# Attachment 3

## GNF Response to EU
## Request for Additional Information (RAI)

## Response to EU Technical Issues

1. *Can you demonstrate the integrity of the pellets under accident conditions of transport? If not, broken pellets of any size will need to be considered in the criticality safety analysis for both the 46.71kg and 48.48kg heterogeneous uranium contents. It is likely that this will lead to the maximum mass of uranium per ICCA being restricted to 40.54 kg (46kg of UO2) for both BWR and PWR pellets.*

**Response:**

GNF-A believes that this has been adequately demonstrated in the criticality analysis already presented. GNF-A has confirmed this by review with the U. S. Nuclear Regulatory Commission. There appears to be a difference in approach within the EU. Based on GNF-As current needs, there is no practical value in continuing the discussion of the technical merits of different approaches and therefore GNF-A is going to modify the application to the U.S. Nuclear Regulatory Commission to reduce reduce the heterogeneous pellet authorized content to 40.54 kg. This should eliminate this concern in the near term.

2. *If you can confirm the integrity of the BWR and PWR pellets under accident conditions of transport, you will still need to revise the criticality safety analysis in order to take into account the most reactive and credible distribution of pellets for the 46.71kg and 48.48kg heterogeneous uranium contents. It is noted that this has already been performed for the 40.54kg heterogeneous uranium content in your report presented in Reference 1. If credit is taken for the shape or packing fraction of the BWR / PWR pellets, these conditions should be clearly stated and demonstrated in your safety report so that they can be included in the European validation certificates. BWR / PWR pellet shapes that could potentially cause a problem are those that are either annular or short (where the height is less than the diameter)*

**Response:**

See answer to item #1. Reducing the heterogeneous pellet content to 40.54 kg should eliminate this concern.

3. *Materials with a hydrogen density greater than that of water are currently allowed to be present within each ICCA of the package. If this allowance is not removed, the criticality safety analysis will need to be revised to take*

*account of these materials, including under accident conditions of transport. If there is any limitation in the composition, distribution or quantity of these materials, then these restrictions should be clearly stated and demonstrated so that they can be included in the European validation certificates.*

**Response:**

GNF-A has re-analyzed the 5x5x6 NPC damaged package array under Hypothetical Accident Conditions (HAC) considering heterogeneous material of unrestricted particle size (40.54 kg U/ICCA) including the effects of a 0.73 cm thick polyethylene bottle inside each ICCA. As expected, the results of the analysis show a decrease in overall system subcritical reactivity due to increased neutron thermalization between ICCA cylinders which increases the effectiveness of the Cadmium poison sleeves. The material dimensions and composition of the polyethylene bottles are specified and controlled in GNF engineering drawing 0012D01, Rev.1.

To facilitate this GNF-A is adding the drawing for the high-density plastic bottle to the SAR, modifying the authorized content tables and footnotes to include a limit on high-density polyethylene and modifying the operating instructions regarding packing.

4. *Can you guarantee that the ICCAs will remain leak tight under accident conditions of transport? (Leak tightness is important not only to ensure that water cannot enter the ICCAs but primarily for the containment of the fissile material.) If this can be guaranteed, can you demonstrate that the bottles, bags and solid contents that may be present within each ICCA in reality have been adequately represented by the dummy content of the ICCAs used in the drop tests? Please see NRC certificate USA/9203/AF for an example of how the package content has been considered in this case as well as other issues related to the pellet trays, annular pellets and the polyethylene limit.*

**Response:**

In discussions of the New Powder Container (NPC) USA/9294/AF-85, there seems to be some degree of lack of clarity on the containment boundary for the package. In addition some lack of clarity on the integrity of the containment boundary under accident conditions including why the criticality evaluations of the package on the one hand assume the assumption that the containment boundary leaks, when evaluating single packages and package arrays, and on the other hand taking the position that there is no leakage of the containment boundary, when evaluation the loss of control of material under accident conditions. The subject needs clarification.

In the Safety Analysis Report (SAR) submitted to the US Nuclear Regulatory Commission for approval of the package, Sections 2.1, 2.1.1 and 2.1.2.1 are identified as discussing the design features/design criteria for the package. These sections are rather brief and the only major point to be learned from their content is that the containment boundary for the package is the ICCA. The ICCA is well described in the SAR both in the drawings and the text.

The design criteria for the package was that the ICCA would in fact be the containment element of the package and that it would not rely on any specific internal packaging of the payload to perform this function. Further more the ICCA was to be leak tight and this leak tightness was to be demonstrated for both the undamaged package (15 m water immersion) and after the hypothetical accident condition testing (0.3 m water immersion). For the purpose of evaluating any potential escape of payload during an accident, the ICCA was designed to be leak tight meaning that no material could escape to cause a radiological or criticality hazard external to the package. For the assumptions used in the criticality safety demonstration, it was assumed that the ICCA leaked when evaluating the reactivity of the single package and the array of packages; however, scenarios involving the loss of material from the containment geometry were not considered because the ICCA was to be demonstrated to be leak tight in this regard.

Twenty-seven ICCAs were prepared for testing. These were loaded with fine dry sand and bags of lead shot to achieve a weight of 60 kg as defined elsewhere. At the top of each ICCA a paper disk was inserted after the weight had been achieved and fluorescein powder was placed above the paper disk. Fluorescein is a very fine and highly mobile powder that is easily detectable by the use of “black” light and is used to detect very small leaks. The paper disk was used to maintain the concentration of fluorescein near the closure of the ICCA during the testing. The dry sand also provided a nice indicator of any water in leakage. The lids were placed on the ICCA and the closure band clamps tightened to the specified 35 inch-pounds torque.

Nine undamaged ICCAs were tested by immersion in water at a pressure equivalent to 15 m of water for 8 hours. Visually there were no signs of damage. Black light examination showed no leakage of fluorescein. The closure band clamp torque was checked and found to be between 24 and 45 inch-pounds torque. The ICCAs were carefully opened and checked for the presence of moisture and all were dry. Based on these nine samples it is clear that undamaged ICCAs meet the design requirements (see SAR 2.7.6).

Twenty-seven ICCAs (all prepared as described previously) were subjected to the hazardous accident conditions tests as described in the SAR for each of three NPC packages (CTU1, CTU2 and CTU3). After these tests the ICCAs were subjected to an immersion test at 0.3 m to evaluate their leak tightness (SAR Section 2.7.5). The results of these evaluations are outlined in the SAR in Sections 2.10.1.7.1.5 & 6 for CTU1, 2.10.1.7.2.5 & 6 for CTU2 and 2.10.1.7.3.5 & 6 for CTU3. With the exception of two ICCAs, twenty-five of the ICCAs had no indication of fluorescein leakage when evaluated with the black light and upon opening there was no indication of in leakage of water. Two of the ICCAs warrant further discussion.

In CTU (1) the ICCA located next to the ICCA nearest the impact point, there was no indication of fluorescein leakage outside of the ICCA. Upon opening the ICCA, there was a visible trace of a very small amount of moisture on the dry sand. A through investigation determined that the cause of the minor moisture intrusion was due to a few sand particles migrating between the ICCA closure lid/seal and the body. This condition was attributed to the elastic “burping” of the closure lid during drop testing.

To confirm this, the sand was wiped clean and the lid resealed with 35 lb-in torque. The ICCA was immersed to a depth of 50 feet (15 m) for eight hours and no leaking was observed.

It is important to note that the original leak was very small – on the order of a few milliliters and would have not contributed to a loss of payload.

In CTU (3) the ICCA located nearest the point of impact showed some indication of fluorescein. In addition there was a slight amount of moisture observed in the dry sand. The amount of moisture intrusion was small – on the order of a few milliliters and was insignificant relative to a quantity that would have fluidized any unrestrained payload. Because of the mechanical damage it was not possible to retest this ICCA as was done for CTU (1) and therefore the exact cause of the minor moisture intrusion could not be verified.

The slight moisture intrusion in the two ICCAs of CTU (1) and CTU (3) lead to the requirement to restrain the payload in either plastic or metal containers within the ICCA. This added containment provides added assurance that no payload would be released under accident conditions.

The payload for testing consisted of fine sand and lead-shot to achieve an ICCA weight loading equal to or slightly greater than the authorized payload. The initial concept was to demonstrate that the authorized content would not require additional constraint for the package to pass the required tests. To model the payload, sand and lead-shot were chosen because they appeared to be representative of the authorized content in a conservative manner (particle size, flowability, density and compressibility).

Subsequent to the testing it was determined that additional constraints had to be placed on the payload to ensure that leakage did not take place. Plastic bags, bottles and thin metal cans were identified as alternatives. Currently the preferred container is a plastic bottle.

The ICCA sees only a small percentage of the kinetic energy in the impact related tests. The highest calculated value is ~ 0.5% (see the SAR, Appendix 2, Table 2.10.2-3). Under these conditions of low energy absorption in the ICCA region, the contents of the ICCA have little impact on the physical performance of the ICCA structure and containment. The unrestrained payload of sand and lead-shot is believed to be the worst case. The addition of a plastic bag, bottle or metal can helps to dampen the influence of the impact energy absorption.

5. *Can you confirm that it is acceptable for liquid contents to be excluded from the package?*

**Response:**

None of the currently authorized contents for the package include liquids. GNF-A is submitting a request for wording changes to the authorized contents that will make it clear that no liquids or solutions are authorized for the package.

6. *Have you assessed the scenario whereby a package is dropped onto a puncture bar at an oblique orientation, so that it hits the middle of a lateral surface? If not, this assessment could be achieved by performing a finite element calculation with the intention of showing that the damage would be less than for the drops already considered. The reason for this additional scenario is that the potential for a larger opening of the package before the fire test could have an important effect on the temperature of the polyurethane foam, polyethylene and the inner bottle which could consequently have an effect on their composition and geometry.*

**Response:**

GNF performed three puncture tests to specifically determine whether tearing of the outer shell occurs during impact and maximize damage to the thermal protection design features of the package. Attachment A summarizes the results for puncture test 12, 13, and 14 from Appendix 2.10.1 of the NPC SAR. Figure A-1 shows the impact orientations for each puncture test. Figures A-2 through A-7 provide photographs of the test preparation and post-test results. The following table is a summary of the puncture test setup and results. Penetration tests for CTU (4), #13 and #14 are most applicable to the question.

**Summary of NPC Puncture Tests**

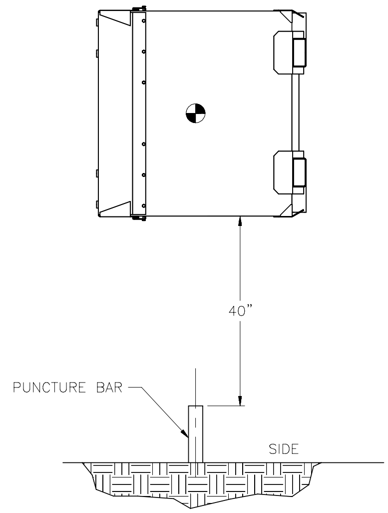
| Test No. | Test Description (Certification Test Unit No.) | Test Temperature (ºF) | Test Unit Angular Orientation | | | Results |
|---|---|---|---|---|---|---|
| | | | X-Axis (0º = horizontal) | Vertical Axis (0º = upright) | Z-Axis (0º = horizontal) | |
| 12 | Puncture drop on Side (CTU-4) | -40 | 90º | 0º | 0º | ~1½" deep × ~16" wide dent |
| 13 | Puncture drop, CG over Lid/Body Interface (CTU-4) | -40 | 107º | 45º | 45º | ~1¾ " deep × ~10" wide × ~12" long dent |
| 14 | Puncture, Oblique CG drop thru Lid (CTU-4) | -40 | 156º | 0º | 0º | ~2½" deep dent in OCA lid |

Figure A-4 shows the cumulative damage of two consecutive puncture tests. The lower indentation is the result of Test 13 and the upper indentation is the result of Test 12. Additionally, Figure A-7 shows the damage following the oblique drop onto the lid. All three drops where performed at -40°C, which reduces the ductility of the stainless steel shell. Because the testing was performed at extreme cold temperatures and cumulative damage is considered, no further analysis is justified.

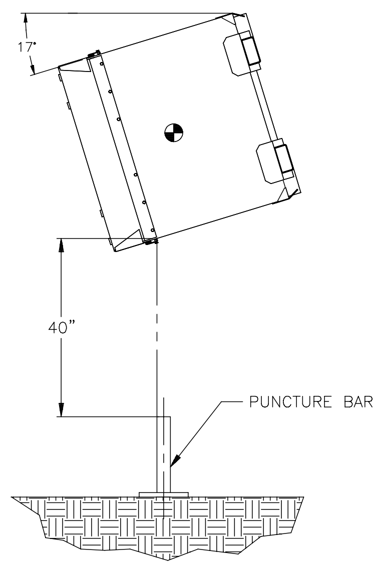
Puncture testing experience indicates that thin metal skin is more susceptible to tearing (puncture) when higher density crushable materials that provide support as in the case of the NPC lid back it. Therefore, the oblique puncture on the lid is predicted to be the most damaging orientation because the lid contains significant 40# density foam and is more rigid than the sides of the package. The following figures are extracted from the SAR for the package.

## ATTACHMENT A

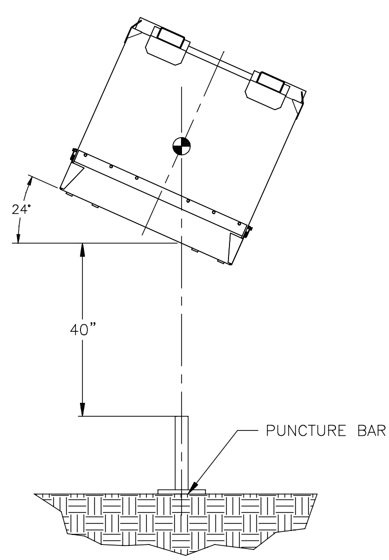
**Puncture Drop No. 12** directly impacts the side of the OCA. The puncture drop height is based on the requirements of 10 CFR §71.73(c)(3). The purpose of Puncture Drop No. 12 is to cause maximum damage to the thermal protection design features of the OCA body.




**Puncture Drop No. 13** directly impacts the area adjacent to the OCA Lid/Body interface. The puncture drop height is based on the requirements of 10 CFR §71.73(c)(3). The purpose of Puncture Drop No. 13 is to cause maximum damage to the most vulnerable feature (OCA Lid/Body interface) of the packaging.




**Puncture Drop No. 14** is an oblique drop that directly impacts the OCA lid. The puncture drop height is based on the requirements of 10 CFR §71.73(c)(3). The purpose of Puncture Drop No. 14 is to cause maximum damage to the thermal protection design features of the OCA Lid.



## CTU-4 Puncture Drop Test No. 12

Puncture Drop No. 12 impacted directly onto the side of the OCA body. As shown in Figure 2.10.1-87, the CTU was oriented 90º with respect to the horizontal impact surface (x-axis angle 90º, vertical axis angle 0º, and z-axis angle 0º). The following list summarizes the test parameters:

- verified x-axis angle as 90º ±1º
- verified vertical axis angle as 0º ±1º
- verified z-axis angle as 0º ±1º
- verified drop height as 40-inches, +1/-0 inches (actual drop height 40-inches)
- measured ambient temperature as 48 ºF
- conducted test at 9:20 a.m. on Thursday, 2/3/00

The packaging rebounded upon impact and rotated off the puncture bar. A circular indentation, approximately 15 to 17-inches in diameter and 1 1/2-inches deep, was created in the side of the OCA. The outer OCA stainless steel skin was not punctured nor was any other damage noted. The impact damage is shown in Figure 2.10.1-88.

## CTU-4 Puncture Drop Test No. 13

Puncture Drop No. 13 impacted obliquely onto the side of OCA body, striking the same surface as Puncture Drop No. 12. As shown in Figure 2.10.1-89, the CTU was oriented 17º with respect to the horizontal impact surface (x-axis angle 107º, vertical axis angle 0º, and z-axis angle 0º). The following list summarizes the test parameters:

- verified x-axis angle as 107º ±1º
- verified vertical axis angle as 0º ±1º
- verified z-axis angle as 0º ±1º
- verified drop height as 40-inches, +1/-0 inches (actual drop height 40-inches)
- measured ambient temperature as 59 ºF
- conducted test at 10:18 a.m. on Thursday, 2/3/00

The packaging rebounded upon impact and rotated off the puncture bar. A crescent-shaped indentation, measuring 1 3/4-inches deep × 10-inches long × 12-inches wide, was formed in the OCA body, approximately 2-inches from the OCA closure strip. The outer OCA stainless steel skin was not punctured nor was any other damage noted. The impact damage is shown in Figure 2.10.1-90 and Figure 2.10.1-91.

## CTU-4 Puncture Drop Test No. 14

Puncture Drop No. 14 impacted obliquely onto the OCA lid. As shown in Figure 2.10.1-92, the CTU was oriented 66º with respect to the horizontal impact surface (x-axis angle 156º, vertical axis angle 0º, and z-axis angle 0º). The following list summarizes the test parameters:

- verified x-axis angle as 156º ±1º
- verified vertical axis angle as 0º ±1º

- verified z-axis angle as 0º ±1º
- verified drop height as 40-inches, +1/-0 inches (actual drop height 40-inches)
- measured ambient temperature as 61 ºF
- conducted test at 10:55 a.m. on Thursday, 2/3/00

The packaging rebounded upon impact and rotated off the puncture bar. A dished-shaped indentation, measuring 2 1/2-inches deep, was formed in the OCA lid. The outer OCA stainless steel skin was not punctured nor was any other damage noted. The impact damage is shown in Figure 2.10.1-93.

**Figure A-1 –** Drop and Puncture Test Orientations

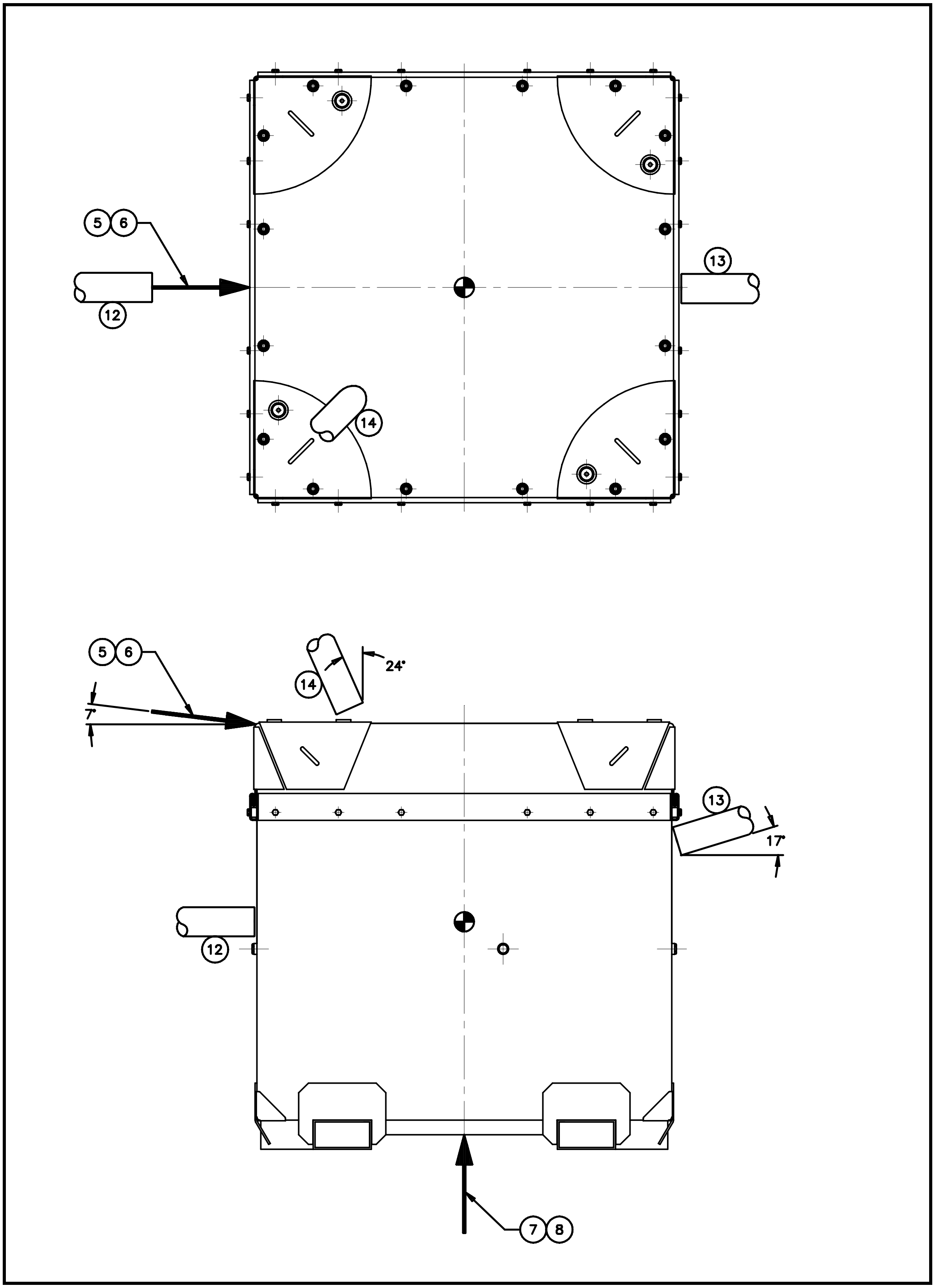


**Figure A-2 –** CTU-4 Puncture Drop Test No. 12; HAC Puncture on Side

**Figure A-3** – CTU-4 Puncture Drop Test No. 12; Close-up View of Damage; ~1½" Deep

**Figure A-4** – CTU-4 Puncture Drop Test No. 13; HAC Oblique Drop on Side

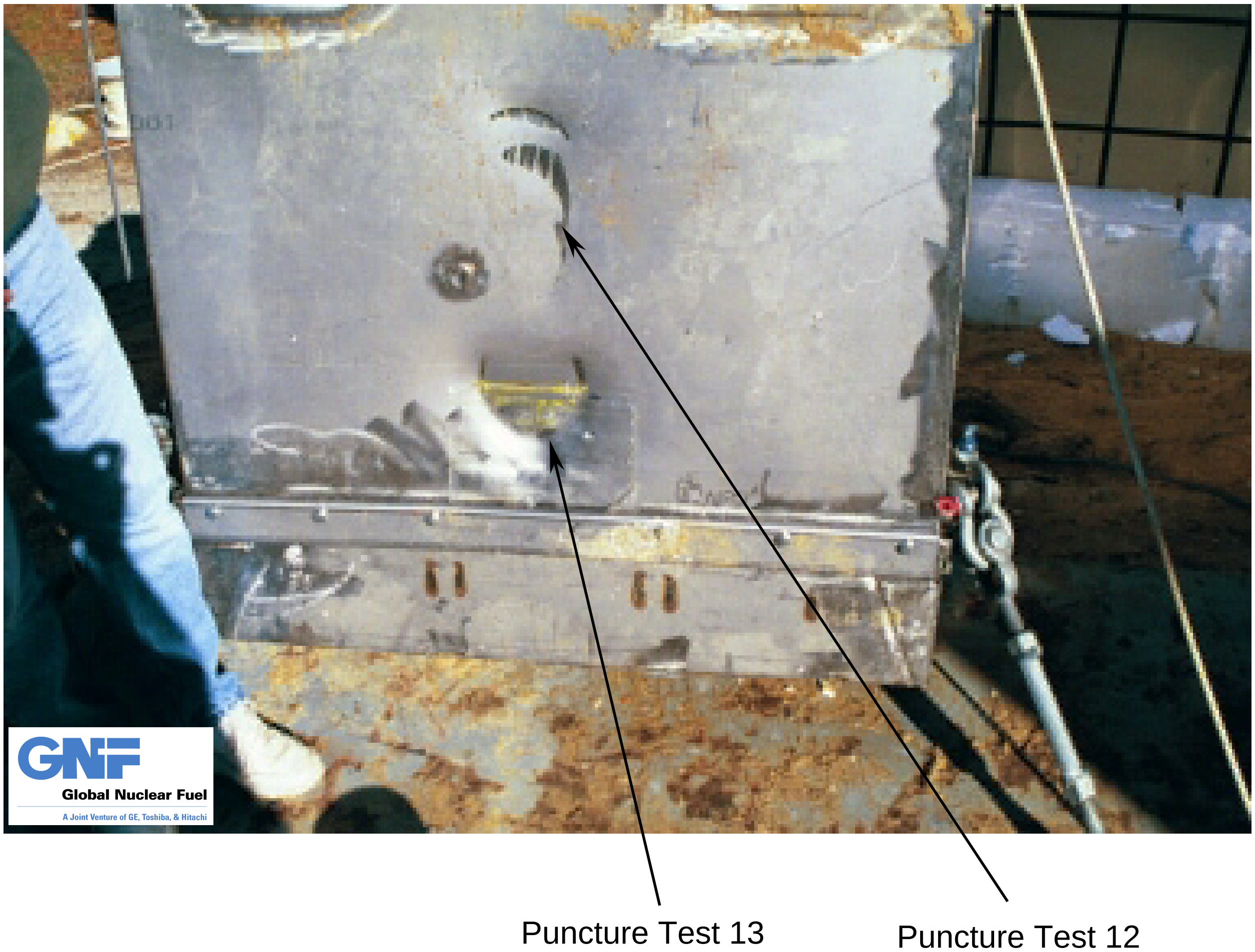


**Figure A-5** – CTU-4 Puncture Drop Test No. 13; Close-up View of Damage; ~1¾ Deep

**Figure A-6** – CTU-4 Puncture Drop Test No. 14; HAC Oblique Puncture on OCA Lid

**Figure A-7** – CTU-4 Puncture Drop Test No. 14; Close-up of Damage; ~2½" Deep

7. *Can you demonstrate that you have taken into account the ambient temperature of 38°C and solar insolation as specified in paragraph 728 of IAEA regulations in order to determine the effect on the various components of the package, under accident conditions of transport?*

**Response:**

Referring to Appendix 2.10.1, prior to fire testing the CTU's were placed into an oven overnight and heated to a uniform temperature consistent with the temperatures calculated for the normal conditions thermal evaluation (see SAR Table 3.4-3). The CTU's were removed from the oven on the morning of the fire tests, wrapped with blankets, and transported to the fire test site. The following is a summary of the fire test initial conditions and results

| Test No. | Test Description (Certification Test Unit No.) | Test Temperature (ºF) | Test Unit Angular Orientation | | | Results |
|---|---|---|---|---|---|---|
| | | | X-Axis (0º = horizontal) | Vertical Axis (0º = upright) | Z-Axis (0º = horizontal) | |
| 15 | HAC Fire Test (CTU-1, CTU-2, CTU-3) | 132 | 90º | 0º | 0º | CTU-1: ~1,809 ºF (987 ºC) temperature, ~32 minutes<br>CTU-2: ~1,972 ºF (1,078 ºC) temperature, ~36 minutes<br>CTU-3: ~2,025 ºF (1,107 ºC) temperature, ~30 minutes |

Since the CTU's were preheated to normal conditions temperatures, the temperature effects due to solar insolation were accounted for prior to fire testing. The subject of thermal effects is discussed in detail in Sections 3.4 – Thermal Evaluation for Normal Conditions of Transport and 3.5 – Thermal Evaluations for Accident Conditions of Transport.