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U.S. NUCLEAR REGULATORY COMMISSION

Office of Nuclear Reactor Regulation
Attn: John F. Stolz, Chief
Operating Reactors Branch No. 4
U. S. Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Sir:

Three Mile Island Nuclear Station, Unit 1 (TMI-1)
Operating License No. DPR-50
Docket No. 50-289
Reactor Building Spray System

This letter is in response to your letter of March 7, 1980 and supplements our responses of April 2, 1980 (TLL154), October 2, 1980 (TLL 496), and January 29, 1981 (L1L 016), concerning the Reactor Building Spray System (RBSS). Your letter requested that either a series of tests be performed to demonstrate that our existing RBSS is capable of meeting its design function or determine that the RBSS operation with sodium hydroxide alone is acceptable. As stated in our previous letters, we have chosen the second approach, that of justifying an RBSS using sodium hydroxide alone. This will entail draining and isolating the sodium thiosulfate tank in addition to implementing the controls described in the attachments.

Sincerely,

R J Toole

H. D. Hukill
Director, TMI-1

HDH:CJS:mar

Attachments

cc: L. Barrett
D. DiIanni
B. H. Grier
H. Silver
B. J. Snyder

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RESPONSE TO NRC LETTER OF MARCH 7, 1980

NRC Item a)

Assure adequate system configuration and concentration at the holdup tanks so that the pH of 8.5 to 11 exists at the spray nozzles and that the long-term solution (after mixing) will be above 8.0. Also consider the draw-down capability of the system from the holdup tanks to the spray nozzles in the containment building and a single worst case failure in this system.

Response to item a

Introduction:

For the modified system, adherence to a pH range of 8.5 - 11.0 is only necessary when a single Reactor Building Spray System (RBSS) train is in operation since only that single train is effective in iodine removal. For the cases where both RBSS trains are in operation, physical processes permit a broader range of pH.

Discussion:

The lower spray solution pH limit of 8.5 is based on the system iodine scrubbing efficiency with only one (100% capacity) header in operation. The system pH may be reduced to as low as 8.0 if both headers are in operation and still maintain dose reduction factor (DRF) equivalent to or better than single train performance with a pH of 8.5, due to increased flow from two train operation.

Two physical processes can be operant in reducing the iodine removal effectiveness with two loop operation. These are the potential surface area reduction of the droplets and the pH dilution potential when droplets of differing pH coalesce.

When the RBSS is in operation the spray droplets can merge together causing a change from the initial droplet conditions during the fall from the spray headers to the point of impingment. Two droplets have greater exterior surface area than does the single droplet produced after they combine. This coalescent effect causes a reduction of the iodine removal coefficient of up to 15%. This reductions is more than adequately compensated by the increased number of droplets as a result of the increased flow of two loop operation.

The iodine removal coefficient can be further affected by different pH levels. Specifically, a droplet originating from a loop with low pH (due to component failures) could dilute a droplet with proper (high) pH to below the pH limit of 8.5. The scenerios which could cause the greatest difference in spray loop pH are; one Decay Heat Removal Pump (DHRP) failing to start, or one Sodium Hydroxide Storage Tank (SHST) valve failing to open. If the DHRP fails to start, calculations show that one loop will have a zero molarity and the other loop will have 0.098 Mole NaOH/liter molarity.

Should one of the SHST valves fail to open, one loop will have zero molarity and the other loop will have 0.14 Mole NaOH/liter molarity. The combined droplet's pH, for these cases, are 0.049 Mole NaOH/liter (pH 8.4) and 0.07 Mole NaOH/liter (pH 8.6) respectively.

Based on the above, in both cases (single and two train) of operation the Iodine Removal Capacity of the RBSS is adequate considering worst case single failures.

The spray solution high pH limit of 11 is based on the following:

1. Biological effects of sodium hydroxide on the operating or maintenance crew.

2. Corrosion effects of sodium hydroxide on safety related equipment.

An operating or maintenance crew could only be exposed to sodium hydroxide if the system were inadvertantly activated. In this unlikely event, a spray solution with pH close to 11 (as a result of component failures) could cause serious coughing, bronchial spasms, or skin and eye irritation and damage. An exposure of less than a half hour could potentially be fatal, according to NUREG-CR-0650, "A Comparative Evaluation of Containment Spray Additives, Detrimental Impact of an Inadvertent Spray Actuation." The drawdown analysis show that the spray solution pH of 11 is reached no sooner than 5 min. after the system activation in the worst component failure scenario, this giving the plant personnel adequate time to effect the isolation of the RBSS and/or exit from the building. We, therefore, consider the potential biological effects of inadvertant actuation of RBSS with sodium hydroxide as the sole chemical additive to the borated water acceptable.

The coalescense effect described above was considered when the system iodine removal ability was considered since it is a more conservative approach. However, the coalescense effect was disregarded when corrosion aggressiveness of sodium hydroxide was considered.

For corrosion considerations evaluation a map of the coverage of separate nozzles was made to determine how loop A and loop B cover the reactor building operating floor.* The results are as follows:

1. The entire operating floor is covered by each spray header.

2. 55% of the operating floor is covered by each spray header twice.

3. 28% of the operating floor is covered by each spray header three times.

If both spray headers are in normal operation the spray overlap described above will assure mixing in the horizontal planes of one liter of spray solution of "A" molarity with three liters of spray solution of "B" molarity as the worst combination of the above possibilities (assuming $A < B$ and A is molarity of the A loop and B is molarity of the B loop.) If the molarity of the 4 liter total is averaged, the resultant molarity will be that of the actual spray solution at the moment of droplet impingment. It is the molarity upon impingment rather than at the nozzles which must meet the

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* Safety related components which could be exposed to RB spray are generally located at or below the operating floor.

ANS-56.5 and DRP 6.5.2 criteria provided that it does not impair the system's iodine removal capability.

Since the pH of 11 is equivalent to a 0.22 Mole NaOH/liter solution the above can be represented with the following expression:

$$1/4\ (A \cdot 3B) \leq 0.22$$

As shown in the following example, a pH of 12 for a single spray header during two header operators can be tolerated. However, if only one header is in operation, a pH of 11 must be maintained.

Example: Calculations show that in the case of a sodium hydroxide valve failure with two RBSS, and two HPI pumps in operation, one header will have solution of 0.29 Mole NaOH/liter at 30 min. after the system actuation and the other will have a zero molarity. The 0.29 molarity corresponds to pH 12.

$$1/4\ (0 + 3 \times 0.29) \leq 0.22$$

$$0.2175 \leq 0.22$$

Draw-down analyses performed for the full transient duration demonstrate that above expression is satisfied for all potential modes of RBSS operation.

In the case of peripheral nozzles at higher elevations, where the spray cones are not developed and do not overlap, the coating of the containment liner will be exposed to solution as it comes out of the nozzles with pH varying (for transitory periods) from 4.5 to 11. According to the RB coating manufacturer, this exposure of the coating to extreme conditions will not cause degradation of the liner since the exposures are of short durations.

Technical and Administrative controls which will be implemented are as follows:

a) A differential level measuring system for the Borated Water Storage Tank (BWST) and the Sodium Hydroxide Storage Tank (SHST) will be provided. This local level instrumentation will enable the operator to determine SHST level relative to the BWST level to ensure that initial tank levels are within the range required for proper functioning of the system. During system operation the BWST and SHST levels will draw-down with velocities linearly proportional to each other because the tanks discharge piping are cross-connected and both open to the atmosphere via vacuum breakers or rupture discs. The liquid columns in thetanks will remain in balance. This means that the sodium hydroxide flow rate does not depend on the number of sodium hydroxide loops in operation but will remain proportional to the BWST rate.

b) The SHST and BWST will have Technical Specification limits on concentration and relative tank levels to assure that pH limits are met. These Technical Specifications will be submitted upon NRC acceptance of this conceptual proposal and will be based on maintaing:
   (1) SHST Level with ± 6 inches (water) of BWST level
   (2) SHST Concentration 12.0 - 13.2 weight % NaOH
   (3) BWST Level per existing Technical Specification Limits.

NRC item b) Determine the iodine removal effectiveness of the spray using the evaluation methods described in NUREG-CR-0009.

Response to item b

The iodine removal effectiveness of the Reactor Building Spray System using only sodium hydroxide was determined using the methods and Iodine Removal Coefficients of ANSI/ANS- 56.5-1979.

NRC item c) Demonstrate that offsite doses for the design basis accident will be within the 10 CFR 100 guidelines based on the calculated iodine reduction.

Response to item c

Our calculations demonstrate that the offsite doses for the design basis accident will be within the 10 CFR 100 guidelines. Specifically, the results obtained for minimum safety features (one spray header pump and one air cooling unit fan operating) show that the two hour dose would be 189 rem thyroid 7.6 rem whole body at the exclusion boundary. If both spray header pumps and all three air cooling unit fans were operating, the two hour dose would be 156 rem thyroid and 7.5 whole body at the exclusion boundary. These are conservative values, and are well below the limits of 10 CFR 100.

The assumptions used in the dose calculation are the spray removal coefficients as per item b above, an exclusion boundary distance of 610 meters, and an average Atmospheric Diffusion Factor (X/Q) of 8.3×10^{-4} sec/m^3 (X/Q derived from meterological data collected since TMI-1 was licensed).