February 9, 1983

Docket No. 50-29
LS05-83-02-018

Mr. James A. Kay
Senior Engineer - Licensing
Yankee Atomic Electric Company
1671 Worcester Road
Framingham, Massachusetts 01701

Dear Mr. Kay:

SUBJECT: RESOLUTION OF TMI ACTION ITEM II.K.3.5, "AUTOMATIC TRIP OF REACTOR COOLANT PUMPS"

The purpose of this letter is to inform you of (1) the staff's conclusions regarding your analysis of LOFT Test L3-6, (2) the continued acceptability of your ECCS evaluation model for predicting small break LOCAs with Reactor Coolant Pump (RCP) operation and (3) criteria for resolution of TMI Action Item II.K.3.5, "Automatic Trip of Reactor Coolant Pumps."

We have completed our evaluation of the YAEC analyses of LOFT Test L3-6 and conclude that the evaluations acceptably predict the test results. Therefore, we find the currently approved YAEC evaluation model for small break LOCAs in continued conformance with Appendix K to 10 CFR 50 for the case of limited RCP operation after reactor trip.

We have reviewed industry analyses and performed our own analyses to determine whether RCP trip is necessary during LOCAs, and evaluated the desirability of continued RCP operation during non-LOCA transients and accidents, including steam generator tube ruptures. We have concluded that there is a wide range of transients and LOCAs where it is beneficial for the operators to maintain forced circulation cooling and mixing through operation of the RCPs. However, some of the calculations show that for certain small break LOCAs, primarily those with only one of the two High Pressure Safety Injection (HPSI) Pumps assumed available, continued operation of the RCPs or continued operation of the RCPs followed by delayed RCP trip could lead to core damage.

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Some uncertainty in these conclusions remains. Specifically, there is a complex interrelationship among break size, break location, RCP trip delay time, available safety systems, and peak cladding temperature (PCT) for each type of NSSS design. Moreover, although the staff's and each vendor's calculational models adequately predicted LOFT test L3-6, there appear to be subtle differences embedded in the computer models which, when applied to large, commercial, PWR designs, yield differing results regarding the necessity for RCP trip during small LOCAs.

Because of this, we place substantial weight on the views of the reactor designers and the utilities which are almost unanimous in asserting that for some small LOCAs with less than the maximum available HPSI flow, delayed RCP trip could lead to core damage. Some utilities indicated their preference to keep the RCPs running for all events; however, this view appeared to be based solely on the desire to maintain forced circulation and did not consider the consequences of delayed RCP trip.

While acknowledging the industry's general conclusion that the RCPs should be tripped for small LOCAs, both the staff and the industry recognized that there are other accident sequences of much higher probability than the small LOCA where the absence of forced circulation makes the operator's job more difficult and can increase the likelihood of operator errors. For this reason, we believe that a balance should be struck between the competing risks associated with tripping the RCPs early and leaving them running following transient and accident events.

Based on our discussions with both licensees and the reactor manufacturers, and our internal evaluations, we believe that appropriate pump trip setpoints can be developed by the industry that would not require RCP trip for those transients and accidents where forced circulation and pressurizer pressure control is a major aid to the operators, yet would alert the operators to trip the RCPs for those small LOCAs where continued operation or delayed trip might result in core damage.

In summary, we have concluded that the need for RCP trip following a transient or accident should be determined by each licensee on a case-by-case basis, considering the Owners Group input. However, the staff must ensure that whatever decision is made regarding pump operation, it will result in safe, reliable operation of reactors and will not adversely affect the ability of licensees to comply with the Commission's rules and regulations.

The enclosure to this letter provides guidance for the development of either (1) satisfactory setpoints for RCP trip or (2) the technical bases for allowing continued RCP operation in the event of a small LOCA at a licensee's facility. As stated in the enclosure, manual tripping of the RCPs for a LOCA can be allowed under certain conditions.

We recognize that possible differences exist between the requirements of 10 CFR 50.46, which assure ample core cooling capacity, and the approaches described in the enclosure which are based upon assuring proper operator/system response under conditions that may be faced during accidents and transients. Accordingly, in such cases, we will consider a request for exemption from specific requirements of 10 CFR §50.46 pursuant to 10 CFR §50.12.

If a licensee elects to trip RCPs, when RCP trip setpoints are developed which are believed to substantially meet the guidance provided in the enclosure, we encourage licensees to begin implementation of these new setpoints at operating plant(s)*. We caution that careful judgment should be used when developing proposed methods and setpoints in accordance with the guidance in the enclosure. If RCPs are to be tripped, we recommend that the licensees utilize event trees to systematically evaluate RCP trip setpoints to minimize the potential for undesirable consequences due to a misdiagnosed event.

Specifically, we recommend the setpoints be evaluated for events where the RCPs could be tripped when it is preferable they remain operational. We further recommend the setpoints also be evaluated for the case when the RCPs are not tripped early in the event and for which a delayed trip may lead to undesirable consequences.

We are not requiring a formal submittal of the analyses which support either RCP trip setpoints or the decision to leave the RCPs operational for all events. However, once the technical bases for the decision are established, we intend to conduct inspections of individual licensees led by Regional personnel. During these inspections, we will examine the translation of the 10 CFR 50, Appendix K, and RCP operation mode evaluations into plant procedures. We would expect the evaluations to include consideration of the guidance contained in the enclosure to this letter. Copies of these evaluations should be made available to the staff at these inspections.

Alternatively, a licensee may choose to make either an individual submittal or reference a generic (i.e., owners group) submittal which provides the technical justification for treatment of RCPs during transients and accidents. In that case, an inspection would not be necessary.

The requirements set forth in this letter supersede the actions rquired in IE Bulletins 79-05C and 79-06C.

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*Unless implementation entails a change to technical specifications or an unreviewed safety question, which require NRC approval prior to implementation.

Accordingly, within 60 days following receipt of this letter, please provide your plans and schedules for resolution of this issue for your facility. You should also indicate whether you desire to make a submittal concerning this issue. If you cannot respond within 60 days, you should indicate within 30 days when your schedule will be submitted. The information requested should be sent to Mr. D. G. Eisenhut, Director, Division of Licensing, Washington, D.C. 20555 pursuant to 10 CFR §50.54(f).

This request for information was approved by the Office of Management and Budget under clearance number 3150-0065 which expires May 31, 1983. Comments on burden and duplication may be directed to the Office of Management and Budget, Reports Management, Room 3208, New Executive Office Building, Washington, D.C. 20503.

If you believe further clarification regarding this issue is necessary or desirable, please contact Dr. B. Sheron (301-492-7460).

Sincerely,

Original signed by
Darrell G. Eisenhut

Darrell G. Eisenhut, Director
Division of Licensing

Enclosure:
Resolution of TMI Action
Item II.K.3.5

cc w/enclosure:
Service Lists

DL: ORB #5
DCrutchfield
2/9/83

DEQA/IE
EJordan
1/28/83

DSI/NRR
RMattson*
1/21/83

*SEE PREVIOUS CONCURRENCES

**See OELD concurrence on letter to W applicants.

OFFICE	ORB#3:DL	C-ORB#3:DL	AD-OR:DL	AD-L:DL	OELD**	D:DL	DL: ORB #5
SURNAME	DJaffe	RClark*	GLainas	TNovak*		DEisenhut	JLyons
DATE	1/ /83	1/19/83	1/26/83	1/23/83	1/ /83	2/3/83	2/8/83

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Sincerely,

Darrell G. Eisenhut, Director
Division of Licensing

Enclosure:
Resolution of TMI Action
Item II.K.3.5

cc w/enclosure:
Service Lists

DEQA/I+E
E. Jordan
1/ /83

DSI/NRR
R. Mattson
1/ /83

OFFICE	ORB#3:DL	C-ORB#3:DL	AD-OR:DL	AD-L:DL	OELD	D:DL	
SURNAME	DJaffe	RClark	GLainas	TNovak		DEisenhut	
DATE	1/ /83	1/19/83	1/ /83	1/ /83	1/ /83	1/ /83	

cc
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RESOLUTION OF TMI ACTION ITEM II.K.3.5

The NRC, its licensees, and the PWR vendors have been evaluating the reactor coolant pump (RCP) trip issue since the accident at TMI. The technical understanding of the industry and the requirements of NRC on this issue have changed twice in that period. As a result, there have been extensive studies to better understand the dynamic response of all classes of PWRs to small break LOCAs. Although some confirmatory information is still to be received concerning some models, we conclude that the analytical models are sufficiently reliable to be used by licensees to choose their own best method for RCP operation upon indication that a LOCA has occurred.

In developing methods for RCP operation (i.e., trip or leave running) during all transients and accidents, we recommend addressing the following items that have been identified by the staff as part of our review of this issue.

We have separated these items into two groups: Those associated with RCP operation criteria which could result in RCP trip during transients and accidents, and those associated with pump operation criteria which allow the RCPs to remain running during transients and accidents, including small break LOCAs.

I. Pump Operation Criteria Which Can Result in RCP Trip During Transients and Accidents

The staff has concluded, that, if sufficient time exists, manual action is an acceptable means for tripping the RCPs following a LOCA. We have based this conclusion in part upon our own probabilistic assessment. It showed that the failure of a designated operator to trip the RCPs within five minutes following receipt of a RCP trip signal is approximately six times more likely than is the failure of an automatic trip. Our probabilistic assessment was limited by a lack of comprehensive information about the complex interrelationships among break size, break location, RCP trip delay time, available ECC systems, and peak cladding temperature (PCT) for each type of NSSS. A complete map of this interrelationship for each design would be prohibitively expensive to generate (tens of computer runs for each design at thousands of dollars per run and hundreds of hours of analyst time). Without such a map, we cannot accurately define the bounds of the region where unacceptable consequences might result from delay in RCP trip. However, based on our understanding of the phenomena in question, analyses performed by the NSSS vendors, limited independent analyses performed by the staff, tests performed in both Semiscale and LOFT, and our probability assessment, we conclude that allowing manual RCP trip is acceptable provided certain conditions are satisfied. Our guidelines for RCP trip setpoints and methods are set forth below. In developing RCP trip setpoints and methods, there are two potential problems with RCP trip that continue to show up in reactor operations. The first problem is caused by the fact that the loss of pressurizer sprays upon RCP trip for transients and for small break LOCAs results in a need in some plants to use power operated relief valves (PORVs) for primary system pressure control. Despite extensive testing of prototypes and improved reliability engineering, these valves continue to show a high propensity for failing to close. Although the question of PORV functionality has been better characterized by the EPRI valve testing program since the accident at TMI, there does not appear to be significant progress in improving the overall operational reliability of PORV systems. A second problem associated with RCP trip is that it tends to produce a stagnant region of coolant in the upper elevations of the reactor vessel. In a number of recent operational events, this hot, stagnant fluid has flashed and partially voided the upper vessel region during depressurization or cooldown situations. Despite wide dissemination of information about these operating events and the learning opportunites that they present, we still perceive that operators (1) are not completely familiar with the significance of a steam bubble in the upper head, (2) have difficulty controlling coolant conditions so as to avoid or control flashing where possible, and (3) may have a tendency to take precipitous actions when a steam bubble exists.

In developing your RCP trip setpoints and methods, the following guidelines should be considered:

1. Setpoints for RCP Trip

   a) The setpoints should be designed to assure that the RCPs will be tripped for all losses of primary coolant in which RCP trip is considered necessary. The setpoints should also ensure continued forced RCS flow during steam generator tube ruptures up to and including the design basis tube rupture. Safety analyses should be performed to demonstrate the achievement of these goals. The symptoms and signals used to alert an operator of the need to manually trip RCPs should be, to the extent possible, uniquely attributable to LOCAs and not other depressurizing transients and actions for which continued pump operation is desirable. In this regard, consideration should be given to partial or staggered RCP trip schemes (e.g., in two loop, four pump plants, trip one pump per loop immediately and trip remaining pumps once the existence of a LOCA is confirmed). If selected pumps are tripped during the initial phase of the transients, licensees should assure that training and procedures provide direction for use of individual steam generators with and without RCPs in operation. Your evaluation should be capable of demonstrating and justifying that the proposed RCP trip setpoints are adequate for small LOCAs but will not result in RCP trip for other non-LOCA transients and accidents (e.g., steam generator tube ruptures).

b) The RCP trip setpoints should be selected so as to exclude extended RCP operation in a voided system (e.g., pump head degradation >10%) unless engineering analyses or tests are available to justify that RCP and RCP seal integrity will be maintained under those conditions.

c) If, for some transients and accidents within the current design basis, and with offsite power available, the setpoints selected will lead to RCP trip even though it is neither required nor desirable, it should be assured that these events will not result in challenges, either automatic or from the operators, to the PORVs to accomplish depressurizing actions normally accomplished by pressurizer sprays. Heated auxiliary spray capability not derived from RCP discharge pressure could be considered as one possible means of eliminating this reliance on the PORVs. On the other hand, if PORV operation is continued to be recommended for use in depressurization, then a program for upgrading the operational reliability of the PORVs should be developed.

d) For any conditions which require or result in RCP trip and the establishment of a hot, stagnant, fluid region at high points in the primary system, emergency procedure guidelines and emergency procedures should specifically describe symptoms of primary system voiding due to flashing of stagnant regions of hot coolant. They should also contain specific guidance on detecting, managing and removing the coolant voids that result from flashing. Operator training programs should specifically address the significance of primary system voids under non-LOCA and LOCA conditions.

e) Transients and accidents which produce the same initial symptoms as a LOCA (i.e., depressurization of the reactor and actuation of engineered safety features) and result in containment isolation may result in the termination of systems essential for continued operation of the reactor coolant pumps (i.e., component cooling water and/or seal injection water). It was the intent of TMI Action Plan

Item II.E.4.2 to have licensees reevaluate essential and non-essential systems with respect to containment isolation. In particular, if a facility design terminates water services essential for RCP operation, then it should be assured that these water services can be restored in a timely manner once a non-LOCA situation is confirmed, and prevent seal damage or failure.

It should be confirmed that containment isolation with continued RCP operation will not lead to seal or pump damage or failure.

f) Parameters used to determine when RCPs should be tripped should provide unambiguous indicators of a LOCA. The inadequate core cooling instrumentation required by the Commission and described in NUREG-0737 should be factored into the emergency procedure guidelines where useful in indicating the need for RCP trip.

2. Guidance for Justification of Manual RCP Trip

Our review of this subject leads us to conclude that, when tripping the pumps is recommended by the licensees, it is preferable to manually (rather than automatically) trip the reactor coolant pumps where it is at all possible to justify it. However, our review indicates that there may be a few plants for which it is not possible to justify manual trip because of reliability considerations. The guidance stated below is intended to assist those plants that can and should rely on manual trip to develop complete justification for and to clearly identify those few plants that may not be able to rely on manual trip.

a) Based on the RCP trip setpoints developed according to the guidance in item one above, analyses* should demonstrate that the limits set forth in 10 CFR 50.46 are not exceeded for the limiting small break size and location. For the purposes of showing compliance with 10 CFR 50.46, operator action to trip the RCPs should be assumed no earlier than two (2) minutes following the onset of reactor conditions corresponding to the RCP trip setpoint. Allowances should be made for instrument error.

b) If manual RCP trip is proposed, then for the limiting small break size(s) and location(s) identified from (a) above, a most probable** best estimate analysis of the amount of time available to the operator to trip the RCPs following the existence of the RCP trip signal should be performed. If this time is less than that recommended in Draft ANSI Standard N660, the acceptability of this time should be justified. An evaluation of operating experience data should

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*Generic analyses of general reactor types is acceptable in lieu of plant specific analyses. The generic analyses should be shown to bound plant specific evaluations.

**Each licensee should identify and justify the most probable plant conditions. Conservative estimates are acceptable in the absence of justifiable most probable plant conditions.

be included when addressing this justification. The consequences if RCP trip is delayed beyond this time should also be addressed. Contingency procedures should be developed and be available to the operator in the event the RCPs are not tripped in the preferred time frame. If the time available is in excess of the standard, no further justification is necessary.

3. Other Considerations

Although acceptance criteria in the following areas are not specified, assurance that they have been considered and good engineering practice has been followed will be required.

a) For the parameter(s) employed in the RCP trip setpoint, the level of quality for the instrumentation that will signal the need for RCP trip should be established. In particular, the basis for the following should be identified:

- The design features chosen for the sensing instruments (e.g., seismic and environmental qualifications, reliability, etc.).

- The degree of redundancy in the sensing instruments.

In general, credit may be taken for all equipment available to the operators and for which sufficient confidence in its operability, during conditions under which it is expected to operate, has been established.

b) It should be ensured that emergency operating procedures exist for the timely restart of the reactor coolant pumps when conditions which will support safe pump operation are established.

c) The training program should instruct operators in their responsibility for performing RCP trip in the event of a SBLOCA. In particular, the operators should be trained in prioritization of actions following engineered safety features actuation.

II. Pump Operation Criteria Which will not Result in RCP Trip During Transient and Accidents

It is recognized that an evaluation could lead to the conclusion that, based on competing risks, both the preferred and safest method of pump operation following a transient or accident event would be to have the pumps running. In order to substantiate this conclusion, the following evaluation guidelines should be considered:

1. Evaluation of Inventory Loss

The industry analysis model comparisons against LOFT test L3-6, while providing good agreement with the experimental data, require additional verification to support continuous pump operation for all transients and accidents, including small break LOCAs. These include:

o Completing evaluations of LOFT L3-6 through the ECCS recovery phase, if not already completed;

o Evaluating all modeling differences which are expected to exist between the LOFT prediction and the large plant analysis (e.g., for B&W plants, how does primary system geometry affect conclusions? Can smaller scale, two-phase, side entry pump performance data be confidently extrapolated to large, bottom entry pumps, in particular in the high void fraction regions?).

2. Pump Integrity

a) During periods of extended two-phase performance, pump integrity is a chief concern (during the TMI-2 accident, one of the operating RCPs was finally tripped due to excessive vibration). The evaluation should conclude why RCP seal and RCP structural integrity will be assured during extended two-phase flow performance. If RCP and/or RCP seal integrity cannot be assured, then the consequences of their failure should be considered in the analyses.

b) If continuous RCP operation is expected in the presence of a containment isolation signal, the ability for continuous RCP operation without essential water services should be addressed, or the capability to rapidly restore essential water services should be provided.

c) The ability of the RCPs to operate in the accident environment (e.g., containment temperature and humidity) should be addressed. If continuous operation in the accident environment cannot be assured, then the consequences of failure at any time during the course of the accident should be addressed.

3. Acceptability of Results

Analyses should be performed which demonstrate that the ECCS acceptance criteria of 10 CFR 50.46 are met using an analysis model which complies with the requirements of Appendix K to 10 CFR 50. These analyses should assume (a) continuous RCP operation, and (b) assumed RCP trip at various times during the accident if continuous pump operation cannot be assured. If the analyses indicate compliance with the criteria of 10 CFR 50.46 cannot be achieved, the staff will consider a request for an exemption to the 10 CFR 50.46 requirements if (a) it is concluded that compliance with 10 CFR 50.46 would require operating the plant in a less safe condition, (this should be supported with risk/benefit analyses), and (b) it is concluded that design modifications (e.g., additional HPI capacity) would not be cost-effective to implement from a safety standpoint.

The risk-benefit analyses can take credit for all equipment for which there is confidence that this equipment will remain operational during the accident.