11/5/02

Section 3.0 Structural Evaluation

Background

This section describes the structural consequences of a jetliner crashing onto a spent fuel dry storage cask facility, as well as onto a transportation cask. The effects of the jetliner fuel tanks and resulting potential for a fire are described in Section 4 (Thermal Evaluation) of this paper. Assessing the structural designs and capabilities of existing certified cask designs, four dry storage cask systems (out of seven) and two transportation casks systems (out of sixteen) were selected for structural vulnerability evaluations. The commercial jetliner selected for the evaluation was a . The primary reason for selecting the jetliner is it was the only structural computer model available for analyses in the short term. A contract was established with Boeing Aircraft Company, to confirm the adequacy of the computer model for NRC's intended purpose and to obtain data on a The aircraft is widely used throughout the world and was used ) The data for the aircraft will enable the staff to develop such a computer simulation for additional studies, if needed. Section 2.0, of this report, describes various commercial jetliners used in this country.

Ex 2

The four storage casks selected for vulnerability studies were the HI-STORM 100, NUHOMS 32P, TN-68, and VSC-24. The two transportation casks selected for vulnerability studies were the NAC-UMS and the NLI 1/2 tied down to a rail or a truck bed, respectively. The selection criteria for cask assessments included construction materials (steel, lead, concrete, etc.), number of casks in operation, heat load, and spent fuel content.

Scenarios of a Jetliner Crash

Looks good.

3.1 Structural Evaluation

Realistic analytic structural evaluations of an aircraft crashing into spent fuel dry storage casks are highly complex and require days of execution on a super computer. Given the limited availability of super computers (used for defense and vulnerability studies for other agencies), the staff focused on one design for this report. Analyses for other cask designs will be completed at a later date.

3.1.1 Storage Cask

The aircraft crash analyses described in this section was on a HI-STORM 100 certified cask design (10 CFR Part 72). The spacing of casks on a concrete pad is approximately 15 to 18 feet in a square or rectangular pattern (See Figure 3-1). Consequently, a jetliner crashing into an ISFSI would affect a number of casks at the same time. Some casks would be impacted by the aircraft's fuselage and other casks would be impacted by the wings and engines. Since the shear strength of the wing connections to the fuselage is not significant, the wings would immediately separate from the fuselage during the crash. Consequently, a fuselage impacting a single cask is the governing event in the cask vulnerability study. The staff, therefore, analyzed the structural responses of a jetliner crashing into a single HI-STORM cask and their interactions on the impacted adjacent casks. Modeling a jetliner crashing into a series of casks would be highly computer time intensive and result in significant delays in obtaining results.

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Portions Ex 2

The HI-STORM 100 cask (see Figure-3.1.1) consists of a concrete overpack.... 360,000 lbs.

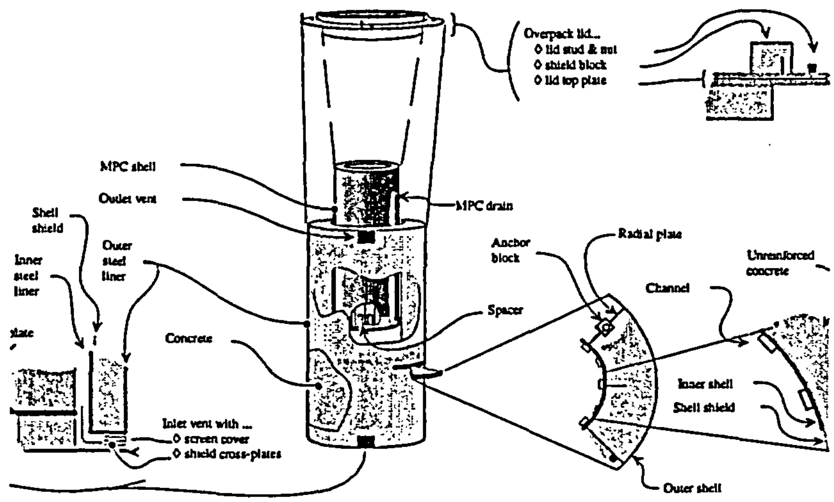


Figure-3.1.1 HI-STORM 100 Cask Description

*Two bounding analyses were performed... ...in the public arena and validated by Boeing for NRC needs.*

Local penetration effects... ...the Riera method (benchmarked by experimental test of a military aircraft crashing onto a concrete slab)...

Calculational Uncertainties:

The analyses performed in these studies were realistic, in that realistic material properties (e.g., mean values) and realistic analytic methods (state-of-the-art structural computer codes) were applied. Recognizing that the analytic methods and material properties have associated uncertainties, the staff attempted to assess the potential implications of those uncertainties.

The following are the major...

Conclusion

Based on the... ...as designed. The major reason for not breaching the canister stems from the fact that the cask is able to move, thereby not absorbing all the energy derived from the plane onto the cask. In addition...

3.1.2 Transportation Cask

The NAC/UMS cask was designed for rail use. The cask is ... (Do we have a picture of the cask?)

A jetliner crashing into the NAC/UMS rail cask could result in dislodging the cask from the rail car. The tie-down system is only designed to resist a loading of 5 times the weight of the cask. Therefore, the cask would be expected to behavior similarly as the storage cask, in that the cask would not absorb all the energy from the jetliner due to its ability to move. Assuming... Why are we extrapolating from the storage results? Why are we not calculating the results?

2.0 Plane Impact Scenarios

a. Plane Selection

i. Types/Selection

A aircraft was selected in the study of jetliner crashing into spent nuclear fuel storage casks. The primary reason for selecting this aircraft is that a finite element computer model was developed for the fuselage at the Sandia National Laboratories. This model was developed in years past to resolve safety issues related to transportation of plutonium by air. The staff contacted other national laboratories, the armed services and other government agencies in search of analytic models of jetliners. The model at Sandia was the only one available. The analytic model was Ex 2

ii. Basis

Delete this section. Boeing said the most likely plane is a because it is frequently chartered. If you want, you could retitle this as "Comparison of a with Other Jetliners." Ex 2

b. Aircraft Model

The finite element model of the aircraft was initially developed from publically available information. The fuselage model was benchmarked dropping a real fuselage onto an unyielding surface (confirm this with SNL). While the resulting load Ex 2

Portions Ex2

from the drop test was far from a crashing aircraft, it provided some assurances that the computer code and the input model of the aircraft fuselage were reasonable. Both the Office of Regulatory Research (RES) and the Office of Nuclear Materials Safety and Safeguards (NMSS) are jointly working on developing an analytic structural model of the aircraft. RES is *performing experimental validation of the analytic computer* code and NMSS is validating the computer input model of the airliner through Boeing. This joint effort has been very productive in developing realistic vulnerability estimates. Ex2

The possible outcome of the model enhancement will be completed by the time this paper goes out. *Do we need it?*

Portion Ex2