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April 09, 1979

MEMORANDUM FOR: Victor Stello, Jr., TMI Operation

FROM: Don Davis, Duty Officer Shift B

SUBJECT: PARTIAL RESPONSE TO REQUEST FOR HEADQUARTER
ADVICE ON COOLDOWN

Attached is a Headquarter Advisory Report on boration and criticality

aspects of cooldown from points A to C. Other aspects of cooldown

review will follow.

Don Davis, Duty Officer Shift B

cc: R. Mattson

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HDQ Comments on Boron Precipitation and Criticality

ction 1 <u>Solubility of Boric Acid</u>

Assuming the initial concentration of boron in the primary coolant
system of 3000 ppm, precipitation of boric acid will not occur until
the temperature of the primary coolant is reduced to below 32°F.

Since there is no boil-off of coolant in the primary system the
concentration of boric acid remains unchanged. It would be necessary
to increase the concentration of boric acid by a factor of 24.5
at operating point "B" (220 F and 1000 psia) and by a factor of
8.5 at operating point "C" (140 F and 1000 psia) before any
precipitation of boric acid could occur. It is concluded that
no precipitation of boron in the primary system would occur when
the operating conditions of the plant is changed from "A" to "B"
and subsequently to "C".

In the letdown system the primary coolant is cooled from its initial
operating temperature to about 120 F (FSAR value). Then it is depressurized
to 14.7 psia. During the depressurization the liquid remains in a
sub cooled condition and no boiling takes place. The concentration
of boric acid in the letdown sytem stays the same as in the primary
system and no precipitation is expected.

ion 2 Criticality

The reactor coolant is presently believe to contain ~2200 ppm boron.
The reactor core geometry <u>if fully intact</u>, at 150°F, <u>2200 ppm</u>
boron, all rods in and burnable poison intact, would have a $K \approx 0.85$.

Rods are worth ~10%Δk; the burnable poison 4%Δk. Thus if rods are out, k goes to ~.95 and if the burnable poison is also out the k goes to ~.99 (at 2200 ppm).

If the clad is removed and borated water (2200 ppm) substituted (i.e. Zr to oxide and washed away) there would be little, if any, change in reactivity, since at this boron level and temperature the moderator reactivity coefficient is near zero (probably slightly positive). Similarly the reactivity state is not sensitive to the temperature in this range (150°F to 280°F).

Thus, if fuel has not redistributed, a boron level of 2200 ppm will keep the system subcritical even if everything but fuel is removed (small effect from thimbles and grids).

If fuel is redistributed (in addition to the above removals) the system could - under optimum conditions of moderation - go critical at 2200 ppm (note: moderation is required since solid UO_2 sphere require enrichments over 5% to be critical). For the worst case - all fuel in a cylinder, or sphere - at optimum moderation - about 3000 ppm would be required to stay subcritical. The calculations are by the B&W Naval criticality group, using Monte Carlo (KENO) and tested cross sections. The calculation used pellet nuclear parameters (because these maximize reactivity) and fuel-water (boron) ratios which had been optimized by sensitivity studies.

The configurations which require boron levels above 2200 appear to be not very probable (unless it is probable that the rods are not there), but B&W believes (strongly) that there should be protection from redistribution criticality by going to 3000 ppm boron.

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There are no problems with 3000 ppm from a physics viewpoint. The problems which have been expressed appear to be only the potential for systems blockage from boron at this level - a concern which appears to have no theoretical basis (see Section 1).

Detectability

If the reactor were to get to a k of about 0.95 subsequent changes of the order of 1%Δk should be reasonably detectable (25% increase in count rate for .95 to .96)on an excore startup detector if conditions are reasonably normal. If may, in these circumstances, be partially masked by (relatively) weak sources, disturbed geometries, nonnuclear changes (e.g., downcomer density changes).

At 2200 ppm the worst configuration is estimated to be several percent supercritical (i.e., k$\sim$1.03). It is very difficult (if not, impossible) to estimate the power level such a system would maintain to compensate for this reactivity. However, going to a water density of about 0.5 should (at least) do it. It is, of course, not generally possible to predict the (hypothetical) rate of reactivity addition in the case of redistribution (when detectable above .95) and thus provide the needed boron insertion rate.

Conclusions and Recommendations

At this time we do not have sufficient concern either to require boration or to prevent it. A primary coolant sample would likely provide information that would allow a more definitive recommendation (e.g., the presence or non-presence of control rod material and a better value on existing Boron Concentration).

There is nothing directly about the cooldown process which would in itself affect the reactivity. If boron blockage is not a problem, however, the boron level should be taken to 3000 ppsi to cover all (remote) possibilities. If decision to borate is made, a 100 ppm stepwise addition with monitoring of potential letdown blockage should be considered. If blockage is sufficiently strongly suspected to cause problems so that this is not carried out it would be highly advisable to be sure the startup range instrumentation is likely to be in good order (would be wise in any case) and it would also be advisable to be sure that boration at some "reasonable" rate is available.