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SACRAMENTO MUNICIPAL UTILITY DISTRICT ☐ 6201 S Street, Box 15830, Sacramento, California 95813; (916) 452-3211

October 24, 1979

U.S. Nuclear Regulatory Commission
Attention: Mr. R. H. Engelken,
Director, Region V
Office of Inspection & Enforcement
1990 North California Boulevard
Walnut Creek Plaza, Suite 202
Walnut Creek, California 94596

Docket No. 50-312
Rancho Seco Nuclear Generating
Station, Unit No. 1

Dear Mr. Engelken:

In the letter to you dated August 27, 1979, the District provided an analysis titled "Analysis Summary in Support of an Early RC Pump Trip".

The attachment to this letter carries a revision to Section III of that analysis.

Sincerely yours,

John J. Mattimoe

John J. Mattimoe
Assistant General Manager
and Chief Engineer

Attachment

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III. IMPACT ASSESSMENT OF A RC PUMP TRIP ON NON-LOCA EVENTS

A. Introduction

Some Chapter 15 events are characterized by a primary system response similar to the one following a LOCA. The Section 15.1 events that result in an increase in heat removal by the secondary system cause a primary system cooldown and depressurization, much like a small break LOCA. Therefore, an assessment of the consequences of an imposed RC pump trip, upon initiation of the low RC pressure ESFAS, was made for these events.

B. General Assessment of Pump Trip in Non-LOCA Events

Several concerns have been raised with regard to the effect that an early pump trip would have on non-LOCA events that exhibit LOCA characteristics. Plant recovery would be more difficult, dependence on natural circulation mode while achieving cold shutdown would be highlighted, manual fill of the steam generators would be required, and so on. However, all of these drawbacks can be accommodated since none of them will on its own lead to unacceptable consequences. Also, restart of the pumps is recommended for plant control and cooldown once controlled operator action is assumed. Out of this search, three major concerns have surfaced which have appeared to be substantial enough as to require analysis:

1. A pump trip could reduce the time to system fill/repressurization or safety valve opening following an overcooling transient. If the time available to the operator for controlling HPI flow and the margin of subcooling were substantially reduced by the pump trip to where timely and effective operator action could be questionable, the pump trip would become less desirable.
2. In the event of a large steam line break (maximum overcooling), the blowdown may induce a steam bubble in the RCS which could impair natural circulation, with severe consequences on the core, especially if any degree of return to power is experienced.
3. A more general concern exists with a large steam line break at EOL conditions and whether or not a return to power is experienced following the RC pump trip. If a return to critical is experienced, natural circulation flow may not be sufficient to remove heat and to avoid core damage.

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Overheating events were not considered in the impact of the RC pump trip since they do not initiate the low RC pressure ESFAS, and therefore, there would be no coincident pump trip. In addition, these events typically do not result in an empty pressurizer or the formation of a steam bubble in the primary system. Reactivity transients were also not considered for the same reasons. In addition, for overpressurization, previous analyses have shown that for the worst case conditions, an RC pump trip will mitigate the pressure rise. This results from the greater than 100 psi reduction in pressure at the RC pump exit which occurs after trip.

C. Analysis of Concerns and Results

1. System Repressurization

In order to resolve this concern, an analysis was performed for a 177 FA plant using a MINITRAP model based on the case set up for TMI-2, Figure 3.1 shows the noding/flow path scheme used and Table 3.1 provides a description of the nodes and flow paths. This case assumed that, as the result of a small steam line break (0.6 ft.^{2} split) or of some combination of secondary side valve failure, secondary side heat demand was increased from 100% to 138% at time zero. This increase in secondary side heat demand is the smallest which results in a (high flux) reactor trip and is very similar to the worst moderate frequency overcooling event, a failure of the steam pressure regulator. In the analysis, it was assumed that following HPI actuation on low RC pressure ESFAS, main feedwater is ramped down, MSIV's shut, and the auxiliary feedwater initiated with a 40-second delay. This action was taken to stop the cooldown and the depressurization of the system as soon as possible after HPI actuation, in order to minimize the time of refill and repressurization of the system. Both HPI pumps were assumed to function.

The calculation was performed twice, once assuming two of the four RC pumps running (one loop), and once assuming RC pump trip right after HPI initiation. The analysis shows that the system behaves very similarly with and without pumps. In both cases, the pressurizer refills in about 14 to 16 minutes from initiation of the transients, with the natural circula-

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tion case refilling about one minute before the case with two of four pumps running (See Figures 3.2, 3.3). In both cases, the system is highly subcooled, from a minimum of 30°F to 120°F and increasing at the end of 14 minutes (refer to Figure 3.4). It is concluded that an RC pump trip following HPI actuation will not increase the probability of causing a LOCA through the pressurizer code safeties, and that the operator will have the same lead time, as well as a large margin of subcooling, to control HPI prior to safety valve opening. Although no case with all RC pumps was made, it can be inferred from the one loop case (with pumps running) that the subcooled margin will be slightly larger for the all pumps running case. The pressurizer will take longer to fill but should do so by 16 minutes into the transient. Figure 3.4 shows the coolant temperatures (hot leg, cold leg, and core) as a function of time for the <u>no</u> RC pumps case.

2. <u>Effect of Steam Bubble on Natural Circulation Cooling</u>

For this concern, an analysis was performed for the same generic 177 FA plant as outlined in Part 1, but assuming that as a result of an unmitigated large SLB (12.2 $ft.^2$ DER), the excessive cooldown would produce void formation in the primary system. The intent of the analysis was to also show the extent of the void formation and where it occurred. As in the case analyzed in Part 1, the break was symmetric to both generators such that both would blow down equally, maximizing the cooldown (in this case there was a 6.1 $ft.^2$ break on each loop). There was no MSIV closure during the transient on either steam generator to maximize cooldown. Also, the turbine bypass system was assumed to operate, upon rupture, until isolation on ESFAS. ESFAS was initiated on low RC pressure and also actuated HPI (both pumps), tripped RC pumps (when applicable) and isolated the MFWIV's. The AFW was initiated to both generators on the low SG pressure signal, with minimum delay time (both pumps operating).

This analysis was performed twice, once assuming all RC pumps running, once with all pumps being tripped on the HPI actuation (after ESFAS), with a short (~5 second) delay. In both cases, voids were formed in the hot legs, but the dura-

tion and size were smaller for the case with no RC pump trip (refer to Figure 3.7). Although the RC pump operating case had a higher cooldown rate, there was less void formation, resulting from the additional system mixing. The coolant temperatures in the pressurizer loop hot and cold legs, and the core, are shown for both cases in Figures 3.5, 3.6. The core outlet pressure and SG and pressurizer levels versus time are given for both cases in Figures 3.8, 3.9. This analysis shows that the system behaves similarly with and without pumps, although maintaining RC pump flow does seem to help mitigate void formation. The pump flow case shows a shorter time to the start of pressurizer refill than the natural circulation case (Figure 3.9), although the time difference does not seem to be very large.

Since the volume of the hot leg loop above the lowest point in the candy cane portion is about 63 cubic feet, these steam formations have the potential for blocking natural circulation in the hot leg loops. As a result of these findings and since TRAP had not been programmed to closely follow this specific condition, an additional TRAP case was run. It is based on the unmitigated 12.2 ft^2 steam line break with RC pump trip, since this case represented the bounding event for steam formation. This case included a more detailed noding scheme and conservative bubble rise velocities (5.0 ft/sec) to the upper regions of the hot legs such that the effect of steam formation on natural circulation in the loops could be observed.

The noding and flow path scheme used in this model is shown in Figure 3.10. Table 3.2 provides a description of these nodes and flow paths. Figure 3.11 details the hot leg - candy cane - upper steam generator shroud noding and flow path model superimposed over a scaled figure of those regions. The flow path positions and sizes were carefully chosen to allow for countercurrent steam and liquid flow at the top of the candy cane. This model is consistent with that used for the small break LOCA analyses described in Section 6.2.4.2 of Ref. 5.

The results of this analysis showed steam formation only in the pressurizer loop (refer to Figure 3.12). These steam volumes are conservative since they include all of the steam that was calculated as being entrained as bubbles in the liquid. The additional steam volumes calculated for this loop, compared with those shown in Figure 3.7, are due to the additional boiling and steam separation

that occurs in the candy cane as the liquid flow rates are reduced by steam formation and aided by metal heating. The lack of steam formation in the non-pressurizer loop 'B' is attributed to a correction in the metal heat transfer and metal heat capacities calculated for the hot legs. The previous analysis erroneously included half of the steam generator tubes, based on the calculations from the ECCS CRAFT model. Since the TRAP code already accounts for the tube metal in its steam generator model, this represented an unnecessary conservatism and it was deleted from the model for this case.

This case showed that the natural circulation flow was temporaril reduced. This flow reduced in the pressurizer loop to 45 to 100 lb/sec from 250 to 360 seconds (refer to Figure 3.13), with flow steadily increasing after this time period. The flow in the non-pressurizer loop remained relatively unchanged at about 1000 lb/sec (refer to Figure 3.14). Core flow was maintained from 1000 to 2000 lb/sec and no void formation occurred (refer to Figures 3.15 and 3.16). The steam bubble was collapsed, natural circulation fully restored, and a greater than 50°F subcooled margin achieved in the pressurizer loop (refer to Figure 3.16). Both steam generators and the pressurizer established level and the system pressure was turned around from the HPI flow by 14 minutes into the transient (ref. to Figures 3.17 and 3.18).

3. Effect of Return to Power

There was no return to power exhibited by any of the BOL cases analyzed above. Previous analysis experience (ref. Midland FSAR, Section 15D) has shown that a RC pump trip will mitigate the consequences of an EOL return to power condition by reducing the cooldown of the primary system. The reduced cooldown substantially increases the subcritical margin which, in turn, reduces or eliminates return to power.

D. Conclusions and Summary

A general assessment of Chapter 15 non-LOCA events identified three areas that warranted further investigation for impact of a RC pump trip on ESFAS low RC pressure signal.

1. It was found that a pump trip does not significantly shorten the time to filling of the pressurizer and approximately the same time interval for operator action exists.

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2. For the maximum overcooling case analyzed, the RC pump trip increased the amount of void formation in the hot leg 'candy cane' of the pressurizer loop; however, natural circulation was not completely blocked. The steam bubble was collapsed and full natural circulation was restored. Core cooling was maintained throughout the transient and no void formation occurred in the core.
3. The subcritical return-to-power condition is alleviated by the RC pump trip case due to the reduced overcooling effect.

Based upon the above assessment and analysis, it is concluded that the consequences of Chapter 15 non-LOCA events are not increased due to the addition of a RC pump trip on ESFAS low RC pressure signal, for all 177 FA lowered loop plants. Although there were no specific analyses performed for TECO, the conclusions drawn from the analyses for the lowered loop plants are applicable.

MINITRAP2 NODE DESCRIPTION

NODE NUMBER	DESCRIPTION
1	Reactor Vessel, Lower Plenum
2	Reactor Vessel, Core
3	Reactor Vessel, Upper Plenum
4,10	Hot Leg Piping and Upper S. G. Shroud
5-7,11-13	Primary, Steam Generator Tube Region
8,14	Cold Leg Piping
9	Reactor Vessel Downcomer
15	Pressurizer
16,24	Steam Generator Downcomer
17,25	Steam Generator Lower Plenum
18-20,26-28	Secondary, Steam Generator Tube Region
21,29	Steam Risers
22,30	Main Steam Piping
23	Turbine
31	Containment

MINITRAP2 PATH DESCRIPTION

PATH NUMBER	DESCRIPTION
1	Core
2	Core Bypass
3	Upper Plenum, Reactor Vessel
4,11	Hot Leg Piping
5,12	Hot Leg Piping and Upper S. G. Shroud
6,7,13,14	Primary, Steam Generator
8,15	RC Pumps
9,16	Cold Leg Piping
10	Downcomer, Reactor Vessel
17	Pressurizer Surge Line
18,19,26,27	Steam Generator Downcomer
20,21,28,29	Secondary, Steam Generator
22,30	Aspirator
23,31	Steam Riser, Steam Generator
24,32	Main Steam Piping
25,33	Turbine Piping
34,35	Break (or Leak) Path
36,37	HPI
38,39,43,44	AFW
40,41	Main Feed Pumps
42	LPI

Table 3.1

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MINITRAP2 NODE DESCRIPTION

NODE NUMBER	DESCRIPTION
1	Reactor Vessel, Lower Plenum
2	Reactor Vessel, Core
3	Reactor Vessel, Upper Plenum
4,10	Hot Leg Piping (including 'Candy Cane')
32,33	'Candy Cane' and Upper S. G. Shroud
5-7,11-13	Primary, Steam Generator Tube Region
8,14	Cold Leg Piping
9	Reactor Vessel Downcomer
15	Pressurizer
16,24	Steam Generator Downcomer
17,25	Steam Generator Lower Plenum
18-20,26-28	Seconda[illegible], Steam Generator Tube Region
21,29	Steam Risers
22,30	Main Steam Piping
23	Turbine
31	Containment

MINITRAP2 PATH DESCRIPTION

PATH NUMBER	DESCRIPTION
1	Core
2	Core Bypass
3	Upper Plenum, Reactor Vessel
4,11	Hot Leg Piping
5,12	Upper Steam Generator Shroud
45,46,47,48	Top of Hot Leg 'Candy Cane'
6,7,13,14	Primary Heat Transfer Region, S. G.
8,15	RC Pumps
9,16	Cold Leg Piping
10	Downcomer, Reactor Vessel
17	Pressurizer Surge Line
18,19,26,27	Steam Generator Downcomer and Plenum
20,21,28,29	Secondary Heat Transfer Region, S. G.
22,30	Aspirator
23,31	Steam Riser, Steam Generator
24,32	Main Steam Piping
25,33	Turbine Piping
34,35	Break (or Leak) Path
36,37	HPI
38,39,43,44	AFW
40,41	Main Feed Pumps
42	LPI

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Table 3.2

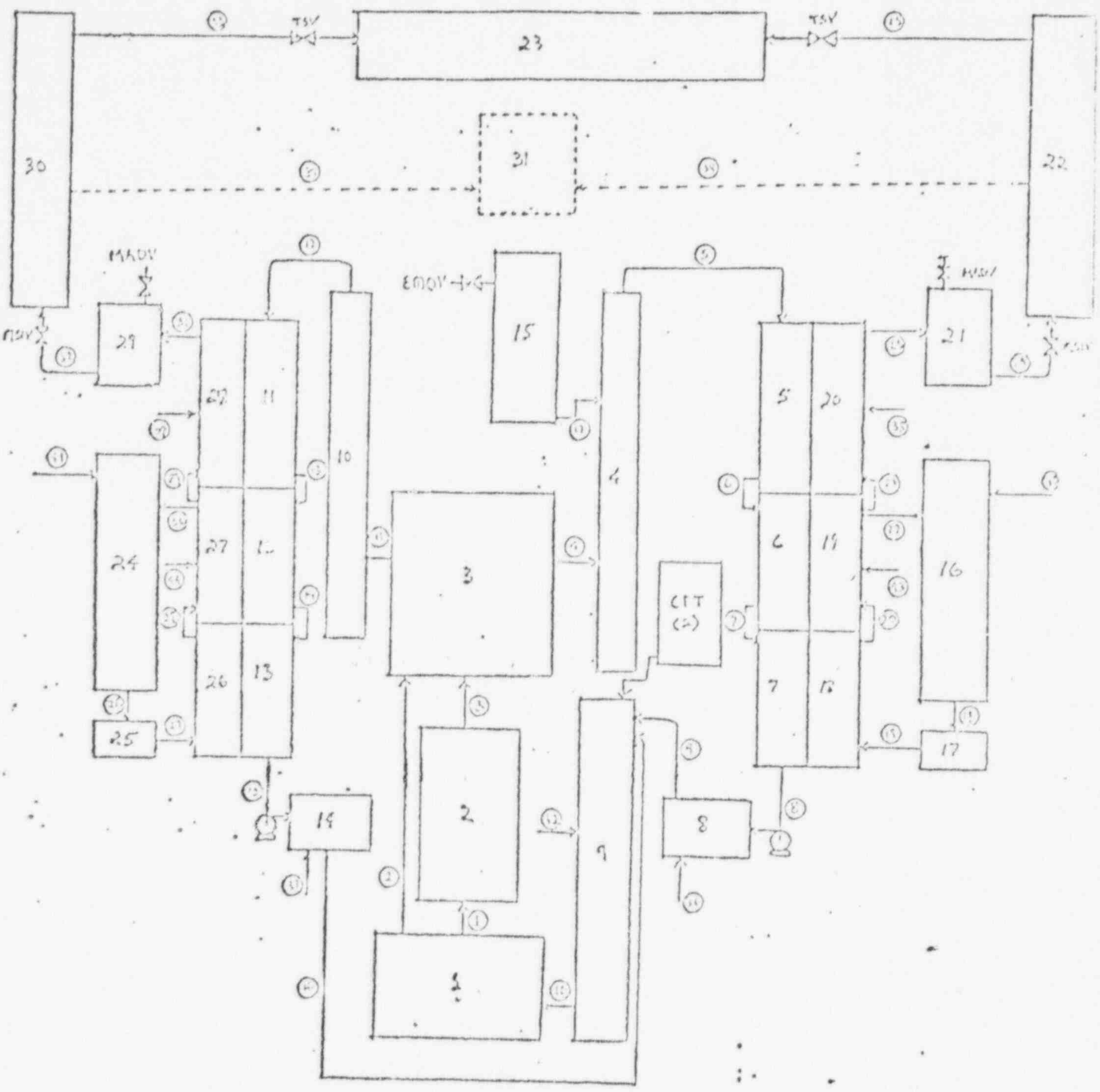

Figure
3.1

MINITRAP2 Noding and
Flow Path Scheme

PRESSURIZER AND STEAM GENERATOR LIQUID LEVEL VERSUS TRANSIENT TIME (102% FP, END OF LIFE, 0.6 FT^2 STEAMLINE BREAK (BOUNDING MODERATE FREQ.). (RC PUMP TRIP)

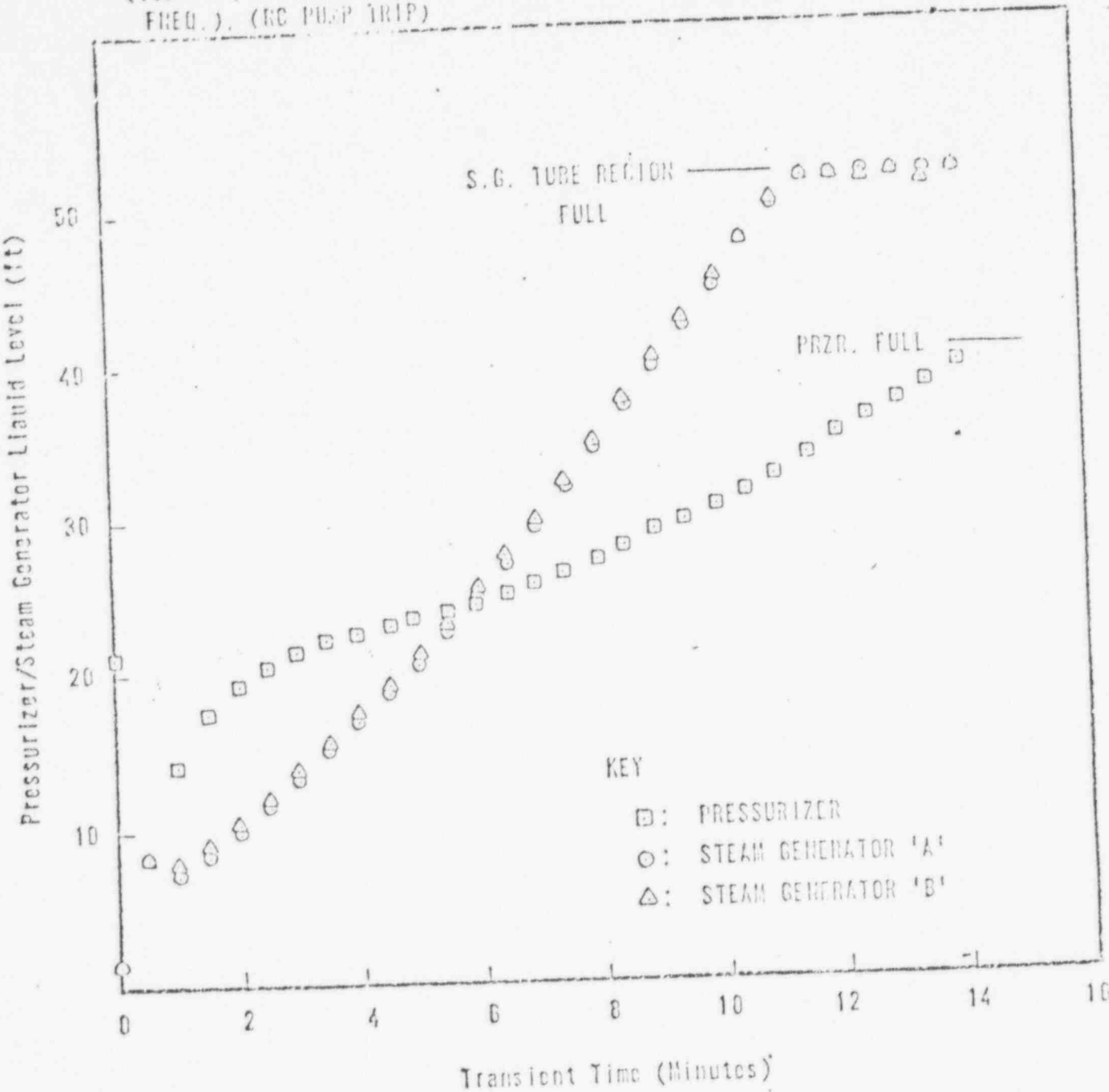

Figure 3.2

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PRESSURIZER AND STEAM GENERATOR LIQUID LEVEL VERSUS TRANSIENT TIME (102% FP, BEGINNING OF LIFE, 0.6 FT^2 STEAMLINE BREAK (BOUNDING MODERATE FREQ.), 1 LOOP ('B') RC PUMP TRIP).

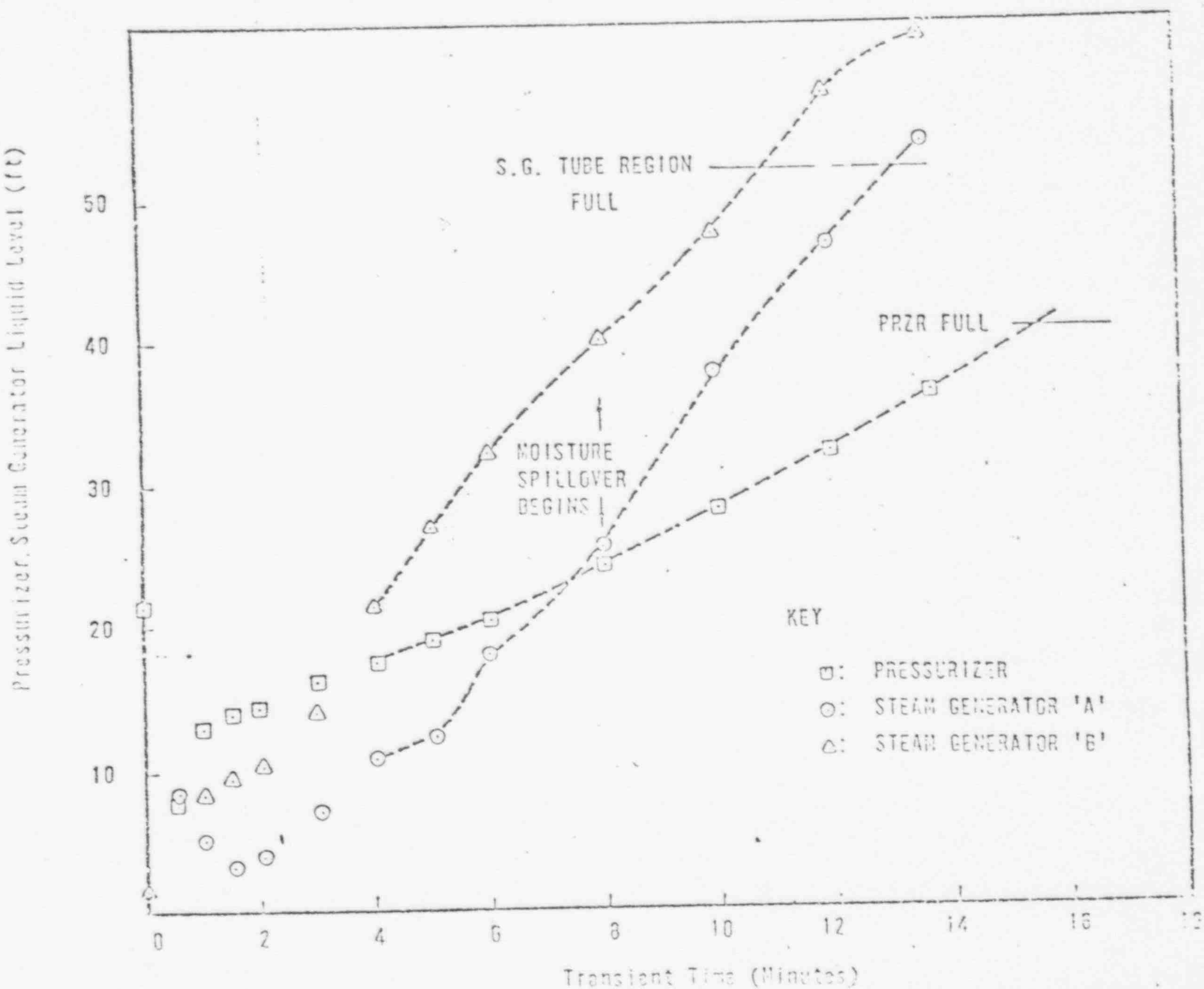

Figure 3.3

COOLANT TEMPERATURES VERSUS TRANSIENT TIME
(102% FP, 0.6 FT^2 STEAMLINE BREAK, RC PUMP TRIP
(WORST MOD. FREQ).)

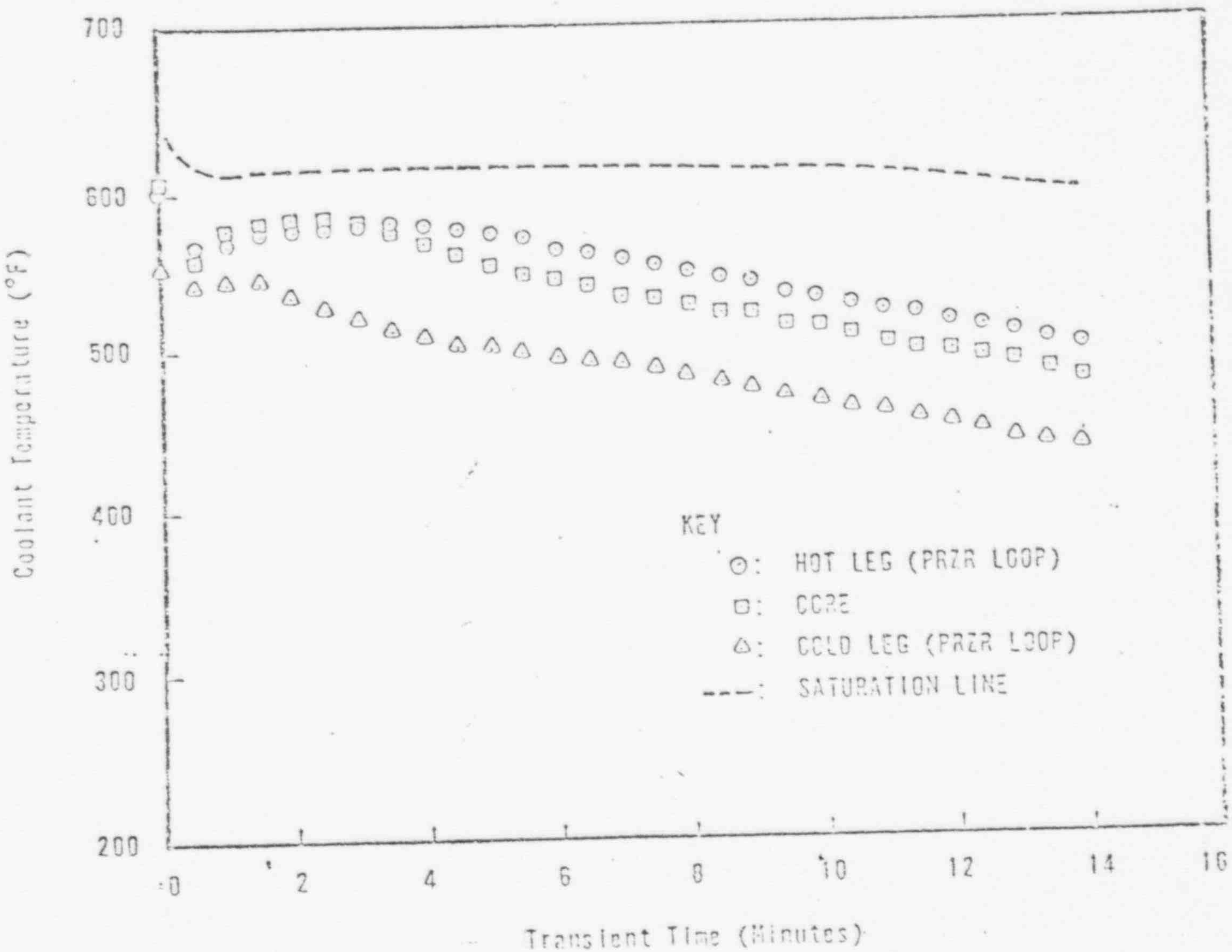

Figure 3.4

COOLANT TEMPERATURES VERSUS TRANSIENT TIME
(102% FP, BEGINNING OF LIFE, 12.2 FT² DOUBLE
END RUPTURE, STEAMLINE BREAK (UNMITIGATED)
NO RC PUMP TRIP)

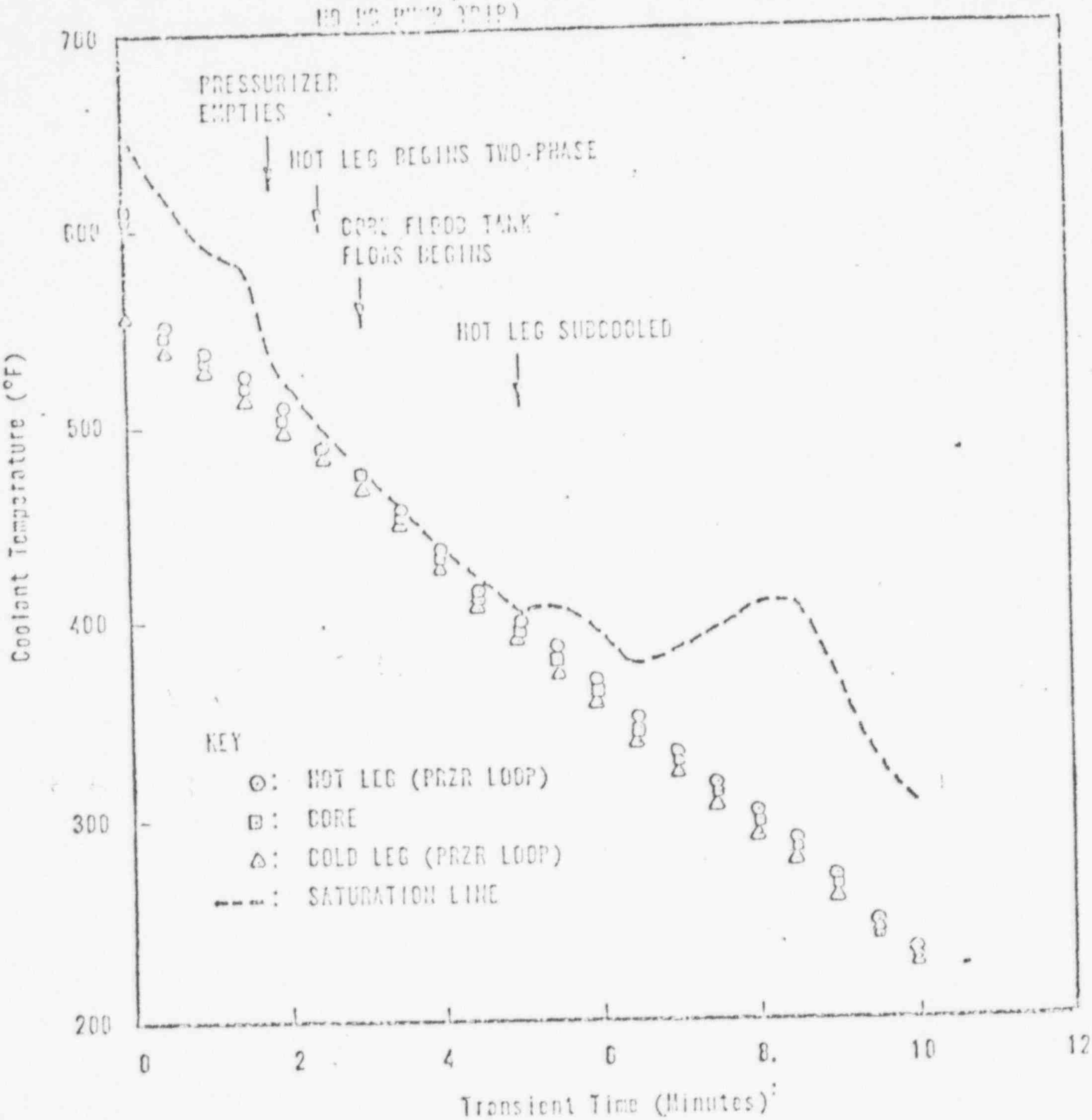

Figure 3.5

COOLANT TEMPERATURES VERSUS TRANSIENT TIME (102% FP, BEGINNING OF LIFE, 12.2 FT² DOUBLE END RUPTURE, UNMITIGATED STEAMLINE BREAK, RC PUMP TRIP)

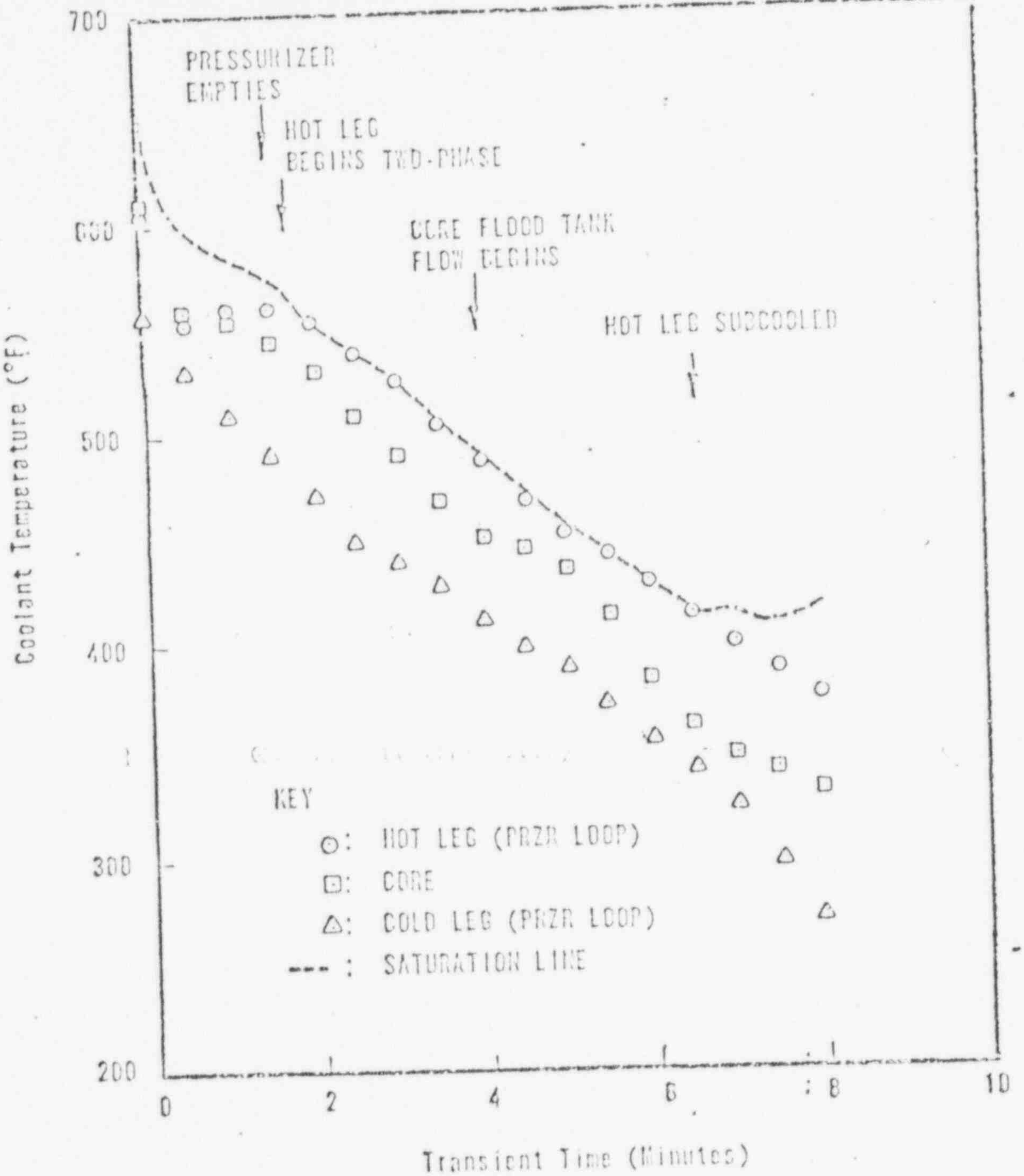

Figure 3.8

TOTAL STEAM BUBBLE VOLUME VERSUS TRANSIENT TIME
(102% FP, 12.2 FT^2 UNMITIGATED DOUBLE-ENDED
STEAMLINE BREAK)

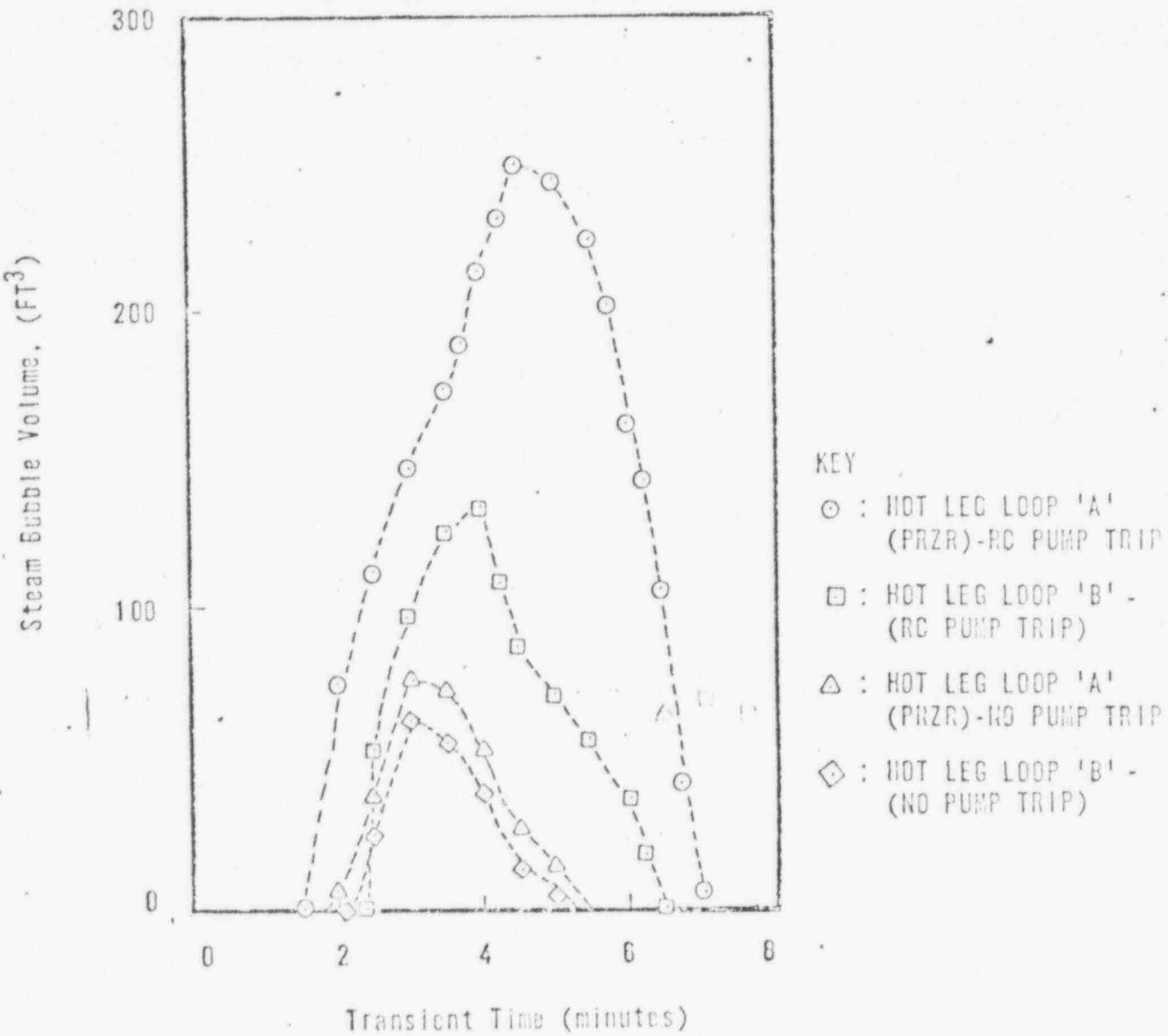

Figure 3.7

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CORE OUTLET PRESSURE VERSUS TRANSIENT TIME
(102% FP, BEGINNING OF LIFE, 12.2 FT^2 DOUBLE
END RUPTURE, UNMITIGATED STEAMLINE BREAK)

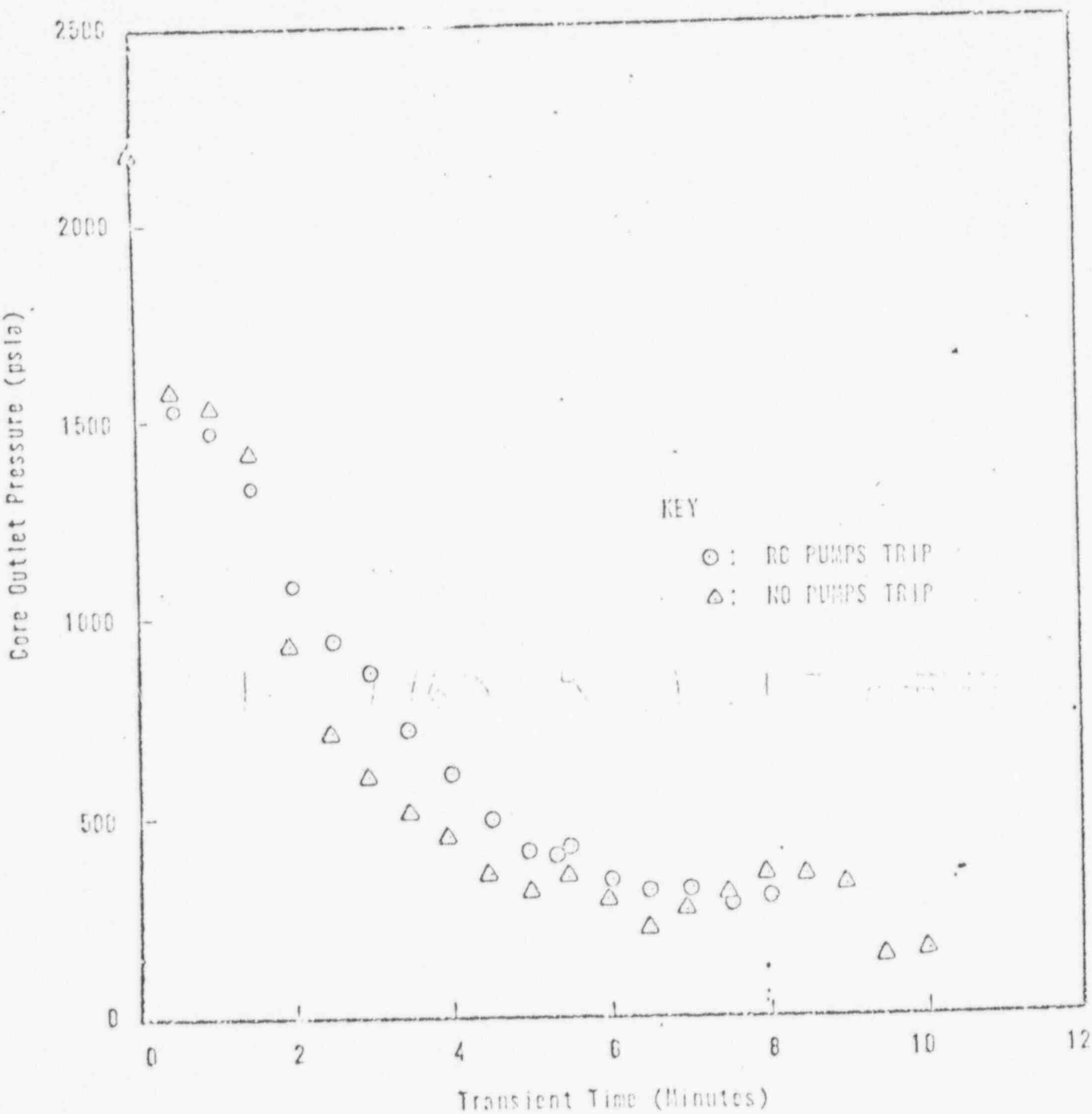

Figure 3.8

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STEAM GENERATOR AND PRESSURIZER LIQUID LEVEL VERSUS TRANSIENT TIME
(102% FP, BEGINNING OF LIFE, 12.2 FT^2 DOUBLE END RUPTURE-UNMITIGATED
STEAMLINE BREAK)

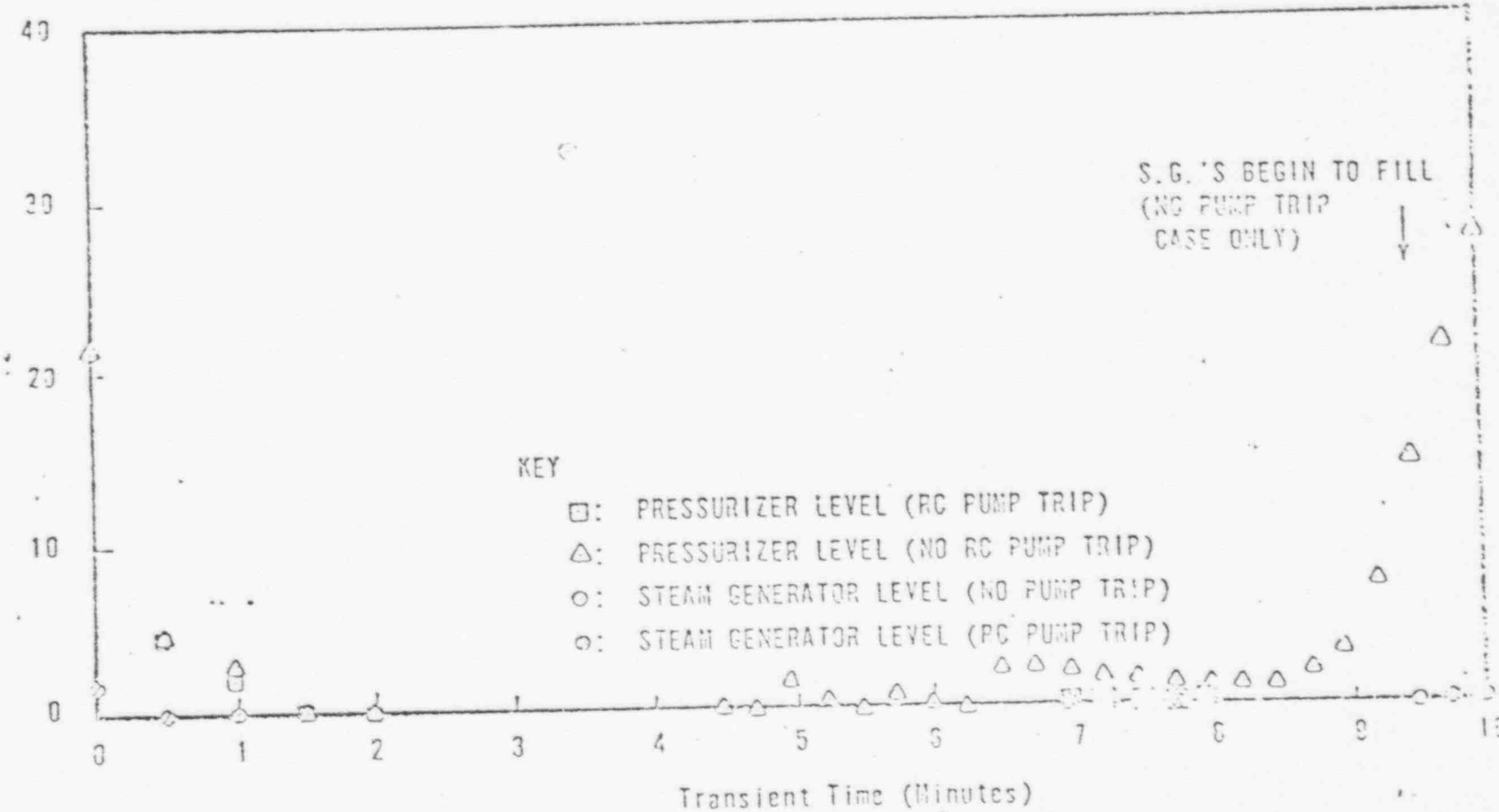


Figure 3.9

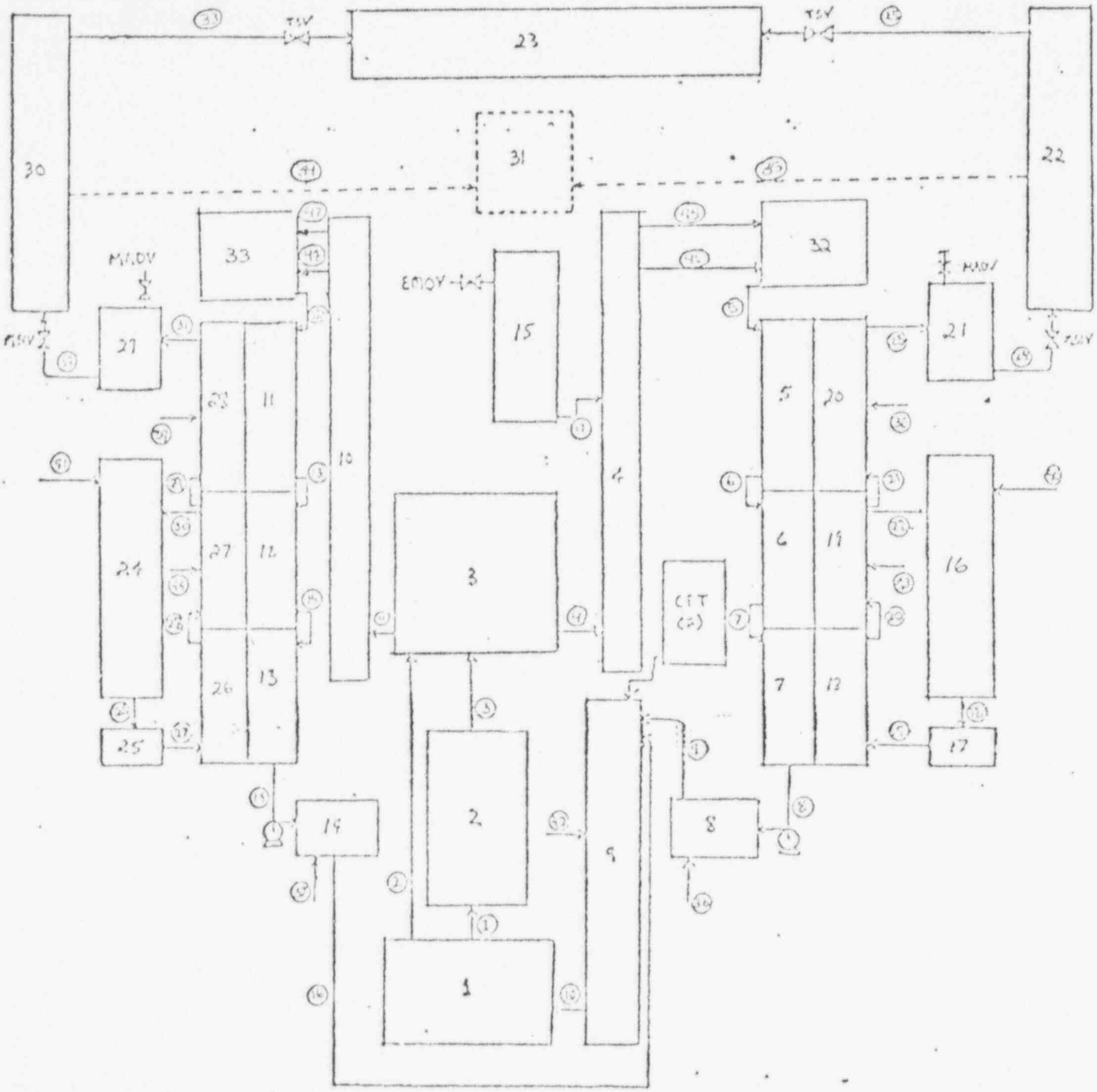
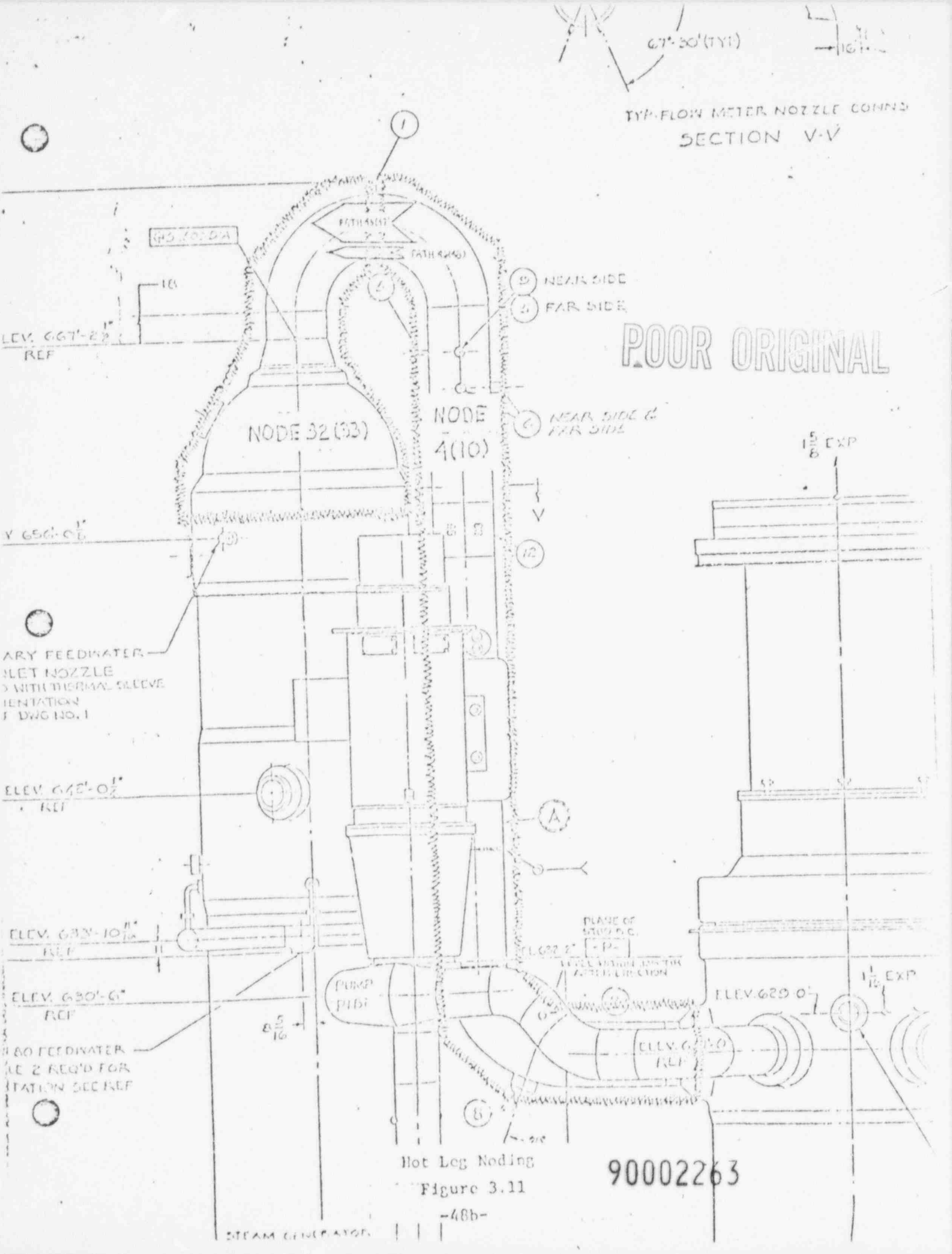


Figure 3.10

MINITRAP2 Noding and

Flow Path Scheme



Hot Leg Noding

Figure 3.11

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TOTAL STEAM BUBBLE VOLUME VS TRANSIENT TIME
(102% FP, 12.2 FT^2 DOUBLE-ENDED UNMITIGATED
STEAMLINE BREAK, RC PUMP TRIP)

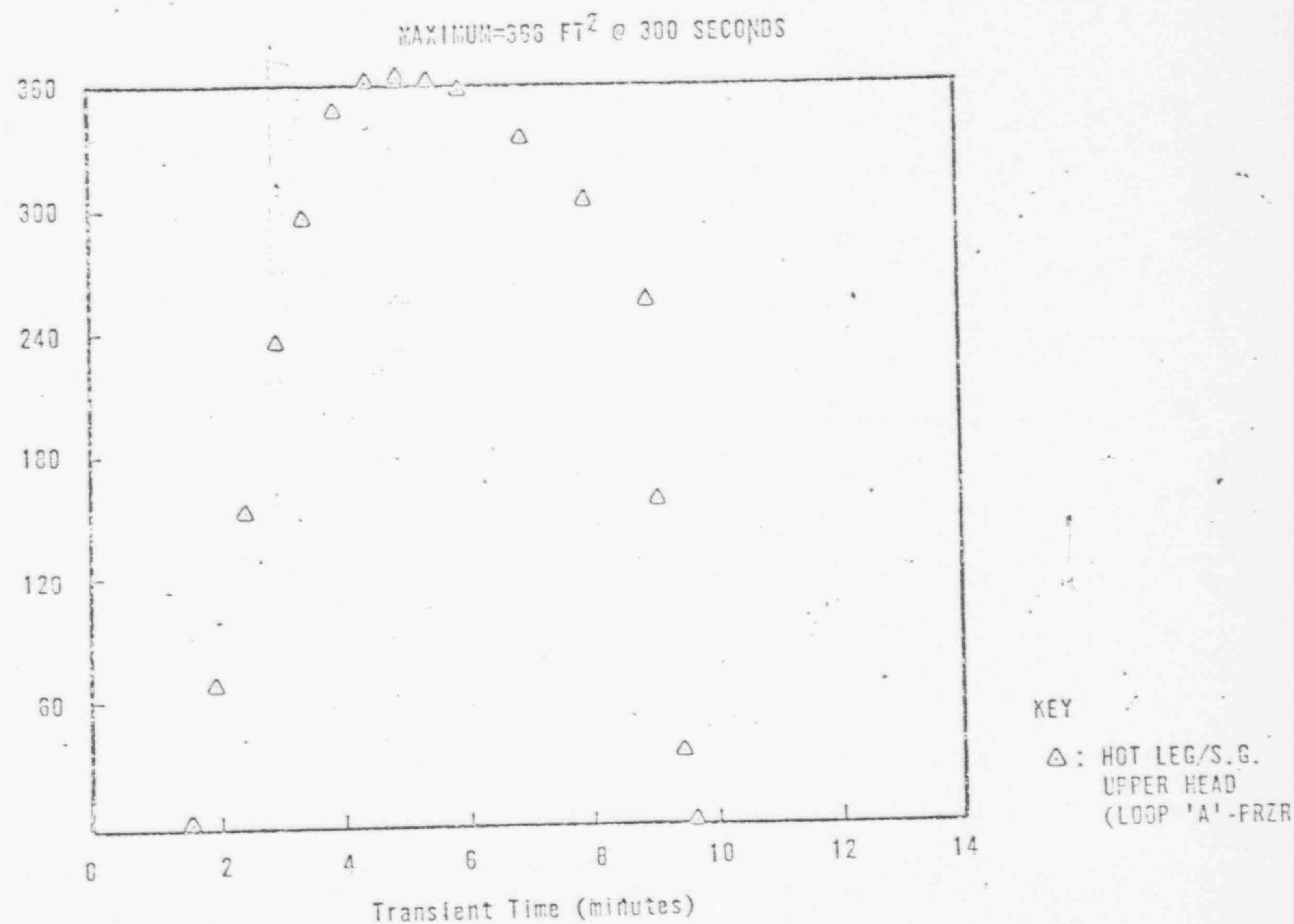

Figure 3.12

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LOOP 'A' CANDY CANE FLOW VERSUS TRANSIENT TIME
(102% FP, 12.2 FT^2 DOUBLE-ENDED UNMITIGATED
STEAMLINE BREAK, RC PUMP TRIP)

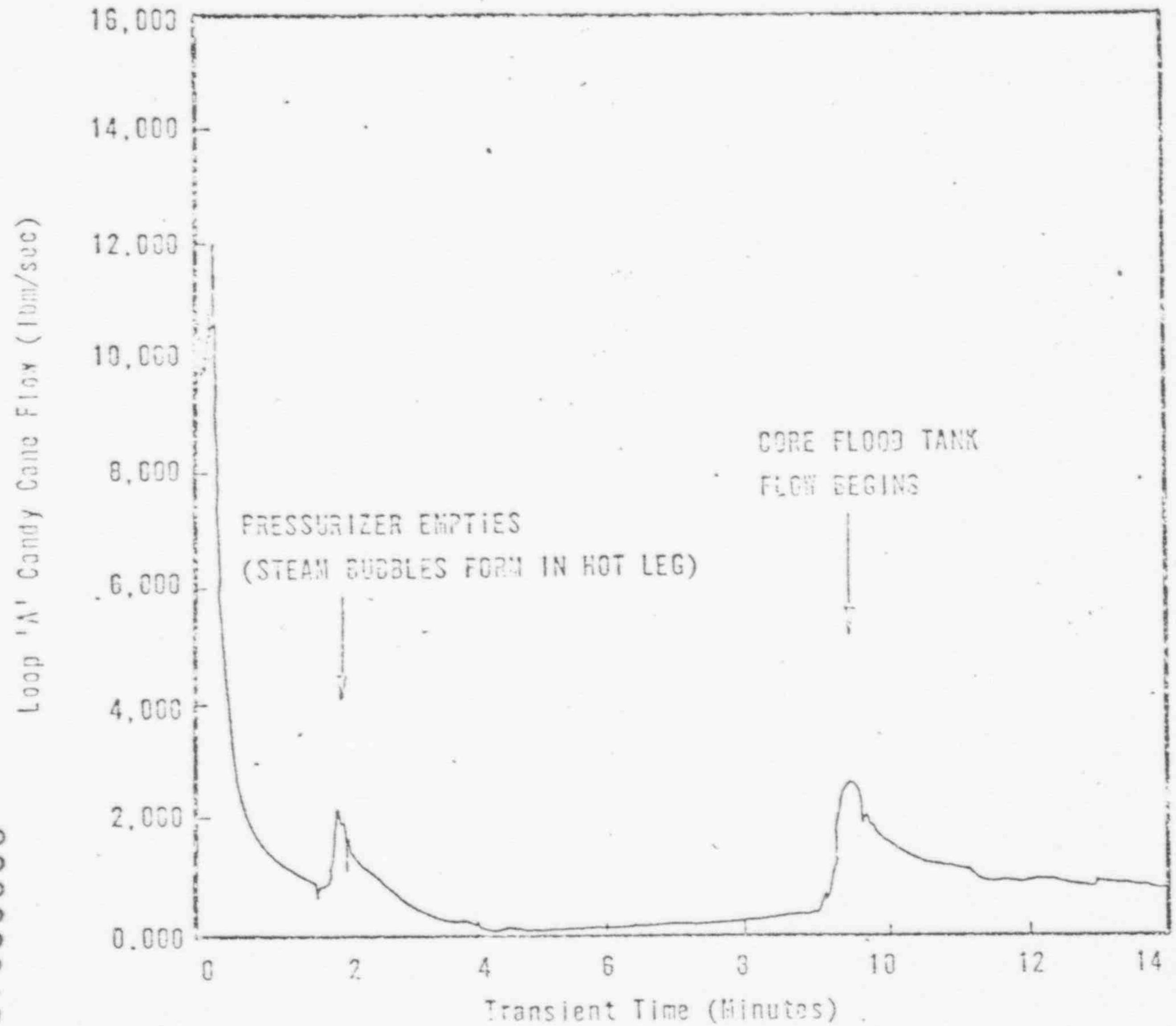

Figure 3.13

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Loop 'B' CANDY CANE FLOW VERSUS TRANSIENT TIME
(102% FP, 12.2 FT^2 DOUBLE-ENDED UNMITIGATED
STEAMLINE BREAK, RC PUMP TRIP)

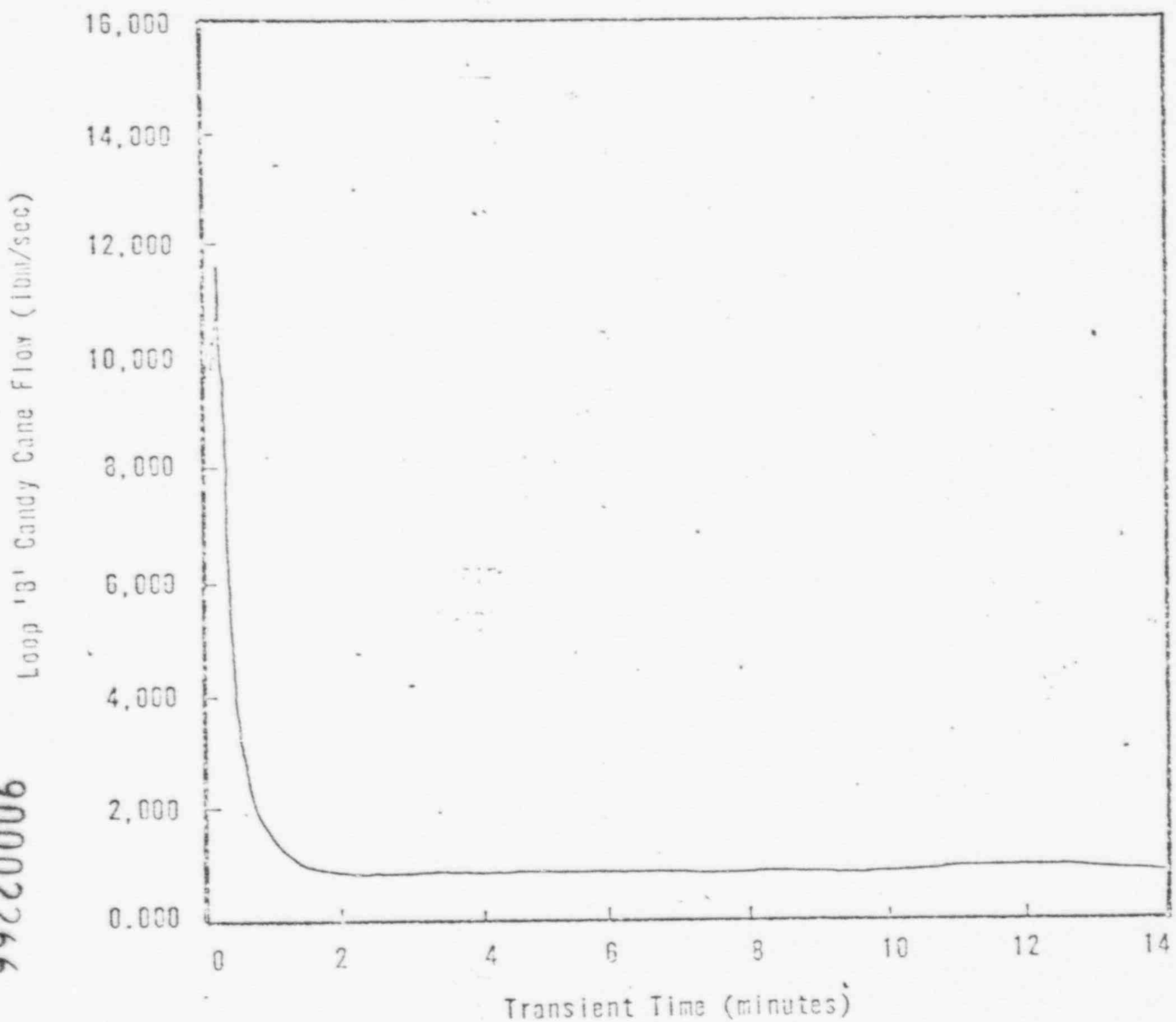

Figure 3.14

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CORE FLOW VERSUS TRANSIENT TIME
(102% FP, 12.2 FT^2 DOUBLE-ENDED
UNMITIGATED STEAMLINE BREAK, RC
PUMP TRIP)

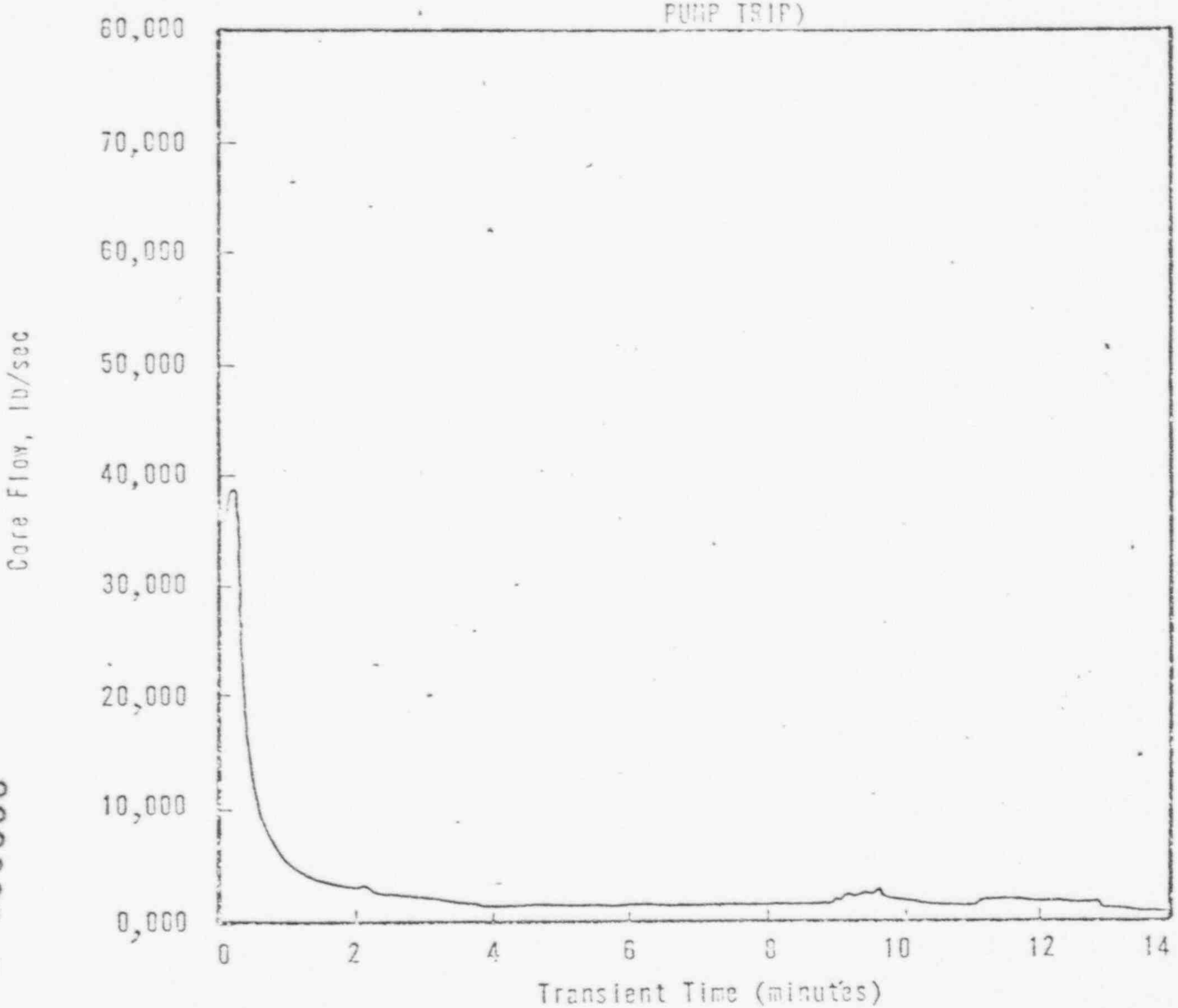

Figure 3.15

COOLANT TEMPERATURES VERSUS TRANSIENT TIME
(102% FP, 12.2 FT^2 DOUBLE-ENDED UNMITIGATED
STEAMLINE BREAK, RC PUMP TRIP)

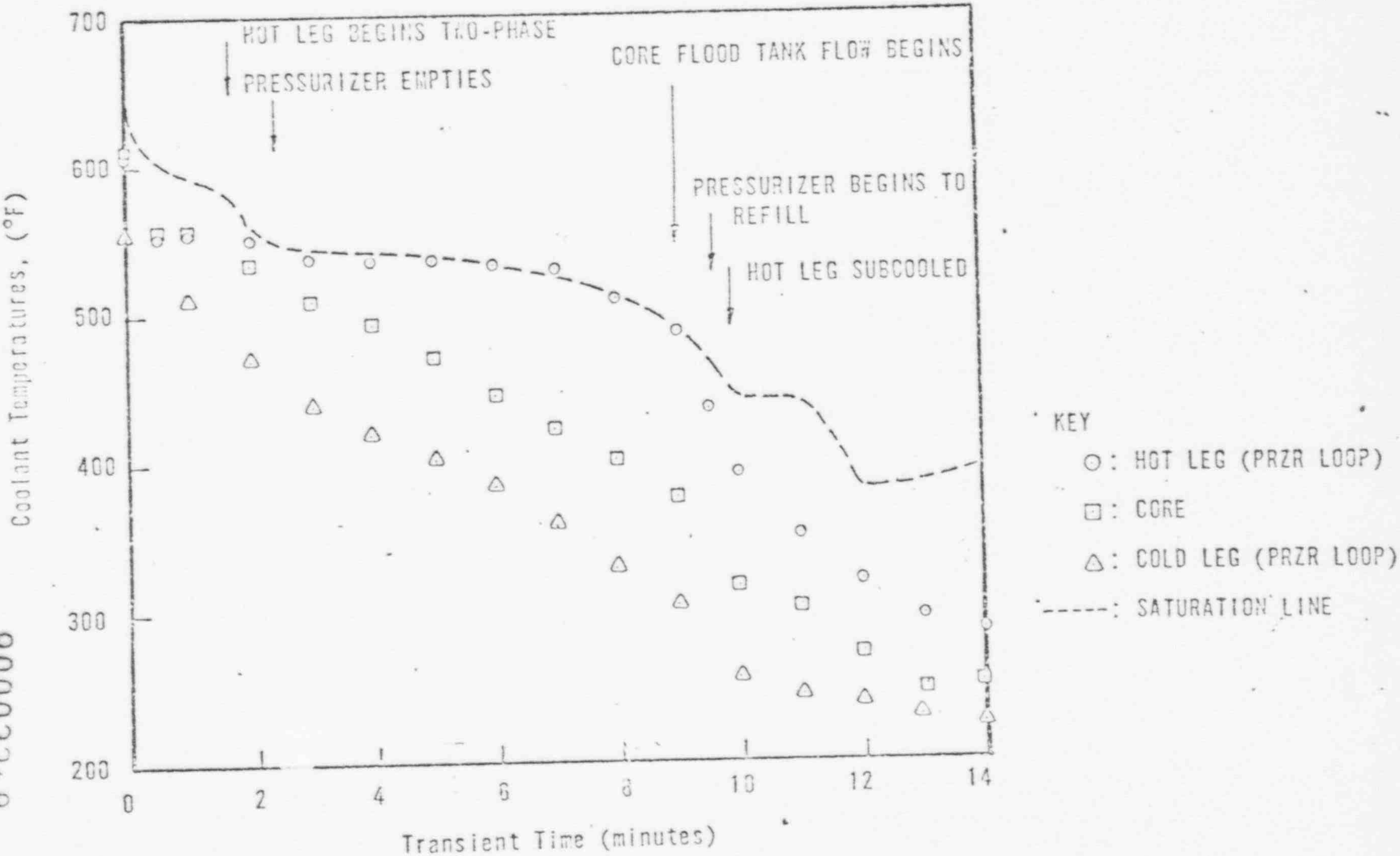

Figure 3.16

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PRESSURIZER AND STEAM GENERATOR LIQUID LEVEL VERSUS TRANSIENT TIME
(102% FP, 12.2 FT^2 UNMITIGATED DOUBLE-ENDED STEAMLINE BREAK, RC PUMP TRIP)

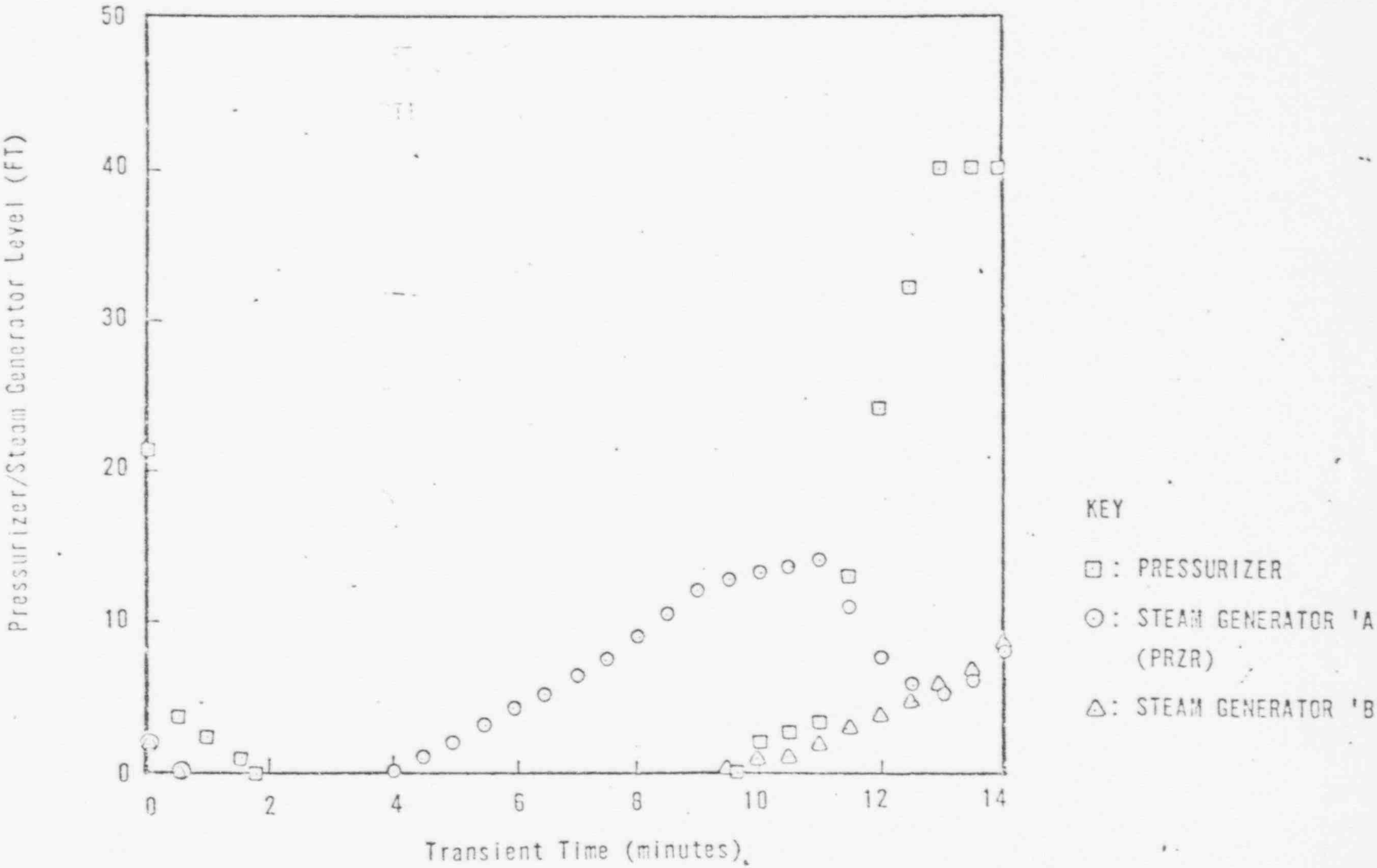

Figure 3.17

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CORE OUTLET PRESSURE VERSUS TRANSIENT TIME
(102% FP, 12.2 FT^2 DOUBLE-ENDED UNMITIGATED
STEAMLINE BREAK, RC PUMP TRIP)

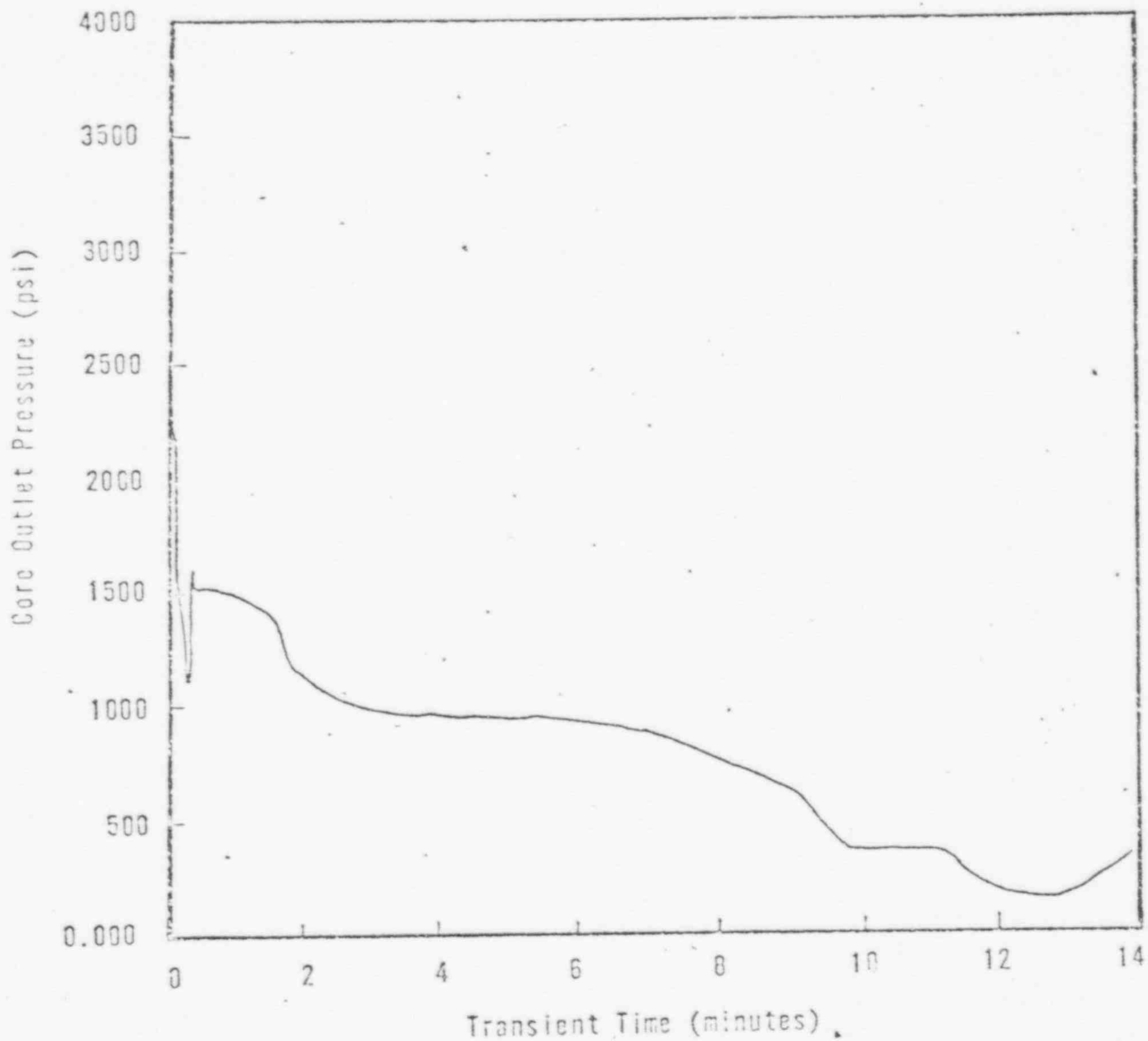

Figure 3.18

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