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JOHNSON,A.R. Project Directorate I-3

SUBJECT: Requests exemption to 10CFR50,App K,Sections I.D.3 & I.D.5 re upper plenum injection reflood requirements.COBRA/TRAC will be used to calculate LOCA transient.

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U.S. Nuclear Regulatory Commission
Document Control Desk
Attn: Allen R. Johnson
Project Directorate I-3
Washington, D.C. 20555

Subject: Request for Exemption to Selected 10CFR Part 50, Appendix K Requirements
R.E. Ginna Nuclear Power Plant
Docket No. 50-244

Dear Mr. Johnson:

Rochester Gas & Electric has evaluated the Ginna plant using an ECCS evaluation model which includes the effects of upper plenum injection. That evaluation will be used to support the next core reload currently scheduled for startup on May 3, 1993. A summary of that evaluation is being submitted under separate cover. 10 CFR 50 App. K assumes certain hardware and evaluation configurations which are not true for upper plenum injection equipped plants. The purpose of this letter is to request exemption from the requirements of 10 CFR Part 50, Appendix K, Sections I.D.3 and I.D.5.

## Basis for Request

The emergency core cooling system for the R.E. Ginna plant, and other Westinghouse two-loop plants, injects the low pressure emergency core cooling system (ECCS) water directly into the upper plenum of the reactor in the event of a loss of coolant accident (LOCA). Westinghouse three and four-loop plants inject the low pressure cooling water into the loop cold legs where it flows into the reactor downcomer and into the lower plenum of the reactor. In the past, LOCA analyses for two-loop Westinghouse plants have assumed that the low pressure water is injected into the lower plenum in the same manner as for the three and four-loop plants. With this assumption, Appendix K can be applied to the analysis without exemption. New LOCA models for two-loop plants model the low pressure cooling water as being injected directly into the upper plenum. Modeling the low pressure cooling water in this manner does not permit compliance with Appendix K, Sections I.D.3 and I.D.5, which assume that all plants utilize cold leg injection. Refer to Exhibit A, "Technical Basis for Exemption to Selected Appendix K Requirements," for a detailed discussion of the basis for this request.



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Determination of Special Circumstances

Section 50.12 "Specific Exemptions," of 10 CFR Part 50 allows the Commission to consider granting an exemption when special circumstances are present. This exemption falls under the special circumstances provided for in Section 50.12(a)(2)(ii), which states that an exemption may be granted if, "application of the regulation in the particular circumstances would not serve the underlying purpose of the rule or is not necessary to achieve the underlying purpose of the rule." Sections I.D.3 and I.D.5 were written for cold leg injection plants. They are not applicable to upper plenum injection plants when the upper plenum injection path is explicitly modeled in the LOCA analysis. Compliance with these sections is therefore not necessary for two-loop plants which explicitly model the upper plenum low pressure cooling water injection point. Refer to Exhibit A for detailed supporting information.

It is requested that this exemption be reviewed and approved by the NRC Staff prior to startup of Cycle 23, currently scheduled for May 3, 1993.

Please contact us if you have any questions related to this request.

Very truly yours,

Robert C. Mecredy

RWE/259

xc: Mr. Allen R. Johnson (Mail Stop 14D1)
Project Directorate I-3
Washington, D.C. 20555

U.S. Nuclear Regulatory Commission
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Ginna Senior Resident Inspector

Exhibit A

R. E. GINNA NUCLEAR GENERATING PLANT

TECHNICAL BASIS FOR EXEMPTION TO SELECTED APPENDIX K REQUIREMENTS

## 1. INTRODUCTION

The emergency core cooling system for all Westinghouse domestic two-loop pressurized water reactors injects the low pressure Emergency Core Cooling System (ECCS) cooling water directly into the upper plenum of the reactor in the event of a LOCA. Westinghouse three- and four-loop pressurized water reactors inject the low pressure cooling water into cold legs where it flows into the downcomer and then into the lower plenum. In the past, Loss of Coolant Accident (LOCA) analysis for two-loop plants assumed that during reflood the low pressure water was injected into the lower plenum (core flooding from below) in the same manner as for the three-loop and four-loop plants With this assumption, 10CFR50, Appendix K could be applied to the analyses without exception.

The NRC is concerned that the analytical assumption of low pressure water injecting into the lower plenum is unrealistic, and potentially non-conservative for two-loop pressurized water reactors (Reference 1). As a result of this concern, Wisconsin Electric Power Company, Northern States Power Company and Westinghouse Electric Corporation have developed a new LOCA model for plants with upper plenum injection (References 2 to 4). The new Upper Plenum Injection Best Estimate Methodology models the injection of low pressure ECCS water directly into the upper plenum.

In the process of reviewing this new model against the 10CFR50 Appendix K requirements, two Appendix K requirements were identified as not applicable to two-loop plants with upper plenum injection. These two requirements, Section I.D.3 and 5, were written for bottom flooding plants i.e., cold leg injection plants, and compliance with these requirements for plants with upper plenum injection would not serve the underlying purpose of the rule. The inapplicable requirements are:

Section I.D.3 Calculation of Core Exit Flow Based on Carryover Fraction

Section I.D.5 Calculation of Heat Transfer During Refill and reflood.

Both of these requirements are imposed on the calculation for the refill and reflood portion of the transient. Section 2, below, describes the refill and reflood phases of the large break LOCA in cold leg injection and upper plenum injection plants. Section 3 contains the applicable Appendix K requirement, the basis or original intent of the requirement, and the proposed analysis methods to be used for upper plenum injection plants.

## 2. DESCRIPTION OF CALCULATED LOCA TRANSIENT

### Introduction

In order to examine the different thermal-hydraulic behavior of a two-loop PWR with UPI for a postulated LOCA, a PWR LOCA transient with cold leg injection is reviewed. The two-loop UPI PWR transient is then contrasted to the cold leg injection PWR.

### Cold Leg Injection Plant

The large break LOCA transient includes three phases: blowdown, refill and reflood. Figure 1 shows the duration of each phase and the accumulator, low pressure and high pressure cooling water flow rates during each phase. The timing and injection flow rates in Figure 1 are from a licensing calculation for a double-ended cold leg guillotine break with a 0.4 discharge coefficient for a cold leg injection plant.

During blowdown, the vessel and loops depressurize and most of the fluid in the vessel and loops goes out the break into the containment. Blowdown ends before the low pressure and high pressure cooling water injection is assumed to start.

During refill, flow out of the break has ceased and the lower plenum and downcomer start to fill from water injected into the cold legs from the cold leg accumulator. The refill period lasts about 10 to 15 seconds and ends when the rising water level reaches the bottom of the core. The accumulators inject for the entire refill period, while the low pressure and high pressure cooling water start injecting near the end of the refill period. As the lower plenum fills, it is assumed that there is only radiation cooling in the core, and the fuel rods heat-up nearly adiabatically.

More recent cold leg injection calculations with realistic models indicate that some flow and core cooling will occur during refill. However, at the time the rule was written, these calculations were not available and it was deemed prudent to require a conservative approach in this area.

Reflood starts when the rising water level reaches the bottom of the core, and continues until the entire core is quenched (usually calculated to be several hundred seconds after the start of reflood in large break LOCA calculations based on conservative licensing assumptions). The accumulators empty about 5 seconds after the start of reflood, so the low pressure and high pressure systems provide the injection flow for the remainder of the transient. Throughout the reflood period, the core refloods from flow entering the core from the lower plenum.

Upper Plenum Injection Plant

The sequence of events of the large break LOCA transient in the two-loop plant with upper plenum injection is similar to that calculated for a cold leg injection plant in the blowdown phase since blowdown ends just after the low head safety injection begins to inject into the upper plenum. Sensitivity calculations indicate that the assumption of on site power yields higher calculated peak clad temperatures. Therefore, there will be some high head safety injection into the cold legs during the end of blowdown, and the low head injection into the upper plenum will begin once the system pressure drops below the low head SI pump shutoff head of a 120

psia. The refill and reflood phases have significant differences due to the injection of the low head cooling water into the upper plenum. These differences are described below.

Refill - With upper plenum injection, the low head safety injection starts before the end of blowdown, and begins to inject flow into the upper plenum, which penetrates into the core. Since there is now a direct source of cooling water which flows down through the reactor core, core cooling is possible during refill (References 5, 6 and 7). The accumulator flow and high head safety injection flows are injected into the cold legs in the same fashion as a cold leg injection PWR.

Reflood* - Accumulator injection into the cold legs continues for about the first 5 seconds of reflood. During this period, core cooling occurs from both bottom flooding resulting from accumulator injection and top flooding which occurs from upper plenum injection. After accumulator injection ends, however, water is added to the core mainly from above by water injected into the upper plenum. A smaller amount of high pressure cooling water is injected into the cold legs. Recent detailed WCOBRA/TRAC (Reference 4) calculations indicate that the UPI flow will easily penetrate lower power fuel assemblies on the outside of the core and will flow down into the core. Since these assemblies are at lower power, there is less steam generation. The UPI flow from the cold channels will crossflow below the quench front to the other assemblies. The remainder of the core will be in combination of cocurrent upflow and counterflow as the UPI flow in the upper plenum penetrates the upper core plate into the fuel region. The water accumulation rate into the vessel plus the liquid entrainment rate up out of the core is smaller than the UPI delivery rate such that both the core and downcomer fill, even though the net core

* To permit comparison with the cold leg injection plant, the term "reflood" is used here for the UPI plant to describe the period after the rising lower plenum water level reaches the bottom of the core. However, as described above, the core may be flooded from above even before the "reflood" period starts.

flooding rate is zero or negative. Heat is transferred to cocurrent or countercurrent two-phase mixture in the core which terminates the temperature rise at the core hot spot. This flow pattern has been observed in UPI simulation tests in the Japanese Cylindrical Core Test Facility (Reference 8) and in a thermal hydraulic calculation of a UPI plant LOCA, performed by Sandia (Reference 9).

## 3. BASIS FOR EXEMPTION FROM APPENDIX K REQUIREMENTS AND PROPOSED ALTERNATIVE ANALYSIS METHODS

### Carryover Fraction (Rule I.D.3)

Appendix K Requirement -

> The ratio of the total fluid flow at the core exit plane to the total liquid flow at the core inlet plane (carryover fraction) shall be used to determine the core exit flow and shall be determined in accordance with applicable experimental data (for example, "PWR FLECHT (Full Length Emergency Cooling Heat Transfer) Final Report," Westinghouse Report WCAP-7665, April 1971; "PWR Full Length Emergency Cooling Heat Transfer (FLECHT) Group I Test Report," Westinghouse Report WCAP-7435, January 1970; "PWR FLECHT (Full Length Emergency Cooling Heat Transfer) Group II Test Report," Westinghouse Report WCAP-7544, September 1970; "PWR FLECHT Final Report Supplement," Westinghouse Report WCAP-7931, October 1972).

Basis/Original Intent of Requirement - The core flooding rate depends on the pressure drop through the reactor coolant loops, the core liquid level and the downcomer liquid level. As the downcomer level increases, it forces more liquid into the core. Some of this liquid accumulates in the core as the vessel fills while a larger fraction of the core inlet mass flow is vaporized due to the core heat release. Vapor generated in the core carries entrained liquid out of the core into the loops. Accordingly, accurate calculation of core flooding rate requires accurate calculation of core exit flow rate. When Appendix K was written, the NRC felt that available codes could not accurately calculate the core exit

flow rate. As a result, Appendix K required core exit flow rate to be calculated using experimental data. Specifically, the core exit flow was determined from the code-calculated core inlet flow times a carryover fraction developed from FLECHT data. Using the terminology in Figure 2(A):

$$W_{core\ exit} = f \times W_{core\ inlet}$$

where f = carryover fraction, determined from FLECHT data as follows:

$$f = \frac{W_{core\ inlet} - dM_{core}/dt}{W_{L,in}}$$

where $dM_{core}/dt$ is the core mass storage rate.

The carryover fraction in the FLECHT tests ranged from about 0.8 to 0.9, i.e., 80% to 90% of the inlet flow was measured to leave the top of the core.

The intent of this requirement was to ensure the flow exiting the core to the loops was calculated by the most appropriate means available. When Appendix K was written, the data-based calculation was considered more appropriate than the code calculation for the bottom-flooding PWR, using the codes then available.

Why Requirement is Inapplicable for UPI Plant - The exit flow calculation method and the cited FLECHT data are for a bottom flooding situation, where the liquid flow direction at the bottom of the core ("inlet plane") is upward and the flow within the core at the top of the core ("exit flow") is also cocurrent upward, as shown in Figure 2(A). In a plant with upper plenum injection, the liquid enters at the top of the core and exits at both the bottom (water) and at the top (steam and water) as shown in

Figure 2(B) and can flow both in a countercurrent and cocurrent fashion in the core. Therefore, the definitions of inlet and exit are different in the two types of plants as well as the flow patterns in the core. To meet the intent of the Appendix K requirement, the liquid and steam flow from the core to the upper plenum is needed. For the cold leg injection plant, this is the core exit flow. The ratio of this exit flow to the inlet flow for the UPI case is significantly different than that in the bottom flooding situation, since the flow situation is markedly different. For example, in a typical CCTF UPI test (Reference 8) the reflood core exit steam mass flow ($W_s$) was about 40% of the net liquid downflow at the top of the core ($W_{L,down}$ - $W_{L,up}$); most of the remainder, about 60%, went out the bottom of the core ($W_{L,bottom}$) and then went up the downcomer to the cold leg break as shown in Figure 2(B). The CCTF instrumentation did not permit separate determination of the liquid downflow and liquid upflow at the top of the core. However, assuming the upward entrained water flow at the top of the core was small, the core exit flow ($W_{L,up} + W_s$) was about 40% of the inlet flow ($W_{L,down}$) in the CCTF UPI tests, compared to 80% to 90% in the FLECHT bottom-flooding tests. Accordingly, both the definitions of "inlet" and "exit," and the relative magnitudes of the flows and flow directions and patterns, are significantly different in the two types of plants. Accordingly, the cited FLECHT data, and the prescribed method of calculating core exit flow, do not apply to the UPI plant.

Proposed Analysis Methods for the UPI Plant - The intent of the Appendix K rule, accurate calculation of core exit flow, can be met by using a code, which has been verified against appropriate experimental data, to calculate core exit flow rate.

The WCOBRA/TRAC code (References 3 and 4) is an improved version of the COBRA/TRAC code which has been recently developed to predict the thermal-hydraulic response of reactor systems to large and small break loss of coolant accidents. This code is a significant improvement over the codes that existed at the time Appendix K was written. WCOBRA/TRAC uses a separated flow, two-phase flow model in which there are three fields for the two phases; a continuous liquid field to model liquid film

and low void fraction flows, a dispersed liquid field to model droplet flows, entrainment and de-entrainment; and a vapor field to model the gas phase. Each field has its own mass continuity equation and momentum equation. Within a given computational cell, the two liquid fields are assumed to be at the same temperature, while the vapor field can be at a separate temperature, hence, there are two energy equations. The interactions between each field are modeled through interfacial heat, mass, and momentum transfer using locally calculated heat transfer and fluid drag relationships. Using this formulation, WCOBRA/TRAC can model the complexities of a two-phase, nonequilibrium flow situation such as that found in the PWR's equipped with UPI. The WCOBRA/TRAC code calculates the amount of flow which penetrates down into the reactor vessel. It also predicts the net amount of steam upflow from the vessel to the loops, and it predicts what fraction, if any, of the water injected into the upper plenum is entrained out of the plenum into the loops. The WCOBRA/TRAC formulation permits accurate calculation of interphase heat and mass transfer, entrainment, de-entrainment, countercurrent flow, and liquid pooling such that steam and water flow carryover into the hot legs for PWR's with UPI can be accurately predicted.

To assess WCOBRA/TRAC's capability for predicting the correct thermal-hydraulic behavior for upper plenum injection situations, WCOBRA/TRAC has been compared to the Japanese Cylindrical Core Test Facility data which models the interaction effects of upper plenum injection in a large scale test facility (Reference 3). WCOBRA/TRAC predicts the thermal-hydraulic effects of the upper plenum injection such that the carryover of steam and water into the hot legs is accurately calculated. The use of WCOBRA/TRAC will meet the intent of requirement I.D.3 of Appendix K.

<u>Refill/Reflood Heat Transfer</u> (Rule I.D.5)

<u>Appendix K Requirement</u> -

> For reflood rates of one inch per second or higher, reflood heat transfer coefficients shall be based on applicable experimental data for unblocked cores including FLECHT results ("PWR FLECHT Full Length

. . Emergency Cooling Heat Transfer Final Report," Westinghouse Report WCAP-7665, April 1971). The use of a correlation derived from FLECHT data shall be demonstrated to be conservative for the transient to which it is applied; presently available FLECHT heat transfer correlations ("PWR Full Length Emergency Cooling Heat Transfer (FLECHT) Group I Test Report," Westinghouse Report WCAP-7544, September 1970; "PWR FLECHT Final Report Supplement," Westinghouse Report WCAP-7931, October 1972) are not acceptable. New correlations or modifications to the FLECHT heat transfer correlations are acceptable only after they are demonstrated to be conservative, by comparison with FLECHT data, for a range of parameters consistent with the transient to which they are applied.

During refill and during reflood when reflood rates are less than one inch per second, heat transfer calculations shall be based on the assumption that cooling is only by steam, and shall take into account any flow blockage calculated to occur as a result of cladding swelling or rupture as such blockage might affect both local steam flow and heat transfer.

Basis/Original Intent of Requirement - The rule prescribes heat transfer calculation methods for three cases; refill, reflood with flooding rate less than one inch per second, and reflood with flooding rate greater than one inch per second. For refill, the assumption of steam cooling is required in the rule because it was felt that there would be no water in the core during this period. For reflood, the requirements and the one inch per second threshold were chosen to ensure the effects of flow blockage were conservatively accounted for. At the time, a limited amount of flow blockage testing had been performed in the FLECHT facility, using a perforated plate to simulate the flow blockage. Tests were performed at flooding rates of 0.6, 1.0, 2.0 and 6.0 inches per second. These tests indicated enhanced heat-transfer due to blockage at flooding rates of one inch per second and higher because of increased turbulence and droplet break-up. The 0.6 inches per second flooding rate test indicated that the blocked bundle heat transfer was degraded relative to a similar unblocked bundle at the same flooding rate. The degraded heat transfer was presumed

to be caused by liquid de-entrainment at the blockage leaving only steam cooling heat transfer. Based on this data, the requirement for flooding rates greater than one inch per second was written to require that transfer coefficients based on undistorted geometry data; this was judged acceptable since the FLECHT data indicated the data would be conservative if blockage were to occur. For flooding rates less than one inch per second, the assumption of steam cooling was required since the FLECHT data indicated this would be the flow regime if blockage were to occur; if there was no blockage, this assumption would be conservative.

More recent data, summarized in Appendix F of Reference 4, indicates that there is no heat transfer penalty for flooding rates below 1 inch per second for blockage shapes which bound the most prototypical blockage geometries found in out-of-pile, and inpile experiments. The experiments also indicate that the flow above the quench front remains two-phase with liquid entrainment down to flooding rates as low as .4 inch per second, such that steam cooling only does not occur during reflood.

Why Requirement is Inapplicable for a UPI Plant - For a PWR with upper plenum injection, the flow patterns and resulting heat transfer mechanisms are different than those assumed in the Appendix K rule. The specific differences are the following:

(1) During refill in the UPI plant, the water injected into the upper plenum will fall into the core and contribute to core cooling. Therefore, the assumption of steam-cooling only during refill is inappropriate for the UPI plant. Further, the heat transfer mechanisms during refill are similar to those during reflood in the UPI plant, so it would be inconsistent to arbitrarily retain this requirement.

(2) The one-inch-per-second flooding rate threshold for steam cooling during reflood is based on bottom-flooding blockage heat transfer data. This threshold is inappropriate for the UPI plant for two reasons: (a) the value of the threshold has no meaning for the UPI plant, because of the different flow situations (see discussion in

the "Carryover Fraction" section above), and (b) the local flow patterns are different, so the behavior observed in the FLECHT reflood and blockage tests is not appropriate. Specifically, the FLECHT reflood and blockage data are for a bottom-flooding situation, with only cocurrent upward steam and water flow everywhere in the core (Figure 2(A)). Cooling is by dispersed cocurrent upflow film boiling and radiation. In the UPI plant, the net steam flow is upward but the net flow of water is downward (Figure 2(B). Further, the steam-water flow patterns vary throughout the core such that the rod surfaces are cooled by film boiling and radiation heat transfer resulting from a combination of cocurrent downflow, cocurrent upflow, and countercurrent flow, as observed in the CCTF tests (References 5, 6, 7, 8).

<u>Proposed Analysis Methods for UPI Plant</u> - To meet the intent of Appendix K, which is to use the most applicable data for this situation; the <u>W</u>COBRA/TRAC code has been verified against two independent sets of experimental data which models the upper plenum injection flow and heat transfer situation.

The first series of tests which have been modeled by <u>W</u>COBRA/TRAC are the Westinghouse G-2 refill downflow and counterflow rod bundle film boiling experiments (Reference 10). These experiments were performed as a full length 17x17 Westinghouse rod bundle array which had a total of 336 heated rods. The injection flow was from the top of the bundle and is scalable to the UPI injection flows. The pressures varied between 20-100 psia which is the typical range for UPI top flooding situations. Both cocurrent downflow film boiling and countercurrent film boiling experiments were modeled using <u>W</u>COBRA/TRAC. Both these flow situations are found in the calculated core response for a PWR with UPI.

In addition to modeling these separate effects tests, <u>W</u>COBRA/TRAC has been used to model the Japanese Cylindrical Core Test Facility experiments with upper plenum injection (References 5, 6, and 7). The tests which have been modeled included test 72 which was a symmetrical UPI injection with maximum injection flow, test 59 which was minimum injection flows with a

nearly symmetrical injection pattern, test 76 which was a minimum UPI injection flow with a skewed UPI injection and test 54 which was a cold leg injection reference test for the UPI tests. A detailed three dimensional WCOBRA/TRAC calculation, sponsored by the USNRC also was performed on test 72 (Reference 11). Coarser noded WCOBRA/TRAC calculations were performed on tests 59, 72, and 76 using noding more typical of PWR evaluation model noding.

The results of these comparisons are documented in References 2 and 10 and show that WCOBRA/TRAC does predict heat transfer behavior for these complex film boiling situations as well as the system response for upper plenum injection situations.

The effect of flow blockage due to cladding burst is explicitly accounted for in WCOBRA/TRAC with models which calculate cladding swelling, burst, and area reduction due to blockage. These models are based on previously approved models used in current evaluation models (References 12 and 13) and on flow blockage models determined to be acceptable by the staff (Reference 14). The effect of flow blockage is accounted for from the time burst is calculated to occur. The fluid models in WCOBRA/TRAC calculate flow diversion as a result of the blockage. Thus the intent of the rule, which requires that flow blockage effects to be taken into account, is met.

## 4. CONCLUSION

The Westinghouse two-loop PWR's equipped with Upper Plenum Injection have unique features which make the application of certain Appendix K reflood requirements inappropriate. By using the best-estimate thermal-hydraulic computer code, WCOBRA/TRAC, the intent of the Appendix K requirements can be achieved. Therefore, it is proposed that the exemption from the inappropriate reflood requirements be granted providing that WCOBRA/TRAC is used to calculate the LOCA transient for PWR's equipped with UPI.

## REFERENCES


1) J. R. Miller to D. M. Musolf, dated February 12, 1985, entitled "Development of an Acceptable ECCS Evaluation Model which Includes the Effect of Upper Plenum Injection."

2) Letter dated March 11, 1985 from D. M. Musolf (NSP) to the Director of NRR, entitled "Upper Plenum Injection LOCA Model Development."

3) Hochreiter, L. E., Schwarz, W. R., Takeuchi, K., Tsai, C-K, and M. Y. Young, "Westinghouse Large-Break LOCA Best Estimate Methodology Volume 1: Model Description and Validation," WCAP-10924-P, April 1986 (Westinghouse Proprietary).

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5) Iguchi, T., et al., "Data Report on Large Scale Reflood Test-99, CCTF Core-II Test C2-16 (Run 076)," JAERI-memo 60-158, February 1985, (JAERI-Proprietary).

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9) Letter dated August [illegible], 1984 from L. Buxton (Sandia) to D. Langford (NRC).

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12) Young, M. Y., et al., "BART-A-1: A Computer Code for the Best Estimate Analysis of Reflood Transients," WCAP-9561-P-A, March 1984.

13) Bordelon, F. M., et al., "LOCTA-IV Program: Loss of Coolant Transient Analysis," WCAP-8301, June 1984.

14) Powers, D. A., and Meyer, R. O., "Cladding Swelling and Rupture Models for LOCA Analysis," NUREG-0630, April 1980.

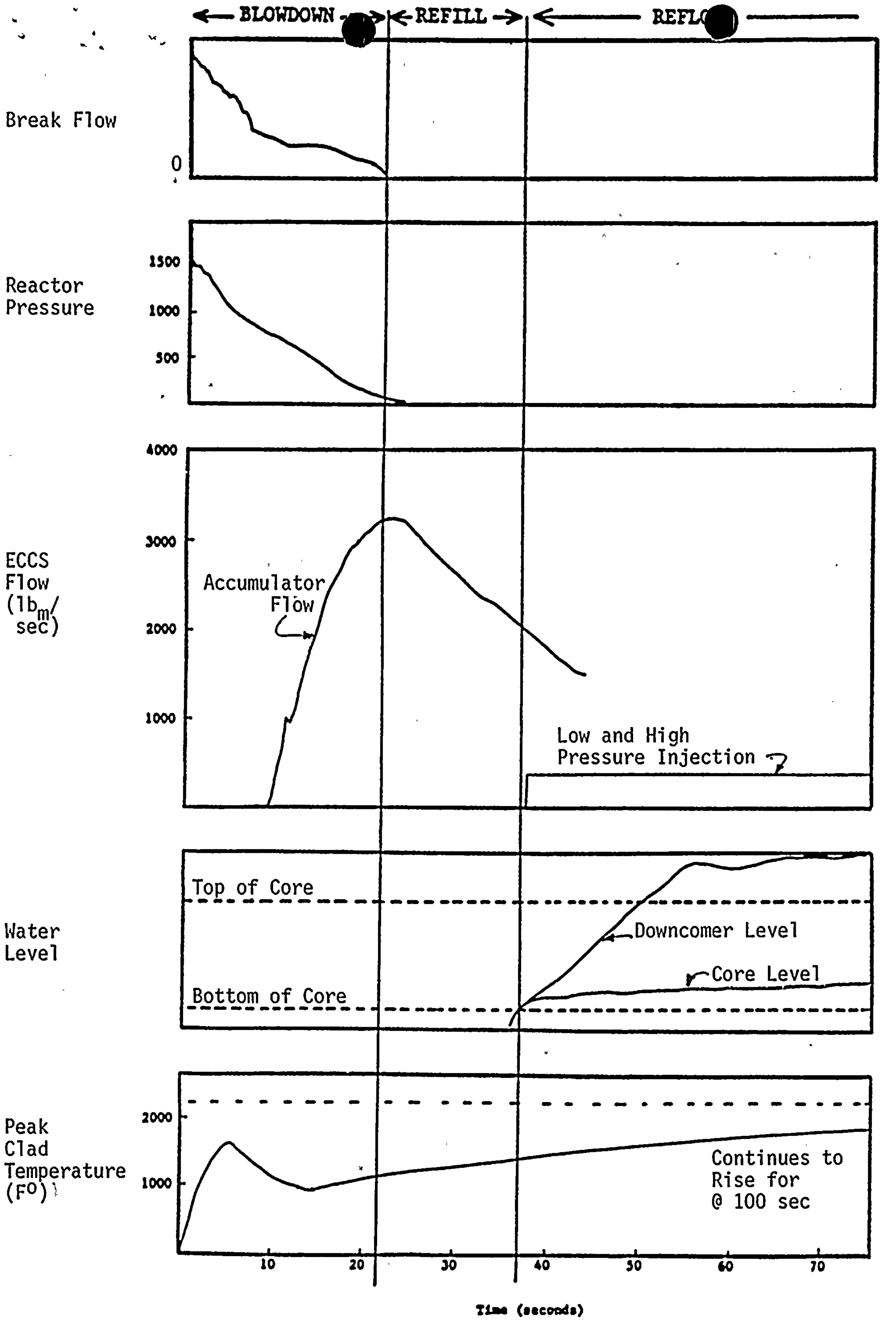


Figure 1: Example Large Break LOCA (0.4 Discharge Coefficient) for a Cold Leg Injection Plant

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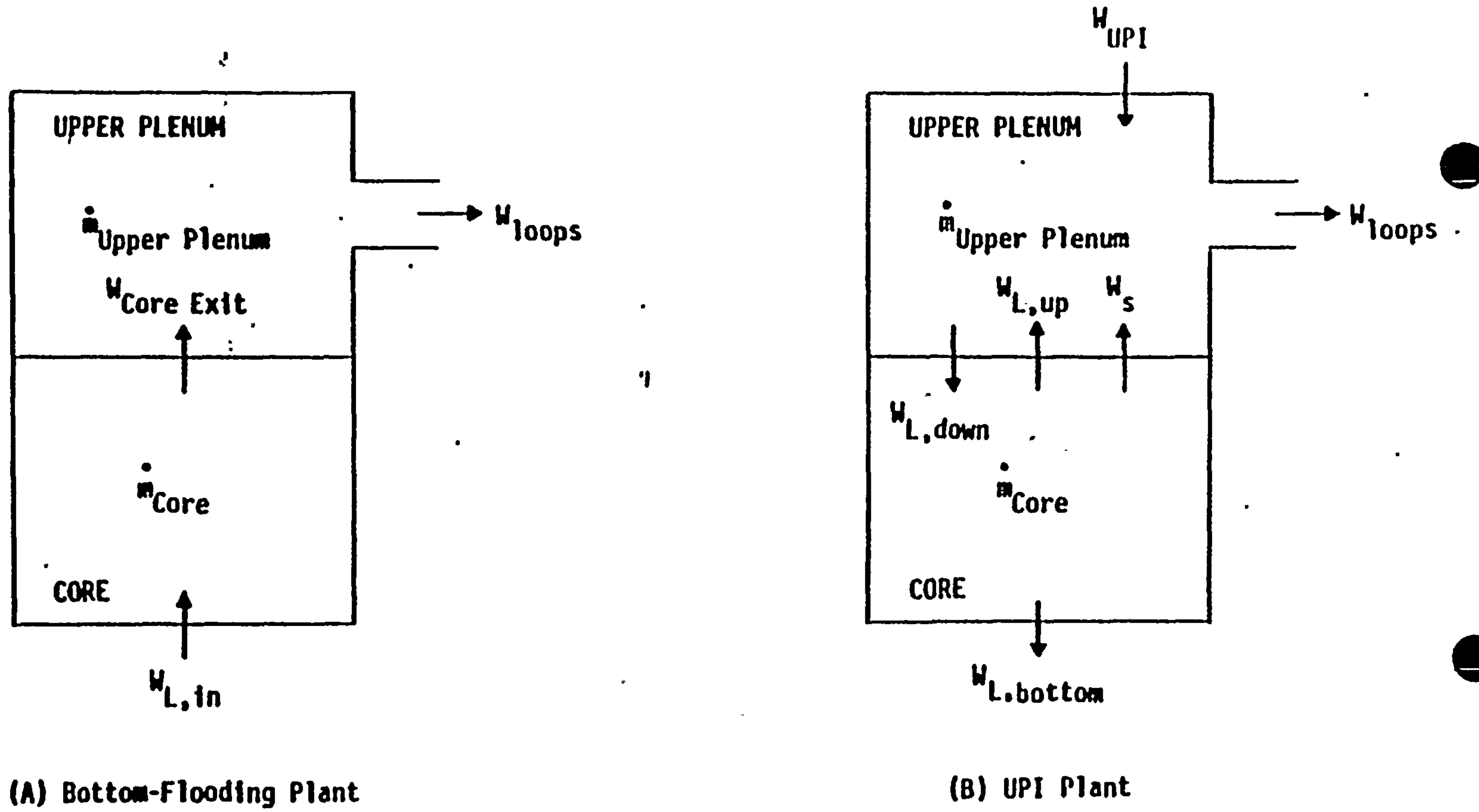
Legend: W = Mass Flow Rate
ṁ = Mass Accumulation Rate
s = Steam
L = Liquid




PWR VESSEL FLOWS DURING REFLOOD
FIGURE 2