ANATECH CORP.

Consulting Engineers

Linking Theory and Practice

April 17, 2003

Dr. E. William Brach, Director
Spent Fuel Project Office
Office of Nuclear Material Safety and Safeguards
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555-0001

2/21/03
68FR 8530
(26)

RECEIVED
2003 MAY 12 PM 1:36
Rules and Directives Branch

Re: Subject: PPS Test Protocols Report (NUREG-1768)

Dear Dr. Brach:

The attachment contains my comments on the Package Performance Study submitted in response to your letter dated February 20, 2003. The comments are given in two parts: General comments on the Test Protocol, and specific comments on the issues raised in the Executive Summary of NUREG-1768. Please let me know if further information is needed.

Sincerely,

Joseph Y. R. Rashid
Chairman

YRR/dg

cc : Dr. Albert Machiels, EPRI
Dr. Andrew J. Murphy, Jr., U. S. Nuclear Regulatory Commission

E-RIDS = ADM-03
Add = A. Snyder (AMS3)
A. J. Murphy (AJM1)

Template = ADM-013

5435 Oberlin Drive, San Diego, CA 92121 • Phone: (858) 455-6350 • Fax: (858) 455-1094 • www.anatech.com

Comments on
The PPS Test Protocols Report (NUREG-1768)

General Comments

1. *Public Perception:* The impact test protocol proposes drop tests at impact velocities in the range of 60-90 mph, which puts the drop event in an unknown accident-category. The NUREG calls this an "improbable extreme accident". While it is possible, but highly improbable, to have a train carrying a spent-fuel cask travel at 90 mph, the impacted surface in the case of derailment would not be an unyielding essentially-rigid surface. In the interest of conveying the correct perception to the public, some word smithing is needed here to remove the impression that the test protocol is an accident simulation.

2. The broadly stated objectives of the study anticipate pre-conceived results, which may not be borne out. If all three objectives, namely, demonstration of the inherent safety of the package, validation of analytical tools, and gathering data for refining dose risk estimates, were to be fully realized, many more tests than planned will be needed requiring a number of test specimens. Moreover, the potential for generating conflicting information is relatively high. For example, in order to validate predictive capabilities, cask response and post-test residual deformations must be sufficiently measurable to ensure quantitatively meaningful validation. Consequently, one would not expect end-closure integrity, which is the primary response entity being tested, to be maintained under a CG-over-corner drop from a 270 foot height onto an unyielding surface. This is in direct contradiction of the current leak tightness criterion, which is the only accepted definition of "inherent safety" at design basis conditions. Since no test is proposed to validate the package performance at, or in the neighborhood of, the design basis, demonstrating leak tightness at beyond-design-basis conditions becomes problematic.

3. To the above comment, testing the cask at the design-basis 9-m drop, as has been recommended by the Structural Panel, should be seriously considered, not as a replacement of the test protocol but as an added test, and only for the rail cask at CG-over-corner drop. If we were to believe the robustness of the cask, as has been advertised, the additional cost should involve only the replacement of the impact limiter and possibly some of the bolts and the seals, which could be determined by a leak test. Value-added of such a test, both in terms of public perception and scientific data, is not to be under-estimated.

4. It is not clear from the description of the test protocol if instrumentation of cask internals is contemplated. If not, then including a surrogate fuel assembly in the cask is an unnecessary costly complication. The response of the fuel assembly is highly complicated and can be treated analytically through passive coupling to the cask, i.e. the assembly responds to input from the cask but does not modify the cask motion in any measurable way. The PPS team is encouraged to study SAND90-2406 carefully to see how the complex assembly behavior was treated.

5. Further to Point 4 above, the special-effects drop test of a bare surrogate assembly should be re-evaluated for its true scientific value. In the first place, it is costly to simulate the mass of UO2 fuel pellets by using depleted uranium, or even the lower-mass-density lead, pellets. More importantly, a fuel assembly with no prior irradiation history behaves totally differently from a real assembly in cask with several assemblies stacked above it, irradiated cladding, incipient flaws, embrittled spacer

grids, etc. Again, SAND90-2406 shows that the governing behavior regime of the assembly is the buckling and crushing of the embrittled spacer grids leading to pinch-loading of fuel rods with ID flaws. This deformation mode gave the highest failure frequency. An unirradiated assembly dropped onto a hard surface will simply bounce and vibrate, which is a deformation mode that is of little value to computer models validation of interest to package performance.

6. No discussion is given in the test protocol as how to ensure a CG-over-corner orientation when the cask hits the impact surface. This would be impossible to maintain, even falling through any height. For example, an impact angle slightly larger than the CG-over-corner angle would result in an end-on secondary impact instead of a horizontal secondary impact. A guide structure or a cable system must be provided, which could interfere with the free-fall based impact velocity as well as the slab-down secondary impact phase of the event.

7. Major importance is given to the peak acceleration as the parameter to match by calculations within 10-20%. In the first place, the impulse momentum is the true measure of loading intensity, not the peak acceleration. Secondly, the high frequency vibrations (noise) in the acceleration record contains sharp acceleration peaks of very high values that have little or no effect on the cask response, and are usually removed by filtering the raw acceleration record. This is all familiar to experimentalists, but the point of this comment is to include the impulse momentum as a response variable to be quantified. For accelerometers mounted close to the cask's center of mass, the time integral of their averaged acceleration records can be directly correlated with the initial velocity, within a small error due to loss of the crushed mass in the impact limiter.

8. With regards to accuracy of input mentioned in Point 7 above, a vertical drop test has a significant advantage over a sled-mounted cask impacting a vertical surface. The appropriate drop height will have to be pre-determined by analysis as suggested in the NUREG-1768. However, the proposed modeling details, finite element representation, materials behavioral constitutive modeling and special components tests can benefit from expert peer review prior to and during the conduct of the analysis. Experience indicates that analysis rigor is not always achieved through the use of large finite element grids. Lessons learned from the SAND90-2406 study would be a good place to start for the PPS analysis team.

9. The impact limiter is the dominant cask component in determining the g-loading on the cask. The finite element model of the impact limiter should first be validated using experimental data from the cask vendor. This data should be available to the PPS since it was used for cask certification. The proposed impact limiter tests, aside from being proposed for technical completeness, imply that either the vendor's experimental data is not available or not sufficiently detailed, or the impact limiter used is not as the one originally fabricated for the cask. In the case of the latter, the question remains open as to the validation of design-basis "inherent integrity" of the casks already in service, as suggested in Comment 3 above.

10. The closure bolts are the most critical components, and should be modeled in detail, including pre-load, bending and shear behavior, bolt-hole clearance and friction on the mating surfaces. Representation of bending stiffness in PRONTO, in the absence of beam-element capability, will require a large number of elements across the bolt diameter, which would be impractical to include for all the bolts. At least, few bolts at diametrically opposite locations can be modeled in detail. Representation of the pre-load might also be a problem for PRONTO, as is evident from the present

pre-test calculations reported in the NUREG. Representation of the pre-load as a pseudo thermal contraction in one direction is a simple analytical device that should be present in PRONTO.

11. As a general comment, the proposed testing program, if billed as a scientific experiment to enhance our analytical capabilities, then this reviewer is totally supportive. However, if the program is advertised as a means to convince concerned members of the public of the "inherent safety" of transportation casks, then it has the potential to create more questions than it answers. In this regard, this reviewer highly recommends modifying the test protocol to include the design-basis drop event described in Comment 3 above.

Specific Comments on the Eleven Issues Raised in the Executive Summary

The following comments constitute a summary of the general comments listed above, and as such are given in a brief form.

1. *Number and type of cask:* The number of casks selected is consistent with the objective of collecting data for computer model validation. Clearly, the more tests one conducts the higher the quality of the validation, but the added improvement is not worth the cost. The types of casks selected have sufficient features for the results to be generally applicable.

2. *Scale of test article:* Full scale as proposed is best suited for the stated objectives because of the highly non-linear behavior anticipated.

3. *Vertical drop vs. horizontal impact:* Vertical drop is preferred.

4. *Speed and Orientation of rail cask:* A horizontal orientation is more governing for fuel assembly behavior, (see SAND90-2406), but this is not a fuel behavior test protocol. Also, the horizontal orientation is easier to analyze, but the CG-over-corner orientation is more challenging analytically and can, therefore, yield wider results.

5. *Impact velocity:* The velocity should be high enough to produce meaningful validation of computer models, and consequently should be selected by pre-test analysis. It should not be based on the probability of the event, because the test protocol is not a simulation of an "accident event".

6. *75 mph speed:* See the previous comment. However, given what we currently know, a 75 mph speed should be adequate.

7. *Speed for the back-breaker truck cask:* Should be the same as the drop-test impact velocity.

8. *Cask fire test:* No comment.

9. *Cask position in fire test:* No comment.

10. *Number and type of fuel assemblies:* No surrogate or real assemblies should be included. Mass simulation only should be considered.