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March 9, 1982

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Mr. A. Schwencer, Chief
Licensing Branch #2
Division of Licensing
U. S. Nuclear Regulatory Commission
Washington, DC 20555

Subject: LaSalle County Station Units 1 & 2
NUREG 0737, Item II.K.3.18
ADS Logic Modification and ATWS
NRC Docket Nos. 50-373 and 50-374

References (a): BWR Owner's Group Submittal to NRC dated February 5, 1982.

(b): LSCS FSAR, Appendix L, Section L.62.

Dear Mr. Schwencer:

The purpose of this letter is to submit to you an advance copy of material regarding "ADS Logic Modification and ATWS" which will be incorporated in Amendment 61 to the LSCS FSAR.

In Reference (a), the BWR Owner's Group submitted their position on Item II.K.3.18 of NUREG 0737. This submittal provides Commonwealth Edison Company's current position on Item II.K.3.18.

If there are any further questions concerning this matter, please contact this office.

Very truly yours,

CW Schroeder 3/9/82

C. W. Schroeder
Nuclear Licensing Administrator

lm

Enclosure

cc: NRC Resident Inspector - LSCS

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PART B. SECOND SUBMITTAL

Introduction

The subject is the need for modification of ADS logic to enable easier inventory control whenever HPCS has failed during the situation where high drywell pressure exists and actuation of ADS is mandatory. This second submittal addresses the ATWS situation, where in addition to the above failures, the control rods are postulated to not insert sufficiently for reactor shutdown. This second treatment is then an ATWS treatment where the ADS inhibit question has always existed for BWR's and where special Emergency Procedure Guidelines (EPG's) are currently relied upon for inventory control by the operator.

Whereas the initial submittal pertains to LOCA-type events whose composite probabilities dominate the ATWS hypothesis by several orders of magnitude for BWR-5's and 6's, this second submittal is provided as a discussion of the relationship between the EPG's and the originally proposed ADS logic modifications calling for either bypass or elimination of the high drywell pressure signal to enable automatic ADS actuation on low water level only. This submittal explains the complexity of ADS inhibit in the ATWS logic; it does not, however, address why the ADS function for LOCA cannot be improved as originally outlined and also inhibited for ATWS as discussed herein. Surely, if the operator has definitive signals to indicate that an ATWS is in progress rather than a LOCA, these same signals can be utilized in a refining logic to control the priorities and alignments needed for safe response to the event. If the event signals cannot differentiate the type of event to either LOCA or ATWS, then the operator's dilemma dominates the problem and a valid solution is not defined yet. Obviously, this second submittal is an interim position requiring further refinement, especially for newer BWR's like LaSalle where only the LOSP-ATWS event is of major consequence provided that the plant unique mitigation capability is utilized to recover from other ATWS events.

Background and Summary

The ADS initiation logic design modifications recorded in Part A above responsed to NUREG-0737, Item II.K. 3.18. They were based on the assumption that neither of these proposed modifictions would complicate the operator actions specified in the BWR Emergency Procedures Guidelines (EPGs). As the EPGs have developed, however, it has become apparent that this assumption is not true.

The Level Restoration Contingency in the EPGs requires operation with RPV water level below the ADS setpoint (Level 2 which is above the top of the active fuel) for an indeterminate period under certain ATWS conditions. Elimination or short-term bypass of the present high drywell pressure permissive in the ADS logic would severely complicate operator actions during ATWS recovery conditions because the operator would be required to reset the ADS logic about every two minutes in order to inhibit normal actuation of this system, which is a premature actuation in the ATWS recovery sequence reported herein and used in the EPG's.

Of greater importance, as a precaution to preserve containment integrity, the Power (reactivity) Control sections of the EPGs now require operation in the same RPV water level region (below L2) for up to 30 minutes during a high-power ATWS with isolation. Under these circumstances the effects of early actuation of ADS are of great significance on suppression pool integrity. This submittal presents a general discussion of the bases for the operator actions to control RPV water level during these ATWS conditions.

Discussion

The EPGs are based upon the premise that for even the most degraded plant conditions the integrity of the primary containment is of paramount importance. For this reason, operator actions specified for response to symptoms indicative of a failure to scram are based on preserving the integrity of the primary containment under these very degraded conditions.

A fundamental requirement for preserving containment integrity is sufficient suppression pool heat capacity to absorb the energy stored within the RPV without exceeding the design pressure of the containment. To this end, suppression pool heat capacity curves have been generated to insure both sufficient suppression pool water and sufficient margin to saturation in the suppression pool during and following any LOCA or actuation of safety relief valves including ADS initiation. These capacity curves are functions of the actual RPV stored energy through the parameter RPV pressure. Typical curves have been extracted from the EPGs and are attached as Figures 1 and 2. The technical bases for these curves were submitted with the EPGs in January, 1981 (NEDO-24934).

The quickest and most effective method of achieving reactor shutdown under failure-to-scram conditions is the insertion of control rods by alternate means (e.g., alternate rod insertion or manual rod insertion). However, should this prove ineffective, the Standby Liquid Control System (SLCS) may be used to inject an aqueous solution of boron into the RPV. For plants currently operating, this system injects the boron solution (typically at 43 gpm) through a standpipe in the lower plenum of the RPV. At this rate, sufficient boron to bring a typical reactor to a hot shutdown condition with a 100% rod pattern would require approximately 30 minutes of injection assuming the solution was uniformly distributed throughout the RPV.

If vessel water level were maintained in the normal operating range and the recirculation pumps were not operating, reactor power would vary from approximately 40% when boron injection was initiated (100% rod pattern, natural circulation) to 2% when boron injection was complete (decay heat at hot shutdown), averaging approximately 20% during this interval. Even with the Residual Heat Removal (RHR) System in the pool cooling mode and an initial suppression pool temperature at the upper Technical Specification limit (typically 95^{o}F or 100^{o}F), the pool temperature would reach the heat capacity temperature limit before the reactor was shutdown. Therefore, vessel depressurization with the reactor at power would be required to maintain pool temperature and vessel pressure below current limits. Manual vessel pressure control and water level control during this evolution would be very difficult because void collapse during depressurization is accompanied by water swell inside the vessel.

In order to achieve reactor shutdown by boron injection prior to reaching the suppression pool temperature limit, reactor power must be suppressed during the boron injection interval. With the control rod drive system ineffective for this purpose, the best remaining mechanism for reactor power control is water level control. With the recirculation pumps not operating, all recirculation flow is natural circulation flow, the magnitude of which is proportional to the natural circulation driving head, which is proportional to the core average void fraction and the level of water in the RPV above the bottom of the active fuel. Because the core average void fraction contributes the negative reactivity which offsets the positive reactivity contributed by the withdrawn control rods, the core average void fraction remains constant. Thus recirculation flow, and thereby reactor power, may be controlled by controlling RPV water level. Reactor power, therefore, may be suppressed by lowering the water level in the vessel.

The boron mixing efficiency from the SLCS standpipe (fraction of injected boron which is mixed with the recirculation flow and transported to the core region) is also a function of recirculation flow. As expected, lower recirculation flow leads to poorer mixing, and boron mixing efficiency is inversely proportional to the amount of time required to achieve reactor shutdown by boron injection (the boron injection interval). Thus whereas reactor power may be suppressed by lowering RPV water level, the lower recirculations flow and poorer mixing extends the time interval for reactor shutdown and thus results in longer heat up of the suppression pool. It is therefore a trade-off relationship among competing variables.

A graphic plot of these relationships for a typical BWR-4 plant are illustrated in Figure 3. Reactor power is plotted as a function of recirculation flow by extrapolating natural circulation test data in the 30% flow region to lower flows using the principles discussed in the preceding paragraphs. Mixing efficiency is also plotted as a function of recirculation flow based on test data obtained from the early two-dimensional boron mixing tests. The dashed lines represent the suppression pool temperature as a function of recirculation flow at which reactor shutdown by boron injection is finally achieved. These are obtained by simple heat balances between the RPV and the suppression pool over the different boron injection intervals. The upper curve is based on the assumption that no suppression pool cooling is available during the boron injection interval, whereas the lower curve is based on the assumption that maximum pool cooling is available during this interval. These curves indicate that although there is an optimum core flow (and thus vessel water level) at which suppression pool heatup is minimized, the minimum suppression pool temperature at which reactor shutdown by boron injection is finally achieved is well in excess of the heat capacity temperature limit for this particular plant even assuming that maximum pool cooling is available. It should also be apparent that refinements in the extrapolation of the natural circulation test data or in the two dimensional boron mixing test data will not alter this conclusion.

Since under even optimum conditions direct power suppression by vessel water level reduction alone cannot achieve reactor shutdown by boron injection before the suppression pool temperature reaches the heat capacity temperature limit, a more complex shutdown sequence is required involving optimum boron injection timing and level control to remix injected boron. When suppression pool temperature reaches the boron injection initiation temperature, which is the maximum temperature at which boron injection can be initiated and the reactor shutdown by this procedure before suppression pool temperature reaches the heat capacity temperature limit, boron injection is initiated. Vessel water level is reduced until either the containment heatup terminates, reactor power drops below approximately 3%, or vessel water level in the downcomer region reaches the top of the active fuel, whichever occurs first. When one of these conditions occurs, vessel water level is stabilized until an amount of boron sufficient to shutdown the reactor has been injected into the vessel. Typically, this requires approximately 30 minutes. Of course under these very low flow conditions, the boron mixing efficiency is also very low and most of the cold, dense boron solution stagnates in the lower plenum with very little entering the core region. However, after boron sufficient to shutdown the reactor is present in the RPV, it is remixed and distributed to the core region by increasing recirculation flow by raising the vessel water level.

Tests have been conducted in a 1/6 scale model of a BWR to evaluate the effectiveness of this remixing sequence. The Boron Remixing Time Constant (BRTC), which is the amount of time required to raise the boron concentration in the core region to 50% of the average vessel boron concentration, was measured with these tests. The BRTC is plotted as a function of core flow in Figure 4. The test data indicates that a recirculation flow of only 10% will transport to the core region half the boron required to shutdown the reactor in 20 seconds. This curve demonstrates the effectiveness of this remixing mechanism.

Conclusion

The operator actions specified in the EPGs for control of vessel water level during high-power ATWS conditions are necessary to shutdown the reactor while maintaining adequate core coverage and taking precautionary actions to preserve containment integrity under these conditions. These actions include maintaining vessel water level below Level 2 (ADS Setpoint) for up to 30 minutes. If the drywell temperature and pressure is successfully controlled with the drywell coolers or by rejecting the majority of the reactor energy to the main condenser or both so that drywell pressure does not reach 2 psig, then elimination or short-term bypass of the present high drywell pressure permissive in the ADS initiation logic would severely complicate operator actions under these conditions. The operator would be required to reset the ADS logic about every two minutes in order to avoid early vessel depressurization with excessive heat transfer to the suppression pool.

Commitment

As a member of the BWR Owners Group, Commonwealth Edison recognizes the significance of generic studies to guide the safety refinements and to broaden safety coverage on BWR's; we support and participate willingly in such endeavors. Edison also recognizes the inherent differences between early vintage BWR's and more recent designs and also the marked differences in primary containments which house these reactors. In as much as the primary containment is of paramount importance in the time sequencing of EPG's, as well as in the engineering resolution of ATWS for specific plants, Edison considers this second submittal as interim information only.

A commitment for the application of EPG's for postulated LOCA events and for a postulated ATWS event is already docketed. Edison's position on the resolution of ATWS is also on the record. Edison is continuing the pursuit of an ATWS solution for its BWR plants via detailed engineering efforts and a future probablistic risk assessment for LaSalle. It is believed that plant unique ATWS evaluations may yield markedly different solutions with what may be significantly different remedial hardware modifications to obtain equivalent reliability goals. Reactor system differences and differences in containment design indicate that possibility.

Endorsement of the BWR Owner's Group interim position on ADS should be construed as a full commitment to resolve the ADS diversity question by this means only. Because of the larger ATWS context and because work is in progress outside the BWR Owner's Group for a more comprehensive resolution of ATWS, the endorsement of this BWR Owner's position on the ADS logic modification is necessary as long as EPG's are relied upon for the primary control for ATWS recovery.

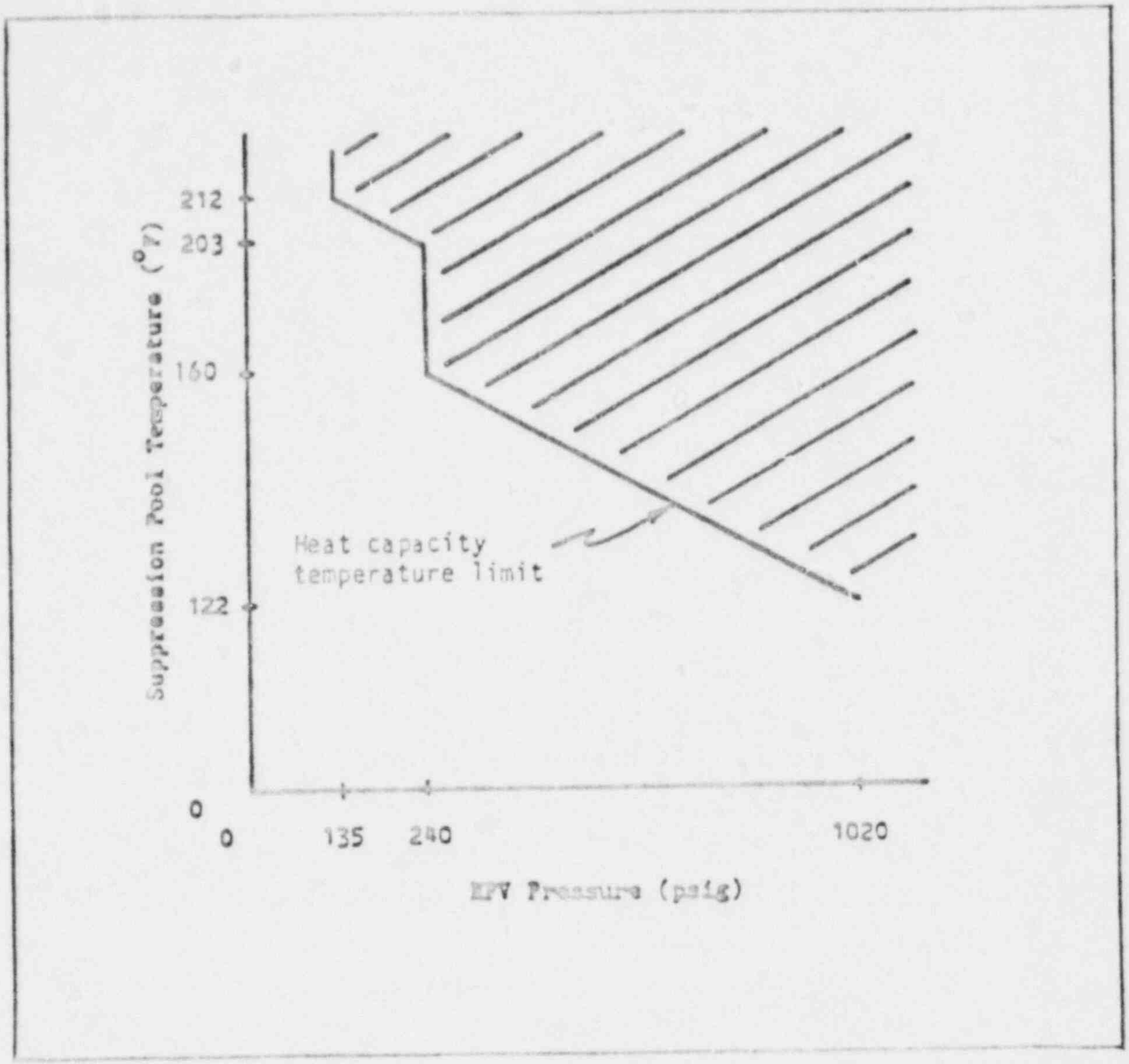
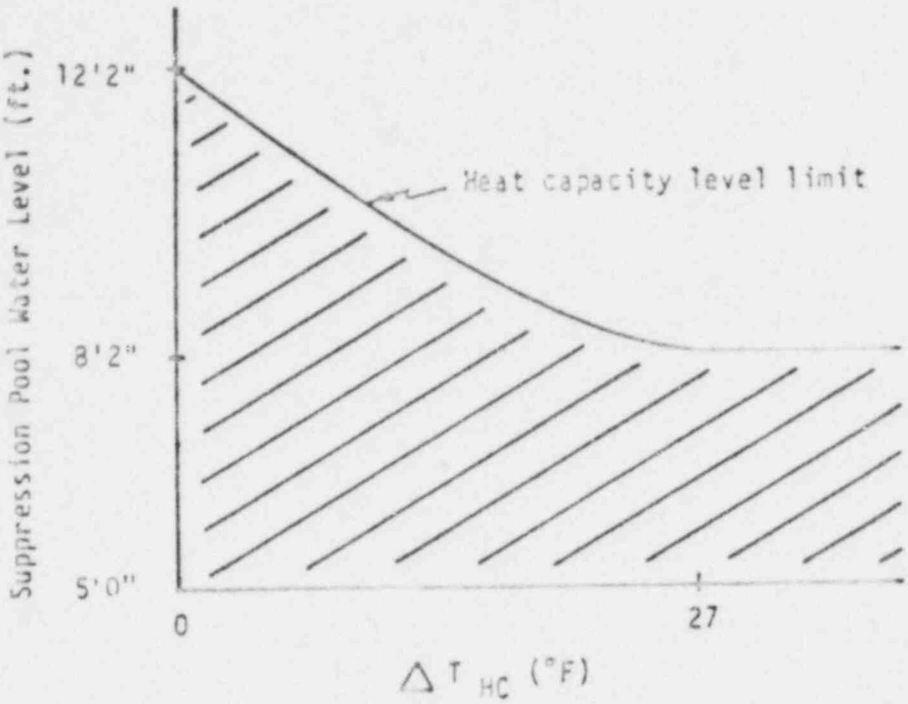


FIGURE L.62-1

TYPICAL HEAT CAPACITY TEMPERATURE LIMIT



Where ΔT_{HC} = heat capacity temperature limit minus suppression pool temperature

FIGURE L62-2

TYPICAL HEAT CAPACITY LEVEL LIMIT

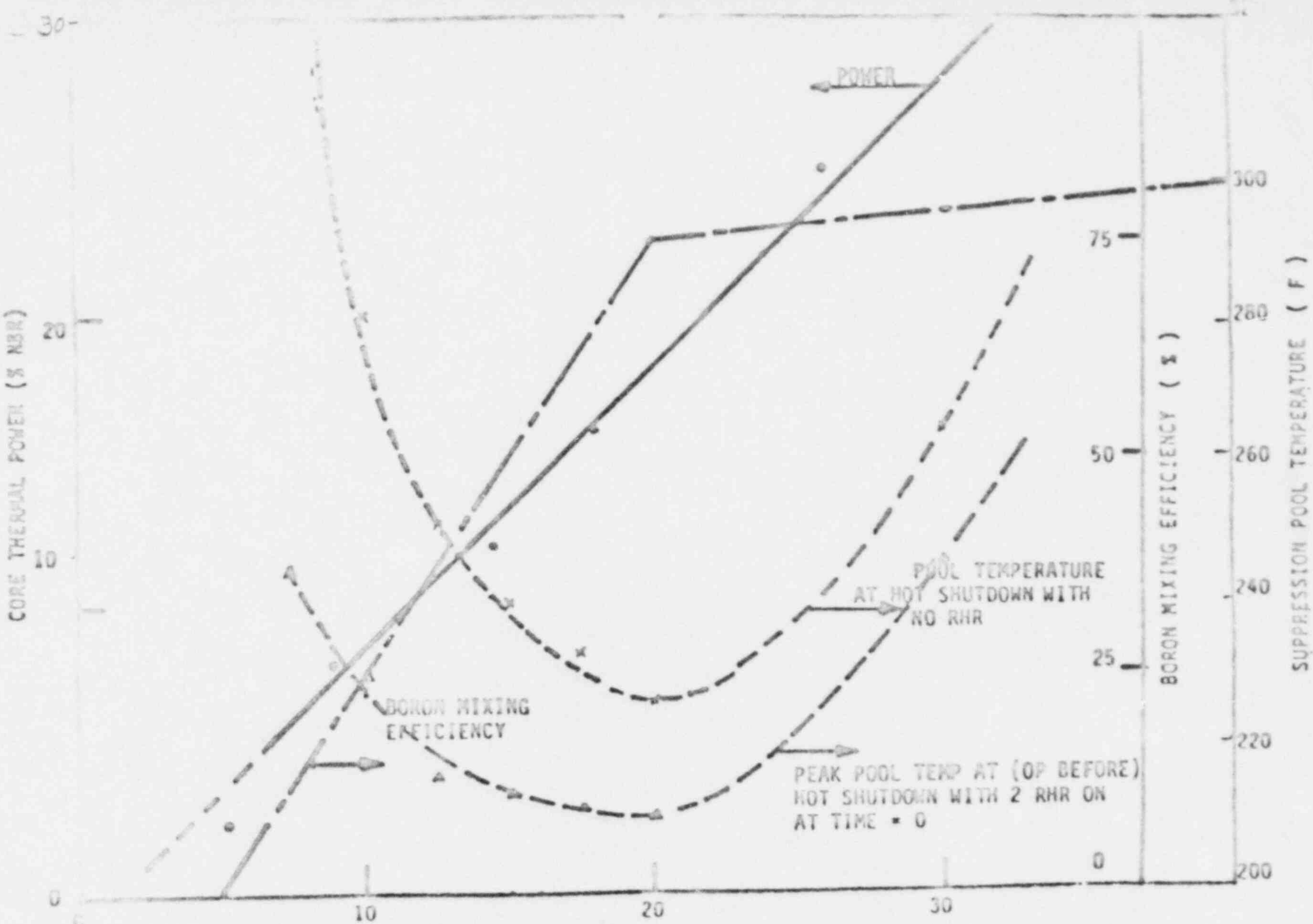


FIGURE 3 L.62-3

PEAK SUPPRESSION POOL TEMPERATURE FOR REACTOR SHUTDOWN BY SLCS

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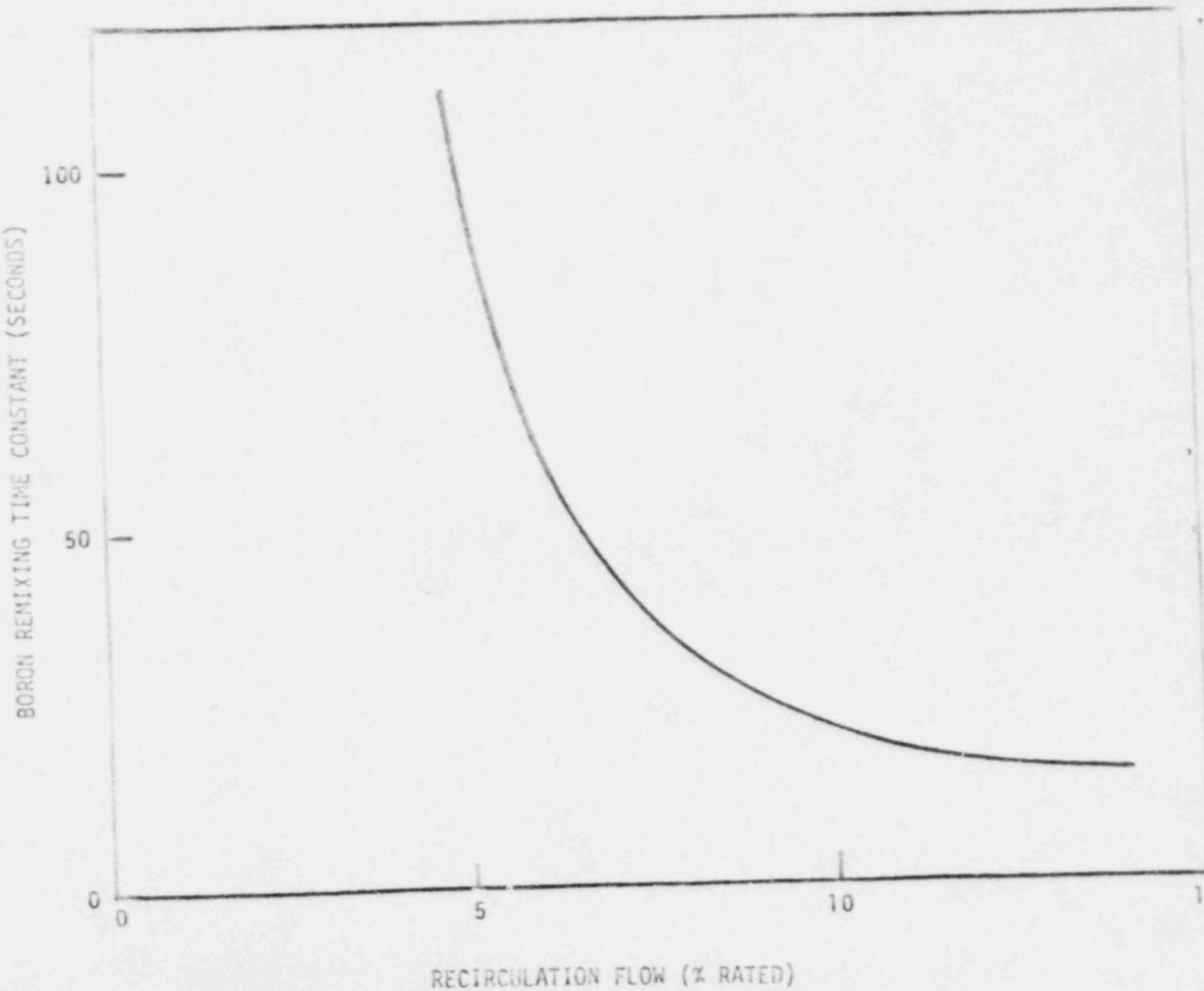

FIGURE ~~4~~ 2.62-2

NATURAL CIRCULATION BORON REMIXING TIME CONSTANT VS RECIRCULATION FLOW

NOTE: Boron remixing time constant is defined as the time required to raise in-core average boron concentration to 50% of total vessel average boron concentration