NOTE TO: **FILE**

DOCKET NO: **71-9315**

SUBJECT: **7/18/05 - CONFERENCE CALL WITH DEPARTMENT OF ENERGY, NATIONAL NUCLEAR SECURITY ADMINISTRATION (NNSA), TO DISCUSS PROPOSED RESPONSES TO A REQUEST FOR ADDITIONAL INFORMATION CONCERNING THE MODEL NO. ES-3100 TRANSPORT PACKAGE**

ATTENDEES:

	NRC	NNSA
	Shawn Williams	Jeff Arbital
	Jason Piotter	Jerry Byington
	Antonio Dias	George Singleton
		Jim Anderson
		Noel Cramer
		Monty Goins
		Kim Handy

DICUSSION:

The discussion followed the discussion notes below that were provided by NNSA:

2-10 Provide relevant details regarding what cases and under what circumstances the modeling techniques utilized are valid.

In three locations in the SAR, the use of the language "has been historically used" (pages 2-173, 2-186), and "has historically shown" (page 2-183), is insufficient to make a determination of fact regarding the adopted FEA modeling approaches.

The text "has been historically used" was meant to indicate that similar techniques were used on previous NNSA-approved shipping packages. If there is a problem with using the wording "has been historically used", then this text can be removed from the SAR.

2-11 Justify the use of LS-DYNA material *MAT_SOIL_FOAM for modeling the Borobond and Cat 277-4 material (HABC).

Given that compressive strength material properties were obtained using ASTM C109-02 *Standard Test Method for Compressive Strength of Hydraulic Cement Mortars* and that reported material properties are more representative of lightweight concrete rather than soil or foam, it is unclear as to why a concrete material model was not used for the Borobond and Cat 277-4 (HABC).

From the LS-Dyna Theoretical Manual, the reference for the derivation of the *MAT_SOIL_FOAM model (also known as "Material Model 5") is: "Krieg, R. D.,"A Simple Constitutive Description for Cellular Concrete," Sandia National Laboratories, Albuquerque, NM, Rept. SC-DR-72-0883 (1972)." Therefore, even though the material model does not include concrete in its title, it can be used as a concrete model. The HABC material 5 model was derived from test data in a similar manner as was the Borobond. The Borobond model used for the ES-3100 was previously used on the Y-12 Highly Enriched Uranium Materials Facility (HEUMF) rackable can storage box (RCSB). Would presentation of previous work (comparison of test vs analysis) using this same HABC model be sufficient?

2-12 Provide an example calculation and source used to derive the pressure vs. volumetric strain relationship from the uniaxial strain information for Cat 277-4 (HABC). Specifically address how the coefficient, mu (:) was derived, where mu is the ratio of lateral strain to longitudinal strain.

Given that volumetric stress strain data is lacking, a full methodology along with assumptions and sample calculations is necessary for determining if the derivation is appropriate.

Section 6.2 in Appendix 2.10.2 contains the methodology used for derivation of the volumetric data used to obtain the volumetric data from the uniaxial data. The use of “ : ” in the equations on page 2-367 is a typographical error and will be changed to “<”, which was obtained directly from the test data. Would the reviewer like to see a detailed calculation with all of the numbers substituted into the correlations?

2-13 Provide methodology and justification for the extrapolation beyond 0.6 volumetric strain for the Kaolite 1600 material.

It is unclear what procedures were used to extrapolate the stress strain curve for the Kaolite material. Test reports indicate that a sixth order polynomial was used, however, the basis and formulation of this technique was insufficient.

LS-Dyna will not extrapolate material data curves. If the end of the material data curve is reached in a solution, the solution will be stopped due to an instability. Therefore, a “lock-up” point or an extreme point needs to be defined before the solution is started. This limiting value is required input in the material *MAT_HONEYCOMB model. This point and the transition from the test data to this point are assumed data points. In general, the Kaolite state of strain throughout the 10 CRF 71 required impacts is within the test data region (i.e., the “lock-up” point is not reached). The regions of Kaolite which exceed the test data in the solution are typically very localized and occur at corners or small regions. Would an image showing the state of strain experienced by the Kaolite during the impact suffice?

2-14 Justify the lack of pre-torqueing of the stud nuts or the CV nut ring in the finite element analysis.

Bolt /stud preload can have a significant effect on the resistance to shear loading. No explanation is given that takes the interaction of shear and tension into account.

Pre-loading is important when all the components remain elastic. Pre-loading of bolted joints has been employed in the past and found not to be beneficial to the model. Drum studs that become highly loaded during an impact reach the plastic range, which releases any elastic pre-load. The pre-load stress in the CV flange throat is on the order of 125 psi, which is a very low elastic stress and is difficult to apply in LS-Dyna.

2-15 The SAR states that, "the lower nodes on the studs are allowed to merge with the angle nodes" (page 2-173). Describe what is meant by merge. There are a variety of ways to construct transitions of this type. It is unclear what has been used.

The process of merging nodes in TrueGrid (preprocessor) results in the creation of a single node from multiple nodes within a prescribed tolerance band. This technique is used in the model to connect welded or fastened components (e.g., nut to stud, or angle to drum). Does this explanation satisfy the comment or is additional information/explanation needed?

2-16 Justify the termination of the transition near the midpoint of the diameter of the adjacent washer rather than at the exterior edge of the washer.

Figure 2.1.7 on page 2-173 shows a shell to solid element transition for the drum lid. The load path in this region is from the nut to washer in bearing and from the washer to lid in bearing. Eliminating the bearing surfaces prematurely may have an impact on the stress distribution in this region.

An LS-Dyna option of using a contact surface based on the plate thickness was employed in the ES-3100 model for bearing between the nut, washer, and lid. The use of this option results in full contact between the angle, lid and washer. Brick elements around the fastener holes in the lid were used since the contact between the lid and stud due to shear is better modeled with these type of elements. Extreme discontinuities at the location on the lid where the brick/plate element transition occurs were not observed in any of the strain plots generated from the analyses.

2-17 Justify the use of constrained Kaolite material properties in the analytical models rather than unconstrained Kaolite material properties.

Using constrained Kaolite material testing properties that were obtained to "simulate the deformation mode of accident conditions…" in effect is overestimating the material properties of the Kaolite. Using constrained Kaolite properties, and then constraining it again with the exterior drum in the ES3100 simulation in effect "double counts" the Kaolite contribution to strength.

Unconstrained Kaolite material data cannot be obtained for the regions of strain which the package will see. The testing of unconstrained samples above the point at which initial cracks are formed results in spalling or degradation of the test specimen.

2-18 Demonstrate that the relative volume at full compaction and the density reported for the low stiffness (V = 0.10, D = 27 lb/ft^3), average stiffness (V = 0.20, D = 22.4 lb/ft^3), and high stiffness (V = 0.12, D = 27 lb/ft^3) are accurate.
The numerical trends for the relative volume at full compaction as well as the density appear to be counterintuitive. The expectation would be that for relative volume at compaction, the average stiffness case would fall between the low stiffness case and the high stiffness case. This is particularly true given that the density of the average stiffness case is lower than both the low and high stiffness case.

This comment is related to RAI 2-13. The point of "lock-up" assumed for the Kaolite material cannot be justified by existing data. These are assumed values as stated in the SAR on page 2-187. The state of strain in the Kaolite does not reach this limiting value. However, these assumed values are required as input to the material model.

2-19 Demonstrate that using engineering stress strain information for 304 stainless steel stud connectors is appropriate for use as input into LS-DYNA numerical models. True stress strain data is presented in the data tables in the SAR but was not used.

LS-DYNA computes true stresses and true strains. The input for material should be true stress / true strain as well. Elongation at failure is not a failure strain but a measure of ductility that can under predict the true failure strain because it is dependent on gauge length. To obtain a true failure strain, one must utilize the reduction of area to calculate the localized strain at the location of necking. Additionally, the use of an engineering stress strain curve severely under predicts the amount of strain energy that can be absorbed by a material. The mixed use of failure strain and ultimate stress is also inappropriate for this analysis. Ultimate stress is generally not considered the point in which the material fails.

The use of the engineering stress/strain data in the model of the studs is conservative from a design point of view. There are many unknowns in the welded stud/lid joint such as static/dynamic friction, properties of the heat-affected zone of the weld and final geometry of the welded stud at the lid interface. There are also tolerance differences that can be critical in situations like the lid corner impact. Analyzing each of these perturbations would be time consuming. The use of engineering stress/strain data has been shown to produce conservative results.

3-1 Justify the assertion (on page 3-29 of the application) that "little or no hydrogen gas is generated inside the containment vessel due to thermal- or radiation-induced decomposition of the water vapor (limiting moisture content in oxide: 3 wt %) or polyethylene bagging (limiting plastic content: 500 grams). Provide a detailed and bounding calculation indicating the time evolution of the hydrogen concentration as it approaches a conservative flammable limit (5% volume in air). Address the generation of helium from the radioactive decay (alpha sources) of the contents. Include the effect of these gases upon the maximum operating pressures (normal and accident conditions). Modify the SAR so that a time limit for keeping a sealed and uranium-filled containment vessel is specified.

Will the comment be resolved if the following change is made in the SAR?

The last sentence of Sect. 3.4.2 will be revised to read as follows:

> Little or no hydrogen gas is generated inside the containment vessel due to thermal- or radiation-induced decomposition of the water content or polyethylene bagging. Radiolysis is not an issue because the contents in this application have a dose rate below the threshold where any significant radiolysis would take place (Sect. 5.0). The uranium content is unirradiated; therefore, only very small quantities of fission gas products will be produced from spontaneous fission and subcritical neutron-induced fission. Fission gas products are produced in such small quantities that they have no measurable effect on the releasable content source term or containment vessel pressurization.