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UNITED STATES
NUCLEAR REGULATORY COMMISSION
ADVISORY COMMITTEE ON REACTOR SAFEGUARDS
WASHINGTON, D.C. 20555-0001

Nov. 4, 1999

MEMORANDUM TO: Savio, Larkins, Powers, Apostolakis, Sorensen

MEMORANDUM #: AWC-107.99

FROM: A. W. Cronenberg

SUBJECT: Request For Approval of Summary for ANS-June Meeting
"*Synergistic Safety Issues Related to Reactor Power Uprates*"

Attached for your review and approval is a Summary for the next ANS annual meeting (San Diego-June 2000). Submittal requirement indicate a date of Jan. 7/2000, but I'd like to submit in mid-December, in view of some anticipated leave during holidays.

You will note that ANS rules require that papers for ANS meetings not be published prior to presentation at annual ANS meeting. Therefore, I'd like to submit attached Summary for the June meeting, so that I might publish full paper at conference later in the year, before my term expires. I would expect that we should have reviews completed by NRR staff by the time ANS completes its own review process (early-March). This should give us the opportunity to make final revisions to ANS Summary, should we receive weighty comments from NRR.

Thanks for your consideration.

Synergistic Safety Issues for Reactor Power Uprates

by

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During the past several decades the NRC has reviewed and approved in excess of 30 licensee requests for power uprates. Each request has been evaluated to assure that current regulatory requirements are satisfied; nevertheless, concerns exist that synergistic processes may not be t adequately covered in such reviews. Specifically the concern is that higher power levels, when combined with system/component degradation via plant aging and fuel life extensions to high burnup, may adversely impact plant safety margins. Such concerns stem from recent operational problems noted for uprated plants, including failure to fully insert control rods in high-power/high-burnup fuel assemblies, piping failures, and deficiencies in both licensee uprate submittal analysis and NRC reviews. An investigation was conducted to assess the adequacy of the power uprate review procedures and the need to consider potential synergistic effects [*synergistic*---the cooperative action of discrete agencies such that the total effect is greater than the sum of the individual effects].

A utility seeking a power uprate will submit a request in the form of a Licensing Amendment Report (LAR), which contains information similar to that found in the original FSAR but at the uprated power level. The LAR centers on a re-evaluation of design basis accidents (DBA) and off-normal transients, and the adequacy of safety related systems to perform their intended function at the higher power. Information presented in the LAR is reviewed by the NRC staff and its findings are reported in an uprate Safety Evaluation Report (SER). The NRC review encompasses consideration of any new or unreviewed safety concerns in accordance with 10CFR-Part 50.59, as well as review of changes to plant technical specification. The uprate application is approved if the case has been made that plant safety margins are not significantly diminished at the elevated power.

The uprate applications reviewed in this study include that for the Brunswick, Maine Yankee, North Anna, Surry and Wolf Creek plants. A review of the LARs and SERs for these plants revealed little documentation with regards to consideration of potential synergistic effects of high core power densities when combined with component aging and/or high burnup fuel effects. A review of operational events for uprated plants however shows evidence that such synergistic effects may occur. Examples include the control rod insertion problems noted at the Wolf Creek and North Anna plants, both having received power uprate approvals in the range of 4-5%. At Wolf Creek five control rods failed to fully insert during scram from full power. The affected control rods involved Westinghouse Vantage-5H fuel assemblies with burnups greater than 47,6000 MWD/t-U. Root cause analysis indicate Zircaloy guide tube distortion due to irradiation induced growth. Since irradiation growth is both fluence (i.e. power level) and time (burnup level) dependant, synergistic effects are evident. Control rod sticking problems have also been noted at North Anna-1. An examination the Wolf Creek and North Anna uprate documentation (LARs and SERs) for control rod behavior did not reveal consideration of the effects of higher

power level when combined with elevated fuel burnup conditions. Other incidents include power offset anomalies for long-cycle/high-power cores tied to crud buildup on high-burnup fuel rods. The crud appears to getter boron causing a distortion of the axial power profile, particularly in high power assemblies, again indicative of potential synergistic effects.

Aged reactor components and systems, in combination with high core power densities, may likewise produce degradation that is greater than the sum of the individual effects. Research has shown that pipe corrosion is often exacerbated at increased fluid velocities, indicative of a synergistic corrosion/erosion process. The main feedwater pipe break at Surry-2 in 1986 provides evidence for such a synergistic pipe corrosion/erosion process. During at-power operation a main feedwater pipe ruptured at the Surry-2 plant, resulting in four site-worker fatalities due to release of scalding steam from the ruptured pipe. Post-accident investigations revealed feedwater pipe thinning and catastrophic rupture due to combined corrosion/erosion effects. Although the Surry-2 plant was operating at its original power rating, a linkage to uprated power conditions is made since they often involve an increase in feedwater flow. Other aging factors include vibrational fatigue, particularly for pumps and valves in the vicinity of moving machinery. Higher coolant velocities associated with power uprates would tend to aggravate vibrational fatigue.

Review inadequacies were also noted in regards to the Maine Yankee and Brunswick uprate applications, where faulty licensee submittal information was not uncovered during the initial review process by NRC. Both incidents indicate a need for independent agency thermal-hydraulic and neutronic analysis capabilities, to verify the accuracy of licensee submittal analysis. NRC in-house computational efforts would go a long way in providing an independent check and verification of what is now essentially a licensee effort. In view of such observations the following recommendations are made:

- NRC should develop a Standard Review Plan (SRP) for review of power uprate applications, which should include acceptance criteria which consider the influence of synergistic effects, specifically high fuel burnup levels and component/system aging effects in combination with uprated power conditions.

- NRC uprate review procedures should include requirements for independent NRC staff analysis (i.e. thermal-hydraulic and neutronic code predictions) and verification of uprate plant predictions submitted by the licensee. Such NRC audit calculations should be included in the SER for each uprate application and include comparisons with licensee submittal analysis.

- A comparison of probabilistic safety measures (e.g. CDF, QHO, LERF) at the uprated and prior power levels is recommended for future uprate applications.