Industrial Nuclear Company
NRC Request for Additional Information (RAI)
Docket No. 71-9360
Model No. Ten Hole Source Changer Package

By letter dated October 2, 2018, Industrial Nuclear Company, Inc. (INC) submitted an application for a Certificate of Compliance (CoC) for the Model No. Ten Hole Source Changer (THSC) transport package. This RAI letter identifies information needed by the staff in connection with its review of the application. NUREG-1609, "Standard Review Plan for Transportation Packages for Radioactive Material," was used by the staff in its review of the application.

Each individual RAI describes information needed by the NRC staff to complete its review of the application to determine whether the applicant has demonstrated compliance with the regulatory requirements.

Materials Review

2.1 Provide Standards for material which are not present in the Drawing and SAR.

The Drawings and SAR do not specify the Standards (e.g., ASTM, ASME) for some of the packaging components. They include, but are not limited to cast alloy, stainless steel, brass and rubber.

Response: The packaging components that are Important to Safety (ITS), Quality Category A or B items, are specified with the appropriate material standards for the component, e.g. ASTM, on INC's Drawing Number THSC-SAR-TA. For the components that are classified as Quality Category C or Not Important to Safety (NITS), a national standard is not required for the item to perform its design function. For example, the seal (Item Number 24) acts a moisture and dust barrier for the THSC interior. Hence, any rubber material would be acceptable for this item to perform this function. Revision 1 of INC general Arrangement Drawing THSC-SAR-TA has been updated to include the Quality Category levels in accordance with the guidance from NRC Regulatory Guide 7.10, Rev. 3, *Establishing Quality Assurance Programs for Packaging Used in Transport of Radioactive Material*, for all packaging components. The quality level clarifies the component's safety importance for performance of the packaging.

Thermal and Shielding Review

3.1 Considering the response of the package to the hypothetical accident condition thermal test (fire), please provide the following:

1) proof that the depleted uranium (DU) shield for the package does not oxidize, and
2) justification that the package will not be adversely impacted by thermal stresses.

Oxidation of the DU shield may result in loss of shield integrity, and an associated loss of shielding ability. Under the hypothetical accident fire condition, the polyurethane foam may char, and after out-gassing has ceased, oxygen could either enter the outer shell to interact with the DU shield which will remain hot for some time after the hypothetical fire accident. In addition, the applicant states that the effects of HAC thermal stresses on the transportation package are minimal. However, the applicant neither performed thermal testing nor provided thermal analyses in the application. Therefore, the application currently does not demonstrate the oxygen inhibitive nature of the charred foam. The application also does not demonstrate that the thermal stresses are in fact minimal and result in no adverse impacts on the package. As a result, the staff requires additional analyses or evaluations to demonstrate that both the oxidation of the DU shield for the package and the thermal stresses experienced by the package under the HAC fire would not adversely impact either the shielding or the structural capability of the package.

Response:

1) As discussed in the conference call with the NRC staff on February 14, 2019, there are four conditions required to occur for potential oxidation of the THSC depleted uranium (DU) gamma shield from the hypothetical accident condition (HAC) thermal test. These four conditions are: (1) the polyethylene pipe plugs would have to melt; (2) the polyurethane foam would have to be damaged; (3) availability of oxygen to the DU metal surface; and (4) temperature of the DU metal needs to reach and exceed the DU oxidizing temperature. Each of these four conditions will be discussed separately in relation to the THSC packaging.

   1. **Melting of Polyethylene Pipe Plugs:** The purpose of the three (3) 1/4-inch NPT pipe plugs, which are installed symmetrically around the THSC body shell, is to melt during the HAC fire event, and allow a passageway for the escaping of gases from the combustion of the polyurethane foam. With the pipe plugs melted, the total open area of these three ∅0.49163 inch pipe threaded holes in the 0.18 inch thick body shell is 0.57 square inches.

   2. **Damaged Polyurethane Foam:** As a result of the 30-foot free drops, the maximum deformation of the THSC stainless steel structure that affected the polyurethane foam occurred during the side drop. For this orientation, the deformation of the outer shell was a flat area approximately 0.2 inch deep × 3¾ inch wide along the package height. For this degree of deformation, the polyurethane foam would have been compressed slightly, and possibly created some cracks within the in-situ poured expanded foam. However, the overall damage to the foam would be minimal. All other free drop and puncture drop orientations resulted in no observed damage or failed weld joints to the THSC package that would have significantly affected the polyurethane foam. Since the foam was not significantly affected by the free and puncture drop events of 10 CFR §§71.73(c)(1) and 71.73(c)(3), the foam will be fully consumed during the 30-minute fire event per 10 CFR §71.73(1)(4). After being fully combusted, the polyurethane foam will act as a charred layer surrounding the DU gamma shield. This charred layer provides insulating benefit to the DU gamma shield surface.

   3. **Availability of Oxygen to Reach the DU Shield:** As noted in Condition 1 discussion, the total open area for the (3) 1/4-inch NPT thread holes is 0.57 square inches. In addition, there is a ∅3/4 inch hole in the center of the mounting plate that also accesses the polyurethane foam cavity, which has an open area of 0.44 square inches. Since no other structural weld joint failures had occurred in either certification test unit (CTU), the total open area to permit oxygen to enter the interior cavity where the DU gamma shield is located is slightly more than 1.0 square inch. Conservatively assuming there is no further out-gassing occurring following combustion of the foam during the remaining fire duration, and no credit for the closure lid providing an additional flow restriction, there is minimal access for oxygen to enter and oxidize the DU metallic surface with the restricted open areas and the charred polyurethane foam surrounding the DU gamma shield.

      For comparison, the IR-100 Exposure Device (Docket Number 71-9157) is similarly constructed with a ∅3/4 inch thru hole into the inner cavity. In addition, one of the certification test units (CTU) sustained a failed fillet weld on the lower weld joint of the body that resulted in a gap into the DU gamma shield cavity. The gap was approximately 3/16-inch wide × 7 inches long (~80% of the package length). The IR-100 CTU was then tested in accordance with the HAC thermal test of 10 CFR §71.73(1)(4) with this failed weld joint and the ∅3/4 inch thru hole. A post- test radiation survey of the IR-100 CTU demonstrated that the DU gamma shield safety function was not degraded. Following the radiation survey, visual examination of the inner cavity revealed the charred foam surrounding the shield, and that no significant oxidation of the DU gamma shield had occurred.

4. **Temperature of the DU Metal:** During the transient HAC thermal test, the THSC package would be exposed to a 1,475 °F (800 °C) fully-engulfing fire. Radiation and conduction heat transfer would then gradually increase the bulk temperature of the THSC package, including the heavy DU gamma shield that is located in the interior cavity. Since the DU gamma shield is surrounded by the polyurethane foam, the foam will act as an insulator until it is fully combusted by the increased temperature. The total mass of the 20 lb_m/ft^3 polyurethane foam is approximately 10 pounds. Once the foam is fully consumed, the foam char will continue to insulate the DU gamma shield to some degree as the duration of the fire continues for the remainder of the 30-minute period. As evidenced of the charred foam behavior, the post-test examination of the much smaller and lighter IR-100 Exposure Device following the full-scale burn test demonstrated that the charred foam remained in-place, surrounding the DU gamma shield, which exhibited no significant oxidation. As documented in the IR-100 SAR, there was no deterioration of the package's shielding safety function due to the accumulated damaged from the free and puncture drops, followed by the thermal test. Note that the IR-100 Exposure Camera has a total of approximately 2 pounds of the same 20 lb_m/ft^3 polyurethane foam, and a DU gamma shield mass of 36-38 pounds. Comparing the mass values of the smaller and lighter IR-100 Exposure Camera to the larger and heavier THSC package, the THSC has five times the polyurethane foam mass, and over six times the DU gamma shield mass. Additionally, the minimum distance from the THSC outer package surface to the DU gamma shield surface is 0.845 inches versus no distance (i.e., contacts the metallic body sides) between the IR-100 outer package surface to the DU gamma shield surface. By this comparison, the peak temperature from the 30-minute thermal test for the THSC DU shield is bounded by the peak temperature experienced by the DU gamma shield in the IR-100 Exposure Device, which did not experience any deterioration of the shielding effectiveness, from the thermal test.

In summary, the degradation of the shielding function of the THSC DU gamma shield assembly will not occur due to oxidation from exposure to the HAC thermal event. As discussed above, the two primary reasons for no significant oxidation of the DU gamma shield to occur are the presence of the polyurethane foam char and the flow restrictions for oxygen to enter the cavity. Section 2.7.4, *Thermal*, of the THSC Safety Analysis Report has been revised to include this additional information that demonstrates oxidation of the DU gamma shield will not occur.

2) The THSC package is a welded, austenitic stainless steel package, which will thermally expand uniformly, resulting in no significant thermal stresses. The DU gamma shield is not rigidly restrained in the THSC stainless steel structure. The DU shield is supported in the welded body of the package at (11) eleven separate points (one on top, two on bottom, and eight on the side). At each DU shield support point in the package, a 1/8-inch thick copper shim is installed between the DU and the stainless steel. These copper shims are ASTM B152, Type 110 copper, which has a specified Rockwell F hardness of 43-57. The Type 304 stainless steel structural packaging material that restrains the DU gamma shield has a Rockwell B hardness of 92. Additionally, depleted uranium metal is extremely hard, with a Brinell hardness of 187 (equivalent to a Rockwell B hardness value of 90.7) for cast DU. Since the copper shim material is softer than either the DU or the stainless steel, the copper shims will plastically deform under any differential thermal expansion that may occur between the stainless steel and

the DU gamma shield, and thus, preclude the formation of any excessive thermal stresses in the THSC package from the single HAC fire event. Additionally, the stresses developed in the package from the multiple 30-foot free drop tests of the full-scale prototypic test units produced plastic deformation of the package stainless steel structure that exceeded any potential thermal stresses from any differential thermal expansion that may occur during the single HAC fire event. Section 3.4.4, *Maximum Thermal Stresses*, of the THSC SAR has been revised to include this additional information, thus supporting the assertion of no detrimental condition affects the shielding or confinement safety functions of the package.