. See Appendix 3.5.3 for a description of the design change and the conservative impact of ignoring the design change for NCT Hot modeling.

Table 3.3-3 – NCT Hot Temperatures for BRR Packaging with ATR Fuel

Component ①	Temperature (°F)	
	8 Elements @ 30 W Each	Max. Allowable
ATR Fuel Plate	197	400
ATR Side Plate	197	400
ATR Fuel Basket	195	800
Cask Cavity Bulk Gas	164	NA

Note: ① Temperatures for packaging components bounded by values in Table 3.3-1.

Table 3.3-4 – NCT Hot Temperatures for BRR Packaging with TRIGA Fuel

Component ①	Temperature (°F)	
	19 Elements @ 20 W Each	Max. Allowable
TRIGA Fuel Element	355	400
TRIGA End Fitting	308	400
TRIGA Fuel Basket	287	800
Cask Cavity Bulk Gas	174	NA

Note: ① Temperatures for packaging components bounded by values in Table 3.3-1.

Table 3.3-5 – Peak Temperatures for Vacuum Drying Operations

Component	Temperature (°F)	
	Steady-state with Air Filled or Evacuated Cask Cavity ①	Max. Allowable
MURR Fuel Plate	480	932
MURR Side Plate	477	932
MURR Fuel Basket	431	800
Inner Shell	197	800
Lead	194	620
Outer Shell	178	800
Thermal Shield	167	800
Lower End Structure	177	800
Upper End Structure	174	800
Shield Plug	188	620 ②
Cask Lid	162	800
Closure/Vent Port Seals	162	250
Drain Port Seal	170	250
Cask Cavity Bulk Gas	326	N/A

Notes: ① Results assume a payload of eight (8) MURR fuel elements dissipating 158 W each and air as the backfill gas.
② Temperature criterion based on melting point of the enclosed lead shielding.

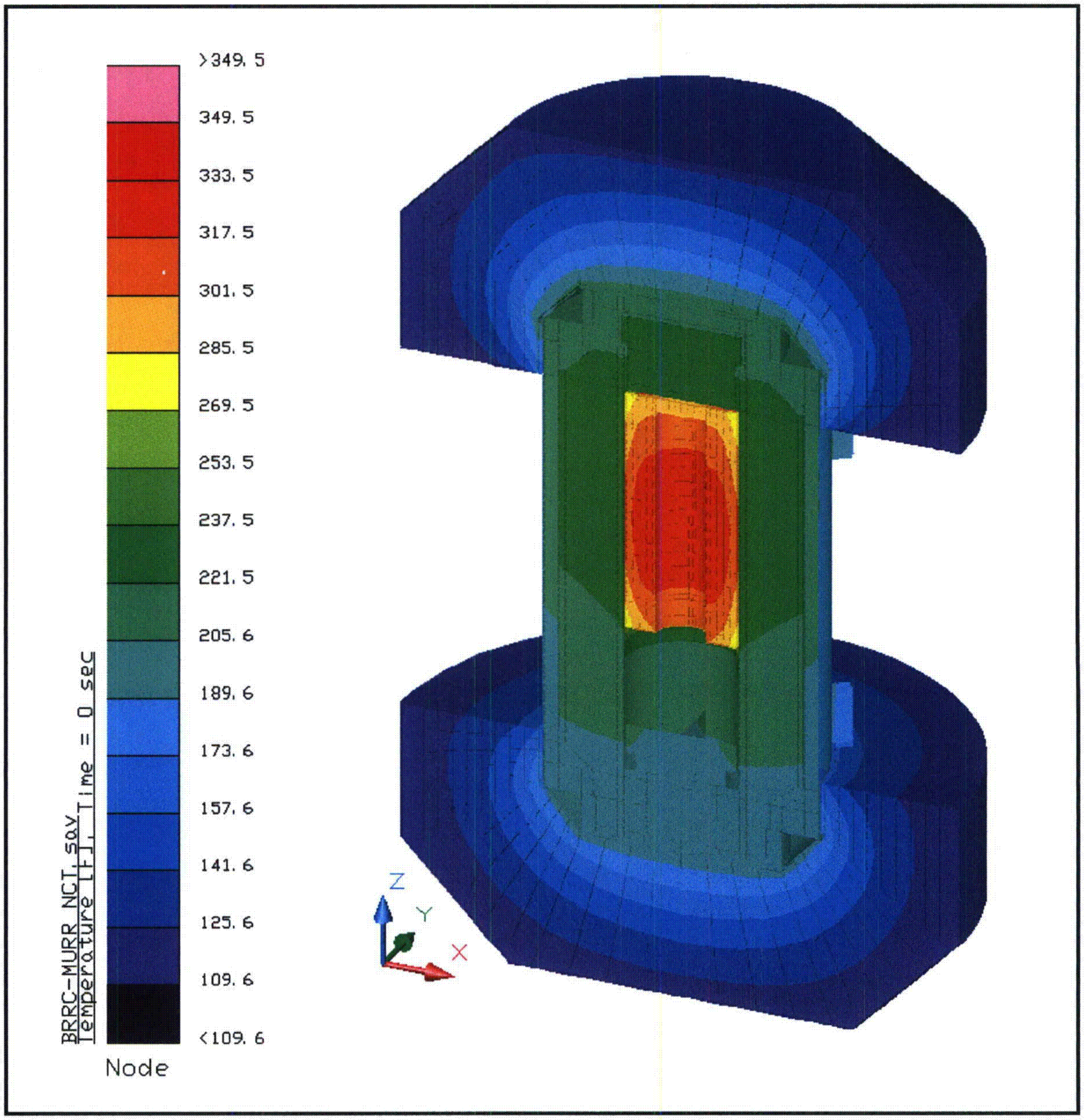
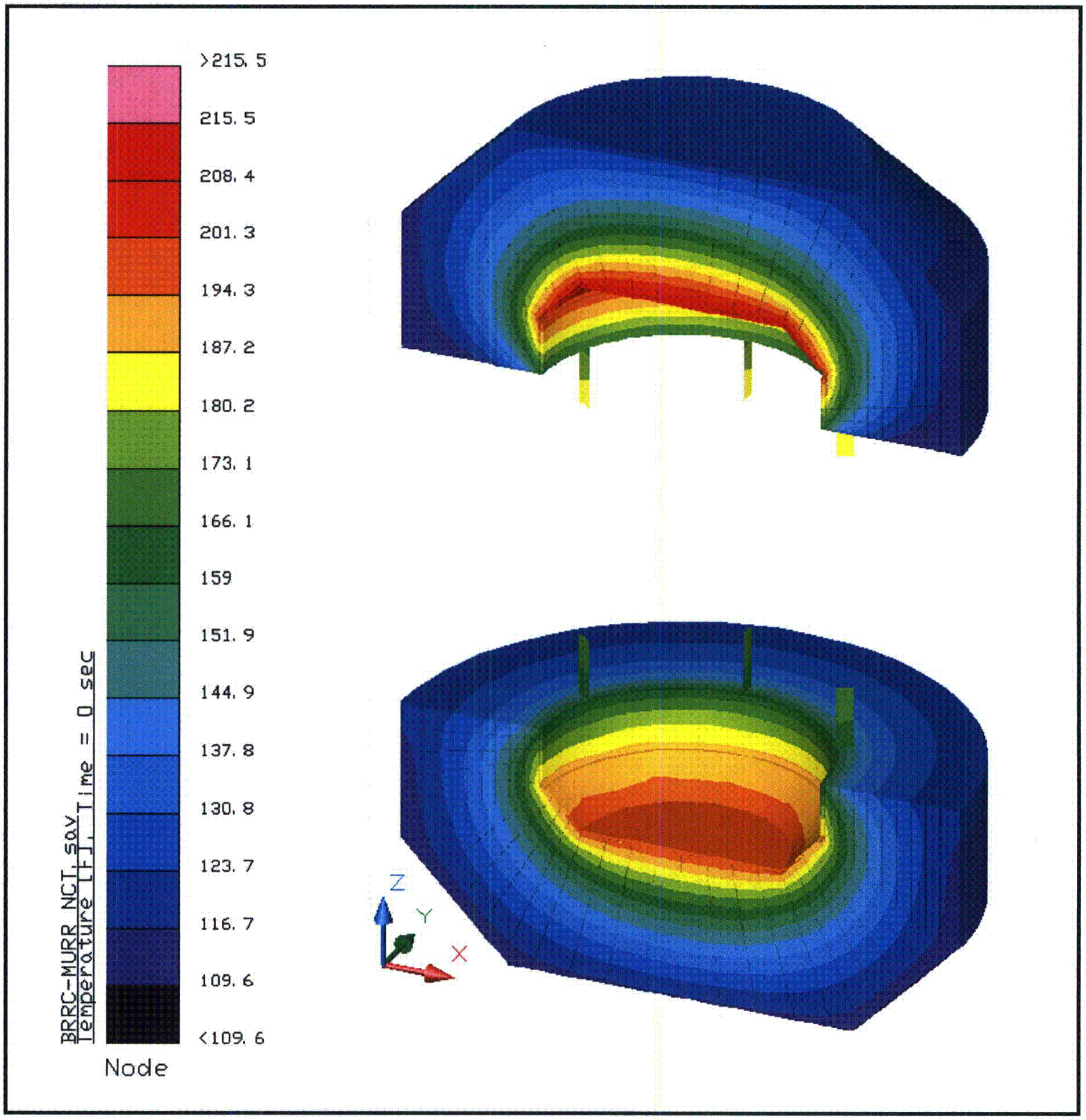


Figure 3.3-1 – BRR Package Temperature Distribution for NCT Hot Condition with MURR Fuel Basket



Note: Earlier design of 6 vs. 8 attachment lugs per limiter depicted. Results bound the revised design under NCT

Figure 3.3-2 – Impact Limiter Temperature Distribution for NCT Hot Condition with MURR Fuel Basket

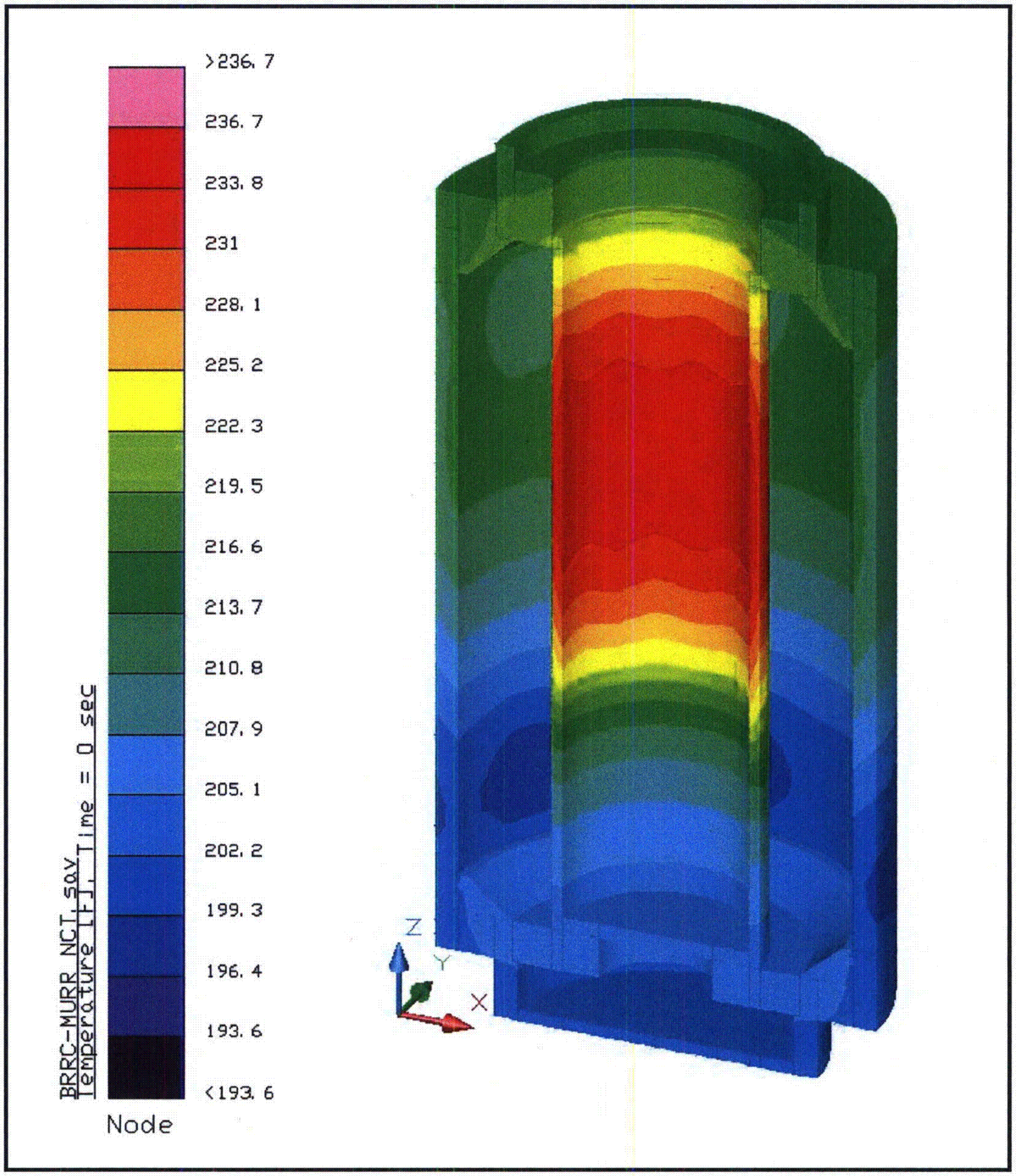


Figure 3.3-3 – Structural Shell Temperature Distribution for NCT Hot Condition with MURR Fuel Basket

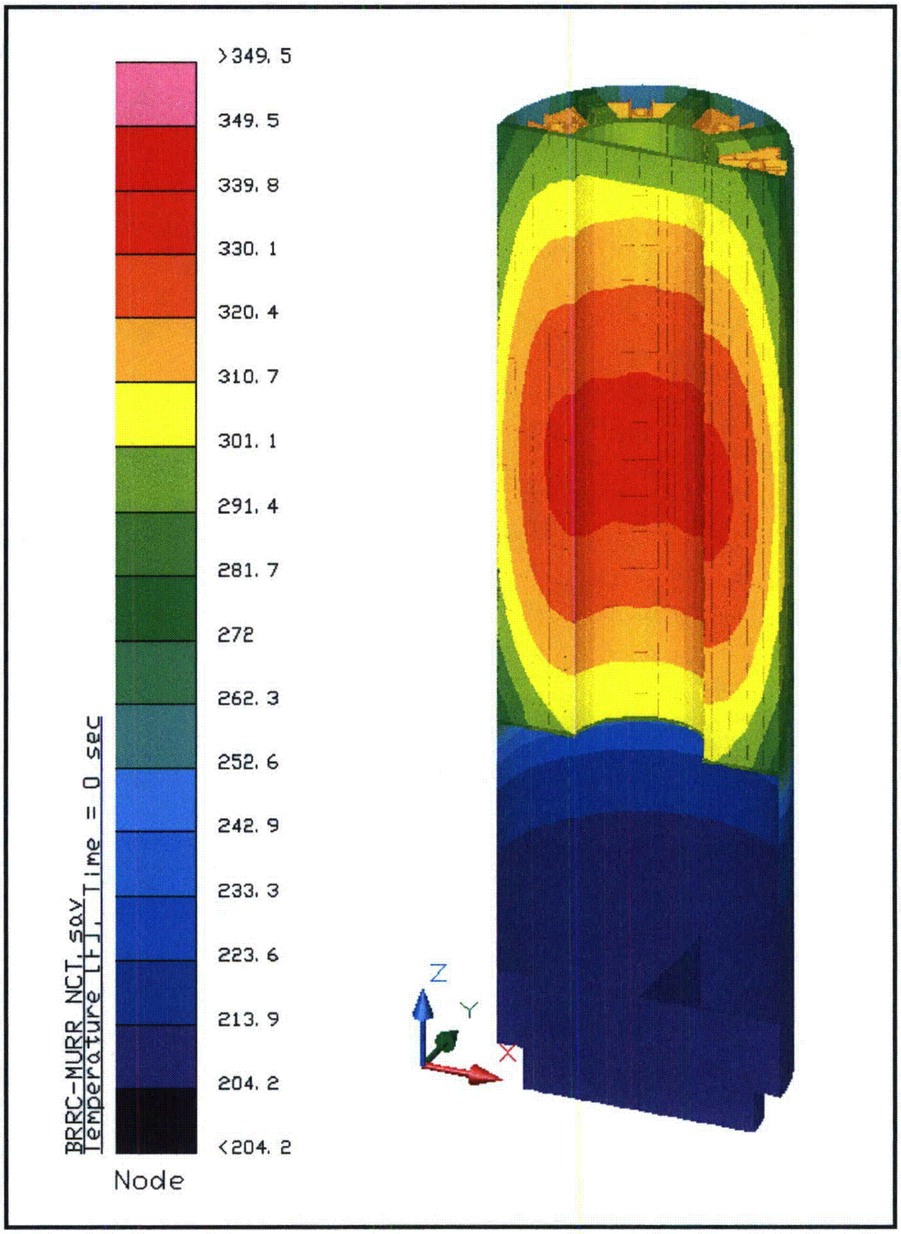
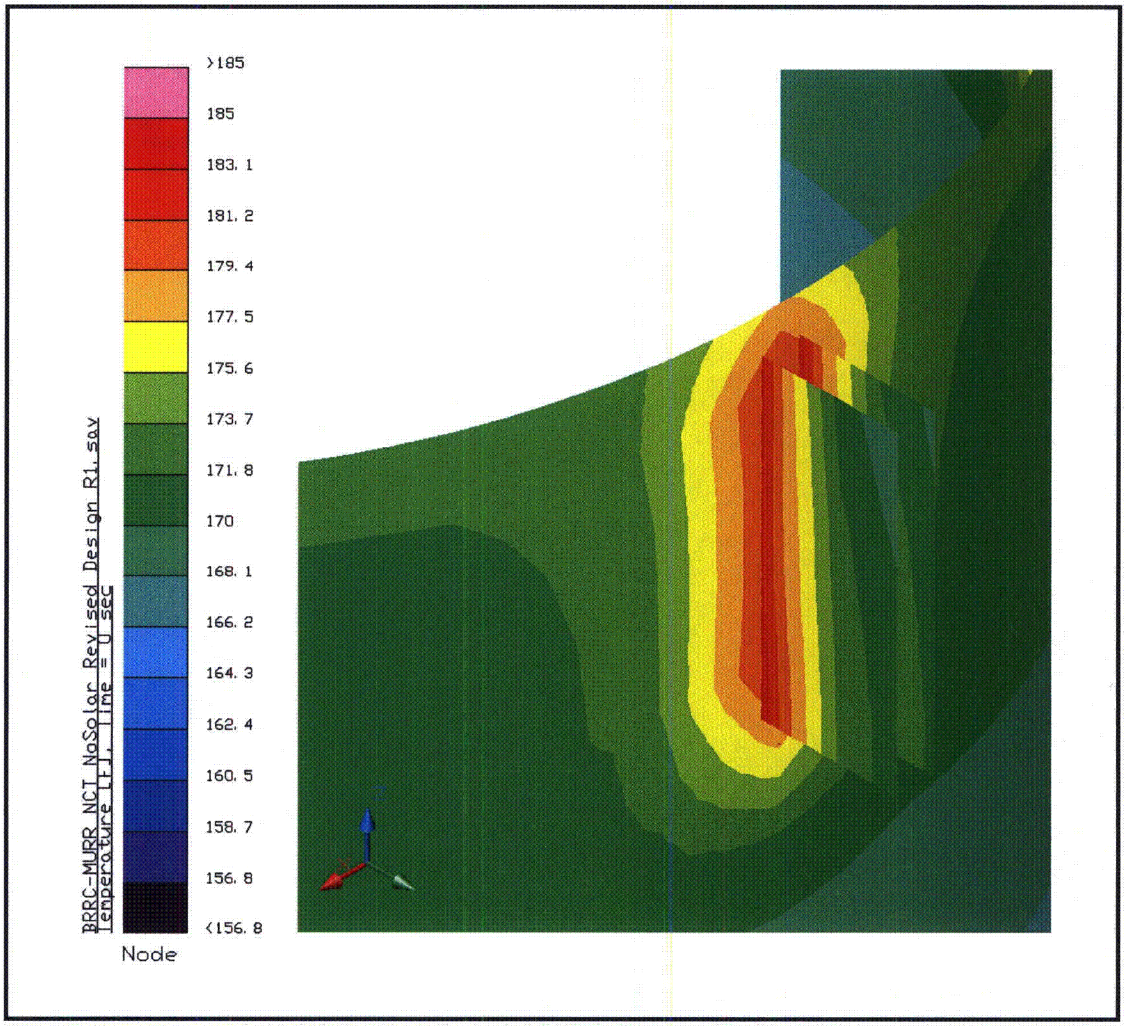
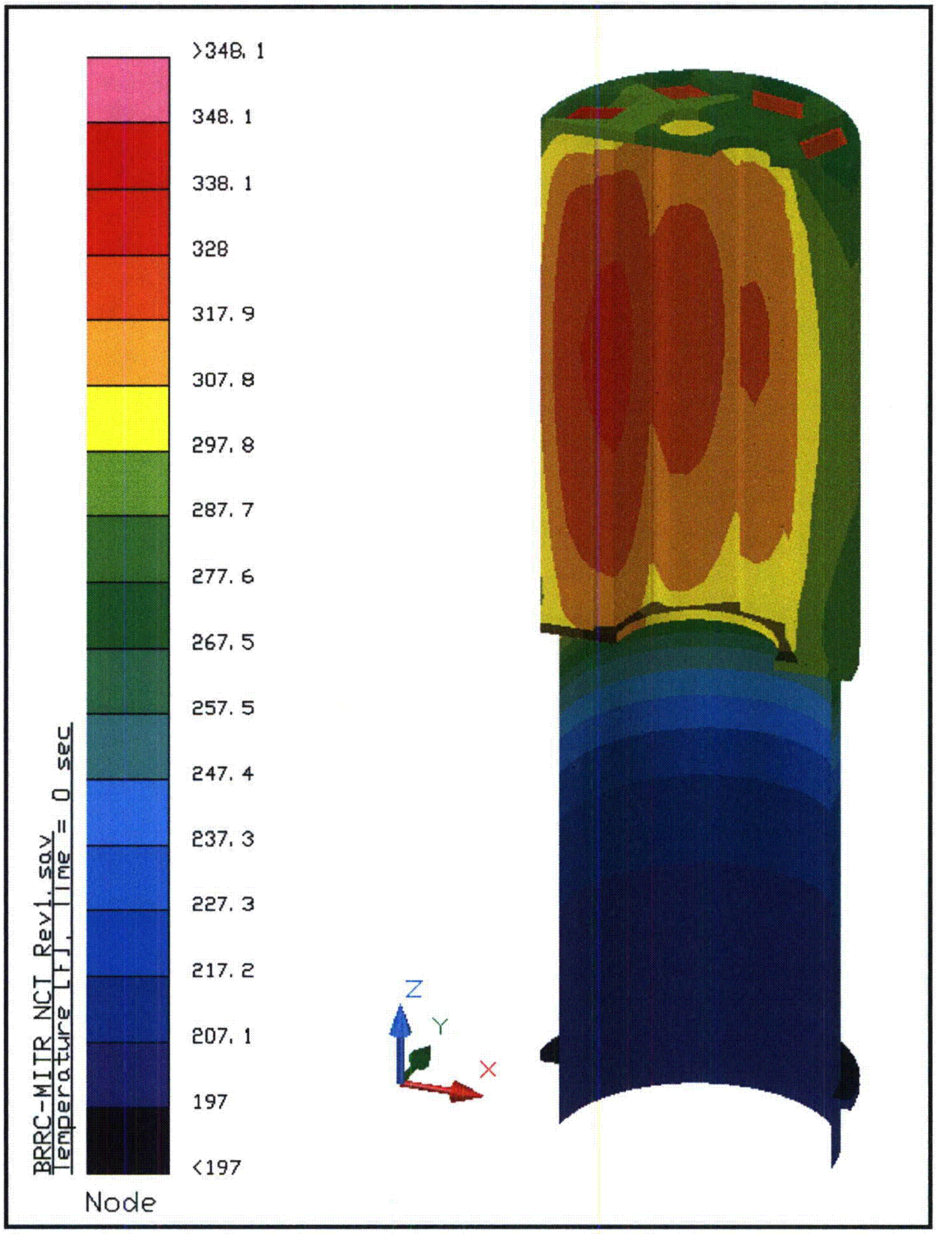


Figure 3.3-4 – MURR Fuel Basket Temperature Distribution for NCT Hot Condition



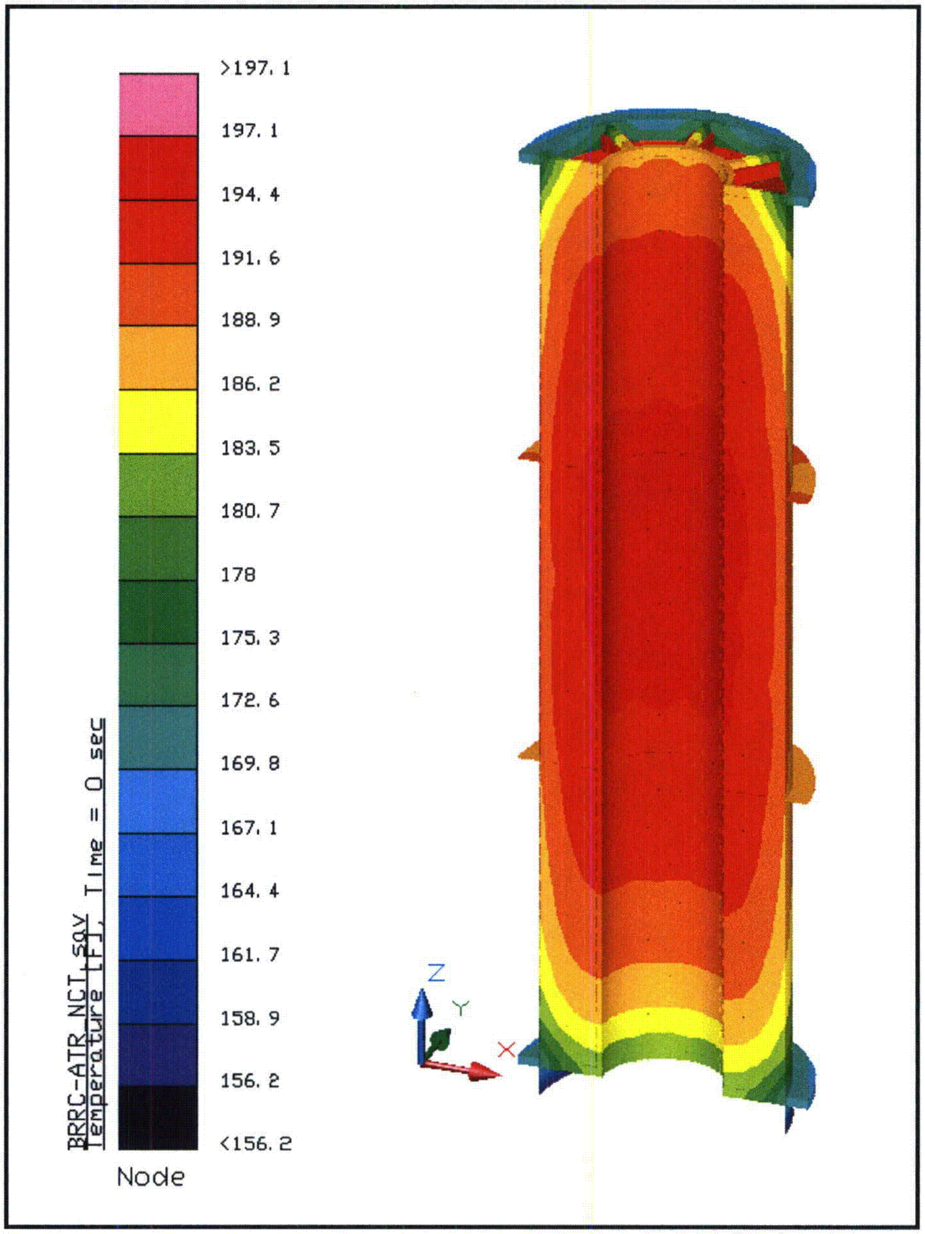
Surface Temperature Distribution in Vicinity of Impact Limiter Attachment Lugs

Figure 3.3-5 – Peak Accessible Surface Temperature for NCT No Solar



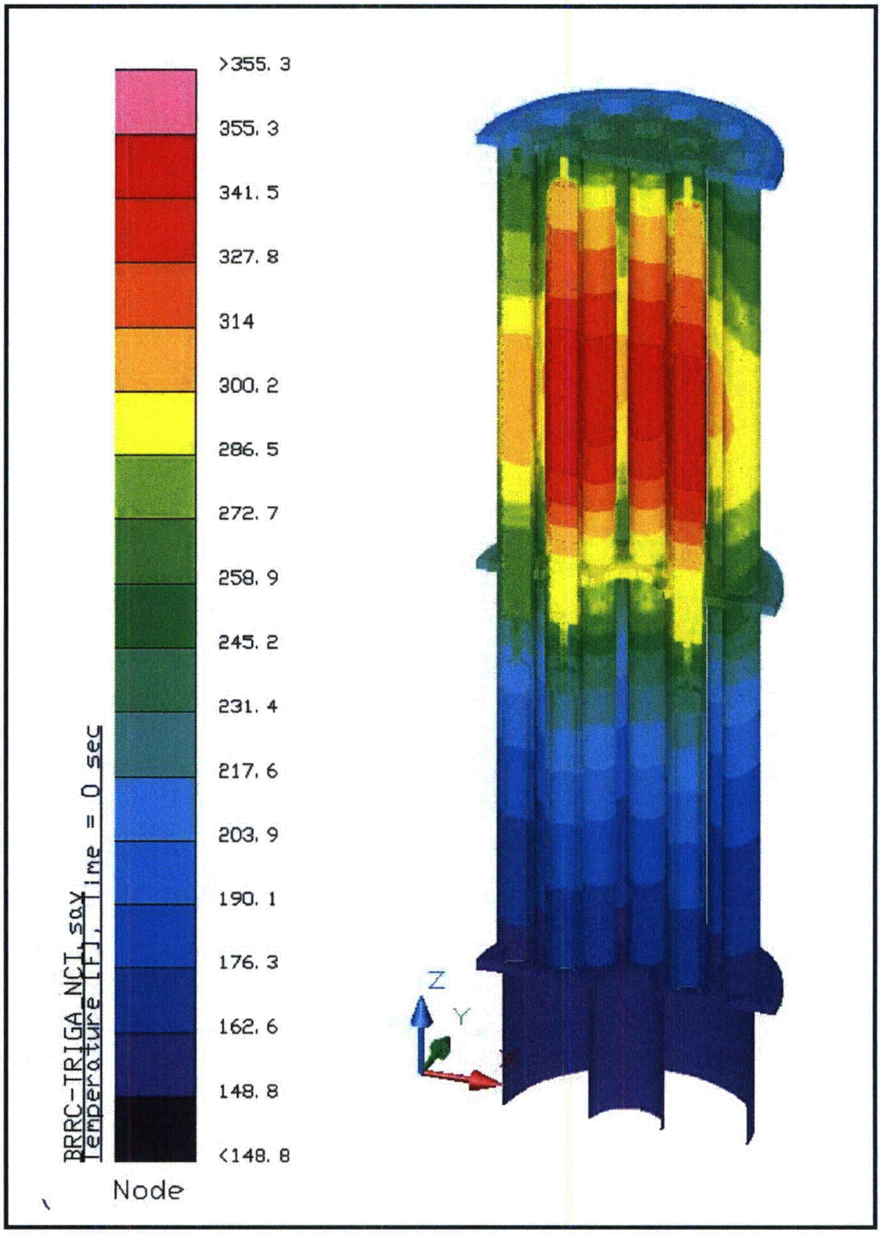
Note: Results are for basket decay heat loading of 1,200 W

Figure 3.3-6 – MITR-II Fuel Basket Temperature Distribution for NCT Hot Condition



Note: Results are for basket decay heat loading of 240 W

Figure 3.3-7 – ATR Fuel Basket Temperature Distribution for NCT Hot Condition



Note: Results are for basket decay heat loading of 380 W

Figure 3.3-8 – TRIGA Fuel Basket Temperature Distribution for NCT Hot Condition

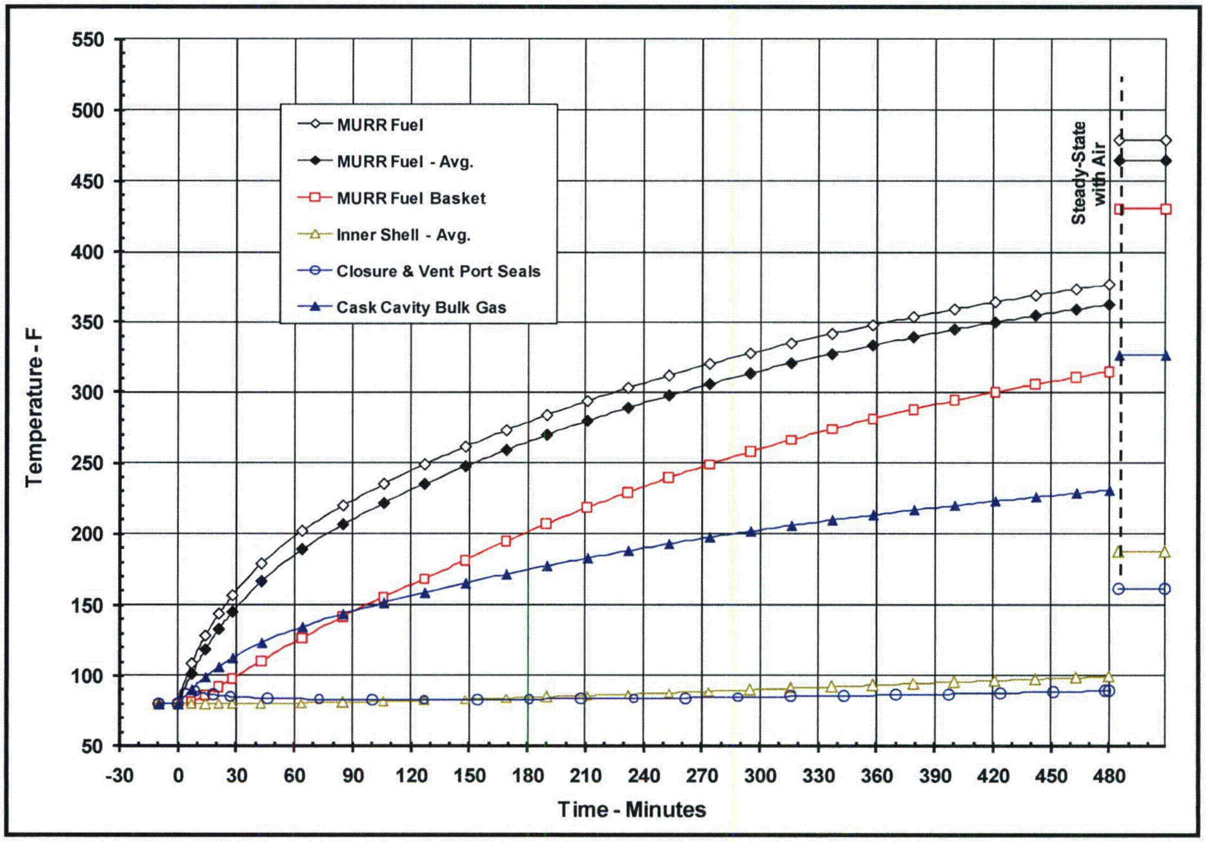


Figure 3.3-9 – Bounding Transient Heat Up During Vacuum Drying

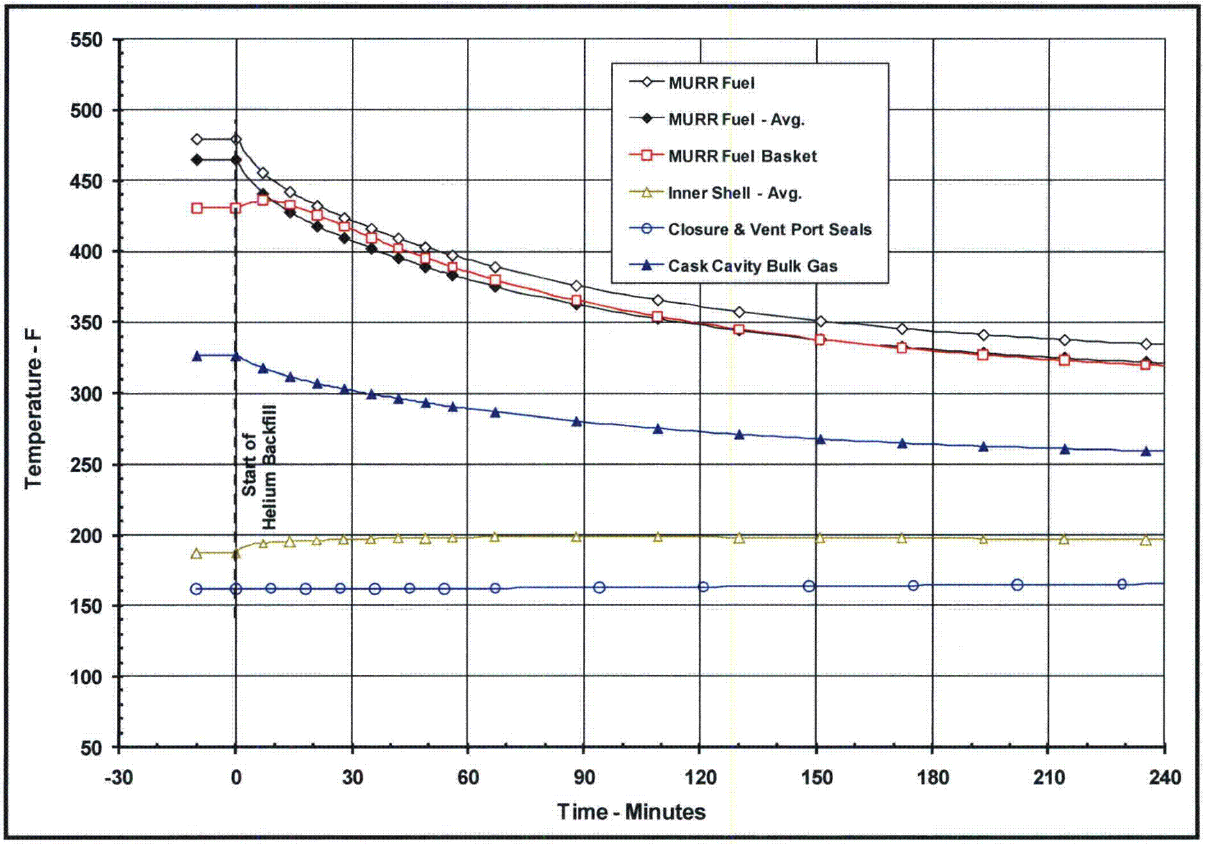


Figure 3.3-10 – Bounding Transient Cool Down Following Helium Backfill

3.5.1 References

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7.0 PACKAGE OPERATIONS

7.1 Procedures for Loading the Package

This section delineates the procedures for loading a payload from the BRR packaging. Hereafter, reference to specific BRR packaging components may be found in Appendix 1.3.3, *Packaging General Arrangement Drawings*.

7.1.1 Preparation for Loading

1. Remove the BRR package tie–down cover from the upper impact limiter.
2. Optionally, remove the cask and transport pallet from the transport trailer using the fork pockets in the pallet. Before lifting the pallet from the trailer, secure the tie–down cover to the pallet using the chains provided. Remove the tiedown cover and chains when pallet movement is complete.
3. Attach rigging to the upper impact limiter using the three (3) 1/2–13 UNC threaded holes marked as impact limiter lift points.
4. Remove the (8) eight ∅1–inch ball lock pins from each upper impact limiter attachment.
5. Using an overhead crane (or equivalent), lift and remove the upper impact limiter from the cask body.
6. Secure the lift adaptor to the cask body using the four (4) 1– 8UNC bolts. If rigging is used, secure the swivel hoist rings in place using swivel hoist ring 1-8UNC fasteners. Tighten the bolts/fasteners to 220 ±20 ft–lb torque.
7. Remove the (8) eight ∅1–inch ball lock pins from each lower impact limiter attachment.
8. Lift the cask body from the lower impact limiter, and place it on the facility transport equipment or in the desired staging location.
9. Secure the cask body to the facility transport equipment or in the staging location, and remove the rigging from the lift adaptor.

7.1.2 Loading of Contents

The BRR package is designed to be loaded either in a pool of water (wet) or in a hot cell (dry), as delineated in the following sections.

7.1.2.1 Wet Loading

1. Remove the twelve (12) 1–8UNC socket head cap screws (SHCSs) that retain the closure lid.
2. Install three (3) hoist rings (or equivalent) into the three (3) 1/2–13 UNC threaded holes in the closure lid.
3. Lift and remove the closure lid from the cask body. Store the closure lid in a manner to minimize potential damage to the O–ring seals and sealing surfaces.

4. Install and secure the sealing surface protector to the cask body.
5. Using the center 1/2–13 UNC threaded hole in the shield plug as a lift point, remove the shield plug from the cask body.
6. If not previously installed, install the appropriate fuel basket into the cask body cavity.
7. Remove the drain port dust cover and then the drain port plug. Install an appropriate drain fitting to the drain port.
8. Using an overhead crane (or equivalent), and attached to the lift adaptor, lift the cask body with the fuel basket from the facility transport equipment or staging location and position over the spent fuel pool staging area.
9. Slowly lower the cask body into the pool until the cavity is flooded, and the cask body is properly positioned and secured for fuel loading.
10. Load a fuel element into each fuel channel in the fuel basket. Up to eight (8) fuel elements may be loaded into the MURR, MITR-II, or ATR baskets. Up to nineteen (19) fuel elements may be loaded into the TRIGA basket.
11. Using the center 1/2–13 UNC threaded hole as a lift point, lower the shield plug into the cask body cavity. Visually verify that the shield plug is properly seated, and reposition if necessary.
12. If required, install the shield plug restraint, or optionally, install the shield plug restraint once the cask body has been raised to the working level.
13. Lift the loaded cask body from the spent fuel pool while rinsing exposed portions with clean demineralized water. Perform a radiological survey of the cask body as it is raised out of the pool.
14. Open the drain fitting to drain the pool water from the cavity. Continue draining the cavity until no appreciable water is noted. Close the drain fitting. Optionally, the cavity may be drained after securing the cask body in the facility work area.
15. Lift the loaded cask body out of the spent fuel pool area and secure it in the facility work area.
16. Connect drain tubing to the drain fitting, and route the drain tubing to an appropriate container. Open the drain fitting.
17. Remove the sealing surface protector and, if installed, the shield plug restraint from the shield plug and cask body.
18. Remove and discard both main O–ring seals (if present), and clean and inspect the sealing surfaces in the closure lid and the mating surfaces on the cask body. If damage is present which is sufficient to impair containment integrity (scratches or dents, etc.), repair the damaged surfaces per Section 8.2.3.2, *Sealing Area Routine Inspection and Repair*.
19. Install two new (unused) O-rings in the appropriate grooves in the closure lid. As an option, sparingly apply vacuum grease to the O–ring seals and/or sealing surfaces.
20. Install the closure lid on the cask body, using the alignment pin to guide the closure lid into position.

21. Visually inspect the closure SHCSs for wear or damage that could impair their function and, if necessary, replace or repair per the requirements of the drawings in Appendix 1.3.3, *Packaging General Arrangement Drawings*.
22. Install the twelve (12) 1–8UNC SHCSs to secure the closure lid to the cask body. Using a star pattern, tighten the closure SHCSs to 220 ±20 ft–lb torque (lubricated).
23. Remove the vent port dust cover, vent port plug, test port dust cover, and test port plug.
24. Install a vent port tool into the vent port, and connect a source of dry pressurized air to the vent port tool.
25. Open the air supply flow control valve to permit dry pressurized air flowing through the cavity, ensuring that the air pressure does not exceed 25 psig. Continue the air supply flow until all apparent free standing water has been removed from the cavity.
26. Remove the drain port fitting and tubing from the drain port.
27. Remove and discard the vent, test, and drain port sealing washers from their respective port plugs (if present), and clean and inspect each sealing surface. If damage is present that is sufficient to impair containment integrity (scratches or dent, etc.), repair the damaged surfaces per Section 8.2.3.2, *Sealing Area Routine Inspection and Repair*.
28. Install the drain port plug and a new (unused) sealing washer in the drain port. Tighten the drain port plug to 20 ±2 ft–lb torque.
29. Using the vent port tool, install the vent port plug with a new (unused) sealing washer. Ensure that the vent port plug is sufficiently loose to allow airflow through the vent port.
30. Install the test port plug and a new (unused) sealing washer in the closure lid approximately finger-tight.
31. Connect a vacuum pump and a shutoff valve to the vent port tool and evacuate the cavity until the internal pressure is 1 – 2 torr. Isolate the vacuum pump from the cask body cavity by closing the shutoff valve and shutting off the vacuum pump, closing the shutoff valve and venting the suction line to atmosphere, or other appropriate means that does not maintain a vacuum on the outlet of the shutoff valve.
32. Monitor the cavity pressure for a minimum of 30 minutes. If the cavity pressure does not exceed 3 torr at the end of the time period, proceed to Step 34. If it appears that cavity pressure will exceed 3 torr, it is not necessary to wait 30 minutes before proceeding to step 33. As an option, repeat Steps 31 and 32 without first performing Step 33.
33. Open the port tool to re–pressurize the cask body cavity to atmospheric pressure and repeat Steps 31 and 32. The cask may be re-pressurized with air, nitrogen, or helium.
34. Disconnect the vacuum pump from the vent port tool and connect a source of helium gas.
35. Provide a helium atmosphere inside the cask payload cavity by backfilling with helium gas to a pressure of slightly greater than atmospheric pressure, i.e., +1, -0 psig.
36. Disconnect the helium gas source from the vent port tool.
37. Using the vent port tool, tighten the vent port plug to 9 ±1 ft–lb torque.

38. Perform leakage rate testing on the containment O-ring seal and the drain and vent port sealing washers per Section 8.2.2.2, *Helium leakage Rate Testing the Main Containment O-ring Seal*, Section 8.2.2.3, *Helium Leakage Rate Testing the Drain Port Sealing Washer*, and Section 8.2.2.4, *Helium Leakage Rate Testing the Vent Port Sealing Washer*.
39. At the conclusion of all leakage rate testing, install the drain port dust cover, the test port dust cover, and vent port dust cover.

7.1.2.2 Dry Loading

Steps 1 – 6 may be performed either inside or outside of the hot cell. A transfer cask may be used in place of the hot cell for this procedure. The cask must remain upright at all times.

1. Remove the twelve (12) 1–8UNC socket head cap screws (SHCSs) that retain the closure lid.
2. Install three (3) hoist rings (or equivalent) into the three (3) 1/2–13 UNC threaded holes in the closure lid.
3. Lift and remove the closure lid from the cask body. Store the closure lid in a manner to minimize potential damage to the O–ring seals and sealing surfaces.
4. Install and secure the sealing surface protector to the cask body.
5. Using the center 1/2–13 UNC threaded hole in the shield plug as a lift point, remove the shield plug from the cask body.
6. If not previously installed, install the appropriate fuel basket into the cask body cavity.
7. If steps 1 – 6 were performed outside of the hot cell, reinstall shield plug in cask.
8. Mate the cask opening with the hot cell. If necessary, place the cask body inside the hot cell.
9. If required, remove the shield plug.
10. Load a fuel element into each fuel channel in the fuel basket. Up to eight (8) fuel elements may be loaded into the MURR, MITR-II, or ATR baskets. Up to nineteen (19) fuel elements may be loaded into the TRIGA basket.
11. Using the center 1/2–13 UNC threaded hole as a lift point and a remote lift adapter, lower the shield plug into the cask body cavity. Visually verify that the shield plug is properly seated, and reposition if necessary.
12. Optionally, install the shield plug restraint.
13. If the cask was placed within the hot cell remove the loaded cask body from the hot cell. Perform a radiological survey of the cask body as it is removed.
14. If the cask was mated to the hot cell, disconnect the cask from the hot cell. Perform a radiological survey of the cask body as it is removed.
15. Remove the sealing surface protector and, if installed, the shield plug restraint from the shield plug and cask body.
16. Remove and discard both main O–ring seals (if present), and clean and inspect the sealing surfaces in the closure lid and the mating surfaces on the cask body. If damage is present

which is sufficient to impair containment integrity (scratches or dents, etc.), repair the damaged surfaces per Section 8.2.3.2, *Sealing Area Routine Inspection and Repair.*

17. Install two new (unused) O-rings in the appropriate grooves in the closure lid. As an option, sparingly apply vacuum grease to the O–ring seals and/or sealing surfaces.
18. Install the closure lid on the cask body, using the alignment pin to guide the closure lid into position.
19. Visually inspect the closure SHCSs for wear or damage that could impair their function and, if necessary, replace or repair per the requirements of the drawings in Appendix 1.3.3, *Packaging General Arrangement Drawings.*
20. Install the twelve (12) 1–8UNC SHCSs to secure the closure lid to the cask body. Using a star pattern, tighten the closure SHCSs to 220 ±20 ft–lb torque (lubricated).
21. Remove the vent port dust cover, vent port plug, test port dust cover, and test port plug.
22. Remove the drain port dust cover and drain port plug.
23. Remove and discard the vent, test, and drain port sealing washers from their respective port plugs (if present), and clean and inspect each sealing surface. If damage is present that is sufficient to impair containment integrity (scratches or dent, etc.), repair the damaged surfaces per Section 8.2.3.2, *Sealing Area Routine Inspection and Repair.*
24. Install the drain port plug and a new (unused) sealing washer in the drain port. Tighten the drain port plug to 20 ±2 ft–lb torque.
25. Using the vent port tool, install the vent port plug with a new (unused) sealing washer. Ensure that the vent port plug is loose enough to allow airflow through the vent port.
26. Install the test port plug and a new (unused) sealing washer in the closure lid approximately finger-tight.
27. Connect a vacuum pump and a shutoff valve to the vent port tool and evacuate the cavity until the internal pressure is 1 – 2 torr. Isolate the vacuum pump from the cask body cavity by closing the shutoff valve and shutting off the vacuum pump, closing the shutoff valve and venting the suction line to atmosphere, or other appropriate means that does not maintain a vacuum on the outlet of the shutoff valve.
28. Monitor the cavity pressure for a minimum of 30 minutes. If the cavity pressure does not exceed 3 torr at the end of the time period, proceed to Step 30. If it appears that cavity pressure will exceed 3 torr, it is not necessary to wait 30 minutes before proceeding to step 29. As an option, repeat Steps 27 and 28 without first performing Step 29.
29. Open the port tool to re–pressurize the cask body cavity to atmospheric pressure and repeat Steps 27 and 28. The cask may be re-pressurized with air, nitrogen, or helium.
30. Disconnect the vacuum pump from the vent port tool and connect a source of helium gas.
31. Provide a helium atmosphere inside the cask payload cavity by backfilling with helium gas to a pressure of slightly greater than atmospheric pressure, i.e., +1, -0 psig.
32. Disconnect the helium gas source from the vent port tool.

33. Using the vent port tool, tighten the vent port plug to 9 ±1 ft–lb torque.
34. Perform leakage rate testing on the containment O-ring seal and the drain and vent port sealing washers per Section 8.2.2.2, *Helium leakage Rate Testing the Main Containment O-ring Seal*, Section 8.2.2.3, *Helium Leakage Rate Testing the Drain Port Sealing Washer*, and Section 8.2.2.4, *Helium Leakage Rate Testing the Vent Port Sealing Washer.*
35. At the conclusion of all leakage rate testing, install the drain port dust cover, the test port dust cover, and vent port dust cover.

7.1.3 Preparation for Transport

1. Utilizing the lift adaptor, or optional rigging, lift and lower the cask body into the lower impact limiter that is located on the transport pallet. Ensure that the cask body is aligned with the impact limiter alignment stripe for correct circumferential location.
2. Install the (8) eight ∅1–inch ball lock pins into each lower impact limiter attachment.
3. Remove the (4) four 1 – 8 UNC bolts that attach the lift adaptor to the cask body. Remove the lift adaptor or rigging hardware. The lifting holes may be optionally plugged.
4. Lift and lower the upper impact limiter onto the cask body. Ensure that the upper impact limiter is aligned with the cask body stripe for correct circumferential location.
5. Install the (8) eight ∅1–inch ball lock pins into each upper impact limiter attachment.
6. Install the tamper–indicating device (security seal) in the appropriate upper impact limiter attachment location.
7. Remove the rigging from the upper impact limiter lift points. The lifting holes may be optionally plugged.
8. Place the BRR package tie–down cover over the upper impact limiter.
9. If the transport pallet was removed from the transport trailer, secure the tie–down cover to the pallet using the chains provided. Using the fork pockets in the pallet, place the pallet on the transport trailer and attach to the trailer. Then, remove the chains between the tie–down cover and pallet.
10. Secure the tie–down cover to the transport trailer using the tie–down attachments. Optionally, install a weather seal on the bottom impact limiter.
11. Monitor external radiation for each loaded BRR package per the requirements of 49 CFR §173.441.
12. Determine that surface contamination levels for each loaded BRR package is per the requirements of 10 CFR §71.87(i) and 49 CFR §173.443.
13. Determine the transport index for each loaded BRR package per the requirements of 49 CFR §173.403.
14. Complete all necessary shipping papers in accordance with Subpart C of 49 CFR 172 [3].