WESTINGHOUSE PROPRIETARY CLASS 3

EVALUATION OF RCP RESTART CRITERIA
FOR SAN ONOFRE UNIT 1

D. F. Holderbaum
August, 1985

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1. INTRODUCTION

This report is provided in support of the response from Southern California Edison (SCE) to the USNRC regarding NRC Generic Letter 83-10d (Reference 1) as it applies to San Onofre Unit 1 (SONGS). This letter has indicated concern about two potential safety issues:

1) Delayed Reactor Coolant Pump (RCP) trip during a Small Break Loss of Coolant Accident (SBLOCA) and the subsequent increased loss of RCS inventory
2) Potential pressurizer Power Operated Relief Valve (PORV) failures.

For SONGS, the delayed RCP trip could occur due to the misdiagnosis of a SBLOCA as a Steam Generator Tube Rupture (SGTR). The second issue, PORV failure, could occur for any PORV use; however the most likely instance for PORV use is during recovery from a SGTR. Both of these safety concerns are addressed in this report.

In response to the delayed RCP trip concern, the Westinghouse Owner's Group (WOG) has developed a generic program to deal with this issue (References 3 and 4). However, this work cannot be applied directly to SONGS due to the unique system design of this plant (which will be covered in the system description, Section 2.2). Therefore, to address the topic of delayed RCP trip, Westinghouse has completed two SBLOCA analyses, a 6-inch and 3-inch, to determine explicitly for SONGS the impact of a delayed RCP trip on Peak Clad Temperatures (PCTs) and available operator action time. The results of these analyses indicate that delayed RCP trip during a SBLOCA does not present any safety concern for SONGS.

The second safety issue addressed in Reference 1 is the probability of PORV failure. The NRC, in Reference 1, has recommended the avoidance of PORV opening whenever possible. However, for SONGS, PORV opening is used in the current approved Emergency Operating Procedure (EOP) (See Appendix C) to aid in SGTR recovery. Although this action can be shown to be logical and safe even in the event of a PORV failure, SCE and Westinghouse propose to revise the SONGS SGTR EOP so it will more closely comply with the recommendations in Reference 1. The proposed EOP revision should preclude PORV opening during a SGTR recovery by means of RCP restart based on information presented in the WOG report (Reference 3). The pressurizer PORVs will then be used only as a secondary recovery method in the event the RCPs cannot be started.

2. SBLOCA WITH DELAYED RCP TRIP: ANALYSIS AND EVALUATION

2.1 BACKGROUND

The SBLOCA analyses were performed in order to address the delayed RCP trip issue outlined in Reference 1. This letter addresses the desirability of RCP operation during a number of transients. While the letter concludes 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," it also states "...for certain SBLOCAs....continued operation of the RCPs or continued operation of the RCPs followed by delayed RCP trip could lead to core damage." Furthermore, the letter says "...the need for RCP trip following a transient or accident should be determined by each applicant on a case-by-case basis..." Accordingly, the WOG generic program was developed to address the items discussed in Reference 1, specifically generation of alternate RCP trip indications to preclude tripping the RCPs for SGTRs and non-LOCA events. However, because the RCPs at SONGS are powered by the turbine generator, a RCP coastdown and trip sequence occurs coincident with loss of turbine generator power (i.e., reactor trip) and the WOG generic program is not directly applicable to SONGS. This unique design at SONGS does incorporate RCP restart when beneficial for plant recovery and a subsequent delayed RCP trip, if necessary, to prevent any damage to the Reactor Coolant System (RCS). Thus, the potential for a delayed RCP trip during a SBLOCA does exist at SONGS in the event of a misdiagnosis of a SBLOCA as a SGTR and therefore must be addressed.

In the event of a SGTR diagnosis, the SONGS SGTR emergency operating procedures recommend that the operators attempt to restart either the RCP which maximizes pressurizer spray system performance or alternatively the other two RCPs soon after entry into the procedure. However, even if the restart is not successful, analyses have demonstrated that the plant safety systems and procedures are designed to effectively mitigate and recover the plant from the consequences of a SGTR. RCP restart would simply aid the operator in the depressurization and cooldown of the RCS through the use of the pressurizer spray system. Although RCP restart minimizes the consequences of tripping the RCPs early for SGTRs and non-LOCA events, the impact of RCP restart and continued operation during SBLOCA events is not considered. Therefore, in the event of a misdiagnosis of a SBLOCA as a SGTR, continued RCP operation could result in an adverse SBLOCA response due to increased loss of RCS inventory. This possibility was identified in WCAP-9584 (Reference 2) and WOG report OG-110 (Reference 3). Since some of the assumptions used in these reports are not applicable to SONGS (the differences will be outlined in the systems description, Section 2.2), the potential for an adverse SBLOCA response was determined specifically for SONGS.

Due to the design differences at SONGS, continued RCP operation for SONGS-specific SBLOCAs has a less severe impact than that demonstrated for other Westinghouse plants. The SONGS specific analyses show that:

1) The PCTs remain far below the 2200°F limit for any delayed RCP trip time
2) The available operator action time to trip the RCPs after restart is at least 10 minutes for any size SBLOCA
3) The present EOPs are effective in recovering the plant from any SBLOCA or SGTR.

While it can be shown that the present SGTR EOPs are effective in recovering the plant, revisions to these EOPs incorporating the NRC recommendation on PORV opening have been developed. These revisions are discussed in Section 3.3.

2.2 SYSTEM DESCRIPTION

SONGS is one of the earliest Nuclear Steam Supply Systems (NSSS) built by Westinghouse. Since the time SONGS was built, many changes to the Westinghouse PWR design have been made. This section will focus on the specific design differences between SONGS and the generic Westinghouse plant used in the WOG analyses (References 3 and 4), and their effect on SONGS-specific transients.

One of the major design differences at SONGS is the automatic pump coastdown and low voltage trip feature. Because the SONGS RCPs are powered by the turbine generators, a turbine trip that occurs coincident with reactor trip results in an automatic RCP coastdown and trip sequence. Additionally, logic has been incorporated in response to IE Bulletin 79-06C (Reference 5) to cause the RCPs to automatically trip upon receipt of a Safety Injection Signal (SIS). However, the results of the SBLOCA analyses indicated that this safety feature may be removed from SONGS without adversely affecting the plant recovery from any size SBLOCA event. The unique automatic pump coastdown and trip sequence at SONGS virtually eliminates the delayed RCP trip concern except for the case of a possible misdiagnosis of a SBLOCA as a SGTR event. In the event that a SGTR has been diagnosed, the EOPs require the attempted restart of at least one RCP in order to establish pressurizer spray control to aid in the depressurization and cooldown of the RCS. Once the pump(s) is(are) restarted, a safety concern arises due to the subsequent delayed trip of the RCP(s) and its eventual impact on coolant inventory when the misdiagnosed SBLOCA is identified. A second major safety concern results from the use of the PORVs during SGTR recovery. Accordingly, these issues are examined in detail in Sections 2.4 - 2.6 and 3.3 - 3.4.

Another significant difference in the SONGS system design is the lack of accumulators. However, the large capacity of the safety injection flow (approximately seven times that of a typical Westinghouse 3-loop plant) more than compensates for the absence of accumulators. Also, SONGS does not have dedicated Safety Injection (SI) pumps and must realign the Main Feedwater (MFW) pumps to inject as SI. This results in the SONGS safety injection system having a much lower shutoff head and a slightly longer time delay prior to injection flow initiation compared to a typical 3-loop plant.

A final significant difference between SONGS and the standard Westinghouse plant is the lack of Main Steam Isolation Valves (MSIVs) which prohibits the isolation of the steam generators during a SGTR transient. However, the current SONGS plant specific EOPs have already taken this into account in the mitigation and subsequent recovery from the event. Therefore, these system design differences do not result in any safety concern.

Table 1 shows the parameters used in the SONGS SBLOCA analyses along with typical values for Westinghouse 2, 3 and 4-loop plants.

TABLE 1

PARAMETER	SONGS	2-LOOP	3-LOOP	4-LOOP
NSSS POWER (MWt)	1347	1882	2830	3411
FUEL CLADDING MATERIAL	STAINLESS STEEL	ZIRCALOY	ZIRCALOY	ZIRCALOY
CORE LENGTH (FEET)	10	12	12	12
RCS VOLUME (CUBIC FT)	6940	6410	9190	12050
STEAM GENERATOR SAFETY VALVE SET (PSIA)	985	1200	1190	1190
NUMBER OF PRESSURIZER PORVs	2	2	3	2
PORV CAPACITY (LBm/HR)	1.08×10^5	2.10×10^5	2.10×10^5	2.10×10^5
PORV SETPOINT (PSIA)	2205	2335	2335	2335
SAFETY INJECTION FLOW @ 1000 PSIA (LBm/SEC)	280	31	41	62
SAFETY INJECTION SHUTOFF HEAD (PSIA)	1160	2000	2400	2100
SAFETY INJECTION DELAY (SEC)	26	25	25	25
AUXILIARY FEED DELAY (MIN)	10	1	1	1

2.3 APPROACH AND ASSUMPTIONS

This section describes the modeling approach taken and the specific assumptions necessary to accurately model SONGS. In order to correctly simulate plant operations for the SBLOCA evaluations, several key assumptions were made. The following is a description of the models and assumptions necessary to ensure a proper analysis and evaluation of SONGS.

The SBLOCA analyses were completed using the Westinghouse WFLASH and LOCTA computer models (References 6 and 7). The LOCTA program was used to calculate the rod heatup portion of the SBLOCA event. WFLASH, using typical Appendix K conservative assumptions unless otherwise noted, was used for the thermal-hydraulic portion of the analyses. Although SONGS is not governed by Appendix K but by the Interim Acceptance Criteria (IAC), Appendix K assumptions were used for conservatism where appropriate. Due to the nature of SONGS and this evaluation, modifications to the WFLASH and LOCTA codes were made to correctly model plant operation as well as to account for the stainless steel fuel cladding. Also, due to the automatic trip system at SONGS, RCP coastdown and restart information had to be manually input to WFLASH. (This manual pump input will be discussed in detail on Page 10 of this Section). Finally, the specific design differences at SONGS discussed in the system description, Section 2.2, are easily accounted for as input to the WFLASH code.

The major modeling consideration for this study is the area of RCP trip and restart. This is the most important subject since any assumption regarding RCP status will directly affect the SBLOCA results. Based on plant specific procedure validation studies (Reference 9), the transition time from a reactor trip signal to the implementation of the SONGS SGTR EOPs is 389 seconds (6 minutes 29 seconds). Additionally, it takes another 725 seconds (12 minutes 5 seconds) to reach the RCP restart step or a total of approximately 1114 seconds (18 minutes 34 seconds) from a reactor trip signal to the RCP restart step in the SGTR EOPs. Specific SBLOCA analyses results presented in Reference 8 demonstrate the primary system pressure would have dropped significantly by that time, clearly resulting in a benefit for SONGS. Figure 1 shows the RCS pressures for the 3- and 6-inch SBLOCA cases based on Appendix K assumptions. These low pressures at the expected time of RCP restart

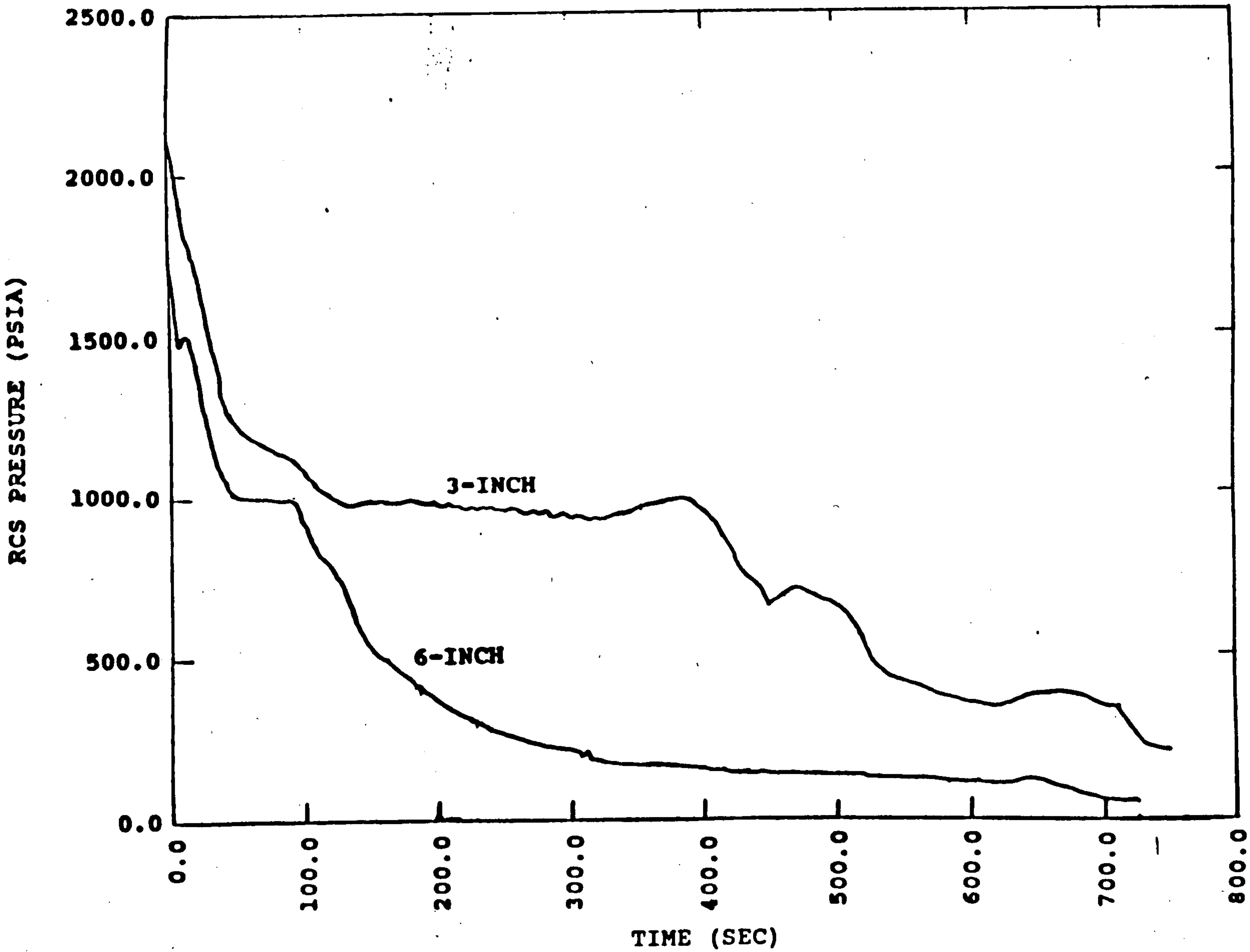


FIGURE 1. RCS PRESSURE FOR SONGS APPENDIX K 3- AND 6-INCH SBLOCAs

accompanied by other significant instrument readings would clearly indicate to the SONGS operator that something other than a design basis tube rupture was in progress. Consequently, it is highly unlikely that the operators would attempt to restart the RCPs. Therefore, in order to maximize the impact of RCP restart on the SBLOCA transients, it was necessary to assume that the RCPs were restarted shortly after the initial automatic trip.

The RCP restart time and the accompanying coast down and restart data used in these studies were chosen to conservatively model the core uncovery transients. In order to obtain the specific pump speed versus time data required to model the RCP coast down and restart, WFLASH was used to generate a typical coastdown of the RCPs. Figure 2 compares the WFLASH data to typical plant coastdown data taken from Page A-53 of the SONGS Final Safety Analysis Report (FSA). As can be observed, the WFLASH data compares favorably with the SONGS specific FSA data and thus will be used to model a SONGS RCP coastdown. Based on the results of the WFLASH run, the RCPs are predicted to coast down to less than 7% speed in 2 minutes. Also, the typical experience of previous plant operators indicated that RCP restart less than 2 minutes following pump trip is improbable. Therefore, to conservatively model the subsequent restart of the RCPs, all pumps were restarted at 2 minutes and brought up to full speed in 90 seconds assuming a linear increase. These conservative restart assumptions should result in maximized coolant inventory depletion for the SBLOCA cases.

The criteria used to select the critical RCP trip times were based on information obtained through previously performed RCP trip studies (References 3 and 4). These studies indicated that the critical (worst) RCP trip time occurred at the time of break uncovery (break flow becomes all steam). These studies also indicated that break uncovery could also coincide with minimum RCS inventory as demonstrated in the Best Estimate analyses (Reference 4). This was also the case for the 6-inch SBLOCA case performed for SONGS. However, due to the atypicalities of the SONGS plant, the SBLOCA transients do not behave similarly to standard Westinghouse plants. Specifically, the break does not remain uncovered due to the magnitude of safety injection flow, and as a result oscillations in break flow occur. Therefore, in order to determine the critical RCP trip time (i.e., the time of minimum RCS inventory)

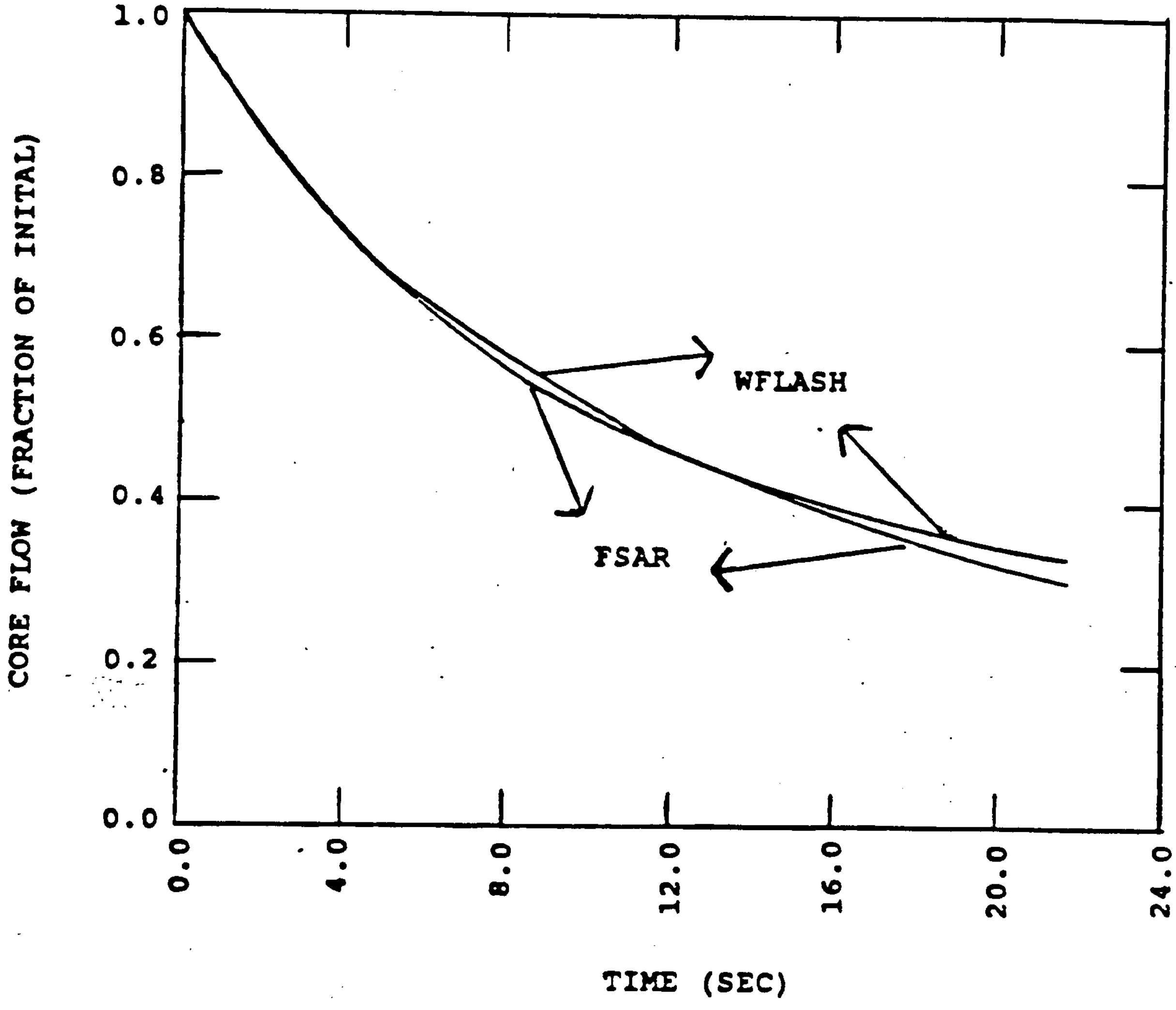


FIGURE 2. CORE FLOW VERSUS TIME DURING RCP COASTDOWN
A COMPARISON OF WFLASH AND SONGS DATA

for SONGS during a SBLOCA, it was necessary to generate a graph of time averaged break flow and safety injection flow versus time for each case. This figure can then be used to determine the minimum RCS inventory time. Additionally, since no downcomer depression occurs following RCP restart, core void collapse at the time of subsequent RCP trip is the only available mechanism which could cause core uncovery. Therefore, in order to support the RCP trip time chosen according to the previous graph, a figure of core void fraction versus time for each case can be generated. Comparing these two figures allows the verification of the critical RCP trip time chosen for SONGS as well as the determination of the subsequent or delayed RCP trip time.

A review of the aforementioned figures supports the selection of RCP trip at minimum RCS inventory time since this time also corresponds to maximum core voiding. RCP trip at any other time would have a negligible impact on core uncovery transients due to increasing coolant inventory and decreasing core voids.

Accordingly, these figure were generated for each small break size analyzed and used to determine RCP status. It should be noted here that with the assumed RCP restart beginning at 120 seconds for each case, the pumps do not reach full speed until 210 seconds; therefore no delayed RCP trip prior to 210 seconds was considered. For the 6-inch SBLOCA analysis, a base case was first run to determine the critical times of RCP status (i.e., the time period when RCP status would adversely affect SBLOCA results). In this base case, the RCPs were restarted and continued at full speed for the remainder of the analysis. Data from this case showed that near the time of minimum RCP speed (approximately 120 seconds) the break flow quality was increasing, the break flow rate was decreasing, the loop seal mixture level was falling to a minimum and the core void fraction was increasing. Figures 3 and 4 graphically show the break flow, safety injection flow, and core void fraction as a function of time. These results indicated that the initial break uncovery was occurring at the end of the initial pump coastdown period following RCP trip. For this reason, a case was run in which the RCPs were allowed to continue coasting down to 0 speed after initial RCP trip. Additionally, the base case showed that the void fraction is at the maximum from 120 seconds to 300 seconds while safety injection flow and break flow equilibrate over this time period. Thus

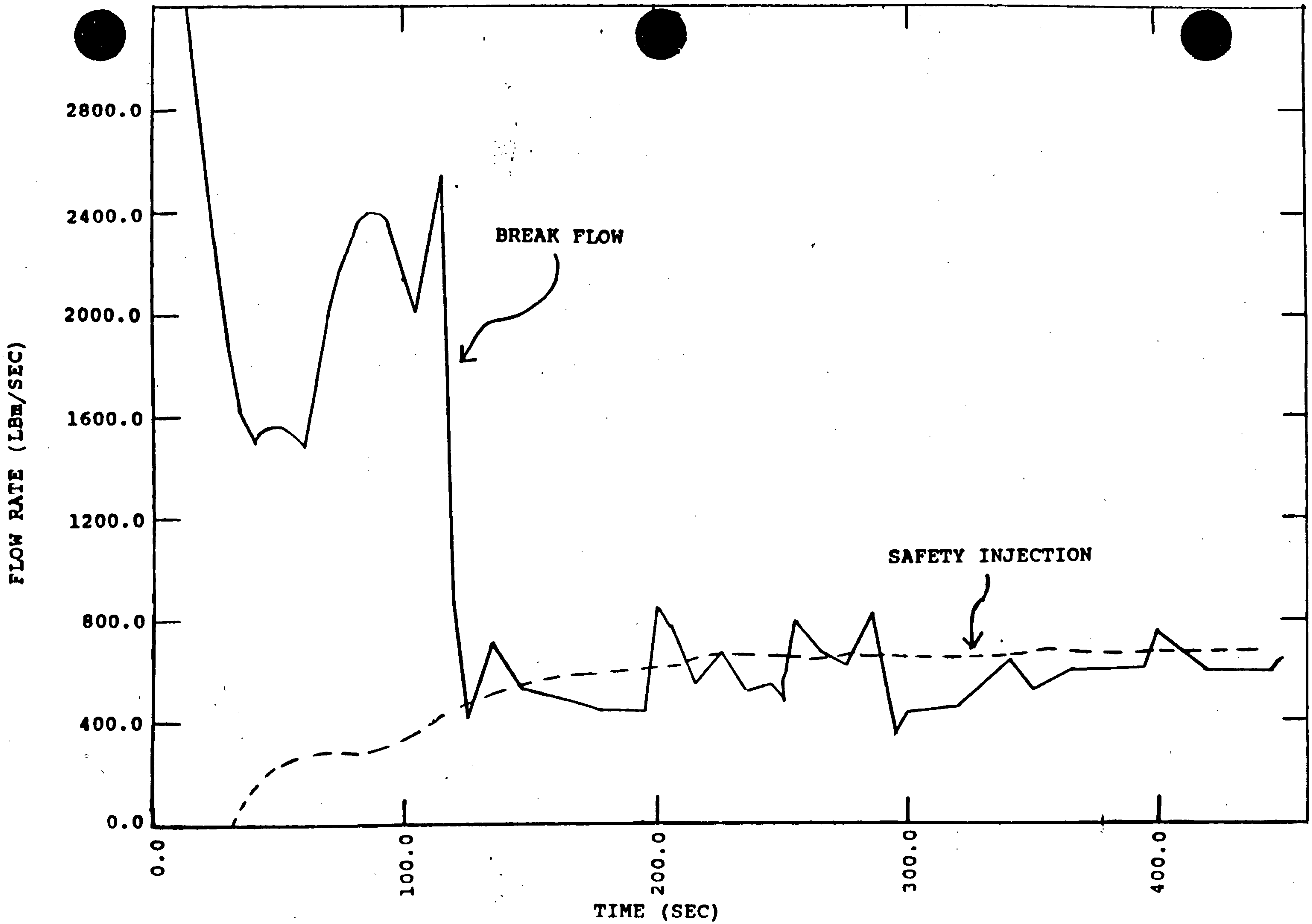


FIGURE 3. TIME AVERAGED BREAK FLOW AND SAFETY INJECTION FLOW VERSUS TIME
6-INCH SBLOCA, RCP RESTART, NO DELAYED TRIP

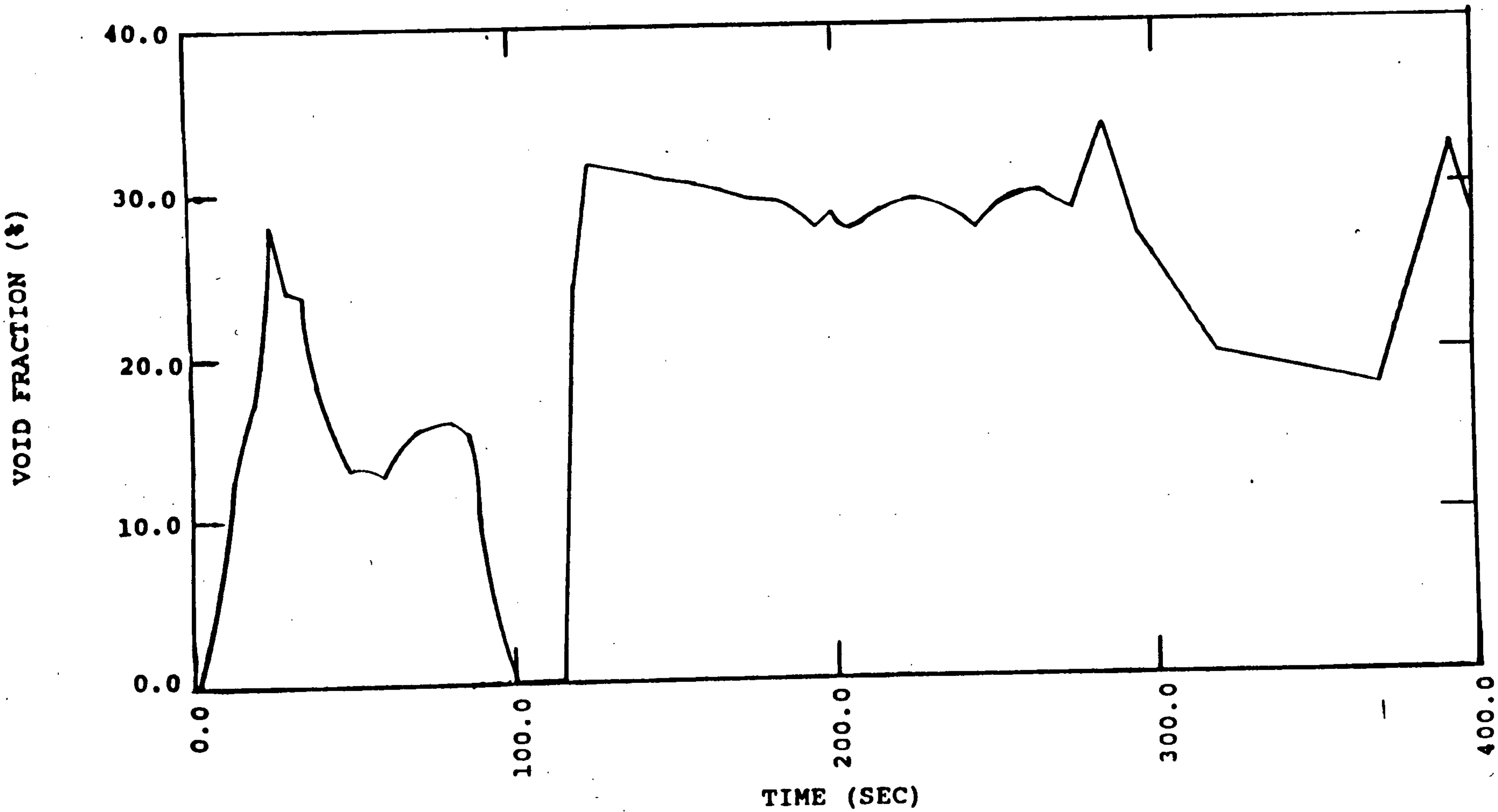


FIGURE 4. CORE VOID FRACTION VERSUS TIME
6-INCH SBLOCA, RCP RESTART, NO DELAYED TRIP

when considering core uncovery due to void collapse, it was necessary to model a delayed RCP trip in this "window of time" (120-300 seconds). Specifically for the 6-inch SBLOCA, the pumps were tripped at 250 seconds to assess the impact of pump trip during maximum void fraction. Finally, in order to determine the effects of continued RCP operation on RCS inventory and PCTs, the base case was run to a maximum time of 600 seconds.

For the 3-inch SBLOCA, a base case was also run in which the RCPs were restarted and remained at full speed. Figures 5 and 6 show the time averaged break flow and safety injection flow versus time and void fraction versus time, respectively. From these figures, it is apparent that minimum RCS inventory and maximum core void fraction occurred before the RCPs reached full speed. Therefore, the only 3-inch SBLOCA analyses completed, other than the base case, is the case in which the pumps were never restarted after initial RCP trip. Any delayed RCP trip for a 3-inch SBLOCA would have a negligible impact on core uncovery transients.

Although the SGTR EOPs call for the restart of one pump at a time, all three RCPs were modeled to start simultaneously in the analyses. This assumption was used in order to maximize inventory loss which in turn maximizes PCTs. However, to assess the sensitivity of system response to the number of RCPs restarted, a case in which only one RCP was started was analyzed. The main concern associated with continued RCP operation is the lengthening of the liquid break flow discharge period. Therefore, only cases which demonstrate significant periods of steam break flow discharge need be examined. Only the 6-inch SBLOCA case exhibited any extended periods of steam break flow discharge, therefore it was the only case examined. The results for this case and all other 6-inch SBLOCA analyses performed will be discussed in Section 2.4.

The 3- and 6-inch SBLOCA analyses were determined to be the bounding size SBLOCAs at SONGS. The 6-inch case was deemed bounding at the larger end of the small break spectrum because breaks larger than a 6-inch would result in a more rapid RCS depressurization transient. This faster depressurization would result in more safety injection flow being delivered to the RCS in a shorter time period. It would also result in a reduction of the clad heatup interval

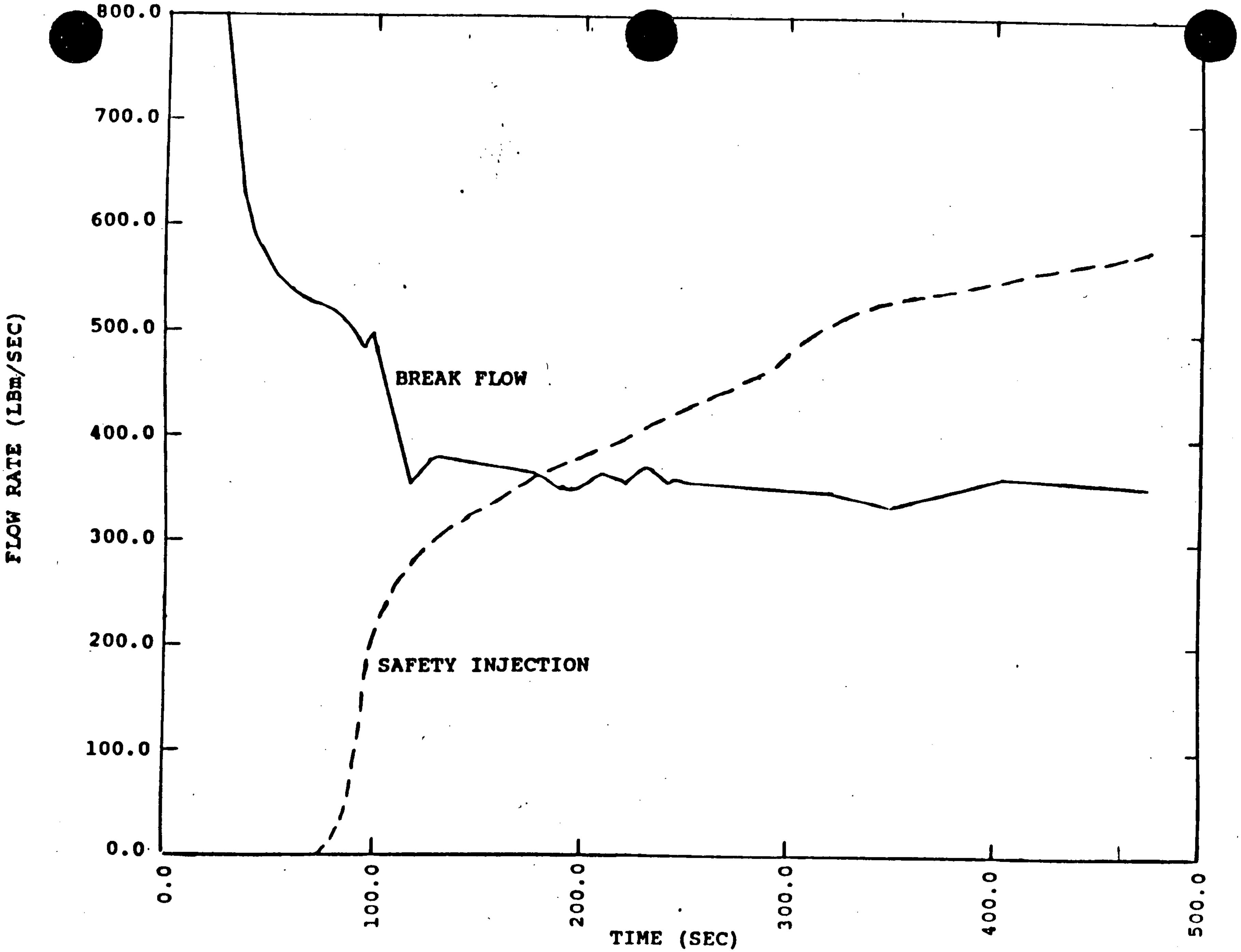


FIGURE 5. TIME AVERAGED BREAK FLOW AND SAFETY INJECTION FLOW VERSUS TIME
3-INCH SBLOCA, RCP RESTART, NO DELAYED TRIP

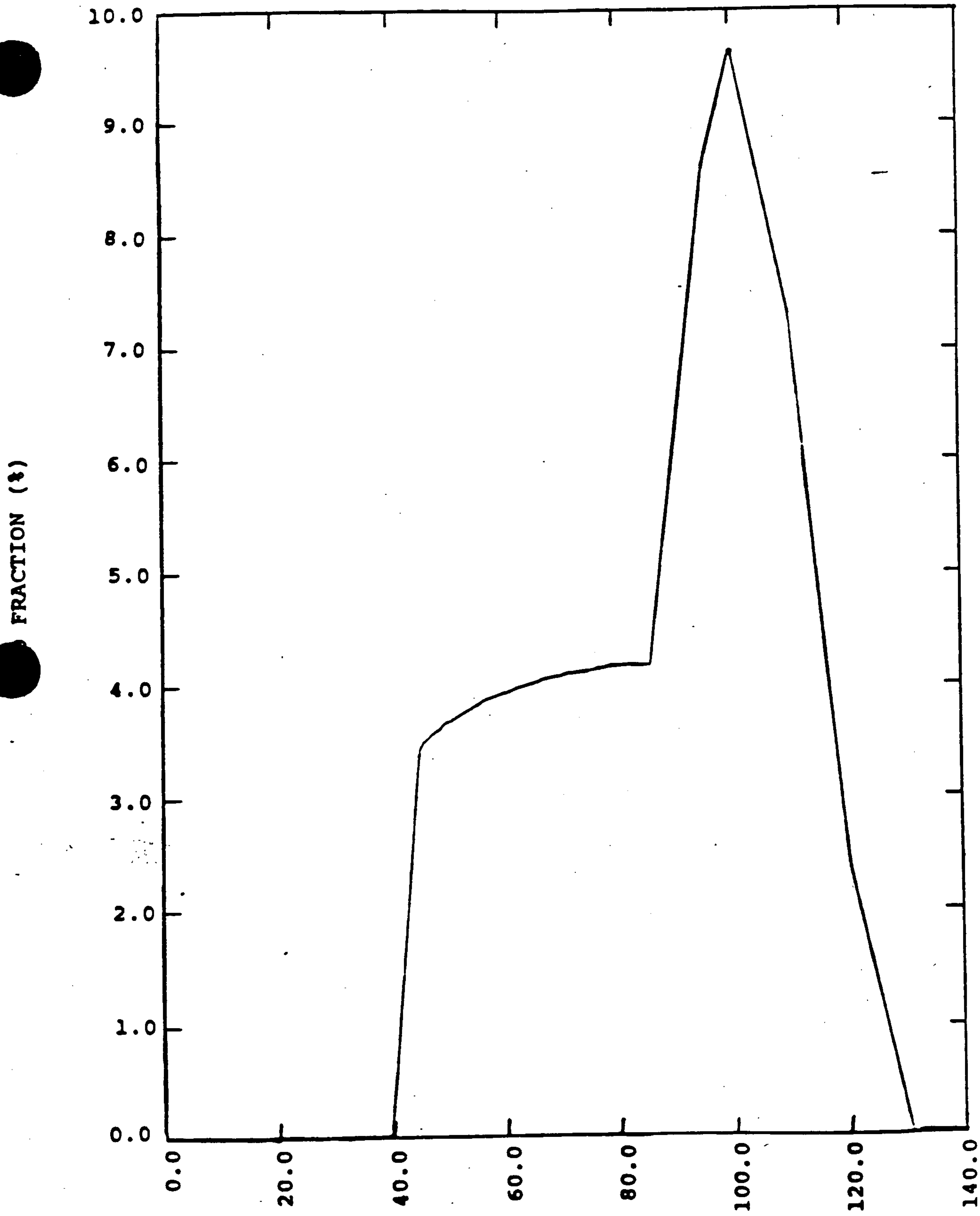


FIGURE 6. CORE VOID FRACTION VERSUS TIME
3-INCH SBLOCA, RCP RESTART, NO DELAYED TRIP

thus resulting in lower clad temperatures than presented for the 6-inch break. The 3-inch break, on the other hand, was chosen as the bounding break size on the lower end of the spectrum since it was considered to be the size for which the RCS pressure could potentially remain above the secondary safety valve setpoint. Should this occur, the potential for not reaching the safety injection delivery point for an extended period of time could exist. Break sizes smaller than 3-inches were not considered for two reasons; 1) the minimum core mixture level increases as a function of decreasing break size as demonstrated in Figure 8 of Reference 4 and 2) the safety injection capacity of SONGS is such that it is capable of matching saturated break flow up to 2.66-inch break size. Figures 8 and 15 demonstrate the difference in core mixture level for the two different size breaks. The core mixture level for the 3-inch break is much higher resulting in more core cooling due to a greater fraction of the core being covered. Additionally, since only a small portion of the core is uncovered, much less water from the Emergency Core Cooling System (ECCS) is required to recover the core as compared to larger breaks with deeper core uncovery. Due to these factors the PCTs are lower for the smaller break size as is evident by comparing the PCTs for the 3- and 6-inch case. Further, any break size smaller than a 3-inch would result in even less core uncovery, more core cooling, a shorter clad heatup interval and lower PCTs. The only SBLOCA cases not discussed thus far are those which fall between a 3- and 6-inch break. The consequences of these intermediate size breaks would be acceptable as the PCTs would be bounded by those for the 3- and 6-inch cases. The reason for this is the depressurization transient. As break size increases from 3- to 6-inches, there would be a deeper core uncovery but the safety injection delivery would occur sooner, thus decreasing the core uncovery time. Although the deeper core uncovery causes a rise in PCTs as the break size increases from 3- to 6-inches, the competing factor of decreased core uncovery time limits the PCTs to no greater than that for the 6-inch case. Because of these factors, the 3- and 6-inch analyses results are bounding for all other size SBLOCAs at SONGS.

2.4 6-INCH SBLOCA RESULTS

The purpose of this section is to provide a summary of the 6-inch SBLOCA results. For the 6-inch analysis, four specific cases were studied. First, all three pumps were restarted after the initial automatic trip with no subsequent delayed trip. Second, the pumps were allowed to coastdown to 0 speed following the initial pump trip. Third, after the initial RCP trip and restart, the pumps were tripped at 250 seconds. Fourth, only 1 RCP was restarted after the initial RCP trip and continued at full speed for the remainder of the analysis.

The reason for analyzing the 6-inch SBLOCA case was due primarily to the result of previous SBLOCA analysis work performed for the SONGS plant using the WFLASH evaluation model. The results obtained from this report, Reference 8, indicated that the 6-inch case has the longest and earliest steam break flow discharge period. Since continued RCP operation lengthens the liquid break flow discharge period and results in increased inventory depletion and potentially higher clad temperatures, it was necessary to assess the impact of delayed RCP trip on this break size first.

To assist in the interpretation of the 6-inch SBLOCA results, Figures 7 through 10 are provided. Figure 7 displays the core mixture level history for the pumps running 6-inch SBLOCA case. Figures 8 and 9 show core mixture level versus time for the pumps off 6-inch SBLOCA case, with Figure 9 being reproduced from a previous report on SONGS SBLOCAs (Reference 8). Figure 9 is included to show that for this case, there is only one time of core uncovery and thus the analysis with pumps off need only be run a short time past this first and only core uncovery period. Finally, Figure 10 shows the core mixture level history for a 6-inch SBLOCA with RCP restart and delayed trip at 250 seconds. As can be seen by these figures, the only core uncovery predicted to occur during these transients was due to the loop seal draining phenomenon. No additional core uncovery was predicted following RCP restart and subsequent trip. Therefore, no adverse impact due to a delayed RCP trip for this break size is predicted. This is due primarily to the magnitude of the safety injection flows at these low system pressures.

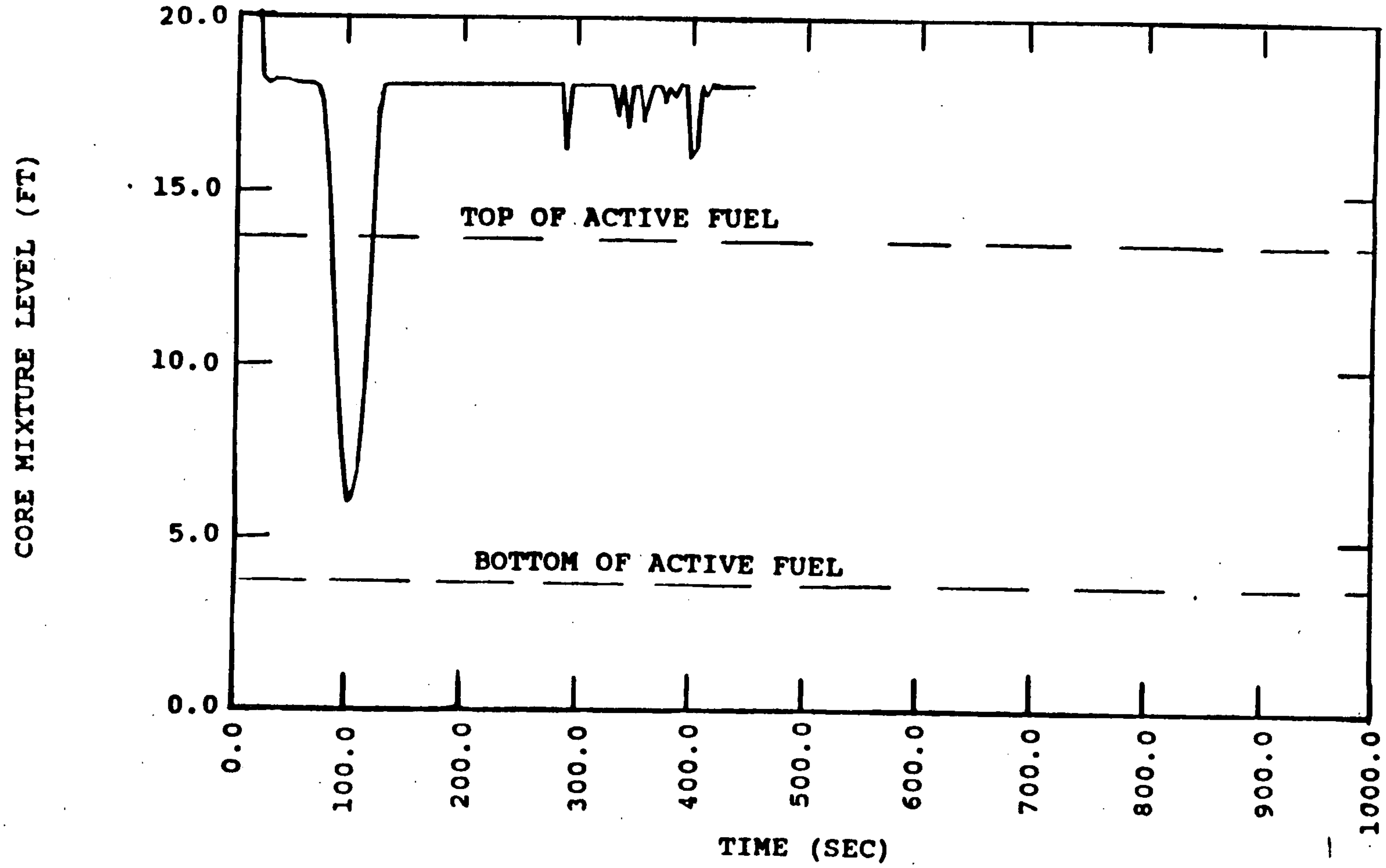


FIGURE 7. SONGS CORE MIXTURE LEVEL
6-INCH SBLOCA, RCP RESTART, NO DELAYED TRIP

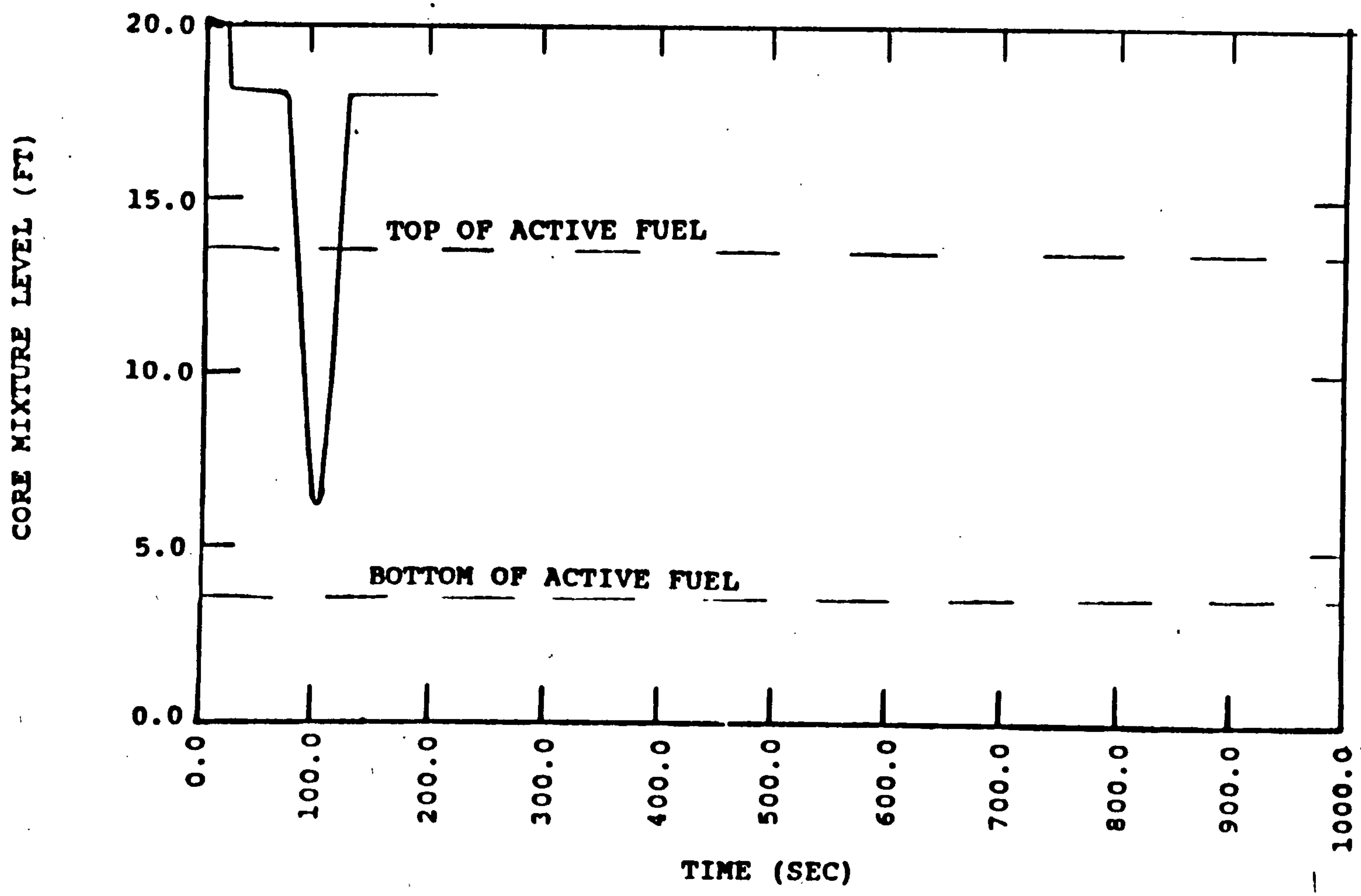


FIGURE 8. SONGS CORE MIXTURE LEVEL
6-INCH SBLOCA, RCP TRIP AT REACTOR TRIP, NO RCP RESTART

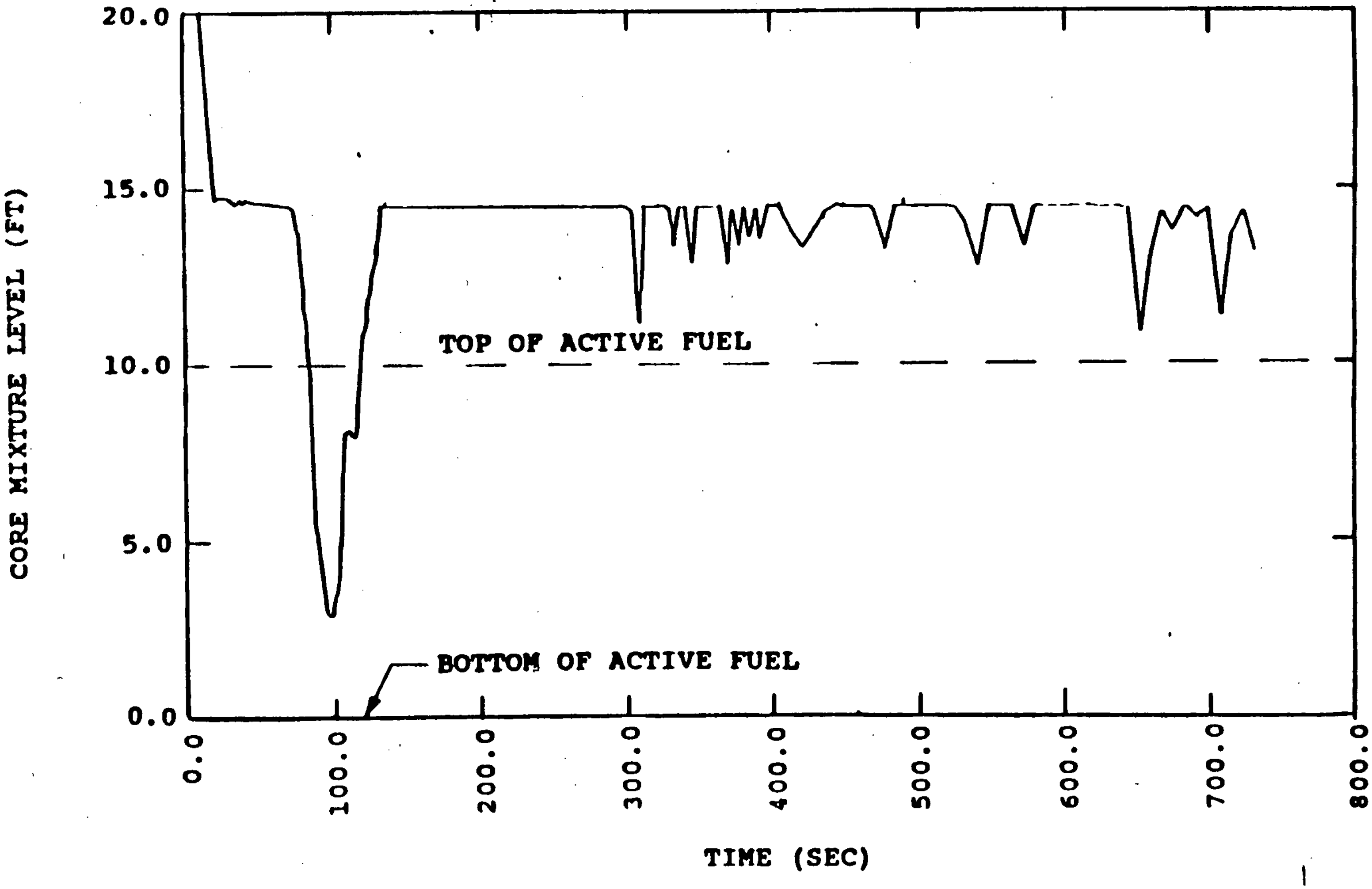


FIGURE 9. SONGS CORE MIXTURE LEVEL
APPENDIX K 6-INCH SBLOCA, NO RCP RESTART

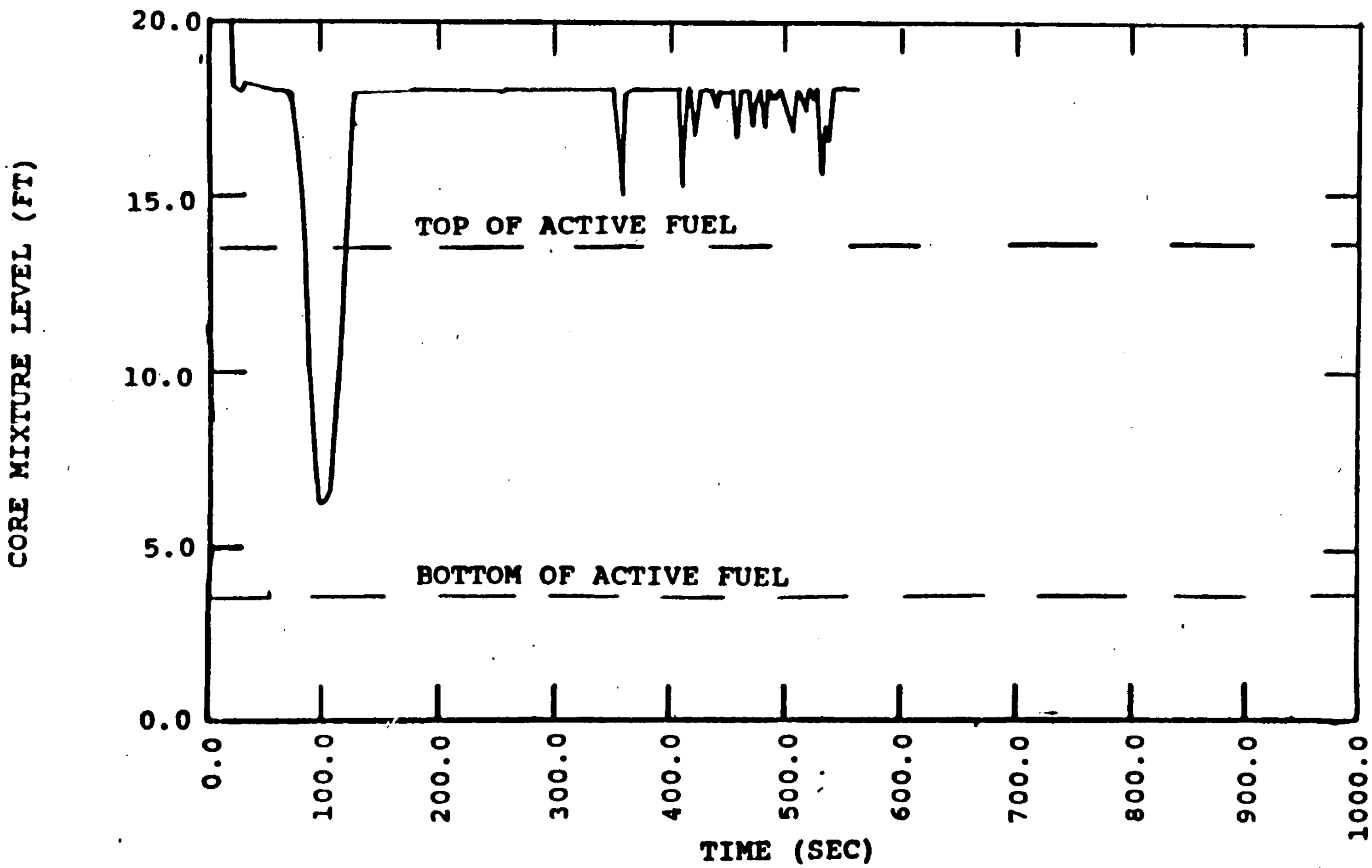


FIGURE 10. SONGS CORE MIXTURE LEVEL
6-INCH SBLOCA, RCP RESTART, DELAYED TRIP AT 250 SEC.

Figure 11 presents a comparison of break flow versus safety injection flow as a function of RCS pressure and break size. Saturated steam break flow discharge using the Moody Break flow model was assumed in generating this figure. As can be seen from Figure 1, had the more realistic RCP) restart time been used for the 6-inch break transient (approximately 18 minutes), the RCS pressure would be approximately 100 psia. At such a reduced pressure, the predicted safety injection flow would overwhelm the saturated steam break flow. Even assuming saturated liquid break flow discharge (Figure 12), SI would still be significantly higher than the break flow for the 6-inch transient case at these low RCS pressures. The net RCS inventory would be increasing from this time on and should RCP restart occur at or later than this time, the effect on PCTs would be negligible.

There is no depression of the downcomer mixture level following the restart of the RCPs for the 6-inch transient. This is due primarily to the magnitude of the safety injection flow, since even with the RCPs operational, sufficient inventory is being replenished in the downcomer region to preclude level depression. This is a major contributor to the lack of core uncovery at SONGS following delayed RCP trip since core and downcomer mixture levels would equilibrate following RCP trip time. Since no downcomer depression was predicted to occur following RCP restart, no further core uncovery would be predicted following RCP trip.

Finally, an analysis was undertaken in order to determine the impact of restarting only one RCP on SBLOCA results. The purpose of this portion of the analysis was to demonstrate that restarting all three RCPs is conservative with respect to delayed RCP trip scenarios. For this analysis, only the penalties associated with continued RCP operation have been examined while one of the major benefits of continued operation has been ignored (pressurizer spray capability). Since SONGS safety injection capability is so large compared to standard Westinghouse plants, the downcomer depression and break uncovery following RCP trip typically seen in standard plants is eliminated. Therefore, the period of steam break flow discharge for SONGS is relatively short, and continued RCP operation has a minor impact on total system inventory. Also, continued RCP operation provides forced flow through the core thereby reducing the potential for core heatup. The results generated

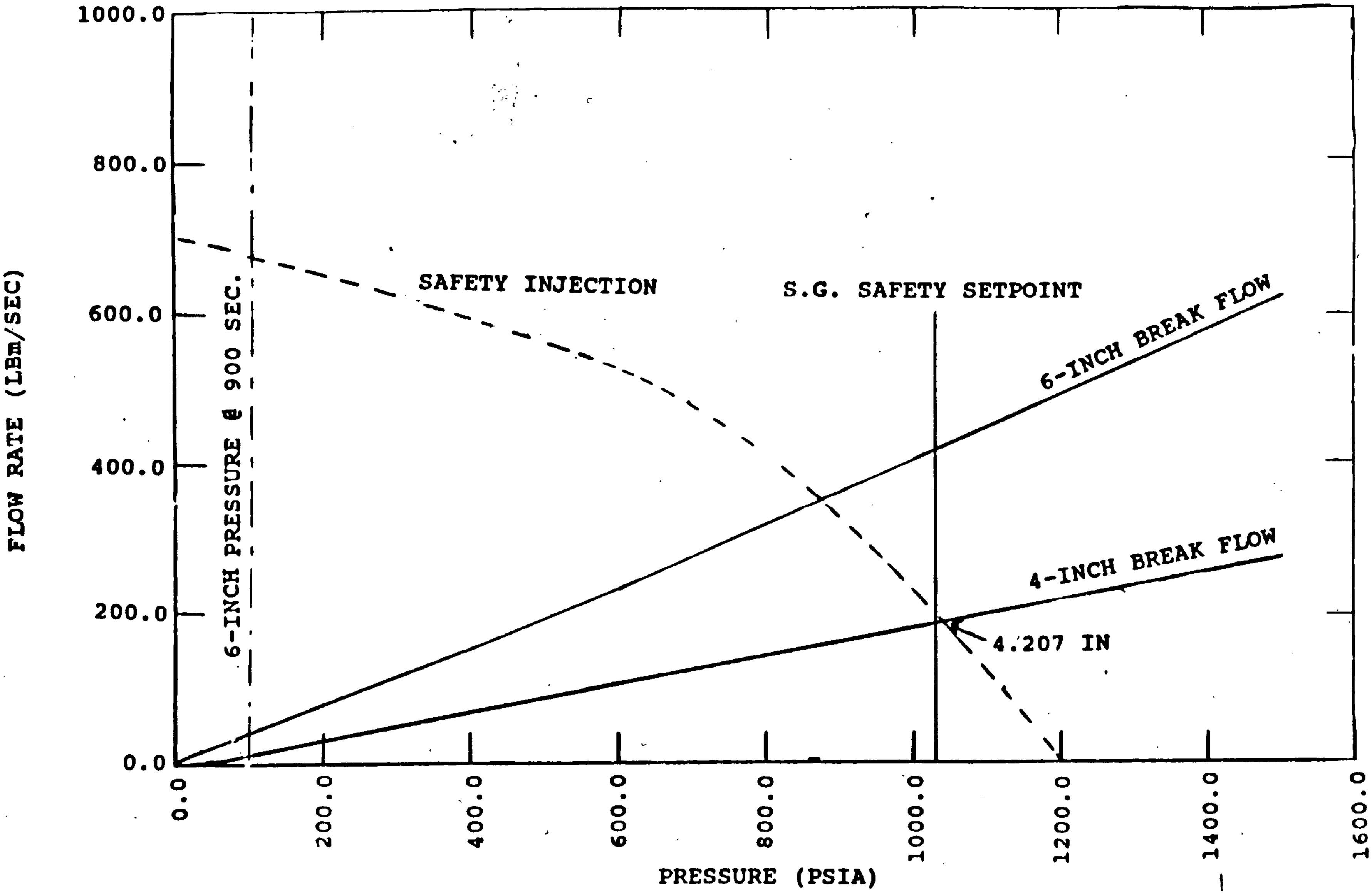


FIGURE 11. SATURATED STEAM BREAK FLOW AND SAFETY INJECTION FLOW VERSUS PRESSURE

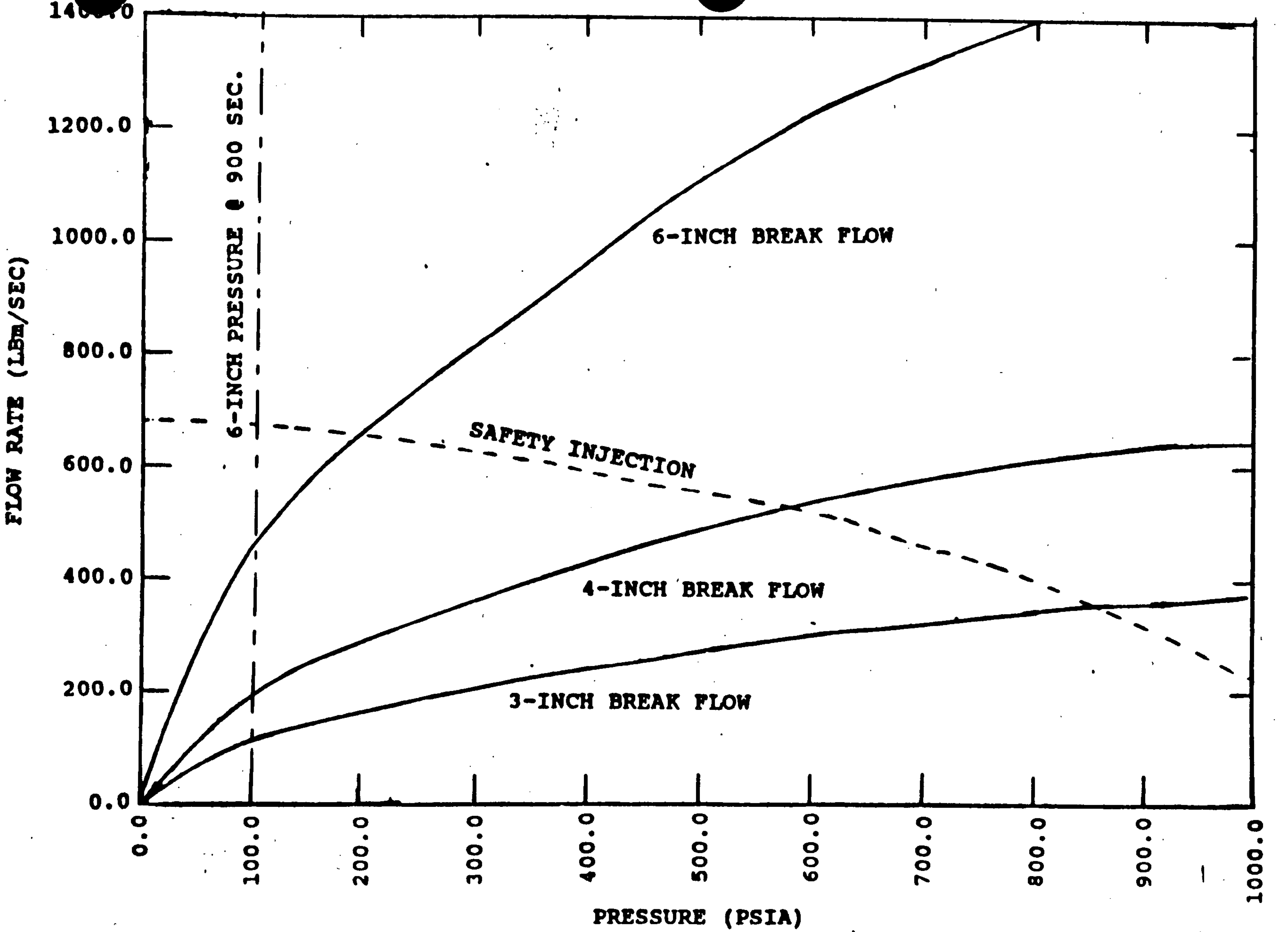


FIGURE 12. SATURATED LIQUID BREAK FLOW AND SAFETY INJECTION FLOW VERSUS PRESSURE

with all 3 RCPs in operation was demonstrated to be more conservative in terms of inventory depletion as can be seen in Figure 13. Therefore, it serves as the bounding case regardless of the number of RCPs in operation, in terms of inventory depletion and associated clad heatup.

Table 2, shown in Section 2.5, presents a summary of the cases analyzed. The maximum predicted PCTs for cases 1 and 3 are identical (867.34) and occur prior to completion of the loop seal drain phenomenon. No LOCTA run was made for case 2 since no core uncovery other than during loop seal draining occurred; therefore, the predicted PCTs for cases 1 and 3 are bounding for case 2. Similarly, the PCTs for cases 1 and 3 also apply to the case where only 1 RCP is restarted. This is due to the fact that the PCT would be predicted to occur prior to restarting the RCP.

Therefore, regardless of the delayed RCP trip time or the number of RCPs restarted, no safety concerns arose due to the possible misdiagnosis of a 6-inch SBLOCA as a SGTR since the predicted PCTs remain well within acceptable limits.

Appendix A contains a series of figures presenting more detailed results of the three 6-inch SBLOCA transient analyses.

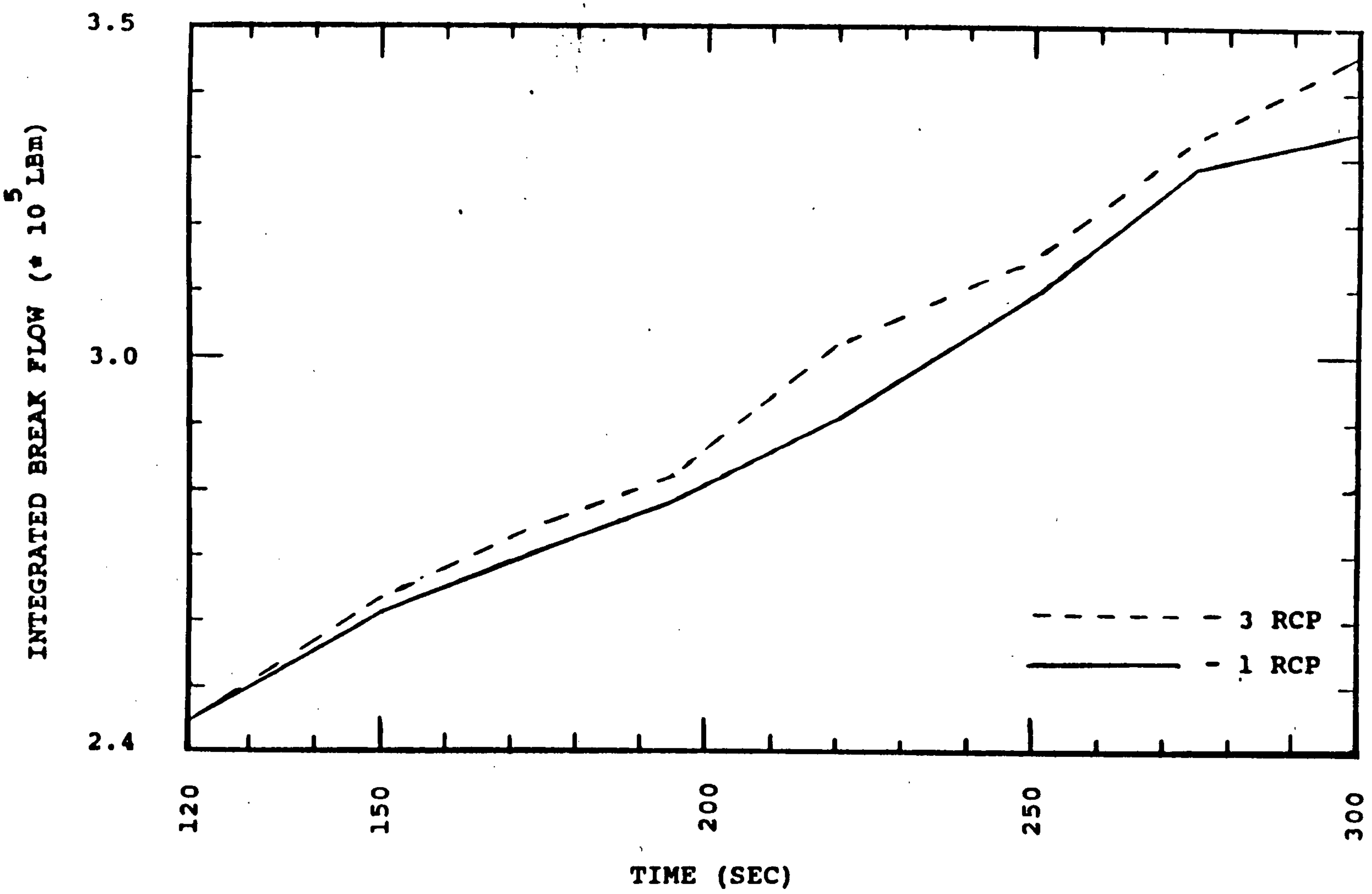


FIGURE 13. INTEGRATED BREAK FLOW VERSUS TIME
A COMPARSION OF RCP STATUS

2.5 3-INCH SBLOCA RESULTS

This section will provide a summary of the results obtained for the 3-inch SBLOCA analyses. Two specific analyses were performed for this break size. First, the RCPs were restarted at 120 seconds and allowed to run at full speed for the remainder of the transient. Second, the RCPs were allowed to coast down to 0 speed after initial trip with no subsequent restart. The basis for analyzing only these 2 cases is provided in the Approach and Assumptions, Section 2.3.

For the first case, where the pumps are restarted, Figure 5 shows that safety injection exceeds break flow from 180 seconds to the end of the transient. Due to the large difference between the safety injection flow and break flow, the system remains subcooled and the break flow never becomes steam. Because there was no downcomer level depression with RCP restart there is no core uncovery, and PCTs for this case remain within a safe operating range. Figure 14 shows the predicted core mixture level for this case. As can be seen, the core was never uncovered and thus no safety concerns arise from this scenario.

In the second case analyzed, the pumps were not restarted after initial trip. As is the case with the larger SBLOCA, the core uncovery occurring during this transient was due to the loop seal draining phenomenon. This can be seen in Figure 15, a graph of the core mixture level history. This uncovery lasted for a time period of approximately 30 seconds while the loop seal was draining. The second spike was caused by the sudden clearing of the loop seal which caused the transition of the break flow to all steam. The venting of steam causes a rapid depressurization transient for that time period, followed by the refilling of the loop seal and the recovery of the core mixture level. Figure 16, a multiplot of RCS pressure, core mixture level and loop seal mixture level, graphically illustrates these phenomena. Also, Figure 17 shows the quality of the break flow throughout the transient; notice the time of the transition from low quality to high quality occurred near the time of the loop seal clearing. Following this period of core uncovery, safety injection flow becomes greater than break flow as the pressure continues to decrease and no further core uncovery was predicted.

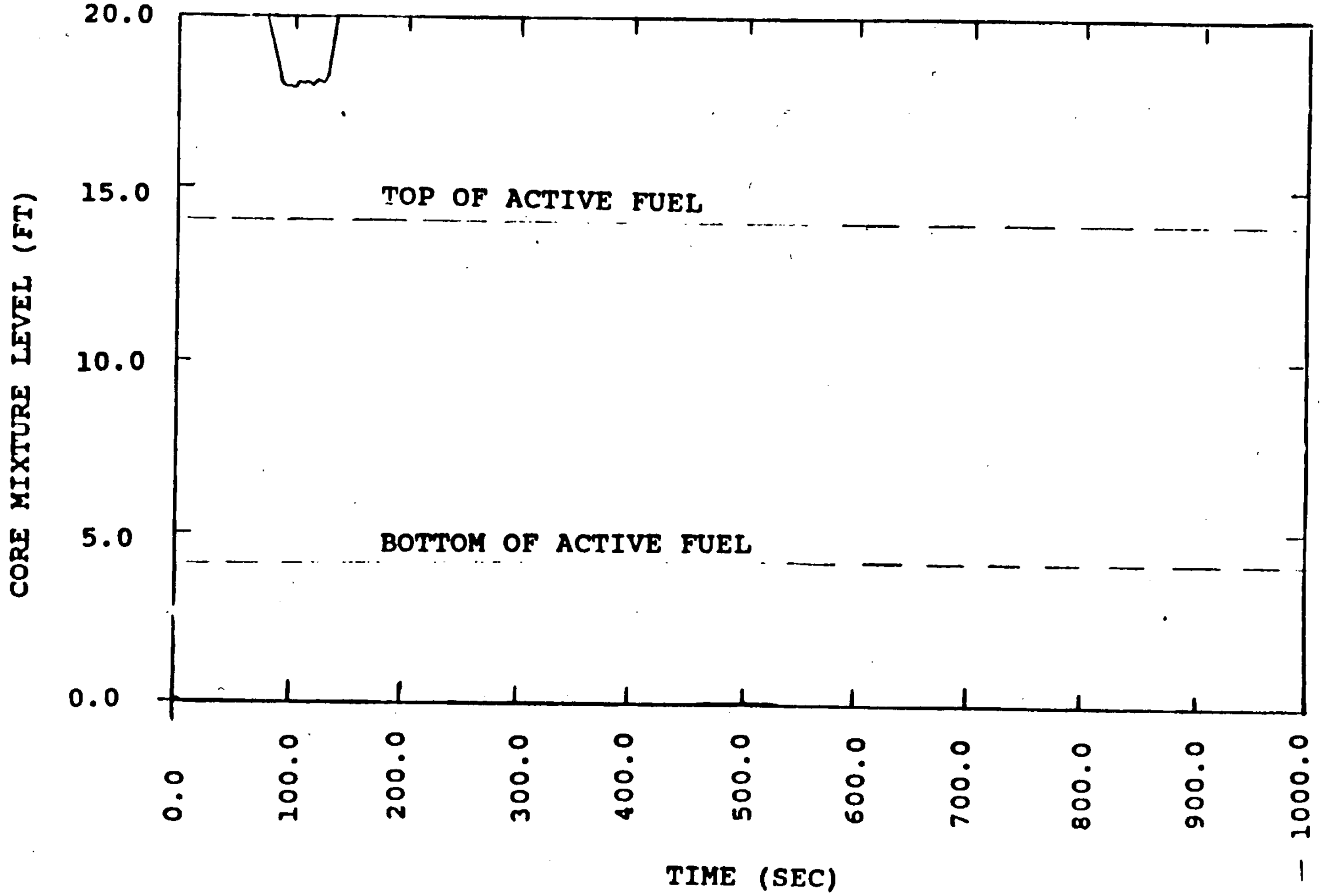


FIGURE 14. SONGS CORE MIXTURE LEVEL
3-INCH SBLOCA, RCP RESTART, NO DELAYED TRIP

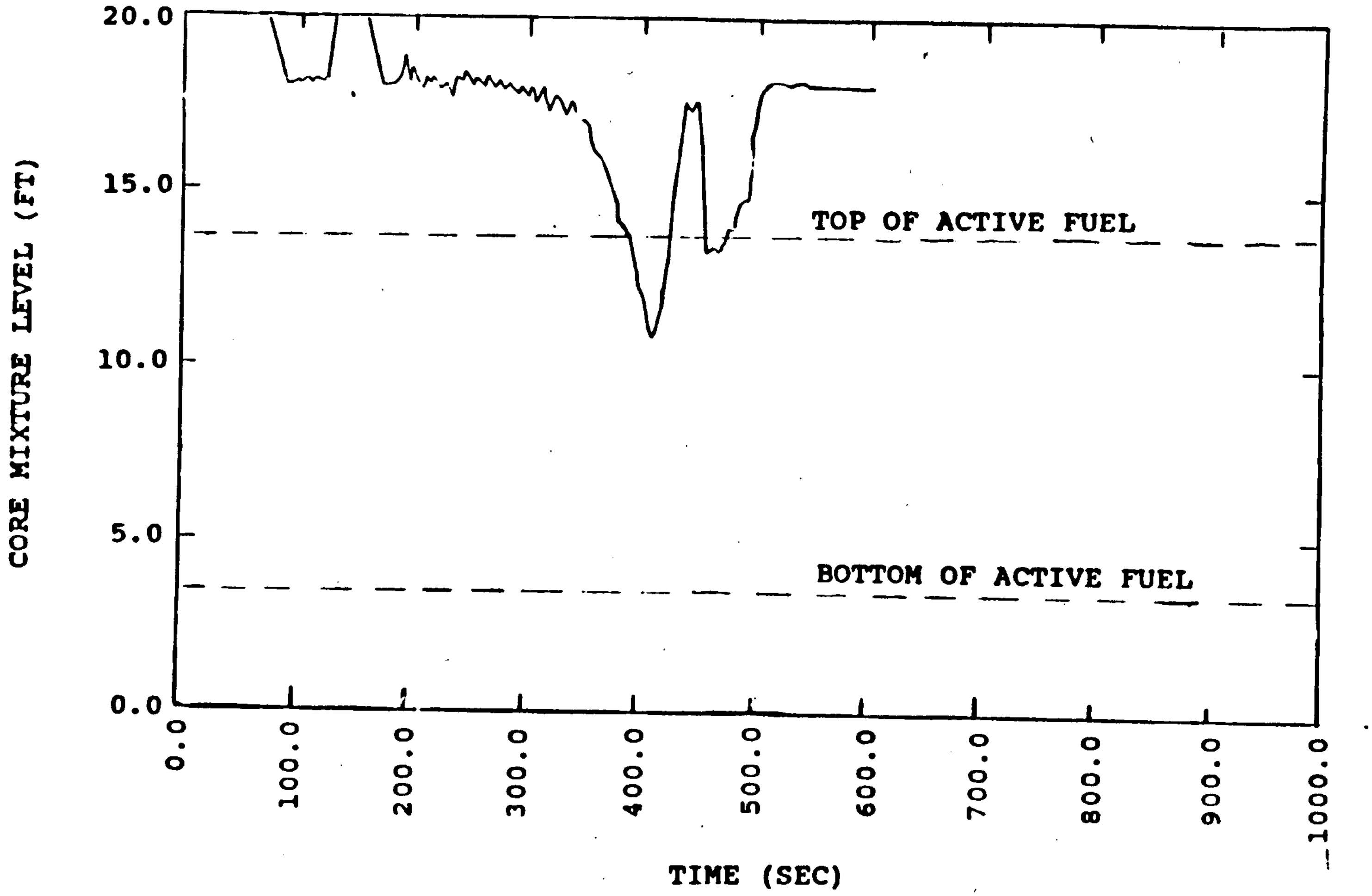


FIGURE 15. SONGS CORE MIXTURE LEVEL
3-INCH SBLOCA, RCP TRIP AT REACTOR TRIP, NO RCP RESTART

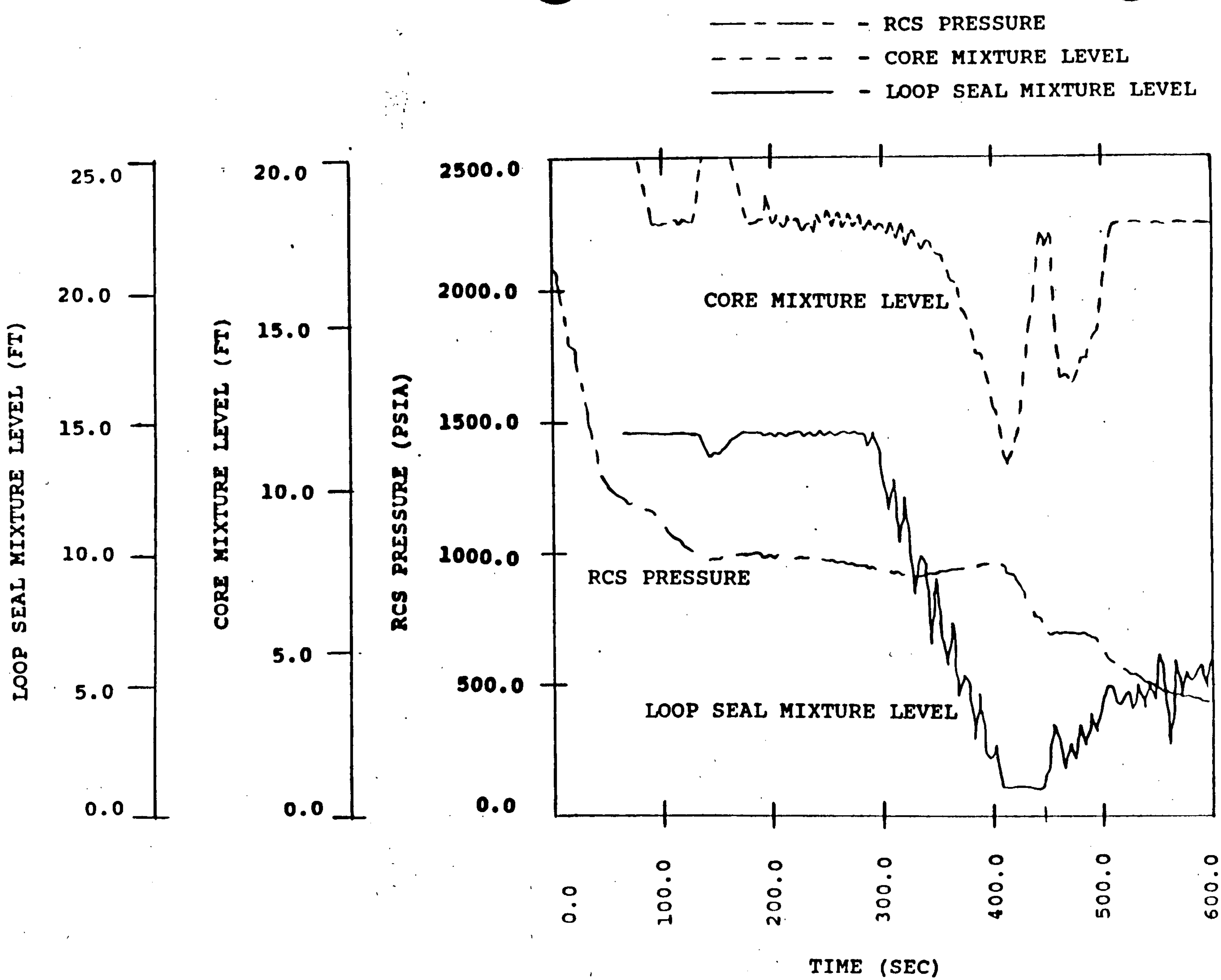


FIGURE 16. SONGS PRESSURE, CORE MIX. LEVEL AND LOOP SEAL MIX. LEVEL VERSUS TIME
3-INCH SBLOCA, RCP TRIP AT REACTOR TRIP, NO RCP RESTART

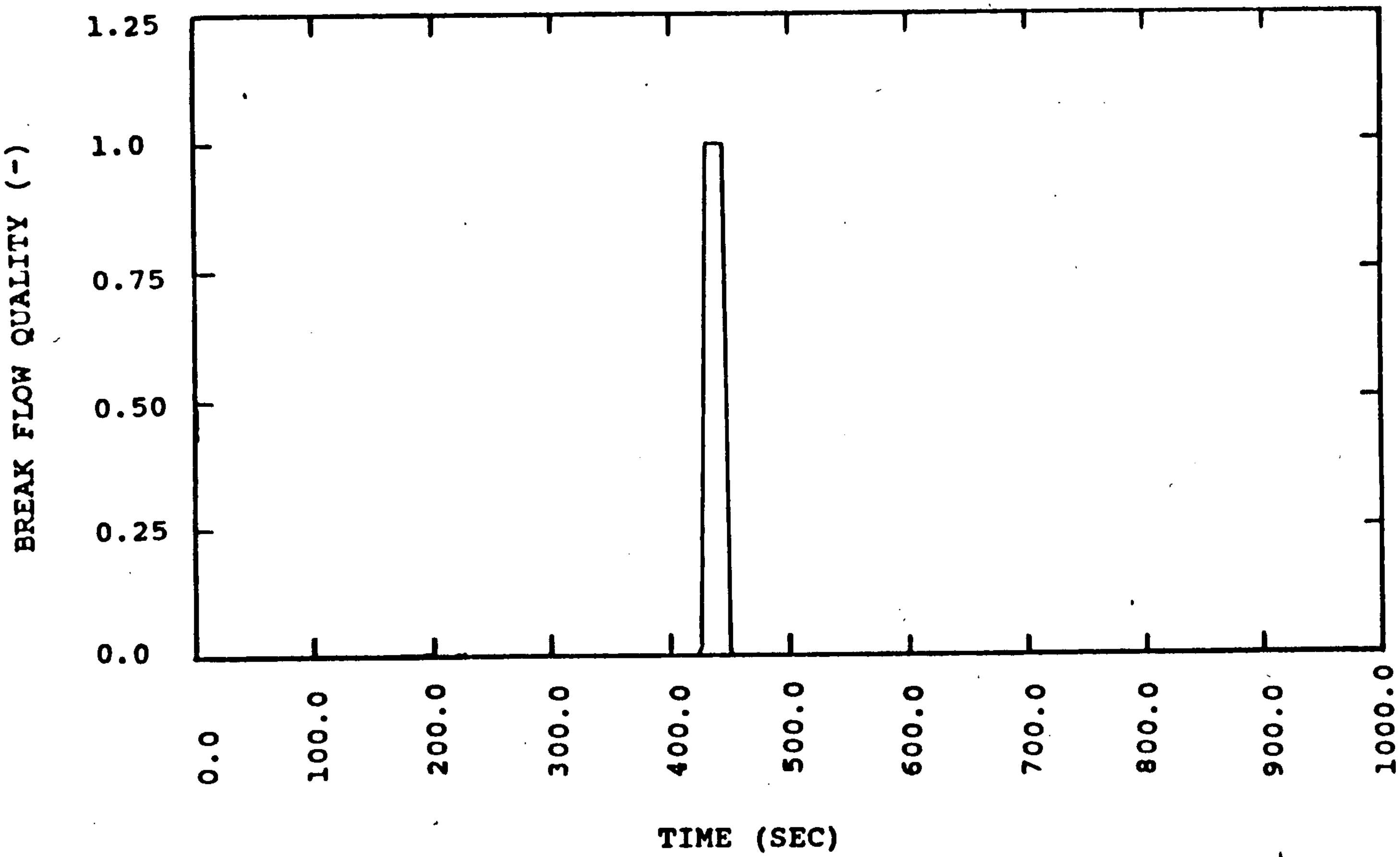


FIGURE 17. SONGS BREAK FLOW QUALITY VERSUS TIME
3-INCH SBLOCA, RCP TRIP AT REACTOR TRIP, NO RCP RESTART

The resulting PCT for this 3-inch SBLOCA shows a minor increase over SONGS normal operating temperatures. Table 2 shows a summary of the cases analyzed and the PCTs for each case. The one loop restart results for the 6-inch cases would also apply to the 3-inch case based on the results of the 3- and 6-inch analyses. Since steam break flow discharge was predicted for the 3-inch SBLOCA only for a short period during the loop seal draining, continued RCP operation would have only a minor impact on total system inventory. Also, the conclusion drawn form the 6-inch cases would apply. Specifically, the 3 RCP restart case will bound all cases regardless of the number of RCPs operational in terms of inventory depletion and associated clad heatup.

Appendix B contains a series of figures presenting more detailed results of the 3-inch SBLOCA analyses.

TABLE 2

Case	Break Size	RCP Status	PCT
1	6-Inch	RCPs restarted at 120 sec., No delayed trip	867.34°F
2	6-Inch	RCPs restarted at 120 sec., Delayed trip at 250 sec.	867.34°F
3	6-Inch	No RCPs restarted	867.34°F
4	6-Inch	1 RCP restarted, No delayed trip	867.34°F
5	3-Inch	RCPs restarted at 120 sec., No delayed trip	714.35°F
6	3-Inch	No RCPs restarted	714.35°F

2.6 SBLOCA SUMMARY

The following conclusions may be drawn from the results of these analyses.

1. Delayed RCP trip after initial automatic trip and manual restart does not adversely affect Small Break LOCA results assuming the automatic RCP trip option operates as designed.

2. The current SONGS SGTR RCP restart instructions do not adversely affect SBLOCA transient results assuming a misdiagnosis of a SBLOCA as a SGTR.

3. There is no RCP trip time, during any SBLOCA transient, following the initial RCP trip and restart that will result in Peak Clad Temperatures in excess of 868°F.

4. Based on available plant-specific operator response time data, the current SONGS SGTR EOPs provide adequate diagnosis time to differentiate between SGTRs and SBLOCAs thereby precluding unnecessary RCP restart.

Finally, it should be noted that these results were obtained using Appendix K conservatisms; therefore, additional safety margin would have been demonstrated had better estimate assumptions been used. These results clearly demonstrate the ability of the SONGS safety systems to recover from SBLOCA transients regardless of the RCP operational status.

3. SGTR EOP REVIEW AND EVALUATION

3.1 BACKGROUND

Since the accident at Three Mile Island in 1979, there has been increasing concern over the use of pressurizer PORVs to aid in plant recovery during SBLOCAs, SGTRs and other similar transients. The situation arises due to the fact that once pressurizer sprays are lost due to RCP trip, PORVs are sometimes used to assist in primary system pressure control. According to Reference 1, "...these valves continue to show a high propensity for failing to close." Also, "...there does not appear to be significant progress in improving the overall operational reliability of PORV systems." Therefore, the NRC has indicated that their position regarding PORV use is: "If...the setpoints selected will lead to RCP trip...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." Accordingly, this section of the report will address the NRC position specifically for SONGS.

For SONGS, the primary challenge to the PORV system would be during a SGTR recovery. Because the SONGS RCPs trip with turbine trip (as described in Section 2.2), the pressurizer sprays would not be available for depressurization purposes unless RCP restart is accomplished. In order to restart the RCP(s) necessary to use the pressurizer sprays, the current EOPs utilize one pressurizer PORV to establish pressurizer level. A minimum pressurizer level of 70% is a required condition prior to RCP restart. However, NRC recommendations stated in Reference 1 advise minimizing PORV use due to the potential for the PORV(s) to fail open. Therefore, if it is desired to minimize PORV use and still depressurize the RCS with pressurizer sprays, a new RCP restart criterion (requirement) must be established.

Section 3 of this report will examine the present SONGS SGTR EOPs. Although the SONGS SGTR EOPs are effective in recovering the plant from a SGTR, revisions will be made to the EOPs to incorporate the NRC recommendations on PORV use. To abate PORV use, various RCP restart criteria will be studied to determine which criterion is most effective at SONGS. Finally, once a RCP restart criterion is established, the revisions to the present SGTR EOPs will be outlined.

3.2 APPROACH

To begin, an examination of the present SGTR EOPs would be in order. Once a SONGS SGTR is identified by the plant EOPs, the major action steps include, in this order:

1) Establish pressurizer level
2) Restart RCP(s)
3) Initiate charging flow and terminate safety injection flow
4) Cooldown RCS
5) Depressurize RCS
6) Transition to cold shutdown.

Since the RCPs are tripped upon turbine trip, the first step in preparing for the depressurization of the RCS is to restart the RCPs. The operation of the RCPs will allow the use of the pressurizer spray system to depressurize the RCS; this is the most desirable method of depressurization. Prior to restarting the RCPs, a restart condition must be met in order to assure that the RCPs will not be restarted in a voided RCS. Such a condition could lead to pump damage since the RCPs are not designed to handle high quality flow. In the present SGTR EOPs, the required restart condition is a pressurizer level of 70%; this level is required in order to account for the potential existence of a bubble in the upper head. Establishing a pressurizer level of 70% assures that following RCP restart with a voided upper head region, the pressurizer level will remain on span. To establish this level, and thus have an indication of primary coolant inventory status, a pressurizer PORV is opened. Once the pressurizer level is verified as stable, the RCP(s) which provide maximum pressurizer spray capability may be restarted. Following this cold leg injection, charging flow is initiated and safety injection flow is terminated, whenever possible. Next, cooldown of the RCS is started and the pressurizer sprays are used for RCS depressurization. Eventually, the Residual Heat Removal (RHR) system is placed in service and the transition from cooldown to cold shutdown occurs.

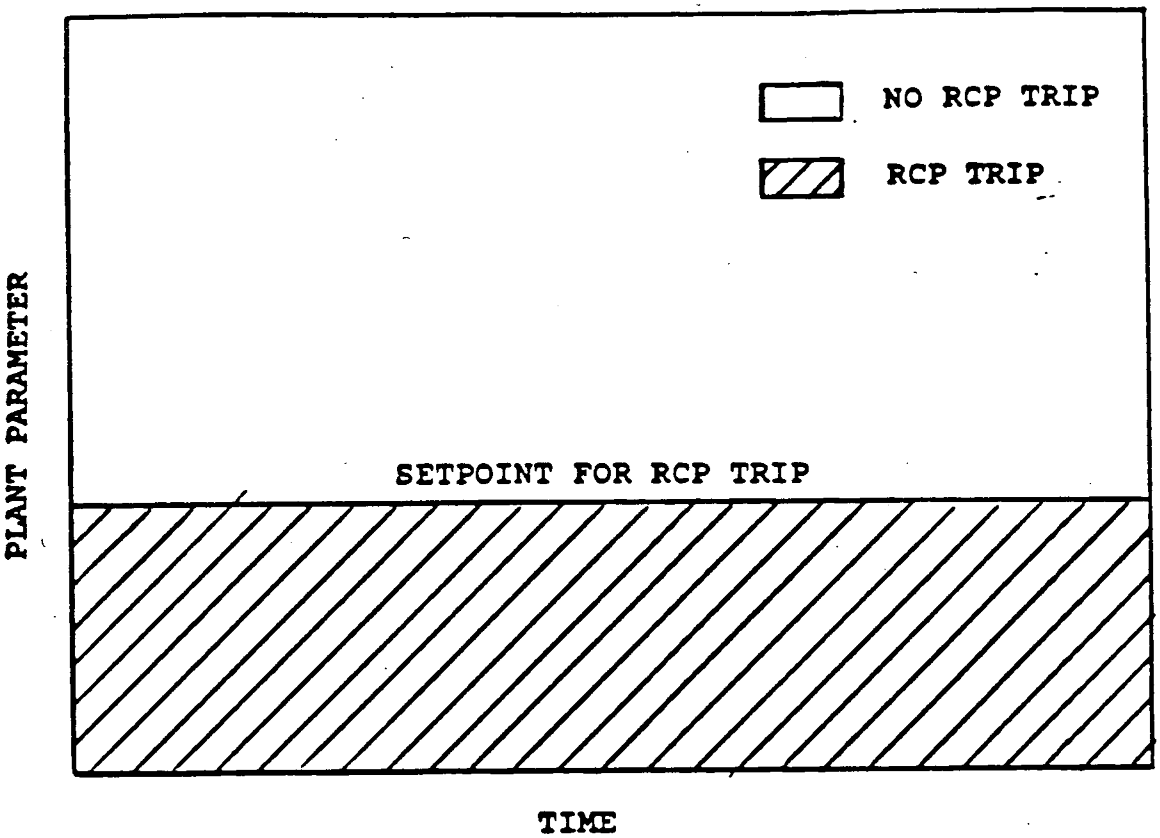
The steps outlined in the preceding paragraph are effective in recovering SONGS from a SGTR. Results presented in a 1982 Westinghouse best estimate analysis (Reference 10) indicated that under various circumstances at SONGS, the SGTR EOPs effectively recovered the plant from a SGTR. This analysis demonstrated that the use of the pressurizer PORVs is effective in establishing pressurizer level (primary coolant inventory status) and if necessary, in depressurizing the RCS. Furthermore, in the event a PORV or both PORVs would fail open, a second Westinghouse study (Reference 8), indicates that due to the high safety injection flow at SONGS, the consequences of such a transient are less severe for SONGS than for a standard 3-loop Westinghouse plant. Specifically, the safety injection would match the volume of water discharged through the PORV(s) creating a stable condition throughout the transient as the system cools down. Finally, the results presented in Section 2 of this report show that in the event of a misdiagnosis of a SBLOCA as a SGTR, the restart and subsequent delayed trip of the RCP(s) would not result in significant PCT increase for any size SBLOCA.

Although the present SGTR EOPs are effective in mitigating the consequences of a tube rupture transient, revisions to the procedure have been proposed. This is done primarily to address the NRC concern of PORV failure identified in Reference 1. To minimize pressurizer PORV use, a revision in the first action step must be made. The RCPs will be restarted earlier using an alternate RCP restart criterion; this alternate criteria is necessary since the pressurizer level necessary for RCP restart may not exist in such a transient. The earlier RCP restart will allow the pressurizer sprays to be available for pressure control as well as establishing pressurizer level earlier without using the pressurizer PORV(s).

Guidelines for the safe restart and operation of the RCPs are also included in Reference 1. Specifically, the RCPs should not be restarted in a voided RCS unless forced core cooling is required (Inadequate Core Cooling conditions), or if following RCP restart the RCS conditions degrade to where RCP trip is required, RCP trip should be assured. Also, there is concern that containment isolation, including inadvertent isolation, may lead to pump damage due to the loss of water services to the RCPs. However, this is not a concern at SONGS since the RCP water services are not terminated upon containment isolation and pump integrity is assured. In addition, Reference 1 indicates a concern about the potential existence of an upper head bubble prior to restart which could create some difficulty for the operators. In response to these concerns, the alternate RCP restart criterion to be used in the revised EOPs will assure that the restart of the RCP(s) does not occur in a highly voided system. Additionally, the SONGS operator training program provides the training necessary for operator action in the event the RCP(s) should be tripped due to operational problems (i.e., excessive vibration, loss of pump seal differential, etc.). This would prevent any unnecessary pump damage. Based on the results of the previous SGTR analysis (Reference 10), the presence of an upper head bubble prior to restart would not be a problem. This is demonstrated by Reference 9 results which show that less than 4% voiding exists in the upper head at the expected time range of RCP restart. For this small amount of voiding, no significant depressurization, loss of subcooling or pressurizer level decrease would occur upon RCP restart. Finally, the earlier restart of the RCP(s) would cause no problem in the unlikely event of a misdiagnosis of a SBLOCA as a SGTR based on the results presented in Section 2 of this report.

The logic used to obtain the alternate RCP restart criterion is presented in a WOG report on alternate RCP trip criteria (Reference 3). This report identifies three potential criteria to evaluate the need for a RCP trip during a plant transient. Using guidelines provided in the report, each plant determines a RCP trip setpoint for each of the three criteria. Then based on plant specific data, each plant must decide which setpoint (criterion) most effectively discriminates between SGTRs and non-LOCAS (transients where RCP operation is beneficial) and LOCAs (transients in which RCP trip is needed). The chosen setpoint should assure RCP trip for all LOCAs that require RCP trip but not result in RCP trip for SGTRs and non-LOCAs. Figure 18 illustrates this concept.

For SONGS, the same methodology is used to determine a RCP trip setpoint. However, since the RCPs are tripped at reactor trip, the setpoint will actually be used as a RCP restart criterion. If the setpoint for RCP trip has not been reached, then the pumps may be restarted. On the other hand, if the RCP trip setpoint is reached indicating a need for RCP trip, then no action would be taken since the RCPs would already be tripped. For SONGS, this setpoint should assure RCP restart for SGTRs and non-LOCAs but not result in RCP restart for all LOCAs. Figure 19 illustrates this concept.



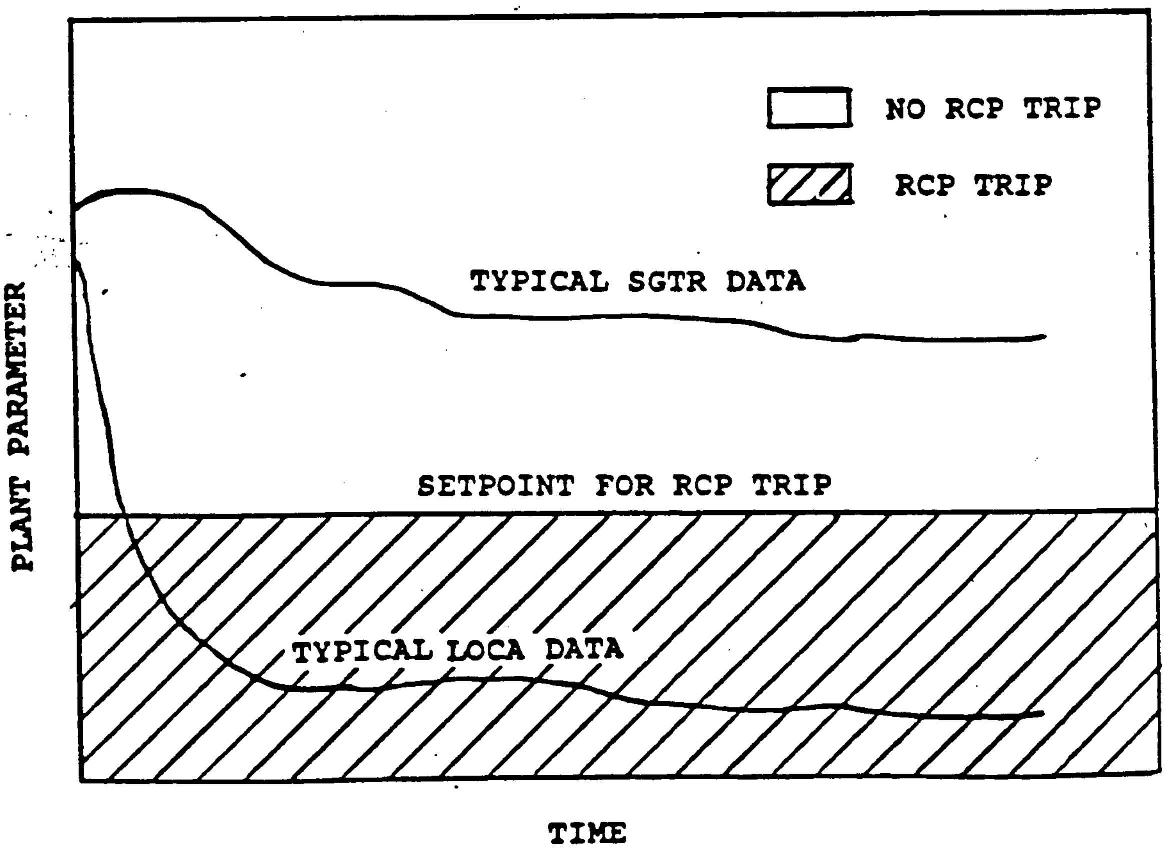
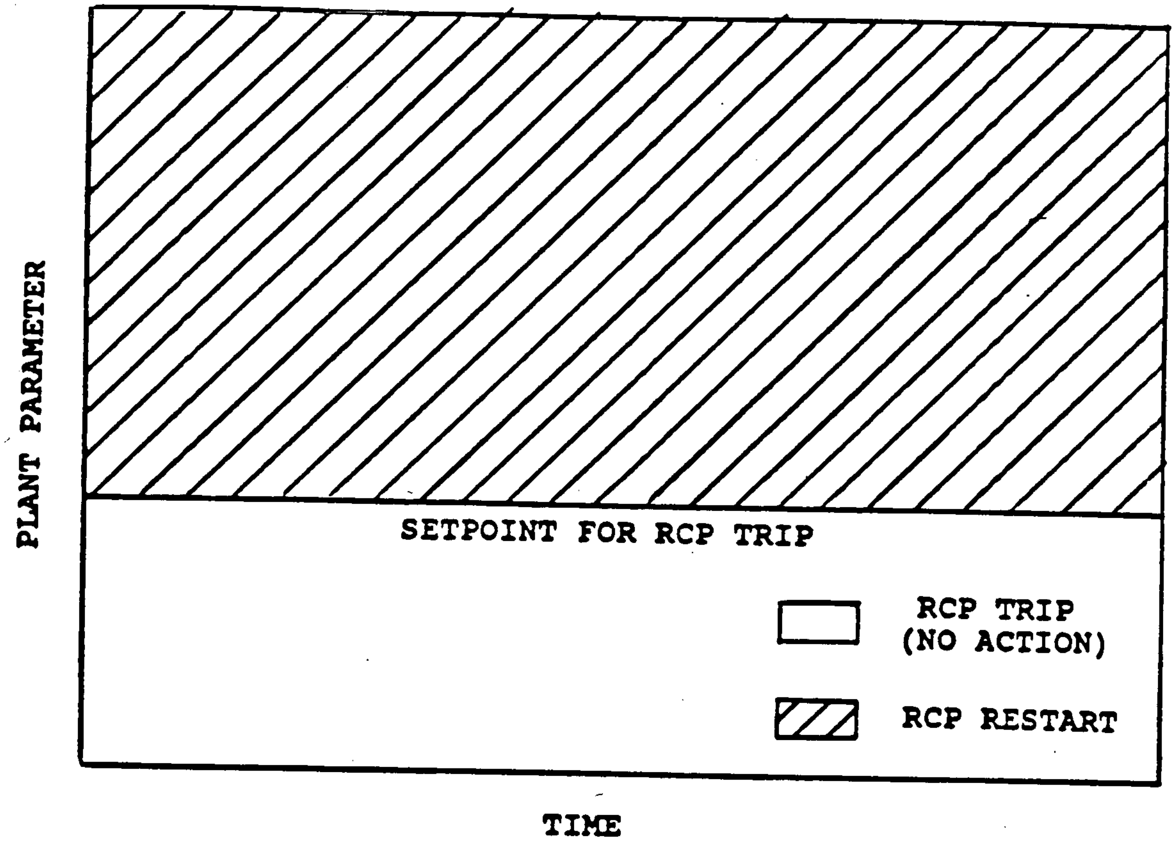


FIGURE 18. RCP TRIP LOGIC



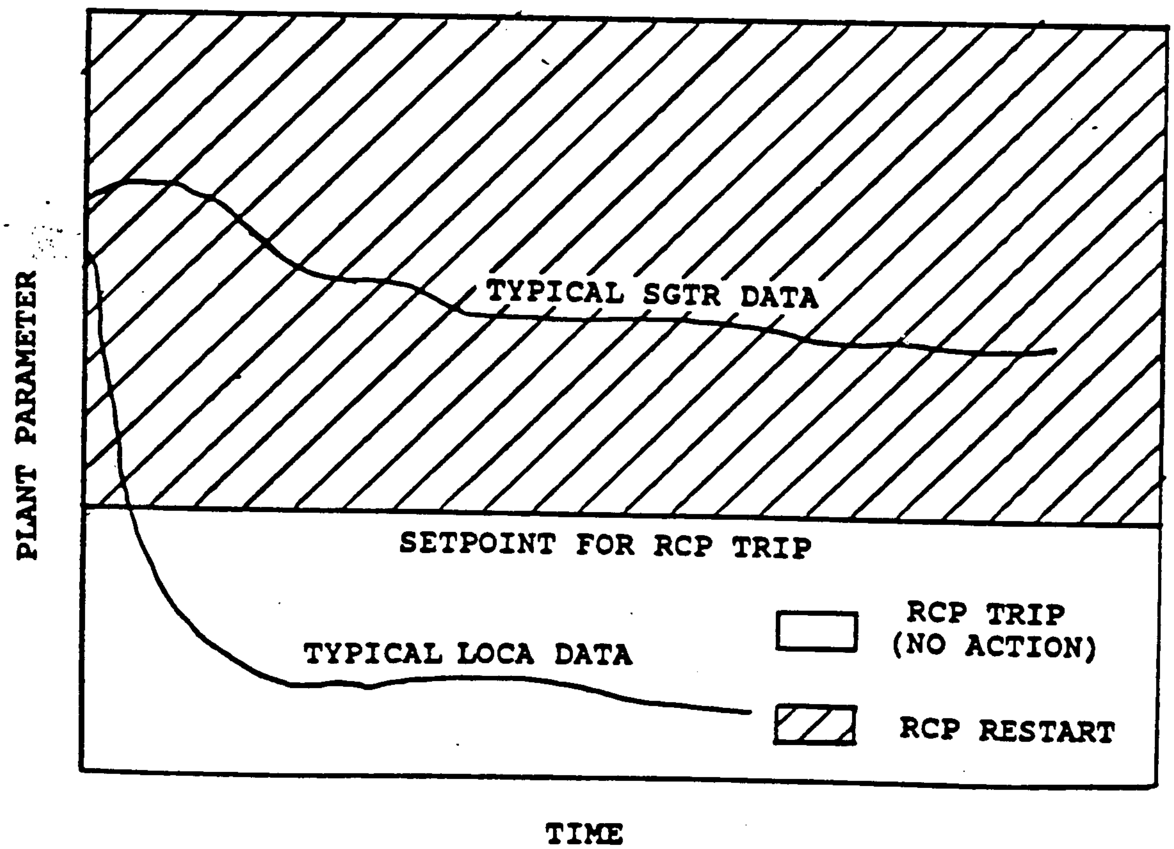


FIGURE 19. RCP RESTART LOGIC

The three alternate criteria referenced in the WOG report are RCS pressure, RCS/secondary pressure differential and RCS subcooling. To minimize PORV use during recovery from a SGTR, one of these criteria will be used as a necessary condition to restart the RCP(s). For SONGS, RCS subcooling has been chosen as the RCP restart criterion. This choice was based on a number of SONGS-specific factors.

To determine which criterion was most suitable to SONGS, data from a SONGS SGTR analysis (Reference 10) was considered. The break area assumed in the analysis considered was conservatively based on the complete severance of a steam generator tube. Otherwise, most probable conditions were assumed for this analysis including offsite power available, RCPs tripped and a saturated cooldown. However, the type of cooldown does not affect the restart evaluation as RCP restart occurs prior to the choice of cooldown mode. The period of time considered important is 10 to 30 minutes, as it is during this time when the RCP restart step is expected to occur. Each criterion was then evaluated relative to the most probable SGTR and SBLOCA results during this time period.

First, RCS pressure was considered as a restart criterion. Figure 20 shows the RCS pressure for the most probable SONGS SGTR along with the RCS pressure for a 3-inch SBLOCA. As can be seen, RCS pressure seems to be effective in discriminating between a SGTR and SBLOCA and warrants consideration as a restart criterion. However, Reference 3 indicates that RCS pressure instrument uncertainty must be added to this setpoint. Based on the current SONGS EOPs, the uncertainties assuming adverse containment conditions are conservatively applied to all setpoints. When the adverse containment uncertainty for RCS pressure is included, the RCS pressure setpoint was no longer able to discriminate, as can be seen in Figure 20. Thus RCS pressure is eliminated as a useful restart criterion at this time.

The second criterion considered was the RCS/secondary pressure differential. Figure 21 shows the RCS/secondary pressure differences for a 3-inch SBLOCA and most probable SGTR. As can be observed, the pressure differentials from 600 to 900 seconds for the two cases are somewhat similar, thus discrimination between a SBLOCA and a SGTR with this setpoint would be questionable in this

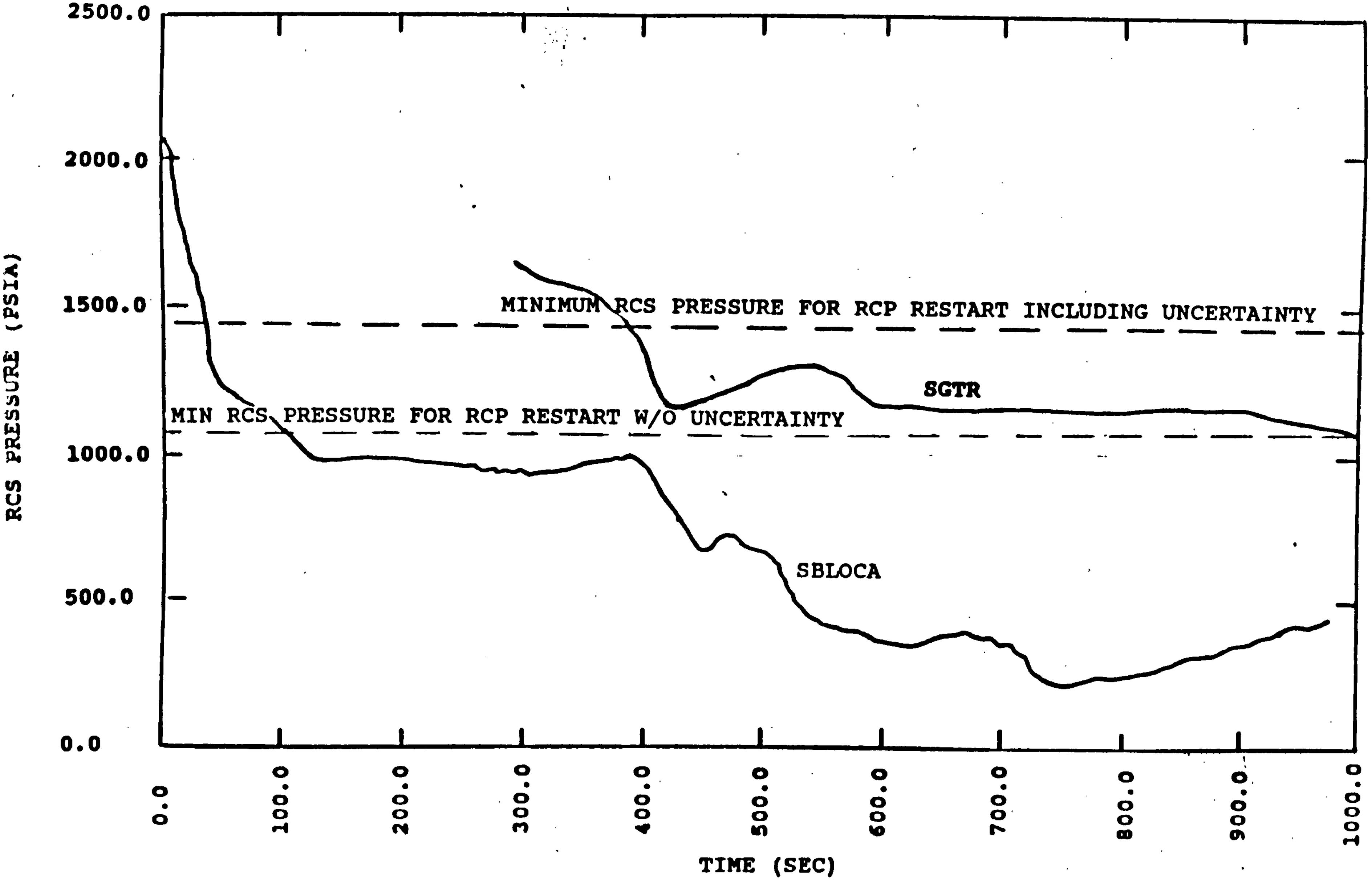


FIGURE 20. RCS PRESSURE FOR A SONGS 3-INCH SBLOCA AND MOST PROBABLE SGTR

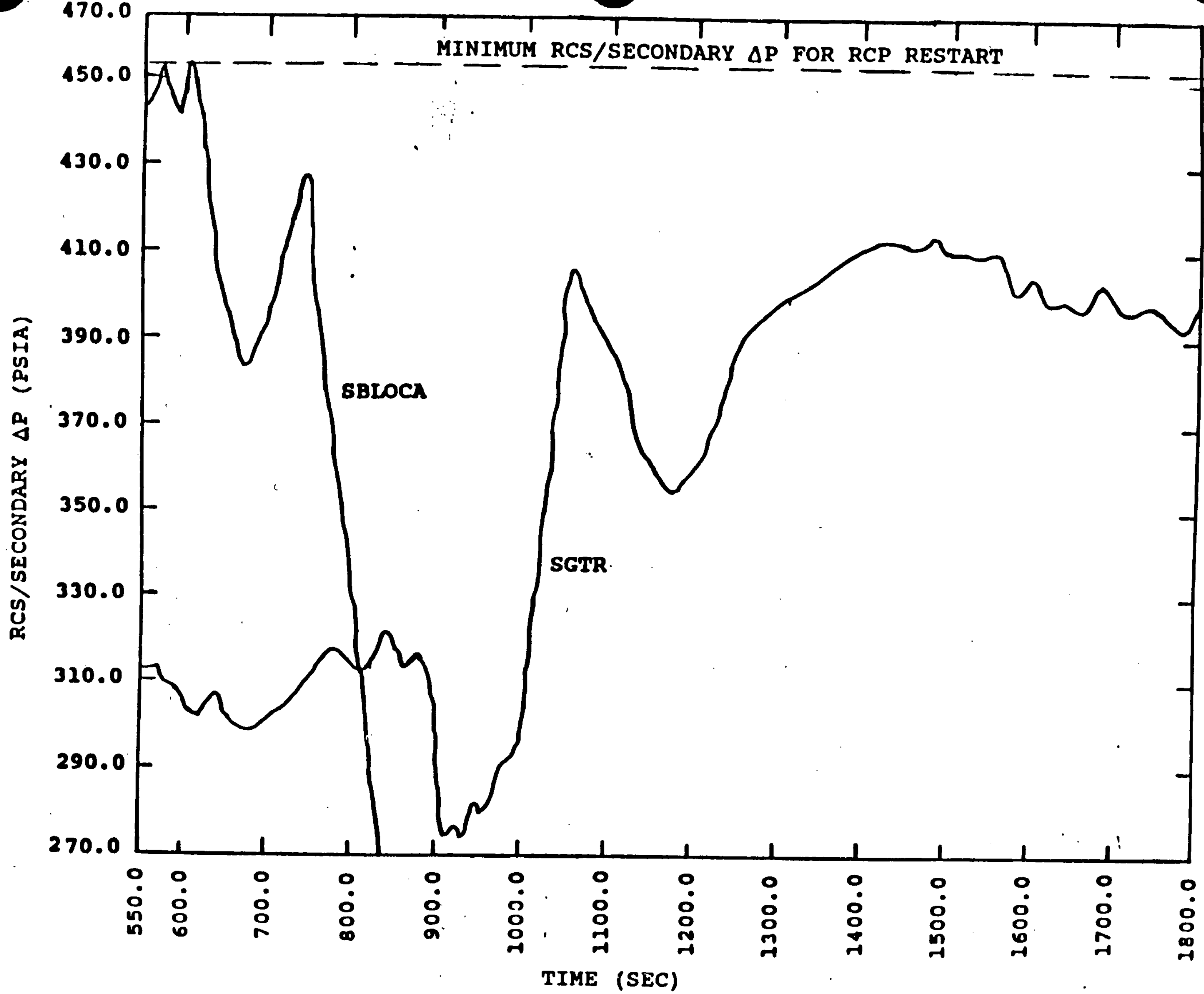


FIGURE 21. RCS/SECONDARY ΔP FOR A SONGS 3-INCH SBLOCA AND MOST PROBABLE SGTR

time range. Furthermore, as with the previous criterion, pressure instrumentation uncertainty for adverse containment must be applied to the pressure differential setpoint. The setpoint including this uncertainty is also included in Figure 21. As with the RCS pressure criterion, this setpoint would keep the pumps tripped for a SGTR, an undesirable situation. For these reasons, the RCS/secondary pressure difference criterion for RCP restart will not be used.

Finally, RCS subcooling was considered. According to Reference 3, 0°F subcooling in the hot leg is required for RCP trip. Again, instrument uncertainty for adverse containment must be applied to this setpoint. However, the subcooling instrument uncertainty are approximately the same for both normal and adverse containment conditions according to Reference 11. Specifically for SONGS, the uncertainty associated with subcooling is no greater than 19°F for RCS pressures above 655 psia. This pressure is chosen since Reference 10 results show that the RCS pressure of 655 psia (which includes adverse containment uncertainty) is the limiting pressure for SGTRs and non-LOCAs during the RCP restart time range. Therefore, a subcooling margin of 19°F or less indicates the need for RCP trip. Conversely, a subcooling margin of greater than 19°F would allow RCP restart. Results from the most probable SGTR indicate that this restart criterion is met 100% of the time in the 10-30 minute time range. Figure 22 shows the subcooling for a most probable SGTR and a 3-inch SBLOCA at SONGS. As can be seen, the subcooling margin for the 3-inch SBLOCA is below the setpoint except for a few peaks caused by slugs of cold safety injection water flowing through the RCS. Thus, subcooling would provide excellent discrimination capability between a SGTR and SBLOCA. Additionally, the subcooling margin for the most probable SGTR case is conservative because safety injection flow was terminated in this specific analysis at 1016 seconds. The operators should also note that the RCS pressure for a SBLOCA will fall below 655 psia by 10 minutes therefore increasing the subcooling instrument uncertainty to greater than 19°F.

Because of these factors, subcooling has been incorporated into the SONGS SGTR EOPs as the RCP restart criterion. It is expected that during a SGTR, SONGS would always have this margin of subcooling available prior to RCP restart as long as safety injection was operating. Provided that the subcooling

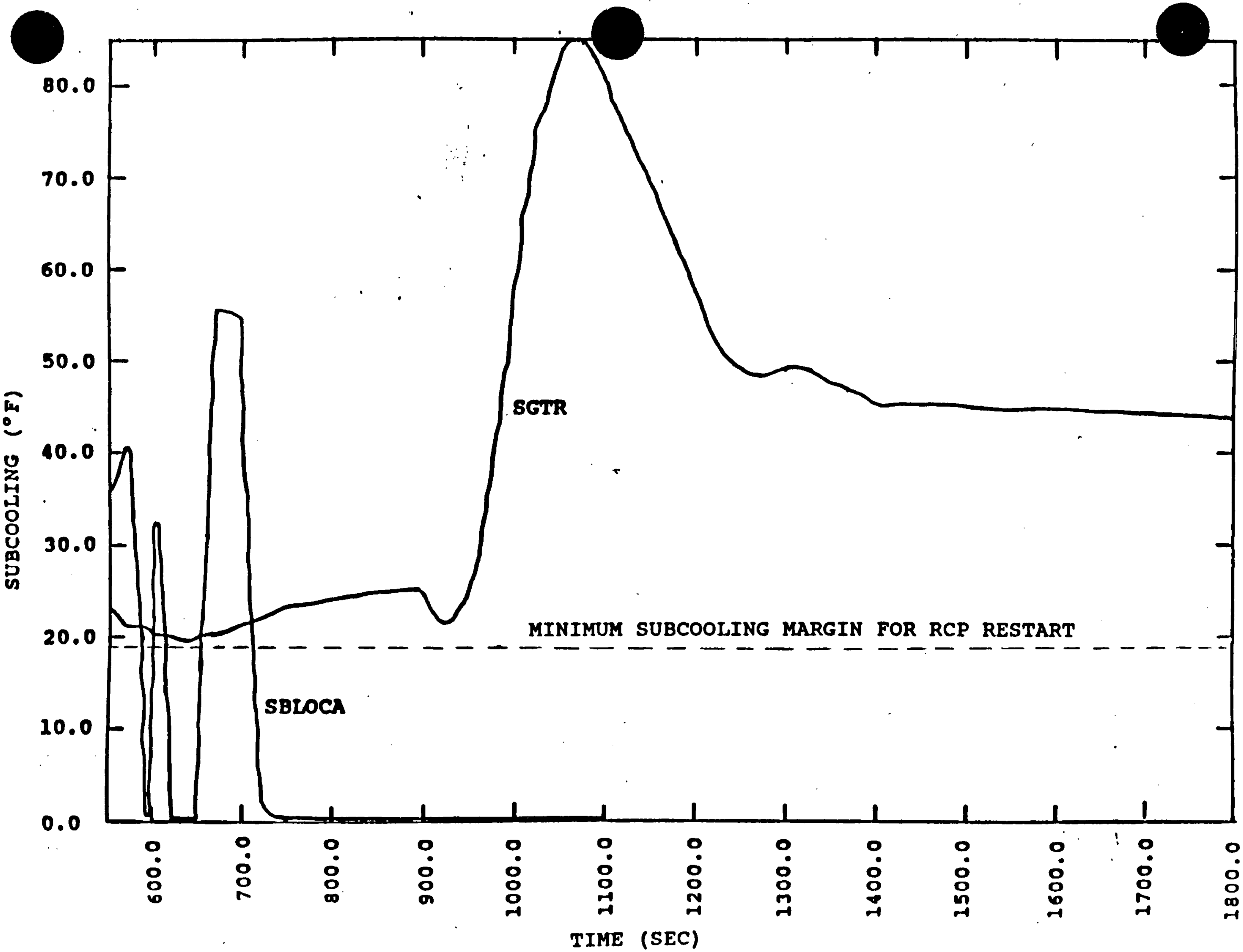


FIGURE 22. SUBCOOLING FOR A SONGS 3-INCH SBLOCA AND MOST PROBABLE SGTR

criterion is met, there is no danger of RCP restart in a voided system and pump cavitation will be avoided. Once RCP restart is accomplished, the pressurizer sprays can be used to establish pressurizer level and to depressurize the primary system, thus averting PORV use.

Once depressurization is underway, the remaining recovery actions would remain identical to the present steps. The only revision would be prior to depressurization, with the earlier restart of the RCPs through the use of the subcooling RCP restart criterion.

3.3 SGTR EOP REVISION

This section will discuss the specific revisions to the SONGS SGTR EOPs. Appendix C contains a copy of the SGTR EOPs with the specific revisions noted.

The first ten steps of the procedure remain the same, as these steps are basically to identify the ruptured steam generator and insure proper operation of all equipment necessary for recovery. However, beginning with the step to establish pressurizer level, revisions are necessary to preclude PORV use. In the current Step 11, if the pressurizer level is less than 70%, a PORV is opened to establish the level at 70%. Once pressurizer level is verified stable at 70%, RCP restart is directed to aid in the subsequent depressurization of the RCS. To minimize PORV use in Step 11, a check of RCS (hot leg) subcooling is implemented in the revised Step 11. If subcooling instrumentation indicates a subcooling margin greater than 19°F, the next step is to restart the RCP which maximizes the pressurizer spray performance. If this RCP cannot be started, then the EOPs recommend the restart of the other two pumps, since these two pumps are needed to adequately supply the pressurizer sprays.

Once RCP restart is accomplished, the pressurizer sprays can then be used to establish pressurizer level and depressurize the RCS. This is the basis for the revised Step 12. The sprays will be used to establish a stable pressurizer level at no greater than 50%. The level is decreased from the previous 70% to 50% here because in the previous procedure an additional 20% was incorporated to the pressurizer level setpoint to account for the possible existence of a bubble in upper head prior to RCP restart. In the revised procedure, no additional margin is necessary because RCP restart would have collapsed any voiding in the upper head, thus eliminating this concern. Once the level is established, the pressurizer heaters are energized to create saturation conditions in the pressurizer. This occurs in the revised Step 13. Following this step, recovery is identical to the previous SGTR EOPs and the operations needed to carry out the remaining action steps remain exactly the same.

The preceeding discussion assumes all expected responses are obtained. If the responses are not obtained, the EOPs can still recover the plant from a SGTR. If the subcooling criterion is not met in Step 11, the procedures move ahead to Step 14 and begin the third major action step - initiation of charging flow and termination of safety injection flow. This is similar to the original EOPs and results from Reference 10 indicate that such a recovery (without RCPs operational) is effective for SONGS. Furthermore, in the unlikely event that RCP restart would not be possible due to some other difficulty, recovery would ensue using PORVs instead of normal spray for establishing pressurizer level and depressurizing the RCS. This type of recovery is also effective based on Reference 10 results. Additionally, as an extra effort to utilize the pressurizer sprays instead of the pressurizer PORVs, the procedures recommend returning to Step 11 and attempting RCP restart if the subcooling restart criterion is met later in the procedure. In this way, the pressurizer sprays are the primary choice for depressurization of the RCS. This precludes the need for PORV use unless the sprays would not be available for depressurization.

3.4 SGTR SUMMARY

Based on Reference 1, the SONGS SGTR EOPs have been revised to minimize the use of the pressurizer PORVs while providing RCP operation during the recovery from a SGTR. Although the previous tube rupture procedure is safe and effective, changes were made to address the NRC recommendations on PORV use. The revisions are provided in Appendix C.

Essentially, the revision consists of an earlier RCP restart based on a newly defined RCP restart criterion. Because of the unique design at SONGS (automatic RCP coastdown and trip), RCP restart as soon as possible and continued operation of the RCP(s) would be beneficial for SGTR and non-LOCA recoveries (See Section 2.1). Other additional advantages of earlier RCP restart for SONGS SGTRs (and non-LOCAs) are discussed in Section 3.2. The new RCP restart criterion used in the revised procedures is effective in precluding the restart of the pumps in a voided RCS, thus assuring the safe restart and operation of the RCPs. Also, the potential misdiagnosis of a SBLOCA as a SGTR is inconsequential due to the favorable results obtained in the SBLOCA analyses, presented in Sections 2.4 - 2.6. Any RCP restart accompanied by a delayed RCP trip would result in PCTs no higher than 868°F.

The new SGTR EOPs eliminate the use of the pressurizer PORVs except in the event pressurizer sprays could not be used for depressurization, an unlikely occurrence. This directly addresses the recommendations set for PORV use in Reference 1. Finally, the revised SONGS SGTR EOPs can effectively recover the plant from any SGTR.

4. CONCLUSION

This report is provided as support for SONGS with regards to Reference 1 recommendations. Reference 1 has identified potential problems with RCP trip during SBLOCAs. Specifically for SONGS the issues are:

1. Delayed RCP trip during a SBLOCA and the subsequent loss of RCS inventory
2. Potential PORV failure.

This first issue could occur due to the misdiagnosis of a SBLOCA as a SGTR and the subsequent restart and delayed trip of the RCP(s). The second issue, PORV failure, could occur for any transient where the PORVs would be utilized for RCS pressure control due to loss of pressurizer sprays. The most likely instance for PORV use would be a SGTR event.

To address the first issue, Westinghouse completed a SBLOCA analysis for SONGS to determine the specific effects of delayed RCP trip times for different size SBLOCAs at SONGS. The results of this analysis indicated that the results of delayed RCP trip at SONGS for any size SBLOCA was more favorable than the equivalent size break compared to the standard Westinghouse 3-loop plant. This was due to the large pumped safety injection flow capability at SONGS. Essentially, it was shown that there is no delayed RCP trip time for SBLOCAs at SONGS that would cause a PCT above 868°F.

The NRC in Reference 1 recommends the preclusion of PORV use if at all possible due to the propensity for failure of these valves. Because SONGS used the pressurizer PORVs in their SGTR EOPs, revisions were necessary to address the recommendations of Reference 1. To abate PORV use, a subcooling criteria was incorporated in the SGTR EOPs as a RCP restart criterion. This minimizes the opening of the PORV(s) which was previously used to establish the RCP restart criterion of pressurizer level. This new criterion also allows the benefit of an earlier RCP restart for SGTRs and non-LOCAs, thus providing the pressurizer sprays as the primary mode of recovery (i.e., establishing pressurizer level, depressurization). Additionally, results of the SBLOCA analysis indicate that the RCP restart time and/or RCP trip time would be inconsequential in the event of a misdiagnosis of a SBLOCA as a SGTR.

As a result of this analysis, it was concluded that for any SBLOCA with delayed RCP trip, adequate core cooling is provided for SONGS. In addition, as a result of proposed revisions to the SONGS SGTR EOPs, the PORV(s) will be used only as a secondary SGTR recovery technique and this EOP revision will provide the benefit of an earlier RCP restart for SGTR recovery. It is concluded that these analyses appropriately address the plant specific Reference 1 concerns for SONGS.

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5. Letter from D. M. Crutchfield (NRC) to R. Dietch (SCE), June 9, 1981; Subject: IE Bulletin 79-06C, Item 1, Automatic Trip of Reactor Coolant Pumps, San Onofre Unit 1.

6. Esposito, V., et. al., "WFLASH-A FORTRAN IV Computer Program for Simulation of Transients in a Multi-loop PWR," WCAP-8261 Rev. 1, (Non-Proprietary), July 1974, WCAP-8200 Rev. 2, (Proprietary), July 1974.

7. Bordelon, F. M., et. al., "LOCTA IV Program: Loss-of-Coolant Transient Analysis," WCAP-8301, (Proprietary), WCAP-8305, (Non-Proprietary), June 1974.

8. Gresham, J., "Study of Small Loss of Coolant Accidents for the San Onofre Nuclear Generating Station, Unit 1," Westinghouse Electric Corporation, Letter TMI-06-167, March 12, 1980.

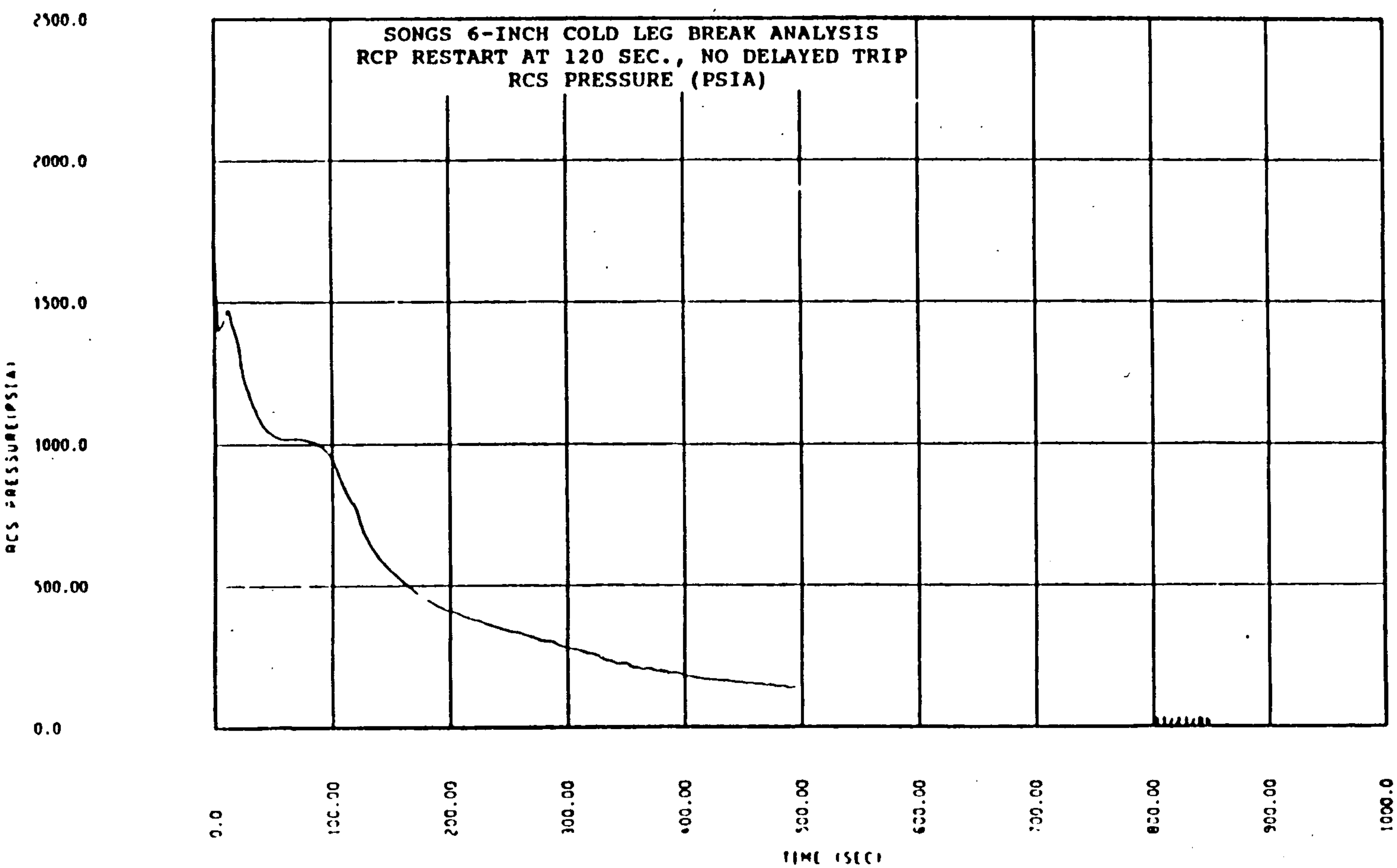
9. EOI Validation Run Number 6A, Zion Simulator, July 10, 1984.

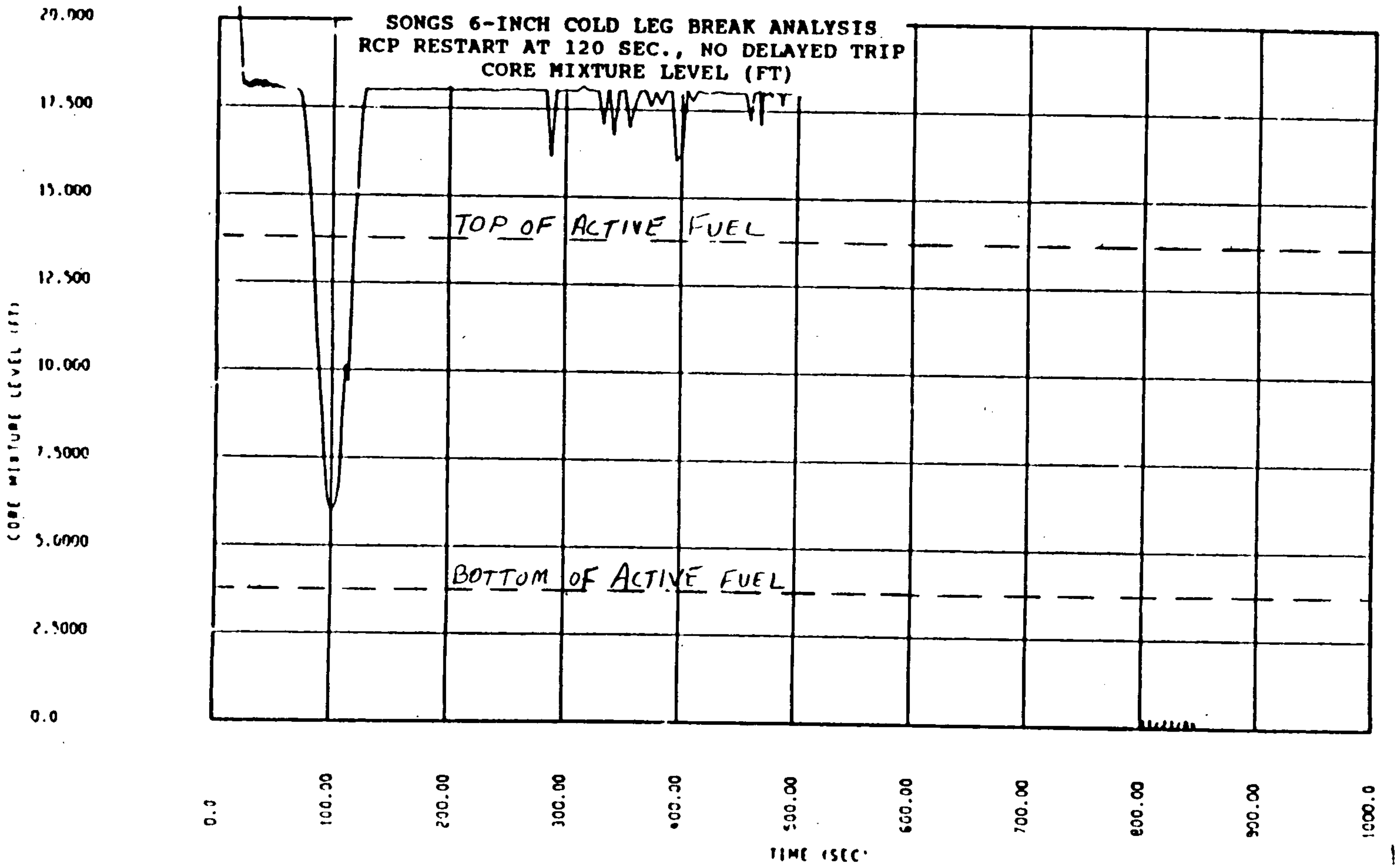
10. Davenport, K. G., "Steam Generator Tube Rupture Analysis," Westinghouse Electric Corporation, Letter SCE-82-557, July 27, 1982.

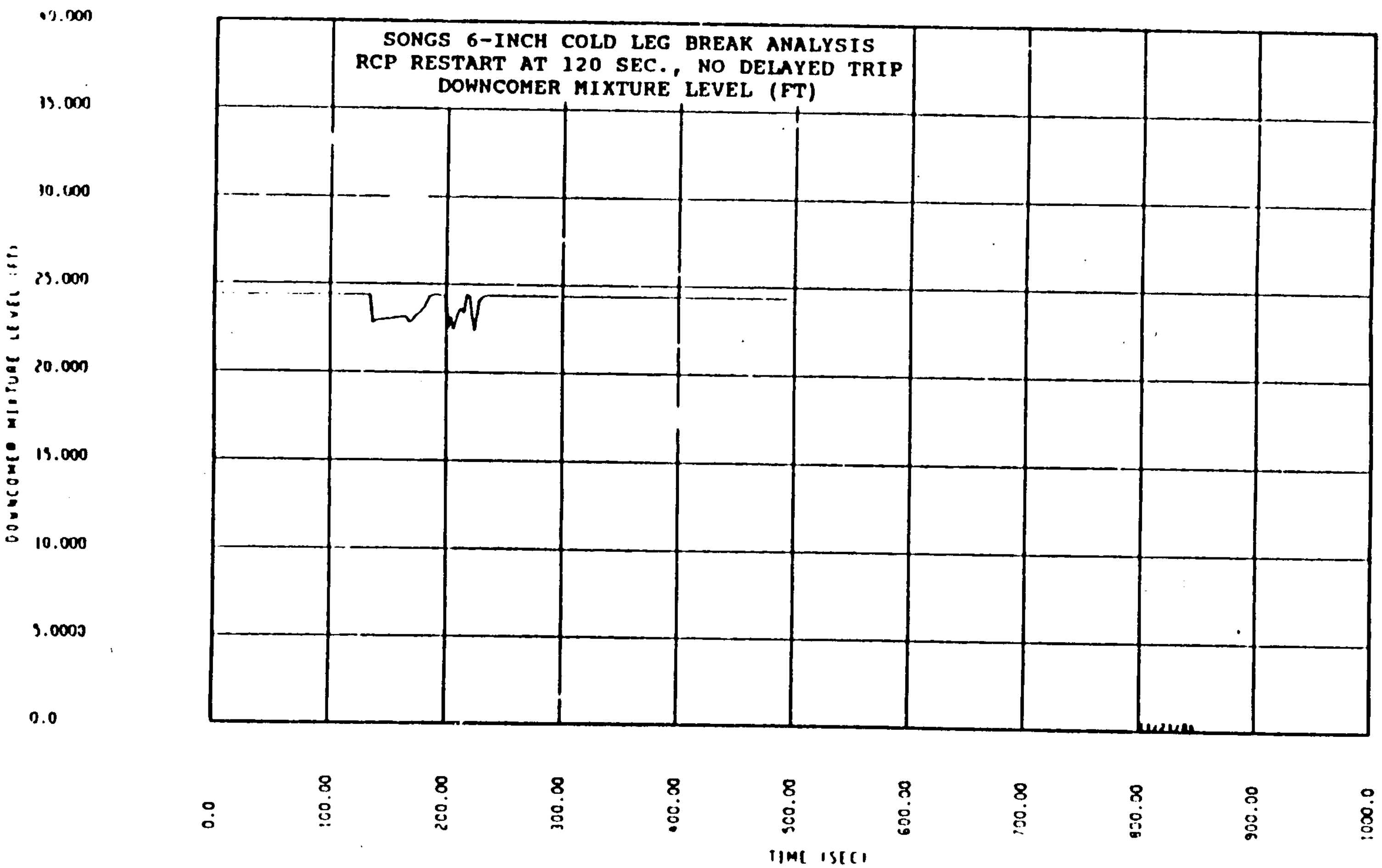
11. Letter from K. P. Baskin (SCE) to D. M. Crutchfield (NRC), April 2, 1982; Subject: NUREG-0737, II.F.2 - Instrumentation for Detection of Inadequate Core Cooling, Subcooling Monitoring System, San Onofre Nuclear Generating Station, Unit 1.

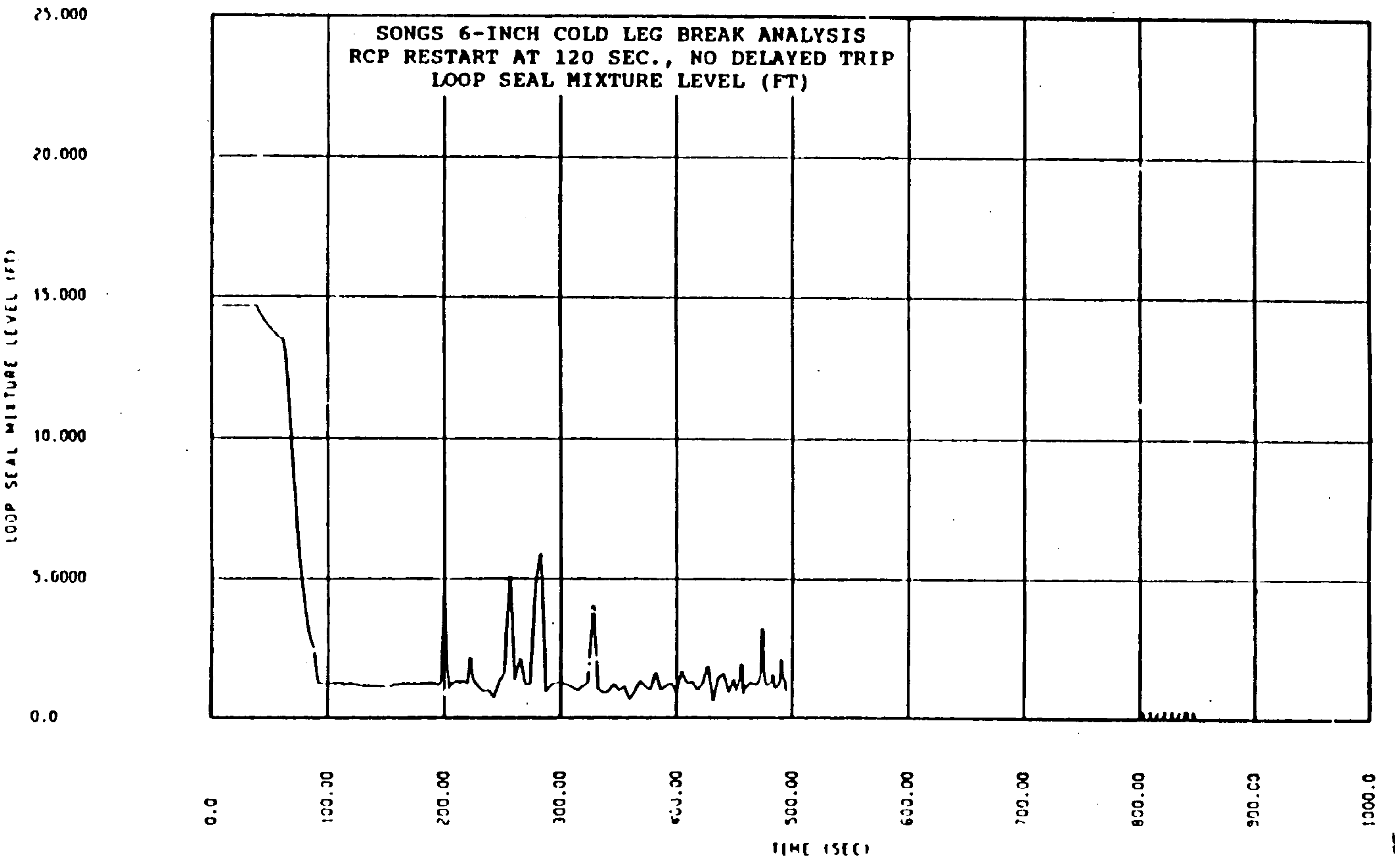
APPENDIX A

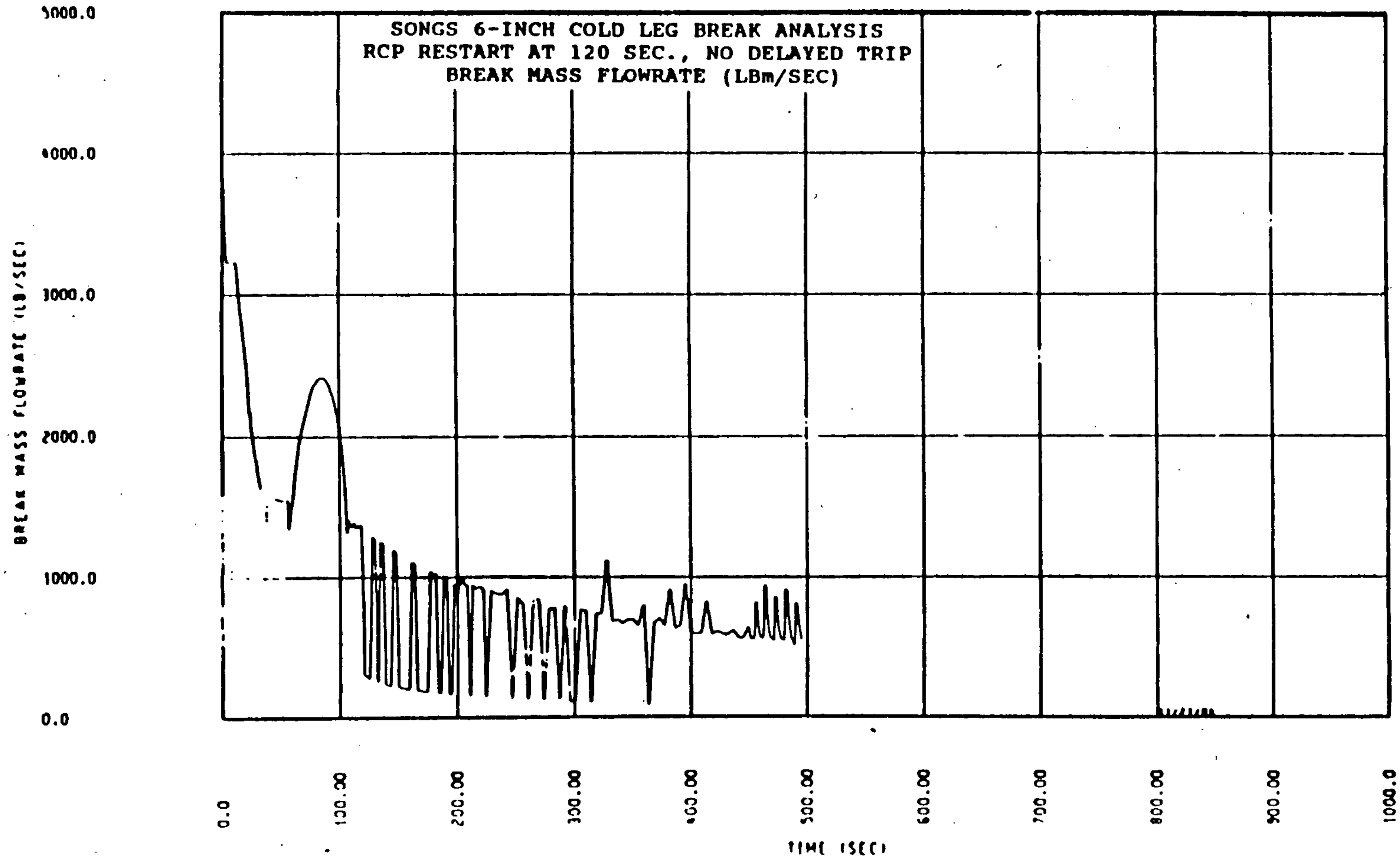
6-INCH SBLOCA FIGURES

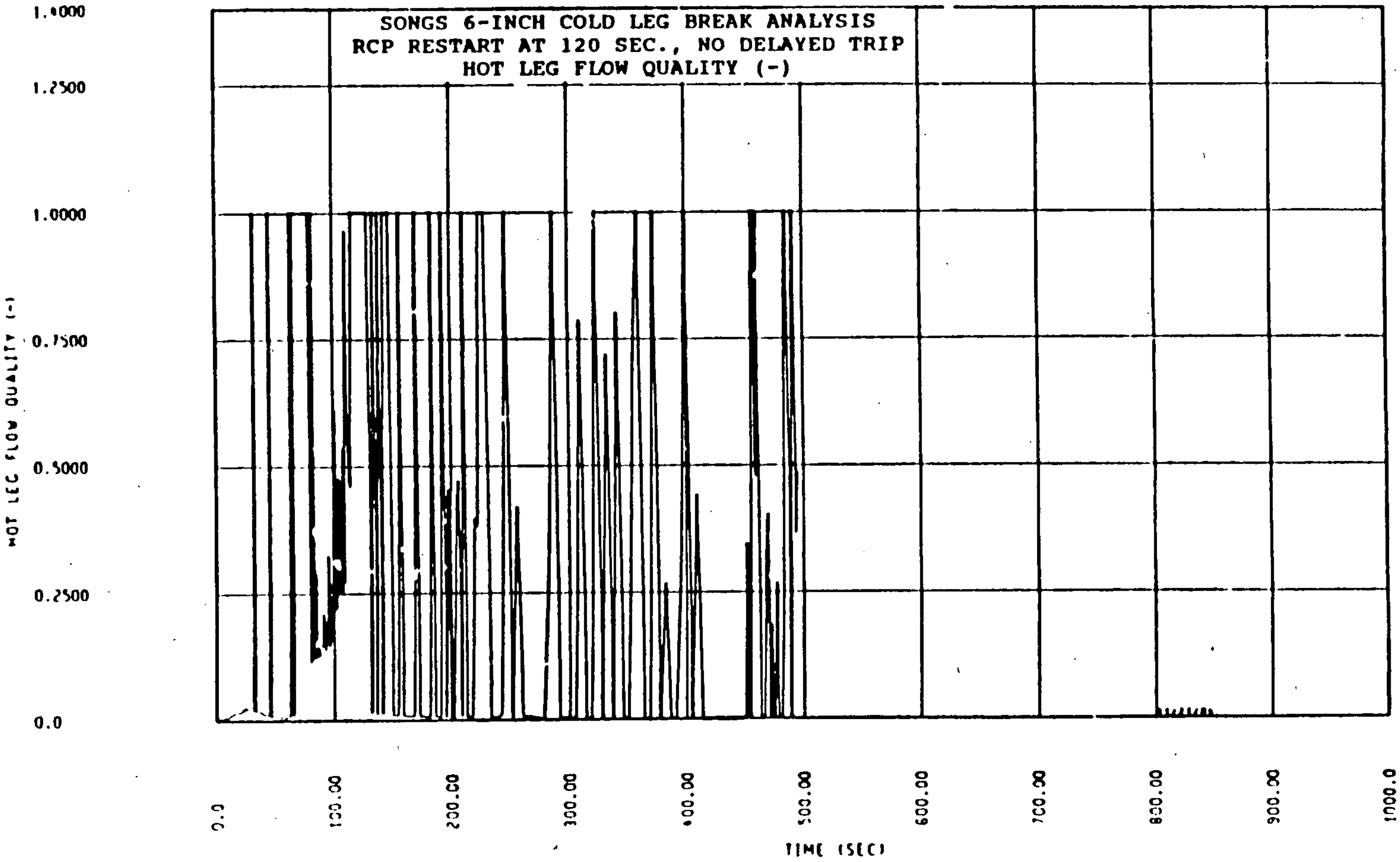

SONGS 6-INCH COLD LEG BREAK ANALYSIS
RCP RESTART AT 120 SEC., NO DELAYED TRIP
RCS PRESSURE (PSIA)
2500.0
2000.0
1500.0
1000.0
500.00
0.0
RCS PRESSURE(PSIA)
0.0
100.00
200.00
300.00
400.00
500.00
600.00
700.00
800.00
900.00
1000.0
TIME (SEC)

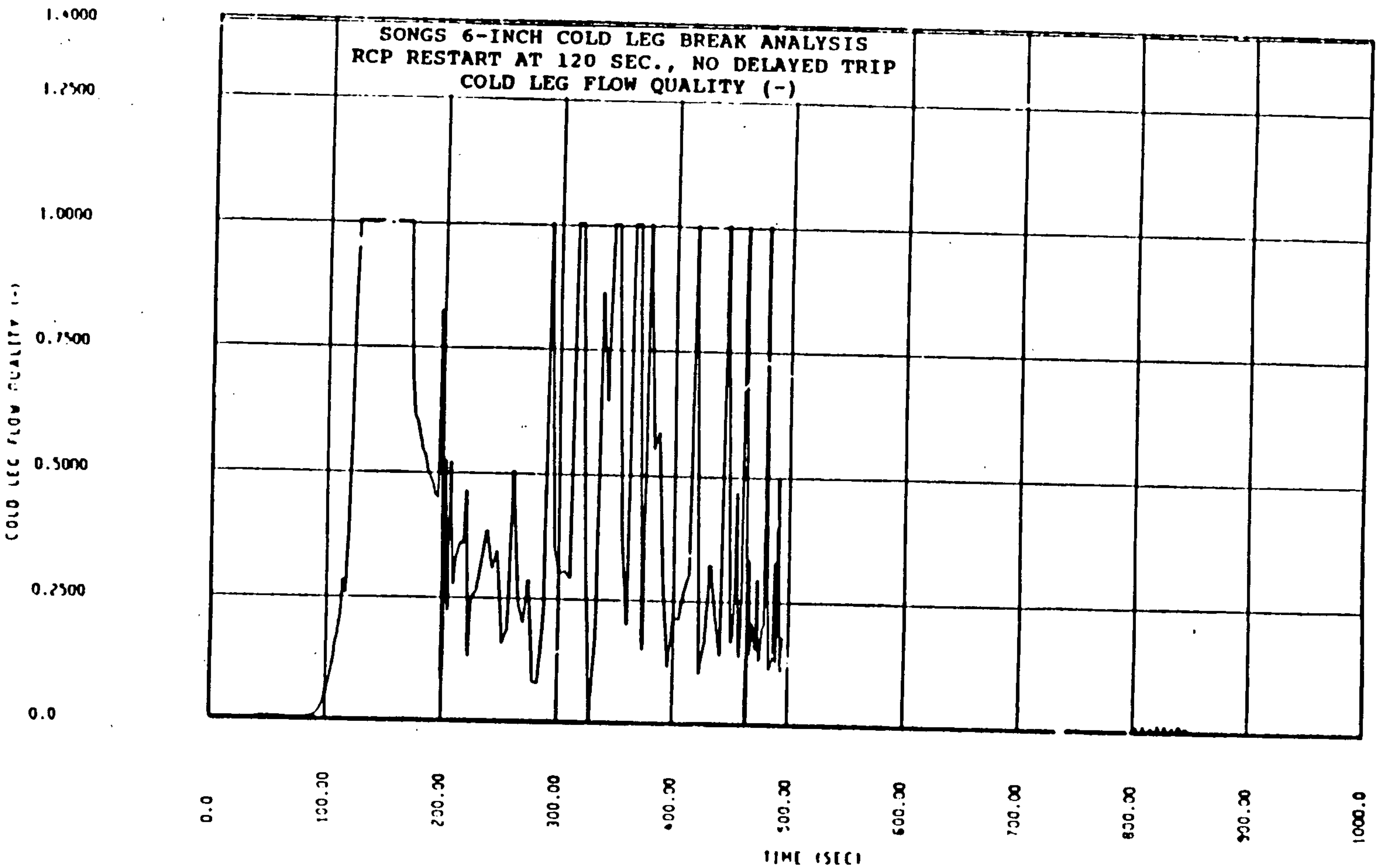

SONGS 6-INCH COLD LEG BREAK ANALYSIS
RCP RESTART AT 120 SEC., NO DELAYED TRIP
CORE MIXTURE LEVEL (FT)
TOP OF ACTIVE FUEL
BOTTOM OF ACTIVE FUEL
CORE MIXTURE LEVEL (FT)
20.000
17.500
15.000
12.500
10.000
7.5000
5.0000
2.5000
0.0
TIME (SEC)
0.0
100.00
200.00
300.00
400.00
500.00
600.00
700.00
800.00
900.00
1000.0

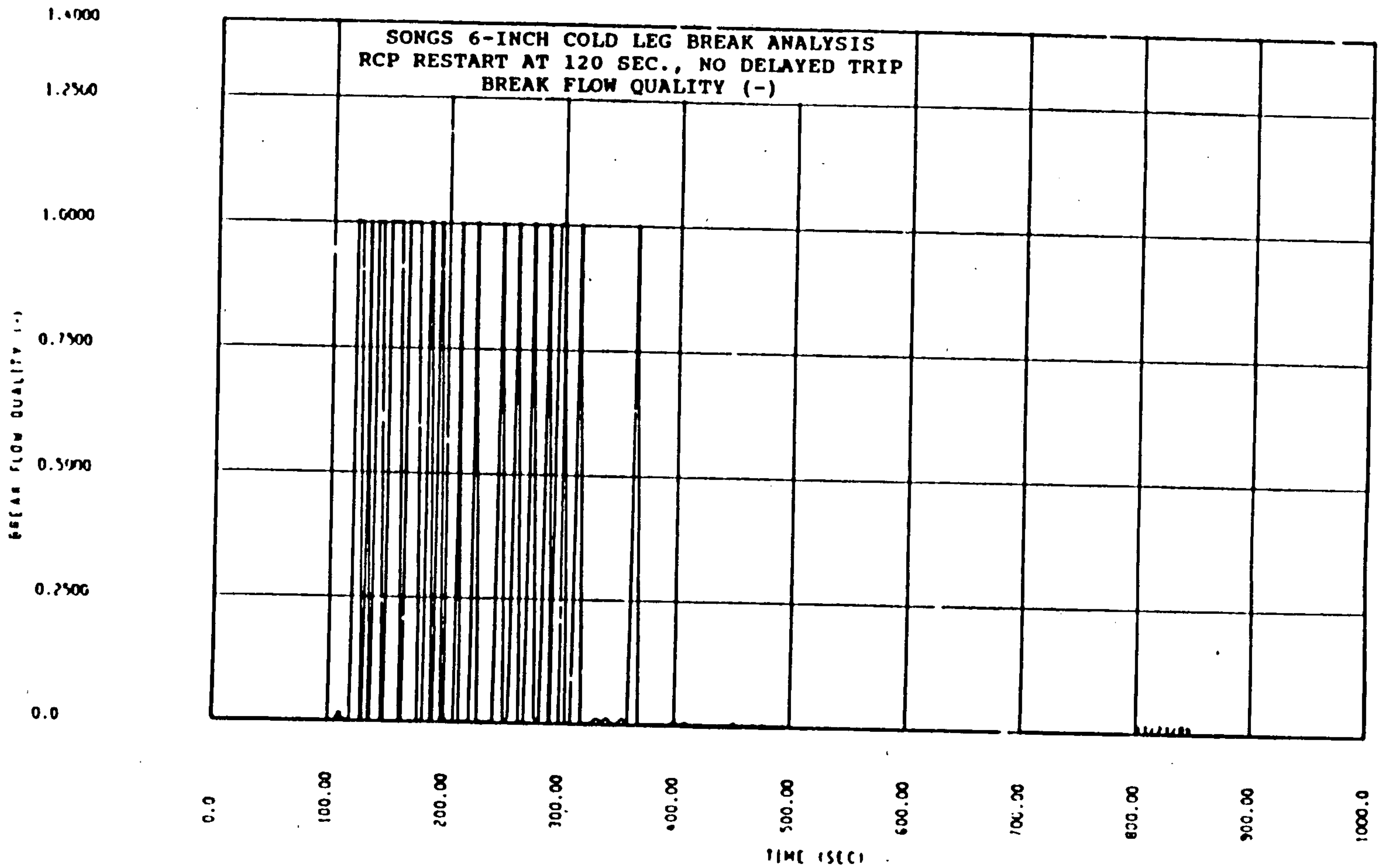

SONGS 6-INCH COLD LEG BREAK ANALYSIS
RCP RESTART AT 120 SEC., NO DELAYED TRIP
DOWNCOMER MIXTURE LEVEL (FT)
35.000
30.000
25.000
20.000
15.000
10.000
5.0000
0.0
100.00
200.00
300.00
400.00
500.00
600.00
700.00
800.00
900.00
1000.0
TIME (SEC)

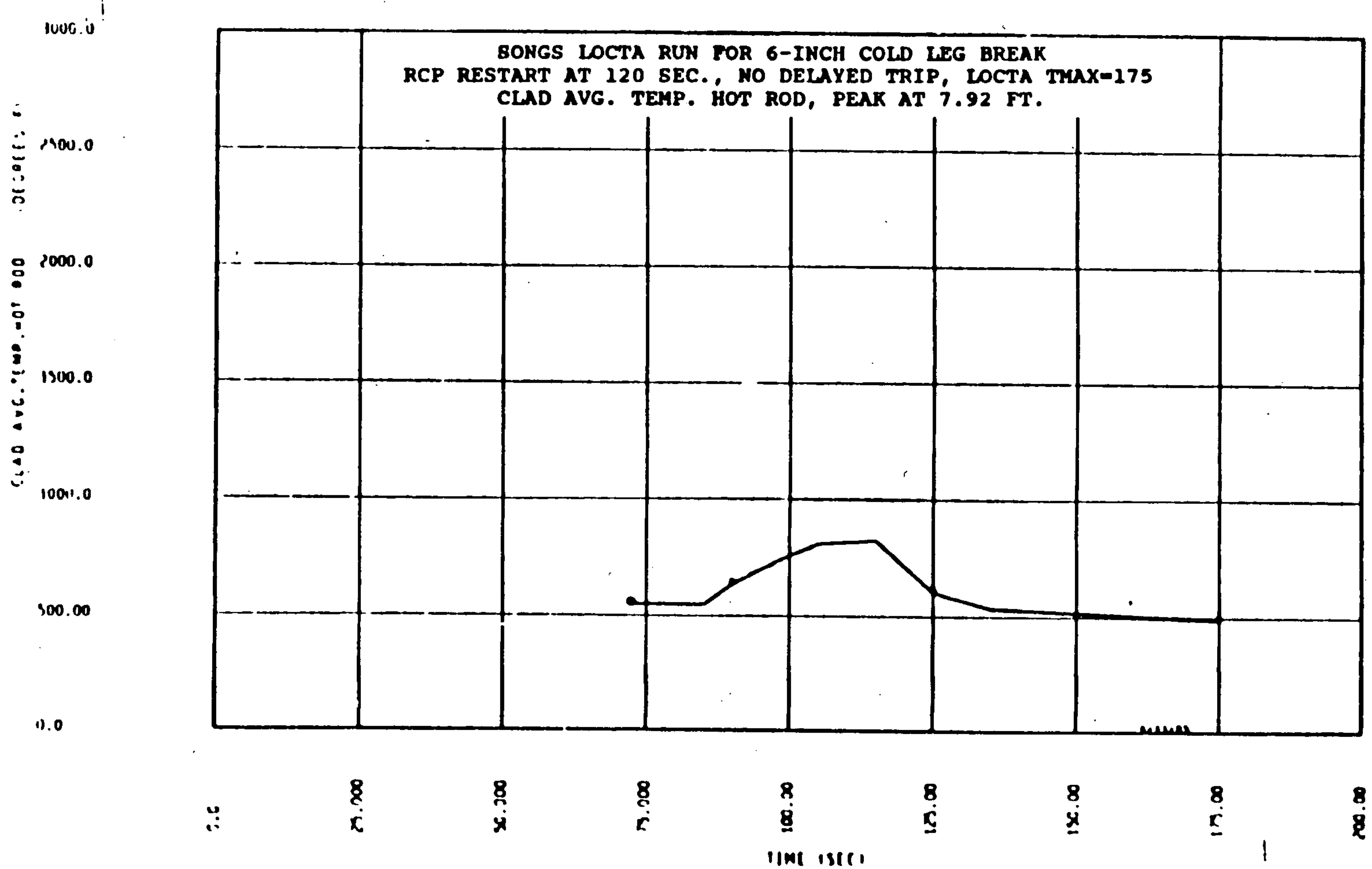

SONGS 6-INCH COLD LEG BREAK ANALYSIS
RCP RESTART AT 120 SEC., NO DELAYED TRIP
LOOP SEAL MIXTURE LEVEL (FT)
LOOP SEAL MIXTURE LEVEL (FT)
25.000
20.000
15.000
10.000
5.0000
0.0
0.0
100.00
200.00
300.00
400.00
500.00
600.00
700.00
800.00
900.00
1000.0
TIME (SEC)


SONGS 6-INCH COLD LEG BREAK ANALYSIS
RCP RESTART AT 120 SEC., NO DELAYED TRIP
BREAK MASS FLOWRATE (LBm/SEC)
5000.0
4000.0
3000.0
2000.0
1000.0
0.0
BREAK MASS FLOWRATE (LB/SEC)
0.0
100.00
200.00
300.00
400.00
500.00
600.00
700.00
800.00
900.00
1000.0
TIME (SEC)

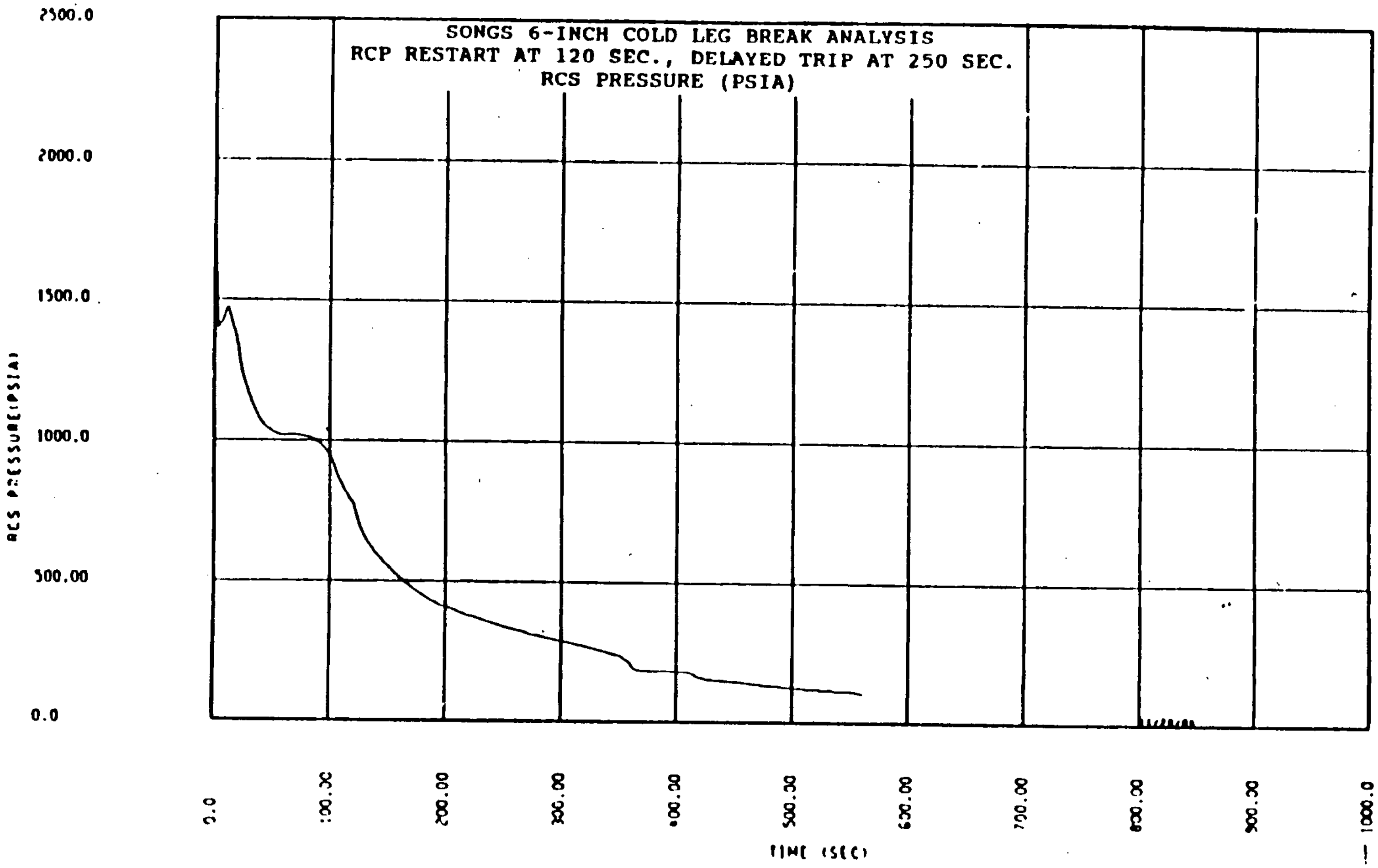

SONGS 6-INCH COLD LEG BREAK ANALYSIS
RCP RESTART AT 120 SEC., NO DELAYED TRIP
HOT LEG FLOW QUALITY (-)
HOT LEG FLOW QUALITY (-)
1.4000
1.2500
1.0000
0.7500
0.5000
0.2500
0.0
0.0
100.00
200.00
300.00
400.00
500.00
600.00
700.00
800.00
900.00
1000.0
TIME (SEC)

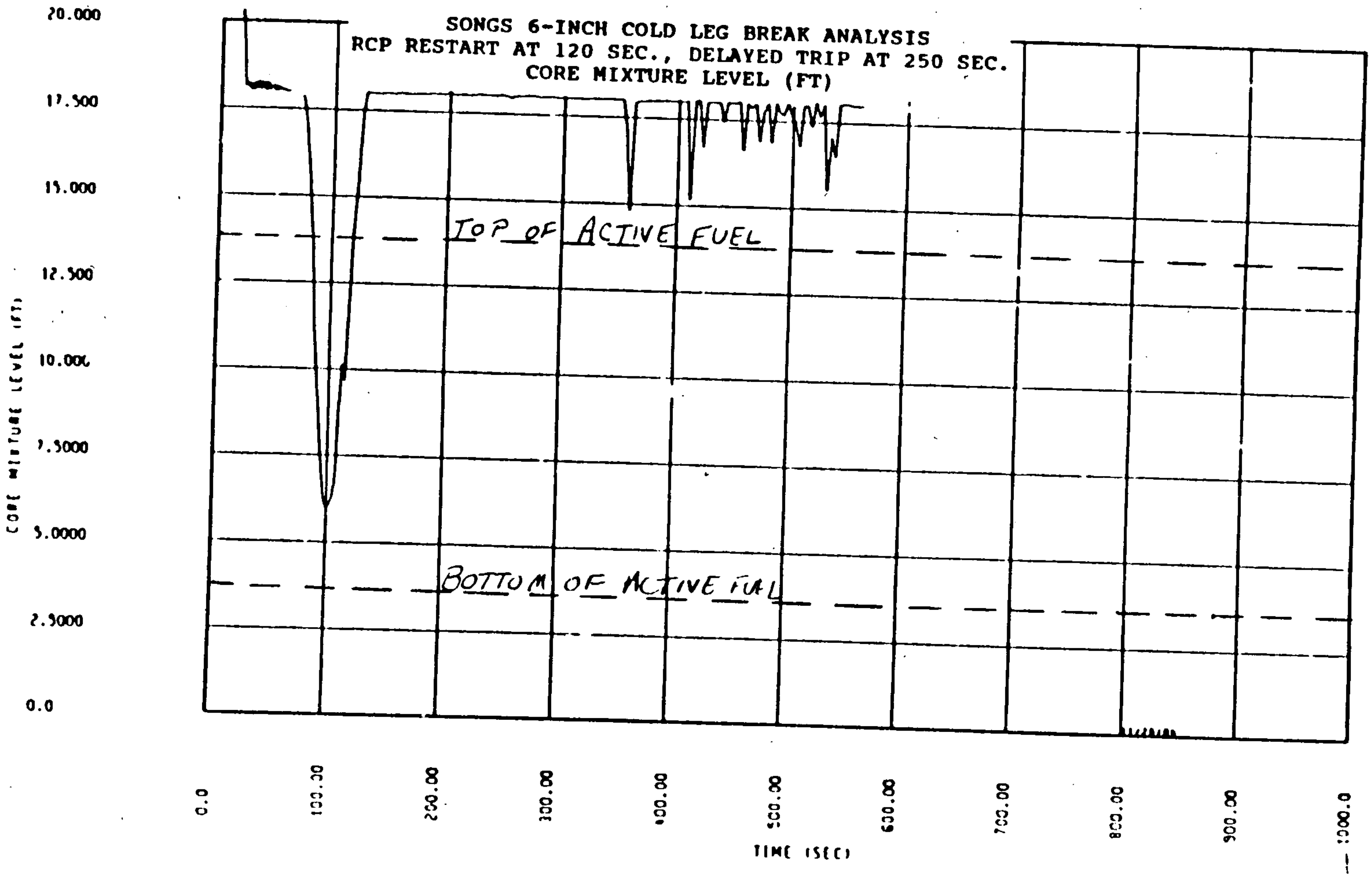

SONGS 6-INCH COLD LEG BREAK ANALYSIS
RCP RESTART AT 120 SEC., NO DELAYED TRIP
COLD LEG FLOW QUALITY (-)
1.4000
1.2500
1.0000
0.7500
0.5000
0.2500
0.0
0.0
100.00
200.00
300.00
400.00
500.00
600.00
700.00
800.00
900.00
1000.0
TIME (SEC)

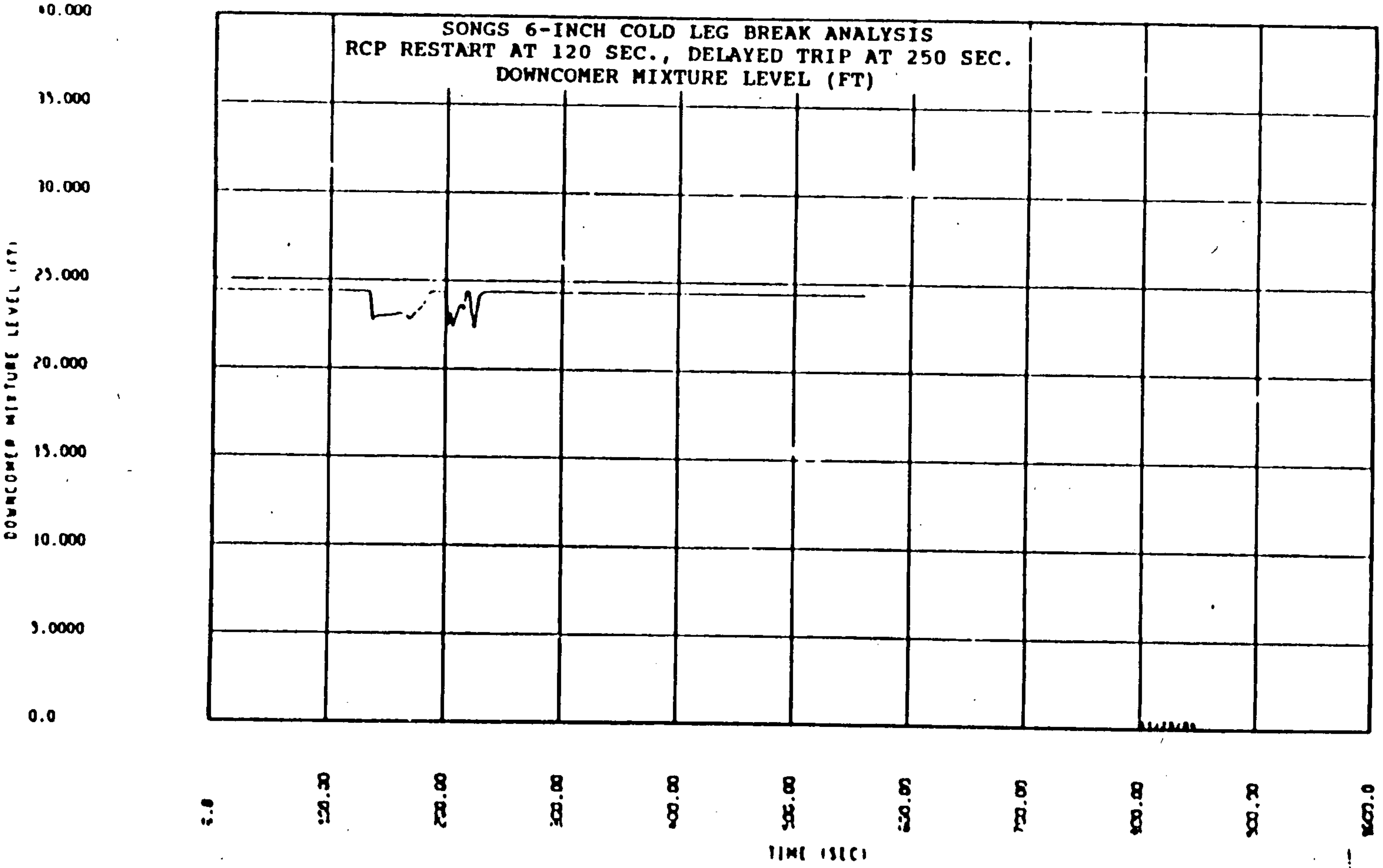

SONGS 6-INCH COLD LEG BREAK ANALYSIS
RCP RESTART AT 120 SEC., NO DELAYED TRIP
BREAK FLOW QUALITY (-)
1.4000
1.2500
1.0000
0.7500
0.5000
0.2500
0.0
BREAK FLOW QUALITY (-)
0.0
100.00
200.00
300.00
400.00
500.00
600.00
700.00
800.00
900.00
1000.0
TIME (SEC)

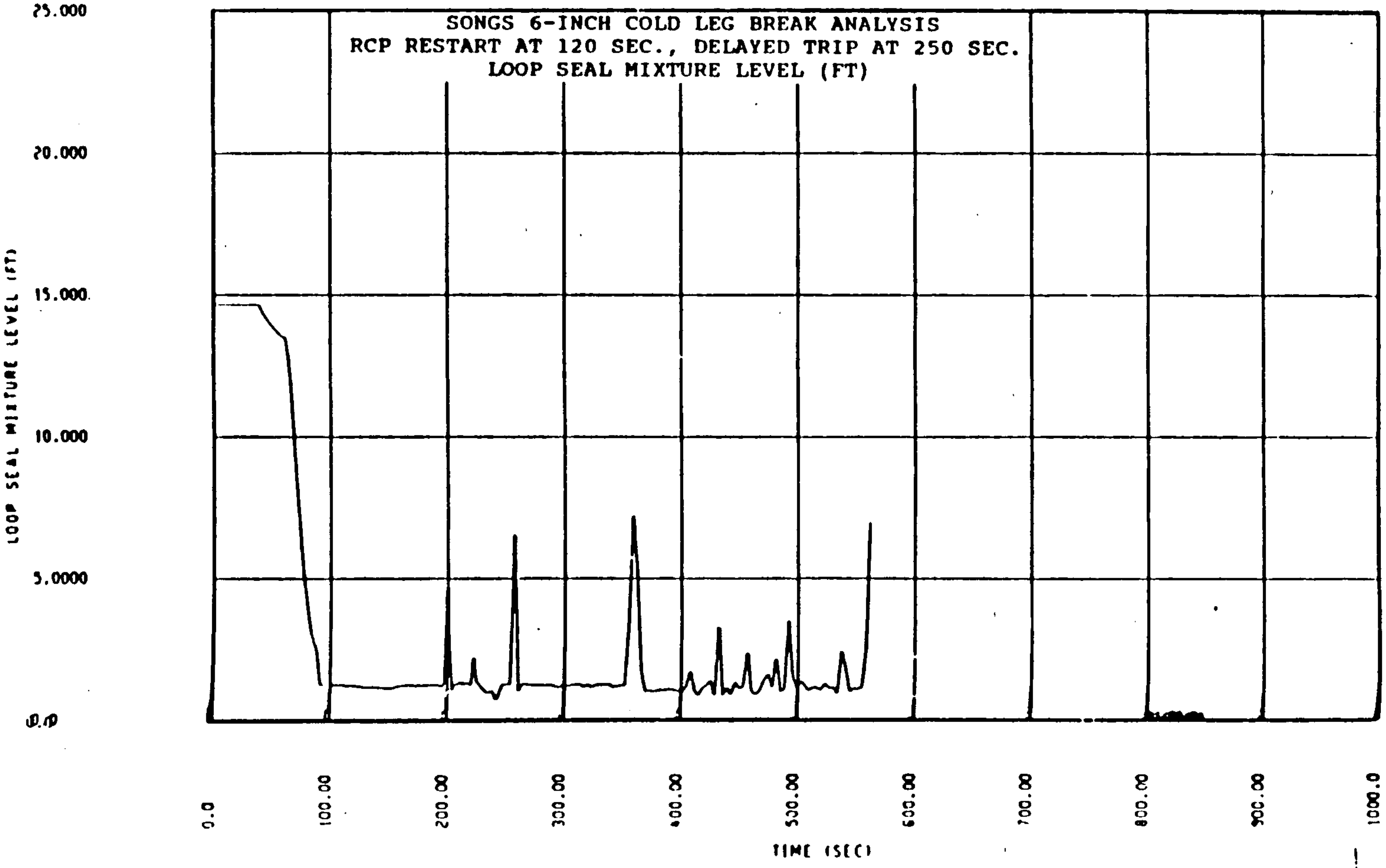


SONGS LOCTA RUN FOR 6-INCH COLD LEG BREAK
RCP RESTART AT 120 SEC., NO DELAYED TRIP, LOCTA TMAX=175
CLAD AVG. TEMP. HOT ROD, PEAK AT 7.92 FT.
2500.0
2000.0
1500.0
500.00
0.0
TIME (SEC)

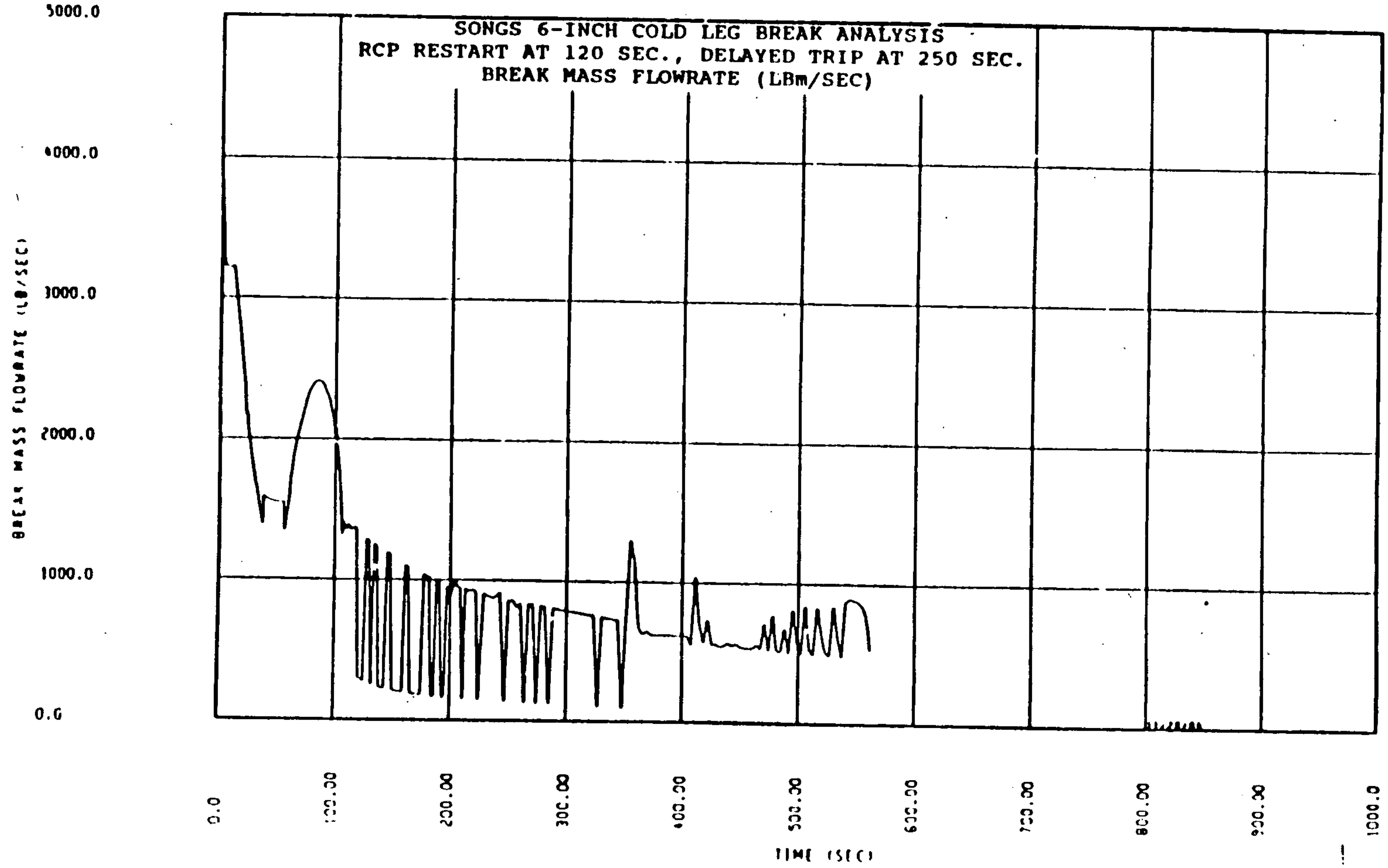

SONGS 6-INCH COLD LEG BREAK ANALYSIS
RCP RESTART AT 120 SEC., DELAYED TRIP AT 250 SEC.
RCS PRESSURE (PSIA)
2500.0
2000.0
1500.0
1000.0
500.00
0.0
RCS PRESSURE(PSIA)
0.0
100.00
200.00
300.00
400.00
500.00
600.00
700.00
800.00
900.00
1000.0
TIME (SEC)

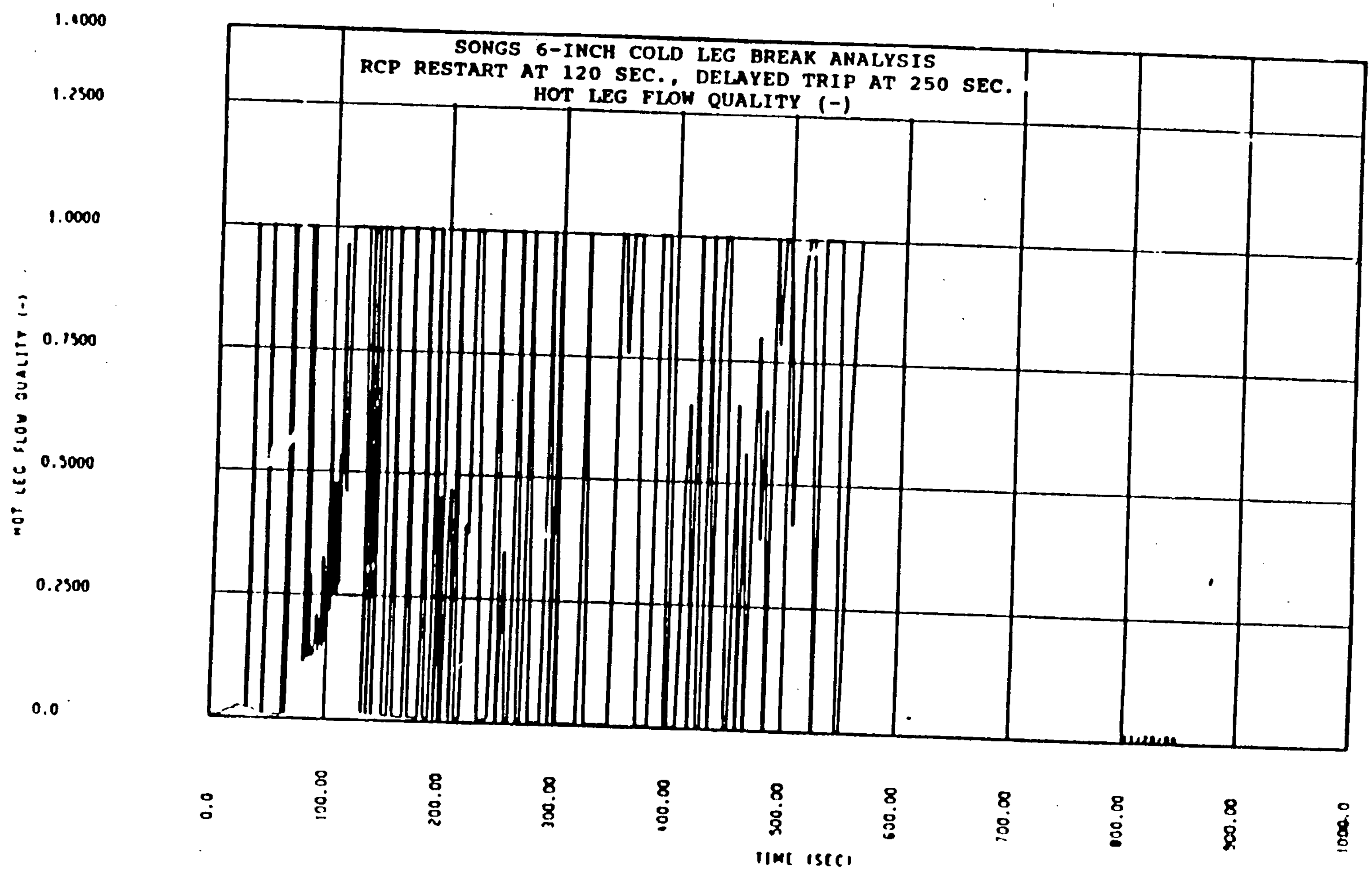

SONGS 6-INCH COLD LEG BREAK ANALYSIS
RCP RESTART AT 120 SEC., DELAYED TRIP AT 250 SEC.
CORE MIXTURE LEVEL (FT)
TOP OF ACTIVE FUEL
BOTTOM OF ACTIVE FUEL
20.000
17.500
15.000
12.500
10.000
7.5000
5.0000
2.5000
0.0
CORE MIXTURE LEVEL (FT)
0.0
100.00
200.00
300.00
400.00
500.00
600.00
700.00
800.00
900.00
1000.0
TIME (SEC)

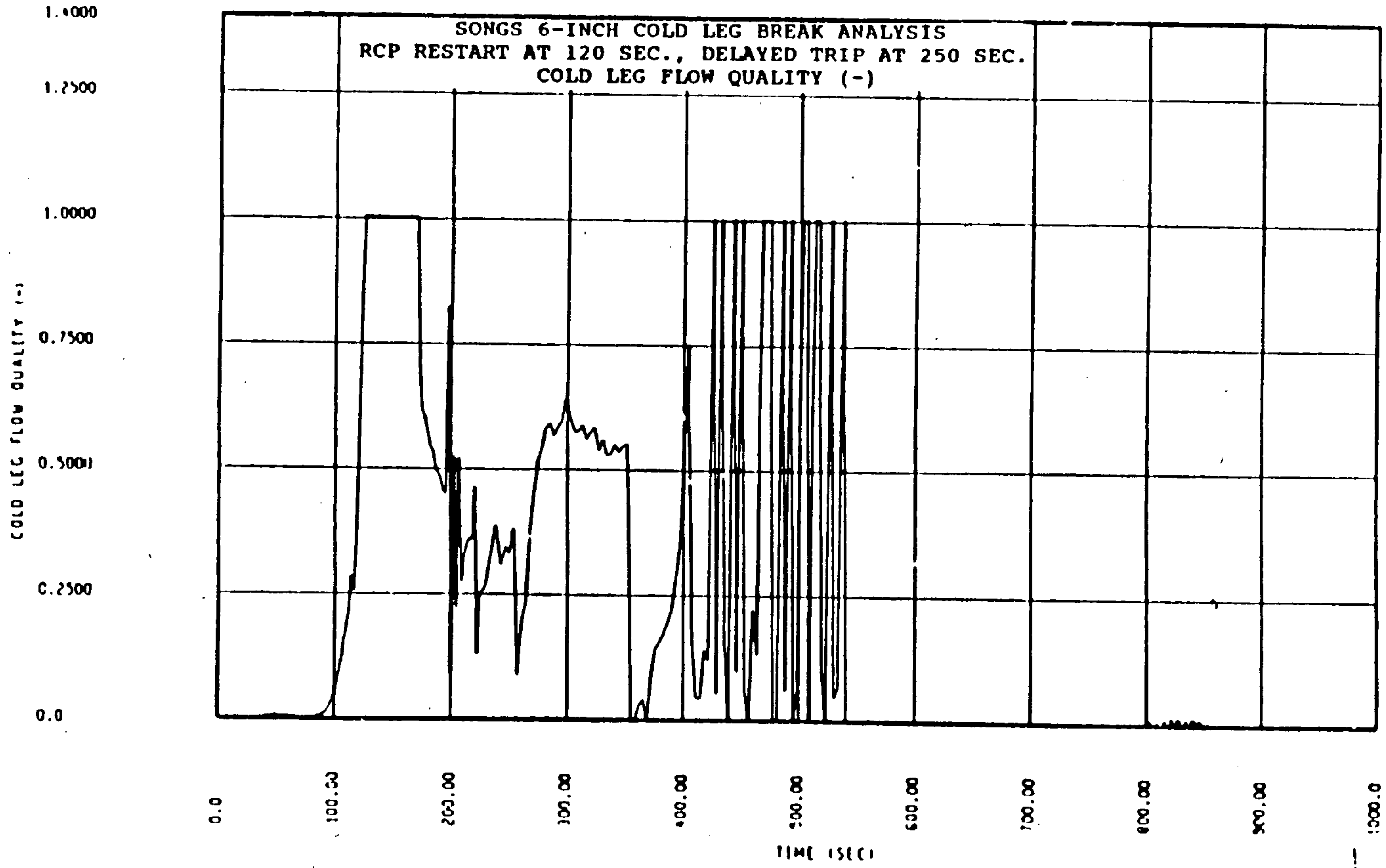

SONGS 6-INCH COLD LEG BREAK ANALYSIS
RCP RESTART AT 120 SEC., DELAYED TRIP AT 250 SEC.
DOWNCOMER MIXTURE LEVEL (FT)
40.000
35.000
30.000
25.000
20.000
15.000
10.000
5.0000
0.0
DOWNCOMER MIXTURE LEVEL (FT)
TIME (SEC)



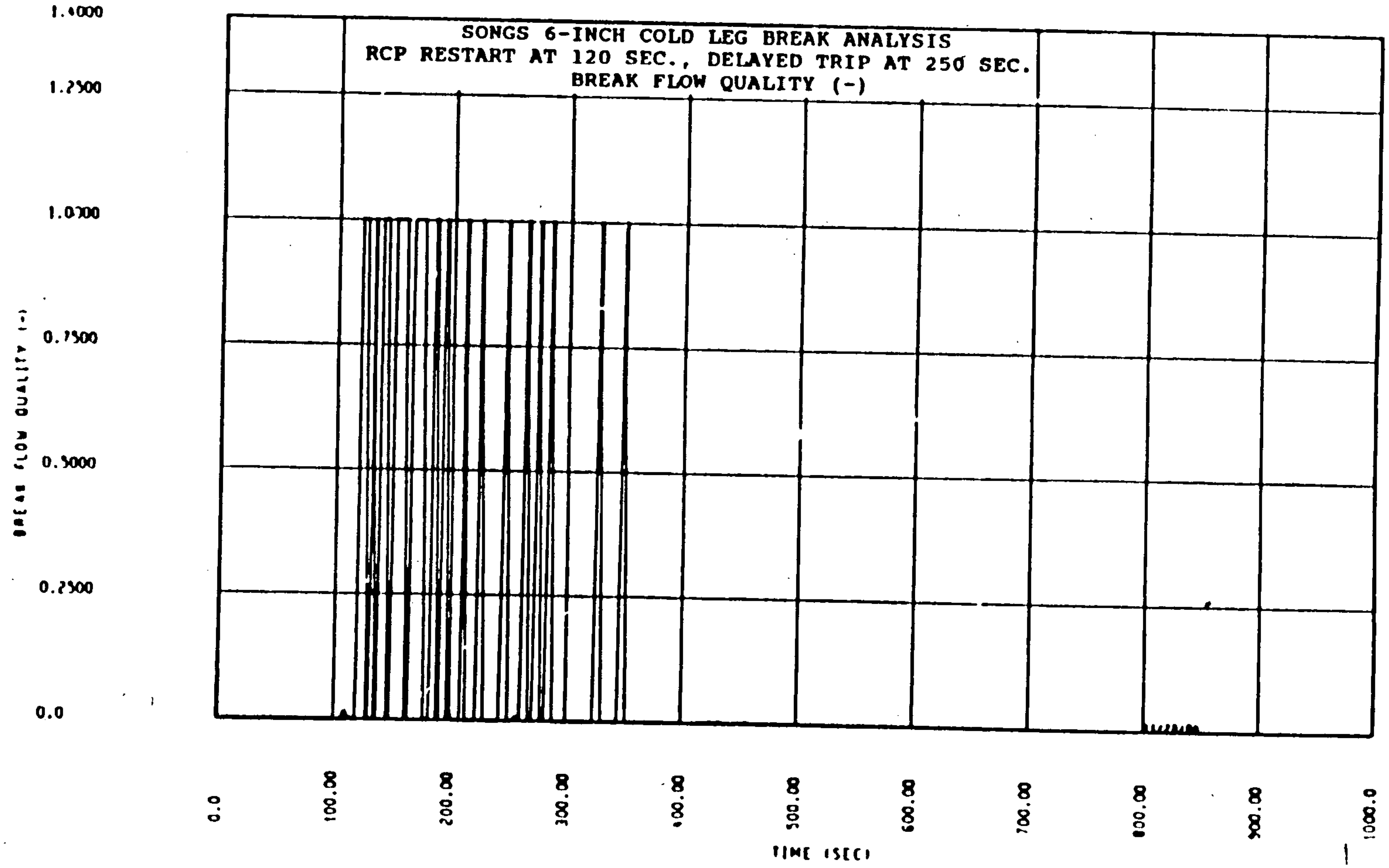
SONGS 6-INCH COLD LEG BREAK ANALYSIS
RCP RESTART AT 120 SEC., DELAYED TRIP AT 250 SEC.
LOOP SEAL MIXTURE LEVEL (FT)
25.000
20.000
15.000
10.000
5.0000
0.0
LOOP SEAL MIXTURE LEVEL (FT)
0.0
100.00
200.00
300.00
400.00
500.00
600.00
700.00
800.00
900.00
1000.0
TIME (SEC)


SONGS 6-INCH COLD LEG BREAK ANALYSIS
RCP RESTART AT 120 SEC., DELAYED TRIP AT 250 SEC.
BREAK MASS FLOWRATE (LBm/SEC)
5000.0
4000.0
3000.0
2000.0
1000.0
0.0
BREAK MASS FLOWRATE (LB/SEC)
0.0
200.00
300.00
400.00
500.00
600.00
800.00
1000.0
TIME (SEC)

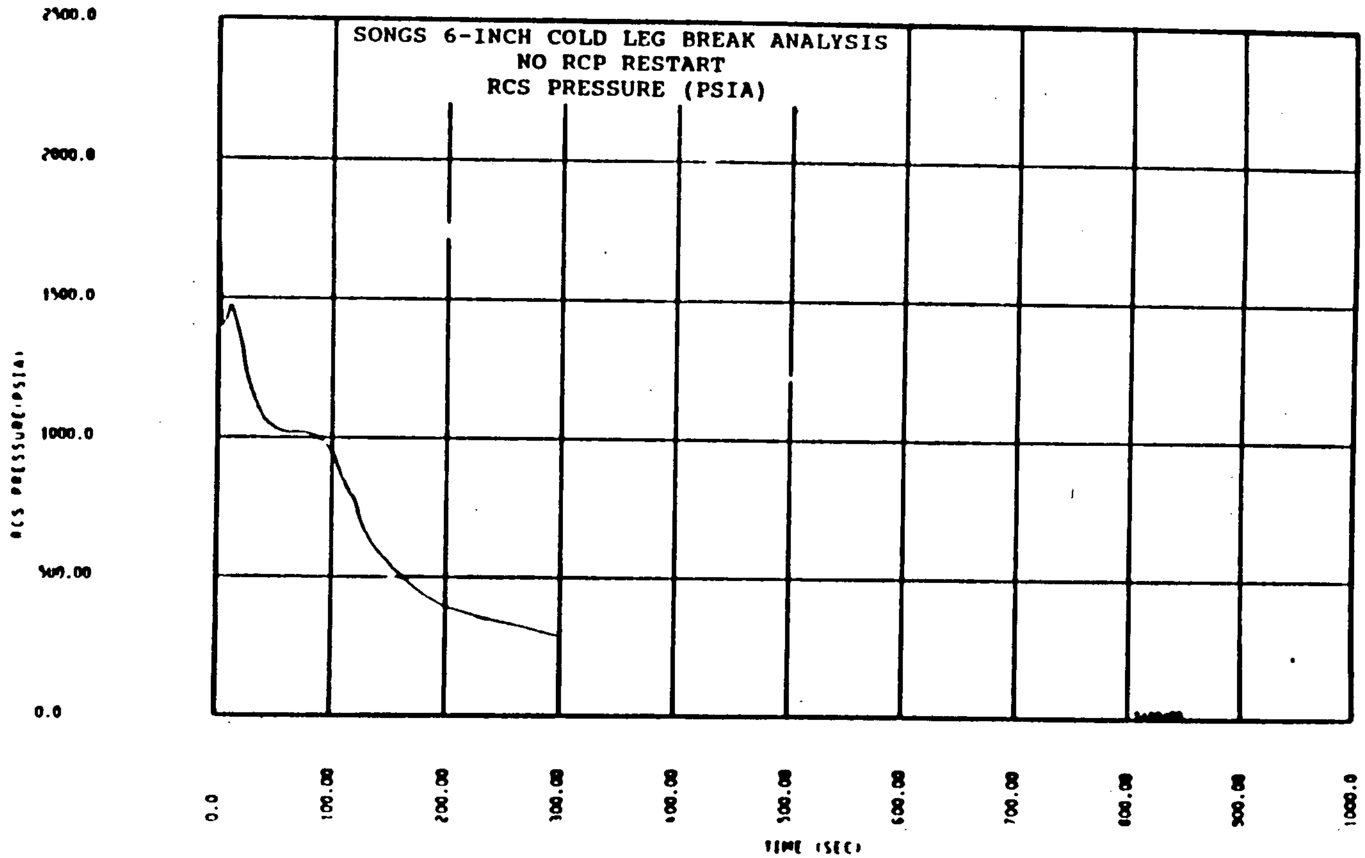

SONGS 6-INCH COLD LEG BREAK ANALYSIS
RCP RESTART AT 120 SEC., DELAYED TRIP AT 250 SEC.
HOT LEG FLOW QUALITY (-)
1.4000
1.2500
1.0000
0.7500
0.5000
0.2500
0.0
HOT LEG FLOW QUALITY (-)
0.0
100.00
200.00
300.00
400.00
500.00
600.00
700.00
800.00
900.00
1000.0
TIME (SEC)

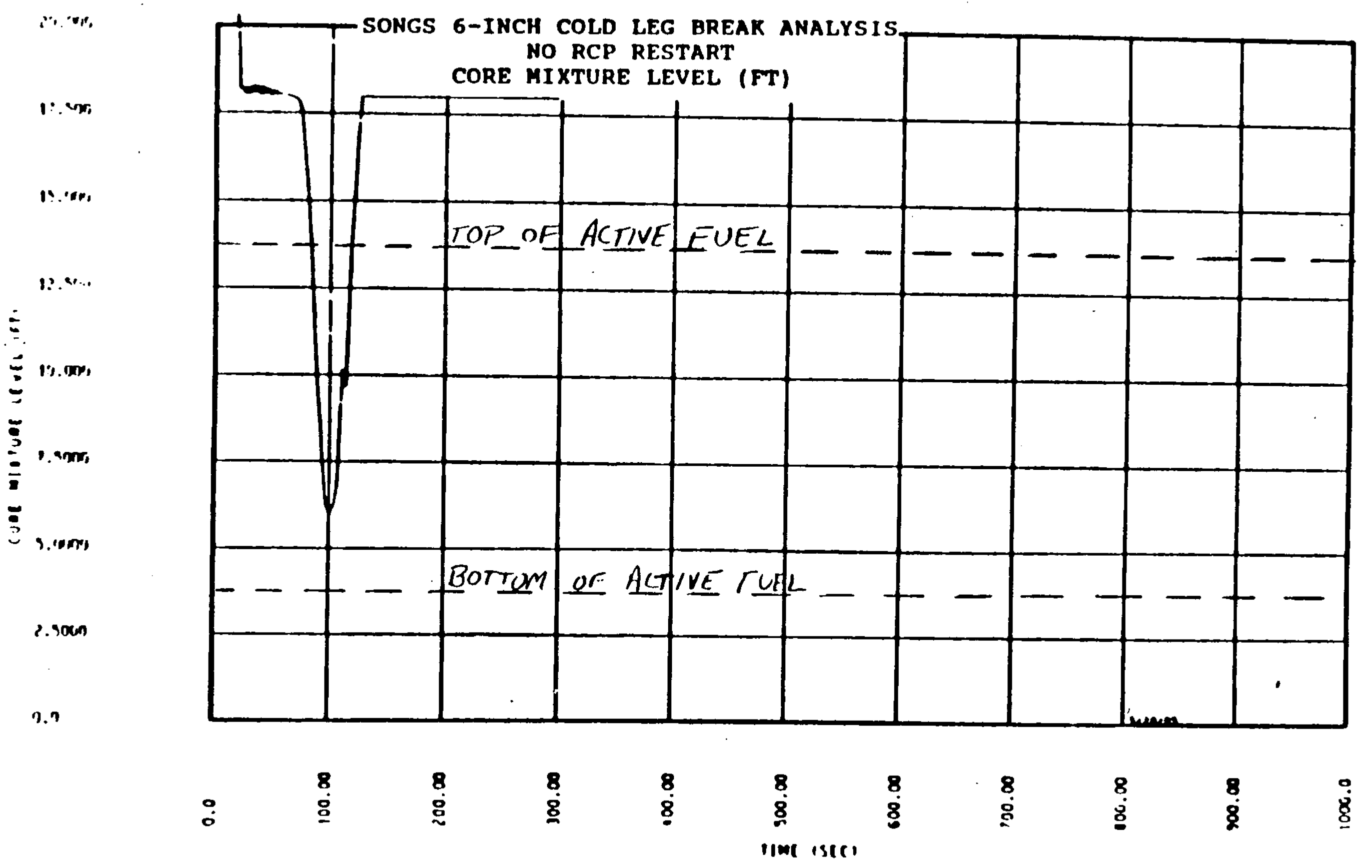


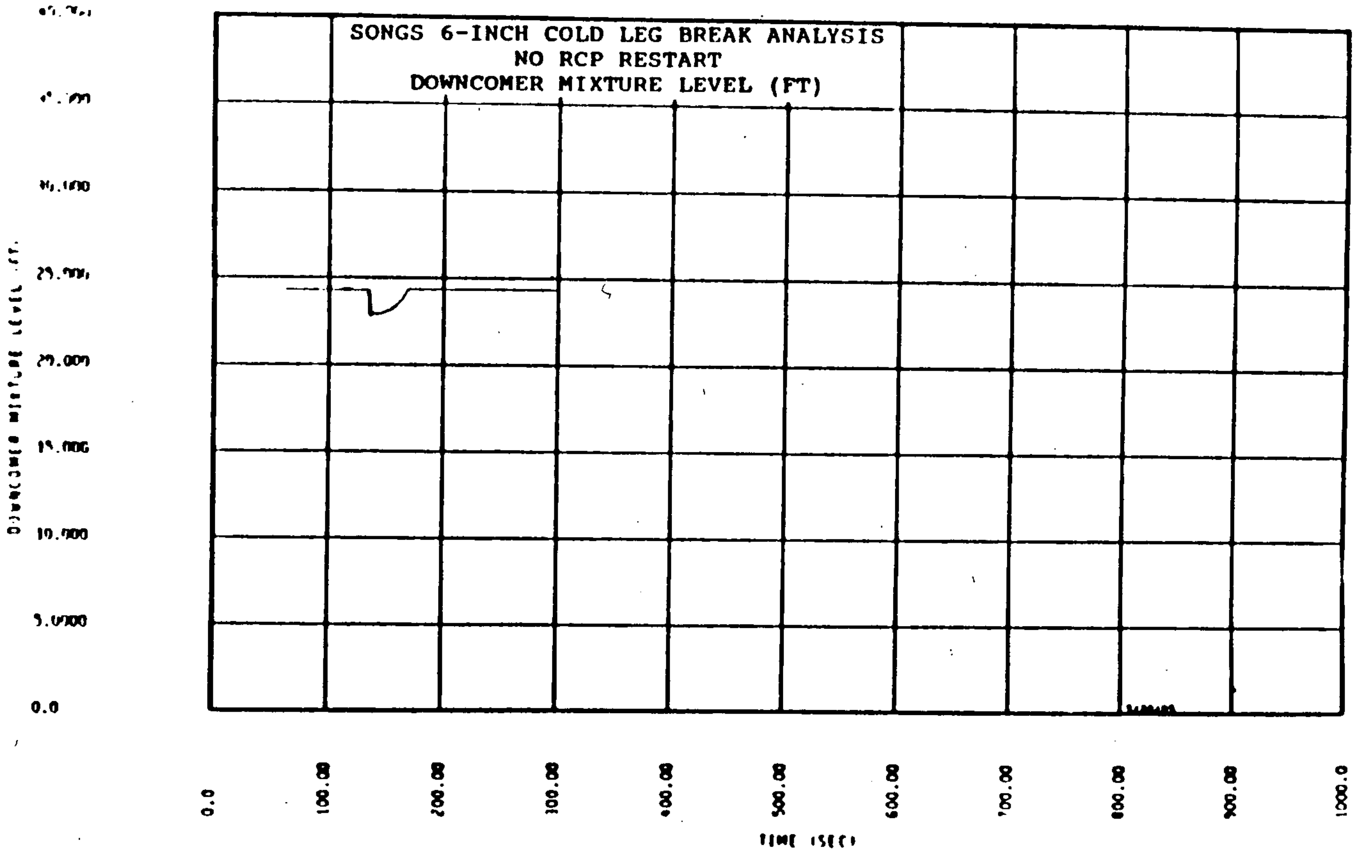
SONGS 6-INCH COLD LEG BREAK ANALYSIS
RCP RESTART AT 120 SEC., DELAYED TRIP AT 250 SEC.
COLD LEG FLOW QUALITY (-)
1.4000
1.2500
1.0000
0.7500
0.5000
0.2500
0.0
COLD LEG FLOW QUALITY (-)
0.0
100.00
200.00
300.00
400.00
500.00
600.00
700.00
800.00
900.00
1000.0
TIME (SEC)

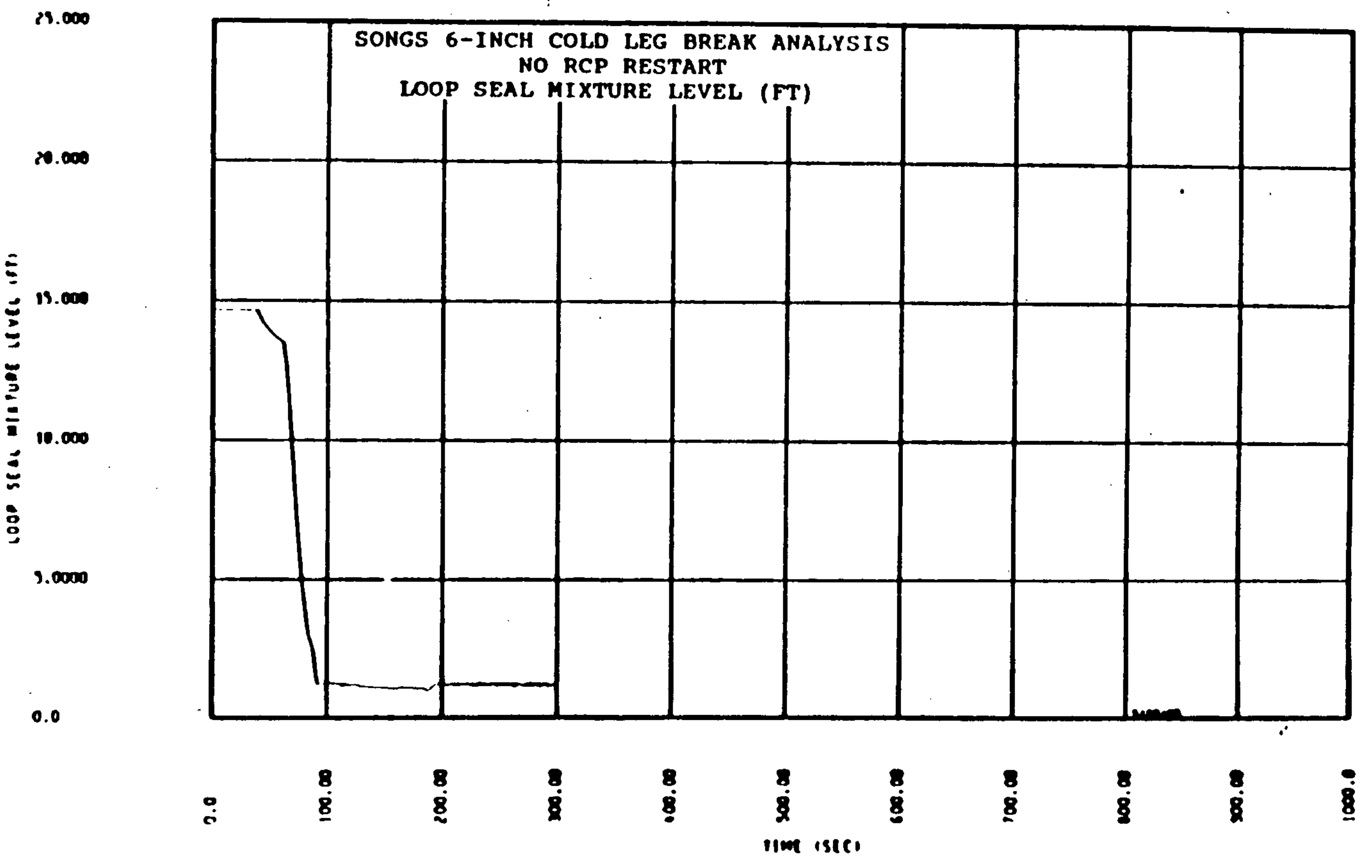


SONGS 6-INCH COLD LEG BREAK ANALYSIS
RCP RESTART AT 120 SEC., DELAYED TRIP AT 250 SEC.
BREAK FLOW QUALITY (-)
1.4000
1.2500
1.0000
0.7500
0.5000
0.2500
0.0
BREAK FLOW QUALITY (-)
0.0
100.00
200.00
300.00
400.00
500.00
600.00
700.00
800.00
900.00
1000.0
TIME (SEC)

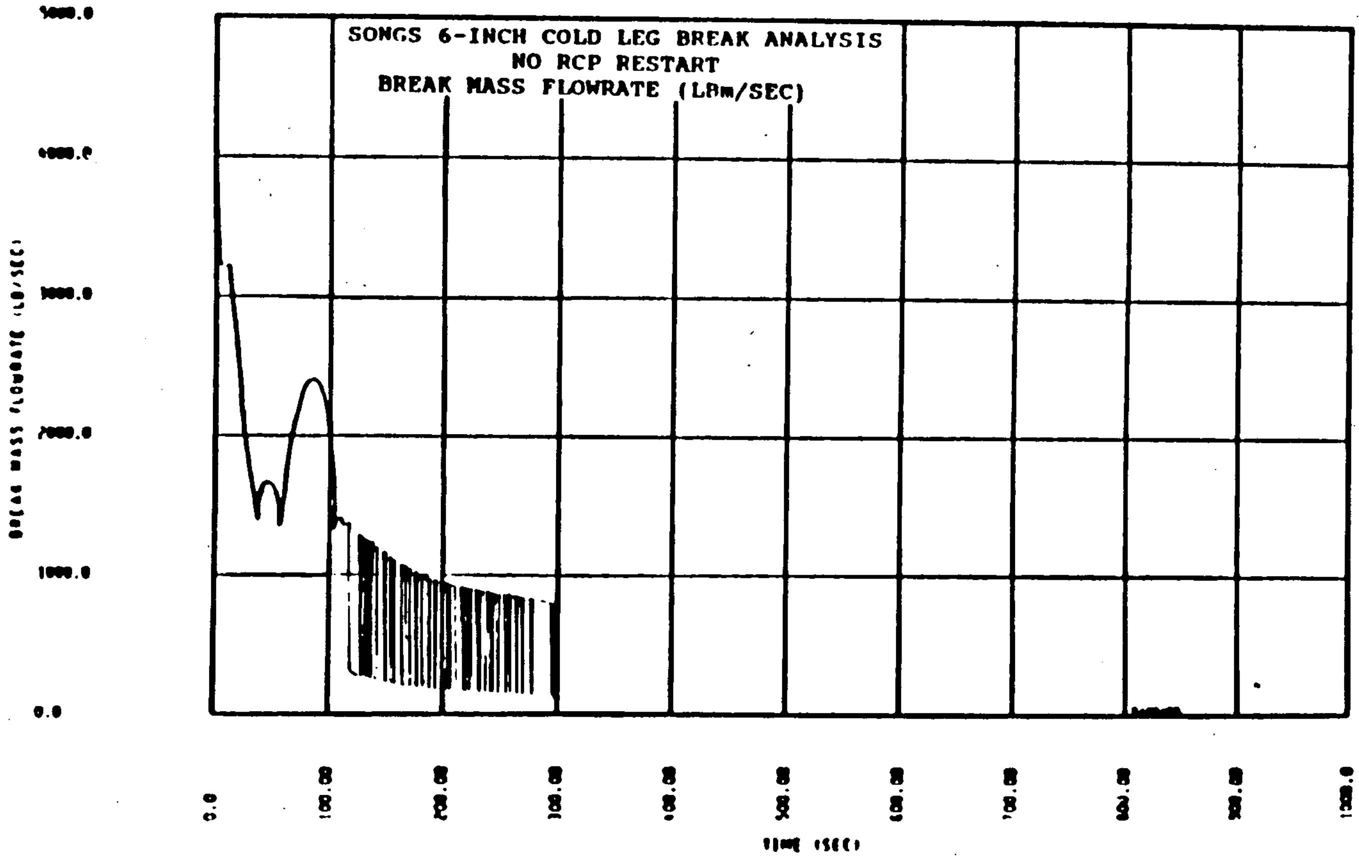

SONGS 6-INCH COLD LEG BREAK ANALYSIS
NO RCP RESTART
RCS PRESSURE (PSIA)
2500.0
2000.0
1500.0
1000.0
500.00
0.0
RCS PRESSURE (PSIA)
0.0
100.00
200.00
300.00
400.00
500.00
600.00
700.00
800.00
900.00
1000.0
TIME (SEC)

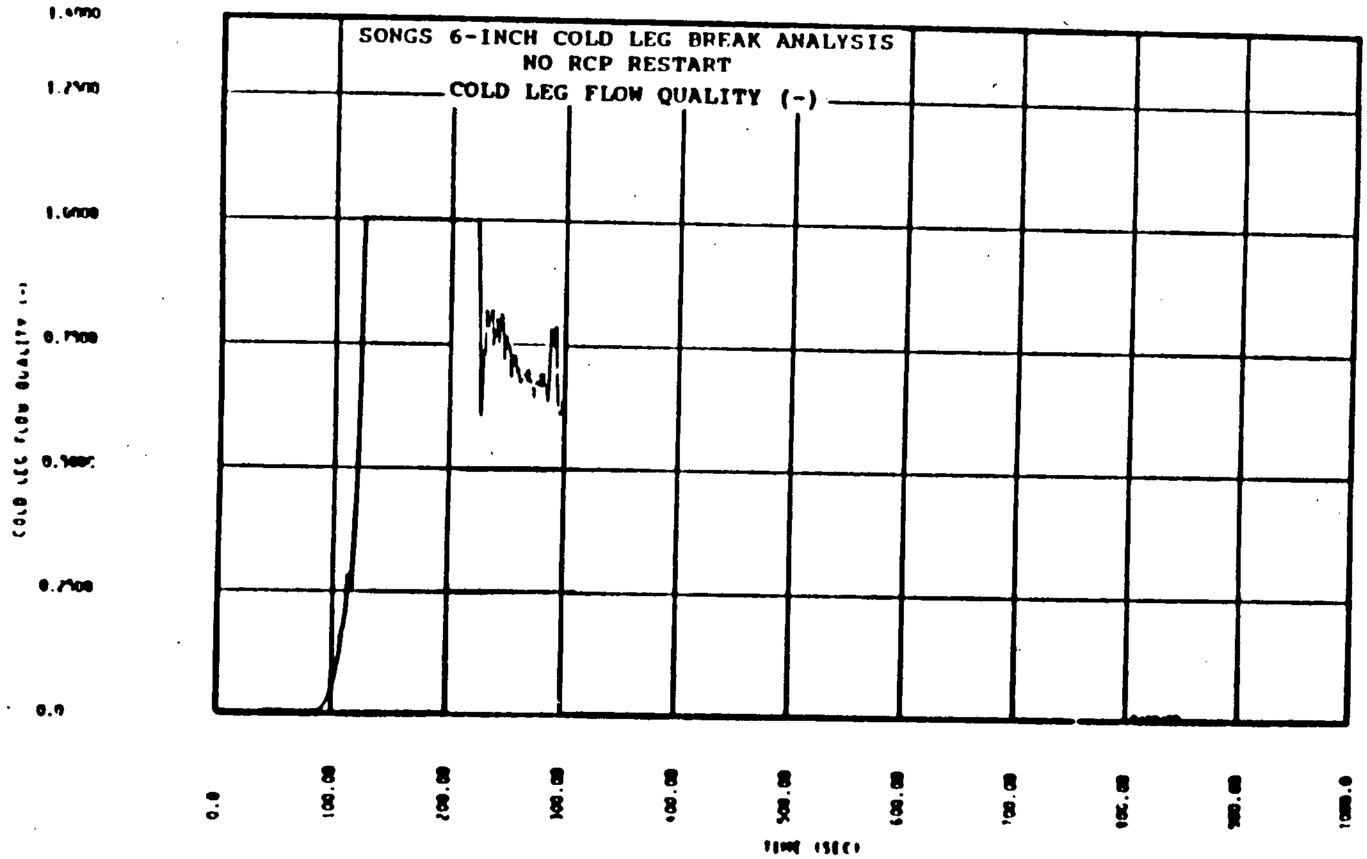

SONGS 6-INCH COLD LEG BREAK ANALYSIS
NO RCP RESTART
CORE MIXTURE LEVEL (FT)
TOP OF ACTIVE FUEL
BOTTOM OF ACTIVE FUEL
0.0
100.00
200.00
300.00
400.00
500.00
600.00
700.00
800.00
900.00
1000.0
TIME (SEC)

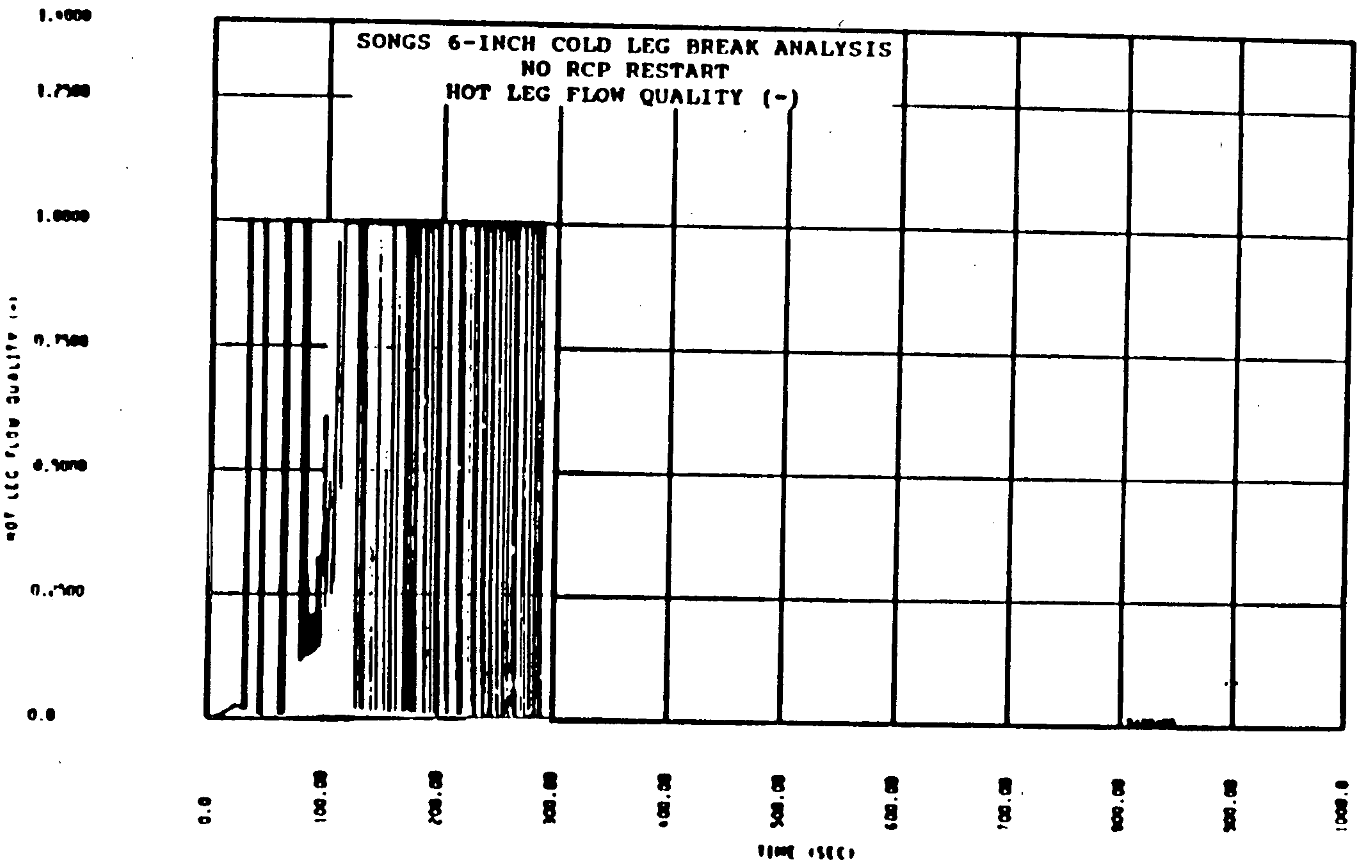

SONGS 6-INCH COLD LEG BREAK ANALYSIS
NO RCP RESTART
DOWNCOMER MIXTURE LEVEL (FT)
0.0
5.0000
10.000
15.000
20.000
25.000
30.000
0.0
100.00
200.00
300.00
400.00
500.00
600.00
700.00
800.00
900.00
1000.0
TIME (SEC)

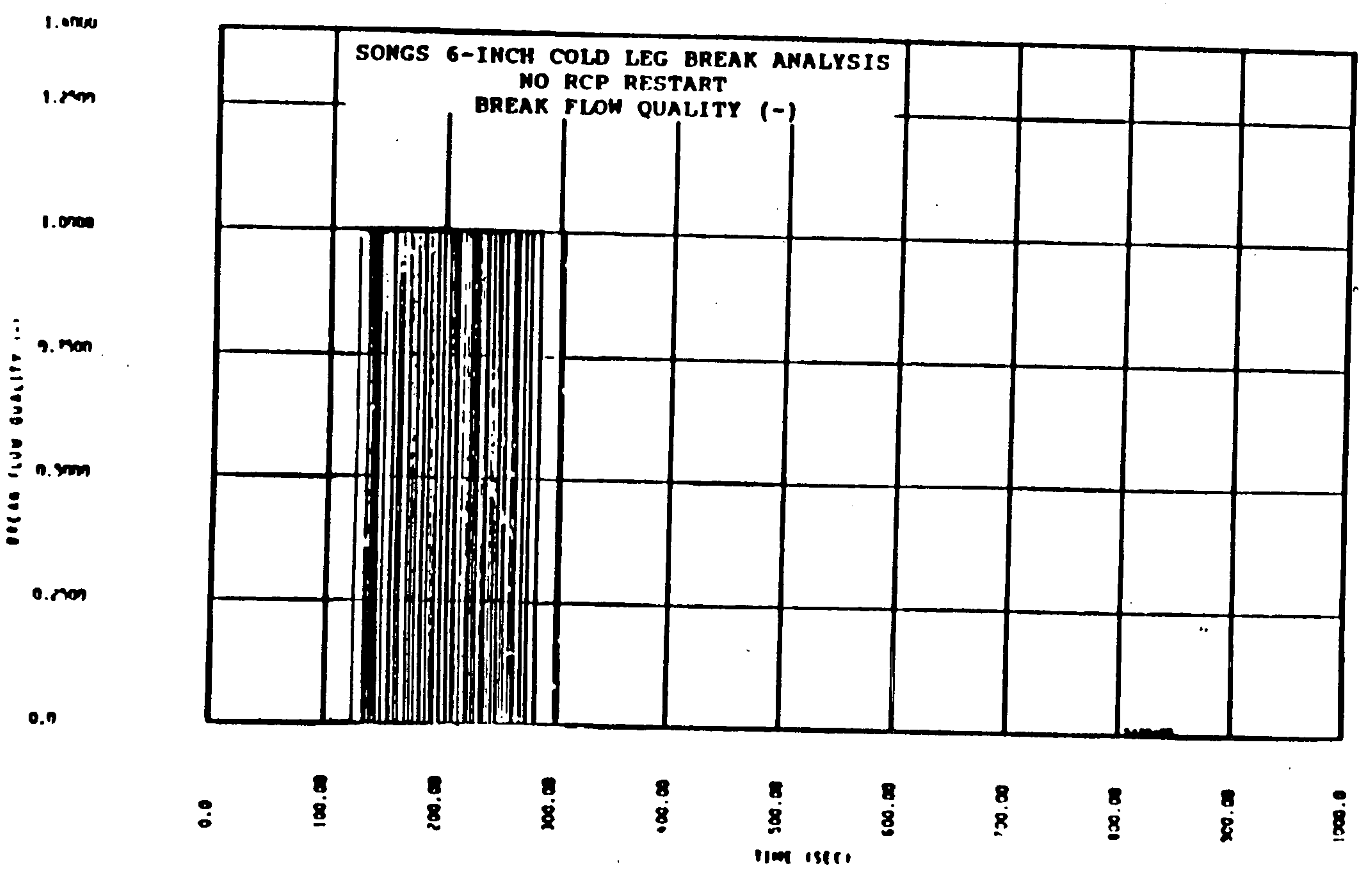


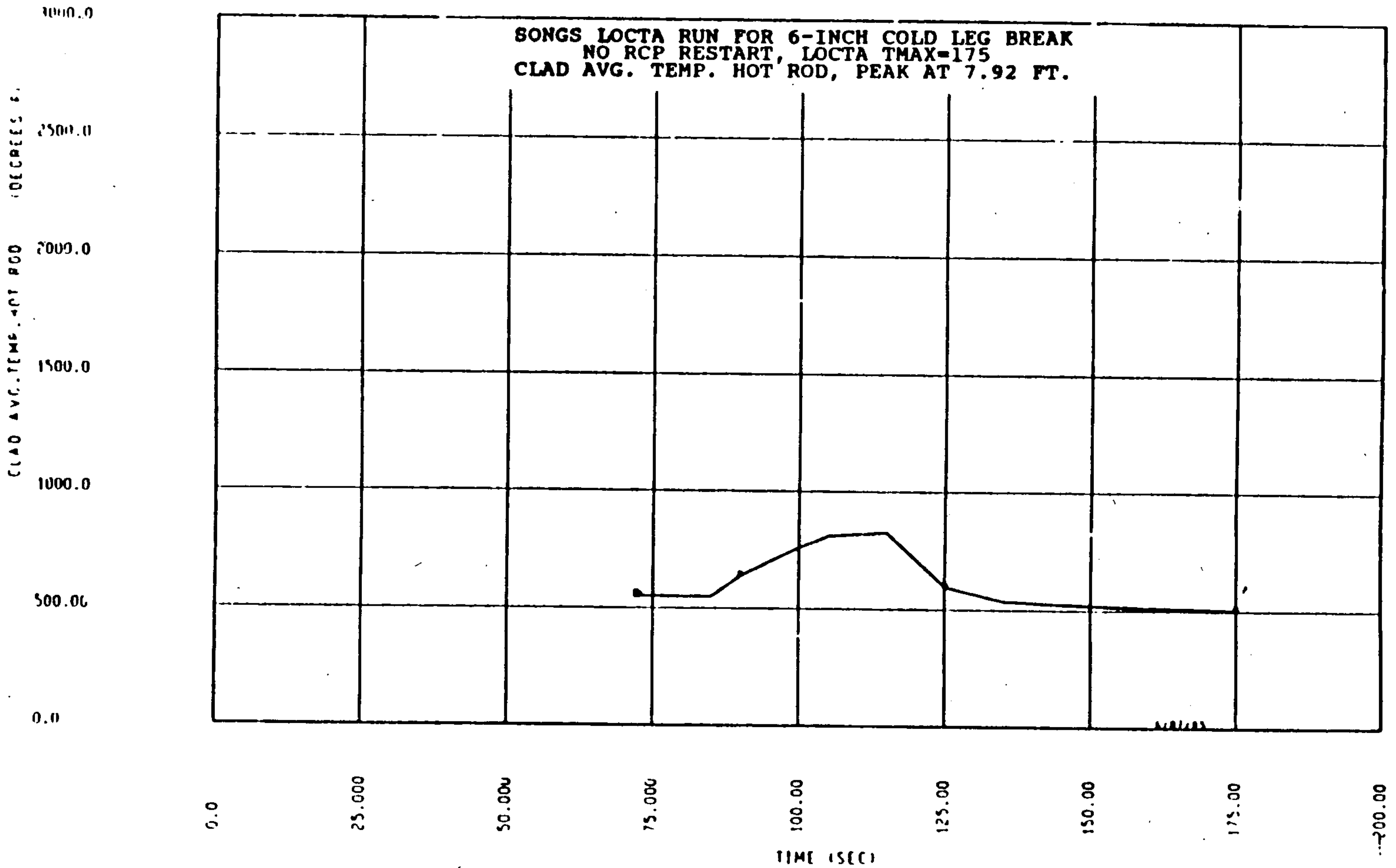
SONGS 6-INCH COLD LEG BREAK ANALYSIS
NO RCP RESTART
LOOP SEAL MIXTURE LEVEL (FT)


SONGS 6-INCH COLD LEG BREAK ANALYSIS
NO RCP RESTART
BREAK MASS FLOWRATE (LBm/SEC)
1000.0
0.0
0.0

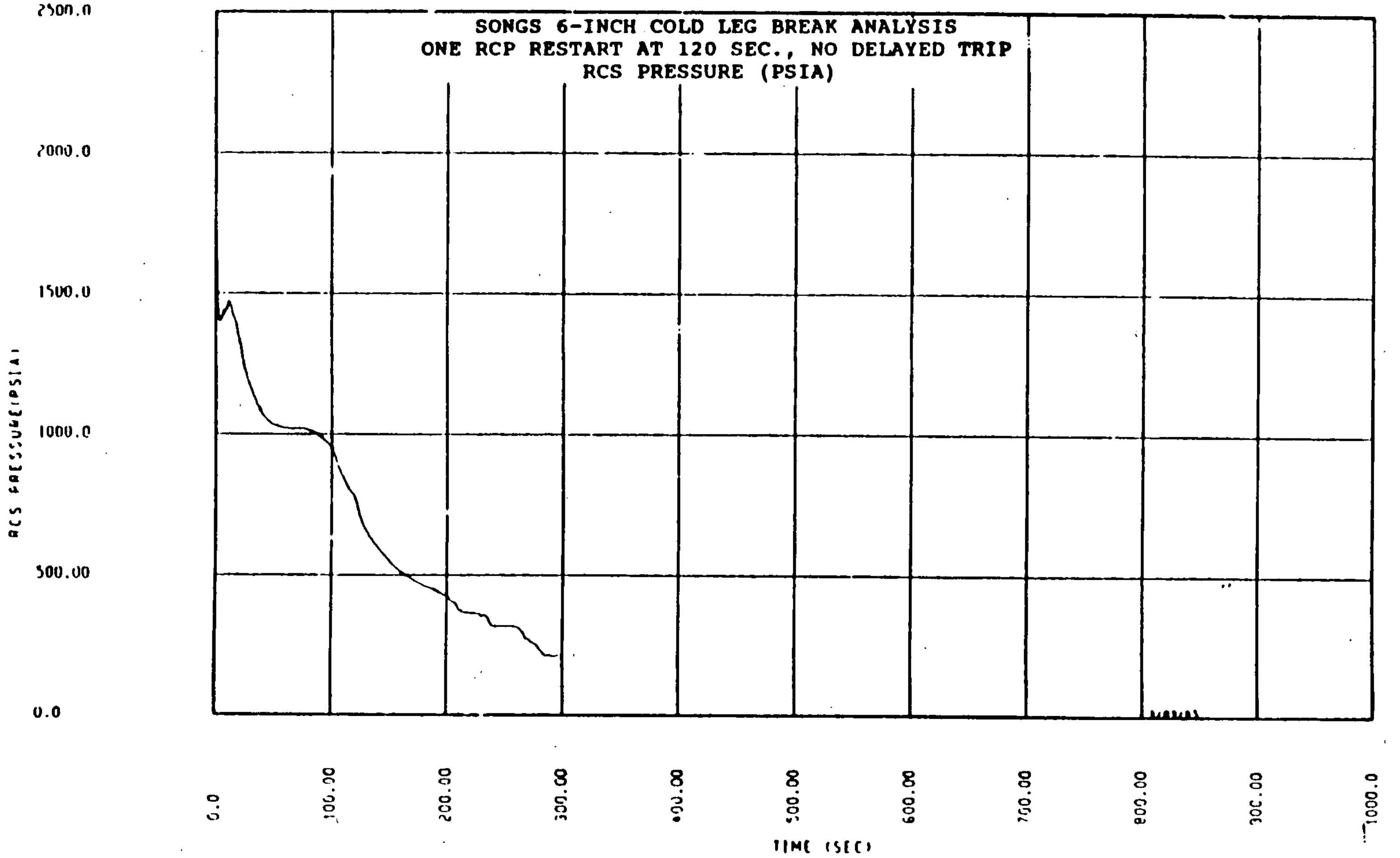

SONGS 6-INCH COLD LEG BREAK ANALYSIS
NO RCP RESTART
COLD LEG FLOW QUALITY (-)

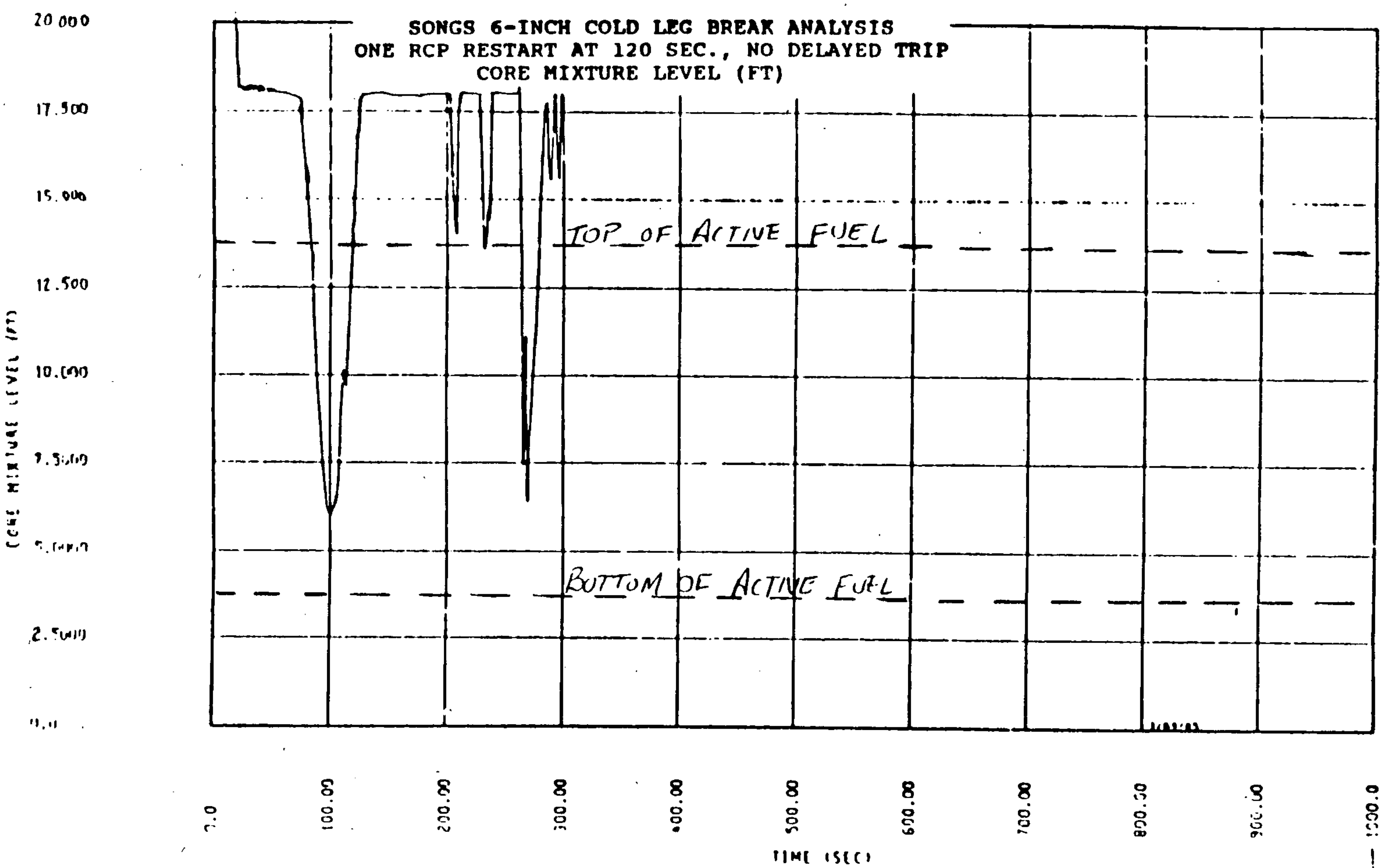

SONGS 6-INCH COLD LEG BREAK ANALYSIS
NO RCP RESTART
HOT LEG FLOW QUALITY (-)
1.0000
0.7500
0.5000
0.0
0.0
100.00
200.00
300.00
400.00
500.00
600.00
700.00
800.00
900.00
1000.0
TIME (SEC)

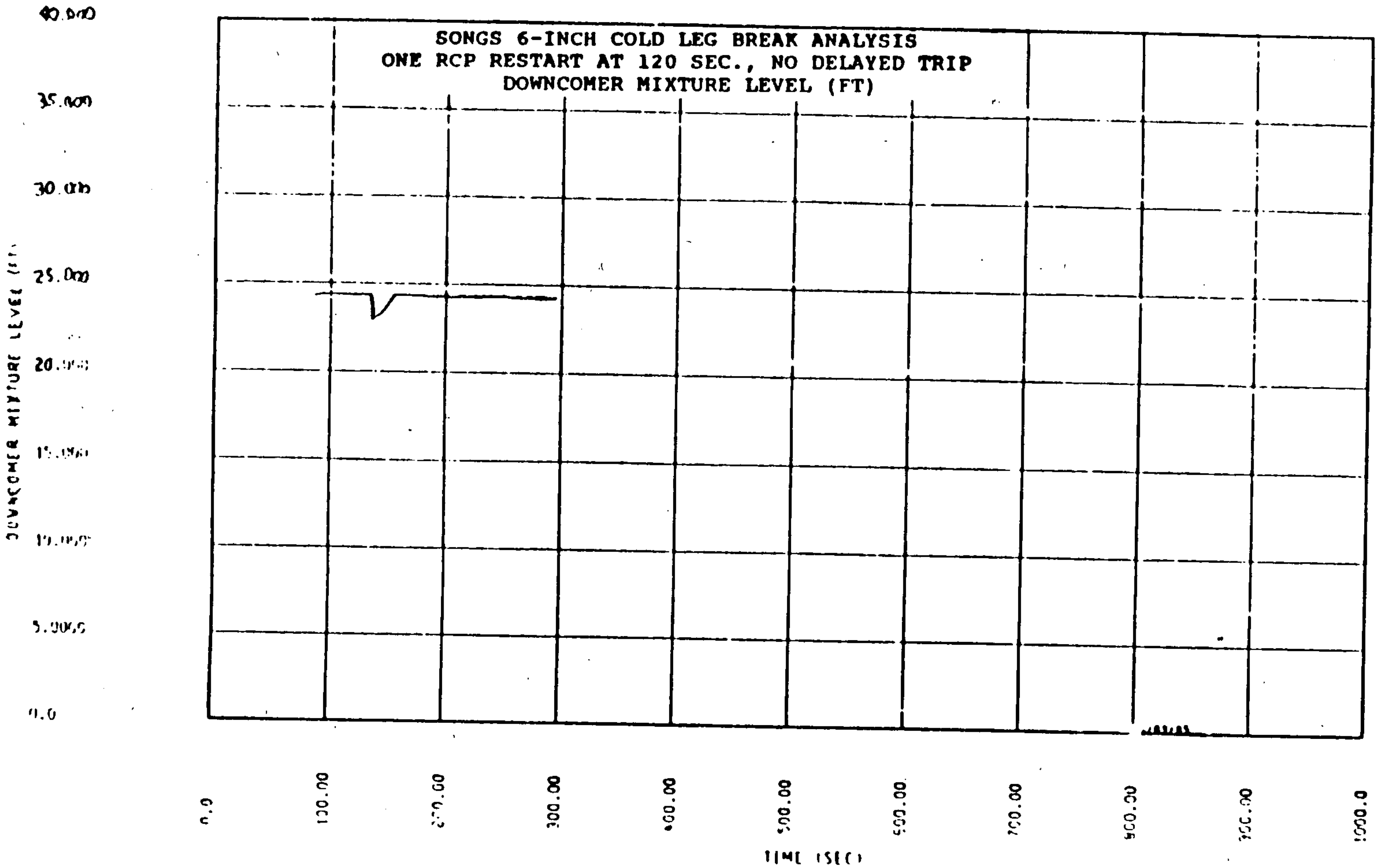

SONGS 6-INCH COLD LEG BREAK ANALYSIS
NO RCP RESTART
BREAK FLOW QUALITY (-)
1.0000
0.0
0.0
100.00
200.00
300.00
400.00
500.00
600.00
1000.0



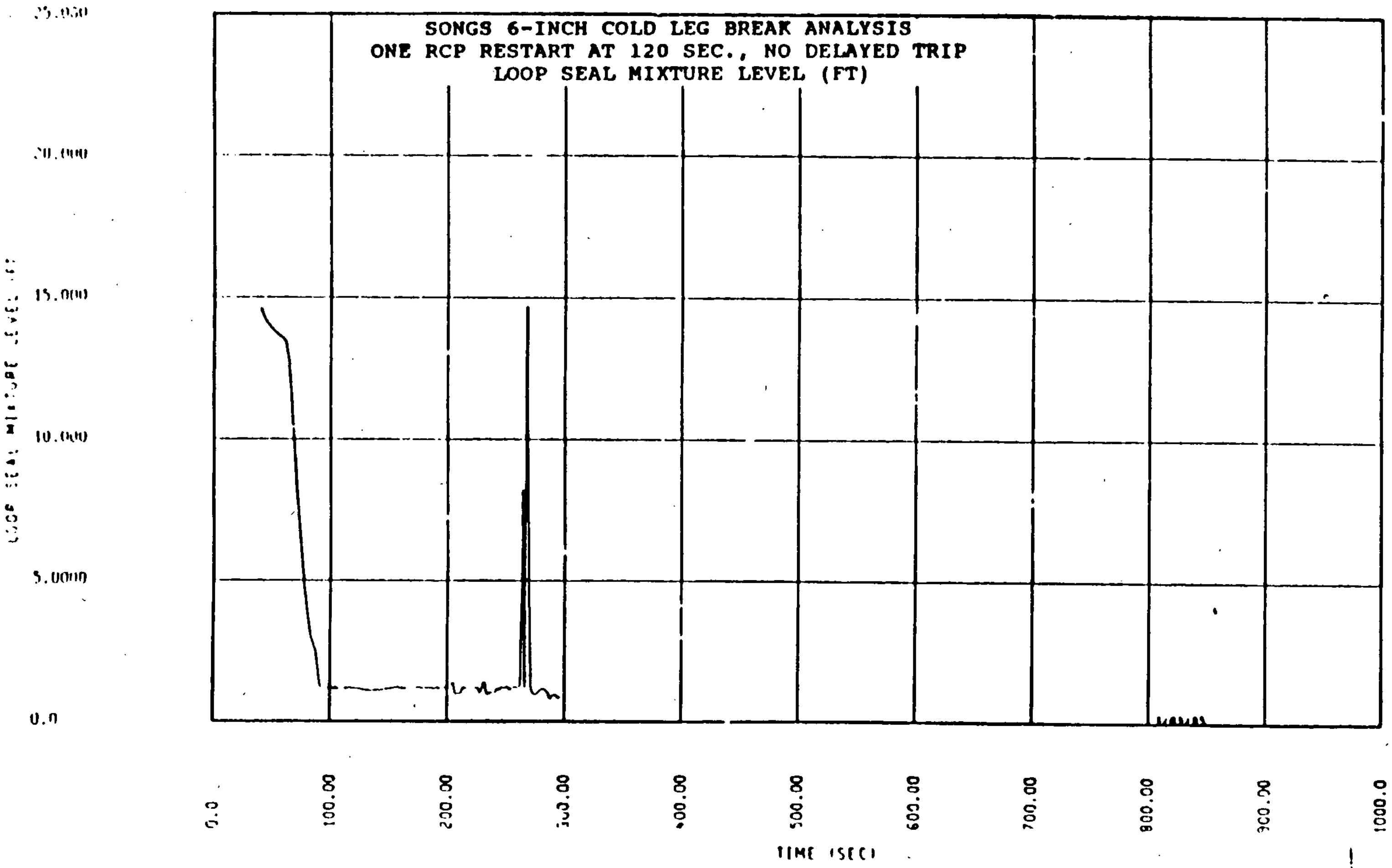
SONGS LOCTA RUN FOR 6-INCH COLD LEG BREAK
NO RCP RESTART, LOCTA TMAX=175
CLAD AVG. TEMP. HOT ROD, PEAK AT 7.92 FT.
3000.0
2500.0
2000.0
1500.0
1000.0
500.00
0.0
0.0
25.000
50.000
75.000
100.00
125.00
150.00
175.00
200.00
TIME (SEC)

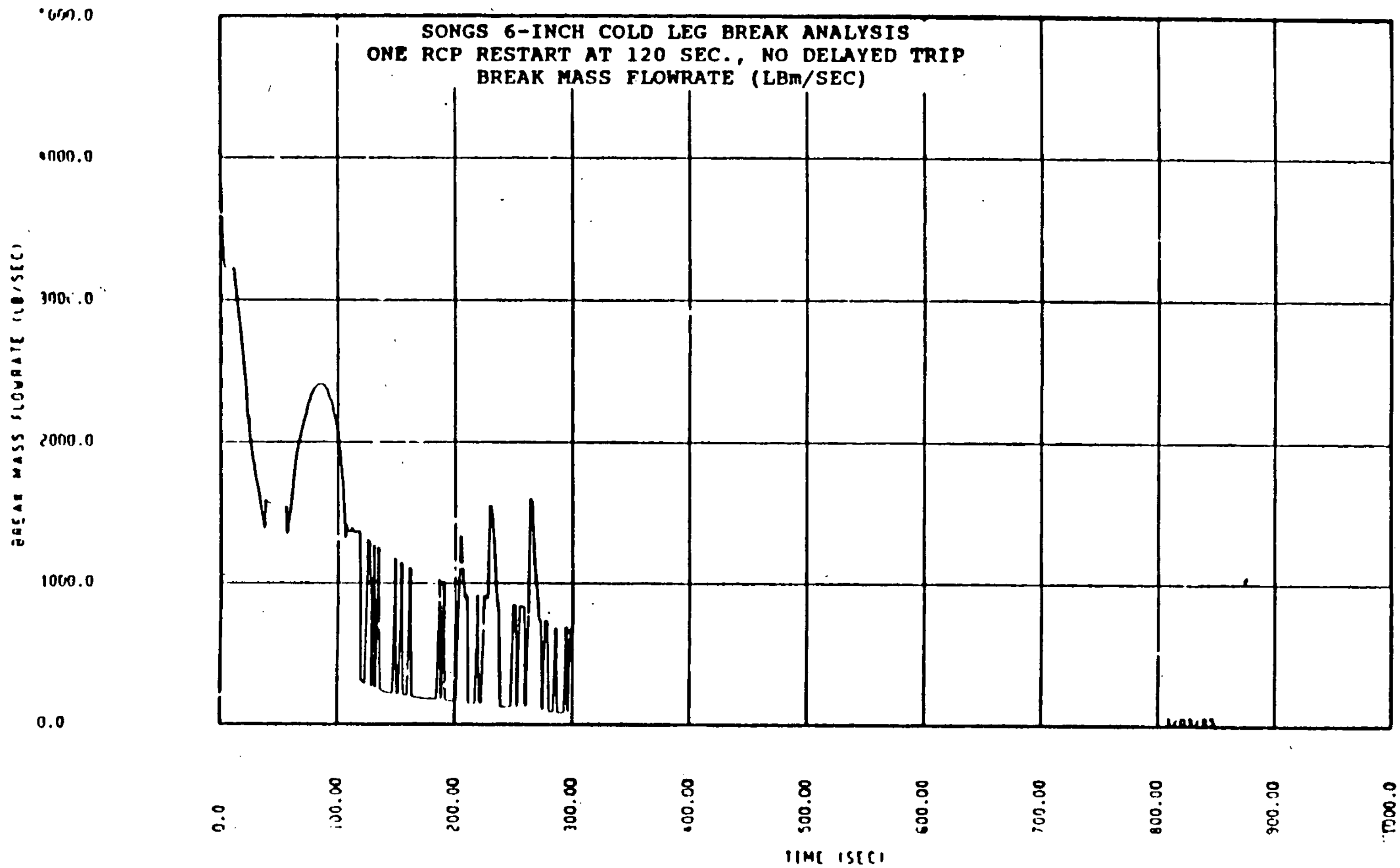

SONGS 6-INCH COLD LEG BREAK ANALYSIS
ONE RCP RESTART AT 120 SEC., NO DELAYED TRIP
RCS PRESSURE (PSIA)
2500.0
2000.0
1500.0
1000.0
500.00
0.0
RCS PRESSURE(PSIA)
0.0
100.00
200.00
300.00
400.00
500.00
600.00
700.00
800.00
900.00
1000.0
TIME (SEC)

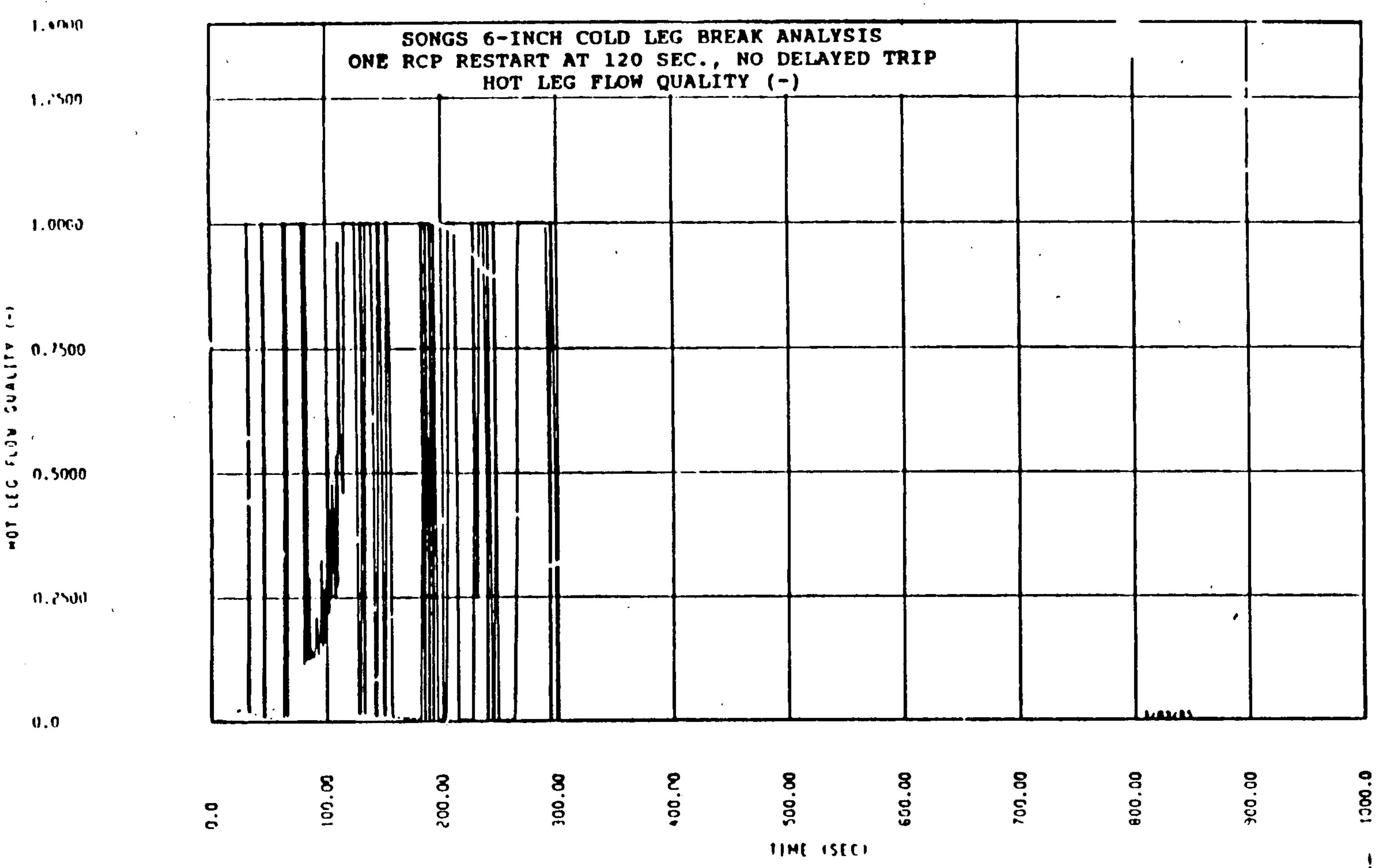

SONGS 6-INCH COLD LEG BREAK ANALYSIS
ONE RCP RESTART AT 120 SEC., NO DELAYED TRIP
CORE MIXTURE LEVEL (FT)
TOP OF ACTIVE FUEL
BOTTOM OF ACTIVE FUEL
20.000
17.500
15.000
12.500
10.000
7.5000
5.0000
2.5000
0.0
CORE MIXTURE LEVEL (FT)
0.0
100.00
200.00
300.00
400.00
500.00
600.00
700.00
800.00
900.00
1000.0
TIME (SEC)

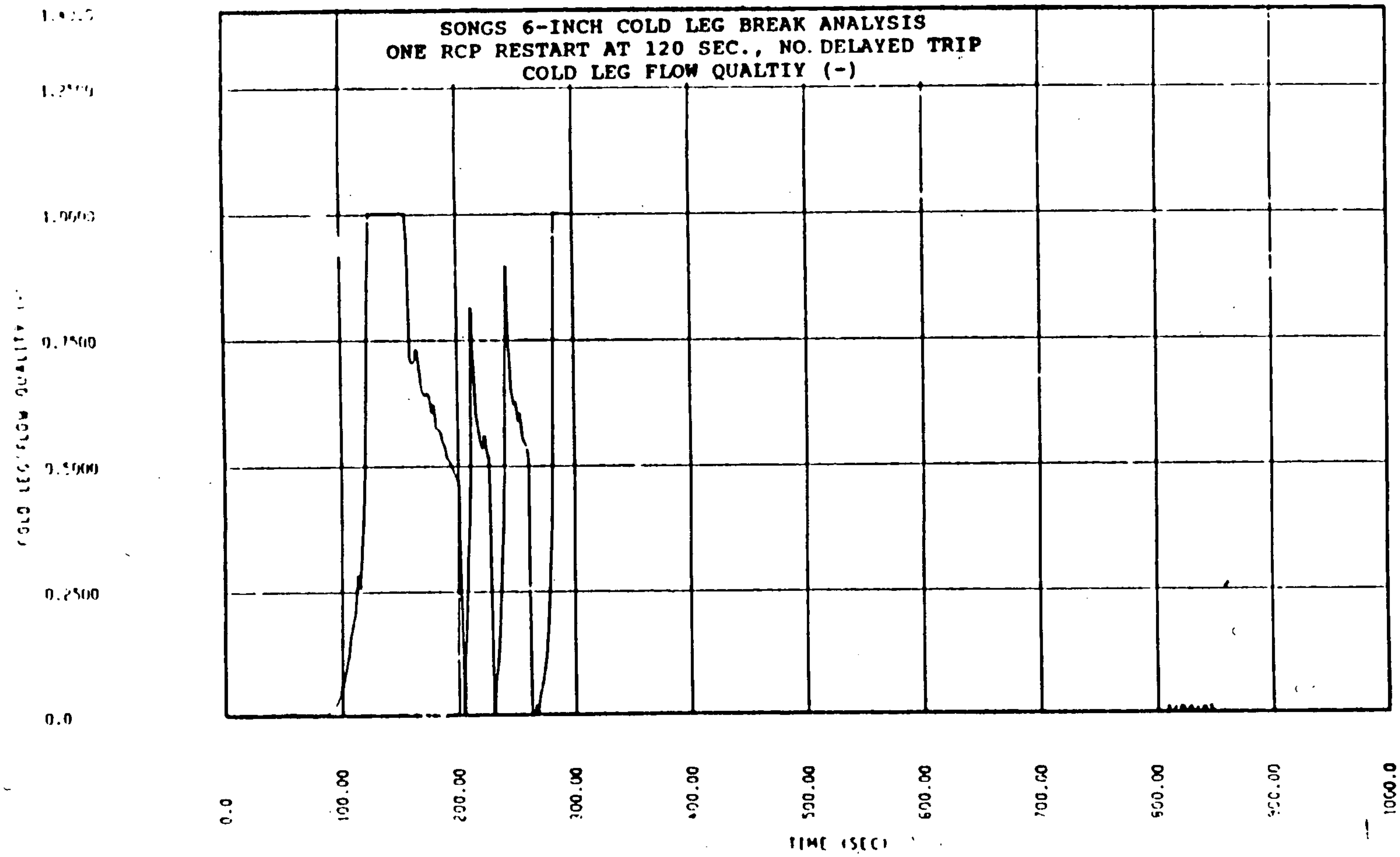


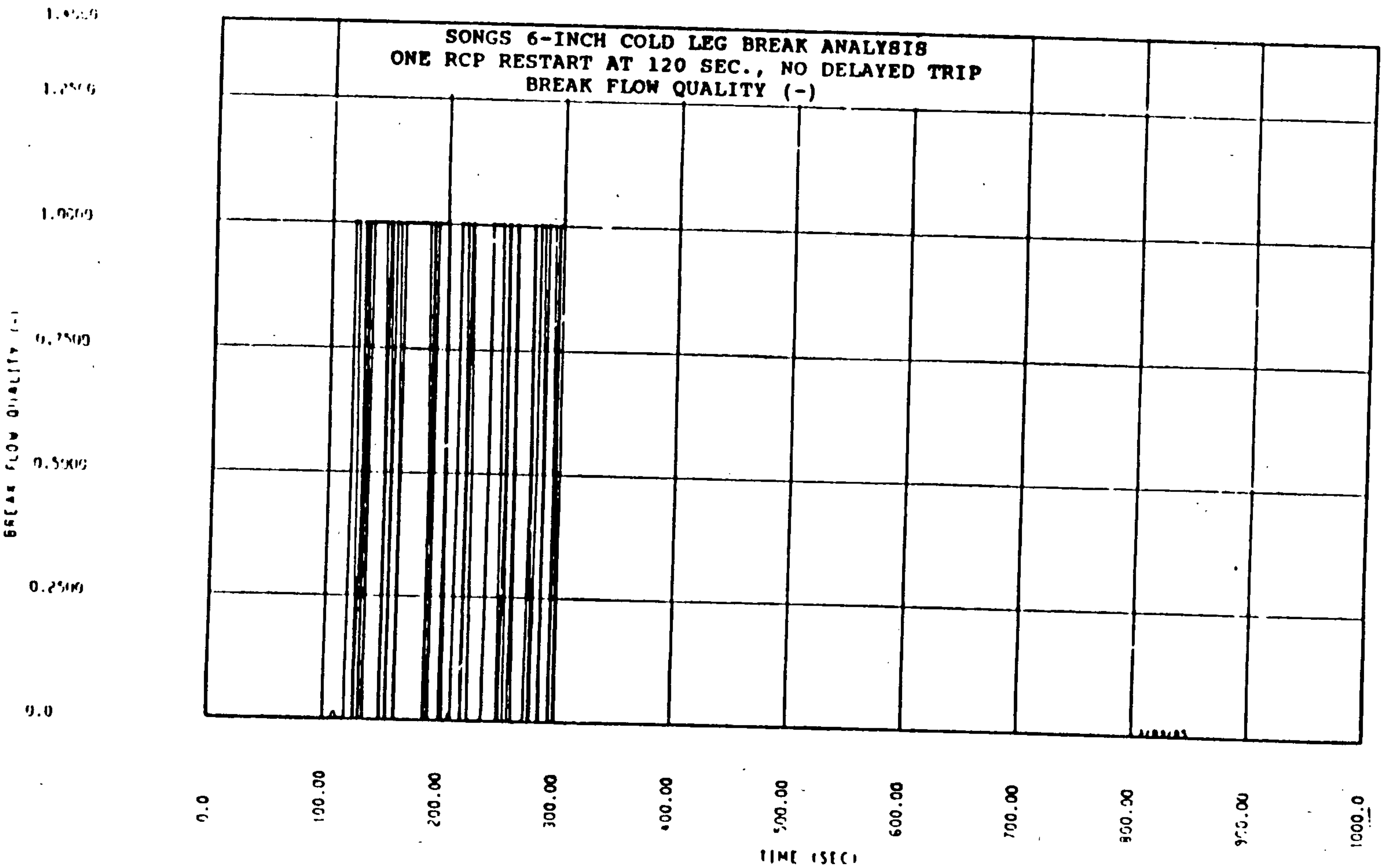
SONGS 6-INCH COLD LEG BREAK ANALYSIS
ONE RCP RESTART AT 120 SEC., NO DELAYED TRIP
DOWNCOMER MIXTURE LEVEL (FT)
40.000
35.000
30.000
25.000
0.0
100.00
300.00
400.00
500.00
600.00
700.00
800.00
900.00
1000.0
TIME (SEC)

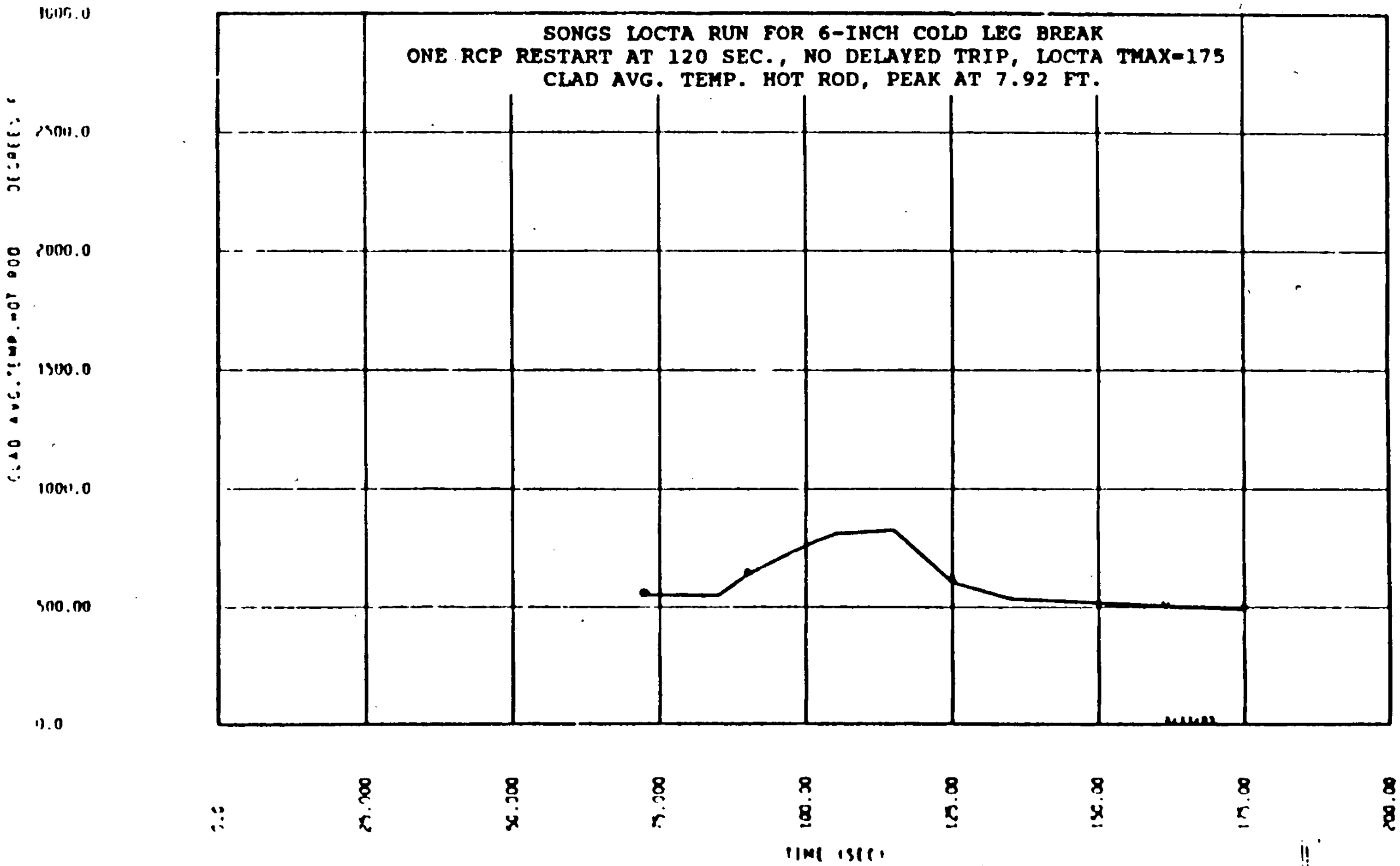

SONGS 6-INCH COLD LEG BREAK ANALYSIS
ONE RCP RESTART AT 120 SEC., NO DELAYED TRIP
LOOP SEAL MIXTURE LEVEL (FT)
25.000
20.000
15.000
10.000
5.0000
0.0
0.0
100.00
200.00
300.00
400.00
500.00
600.00
700.00
800.00
900.00
1000.0
TIME (SEC)


SONGS 6-INCH COLD LEG BREAK ANALYSIS
ONE RCP RESTART AT 120 SEC., NO DELAYED TRIP
BREAK MASS FLOWRATE (LBm/SEC)
4000.0
2000.0
1000.0
0.0
0.0
200.00
300.00
400.00
500.00
600.00
700.00
800.00
900.00
TIME (SEC)


SONGS 6-INCH COLD LEG BREAK ANALYSIS
ONE RCP RESTART AT 120 SEC., NO DELAYED TRIP
HOT LEG FLOW QUALITY (-)
1.2500
1.0000
0.7500
0.5000
0.2500
0.0
0.0
100.00
200.00
300.00
400.00
500.00
600.00
700.00
800.00
900.00
1000.0
TIME (SEC)

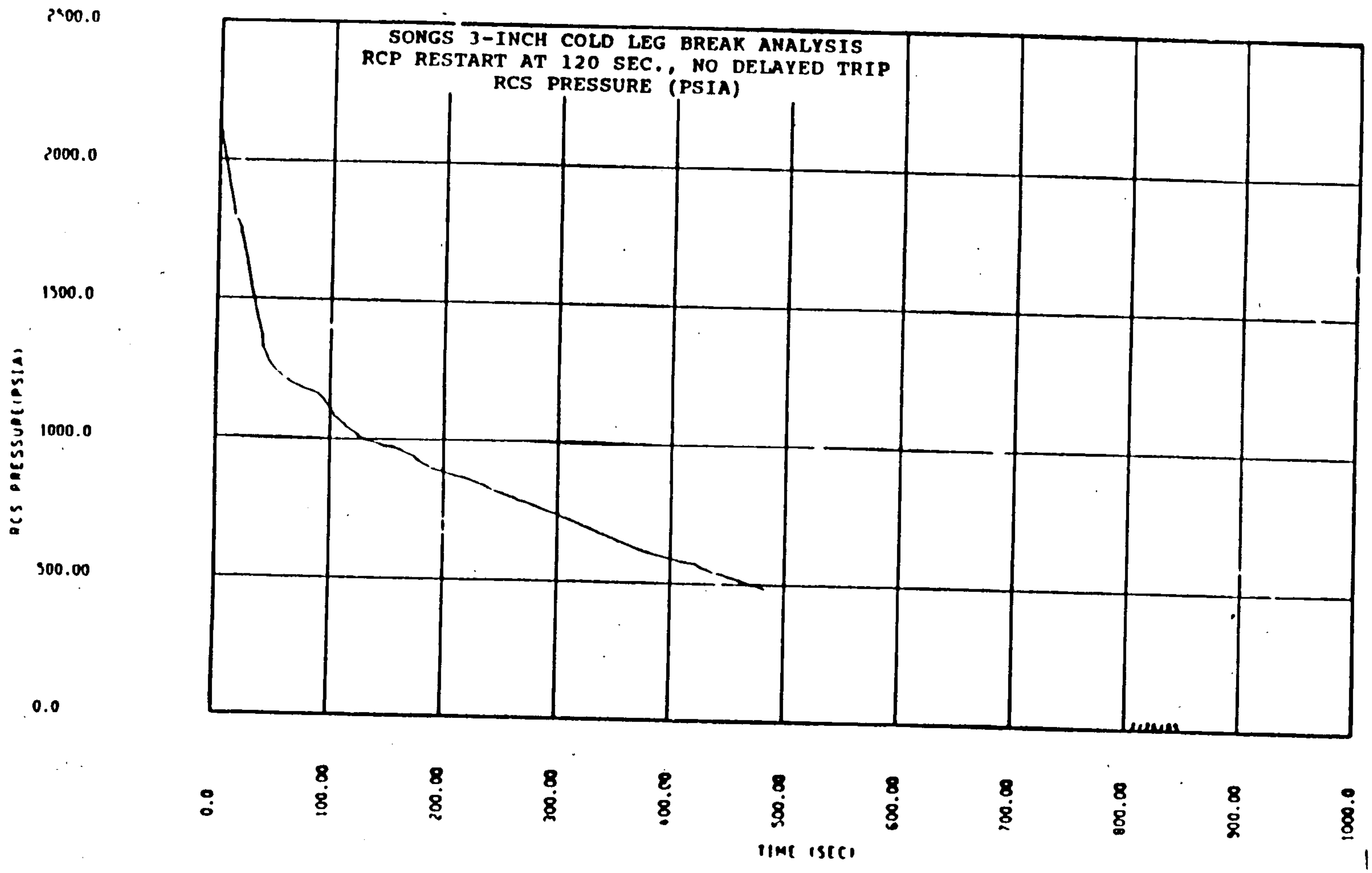

SONGS 6-INCH COLD LEG BREAK ANALYSIS
ONE RCP RESTART AT 120 SEC., NO. DELAYED TRIP
COLD LEG FLOW QUALTIY (-)
1.0000
0.7500
0.5000
0.2500
0.0
0.0
100.00
200.00
300.00
400.00
500.00
600.00
700.00
800.00
1000.0
TIME (SEC)

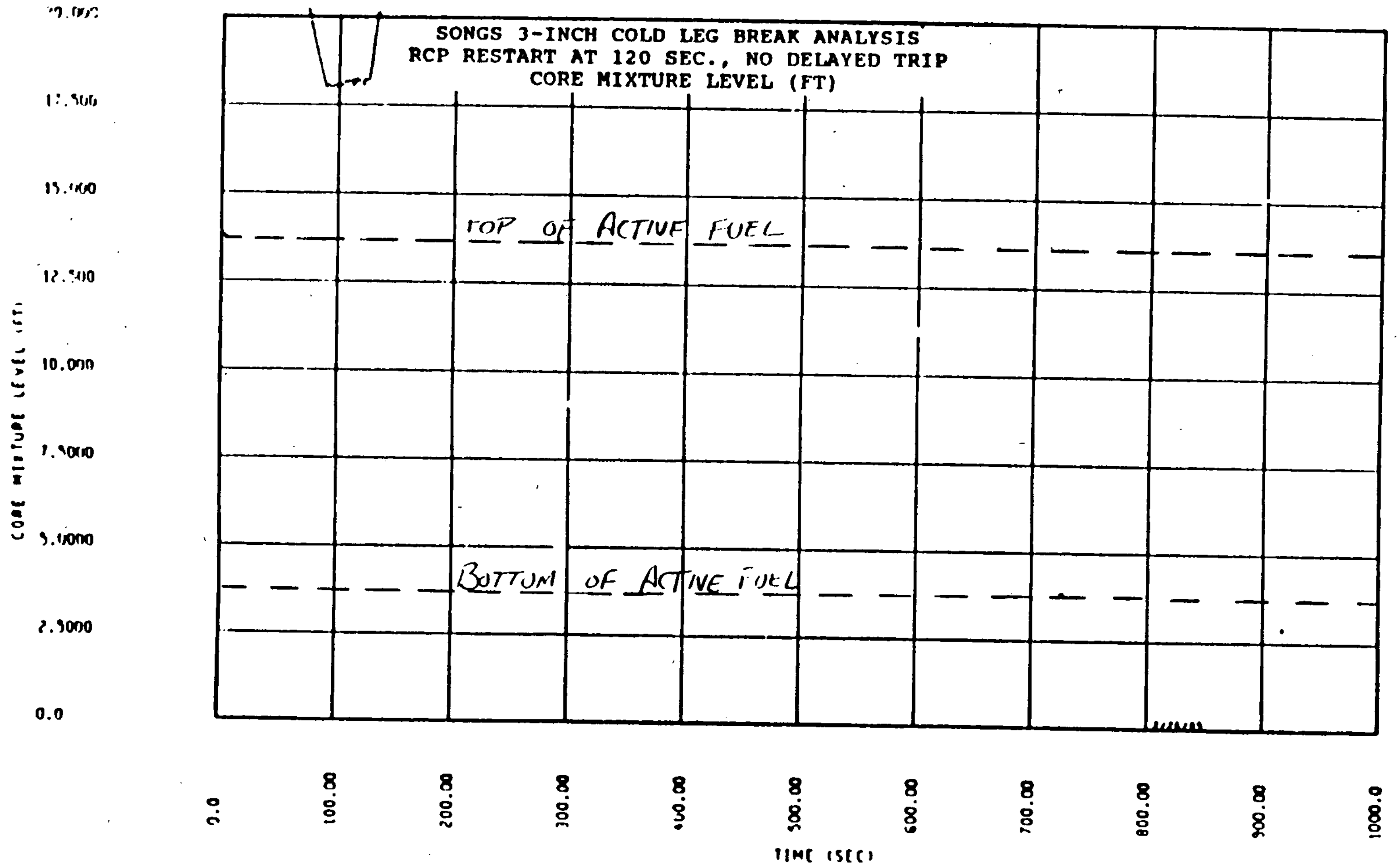

SONGS 6-INCH COLD LEG BREAK ANALYSIS
ONE RCP RESTART AT 120 SEC., NO DELAYED TRIP
BREAK FLOW QUALITY (-)
1.0000
0.7500
0.5000
0.2500
0.0
BREAK FLOW QUALITY (-)
0.0
100.00
200.00
300.00
400.00
500.00
600.00
700.00
800.00
900.00
1000.0
TIME (SEC)

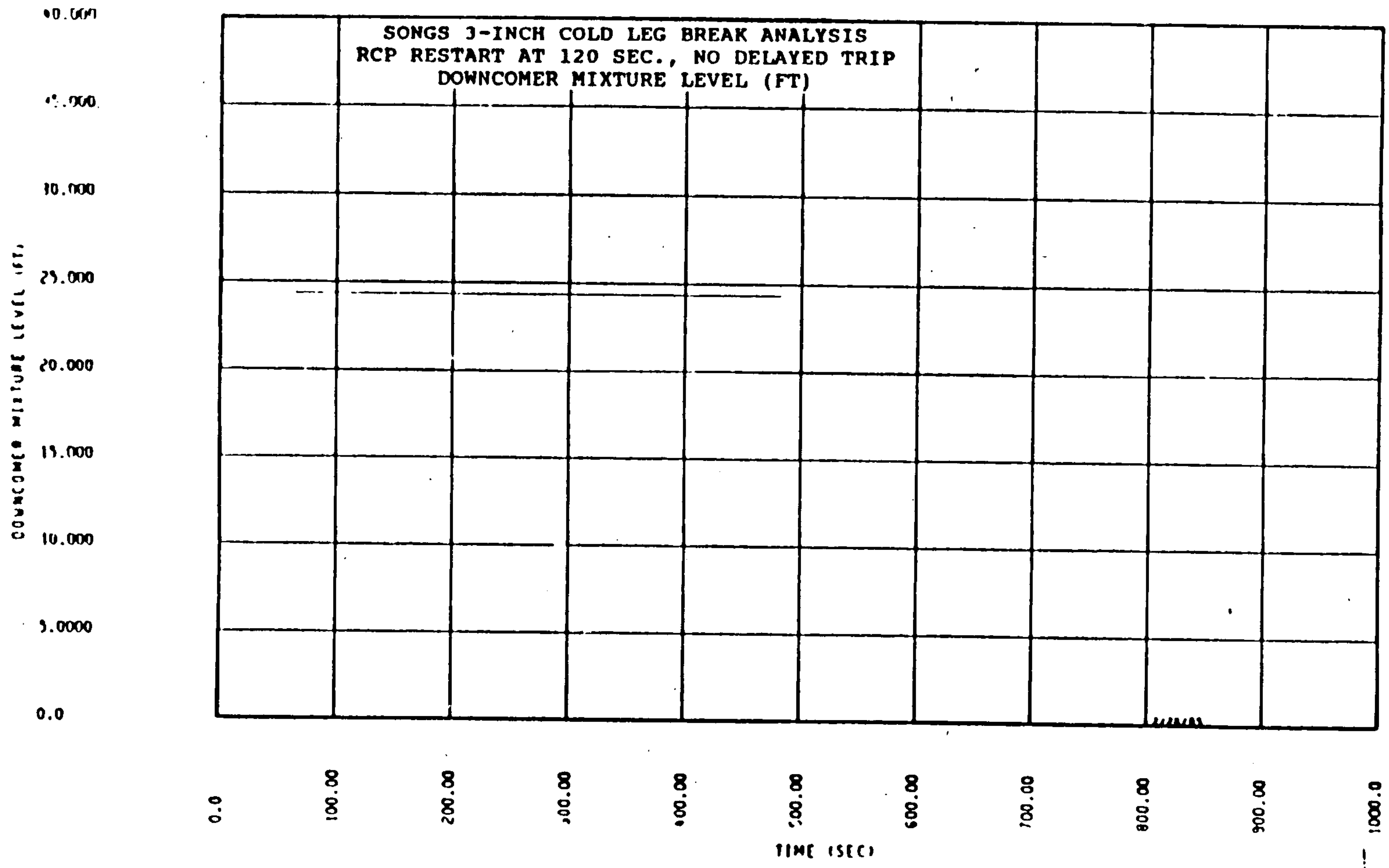

SONGS LOCTA RUN FOR 6-INCH COLD LEG BREAK
ONE RCP RESTART AT 120 SEC., NO DELAYED TRIP, LOCTA TMAX=175
CLAD AVG. TEMP. HOT ROD, PEAK AT 7.92 FT.
2500.0
2000.0
1500.0
1000.0
500.00
0.0

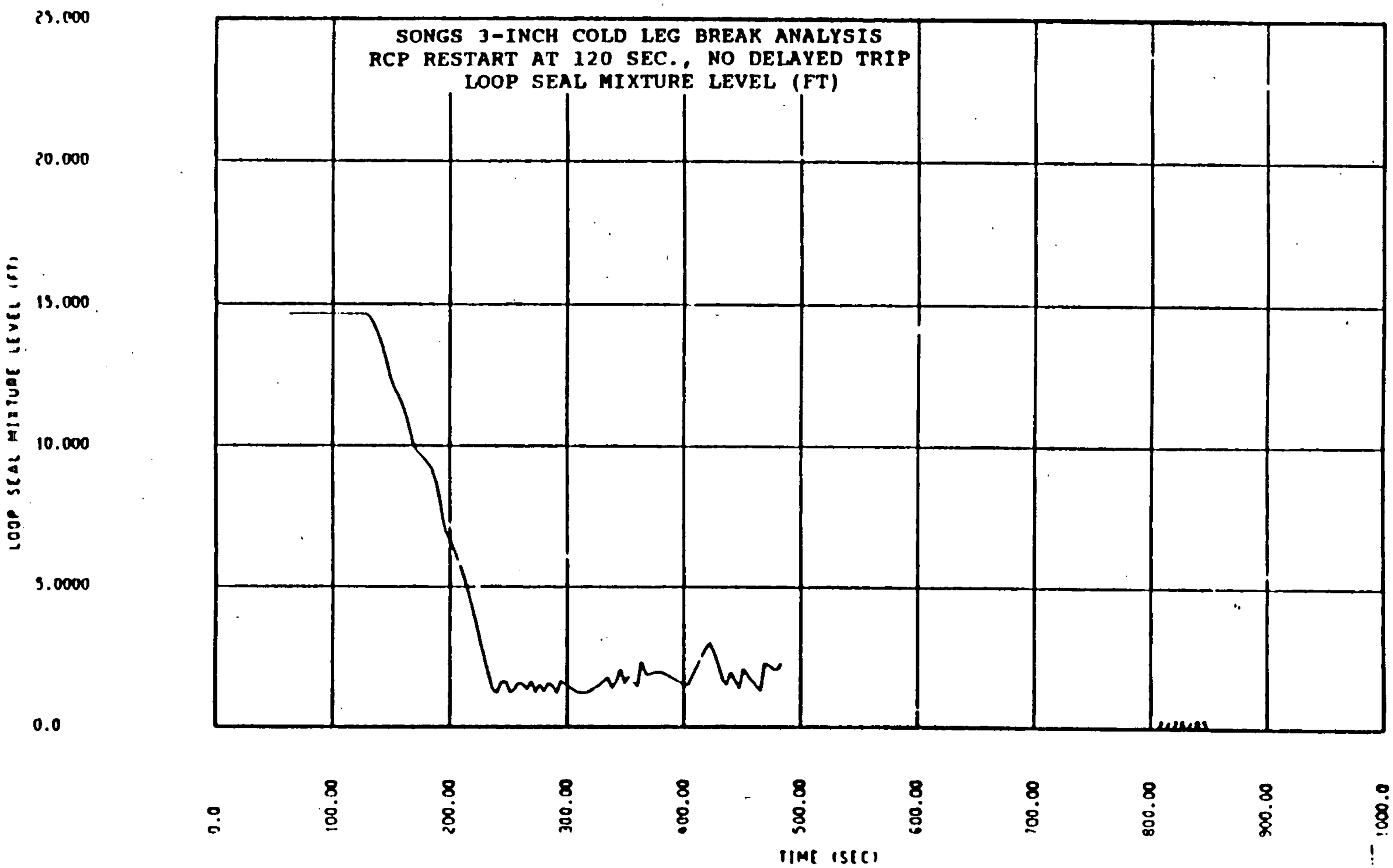
APPENDIX B

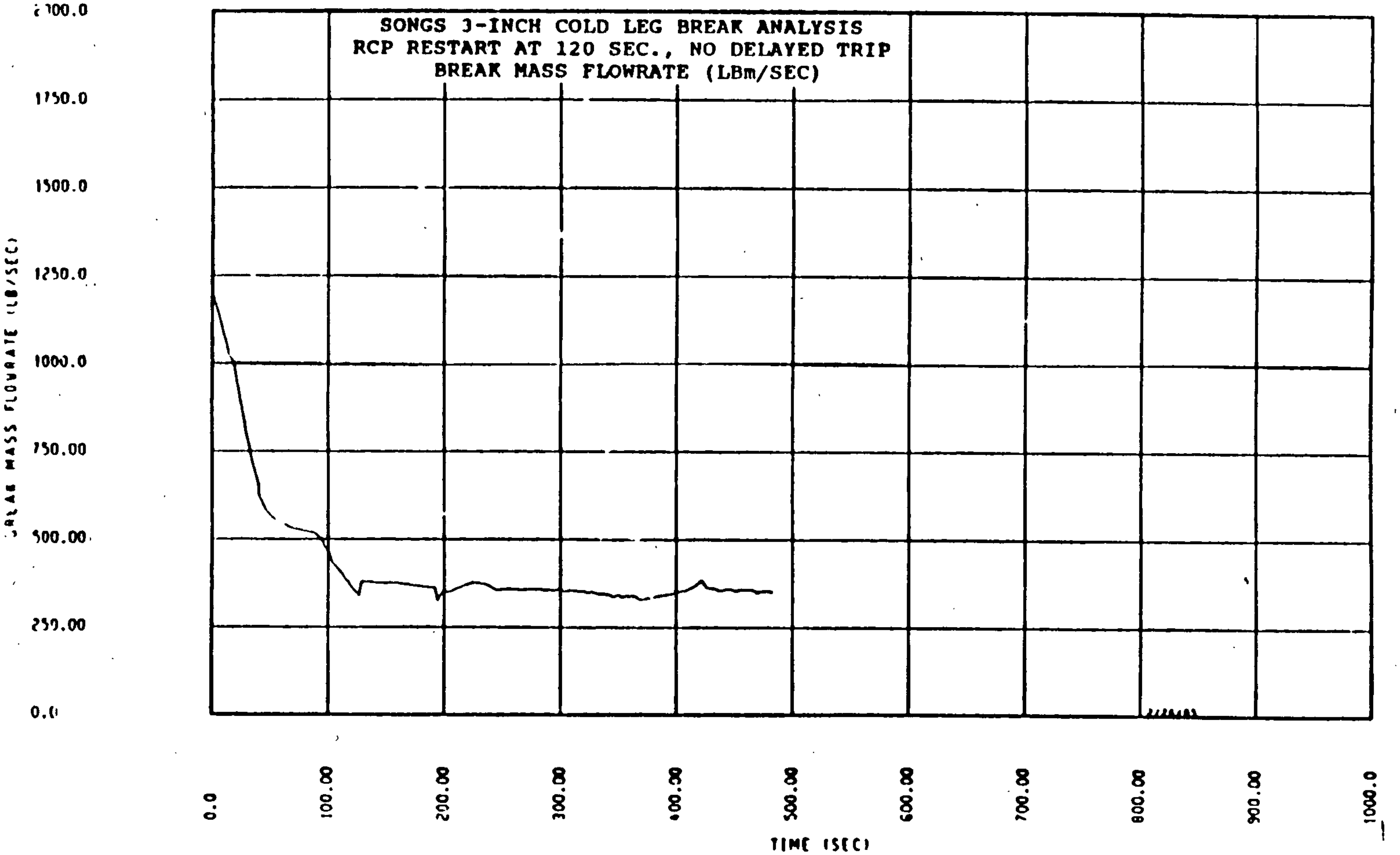
3-INCH SBLOCA FIGURES

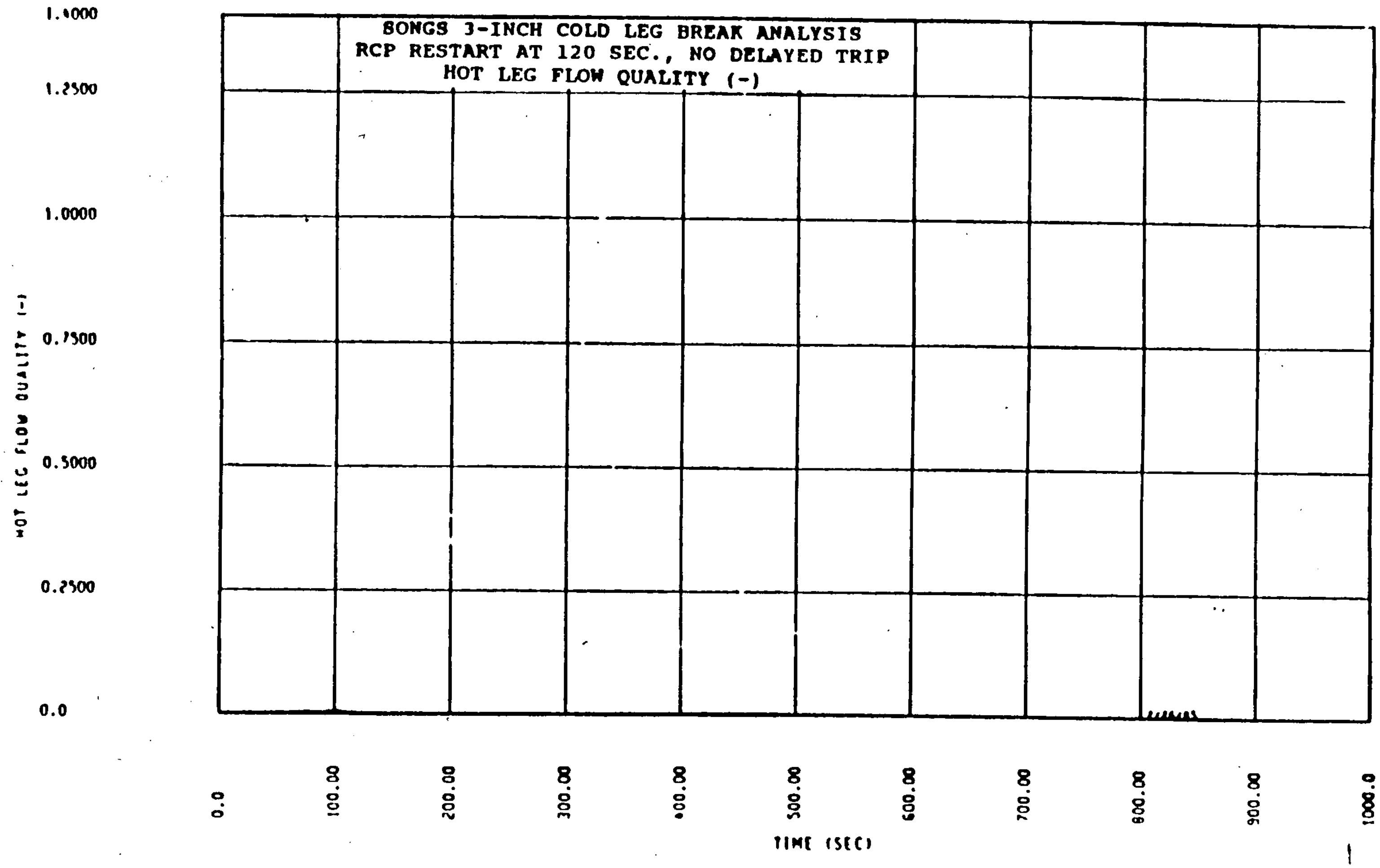

SONGS 3-INCH COLD LEG BREAK ANALYSIS
RCP RESTART AT 120 SEC., NO DELAYED TRIP
RCS PRESSURE (PSIA)
2000.0
1500.0
1000.0
500.00
0.0
0.0
100.00
200.00
300.00
400.00
500.00
600.00
700.00
800.00
900.00
1000.0
TIME (SEC)

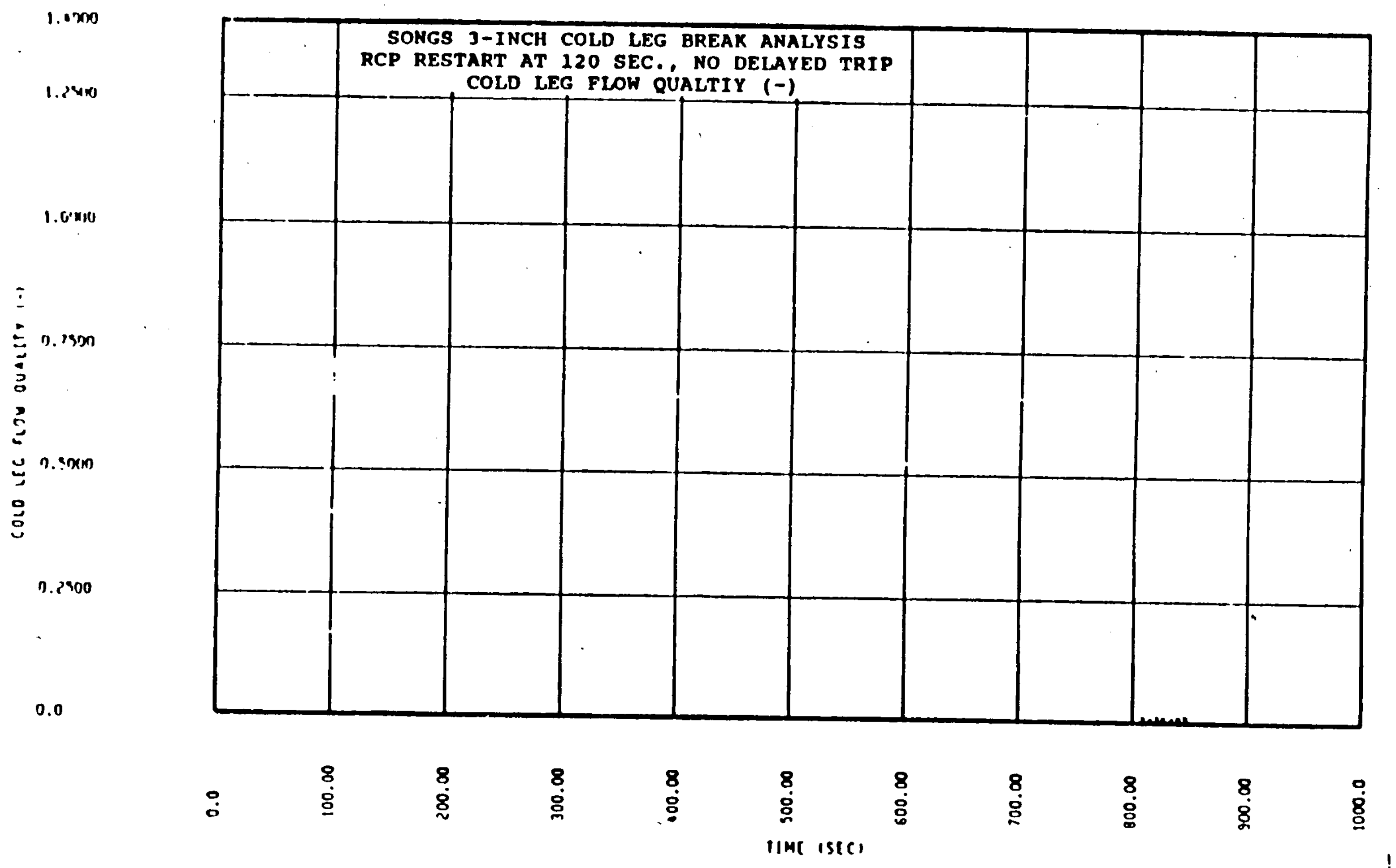

SONGS 3-INCH COLD LEG BREAK ANALYSIS
RCP RESTART AT 120 SEC., NO DELAYED TRIP
CORE MIXTURE LEVEL (FT)
TOP OF ACTIVE FUEL
BOTTOM OF ACTIVE FUEL
CORE MIXTURE LEVEL (FT)
0.0
2.5000
5.0000
7.5000
10.000
12.500
15.000
17.500
0.0
100.00
200.00
300.00
400.00
500.00
600.00
700.00
800.00
900.00
1000.0
TIME (SEC)

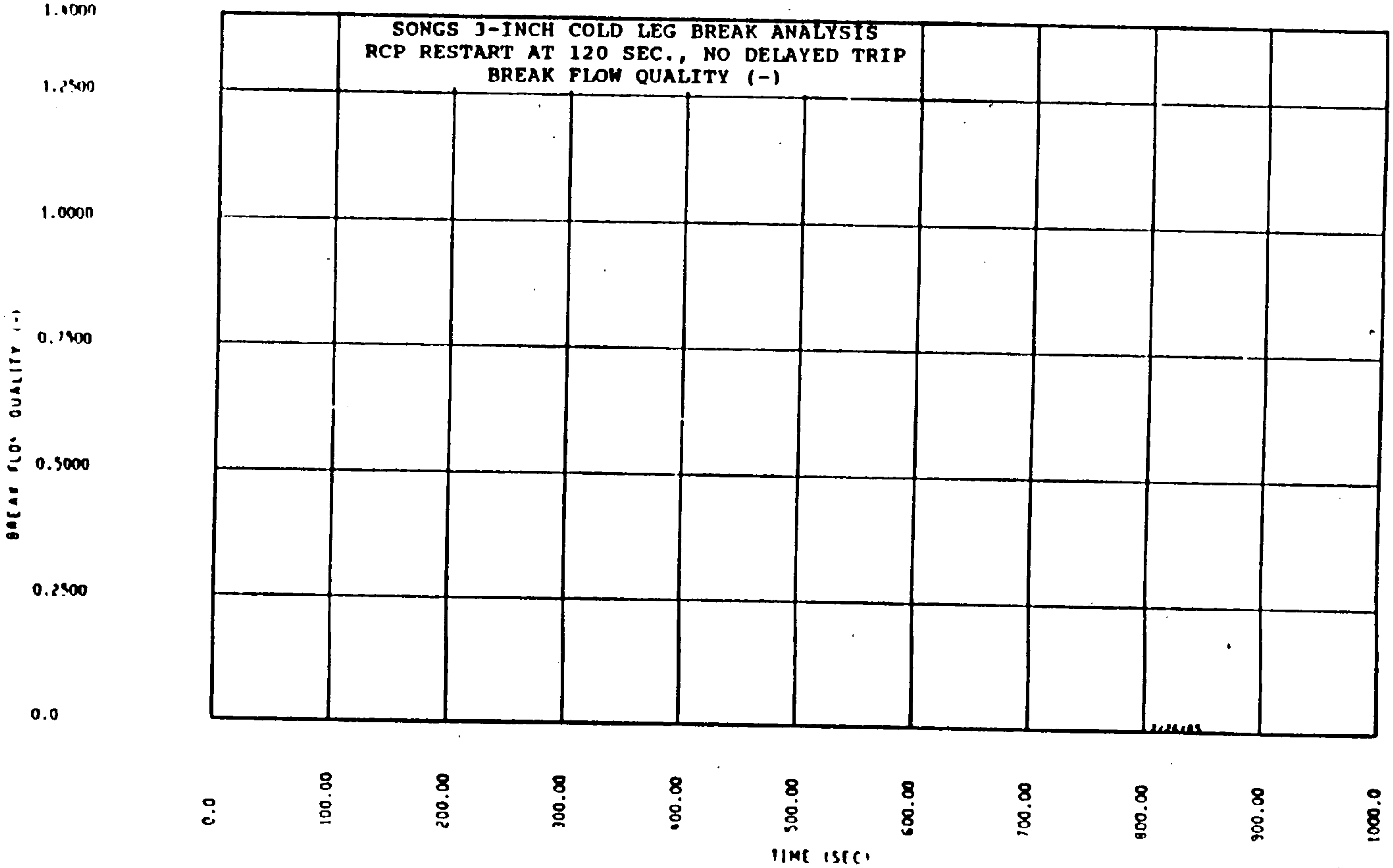

SONGS 3-INCH COLD LEG BREAK ANALYSIS
RCP RESTART AT 120 SEC., NO DELAYED TRIP
DOWNCOMER MIXTURE LEVEL (FT)
DOWNCOMER MIXTURE LEVEL (FT)
40.000
35.000
30.000
25.000
20.000
15.000
10.000
5.0000
0.0
0.0
100.00
200.00
300.00
400.00
500.00
600.00
700.00
800.00
900.00
1000.0
TIME (SEC)

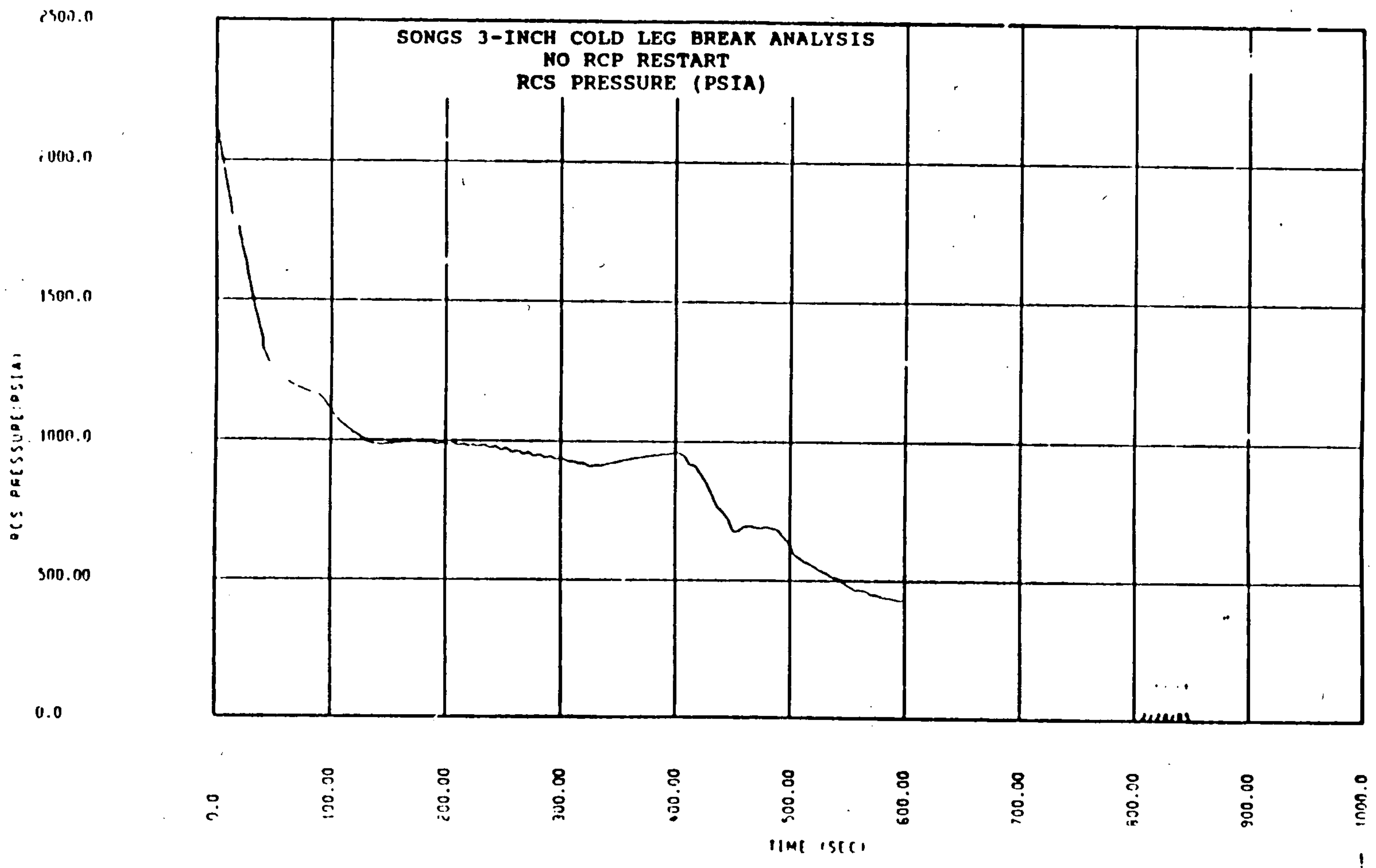

SONGS 3-INCH COLD LEG BREAK ANALYSIS
RCP RESTART AT 120 SEC., NO DELAYED TRIP
LOOP SEAL MIXTURE LEVEL (FT)
25.000
20.000
15.000
10.000
5.0000
0.0
LOOP SEAL MIXTURE LEVEL (FT)
0.0
100.00
200.00
300.00
400.00
500.00
600.00
700.00
800.00
900.00
1000.0
TIME (SEC)


SONGS 3-INCH COLD LEG BREAK ANALYSIS
RCP RESTART AT 120 SEC., NO DELAYED TRIP
BREAK MASS FLOWRATE (LBm/SEC)
BREAK MASS FLOWRATE (LB/SEC)
1750.0
1500.0
1250.0
1000.0
750.00
500.00
0.0
0.0
100.00
200.00
300.00
400.00
500.00
600.00
700.00
800.00
900.00
1000.0
TIME (SEC)

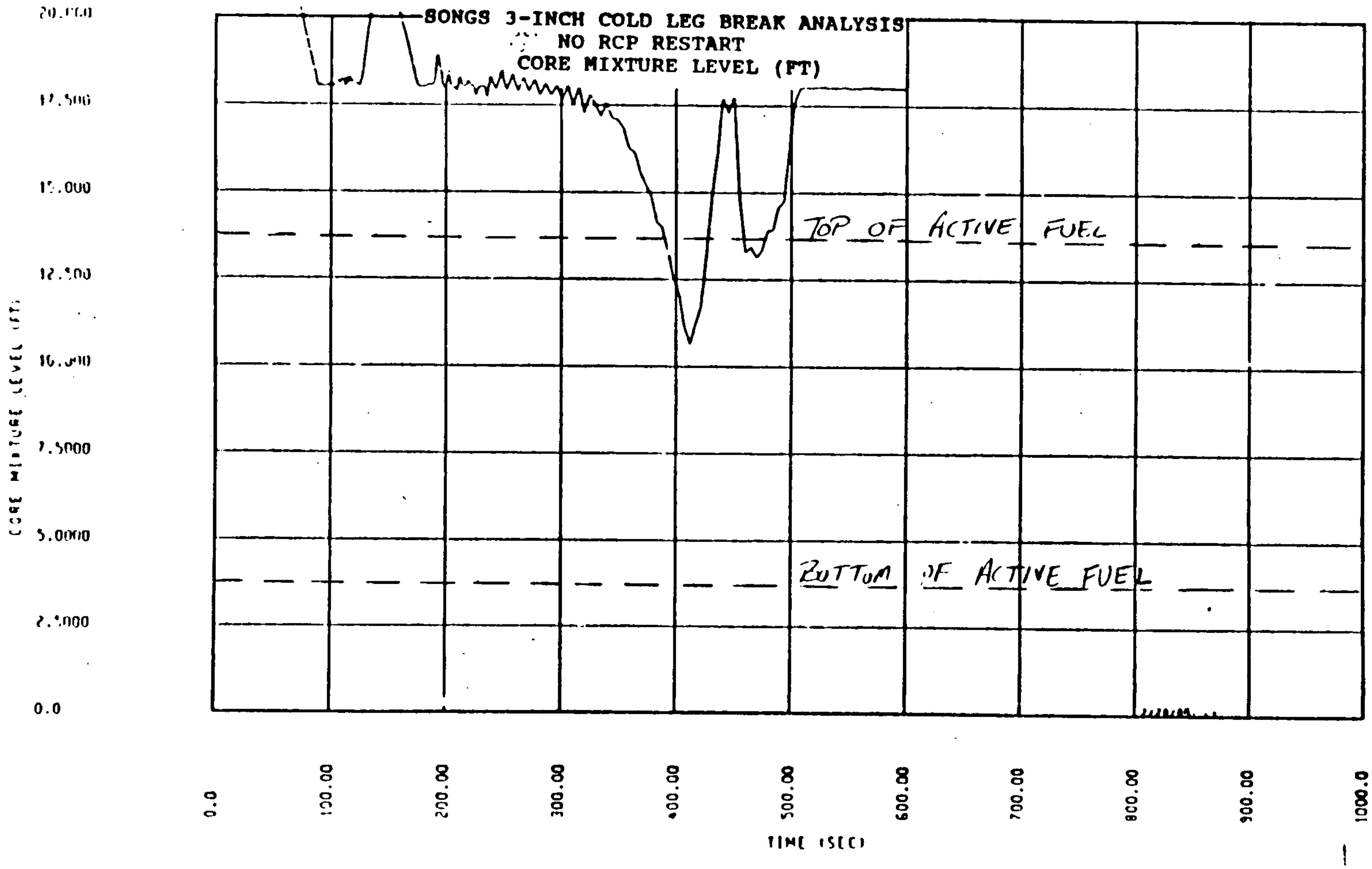

SONGS 3-INCH COLD LEG BREAK ANALYSIS
RCP RESTART AT 120 SEC., NO DELAYED TRIP
HOT LEG FLOW QUALITY (-)
HOT LEG FLOW QUALITY (-)
1.4000
1.2500
1.0000
0.7500
0.5000
0.2500
0.0
0.0
100.00
200.00
300.00
400.00
500.00
600.00
700.00
800.00
900.00
1000.0
TIME (SEC)

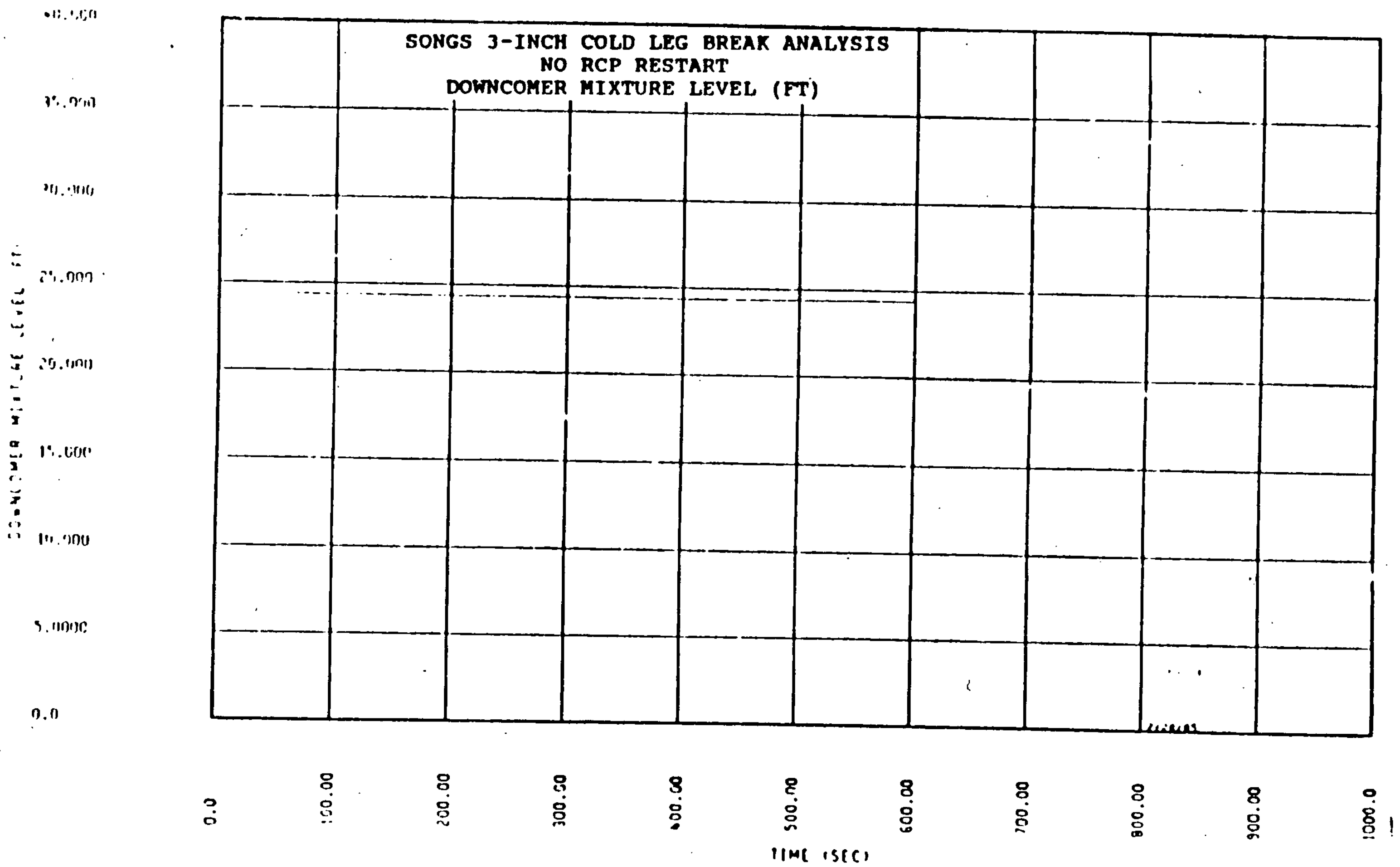

SONGS 3-INCH COLD LEG BREAK ANALYSIS
RCP RESTART AT 120 SEC., NO DELAYED TRIP
COLD LEG FLOW QUALTIY (-)
COLD LEG FLOW QUALITY (-)
0.0
0.2500
0.5000
0.7500
1.0000
1.2500
0.0
100.00
200.00
300.00
400.00
500.00
600.00
700.00
800.00
900.00
1000.0
TIME (SEC)

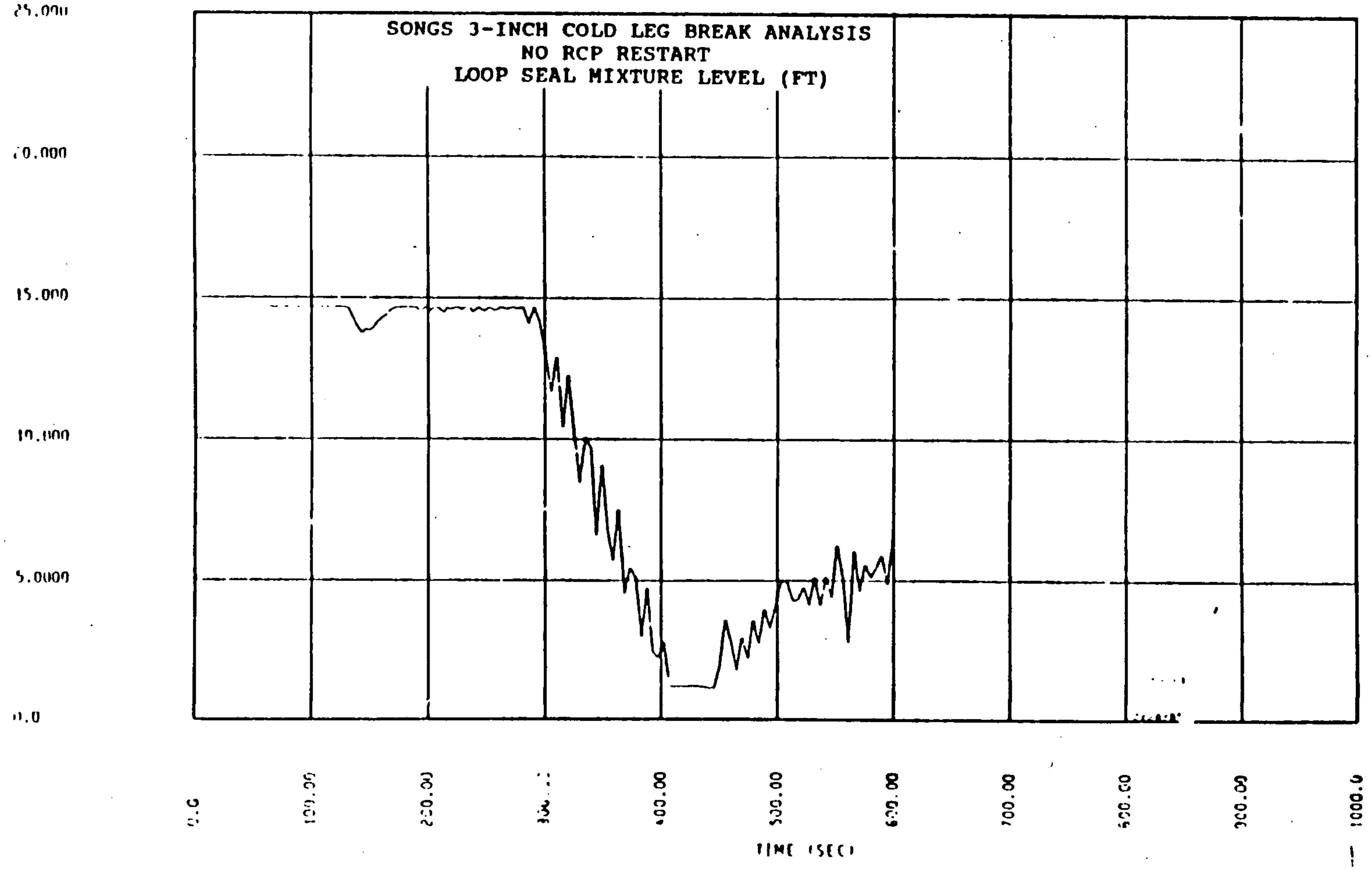

SONGS 3-INCH COLD LEG BREAK ANALYSIS
RCP RESTART AT 120 SEC., NO DELAYED TRIP
BREAK FLOW QUALITY (-)
1.2500
1.0000
0.7500
0.5000
0.2500
0.0
BREAK FLOW QUALITY (-)
0.0
100.00
200.00
300.00
400.00
500.00
600.00
700.00
800.00
900.00
1000.0
TIME (SEC)

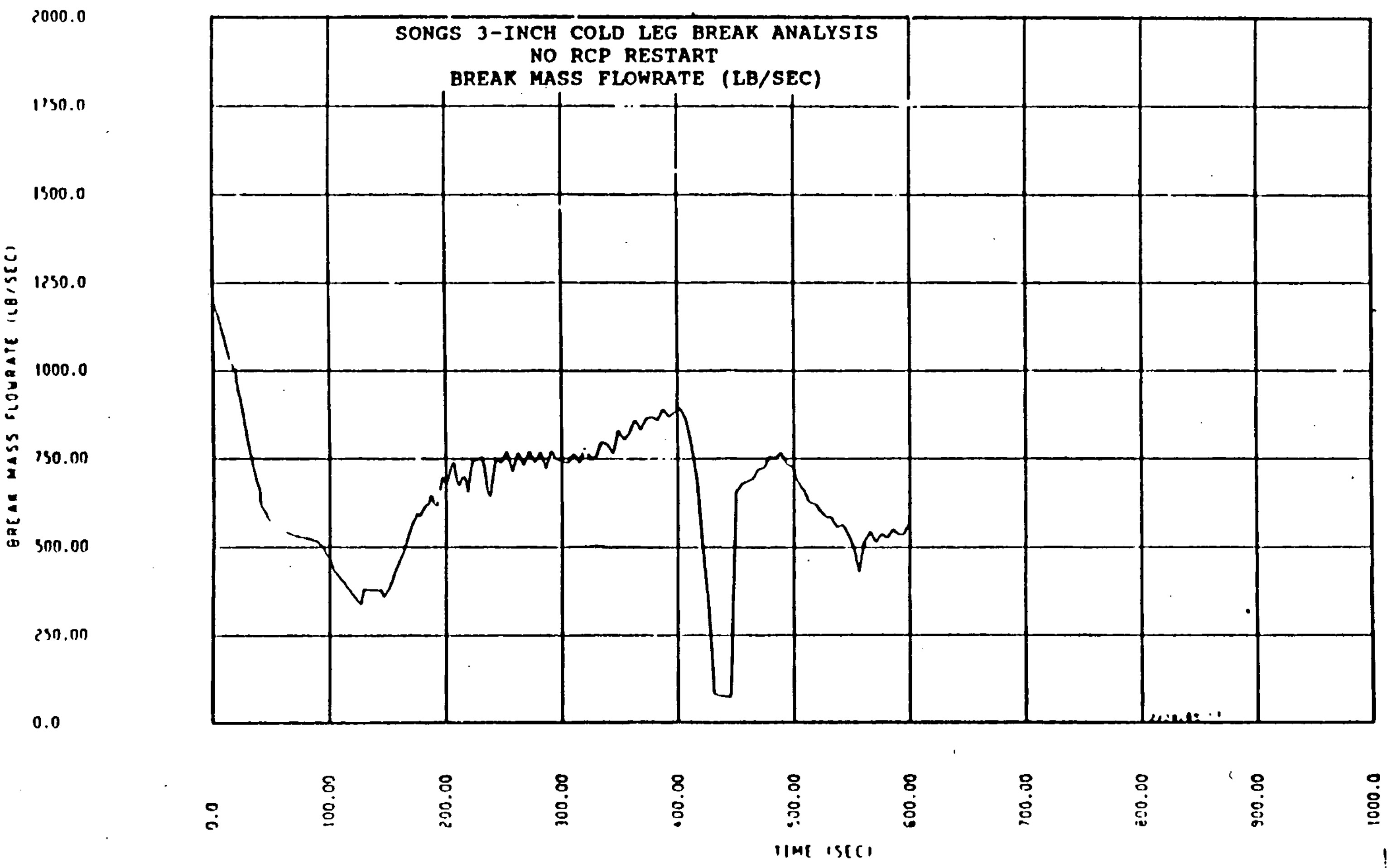


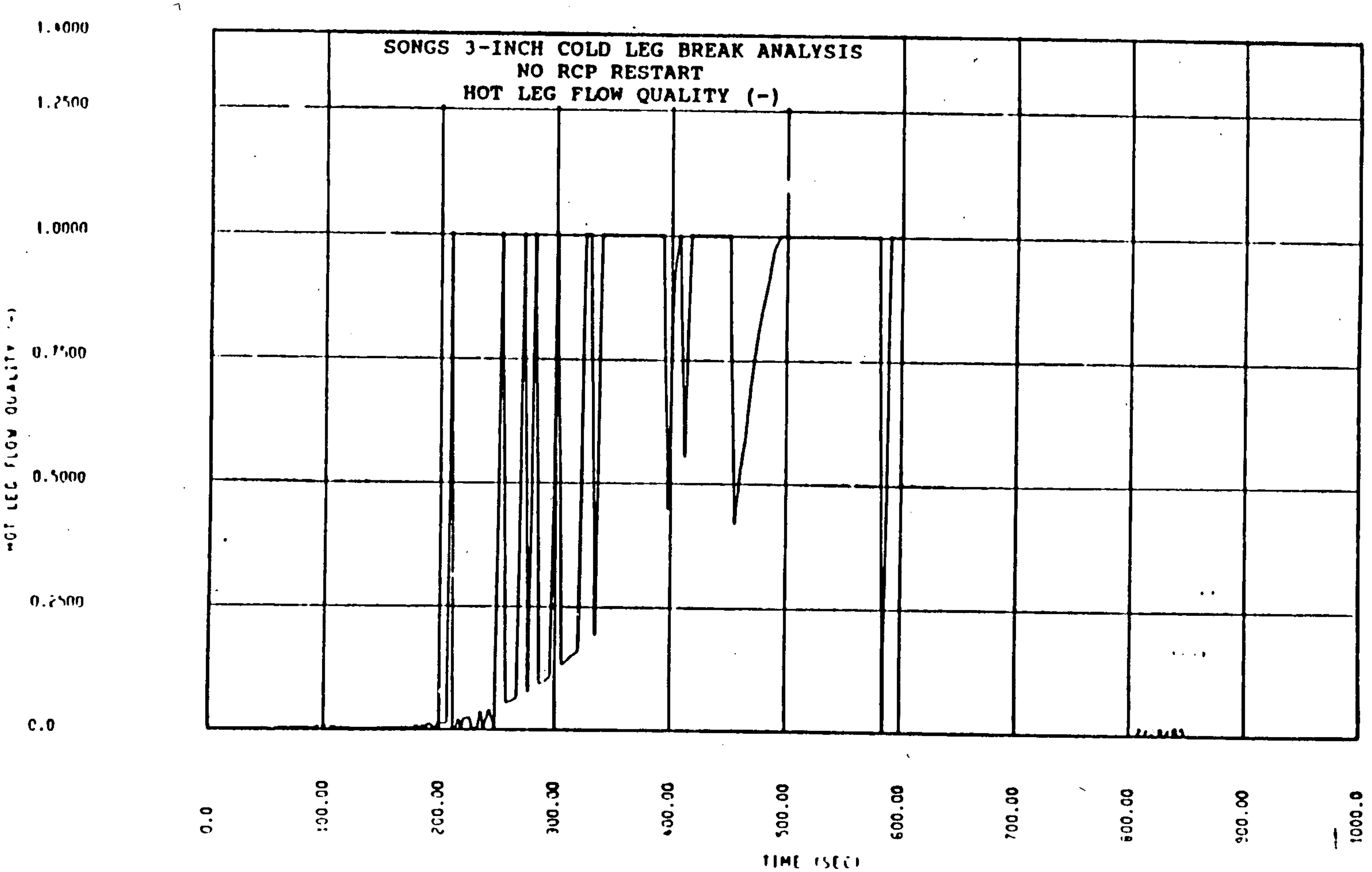
SONGS 3-INCH COLD LEG BREAK ANALYSIS
NO RCP RESTART
RCS PRESSURE (PSIA)

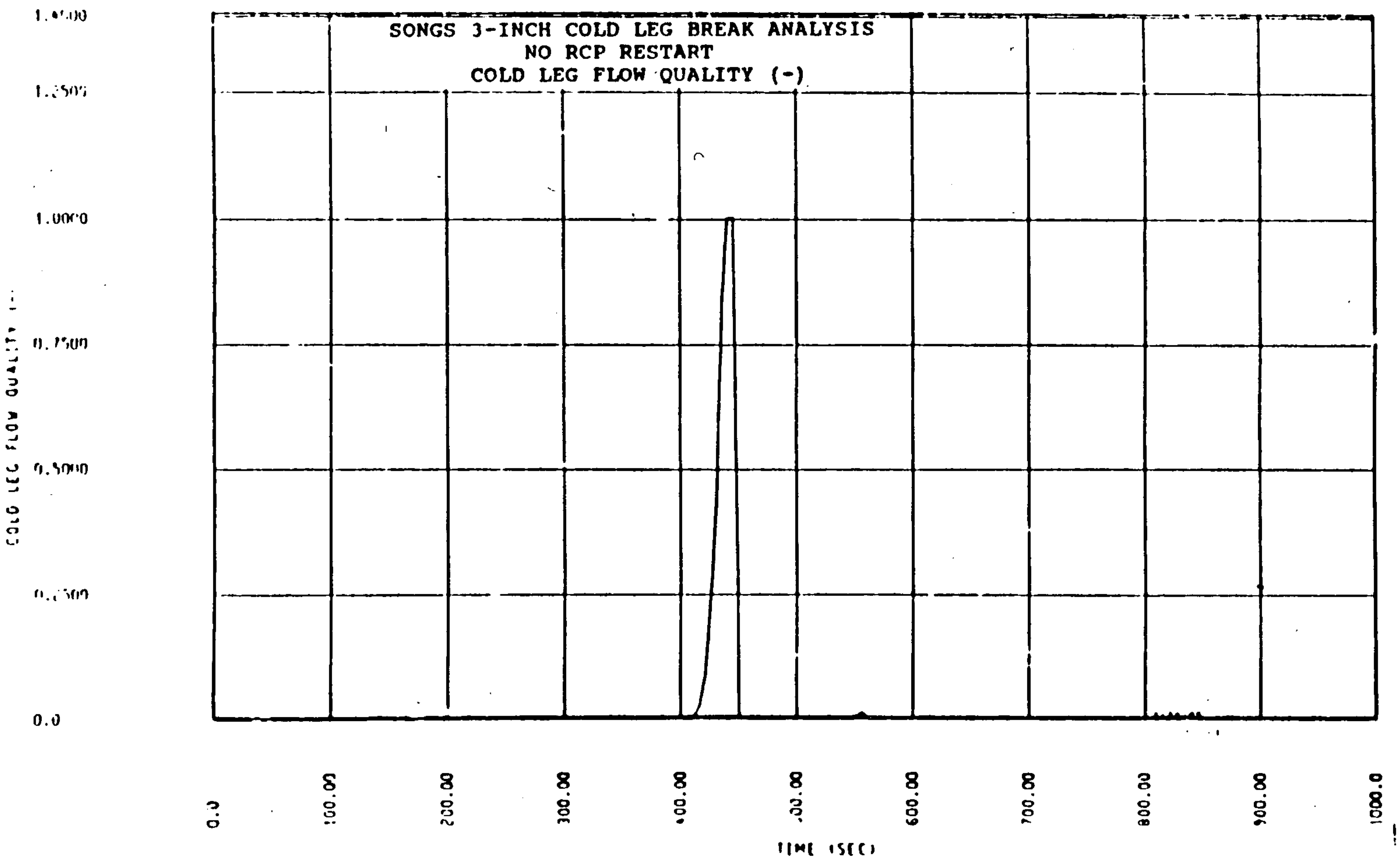

SONGS 3-INCH COLD LEG BREAK ANALYSIS
NO RCP RESTART
CORE MIXTURE LEVEL (FT)
TOP OF ACTIVE FUEL
BOTTOM OF ACTIVE FUEL
TIME (SEC)
0.0
100.00
200.00
300.00
400.00
500.00
600.00
700.00
800.00
900.00
1000.0
5.0000
0.0


SONGS 3-INCH COLD LEG BREAK ANALYSIS
NO RCP RESTART
DOWNCOMER MIXTURE LEVEL (FT)
0.0
5.0000
15.000
0.0
100.00
200.00
300.00
400.00
500.00
600.00
700.00
800.00
900.00
1000.0
TIME (SEC)

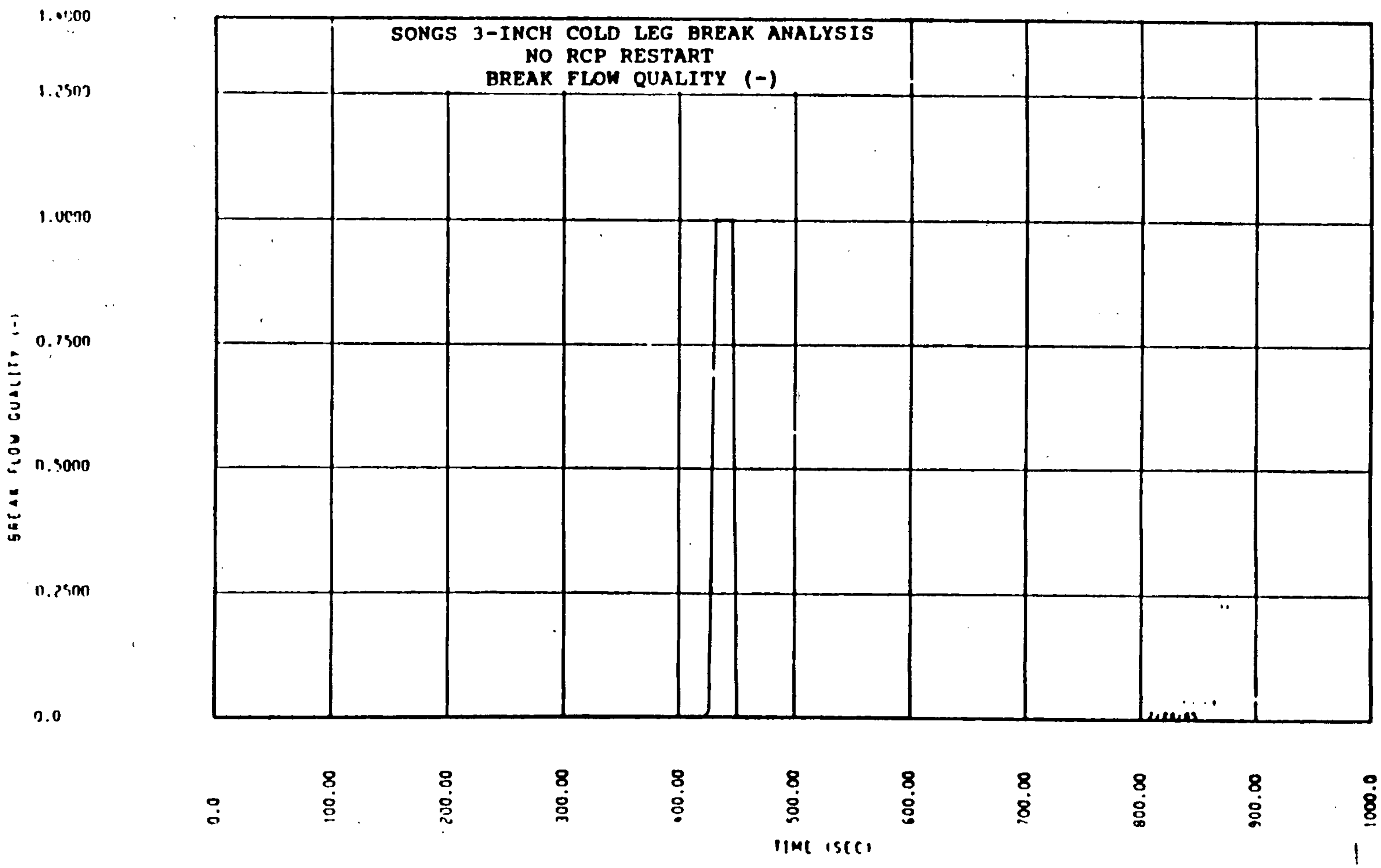

SONGS 3-INCH COLD LEG BREAK ANALYSIS
NO RCP RESTART
LOOP SEAL MIXTURE LEVEL (FT)
25.000
20.000
15.000
10.000
5.0000
0.0
0.0
100.00
200.00
300.00
400.00
500.00
600.00
700.00
800.00
900.00
1000.0
TIME (SEC)

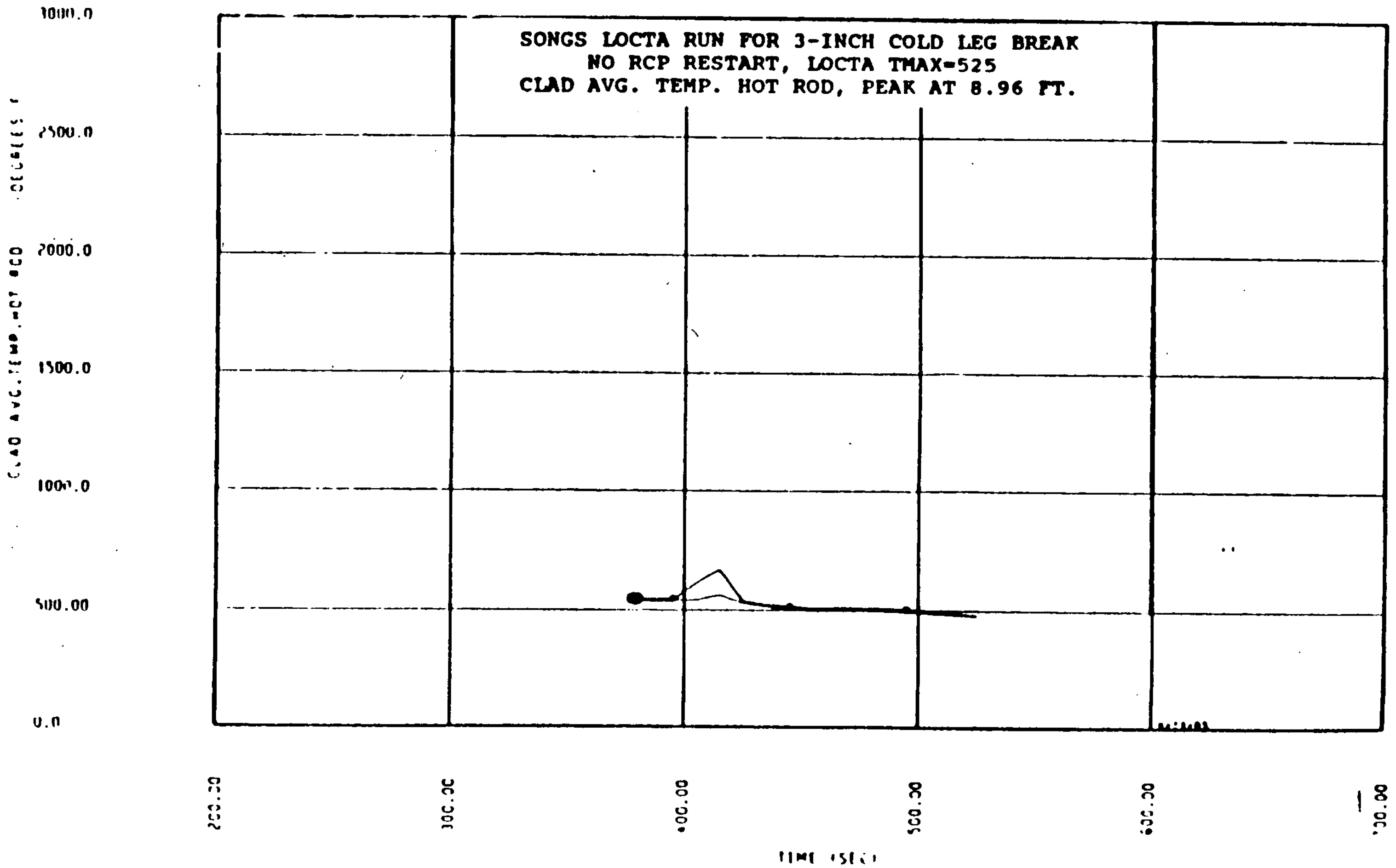

SONGS 3-INCH COLD LEG BREAK ANALYSIS
NO RCP RESTART
BREAK MASS FLOWRATE (LB/SEC)
2000.0
1750.0
1500.0
1250.0
1000.0
750.00
500.00
250.00
0.0
BREAK MASS FLOWRATE (LB/SEC)
0.0
100.00
200.00
300.00
400.00
500.00
600.00
700.00
800.00
900.00
1000.0
TIME (SEC)


SONGS 3-INCH COLD LEG BREAK ANALYSIS
NO RCP RESTART
HOT LEG FLOW QUALITY (-)
1.2500
1.0000
0.7500
0.5000
0.2500
0.0
0.0
100.00
200.00
300.00
400.00
500.00
600.00
700.00
800.00
900.00
1000.0
TIME (SEC)



SONGS 3-INCH COLD LEG BREAK ANALYSIS
NO RCP RESTART
COLD LEG FLOW QUALITY (-)
1.0000
0.7500
0.5000
0.0
0.0
100.00
200.00
300.00
400.00
600.00
700.00
800.00
900.00
1000.0
TIME (SEC)


SONGS 3-INCH COLD LEG BREAK ANALYSIS
NO RCP RESTART
BREAK FLOW QUALITY (-)
1.2500
1.0000
0.7500
0.5000
0.2500
0.0
0.0
100.00
200.00
300.00
400.00
500.00
600.00
700.00
800.00
900.00
1000.0
TIME (SEC)


SONGS LOCTA RUN FOR 3-INCH COLD LEG BREAK
NO RCP RESTART, LOCTA TMAX=525
CLAD AVG. TEMP. HOT ROD, PEAK AT 8.96 FT.
3000.0
2500.0
2000.0
1500.0
1000.0
500.00
0.0
400.00
500.00
600.00

STEAM GENERATOR TUBE RUPTURE

EFFECTIVE DATE NOV 21 1984

PURPOSE

The purpose of this instruction is to provide the diagnostics to enable confirmation of a STEAM GENERATOR TUBE RUPTURE, the initiation of RCS cooldown and depressurization concurrent with steam header depressurization to the point of placing RHR in service, and to minimize the release of radioactivity. Additionally this instruction directs the implementation of procedures to ensure long term shutdown and cooling of the reactor.

SYMPTOMS

A reactor trip and safety injection has occurred. Electrical power is available and functioning of emergency systems has been checked. One or more of the following indicates a possible SG tube rupture:

Radiation monitors are above alarm setpoints or abnormally high:

- ORMS R 1215 - air ejector monitor
- ORMS R 1216 - SG blowdown monitor
- R 1256 A and B east steam header monitors
  OR
  R 1258 A and B west steam header monitors

Level in at least one SG is rising uncontrolled.

STEAM GENERATOR TUBE RUPTURE

STEP	ACTION/EXPECTED RESPONSE	RESPONSE NOT OBTAINED

NOTE: A foldout page is attached which provides guidance that may be required at any time during implementation of this instruction.

STEP	ACTION/EXPECTED RESPONSE	RESPONSE NOT OBTAINED
1	ATTEMPT To Identify Ruptured SG(s):	
	a. Check SG narrow range level for - AN UNEXPECTED LEVEL RISE IN ANY SG.	a. IF ruptured SG is NOT immediately identified, THEN 1) Request individual SG activity samples. 2) Continue with this procedure while monitoring SG blowdown activity on ORMS 1216 as follows: - Override and open blowdown sample isolation valves at the Containment Isolation Panel: SV-122. SV-123. SV-124. - Alternately select individual SG's and purge the lines at the ORMS 1216 drawer to identify the ruptured SG(s).
	b. Attempt to maintain 10% narrow range level in ruptured SG by throttling AFW flow.	

STEAM GENERATOR TUBE RUPTURE

STEP	ACTION/EXPECTED RESPONSE	RESPONSE NOT OBTAINED
2	VERIFY AFW Pump Status:	
	a. Ensure motor-driven AFW pump breaker - CLOSED.	a. IF motor-driven AFW pump will NOT START, THEN 1) Do NOT STOP turbine-driven AFW pump. 2) Go to step 3.
	b. Stop turbine-driven AFW pump: 1) Depress AFW system MANUAL mode and RESET pushbuttons. 2) Depress STOP pushbutton. 3) Verify pump discharge pressure - DECREASING.	b. Position pump valves for turbine shutdown.
	c. Verify total AFW flow CAPABILITY - GREATER THAN 165 GPM.	c. IF NOT able to obtain total feed flow CAPABILITY - GREATER THAN 165 GPM, THEN depress AUTO and INITIATE pushbuttons for turbine-driven AFW pump.

STEAM GENERATOR TUBE RUPTURE

STEP	ACTION/EXPECTED RESPONSE	RESPONSE NOT OBTAINED
3	CHECK Pressurizer PORV's And Block Valves:	
	a. Ensure power to block valves - AVAILABLE.	
	b. Check RCS pressure - LESS THAN 2190 PSIG.	b. 1) Ensure proper cycling of pressurizer PORV's. 2) Go to step 4.
	c. Check pressurizer PORV's - CLOSED: CV 545. CV 546.	c. Close associated PORV block valve: CV 531 for CV 545. CV 530 for CV 546.
4	VERIFY Steam Dump Mode:	
	a. Ensure steam dump mode selector switch in - PRESSURE CONTROL, ATMOS AND CONDENSER.	
	b. Ensure steam dump controller PC 418A in - AUTO, SET AT 930 PSIG.	
5	VERIFY SG Blowdown Status:	
	Ensure SG blowdown - NOT IN PROGRESS.	

STEAM GENERATOR TUBE RUPTURE

STEP	ACTION/EXPECTED RESPONSE	RESPONSE NOT OBTAINED
6	VERIFY Offsite Power Available: Verify 220 KV switchyard - ENERGIZED.	Notify the SCE Energy Resource Supervisor.
7	ESTABLISH Steam Generator Levels: a. Check all SG narrow range levels - GREATER THAN 26%.	a. Maintain feed flow to each SG with level less than 26% - LESS THAN 150 GPM, AND Maintain COMBINED feed flow CAPABILITY - GREATER THAN 165 GPM.
	b. Adjust AFW flow to establish and maintain non-ruptured SG narrow range levels - APPROXIMATELY 50%.	
	c. Adjust AFW flow to the ruptured SG to control level - ABOVE 10% AND ON NARROW RANGE SCALE.	

STEAM GENERATOR TUBE RUPTURE

STEP	ACTION/EXPECTED RESPONSE	RESPONSE NOT OBTAINED

CAUTION

If offsite power is lost after SI is reset, manual SI initiation will be necessary to load safeguard equipment onto the diesel powered 4 KV busses.

STEP	ACTION/EXPECTED RESPONSE	RESPONSE NOT OBTAINED
8	<u>RESET SI:</u>	
	a. Reset SI at SLSS surveillance panels.	a. Reset SI at the sequencers.
	b. Ensure MCC lockout switches - RESET.	
9	<u>CHECK SG Tube Rupture Indications:</u>	
	Check ruptured SG - IDENTIFIED.	• Check containment conditions: 1) Pressure - LESS THAN 1.4 PSIG, AND NOT INCREASING. 2) Radiation on R 1255 and R 1257 - LESS THAN ALARM POINT, AND NOT INCREASING. 3) Sump level - LESS THAN ALARM SET POINT, AND NOT INCREASING (A-12). <u>IF</u> any containment condition is HIGH, <u>THEN</u> go to S01-1.0-20, LOSS OF REACTOR COOLANT.

STEAM GENERATOR TUBE RUPTURE

STEP	ACTION/EXPECTED RESPONSE	RESPONSE NOT OBTAINED
10	ESTABLISH Auxiliary Electrical Alignment:	
	a. Verify 220 KV switchyard - ENERGIZED.	a. Go to step 14.
	b. Verify 4KV busses 1C and 2C - ENERGIZED FROM THE SWITCHYARD.	b. Implement S01-1.0-61, LOSS OF ALL AC POWER RECOVERY, step 15, to energize 1C and 2C from switchyard.
	c. Energize 4 KV busses: 1A. 1B.	

SEE INSERT A

STEAM GENERATOR TUBE RUPTURE

STEP	ACTION/EXPECTED RESPONSE	RESPONSE NOT OBTAINED

CAUTION
=======

Depressurizing the RCS may result in steam voiding in the upper head and rapid filling of the pressurizer.

If the PRT rupture disk is blown, abnormal containment conditions may not be reliable indications of a LOCA.

STEP	ACTION/EXPECTED RESPONSE	RESPONSE NOT OBTAINED
11	<u>ESTABLISH Pressurizer Level:</u>	
	a. Check pressurizer level - LESS THAN 70%.	a. Go to step 12.
	b. Depressurize RCS to establish pressurizer level: 1) Open one pressurizer PORV. 2) Establish pressurizer level at 70%. 3) Close the pressurizer PORV.	b. <u>IF</u> the PORV will <u>NOT</u> close, <u>THEN</u> close associated PORV block valve. CV 531 for CV 545. CV 530 for CV 546.
	c. Verify pressurizer level - STABLE.	c. <u>IF</u> pressurizer level continues to increase after closing the PORV, <u>THEN</u> close associated PORV block valve. CV 531 for CV 545. CV 530 for CV 546.

STEAM GENERATOR TUBE RUPTURE

STEP	ACTION/EXPECTED RESPONSE	RESPONSE NOT OBTAINED
12	ENERGIZE Pressurizer Heaters: Close pressurizer heater breakers.	

CAUTION

Pressurizer level may drop when RCP is started due to collapsing of bubble in upper head.

STEP	ACTION/EXPECTED RESPONSE	RESPONSE NOT OBTAINED
13	START At Least One RCP:	
	a. Implement SO1-4-3, REACTOR COOLANT PUMP (RCP) OPERATION (section B), to prepare for RCP restart.	
	b. Check that SG B has not been identified as ruptured.	b. Start RCP's A and C. IF Both RCP's A and C can be run, THEN go to step 14.
	c. Start RCP B.	c. Start RCP's A and C. IF No RCP will start, THEN continue with this procedure and start an RCP when conditions allow.

INSERT A

STEAM GENERATOR TUBE RUPTURE

CAUTION

If there is pressurizer level and a bubble in the upper head, the pressurizer level may drop when an RCP is restarted due to collapsing of upper head bubble.

---

11. CHECK IF RCP(s) SHOULD BE STARTED:

a. Check RCS subcooling based on core exit thermocouples - GREATER THAN 19°F.	a. Go to step 14 and continue procedure. When subcooling criterion met return to step 11.
b. Implement SO1-4-3, RCP operation (section B), to prepare for RCP restart.	
c. Check that SG B has not been identified as ruptured.	c. 1) Start RCP A. 2) Wait two minutes. 3) Start RCP C. IF both RCP A and RCP C can be run, THEN go to step 12.
d. Start RCP B.	d. 1) Start RCP A. 2) Wait two minutes. 3) Start RCP C. IF no RCP will start, THEN continue with this procedure and start an RCP when conditions allow.

CAUTION

Depressurizing the RCS without any RCPs running may result in steam voiding in the upper head and rapid filling of the pressurizer.

If the PRT rupture disk is blown, abnormal containment conditions may not be reliable indications of a LOCA.

---

12. ESTABLISH PRESSURIZER LEVEL:

a. Check pressurizer level - LESS THAN 50%.	a. Go to step 13.
b. Depressurize RCS to establish pressurizer level by: 1) Open normal pressurizer spray valve. 2) Establish pressurizer level at 50%. 3) Close normal pressurizer spray valve.	b. IF normal pressurizer spray is not available, THEN use one pressurizer PORV.
c. Verify pressurizer level - STABLE.	c. If pressurizer level continues to increase, check if PORVs are closed. IF any PORV cannot be closed, THEN close associated PORV block valve. CV531 for CV545. CV530 for CV546.

13. ENERGIZE PRESSURIZER HEATERS:

a. Close pressurizer heater breakers.

STEAM GENERATOR TUBE RUPTURE

STEP	ACTION/EXPECTED RESPONSE	RESPONSE NOT OBTAINED
14	<u>POSITION Charging Flow Through The SI Cold Leg Injection Lines:</u> a. Position RCP seal supply flow controllers in - MANUAL, and maintain previous valve position: FC 1115 A. FC 1115 B. FC 1115 C. b. Open cold leg injection valves: 1) MOV 356. 2) MOV 357. 3) MOV 358. 4) MOV 18. 5) MOV 19.	

CAUTION

Do not exceed total charging pump flow of 600 GPM with two charging pumps or 330 GPM with one charging pump to avoid potential damage to charging pumps.

STEP	ACTION/EXPECTED RESPONSE	RESPONSE NOT OBTAINED
15	<u>ESTABLISH Charging Flow Capability:</u> a. Reset the non-running charging pump lockout. b. Start the second charging pump.	

STEAM GENERATOR TUBE RUPTURE

STEP	ACTION/EXPECTED RESPONSE	RESPONSE NOT OBTAINED
16	<u>ESTABLISH Flow Through The SI Cold Leg Injection Lines:</u> a. Close normal charging valves: FCV 1112. CV 304. b. Throttle RCP seal supply flow controllers to maintain pressurizer level - BETWEEN 25% AND 70%.	• <u>IF</u> unable to establish flow due to loss of instrument air, <u>THEN</u> position backup nitrogen supply for each controller IN SERVICE as follows: 1) Position aux nitrogen supply switch to ON. 2) Position aux position control switch to ON. 3) Position aux controller to obtain desired flow.

STEAM GENERATOR TUBE RUPTURE

STEP	ACTION/EXPECTED RESPONSE	RESPONSE NOT OBTAINED
17	CHECK IF SI System Pumps Can Be Stopped:	
	a. Check RCS pressure - STABLE OR INCREASING.	a. Go to SO1-1.0-20, LOSS OF REACTOR COOLANT.
	b. Check pressurizer level - GREATER THAN 25%.	b. Raise pressurizer level to GREATER THAN 25% with normal pressurizer spray or by cycling one PORV.
	c. Stop both feed pumps.	
	d. Stop both SI pumps.	
18	INITIATE RCS Cooldown:	
	a. Position steam dump mode selector switch to - PRESSURE CONTROL, CONDENSER.	a. IF steam dump to the condenser is NOT AVAILABLE, THEN position steam dump mode selector switch to - PRESSURE CONTROL, ATMOS.
	b. Position steam dump controller PC 418A to - MANUAL.	
	c. Control dumping to establish but not exceed 100°F/HR cooldown rate.	
19	CHECK Ruptured Steam Generator Level:	
	Check ruptured SG - ON NARROW RANGE SPAN, AND NOT INCREASING RAPIDLY.	IF ruptured SG level is - OFF SCALE HIGH OR INCREASING RAPIDLY, THEN go to step 22.

STEAM GENERATOR TUBE RUPTURE

STEP	ACTION/EXPECTED RESPONSE	RESPONSE NOT OBTAINED
20	<u>PARTIALLY DEPRESSURIZE RCS:</u>	
	a. Depressurize RCS to approximately 100 PSIG GREATER THAN MAIN STEAM PRESSURE with normal pressurizer heaters and spray.	a. <u>IF</u> spray and heater pressure control is not effective, <u>THEN</u> depressurize by cycling one PORV.
	b. Maintain pressurizer level - LESS THAN 70%.	b. Reduce pressurizer level: 1) Ensure normal spray valves and PORV's - CLOSED. 2) Reduce charging flow.
21	<u>VERIFY Break Flow Is Not Excessive:</u>	
	a. Verify pressurizer level - GREATER THAN 25% <u>AND</u> Ruptured SG level - NOT INCREASING UNCONTROLLED.	a. Go to step 22.
	b. Go to step 23.	

STEAM GENERATOR TUBE RUPTURE

STEP	ACTION/EXPECTED RESPONSE	RESPONSE NOT OBTAINED
22	DEPRESSURIZE RCS to Saturation	
	a. Manually control normal spray and heaters to depressurize RCS to APPROXIMATELY MAIN STEAM PRESSURE.	a. IF sprays are NOT effective, THEN depressurize by cycling one PORV.
	b. Adjust cold leg injection flow rate to maintain pressurizer level - BETWEEN 25% AND 70%.	b. IF pressurizer level is GREATER THAN 70%, THEN stop depressurization due to possible voids in the vessel head. IF pressurizer level is LESS THAN 25%, THEN temporarily reduce steam dump to reduce break flow and reestablish pressurizer level.
23	POSITION NIS Recorder Indication:	
	Position NIS switches to record one source and one intermediate range channel.	
24	START One Condensate Pump:	
	a. Start one condensate pump.	
	b. Verify condensate system mini-flow - ESTABLISHED.	b. Locally establish condensate system mini-flow.
25	VERIFY Adequate Shutdown Margin:	
	Verify RCS boron sample - AT LEAST 5% SHUTDOWN CONCENTRATION.	Manually borate RCS to - AT LEAST 5% SHUTDOWN CONCENTRATION.

STEAM GENERATOR TUBE RUPTURE

STEP	ACTION/EXPECTED RESPONSE	RESPONSE NOT OBTAINED
26	<u>MINIMIZE Release Of Contaminants:</u>	
	a. Locally position hotwell drawoff block valves - CLOSED: CND 340. CND 342.	
	b. Locally position AFW pump flush water valves - CLOSED: AFW 333. AFW 334.	
	c. Locally position steam to ammonia strippers - CLOSED: CNA 365. CNA 366.	
	d. Ensure air ejector after condenser drain valves lined up - TO CONDENSER: CNA 393 - CLOSED. CNA 394 - CLOSED. CNA 395 - OPEN. CNA 396 - OPEN.	
	e. Locally close unnecessary chemistry lab sample valves.	
	f. Locally position chemistry lab sample header to radwaste: FSS 413 - CLOSED. FSS 414 - OPEN. FSS 415 - CLOSED.	
	g. Locally limit hotwell overboarding by limiting operation of: 1) CND 318 5) CND 320 2) CND 456 6) CND 458 3) CND 317 7) CND 319 4) CND 457 8) CND 459	
	h. Locally limit reheater sump pump usage.	
	i. Verify condenser vacuum - GREATER THAN 26" Hg.	i. <u>IF</u> condenser vacuum is - LESS THAN 26" Hg, <u>THEN</u> go to step 27.
	j. Stop both vacuum pumps.	

STEEAM GENERATOR TUBE RUPTURE

STEP	ACTION/EXPECTED RESPONSE	RESPONSE NOT OBTAINED
	NOTE: RCS temperature may be higher than normal RHR system alignment temperature. The initial RHR system in-service temperature of 350°F does not apply for this instruction with RCP's running.	
27	<u>CHECK If RHR System Can Be Placed In Service:</u>	
	a. Check main steam pressure - LESS THAN 350 PSIG.	a. Continue dumping steam until main steam pressure is LESS THAN 350 PSIG.
	b. Verify at least one RCP - RUNNING.	b. <u>IF</u> No RCP is RUNNING, <u>THEN</u> Continue dumping steam until RCS temperature is - LESS THAN 350°F.
	c. Adjust nor[illegible]l spray and heaters to [illegible]stablish RCS and main steam pressure at APPROXIMATELY 350 PSIG.	

STEAM GENERATOR TUBE RUPTURE

STEP	ACTION/EXPECTED RESPONSE	RESPONSE NOT OBTAINED
28	<u>ESTABLISH RHR In Service:</u> a. Ensure RHR cooling water systems operating: 1) two saltwater cooling pumps - RUNNING. 2) three CCW pumps - RUNNING. b. Position RHR heat exchanger temperature controllers in MANUAL, SET AT 30% OPEN: TCV 601A. TCV 601B. c. Close PCV 1105. d. Position RHR system valves - OPEN: 1) MOV 822 A. 2) MOV 822 B. 3) MOV 813. 4) MOV 814. 5) MOV 833. 6) MOV 834. e. Start both RHR pumps. f. <u>Slowly</u> continue opening TCV 601 A and B to 144 AMPS on any CCW pump. g. Slowly position RHR flow control valve HCV 602 to control cooldown rate and not exceed either 150°F CCW temperature, <u>OR</u> 89 AMPS on either RHR pump.	

STEAM GENERATOR TUBE RUPTURE

STEP	ACTION/EXPECTED RESPONSE	RESPONSE NOT OBTAINED
29	<u>ALIGN Secondary Plant For Shutdown Condition:</u>	
	a. Open turbine drains.	
	b. Close reheater steam supply MOV's.	
	c. Ensure turbine auxiliary oil pump breaker - CLOSED.	
	d. Verify automatic turbine turning gear engagement:	d. <u>IF</u> turbine is STOPPED, <u>THEN</u> ensure turbine is placed on the turning gear.
	1) Turning Gear motor indicating light - ON	
	2) Unit rotation stopped alarm - OFF (TG-22).	

STEAM GENERATOR TUBE RUPTURE

STEP	ACTION/EXPECTED RESPONSE	RESPONSE NOT OBTAINED
30	CONTINUE RCS Cooldown With RHR:	
	a. Attempt to cool down the RCS with the RHR system to APPROXIMATELY 140°F.	a. IF RCS heat load is GREATER THAN RHR CAPACITY, THEN manually dump steam.
	b. Limit cooldown rate to LESS THAN 50°F/HR.	
	c. Maintain RCS pressure APPROXIMATELY EQUAL TO MAIN STEAM PRESSURE using one of the following methods in order of desirability: 1) Normal pressurizer spray with heaters while operating a RCP. 2) Auxiliary spray (if the 320°F delta T requirement is satisfied). 3) Use of one PORV provided the pressurizer level indicating range is not exceeded.	
	d. WHEN RCS pressure is LESS THAN 350 PSIG, THEN stop any operating RCP's.	
	e. Maintain pressurizer level high in the indicating range.	

STEAM GENERATOR TUBE RUPTURE

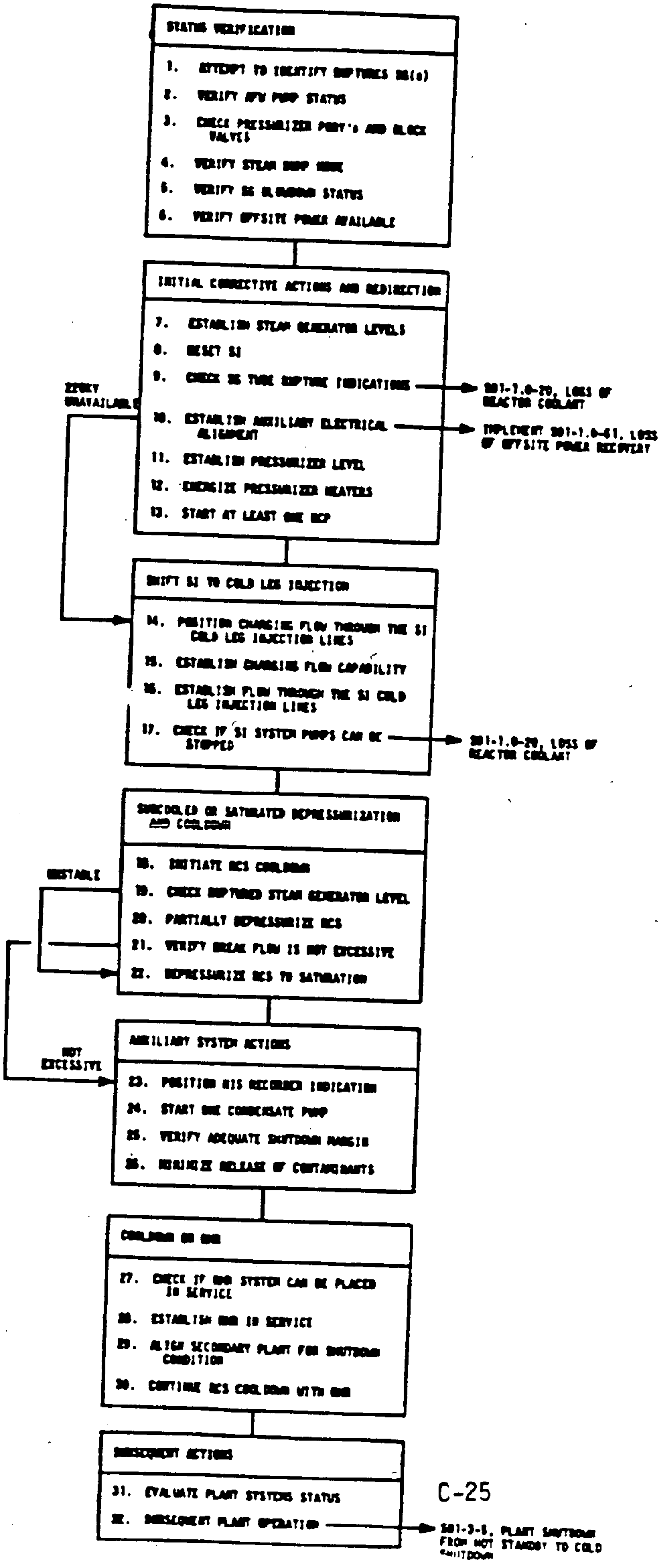
STEP	ACTION/EXPECTED RESPONSE	RESPONSE NOT OBTAINED
31	EVALUATE Plant Systems Status: a. Ensure inservice safety systems - OPERATING. b. Ensure standby safety systems - OPERABLE. c. Ensure necessary balance of plant systems - FUNCTIONAL. d. Evaluate long term plant status.	
32	SUBSEQUENT Plant Operation: a. Evaluate S01-3-4, PLANT SHUTDOWN FROM FULL POWER TO HOT STANDBY for applicable actions. b. Go to S01-3-5, PLANT SHUTDOWN FROM HOT STANDBY TO COLD SHUTDOWN and evaluate for applicable actions.	

-END-

MM:jmd:0036G

STEAM GENERATOR TUBE RUPTURE

EXECUTIVE SUMMARY



STEAM GENERATOR TUBE RUPTURE

NOTE: The following step is specific to this instruction only:

RUPTURED SG OVERFILL	IF	Ruptured SG level is - OFF SCALE HIGH OR INCREASING RAPIDLY	THEN:	Depressurize the RCS to APPROXIMATELY MAIN STEAM PRESSURE per step 22 and continue this procedure fro the current step.

NOTE: The following steps are always applicable:

ADMINISTRATIVE FUNCTIONS	1) Watch Engineer verify/notify STA. 2) Notify Shift Communicator 3) Refer to S01-VIII-1, RECOGNITION AND CLASSIFICATION OF EMERGENCIES. 4) Refer to S01-14-13, NOTIFICATION AND REPORTING OF SIGNIFICANT EVENTS

TRANSFER TO COLD LEG RECIRCULATION	IF	RWST level approaches 21%	THEN:	Go to S01-1.0-23, TRANSFER TO COLD LEG INJECTION AND RECIRCULATION.
CONTAINMENT SPRAY	IF	Containment pressure $>$ 10 PSIG	THEN:	Verify OR Initiate Containment Spray
MOTOR DRIVEN AFW PUMP TRIP	IF	Pump trips on low discharge pressure OR Pump running current exceeds - 300 AMPS	THEN:	1) Lower AFW CV setting. 2) IF pump tripped THEN Reset and restart pump
LOW AUXILIARY FEEDWATER TANK LEVEL	IF	AFT level approaches 4 FT	THEN:	Establish an alternate AFW supply by implementing S01-7-3, AUXILIARY FEEDWATER SYSTEM.

RCP RESTART INSTRUMENTATION
DESIGN INFORMATION
SAN ONOFRE UNIT 1

FUNCTION

The Subcooling Monitoring System, consisting of Reactor Coolant System temperature elements, pressure transmitters, electronic signal processing equipment, and indicators, provides continuous on line indication of reactor coolant saturation conditions.

DESIGN CRITERIA

SYSTEM

The subcooling monitoring system consists of two independent and redundant safety grade monitoring channels.

Each channel utilizes redundant Reactor Coolant System (RCS) temperature inputs from four core exit thermocouples and three hot leg RTD's. The incore thermocouple signals are derived from thermocouples also used for the flux mapping system.

Thermocouple switches are utilized to direct the thermocouple signals between the flux mapping system and the subcooling monitor channel. Of all the RCS temperatures, the highest (the most critical) is automatically selected through high signal select modules. Annunciation is provided to alarm when any switch is in the flux mapping position.

Each channel utilizes RCS pressure signals from pressurizer transmitter loops. The RCS pressure signal is processed through low signal select module. The selected pressure signal is transmitted to a function generator in which a saturation curve is characterized over the range of saturation conditions. The output signal of the function generator represents the saturation temperature (calculated with the lowest RCS pressure). A signal representing the difference between the saturation temperature (Tsat) and the highest limiting RCS temperature (Thot) is the output. This signal (Tsat-Thot), represents the margin to saturation and is processed through alarm bistable providing annunciation when approaching saturated conditions (alarm occurs when margin is 40°F or less).

The subcooling monitoring system has redundant information displays (one per channel), located in the main control room, to provide continuous indication of the following parameters:

- A, B, C Hot Leg Temperatures	(range: 100° - 700°F)
- Saturation Temperature (Tsat)	(range: 100° - 700°F)
- Limiting RCS Temperature (Thot)	(range: 100° - 700°F)
- Margin to Saturation (Tsat-Thot)	(range: -50° to +150°F)

COMPONENTS

A. In Core Thermocouples

The subcooling monitor utilizes RCS temperature signals from eight non-safety grade incore thermocouples. One thermocouple per core quadrant is utilized per channel. The operating range of each thermocouple is 100° - 2200°F. The output of the thermocouples can be switched from the subcooling monitoring system, for flux mapping purposes, utilizing thermocouple switches. Annunciation is initiated if any switch is in the flux mapping position.

B. Hot Leg Resistance Thermal Devices (RTD's)

In addition to utilizing incore thermocouples, the subcooling monitoring system uses inputs from six hot leg RTD's. Redundant RTD's are used on each hot leg. Each RTD consists of dual elements in a signal protective sheath providing outputs to the Reactor Protection and Control System in addition to the subcooling monitor. The calibrated temperature range covered by each RTD is 100°F to 700°F. RTD's are presently qualified in accordance with the following standards:

- IEEE-323-1971
- IEEE-344-1975

C. RCS Pressure

Subcooling RCS pressure input signals are obtained from wide range pressure transmitters. The range covered by each pressure transmitter loop is 0-3000 psig.

D. Signal Processing Components

The subcooling monitor analog signal processing components consist of Foxboro Spec 200 electronic modules. This equipment includes the following analog components:

1. Resistance to Voltage Converter
2. EMF to Voltage converter
3. Current to Voltage Converter
4. Voltage to Voltage Converter
5. Hi/Lo Signal Selector
6. Summer
7. Dual Absolute Alarm
8. Dual Linear Scaler
9. Signal Characterizer
10. Contact Input Isolator
11. Contact Output Isolator

This portion of the subcooling monitoring system and components meet the requirements of the following standards and guides:

- IEEE-323-1974
- IEEE-344-1975
- IEEE-279-1971
- Regulatory Guide 1.89

E. Indicating Components

Analog information displays consist of redundant Sigma Model 9270 gas discharge analog bar indicators. Each display unit is qualified in accordance with the following standards:

- IEEE-323-1971
- IEEE-344-1974