TENNESSEE VALLEY AUTHORITY

CHATTANOOGA, TENNESSEE 37401

400 Chestnut Street Tower II

January 5, 1982

RECEIVED JAN 8 1982

Director of Nuclear Reactor Regulation
Attention: Ms. E. Adensam, Chief
Licensing Branch No. 4
Division of Licensing
U.S. Nuclear Regulatory Commission
Washington, DC 20555

Dear Ms. Adensam:

In the Matter of	)	Docket Nos. 50-327
Tennessee Valley Authority	)	50-328

As requested by R. L. Tedesco in a letter dated July 8, 1981 to H. G. Parris, our initial response on October 1, 1981 provided information on questions 1, 2, 4, and 5 on hydrogen control at our Sequoyah Nuclear Plant. A subsequent submittal was made on December 1, 1981 which provided responses to questions 3, 6, 7, 8, 11, 12, 13, and 14, as well as revised responses for questions 1 and 2.

Enclosed is our response to questions 9 and 10. This completes our requirements for responding to your July 8, 1981 request.

Very truly yours,

TENNESSEE VALLEY AUTHORITY

L. M. Mills

L. M. Mills, Manager
Nuclear Regulation and Safety

Sworn to and subscribed before me
this 5th day of January 1982

Bryant M. Lowery
Notary Public
My Commission Expires 4/4/82

Enclosure

B021
s
1/1

8201110544 820105
PDR ADOCK 05000327
P PDR

An Equal Opportunity Employer

ENCLOSURE

RESPONSES TO NRC QUESTIONS
SEQUOYAH NUCLEAR PLANT

Question Nos. 9 and 10

A study was conducted to identify the major fog formation and removal mechanisms within an ice condenser containment. Additionally, the effect of any resulting fog on the operation of the distributed ignition system was evaluated. Fog concentrations throughout containment were obtained by simultaneously solving the mass conservation equations for fog droplets in each of the containment's subcompartments. These equations incorporated fog formation due to condensation and reactor coolant system blowdown as well as fog removal by gravitational settling and sprays. The calculated results were: (1) fog will not affect the standard hydrogen flammability limits in the lower and upper compartments; and (2) although unlikely, fog present in the upper plenum may raise the lower flammability limit slightly. However, ignition will occur at the design basis hydrogen concentration of 8.0-8.5 v/o.

Analytical work has shown that the mean droplet size formed by the break flow is approximately 4 microns. To account for condensation and agglomeration, this study assumed a mean droplet diameter of 10 microns. Further analysis indicated that significant amounts of fog are generated only when the initial state of the break flow is subcooled or saturated liquid. Therefore, fog generation was assumed to terminate when the reactor vessel level fell below the break elevation. Approximately 50 percent of the break flow was vaporized, leaving the remaining mass suspended as fog droplets. Knowing that thermal boundary layers are formed near cold surfaces, the Hijikata-Mori theory of fog formation within a thermal boundary layer was used to evaluate fog formation due to nucleation. Analysis has shown that when local vapor supersaturation reaches critical supersaturation, rapid fog formation occurs within the boundary layer. Since micron-sized droplets are obtained within a few milliseconds, very little supersaturation is required for further growth. During fog formation within the boundary layer, the bulk fluid temperature is decreased via heat transfer to the cold surface. If the bulk fluid temperature has dropped below the dew point, then it was assumed that bulk stream condensation has occurred. Calculations based on studies of the growth of cloud drops by condensation and observations of valley fogs have shown that the mean droplet size varies from 8 microns to 14 microns. A 10-micron droplet diameter was, therefore, assumed.

The only significant fog removal mechanism considered was collision with spray droplets. A removal efficiency of 100 percent within the volume covered by containment sprays was assumed. (Varying the fog removal efficiency did not significantly affect the study's conclusions.) Although removal by gravitational settling was evaluated, the terminal velocity of a 10-micron droplet is so small that the effect was minimal. Agglomeration is a potentially significant removal mechanism that was simplistically treated by assuming the mean droplet size grew 10 microns. Other potentially significant removal mechanisms that were not considered are impingement on structures and the "spray" resulting from ice melting.

The effect of a fog on hydrogen combustion was evaluated by utilizing the work of von Karman. Three energy equations were developed to model the combustion kinetics and heat transferred to the unburned gas and fog. Comparisons between von Karman's work and experimental data obtained from Factory Mutual were good. Analysis has shown that the minimum fog inerting concentration varies approximately with the square of the volume mean droplet diameter.

Analysis of fog formation and removal rates revealed that the upper and lower compartments maintained lower fog concentrations than the upper plenum. When the hydrogen concentration reached the lower flammability limit (4 percent) in the lower and upper compartments, the calculated fog concentrations were factors of ten and five, respectively, below the inerting limit of approximately 8×10^{-4} v/o. The calculated fog concentration in the upper plenum was sufficient to inert the mixture when a hydrogen concentration of 4 v/o was achieved. However, when the hydrogen concentration reached 8.0-8.5 v/o, the calculated fog concentration was at least two times smaller than the required concentration for inerting, approximately 2×10^{-2} v/o.

Because of the conservatisms mentioned earlier, essentially all fog generated within the lower compartment was transported to the upper plenum. The severity of these conservatisms was obvious when the analytical model was compared to the complex geometry and congestion present within an ice condenser containment. However, due to the complexity of the analysis, fog removal by mechanisms other than spray collision and gravitational settling was not quantifiable. As a result, it was recognized at the beginning of the study that the calculated results would be more qualitative than quantitative. Considering the calculated results and the conservatisms inherent in the analytical methodology discussed earlier, it was concluded that: (1) fogs present in the lower and upper compartments would not affect the hydrogen lower flammability limit; and (2) fogs present in the upper plenum are not expected to significantly affect hydrogen's lower flammability limit. Ignition is expected to occur at concentrations well below the design basis concentration of 8.0-8.5 v/o.