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April 6 , 1981
TLL 637

Office of Nuclear Reactor Regulation
Attn: R. W. Reid, 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
Analysis of the Boron Dilution Event

This letter and attachments are in response to discussions held with Mr. D. DiIanni of your staff concerning the potential for boron dilution events. Specifically, the pathways for a boron dilution event have been reviewed using the drained down RCS volume and the 15 minute criteria required by SRP 15.4.6 for hot and cold shutdown modes. Our response concludes that there are no dilution pathways with significant flow rate which could be established through a single failure or operation error which would completely eliminate the shutdown margin. Therefore, no further response is required.

Sincerely,

H. D. Hukill
Director, TMI-1

HDH:DGM:lma

Attachments

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

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BACKGROUND

A review of the plant systems and procedures has been performed to determine the potential pathways for a moderator dilution event. The purpose of this review and evaluation is to determine if a possible moderator dilution event exists with a closed Reactor Coolant System (RCS) in a drained down state, which was not previously considered and would cause a loss of shutdown margin. Four general pathways have been identified. The Makeup and Purification System, Liquid Waste Disposal System, Reactor Building Spray System, and leakage through seals and/or packing.

CONCLUSION

The conclusion of this review is that there are no dilution pathways with significant flowrates which could be established through a single failure or operator error during cold shutdown. Furthermore, the normally available shutdown margin would not be lost even in the unlikely event of multiple failures leading to the establishment of a significant dilution pathway.

DISCUSSION

The Reactor Building Spray System dilution path via the Decay Heat Removal System has been studied for a full RCS and the method for precluding this dilution event is considered acceptable by the NRC (Letter to R. C. Arnold from Robert W. Reid, Chief ORB #4, dated December 31, 1979). This method is equally applicable during drained down conditions and therefore need not be addressed further in this context.

During drained down conditions, the systems which indirectly interface with the RCS through seals, motor coolers, or packings are either shutdown or create a potential for such small dilution rates as to be insignificant. Dilution events of this nature occur slow enough that operator action to terminate or compensate for deboration can be made based on periodic boron samples and/or the control room instrumentation.

The Makeup & Purification System provides one possible pathway for injection to the RCS of unborated water from the makeup tank, but only through an extensive valve lineup. Under drained down conditions, or any cold shutdown condition, administrative measures are applied which prevent injection of water from the makeup system. These include racking out the breakers for the makeup pumps, closing their associated makeup valves V217, V16A, V16B, V16C and V16D, and opening their respective breakers. Also, injection of unborated water from the makeup tank would terminate with greater than 2.0% shutdown margin remaining. (See Attachment I for details). In view of this, any likelihood of injection from the makeup tank during cold shutdown is very small and even if it would occur during drained down conditions, would not result in a loss of the shutdown margin.

Since the Decay Heat Removal System is normally in operation when the RCS is in cold shutdown, this system provides another possible pathway by which unborated water from an RC Bleed Tank in the Liquid Waste Disposal System could be added to the RCS. However, this would also require an extensive valve

lineup (See Attachment II). Although highly unlikely, if injection of unborated water from an RC Bleed Tank to the RCS were to occur, the consequences are even less severethan addition from the makeup tank resulting in an even larger shutdown margin remaining.

All calculations were performed using a conservative volume for the drained down RCS and the applicable sections of the NRC Standard Review Plan.

Consequences of the addition of unborated water to the RCS from the makeup tank during RCS drained down conditions:

Using initial conditions as follows:

1. BOC-5 (worst case for dilutions reactivity effect)
2. Temperature - 68°F
3. Pressure - Atmospheric
4. Volume of contained water - 20,070 gallons.
5. RCS boron concentration - 1366 ppm
6. Makeup tank volume - 4500 gallons
7. All rods in
8. Complete mixing of all unborated water additions

The analysis is based on the maximum moderator coefficient, Beginning-of-Core life doppler coefficient and initial RCS boron concentration at cold shutdown. Both the moderator coefficient and boron concentration values used are conservative.

A reactivity balance at these initial conditions and assuming the worst case stuck rod reveal the initial shutdown margin as follows:

Core excess Rho	+16.466
Rod worth (gps 1-7)	- 5.32
boron worth (at 1366ppm)	-18.79
stuck rod worth	+ 1.657
Net Rho	- 5.99% ΔK/K

Injection of 4500 gallons of unborated water to the RCS at this time will reduce the shutdown margin as follows:

$$\text{New boron concentration} = \frac{20070}{20070+4500}\ \text{Ci} = .817\ \text{ci}$$

$$= .817\ (1366) \quad \doteq 1116\text{ppm}$$

Core excess Rho	+16.466
Rod worth (gps1-7)	- 5.32
boron worth (at 1116ppm)	-15.35
stuck rod worth	+ 1.657
	- 2.55% ΔK/K

For additional conservatism, Gp 8 worth is removed from the balance to get a final shutdown margin of:

$$-2.55\% + 0.135\% = -2.42\%\ \Delta K/K$$

Therefore: an injection of 4500 gallons of unborated water to this volume of water in the RCS at the above conditions will leave greater than 2% shutdown margin remaining to preclude criticality.

In addition, administrative measures are used to prevent injection from the makeup system at cold shutdown. These include racking out the breakers for the makeup pumps, closing makeup valves V217, V16A, V16B, V16C and V16D, and

opening their respective breakers.

In view of the above, any likelihood of injection from the makeup tank during shutdown is very small and even if it would occur, would not result in criticality or loss of the shutdown margin.

Pathway from "A" RC Bleed Tank to D. H. Pump "A suction

WDL-V164 → WDL-V340 → WSL-V23 → WDL-P6A → WDL-V343 → WDL-V32 →

WDL-V38 → WDL-V51 → SF-V43 → SF-44 → DH-V50 → DH-V15A → DH-P1A

Valve Lineup for D. H. Pump A from A R.C. Bleedtank

Closed valves	Open Valves
WDL-V26	WDL-V23
WDL-V29	WDL-V32
WDL-V24	SF-V44
WDL-V25	SF-V43
WDL-V35	WDL-V51
WDL-V11	WDL-V38 adjust to 150 gpm
WDL-V33	
WDL-V39	
WDL-V40	
WDL-V68	
WDL-V69	
WDL-V70	
WDL-V71	
WDL-V41	
WDL-V42	
WDL-V43	
WDL-V44	
SF-V56	
SF-V45	
SF-V46	
SF-V47	

Since the Decay Heat System is normally in operation with the RCS in cold shutdown, this system provides a pathway by which unborated water could be added to the RCS. The Decay Heat Removal System draws water directly from the "B" Hot leg of the RCS to the suction on the two Decay Heat Pumps through two Decay Heat Removal Coolers and returns it through the core flood inlet nozzles.

It is possible to intentionally lineup one of the RC Bleed Tanks to the "A" Decay Heat Pump suction, thereby establishing a path for unborated water to be added to the RCS from a RC Bleed Tank. If this pathway is established during Decay Heat Removal System with the RCS in a drained down condition, a boron dilution event will occur. However, as shown below, a more than adequate shutdown margin will remain.

The following initial conditions and calculations form the bases for this determination:

1. BOC-5 (worst case for dilutions reactivity effect)
2. Temperature - 68°F
3. Pressure-Atmospheric
4. Volume of contained water - 20,070 gallons
5. RCS boron concentration - 1366ppm
6. All rods in
7. Maximum possible flow from bleed tank - 150 gpm
8. Indication of waste transfer pump operation in Control Room commences 15 minute time interval for operator action. Indication of RC Bleed Tank level is also available.
9. Complete mixing of all water additions

under these initial conditions at cold shutdown, and accounting for the worst case stuck rod, the initial shutdown margin is shown as:

Core excess Rho	+16.466
Rod worth (gpsl-7)	- 5.32
boron worth (at 1366ppm)	-18.79
stuck rod worth	+ 1.657
Net Rho	- 5.99 % ΔK/K

Injection of 2250 gallons of demineralized water results in a new boron concentration of:

$$Cf = \frac{20070}{20070 + 2250} Ci = .899\ ci$$

New boron concentration = .899 (1366) = 1228ppm

Thus, the final shutdown margin is determined to be:

Core excess Rho	+16.466
Rod worth (gpsl-7)	- 5.52
boron worth (at 1228ppm)	-16.89
stuck rod worth	+ 1.657
Net Rho	- 4.09% ΔK/K

For additional conservatism, Gp 8 worth is removed from the balance to get a final shutdown margin of:

$$-4.09\% + 0.135\% = -3.95\% \ \Delta K/K$$