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

October 14, 1982

Honorable Nunzio J. Palladino
Chairman
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Dr. Palladino:

SUBJECT: ACRS REPORT ON DRAFT NRC STAFF EVALUATION OF PRESSURIZED THERMAL SHOCK DATED SEPTEMBER 13, 1982

During its 270th meeting, October 7-8, 1982, the Advisory Committee on Reactor Safeguards reviewed the Draft NRC Staff Evaluation of Pressurized Thermal Shock dated September 13, 1982. This matter was also considered at a Subcommittee meeting on September 30, 1982 in Washington, D.C. In its review the Committee had the benefit of discussions with representatives of the NRC Staff, the Westinghouse, Combustion Engineering, and Babcock and Wilcox Owners Groups, and the Southwest Research Institute. The Committee reported previously to you regarding this matter on June 7, 1982.

The NRC Staff is developing a regulation based on a combination of deterministic and probabilistic analyses to establish requirements concerning pressurized thermal shock (PTS). The NRC Staff proposes to use RT_{NDT} screening criteria for reactor vessels as the basis for further action concerning PTS. A value of $270^{\circ}F$ for longitudinal welds and base material and a value of $300^{\circ}F$ for circumferential welds have been selected. These proposed criteria are reasonable on the basis of current knowledge and provide adequate time for licensees to demonstrate plant-specific capability or planned actions in order to avoid unacceptable public safety consequences from PTS. For reactor vessels that are expected to be the earliest to exceed the screening criteria, we wish to be kept informed about PTS control actions under consideration.

The NRC Staff report indicates that several years are available before the first plant will exceed the screening criteria limits. This provides adequate time to conduct an orderly, comprehensive research program concerning measures needed to protect against pressurized thermal shock if a diligent effort to implement the program is applied. The NRC Staff has not yet defined a suitable program. We believe that the following should be elements of such a program: improved nondestructive examination capability; a more complete study of in situ reactor vessel annealing; improved fracture mechanics analysis methods that will account for realistic crack geometry, cladding effects, and crack arrest phenomena; use of three-dimensional and elastic-plastic techniques where appropriate; and potential improvements in diagnostic capability to help the operator recognize and control thermal shock events.

In accord with your desire to obtain our views on short-term steps regarding the NRC Staff's program on PTS, the recommendations in our letter of June 7, 1982 still apply. The following items deserve special attention:

- The reactor vessels with the greatest potential increase in RT_{NDT} are those having relatively high copper content. Only a small fraction of the available irradiation test data can be fully correlated with composition effects at high fluence levels. The correlations relating the rise in RT_{NDT} to metallurgical composition would benefit from a careful assessment of the uncertainties and special circumstances related to each data point used in the correlation.

- Improvements in PTS-related operator training and procedures should be carried out by all licensees with special emphasis on those plants indicated to have high RT_{NDT} vessels. Operational problems that need to be dealt with include the conflicting need to maintain adequate pressure for core cooling purposes while avoiding PTS, the control of feedwater and auxiliary feedwater to provide adequate heat removal while avoiding overcooling, and the recovery after a transient event which has caused violation of the cooldown rate limits.

- The range of initiating events and subsequent operator actions which are most likely to cause PTS need to be better characterized. A more extensive evaluation of operational events, including operator errors of commission as they apply to specific plant designs, will improve our understanding.

- The ACRS has considered the value of heating the ECCS water as a means of reducing public safety risk from PTS. Heating ECCS water may be helpful in the specific set of small break LOCAs that result in primary loop flow stagnation. If this case is an important contributor to the overall thermal shock risk and if heating the water does not unacceptably diminish containment integrity margins, then it can be a useful measure.

- Fast neutron fluence reduction is being implemented in some plants by using revised fuel management techniques. Further fluence reduction can be achieved by changing the core design. The value of such measures and the penalties involved must be determined for each plant individually.

The Committee believes that if due consideration is given to the items mentioned above, and if regulatory actions are based on the proposed screening criteria, the pressurized thermal shock matter should not present an undue risk to the health and safety of the public.

Additional comments by ACRS Member David Okrent are presented below.

Sincerely,

P. Shewmon

P. Shewmon
Chairman

Additional comments by ACRS Member David Okrent

I generally support the ACRS recommendations in this report and have no problem with use of the proposed screening criteria on an interim basis. The comments which follow are made in no small part because of the generic implications to the regulatory process of how an issue like pressurized thermal shock is handled.

I believe it has been useful for the NRC Staff to attempt to examine the PTS issue probabilistically. The preliminary probabilistic studies reported thus far should be made more comprehensive, reported in depth, and subjected to extensive independent review.

In Section 8.4 of the September 13, 1982 Draft NRC Staff Evaluation of PTS, the NRC Staff compares its proposed PTS requirements to the Commission's, proposed policy statement on "Safety Goals for Nuclear Power Plants: A Discussion Paper," NUREG-0880.

If, for purposes of discussion, I accept the NRC Staff PRA results in Figure 8-3, as well as its statement that at the $270^{\circ}F$ screening criterion, RT_{NDT} is likely to have a mean value of $210^{\circ}F$ (RT_{NDT} of $270^{\circ}F$ representing a 2σ upper confidence bound), I have trouble agreeing with some significant statements made by the Staff in Section 8.4.

On page 8-5, the NRC Staff says the following:

> "The core melt Safety Goal guideline states, 'The likelihood of a nuclear reactor accident that results in a large-scale core melt should normally be less than one in 10,000 per year of reactor operation.' This suggests that the core melt frequency ascribable to one sequence, for example PTS, should not exceed approximately 10^{-5} per reactor-year.

"Because of the unusually large uncertainty in the risk estimation for PTS, compared to other sequences, a value of less than 10^{-5} might well be assigned for a safety goal for PTS. We have not done this in the discussion in this section, but have used 10^{-5}. The reader should keep in mind that the risk numbers for PTS given in the following discussion are highly uncertain.

"We have no technical analysis of the course and consequences of a PTS sequence that involves RPV failure. Determination of the RPV failure mode (better, estimation of the probabilities of the various failure modes) has not been done and is dependent on the details of the scenario. Moreover, the outcome would likely be dependent also on the plant design details. In particular, ice condenser containments would be expected to have different failure modes, with different probabilities, than large dry containments."

I disagree with the use of 10^{-5} per reactor-year for at least two reasons. First, there are many more than ten potential initiators of large-scale core melt. Allocating 10^{-5} per reactor-year to a single initiator is questionable. It is even more questionable in view of the large uncertainty. Most importantly, until one knows with considerable confidence that a PTS failure has only a small likelihood of leading to early containment failure or otherwise leading to one of the large radioactivity release categories, the assignment of 10^{-5} per reactor-year (best estimate, with very large uncertainties) is probably unacceptable.

The NRC Staff states it has no technical analysis of the course and consequences of a PTS sequence that involves reactor pressure vessel failure. However, on page 8-6 the NRC Staff defines a quantity Y as the fraction of PTS-caused failure leading to core melt which leads to significant radioactive release. In the September 13, 1982 draft report, the NRC Staff used values of Y between $5x10^{-2}$ and $5x10^{-3}$ in suggesting that its proposed screening criterion is compatible with a PTS risk less than 10% of the proposed safety goal guidelines. In its oral presentation during the 270th ACRS meeting, the NRC Staff modified its approach such that a value of $Y = 8x10^{-2}$ is compatible with meeting the safety goal.

The NRC Staff provides no basis for these values of Y, which are much less than unity. In the absence of any reasonable justification for the suggested range for Y, this aspect of the logic supporting the choice of the screening criterion becomes weak.

I recommend that, before the proposed screening criteria are adopted for the long term, the relevant information on containment behavior, given a PTS failure, be developed and included in an expanded probabilistic study which attempts to deal quantitatively with all contributions to uncertainty and states which uncertainties cannot be addressed meaningfully and why. The sensitivity studies reported in Appendix H are useful but do not take the place of a critical examination and evaluation of uncertainties, which the NRC Staff currently estimates are a factor of 100 in either direction.

The NRC Staff should then state a recommended position and include reasons for whatever approach is recommended in light of the uncertainties.

I might note the incongruity illustrated by the NRC Staff's comment on page 8-7 that "For scenarios involving core melt without significant releases, the core melt guideline will govern and ALARA is not a consideration." This conclusion by the NRC Staff may be compatible with NUREG-0880. However, I find it hard to believe that the Commission would not credit an appropriate benefit to some measure which significantly reduced the likelihood of pressure vessel failure, even if such failure were estimated to lead to core melt without significant release of radioactivity.

Finally, I should like to observe that PTS is a real issue in which the NRC Staff, the industry, and others are using probabilistic considerations coupled with ad hoc safety criteria as one input into engineering judgment. PTS is a significant issue which is subject to such large uncertainties that a plausible set of confidence bounds may well encompass a risk band which separates the clearly acceptable and clearly unacceptable areas and that these confidence bounds may also extend into those areas. Quite aside from any Commission action on safety goals, it seems to me important that the Commission take steps to assure that the probabilistic aspects of this issue are done as well as practical and that the appropriate review processes are established and accomplished. I also recommend that the Commission participate actively in establishing the criteria to be used on this issue for decision making under uncertainty. This includes the basis for action if and when flaws or indications of flaws in the size range of interest are found during forthcoming inspections of reactor vessels.

References:

1. Draft NRC Staff Evaluation of Pressurized Thermal Shock, dated September 13, 1982, including Appendices A-P, dated September 15, 1982.
2. Letter from Demetrios L. Basdekas, NRC to P. G. Shewmon, ACRS concerning comments on the September 13, 1982 Draft NRC Staff Evaluation of Pressurized Thermal Shock, dated October 6, 1982.