Robert E. Luna, Ph.D., PE
Consultant
10025 Barrinson NE • Albuquerque, NM 87111 • (505) 821-9110 • FAX (505) 858-0764 • lunar@asme.org

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To: John Cook, USNRC

From: R. E. Luna, Consultant

Re: Analysis of 12/15/99 LLNL Memo Report to Ms. Patricia Eng, USNRC Spent Fuel Project Office (NTSS00-24/LEF)

The referenced memo contains an account of issues remaining from an LLNL review of the draft SNL report that updates the risk analysis for spent fuel shipments contained in NUREG-00170. The initial portion of the LLNL memo documents the review process through December 15, 1999 and is not the subject of this memo. The remainder of the memo deal s with what LLNL believed were significant remaining problem areas with the SNL report prior to the SNL work to revise and issue the final report.

This memo is an attempt to put the issues cited by LLNL in perspective relative to the entire project and to identify which, if any, of these are potential "show stoppers". Since the activity is now on a highly time compressed plan to proceed to publication in February 2000, any significant problems might require pursuing a re-write and or re-analysis.

I have reviewed the same version of the report as the LLNL team and share some of the misgivings expressed, in general by the LLNL reviewers with regard to its clarity and communicability to the public. The version to be completed thin month will likely respond to many of the LLNL review comments. I would disagree with the LLNL suggestion that it lacks robustness. In comparison with NUREG 00170 and the Modal Study, the current study is much more complete and better grounded in technology and data sources than the earlier documents. It may be that the question of robustness arises from a desire to see all features of the risk calculation resolved to the same degree of certainty/detail. This is neither feasible nor necessary. Emphasis on resolving detail and achieving a level of certainty must be placed on aspects of the models and data that have the largest effect on the magnitude of the risks. It would be wasteful of effort to do otherwise.

With regard to communicability to the public, it is not clear that a report such as this is ever a tool for communicating to the public in general. The SNL document is written primarily for communication with technologists and some segments of the interested public. Even in that role it lacks (as do many technical documents) all of the detail that every specialist would like to see and believes that they put into their own reports. It seems clear to me that communication of these results to the public must be in a separate document written with the general public as the primary audience as was done by NRC in the past for the Modal Study undertaken by LLNL. In such a document the relationship in time, detail and scope among NUREG-00170, the Modal Study, the current study, and other program/agency specific risk assessments can be put into perspective.

Overall I believe that the LLNL review contains no technical showstoppers, but provides some valuable questions and insights that could improve the product now in hand, were there time and resources. However, I do not expect that the technical issues put forward by LLNL would change the results significantly.

Detailed Evaluation of Issues Raised in the LLNL Memo Report

The following is divided into eight sections to parallel the structure of the LLNL memo.

Methodology/ RADTRAN (pp 4-5) – This first section is mainly a request for more explanation of how the problem was organized, what assumptions were made, how the calculation of risk was carried out, and how consequence is calculated in the RADTRAN code. Much of the information the reviewers desire is provided is in voluminous RADTRAN reference material that the authors presumably felt need not be included in the report.

One suggestion made is that the LHS selection process for route segments gives a result that washes out the contribution of very high or very low risk routes from the result. Since the segment characteristics are selected using structured Monte Carlo methods to sample each distribution of route parameter values, parameter values are chosen from each portion of the range of each distribution. In the report, the use of 200 samples is shown to be adequate. Thus the results developed should capture both the extremes of the sampled distributions and also their means and the high or low risk routes should not be unduly slighted.

Summary – Clearer description of the new aspects of this study could be expected in the next draft, but reliance on references that are generally available for detail seems to be within reason for a technical publication.

RADTRAN INPUT (pp 5-6) – Much of this section relates to the TI for the packages selected for use in RADTRAN. The presentation deals with some of the details of how RADTRAN gets an effective TI for the package, but doesn't really suggest the values used in the report were incorrect. It does question using two different spent fuel age design base assumptions for the calculations. This seemed a bit peculiar to me as well, but really has no bearing on the incident free risk calculation, because the TI used in the analyses is constrained to keep the external radiation field near and somewhat below the regulatory limit as pointed out by the reviewers. The observation that short cooled fuel couldn't be shipped in a rail cask of current design is probably true, but not relevant here. Apparently SNL used the hotter fuel as the basis for the accident calculations to provide some additional conservatism in the results (since the accident risk is always the focus of interested parties). It might have been better to use the same assumption for the incident free risk calculation, but those results would not have changed in any significant way.

The last paragraph of this section addresses what is apparently a clear error in the reviewed text relating to the importance of californium 252 to the neutron fluence. Curium is the primary nuclide related to neutron fluence. I am given to understand that this error is corrected in the new draft.

Summary – I detect no significant technical problems here.

Generic Casks (p 6) – LLNL says there are no remaining problems here.

Structures/Closures/Fuel (p 6-7) – The first paragraph suggests that the finite difference calculation was not zoned with enough detail to portray the extension of the bolts under impact load and thus the leakage rates would be underestimated for the accidents with impacts above 45 mph. NRC reviewers Lee and Tang made a similar comment. This is not in my area of expertise, but the effect on risk seems unlikely to have a major impact on the study results because the likelihood of impacts on real surfaces at speeds equivalent to 45 mph impact on a rigid surface is very small. If the area of the leak path is a significant determinant of total release (not just its duration of release) it may be necessary to adjust consequence estimates for these events. Any impact will be well down in the tail of the CCCD curves.

The second paragraph seems to suggest that the scheme used to translate real surface impacts to rigid surface impacts was only approximate and should have been done in full detail by finite difference codes. I am sure that the full 3D calculations could have been carried out, but limited time and funds probably precluded doing all calculations in full detail (note previous paragraph). The shortcoming depicted above was probably an attempt to get physical behavior correct without breaking the bank in cost and computing time.

This paragraph suggests that using a 4% strain rate for failure of the rod clad under predicts rod failure and that the correct value is closer to 2%. It is my understanding from Jerry Sprung that 3.6% is the population mean strain rate for cladding failure based on the population (by age and burnup) of spent fuel likely to be shipped to a repository. It may be that this parameter should have been included in the LHS routine to delineate results of variability from this source, but the mean behavior should be representative.

Summary – I would not expect the problems outlined in this section to affect results greatly, but they probably deserve evaluation to determine what effect a change has on the resultant consequence.

Thermal Section (pp7-8) – This section suggests, based on LLNL calculations, that short cooled and high burnup fuel cannot be shipped in the postulated 24-element rail cask design without exceeding temperatures that lead to early failure of fuel. I have no reason to believe that LLNL estimates are not correct. However, it seems from the comments made, that the SNL estimates of the temperatures are not out of line with what would be the case if the rail casks contained the correct age and burnup fuel. If this is so, then a text revision is needed to explain why a flawed calculation concept led to a reasonable result. This may not require any change in consequence

calculations since there is no suggestion by the reviewers that the problem has impact on the results of the study.

Summary – No apparent effect on results, but a change in text relating to the thermal calculations could be required. This may be accommodated in the final version to be released soon.

Containment/Release (pp 8-9) - The first part of this section seems to requests additional text explaining the derivation of the volatile and particle source term. This is probably a reasonable request, but, again, it may fall into the category of information thought to be reasonably well explained in the references provided in the various sections. It could be inferred from the text that LLNL believes that the particle source term is unrealistically low as a result of too rapid deposition of aerosols in the cask. This assertion neglects the fact that the interior of the cask is broken into very small volumes in which allows particles to migrate quickly to a nearby surface. In my view, rapid deposition is very likely and does not depend on the interior gas being stagnant as suggested by the LLNL reviewers. The end of the first part of this sub-section casts doubt on the estimate of the quantity of particles exiting the fuel rods and finding their way into the cask interior. It suggests that holes in the rods in accidents situations will be too large for effective buildup of a particle bed to filter particles carried by the escaping fill gas. No data is provided by LLNL to support this assertion, but it seems likely that the highly fractured spent fuel pellets could make a fairly effective filter bed for fine particles.

The remaining two paragraphs of this section seem to be an attempt to apply the techniques used in package certification formalism for leak tightness requirements in normal and accident conditions of transport. These are not appropriate here. ANSI N14.5 may consider 0.1cc/min to be a large leak, but this analysis relates to accidents that are well above the Type B qualification test limits where such considerations are applied. I believe that the reviewer's A_2 release calculation assumes that all source term nuclides act like gases and neglects the considerable deposition processes that occur within the cask. Such an approach, while unrealistic, is accepted for assessing seal leakage after the hypothetical accident tests, but has no place in a risk assessment where a realistic (but conservative) estimate of potential harm is needed. I do not understand the basis of the conclusion reached by LLNL that their analysis suggests that SNL should have looked at the releases from smaller area sources. I cannot see that it is supported by their analysis.

Summary –Better explanation of the volatile/particle source term development might be warranted if the references aren't fully to the point. Using a single upper limit leak area for the risk calculation might be overly conservative, but looking at several smaller leak areas and deciding what probability is attached to each them may have been seen as adding little to the overall product. I see no significant problem with the current mode of analysis.

Results (p 9-12) – This section of the review is rather long. Many of the comments ask for more information in the report or interpret results of the analysis with implied questions but without offering much in the way of specific critique of what was done in the analysis. On page 10 the very strong statement is made that the radiation doses were not done correctly, but without any

other comment. I assume this goes back to the comments in section 2. If so, I do not think this is in error or a serious under prediction.

The groundshine component of dose is mentioned several times. In particular, it suggests that the dose estimates assumed that people are exposed for 50 years to a groundshine source that is above regulatory limits. If true, this would need to be corrected; however, for the current RADTRAN calculations (see Clean-up level in Table 3.4), contaminated ground is assumed to be condemned if it cannot be decontaminated to a level that is $\leq 0.2\ \mu Ci/m^2$. As this is an reasonably stringent decontamination criterion, long-term contributions to groundshine dose are minimal.

Summary – There are significant analysis of results and statements that could prompt additional discussion of results in the report (were there time to think about it).

Special Topics (p 12) – This section addresses two main issues. First, it calls for more clarity in the elaboration of the loss of shielding section and suggests that it might be more clear if tied to scenarios related to calculated lead slump or burn off of the neutron shielding which both lead to an increase in external radiation levels. Second, it questions the use of the 80% population move statistic to justify not including ingestion dose over 50 years while counting dose from groundshine for the whole 50 years. The obvious reason for the differentiation is that ingestion is usually a second order effect in long-term dose assessment, but perhaps the rationale can be made clearer.

Summary – A request for more explanation but no issues that are likely to have major effects.

CC:

H. R. Yoshimura
G. R. Sprung