Spent Fuel Project Office
Interim Staff Guidance - 7

Issue: **Potential Generic Issue Concerning Cask Heat Transfer in a Transportation Accident**

Staff raised two major issues concerning the adverse effects of fission gases to the gas-mixture thermal conductivity in a spent fuel canister in a post accident environment. The two major concerns were: (1) the reduction of the thermal conductivity of the canister gas by the mixing of fission gases expelled from failed fuel pins and (2) the resultant temperature and pressure rise within the canister. Since the fission gas is typically of a lower conductivity than the cover gas, its mixing with the cover gas tends to lessen the thermal performance of the mixture. Furthermore, since additional gas is introduced into the canister, the internal pressure will increase as will the bulk temperature of the gas. The combination of these phenomena, if they are great enough, would pose a containment issue if the design basis pressure is exceeded.

The first step in resolving this issue involved reviewing NUREG/CR-5273, Vol. 4, describing a suitable method to predict the change in gas conductivities as a function of increasing fission gas concentrations. Although the fission gases are a collection of iodine (I), krypton (Kr), and xenon (Xe), as a conservatism, all fission gases generated were assumed to be the heaviest gas present, which is usually xenon. This reduced the problem to a binary mixture and simplified the calculation of the gas mixture properties. The practicability of this assumption is that the heavier gases exhibit a lower thermal conductivity for standard temperature and pressure conditions. Two separate methods were used to verify the reduction in the thermal conductivity with respect to temperature and concentration. Of the methods selected, the mixture properties were determined using the mole fraction of the mixture and a complex function of viscosities and molecular weights. These estimation techniques are based on the kinetic theory of gases.

The VSC-24 was selected for modeling as being a general cask representative of those in operation today. The sealed VSC-24 canister is backfilled with 1 atm of helium (He). In accordance with the Nuclear Regulatory Commission-accepted practice of assuming that all fuel rods fail during an accident with 30% of the fission gases entering the canister, the appropriate thermal properties of the He-Xe mixture were evaluated as a function of bulk temperature at standard pressure. These thermal conductivities were compared with those of pure He at the same standard pressure. This revealed a general percentage reduction in the mixture conductivites over a wide range of temperatures. In this study, the percentage reduction was a sizable 70%. Applying this reduction to the cask model, a parametric study of the cask was performed to determine the impact of the changing conductivity on the inner-canister component temperatures. The bulk temperature of the gaseous region was also evaluated to gauge the pressure increase within the canister. The results of this analysis are presented in the table below.

Modeled Case	Temperature w/Original Thermal Conductivity [R]	Temperature w/70% Reduced Thermal Conductivity [R]	Temperature Location
12 hr Maximum Thermal Load Transient	847 1235	868 1272	Bulk Gas Peak Clad
VSC Canister in Transfer Cask	973 1348	987 1371	Bulk Gas Peak Clad

As can be seen from the table, the large decrease in gas conductivity elevated the peak cladding temperature by less than 3% and increased the bulk gas temperature by less than 3%. The resultant pressure increase accounting for the higher gas temperature was a maximum of 4 psi which is less than a 10% increase in the reported value. This pressure increase is a very conservative estimate based on the assumption that the initial gas temperature was that of the canister shell.

Recommendation:

Change the Standard Review Plan for Transportation Packages for Spent Nuclear Fuel, NUREG-1617, and the Standard Review Plan for Dry Cask Storage Systems, NUREG-1536 as follows:

> Under the conditions where any of the cask component temperatures are close (within 5%) to their limiting values during an accident or the MNOP is within 10% of its design basis pressure, or any other special conditions, the applicant should consider, by analysis, the potential impact of the fission gas in the canister to the cask component temperature limits and the cask internal pressurization.

Approved ____

William F. Kane **Date**