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May 21, 1993

Mr. Paul Boehnert
Advisory Committee on Reactor Safeguards
U. S. Nuclear Regulatory Commission
Washington, DC 20555

Subject: Thermal-Hydraulic Phenomena Subcommittee Meeting on May 12, 1993

Dear Paul:

Among the BWR stability and water level instrumentation issues discussed at the meeting, I will concentrate on the ATWS mitigation and control strategy in this letter. There remain open questions regarding uncertainties or errors in water level instrumentation and they should be addressed fully before the water level control strategy is adopted. I still have some concerns regarding the proposed water level reduction strategy and offer the following comments:

1. We all agree that a reduction in feedwater flow decreases the inlet subcooling of core flow, which in turn inserts a negative reactivity and reduces the power level. Thus, in the absence of nuclear-coupled density wave oscillations (NCDWOs), a reduction in water level will reinforce the effects of the recirculation pump trip and minimize the burden on the suppression pool. But a reduction in core flow and the corresponding increase in void fraction in the coolant channel are the key factors that enhance and, in fact, initiate unstable density wave oscillations. Furthermore, since the negative void coefficient of reactivity also decreases the NCDWO stability and the magnitude of the void coefficient of reactivity increases significantly as void fraction increases, a water level reduction would tend to add destabilizing effects to the system dynamics. These destabilizing effects thus work against the stabilizing effect due to the reactivity and power decreases. It appears that, in a limited number of computer simulations performed by General Electric, the net effect of a level reduction is an increase in NCDWO stability. We should make sure that this will indeed be the case for all relevant ATWS cases.

2. To better understand the interplay between the two competing effects associated with a level reduction, it would be useful, for example, if we could compare the magnitude of the negative reactivity inserted through the feed flow decrease with that of the maximum positive reactivity reached during the oscillations. This may help us explore under what conditions, if any, the destabilizing effects of a flow reduction may dominate. In particular, the NCDWO cases of NEDO-32047 and -32164 use void coefficients of reactivity for the middle of cycle. Since the magnitude of the negative void coefficient of reactivity is in general much larger at the beginning of cycle, with a larger fraction of control rods inserted, than at any other time in the cycle, the net effect of flow reduction could go in a different direction. In this regard, we should also remember that some European BWRs, including Caorso, have used core flow *increase* as a means to control

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NCDWOs and that, in the case of feedwater heater losses, core flow reduction below some level (~40% of rated) should be accompanied by control rod insertion.

3. I also want to make sure that induced transients, such as feedwater flow reduction maneuvers, do not aggravate any ongoing transient. With this purpose in mind, we may want to understand, for the case of level control below feedwater sparger reported in NEDO-32164, why feedwater and steam flow undergo rapid and erratic fluctuations after feedwater control is terminated (Figure 4-5). With such large flow fluctuations, it is also unclear if the reduction in NCDWO magnitude (Figure 4-4), due to the water level control, will sustain after the 300-second duration of the transient simulated. For that matter, if the TRACG code is capable of handling such rapid flow fluctuations accurately may have to be questioned.

4. In connection with the importance of the void coefficient of reactivity discussed in Comment 2, special attention should be given to the calculation of the reactivity coefficient when the upper part of the core is voided. In this situation, the out-channel or bypass region of fuel assemblies will be filled with a two-phase mixture, while in normal BWR operation liquid water flows in the out-channel region. Although the water density averaged over the in- and out-channel regions of a fuel assembly may be the same, the two cases will show in general considerably different neutronic behavior. This is because the neutron flux spectrum would reflect two rather different heterogeneous configurations. For this reason, I raised a question at the meeting if we could meaningfully use, for the out-channel voided cases, the reactivity coefficients calculated for a regular channel configuration without out-channel voiding. In addition, for these rather extreme assembly configurations with a hard neutron spectrum, the accuracy of standard BWR lattice physics codes may also be suspect.

5. In terms of actual implementation of the level reduction strategy, I would suggest that we limit the control maneuver to the extent definitely necessary, namely Strategy A considered by the BWROG. This will minimize the potential for core uncovery or flow reversal and is marginally inferior to Strategy B only if the Standby Liquid Control System were unavailable. Even with Strategy A, the ECCS injection has to be bypassed during the control maneuver. We should perhaps ask how prudent this deliberate action is in the overall picture of reactor safety and should also investigate how it is handled in typical Emergency Procedure Guidelines.

I hope the above comments are useful to the Committee.

Yours sincerely,

John C. Lee

xc: I. Catton