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NOV 21 1963

Lt. Col. W. K. Kern
Engineering and Test Branch
Division of Reactor Development
U.S. Atomic Energy Commission
Washington 25, D.C.

Dear Werner:

Attached are our comments on the section of the Hittman Associates white paper report which you had requested Sandia to review. As far as we can tell from this section of the report, this study certainly seems appropriate and appears to be an attempt towards setting up a general safety criteria applicable to all aerospace nuclear safety systems. In some cases our ability to comment on the text has been hampered by uncertainties regarding the purpose of the report and by not having the complete text. We have, however, attempted to be objective in our criticisms in the belief that this is what you desired, and therefore most of our comments amount to an attempt at recognizing what we believe to be errors in the above data or philosophy. Let me make clear that overall we believe that the subject report is valuable, however, it does tend to leave one with the feeling that most of the safety problems have been solved, which is probably an oversimplification.

Original Signed By
V. E. BLAKE

V. E. Blake, Manager
Department 7410

HEHansen:7411:cc

Enc. CRD "Comments on Hittman Associates, Inc., Report"

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COMMENTS ON HITTMAN ASSOCIATES, INC., REPORT

III.A.2 Aborts on the ground or during the ascent to orbit may constitute a hazard to the public. While it is generally true that aborts of the SNAP-9A system would not result in an unacceptable radiological situation, it does not follow, apriori, that this is the case for any future system. Any future system must be evaluated on its own merit.

On the SNAP-9A launch, if the fuel capsules had been released from the generator by an abort, it is doubtful that the capsules would have ever been found (depending on where in the launch environs the capsules had fallen). Similarly for the ascent trajectory, an abort during a particular part of the ascent could have caused debris to land on Russia. Since the ultimate disposition of the tantalum liners of the fuel capsules is unclear, the consequences of such an abort are unknown but could be considerable.

The testing program demonstrating containment of the SNAP-9A fuel was not "very" conservative.

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III.B.1.1 Concerning the approximate fall time for micron size particles, it would be desirable to know:

1. The assumed particle density.
2. The method of calculating the fall velocity or fall time.

It is surmized a particle density characteristic of Sr O and Stokes formula were used in the fall time calculations.

III.B.1.2,3 In regard to the computed vertical diffusion factor:

1. It cannot be used to compute the actual sea level volumetric concentration of contamination since it was derived from rate equations in which elevation does not appear as a variable.

2. The quantity arrived at where this factor is applied is the average tropospheric concentration existing when the tropospheric burden is at a maximum.

3. The fact that this vertical diffusion factor gives reasonable results when applied to the 1961-62 bomb tests is not surprizing since it is based on residence times characteristic of and measured for bomb debris.

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4. In view of the method of deriving the vertical diffusion factor, its application to obtain plutonium concentration amounts to nothing more than taking the Martin Company results and multiplying, and then dividing them by the total quantity of plutonium originally injected into the atmosphere.

III.B.1.4 More recent values of the MPC's are available - specifically the 1958 values appearing, among other places, in Health Physics, Volume 3, 1960. Additionally, the values tabulated are for occupational exposure and not for the general population, and hence the conclusions reached concerning the number of systems that could be safely re-entered would have to be revised accordingly.

III.B.1.5 This analysis is, of course, based on burnup of systems into one-micron and less, sized particles with atmospheric behavior similar to bomb debris. Although it is possible by calculational methods to demonstrate this, no experimental evidence exists to support this premise.

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The assumption that release of the fuel represents an inhalation hazard, alone, cannot be justified unless the final chemical composition and properties of the fuel are known.

The argument that the number of watts of power that may be safely launched can be based on an MPC is somewhat questionable since it appears to imply that any future, further contamination of the atmosphere will be the result of U.S. launched power units only.

III.B.2.2

(a) Figure 11 is based on the studies contained in Reference 10, which, it is now believed, used inadequate assumptions. The effects of oxidation may be protective to the fuel element or may enhance burnup. The true effect is not certainly known. The altitude of fuel element release is not as well known as this curve implies. Additionally, the heat dissipated in the dissociation of hydrogen was not considered in the calculations. Inclusion of this energy loss alters, considerably, the temperature-altitude history of the fuel rods.

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III.B.2.2

(b) In the consideration of the burnup of the SNAP-9A fuel capsule, it is stated that peak capsule surface temperatures are 3400° -- 3800°R. While this temperature is sufficient to melt the Haynes 25 wall, it is not sufficient to melt the tantalum liner. No mention is made of the disposition of the tantalum. Sandia has tests scheduled which it is hoped will allow evaluation of the destruction of the tantalum. The eventual size of the Pu droplets is not estimated but does need to be evaluated.

III.B.2.3 Figures 11 and 13 may be typical for a decaying circular orbit, but certainly not for all re-entry trajectories in which we are interested.

III.B.3.1 Re-entry velocities much higher than orbital decay velocities do not necessarily assure one-micron particle sizes. Fuel release would be at a different altitude on a different re-entry trajectory. A high re-entry velocity and steep re-entry angle will result in less total heat than an orbital decay under many conditions.

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Appendix I Assumptions:

1. The validity of this assumption is questioned because the initial size of plutonium particles is probably much larger than 250 microns. This does not necessarily invalidate the analysis since the altitude of release of fuel may be higher than 200,000 feet. This is probably the case of the SNAP-9A system if the tantalum liner is removed soon enough.

2. In assumption No. 4, it is stated that neglecting radiation and finite time necessary to reach vaporization temperature is conservative because actually larger particles will result. This is confusing. If the criterion is a one-micron particle, and a one-micron particle is not achieved, than the criterion has not been met. It would seem that neglecting effects leading to larger particles would be unconservative.

Appendix II The approach taken in the analytical work appears to be reasonable and acceptable in principle. The results and conclusions are, however, in error due to an incorrect evaluation of the heat of reaction. Consider the reaction

$$XA + \frac{Y}{2} O_2 = A_x O_y - \Delta H^T \qquad (1)$$

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Where ΔH^T is the heat of reaction at temperature T and is not equal to the heat of formation of the oxide at that temperature.

If ΔF^T is a tabulated function of temperature and if ΔH^T is to be evaluated, then, the heat of reaction, neglecting phase changes, is given by

$$\Delta H^T = \Delta F^T + T \int_{298.16}^{T} \Delta Cp \frac{dT}{T} \qquad (2)$$

$$\text{where } \Delta Cp = Cp\,(A_xO_y) - X\,Cp\,(A) - \frac{y}{2}\,Cp\,(O_2) \qquad (3)$$

and the result differs significantly from Equation (1), page 8 of the Appendix. Although no actual computations were made, it is believed that ΔH^T for ZrO_2, at least, will not be vastly different from that at 25°C in the temperature range considered in the Appendix, and that the resulting chemical heat flux in Figure B, page 12 will be substantially greater than that actually indicated. The conclusions regarding the relative magnitude of the chemical heat flux should be re-examined in view of the results presented above.

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Various phenomena, such as particle explosions and "bubble formation", are known to occur in some reactive particle systems below the boiling point of the metal. At our present state of knowledge, it is difficult to account for this phenomena, but it is clear that they will greatly influence the ultimate particle size spectrum.

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