NORTHEAST UTILITIES

THE CONNECTICUT LIGHT AND POWER COMPANY
WESTERN MASSACHUSETTS ELECTRIC COMPANY
HOLYOKE WATER POWER COMPANY
NORTHEAST UTILITIES SERVICE COMPANY
NORTHEAST NUCLEAR ENERGY COMPANY

General Offices • Selden Street, Berlin, Connecticut

P.O. BOX 270
HARTFORD, CONNECTICUT 06141-0270
(203) 665-5000

October 6, 1989

Docket No. 50-213
A08191
Re: Zircaloy Clad Conversion
ISAP Topic 2.17

U.S. Nuclear Regulatory Commission
Attention: Document Control Desk
Washington, D. 20555

Gentlemen:

Haddam Neck Plant
Additional Information
Small-Break Loss of Coolant Accident Analysis--
Zircaloy Clad Fuel

In a letter dated July 18, 1989,(1) the NRC Staff requested that Connecticut Yankee Atomic Power Company (CYAPCO) provide additional information regarding Topical Report NUSCO-163, "Haddam Neck Plant Small-Break Loss of Coolant Accident (LOCA) Analysis--Zircaloy Clad Fuel," submitted to the Staff in a letter dated December 30, 1988.(2)

In accordance with the NRC Staff request, CYAPCO is hereby providing the attached additional information in response to the NRC Staff's 11 questions. Please contact us if you have any additional questions.

Very truly yours,

CONNECTICUT YANKEE ATOMIC POWER COMPANY

E. J. Mroczka
Senior Vice President

Attachment
cc: W. T. Russell, Region I Administrator
A. B. Wang, NRC Project Manager, Haddam Neck Plant
J. T. Shedlosky, Senior Resident Inspector, Haddam Neck Plant

---

(1) A. B. Wang letter to E. J. Mroczka, "Request for Additional Information Regarding Northeast Utilities' Topical Report NUSCO-163, 'Haddam Neck Plant, Small Break LOCA Analysis, Zircaloy Clad Fuel,'" dated July 18 1989.

(2) E. J. Mroczka letter to the U.S. Nuclear Regulatory Commission, "Haddam Neck Plant, Small Break LOCA Analysis," dated December 30, 1988.

A001
1/1

Docket No. 50-213
A08191

Attachment

Haddam Neck Plant

Additional Information

October 1989

Question 1

NUREG 0630 provides information regarding the zircaloy-clad material and deformation behavior for use in ECCS licensing analyses. Demonstrate that the clad behavioral model in NULAP5 is consistent with or conservatively bounds the data in NUREG 0630.

Response

The clad behavior model in NULAP5 conservatively bounds NUREG 0630 for the NUSCO 163 break spectrum. The 0.4 ft2 break was the maximum cladding temperature case (1410 degF) and the only case for which any swelling was calculated to occur by the NULAP5 method. The 0.4 ft2 case has been repeated, imposing NUREG 0630 methods for calculating rupture. NUREG 0630 Equation 3-2 for TR, rupture temperature, and 3-1 for hoop stress were solved throughout the transient using NULAP5 transient data for clad differential pressure and heating rate. As shown in the attached 7 figures of clad temperature and rupture temperature vs. time for the top 7 of 24 hot rod nodes, NUREG 0630 rupture conditions are never achieved. NUREG 0630 deformation in the form of reduction of flow area follows only from rupture. Thus, using the NUREG 0630 data, no swelling would be predicted. Therefore, any calculation of swelling, as NULAP5 did calculate for the 0.4 ft2 break, conservatively bounds NUREG 0630 data.

FIGURE 1-1
HADDAM NECK PLANT ZIRCALOY SBLOCA

NUREG-0630 RUPTURE TEMPERATURE VS.
NULAP-5 PEAK CLAD TEMPERATURE

HOT ROD 1ST UPPER NODE OF 24

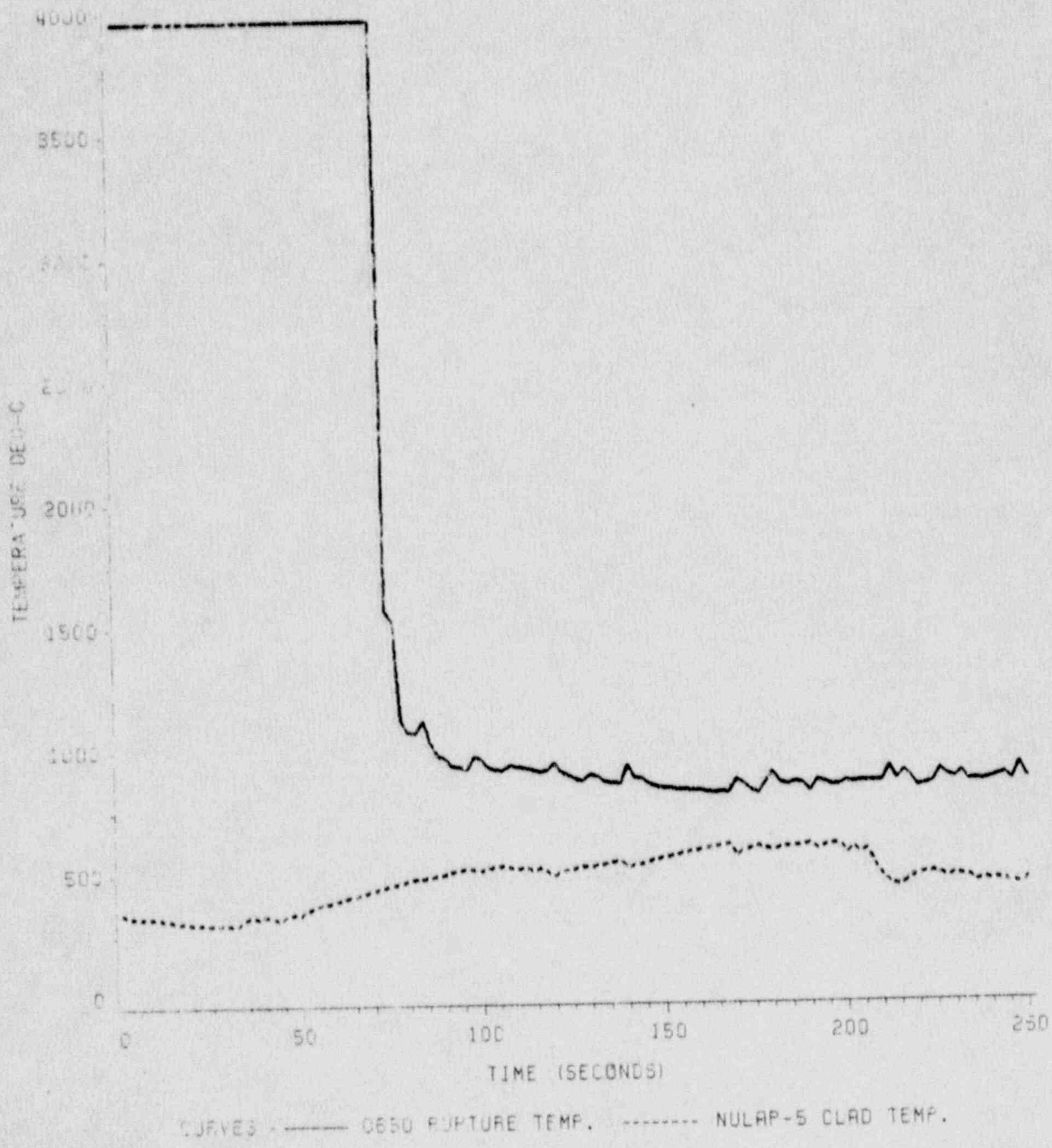


FIGURE 1-2
HADDAM NECK PLANT ZIRCALOY SBLOCA

NUREG-0630 RUPTURE TEMPERATURE VS.
NULAP-5 PEAK CLAD TEMPERATURE

HOT ROD 2ND UPPER NODE OF 24

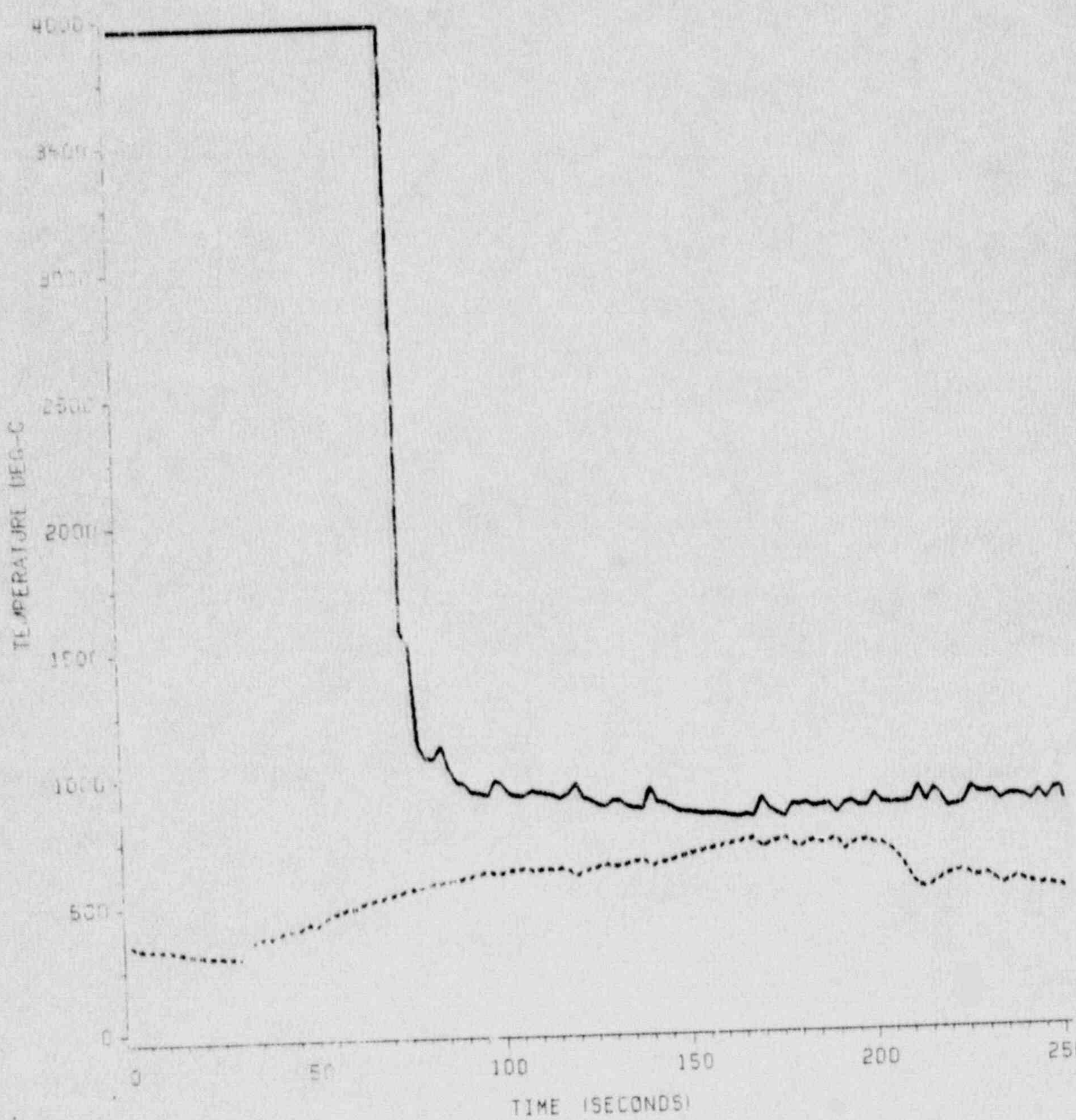


FIGURE 1-3
HADDAM NECK PLANT ZIRCALOY SBLOCA

NUREG-0630 RUPTURE TEMPERATURE VS.
NULAP-5 PEAK CLAD TEMPERATURE

HOT ROD 3RD UPPER NODE OF 24

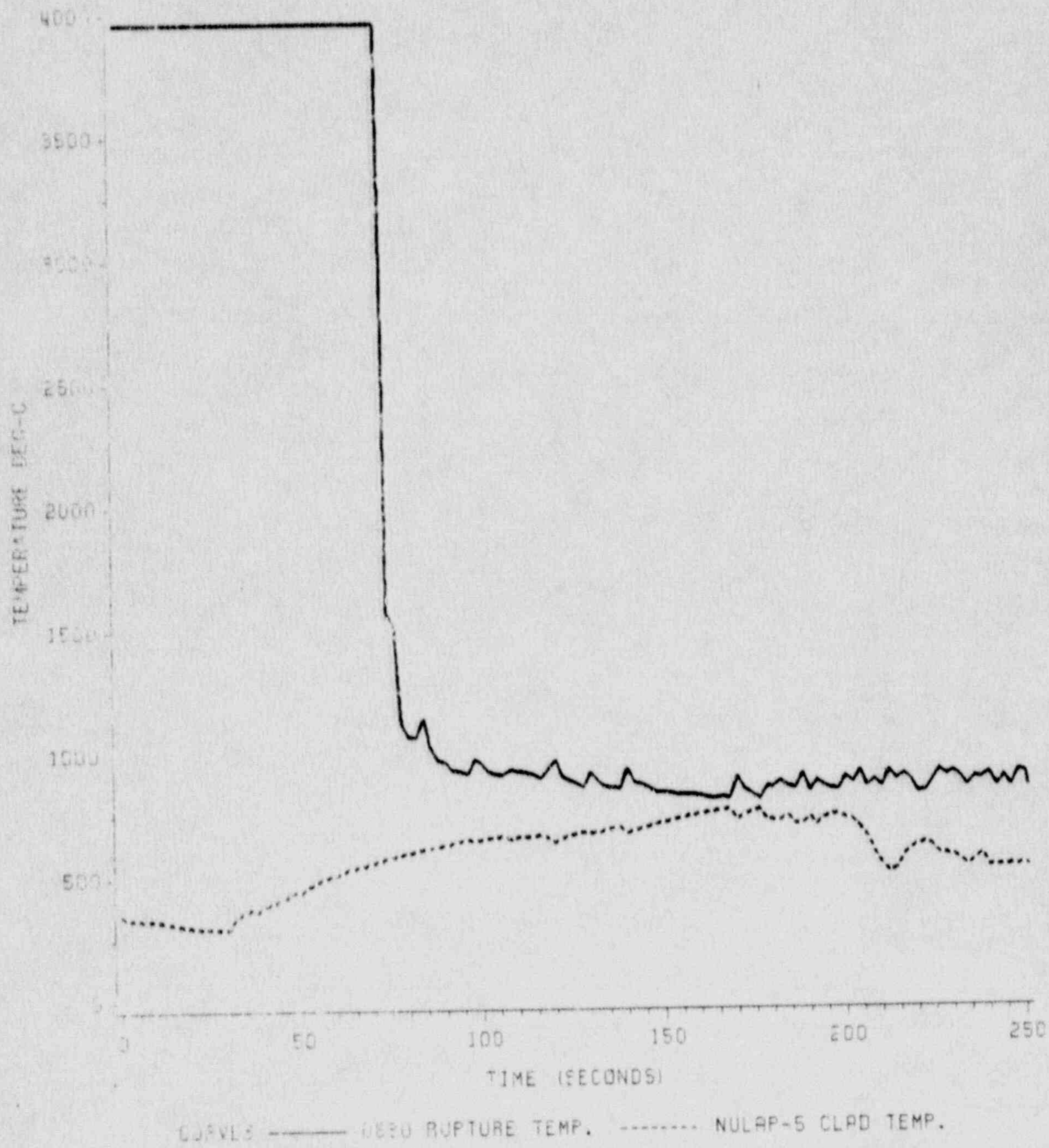


FIGURE 1-4
HADDAM NECK PLANT ZIRCALOY SBLOCA

NUREG-0630 RUPTURE TEMPERATURE VS.
NULAP-5 PEAK CLAD TEMPERATURE

HOT ROD 4TH UPPER NODE OF 24

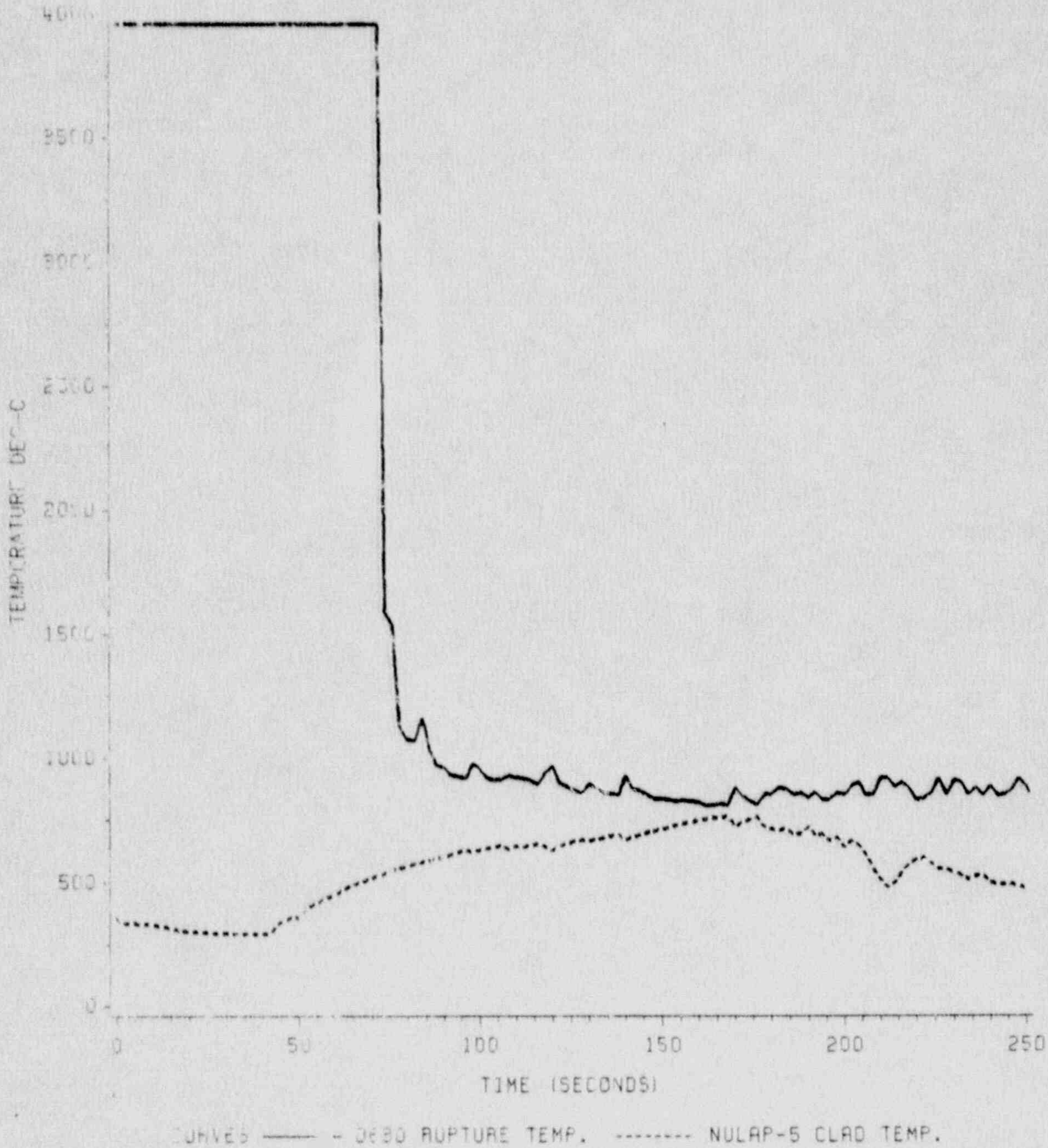


FIGURE 1-5
HADDAM NECK PLANT ZIRCALOY SBLOCA

NUREG-0630 RUPTURE TEMPERATURE VS.
NULAP-5 PEAK CLAD TEMPERATURE

HOT ROD 5TH UPPER NODE OF 24

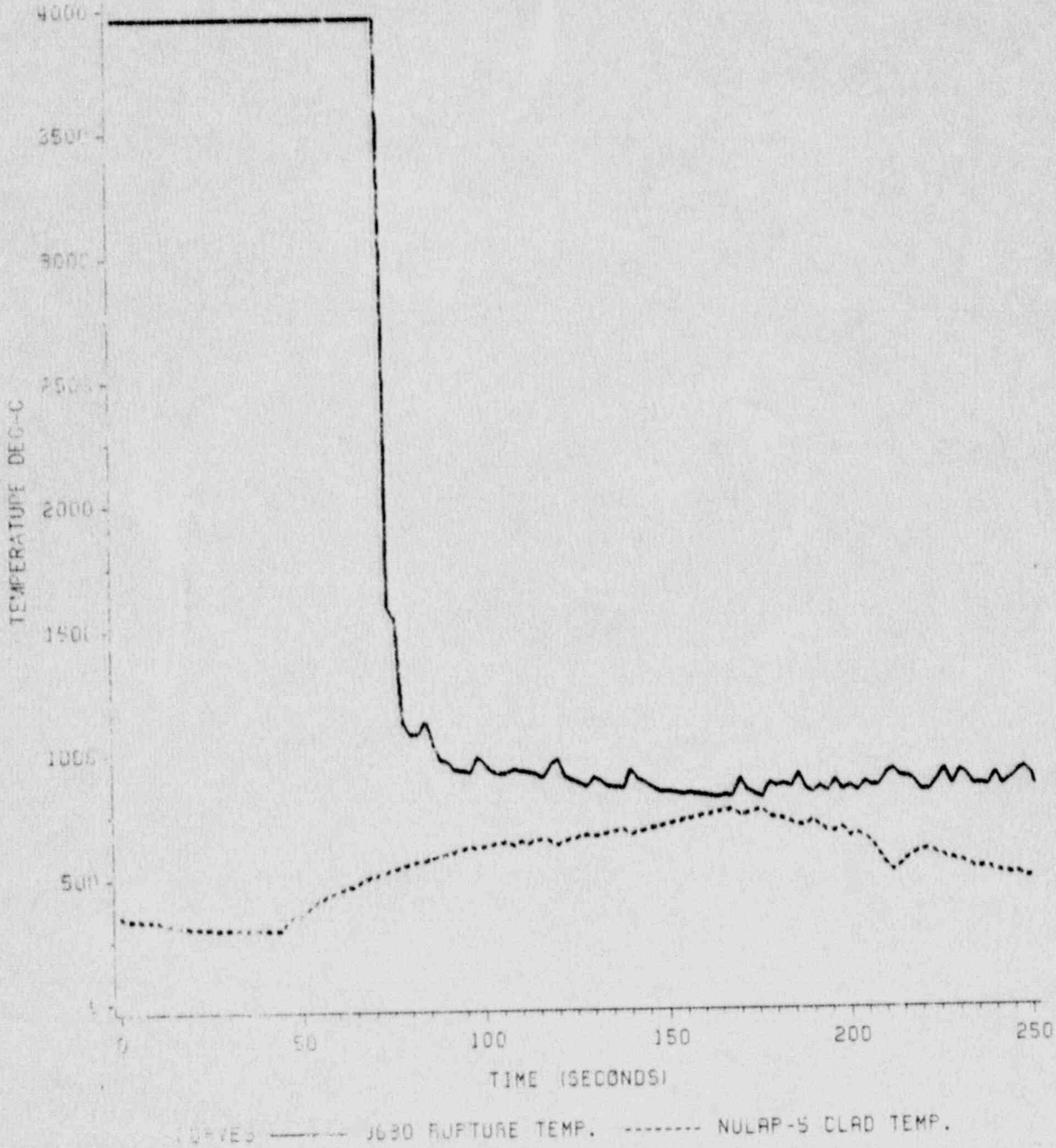


FIGURE 1-6
HADDAM NECK PLANT ZIRCALOY SBLOCA

NUREG-0630 RUPTURE TEMPERATURE VS. NULAP-5 PEAK CLAD TEMPERATURE

HOT ROD 6TH UPPER NODE OF 24

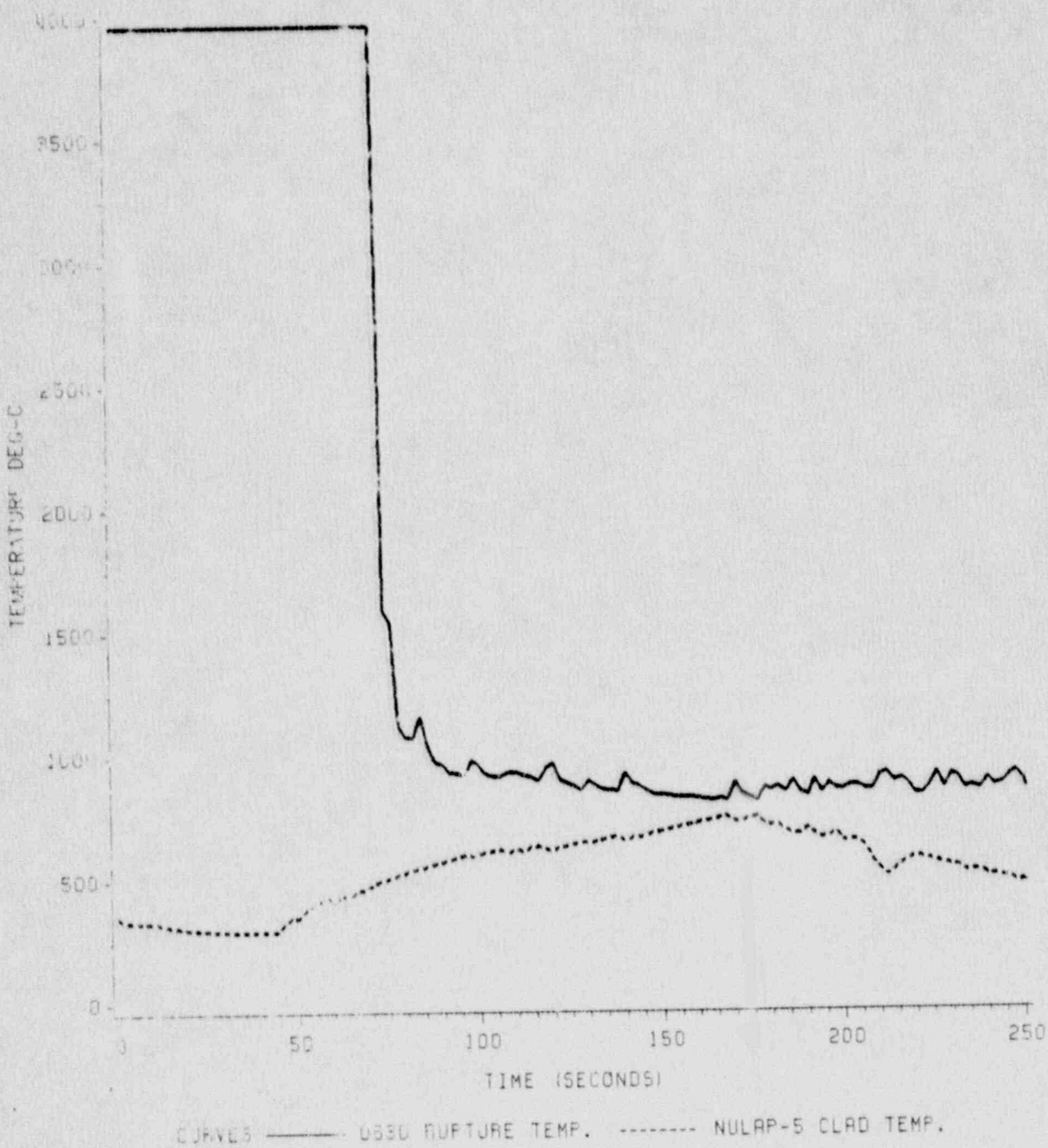
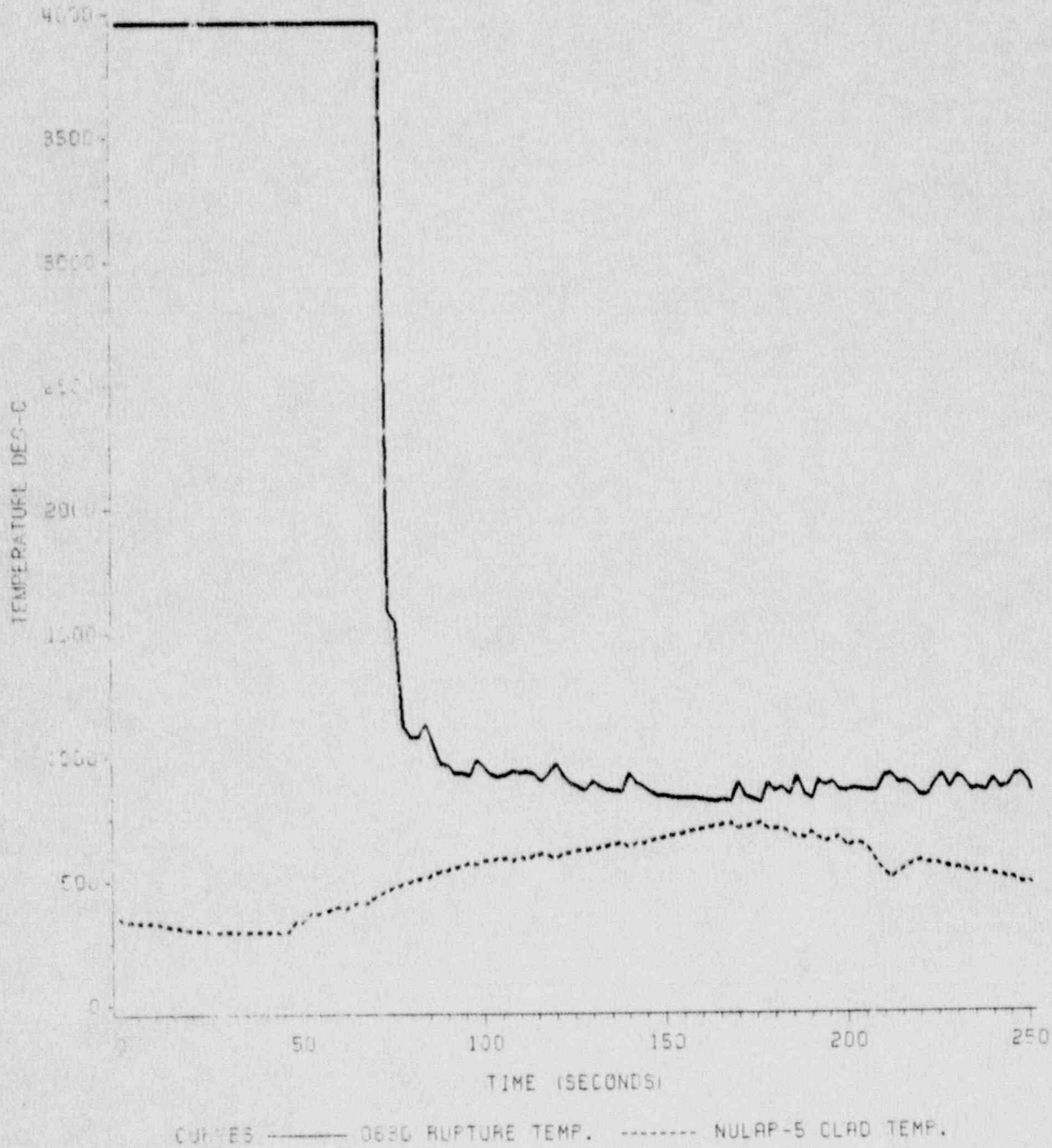


FIGURE 1-7
HADDAM NECK PLANT ZIRCALOY SBLOCA

NUREG-0630 RUPTURE TEMPERATURE VS.
NULAP-5 PEAK CLAD TEMPERATURE

HOT ROD 7TH UPPER NODE OF 24



1

IMAGE EVALUATION TEST TARGET (MT-3)

150mm

6"

1

IMAGE EVALUATION
TEST TARGET (MT-3)

150mm

6"

1

IMAGE EVALUATION TEST TARGET (MT-3)

150mm

6"

1

IMAGE EVALUATION TEST TARGET (MT-3)

150mm

6"

Question 2

Explain why the initial portion of the power transients for the stainless steel-clad fuel (of the previous analysis) results in a higher overpower than that for the zircaloy-clad fuel.

Response

The analyses results provided in NUSCO 163 were based on moderator and doppler defect curves that were calculated specifically for zircaloy clad fuel. These curves resulted in less positive reactivity insertion during the initial portion of the transient. As such, the overpower calculated for the zircaloy clad fuel analyses was less than that for the stainless steel clad fuel analyses.

The differences in the overpower transients were mainly due to the difference in the moderator defect curves. The moderator defect curve for the zircaloy clad fuel analyses was based on an MTC of 0.0 pcm/°F while the stainless steel clad curve was based on an MTC of +7.1 pcm/°F.

It should be noted that the MTC listed in Table 3 of NUSCO 163 is wrong. The correct value is 0.0 pcm/°F.

Question 3

(a) What are the limiting time-of-life fuel parameters for use in initializing the hot rod for small break LOCA analyses?

(b) If the fuel rod cladding temperatures could achieve rupture conditions, would end-of-life conditions (when pin pressure is a maximum) be more limiting than early in life when the stored energy is at a maximum?

Response

(a) Time of life fuel parameters used to initialize the hot rod for small break LOCA analyses for Haddam Neck are associated with beginning of life. Since NULAP5 treats the effects of rod strain on heat transfer area and coolant flow area, parameters that would increase clad strain (initial pin pressure) improve the heat transfer from the cladding. Therefore, using beginning of life fuel parameters is conservative.

(b) Of course, this argument can break down if clad strain becomes so great as to cause extreme channel blockage. However, because of the high capacity ECCS pumps, the duration of uncovery is so short that it is not possible to achieve enough clad strain to create extreme blockage. In response to the second part of the question, we have no definitive proof that end-of-life conditions would become limiting if rupture were to occur. For Haddam Neck, the question is academic.

Question 4

Explain why the limiting break areas are significantly different for the stainless steel-clad and zircaloy-clad fuels? What effect did the change in critical flow modeling have on the limiting break size? In addition, justify why additional break sizes between .02 and .075 sq. ft. were not analyzed to ensure the determination of the maximum peak clad temperature for a small break LOCA.

Response

The differences in the limiting break area for the stainless steel clad and zircaloy clad fuel analyses are attributed primarily to changes in the input data which was required to accommodate the zircaloy clad fuel. Major changes to the input deck included initial TCOLD, initial RCS flowrate, reactivity defect curves and increased tube plugging. The clad heatup calculated for the Haddam Neck Plant is only due to the short term core uncovery that occurs during the loop seal clearing and steam generator water drainage time period. No long term uncovery is predicted due to the large capacity of the ECCS. The loop seal clearing phenomenon is primarily system geometry dependent and is only weakly dependent on ECCS capacity. As such, changes to the RCS initial conditions or geometry (tube plugging) will simply shift the break size which yields the highest clad temperature during loop seal clearing. Also, the 0.4 ft2 break yielded the highest clad temperature for the zircaloy clad fuel spectrum. The largest break size analyzed for the stainless steel clad fuel was 0.3 ft2. A comparison of the trend in clad surface temperature for break sizes 0.1 ft2 and greater shows that the maximum clad surface temperatures tend to increase as break size increases for both the zircaloy and stainless steel clad fuel analyses. It is possible that if a 0.4 ft2 break was analyzed for the stainless steel clad fuel, then this break may have yielded the highest clad surface temperature.

It should be noted here that it is considered difficult, if not impossible, to define a "limiting" or "worst case" break size when the maximum clad surface temperature for each break analyzed in the small break spectrum is solely a result of loop seal clearing phenomena and not a result of long term core uncovery. Typically, a "limiting" break size can be defined for a spectrum of small breaks where long term uncovery is predicted. Clad surface temperature transients during a long term uncovery period are primarily governed by system pressure, break size and ECCS capacity and are thermal-hydraulically more quasi-steady. Clad surface temperature transients during the loop seal clearing and steam generator water drainage period are governed by system geometry and are very sensitive to small differences in predicted parameters prior to the event particularly if significant water holdup is predicted to occur in the steam generator U-tubes. This is the case with the NULAP5 code predictions of the Haddam Neck Plant small break spectrum analyses. Due to the high capacity of the ECCS, no long term uncovery is predicted and maximum clad surface temperatures are a result of the loop seal clearing process. We expect that, should future reanalysis be required to accommodate increased tube plugging, reduced RCS flowrate or changes in reactor vessel inlet temperature, the "limiting" break size will shift again. However, we do not expect that the maximum clad surface temperatures predicted by NULAP5 during the loop seal clearing process will ever approach the licensing limit of 2200°F. The NULAP5 predictions of clad surface temperature during loop seal clearing are considered highly conservative. This is due primarily to the large amount of water held up in the steam generator U-tubes which results in increased core level depression. This phenomenon is due to the conservative nature of the NULAP5 interfacial drag model.

Changes to the critical flow modeling have limited effect on limiting break size. The changes only affected stratified subcooled/saturated flow conditions in the break node. A comparison of the break mass flowrates for the zircaloy clad and stainless steel clad fuel analyses indicated that the trends are essentially identical. In some cases the break flows for the zircaloy clad fuel analyses are slightly higher. This is probably due to the reduced initial cold leg temperature assumed in the zircaloy clad fuel analyses. It is impossible to exactly quantify the effect of the change to the critical flow model since other changes to the input deck were made to accommodate the zircaloy clad fuel. As discussed above, changes such as reduced TCOLD, reduced RCS flowrate, and increased tube plugging were considered to be the dominant contributors to the shift in the limiting break size.

Additional break sizes between .02 ft2 and .075 ft2 were not analyzed because the break spectrum provided in NUSCO 163 was considered sufficient to verify that modeling of zircaloy clad fuel as well as changes to plant initial conditions do not significantly change the clad surface temperature response during the loop seal clearing period.

Question 5

The clad surface temperature for the .01 sq. ft break shows an increasing trend to 2,000 seconds. Explain why the transient was not extended past 2,000 seconds to ensure that the clad surface temperature had peaked.

Response

The sudden change in clad surface temperature at approximately 980 seconds is due to the sudden change in heat transfer coefficient as a result of NULAP5 predicting a DNB condition. Since NULAP5 does not allow return to nucleate boiling, the heat transfer coefficient remains low which requires a readjustment to clad surface temperature to allow transfer of decay heat to the coolant. This temperature readjustment is typically 200-300°F as can be seen on Figure A.14. Figure A.15 and Figure A.17 verify that core level is stable or increasing and that total RCS inventory is increasing. Table 4 shows that after 582 seconds, HPSI flow exceeds core boiloff and long term uncovery is not possible. Based on the above, it was not considered necessary to continue the transient beyond 2,000 seconds.

Question 6

Please supply plots of the hot rod channel steam temperatures and saturation temperatures for each of the breaks.

Response

Figures 6-1 through 6-6 provide the requested information.

FIGURE 6-1
HADDAM NECK PLANT ZIRCALOY SBLOCA
0.01 FT2 DISCHARGE LEG BREAK

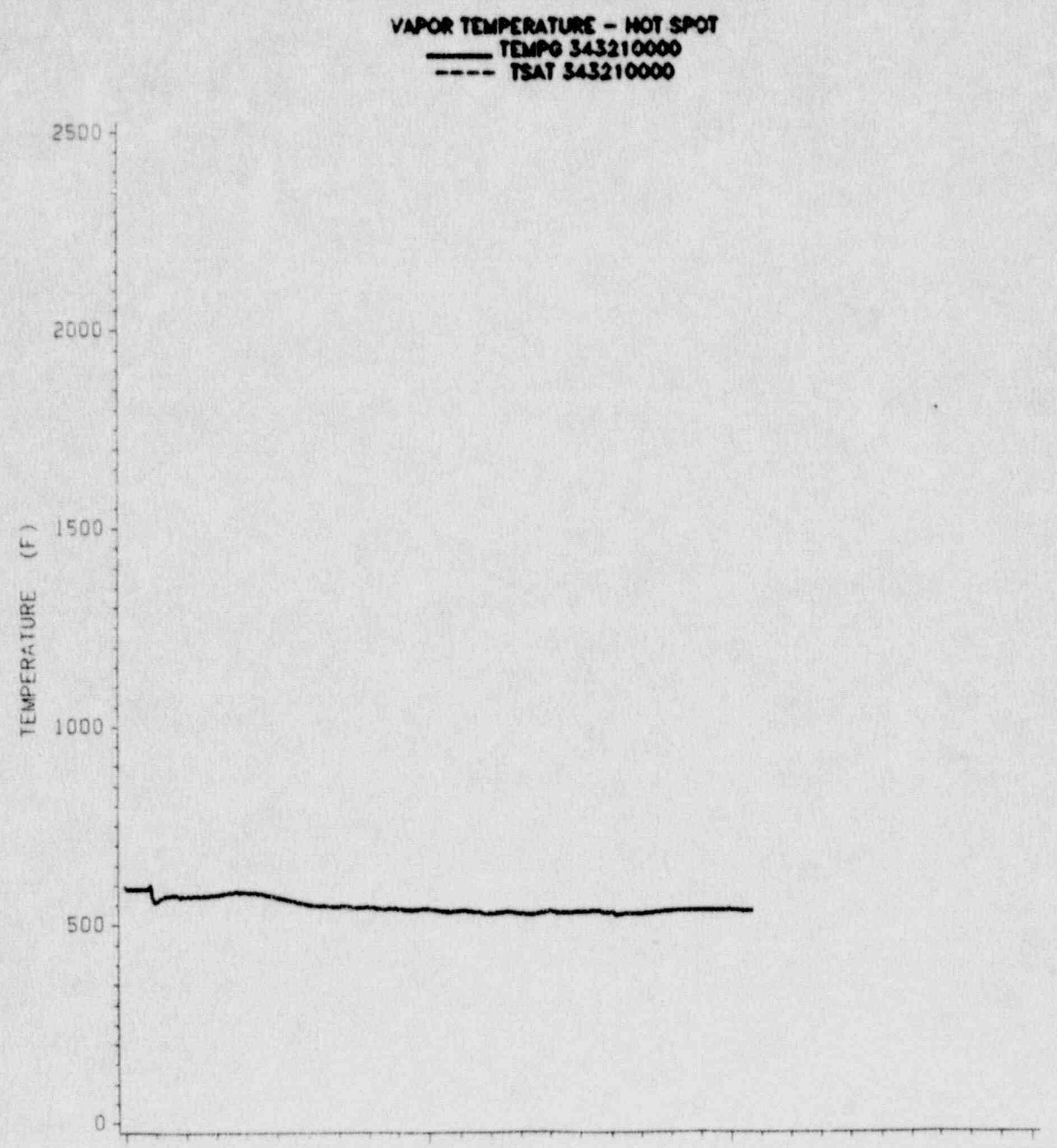


FIGURE 6-2
HADDAM NECK PLANT ZIRCALOY SBLOCA
0.02 FT2 DISCHARGE LEG BREAK

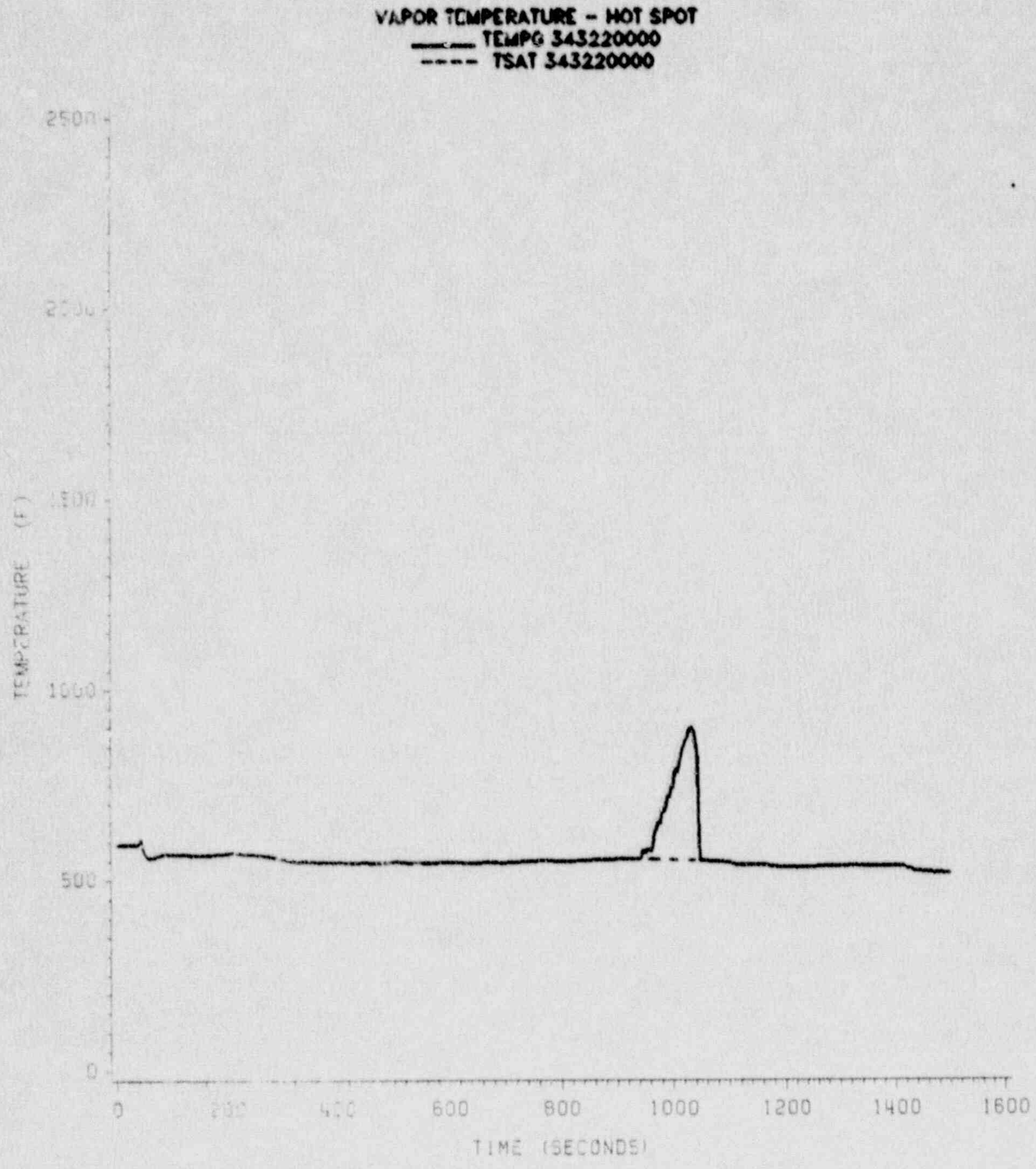


FIGURE 6-3
HADDAM NECK PLANT ZIRCALOY SBLOCA
0.075 FT2 DISCHARGE LEG BREAK

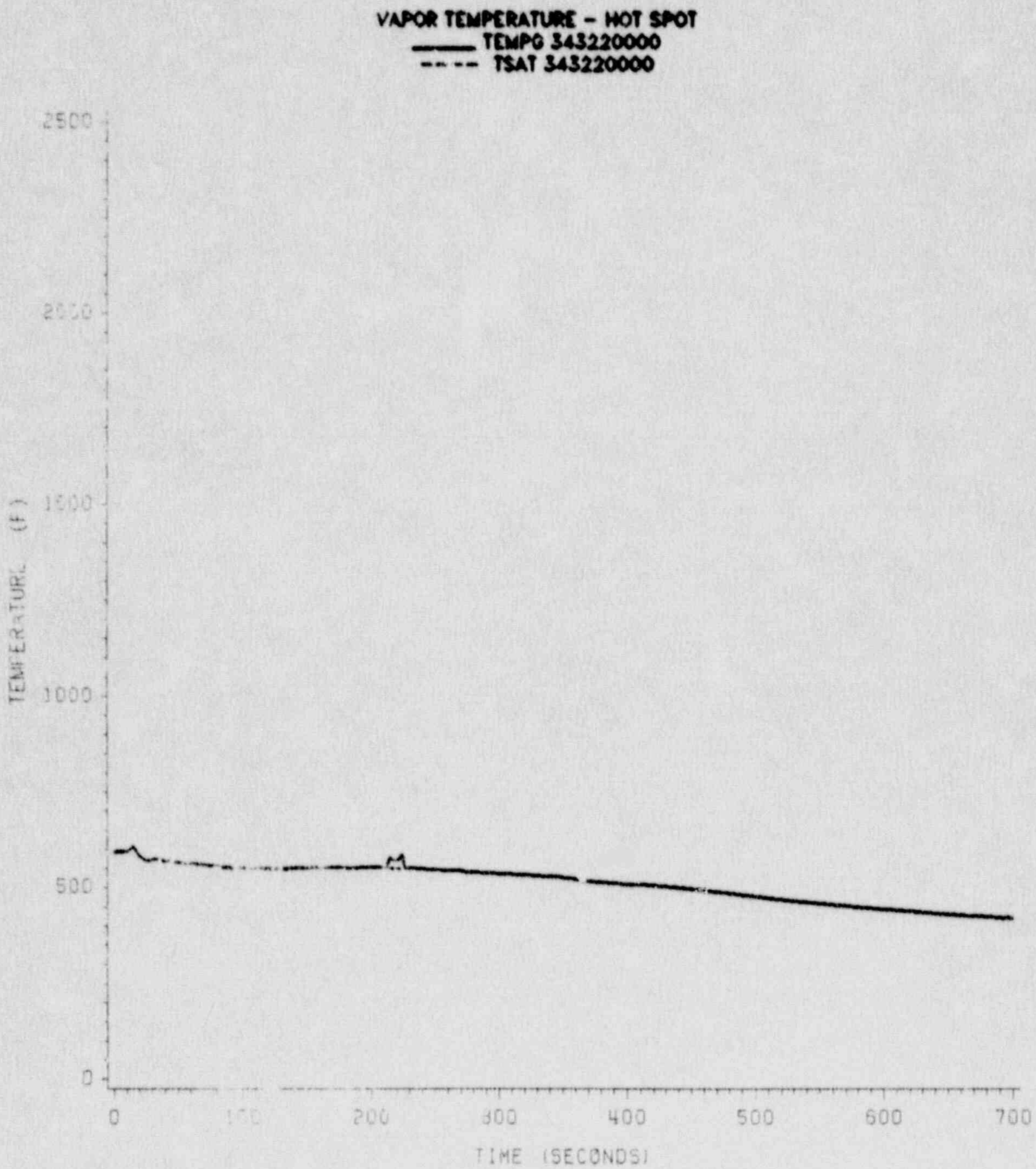


FIGURE 6-4
HADDAM NECK PLANT ZIRCALOY SBLOCA
0.1 FT2 DISCHARGE LEG BREAK

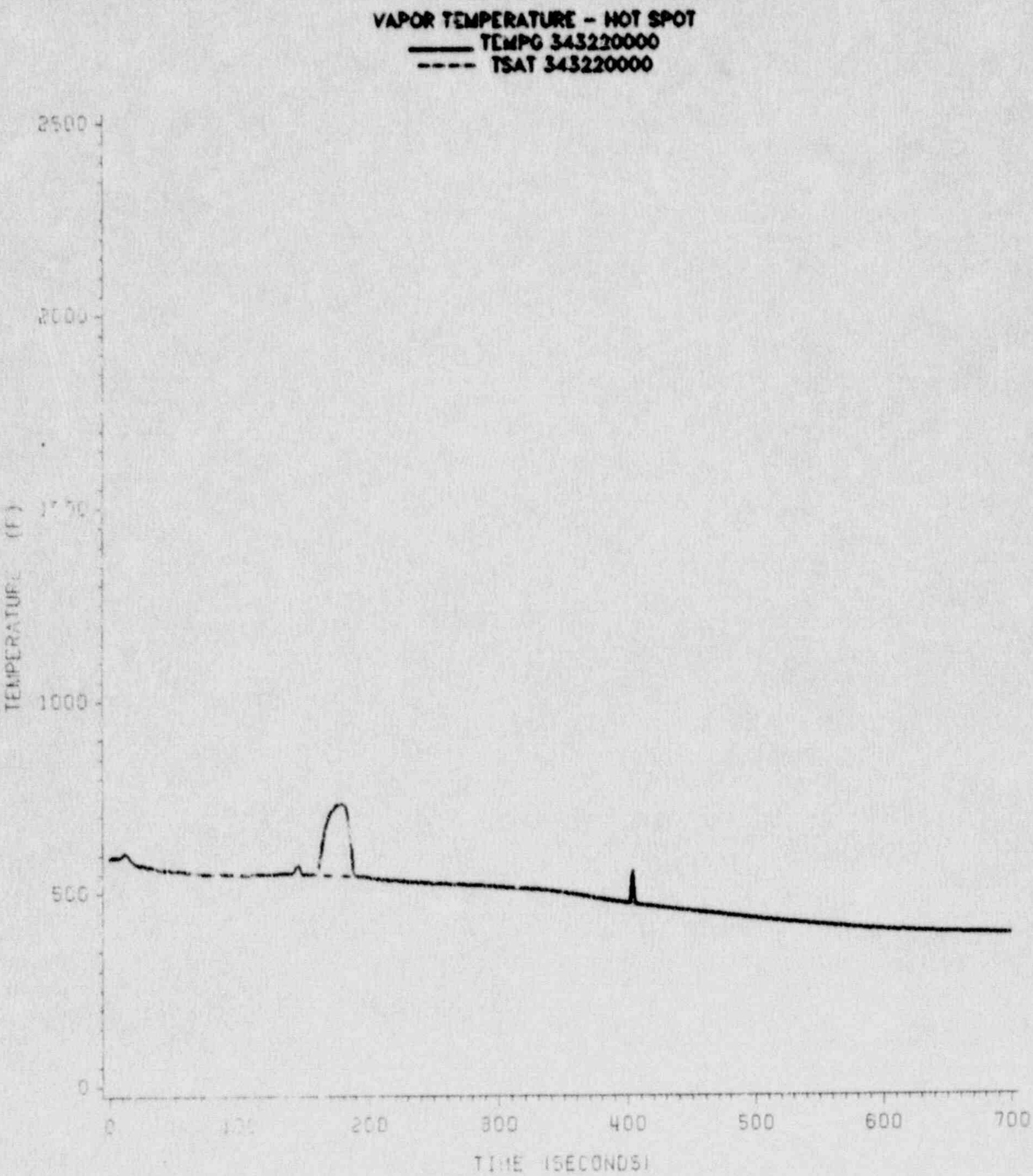


FIGURE 6-5
HADDAM NECK PLANT ZIRCALOY SBLOCA
0.2 FT2 DISCHARGE LEG BREAK

VAPOR TEMPERATURE - HOT SPOT
_____ TEMPG 343220000
---- TSAT 343220000

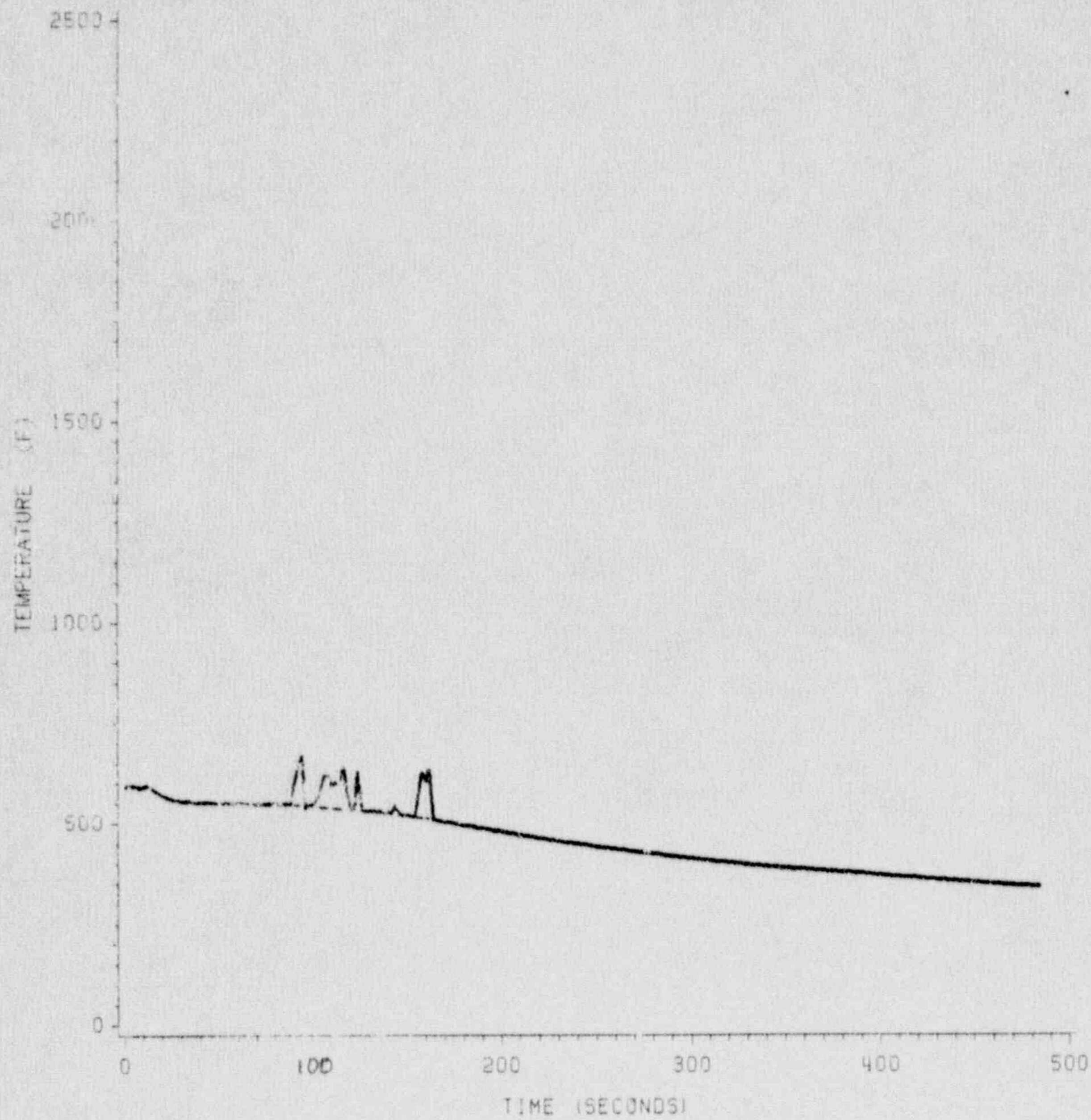
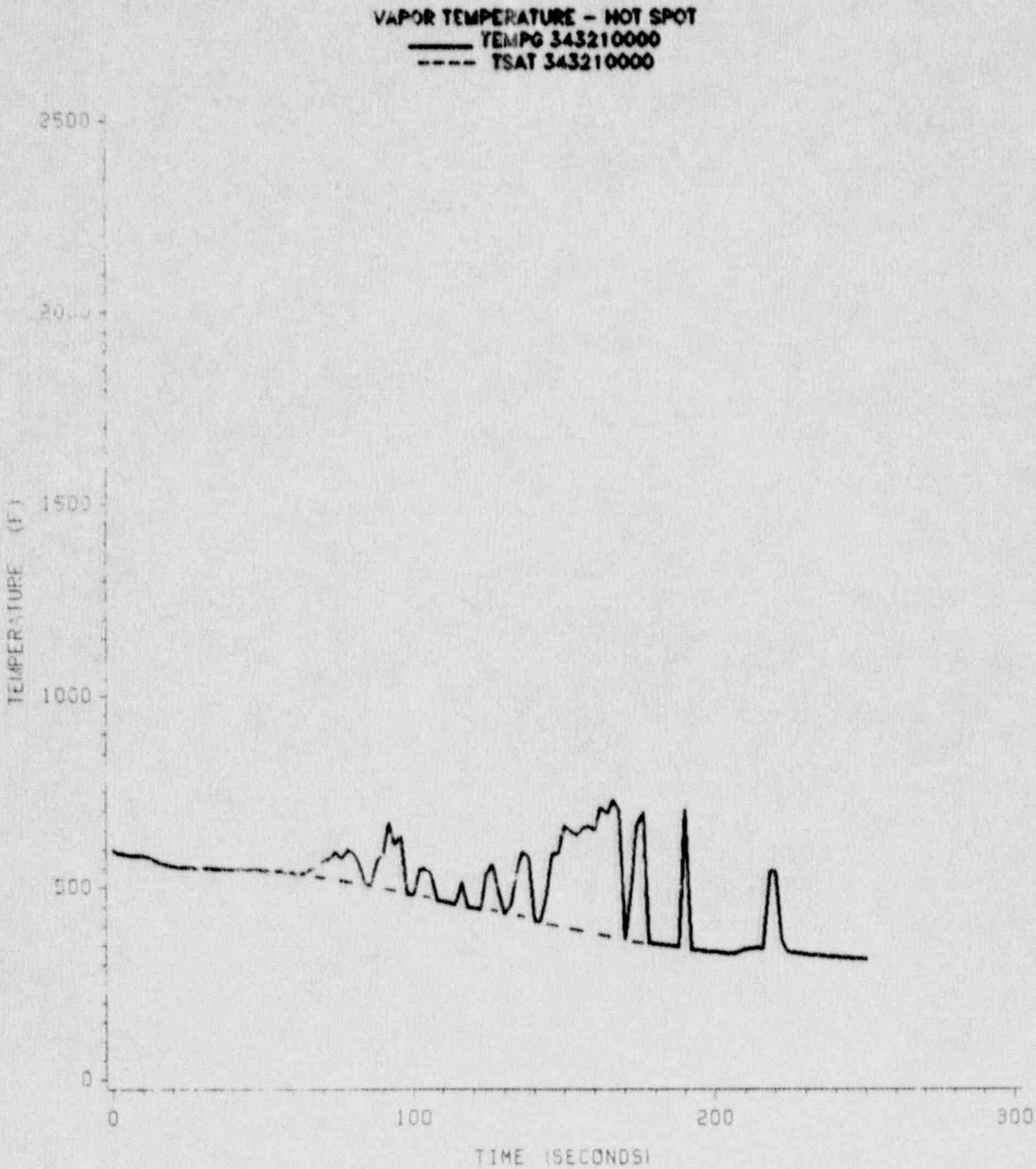


FIGURE 6-6
HADDAM NECK PLANT ZIRCALOY SBLOCA
0.4 FT2 DISCHARGE LEG BREAK



Question 7

By letter dated August 3, 1988, the staff provided a safety evaluation of the use of the NULAP5 code. Conclusion 7 of the evaluation stated that the licensee committed to review the core thermal-hydraulics and clad temperature response in all future calculations to ensure that the clad temperature increase is not artificially terminated by the existence of mist flow in the upper core during the loop seal clearing uncovering period. Provide evidence of this review.

Response

To ensure that the clad temperature increase is not artificially terminated by the existence of mist flow in the upper core during the loop seal clearing uncovering period, the following calculated parameters were reviewed:

- Clad surface temperature
- Collapsed and two-phase level
- Hot spot vapor velocity
- Void fraction in lower plenum volume 335

The clad surface temperatures are provided in NUSCO 163. Collapsed and two-phase level plots are provided in the response to Question 8. Figures 7-1 through 7-12 provide the hot spot vapor velocity and void fraction in lower plenum volume 335 for each of the breaks analyzed in NUSCO 163.

The collapsed and two-phase level plots provide the time frame for the loop seal clearing uncovering period. It can be seen from the clad temperature responses that the clad temperature increase is terminated during or subsequent to the core level recovery period following loop seal clearing for each of the breaks analyzed. In order to terminate the clad temperature increase during the loop seal clearing uncovering period, a sudden increase in hot spot vapor velocity would have to occur resulting in an increase in heat transfer coefficient. An increase in hot spot vapor velocity could potentially be calculated to occur if the lower plenum volume 335 significantly voided as core level approached the minimum value. Generally, the void fraction in volume 335 would have to be greater than approximately 0.6 for this phenomenon to occur. The lower plenum volume 335 void fraction plots provided verify that the void fraction never approaches 0.6 during the loop seal clearing uncovering period.

Based on the above, it was concluded that, for each of the breaks analyzed in NUSCO 163, the clad temperature increases were not artificially terminated by the existence of mist flow in the upper core during the loop seal clearing uncovering period and that no additional analysis was required.

FIGURE 7-1

HADDAM NECK PLANT ZIRCALOY SBLOCA
0.01 FT2 DISCHARGE LEG BREAK
HOT SPOT VAPOR VELOCITY

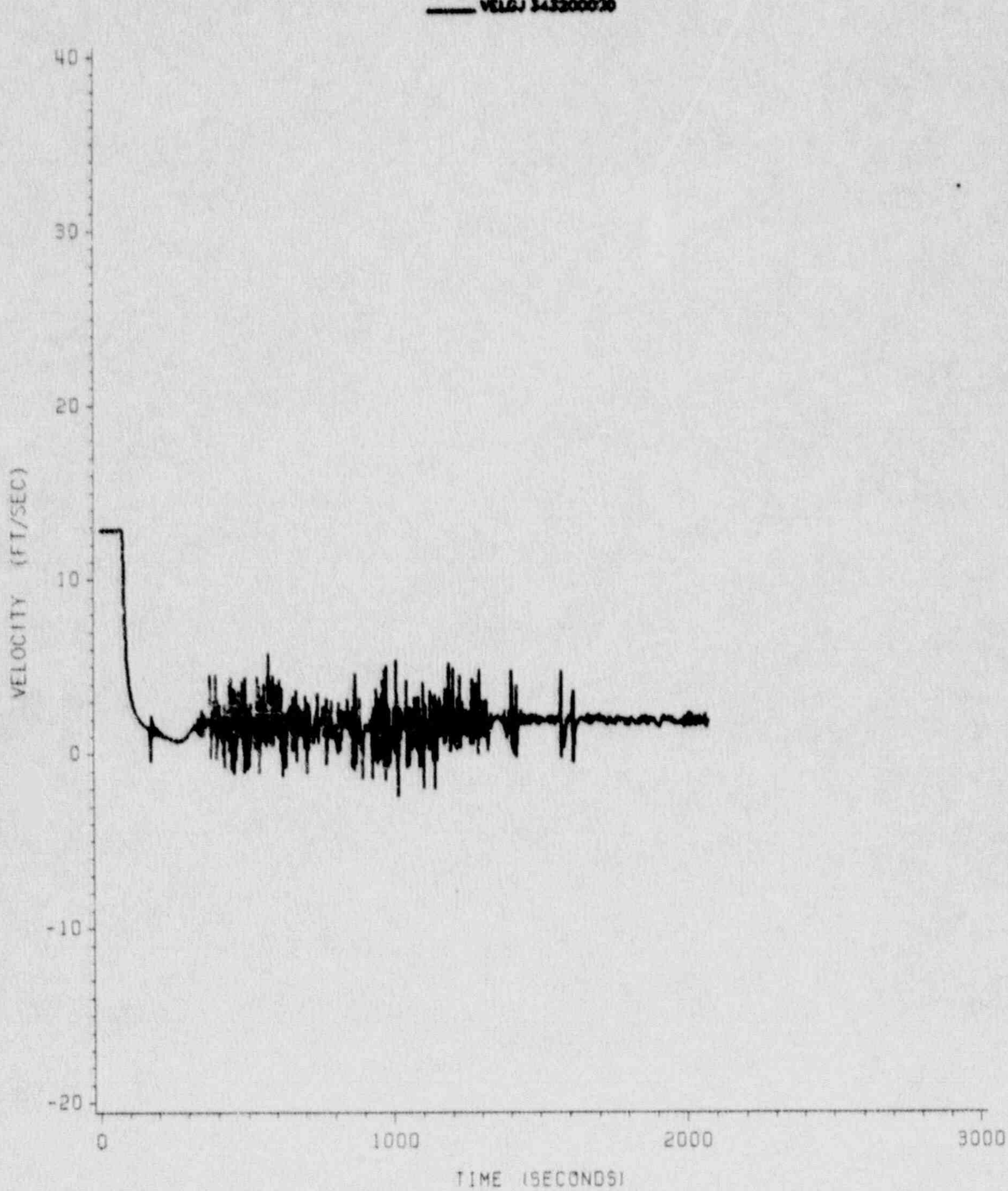


FIGURE 7-2

HADDAM NECK PLANT ZIRCALOY SBLOCA
0.01 FT2 DISCHARGE LEG BREAK

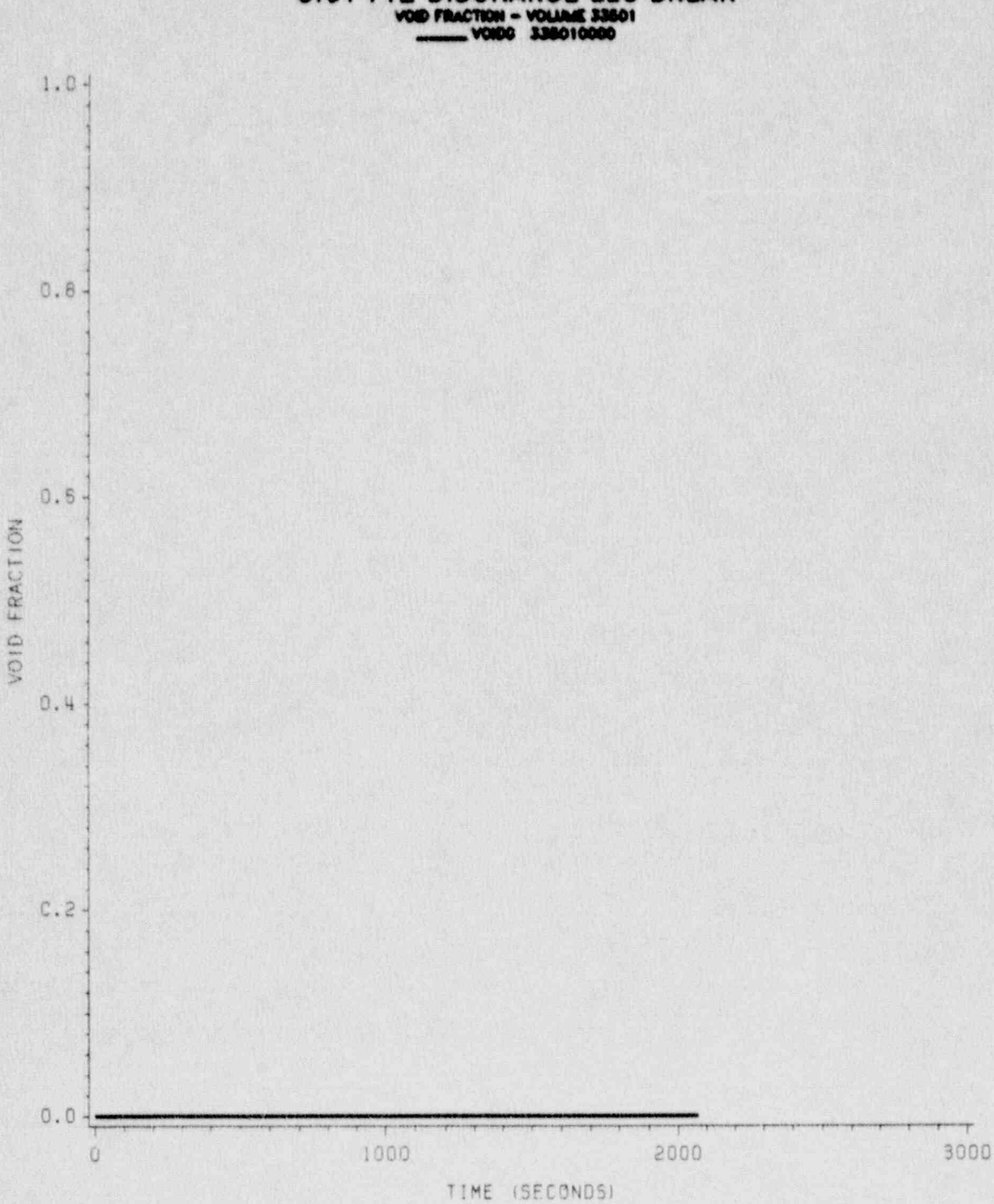


FIGURE 7-3

HADDAM NECK PLANT ZIRCALOY SBLOCA
0.02 FT2 DISCHARGE LEG BREAK

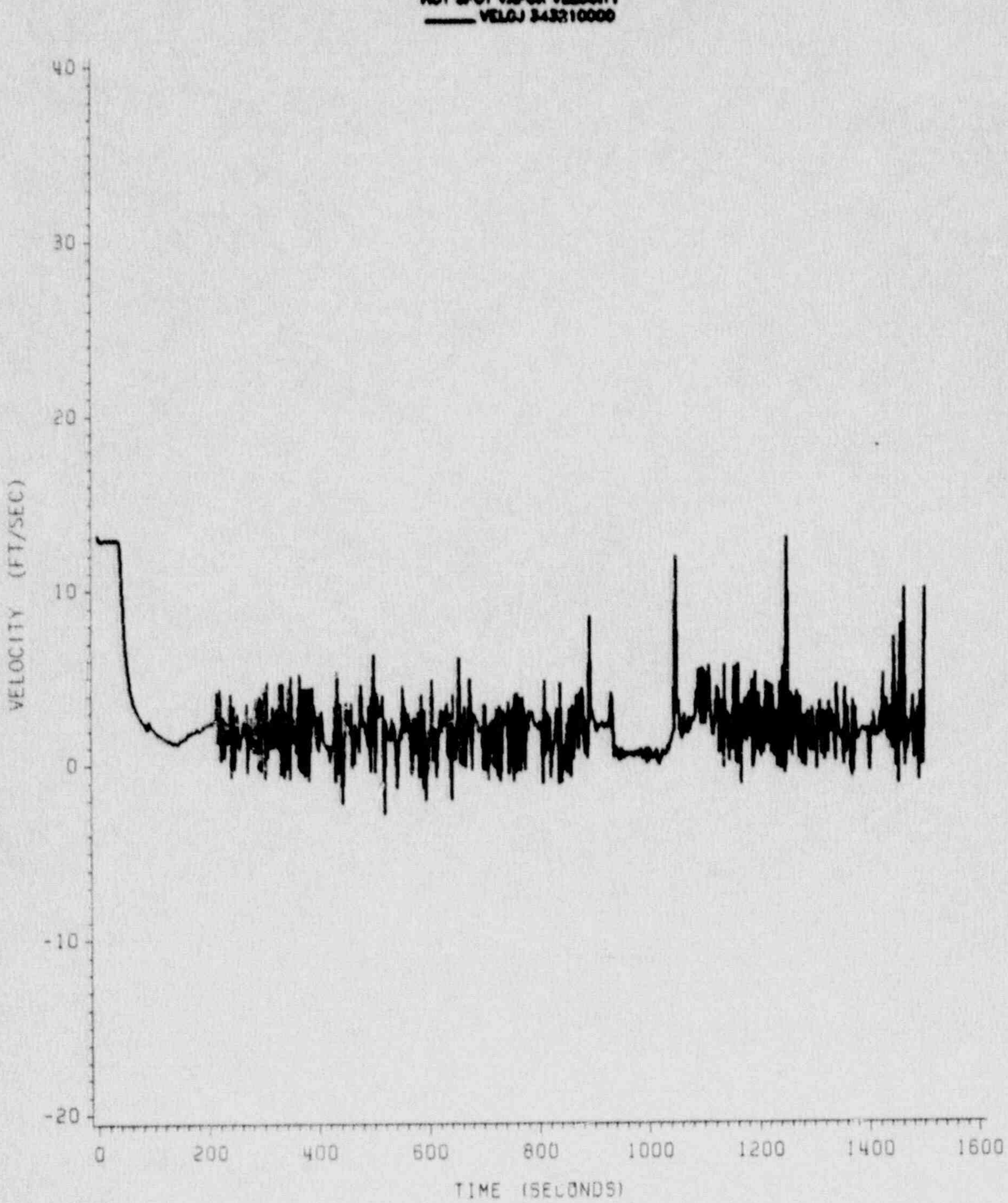


FIGURE 7-4

HADDAM NECK PLANT ZIRCALOY SBLOCA
0.02 FT2 DISCHARGE LEG BREAK

VOID FRACTION - VOLUME 33601

——— VOIDG 336010000

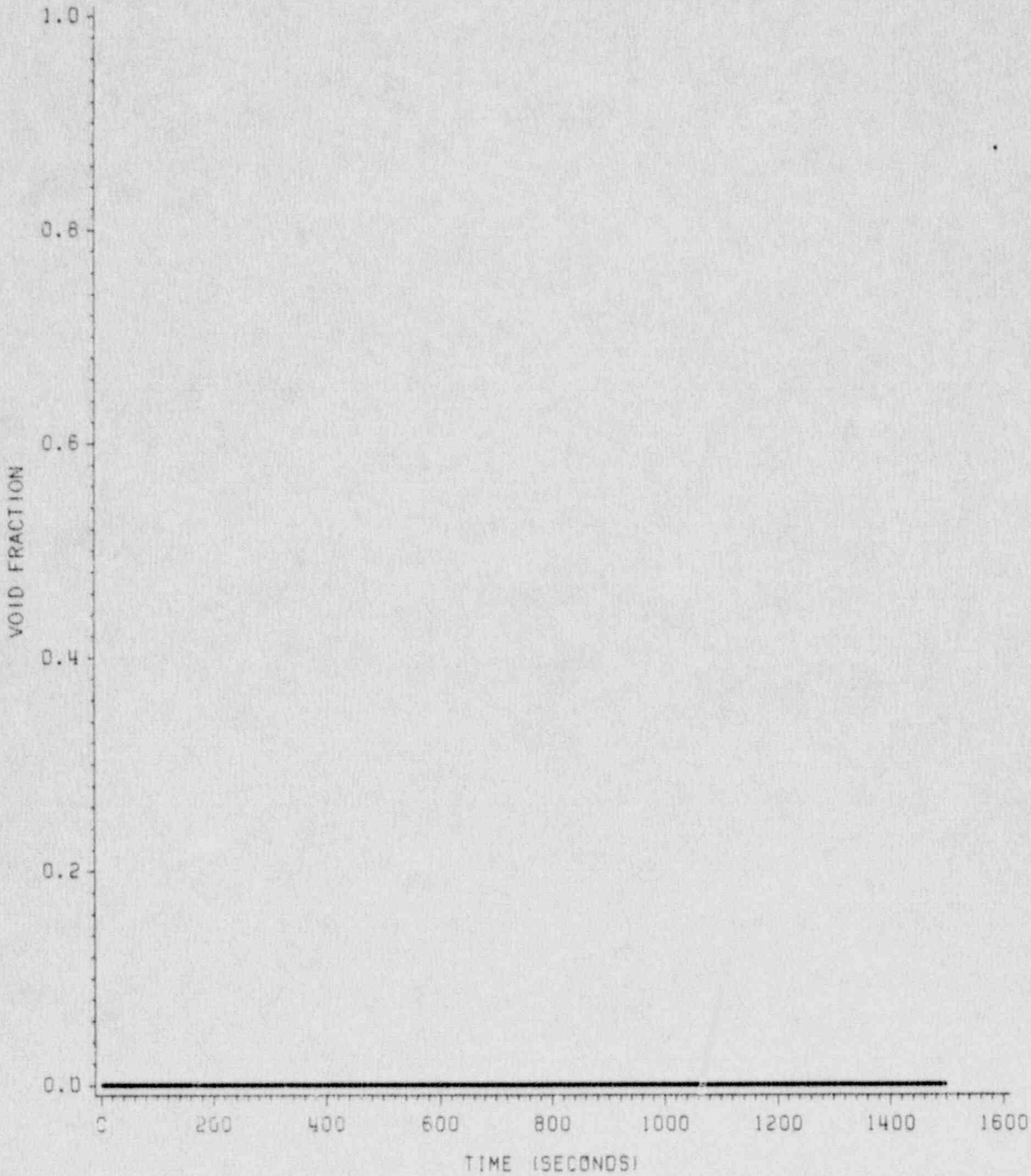


FIGURE 7-5

HADDAM NECK PLANT ZIRCALOY SBLOCA
0.075 FT2 DISCHARGE LEG BREAK

HOT SPOT VAPOR VELOCITY

——— VELGJ 343210000

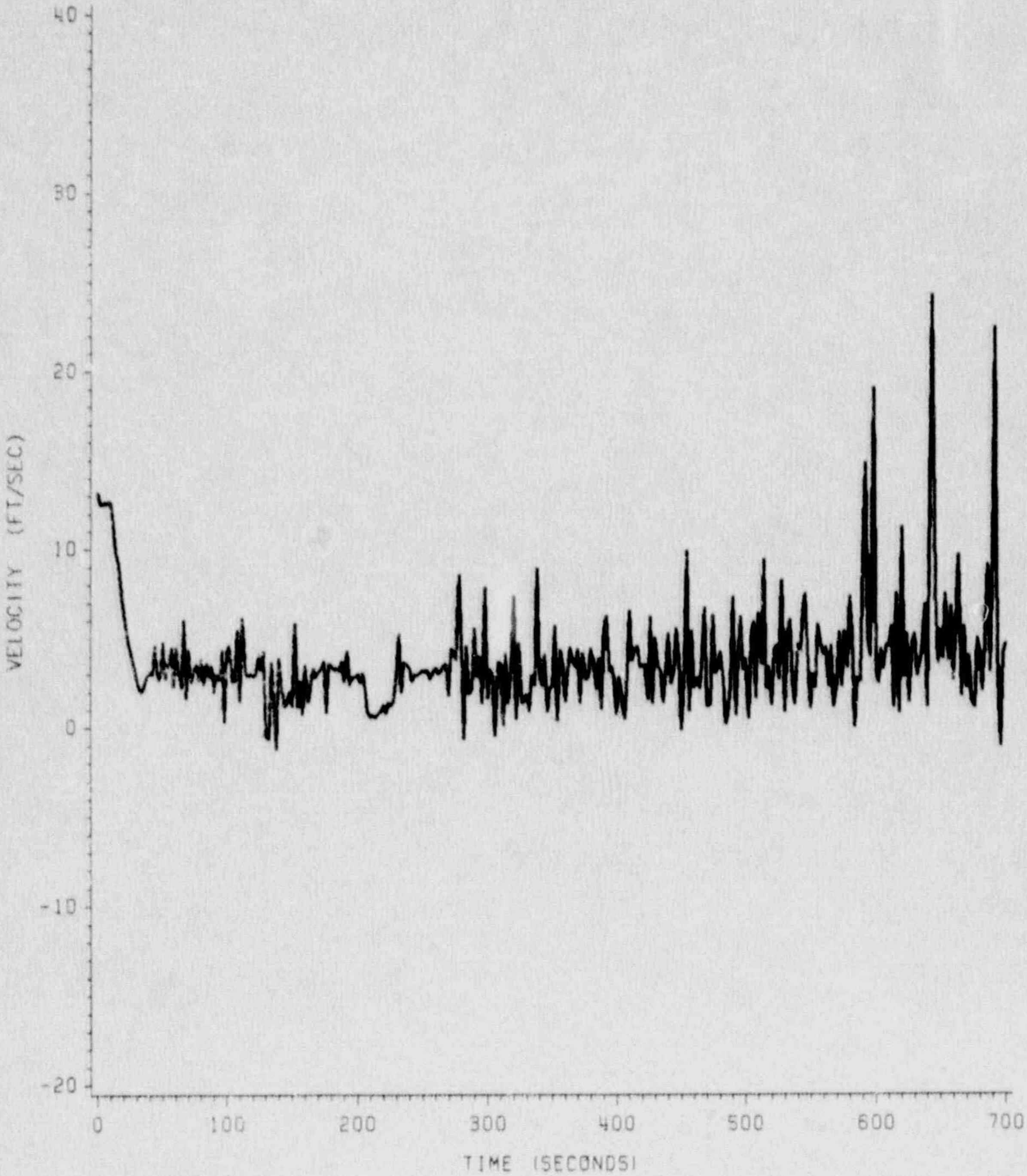


FIGURE 7-6

HADDAM NECK PLANT ZIRCALOY SBLOCA
0.075 FT2 DISCHARGE LEG BREAK

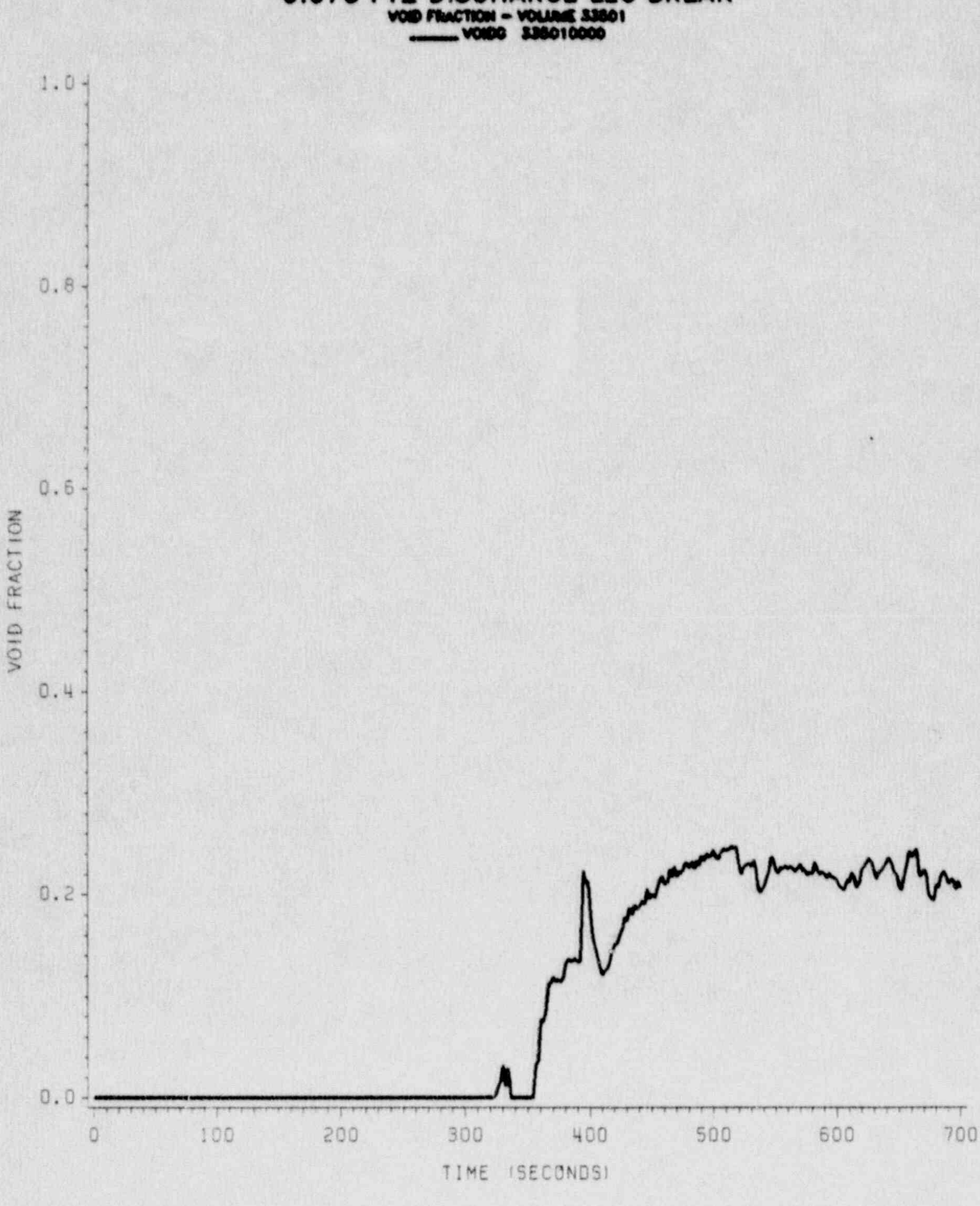


FIGURE 7-7

HADDAM NECK PLANT ZIRCALOY SBLOCA
0.1 FT2 DISCHARGE LEG BREAK

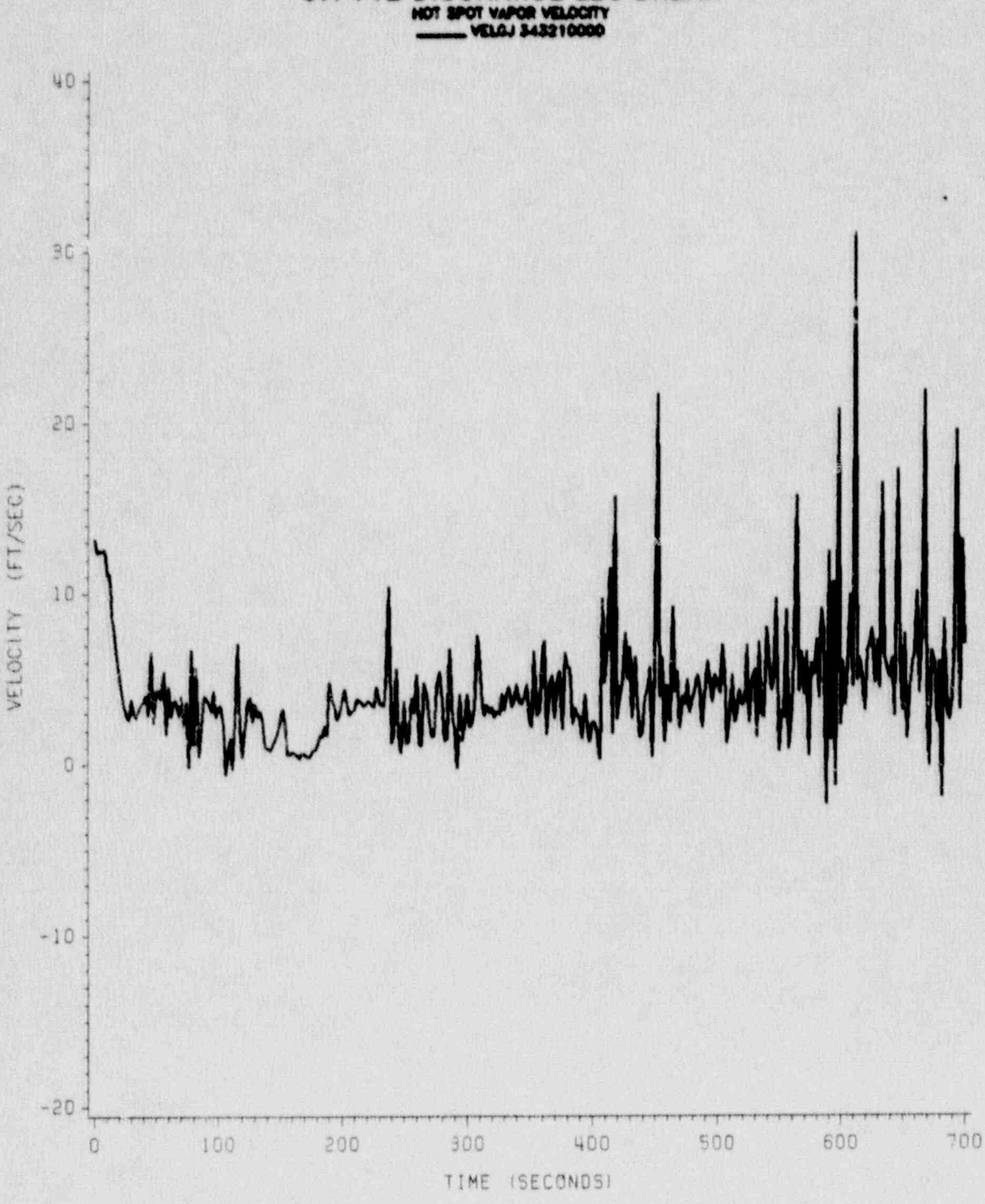


FIGURE 7-8

HADDAM NECK PLANT ZIRCALOY SBLOCA
0.1 FT2 DISCHARGE LEG BREAK

VOID FRACTION - VOLUME 33601

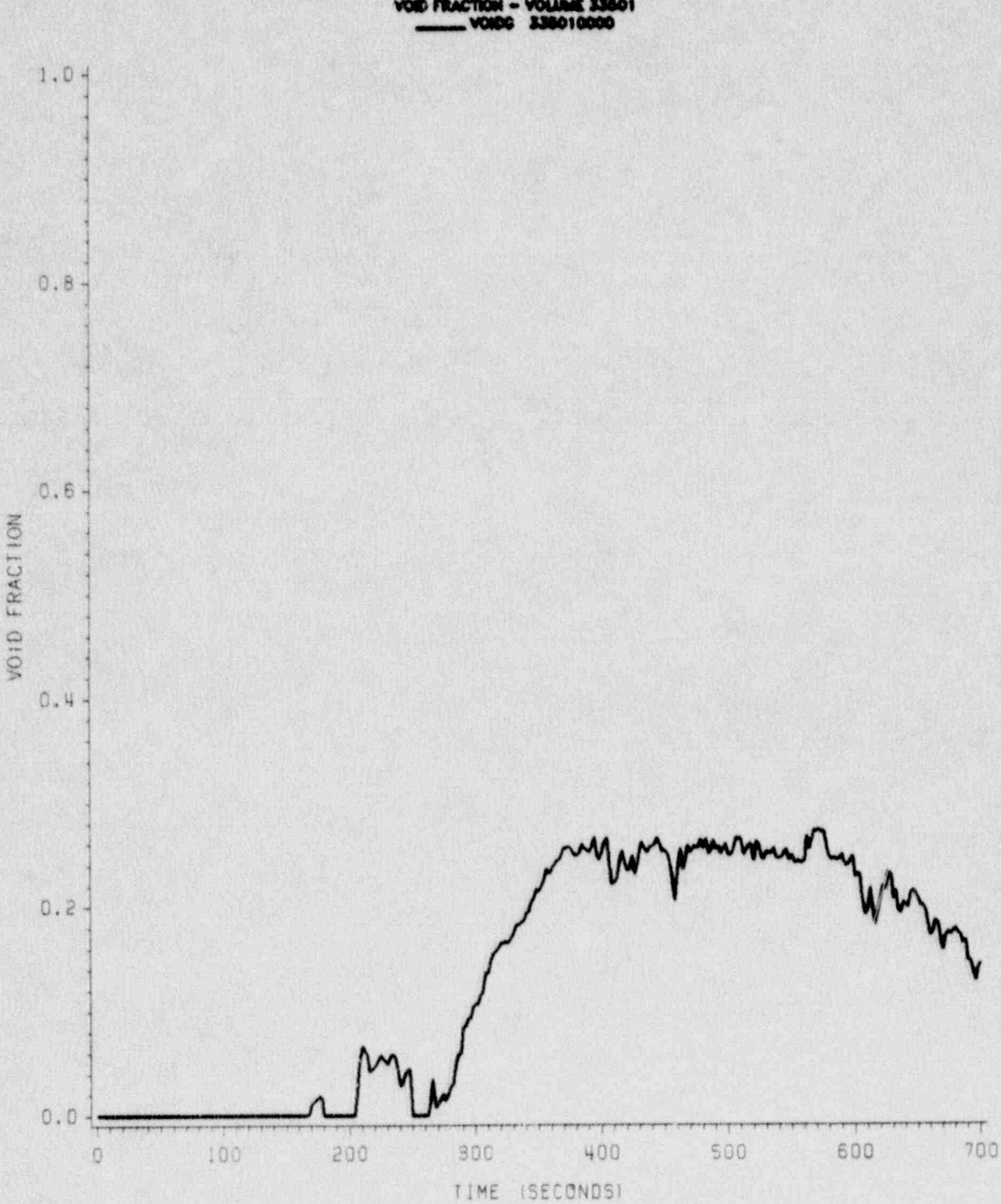


FIGURE 7-9

HADDAM NECK PLANT ZIRCALOY SBLOCA
0.2 FT2 DISCHARGE LEG BREAK

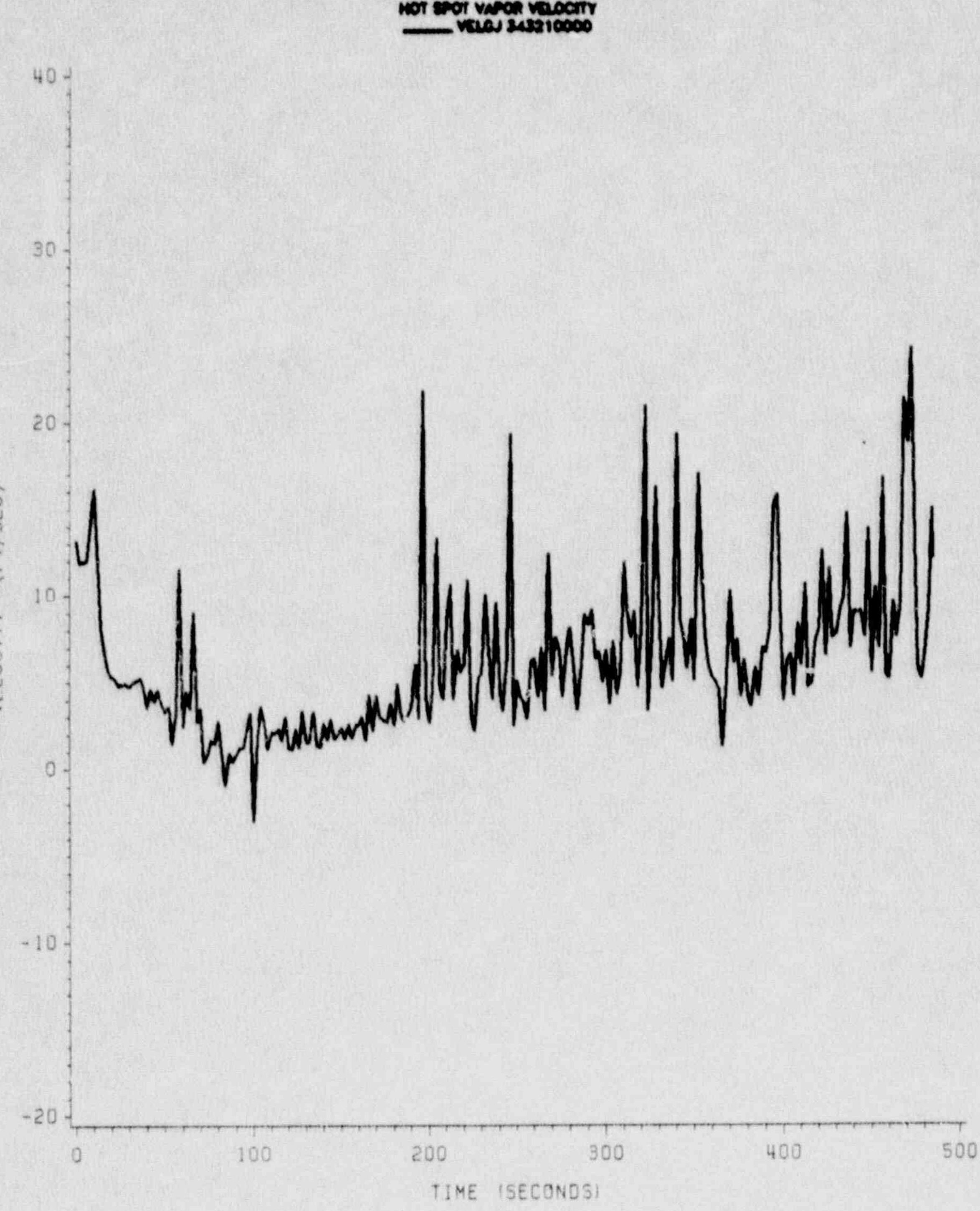


FIGURE 7-10

HADDAM NECK PLANT ZIRCALOY SBLOCA
0.2 FT2 DISCHARGE LEG BREAK
VOID FRACTION – VOLUME 33801
——— VOIDG 338010000

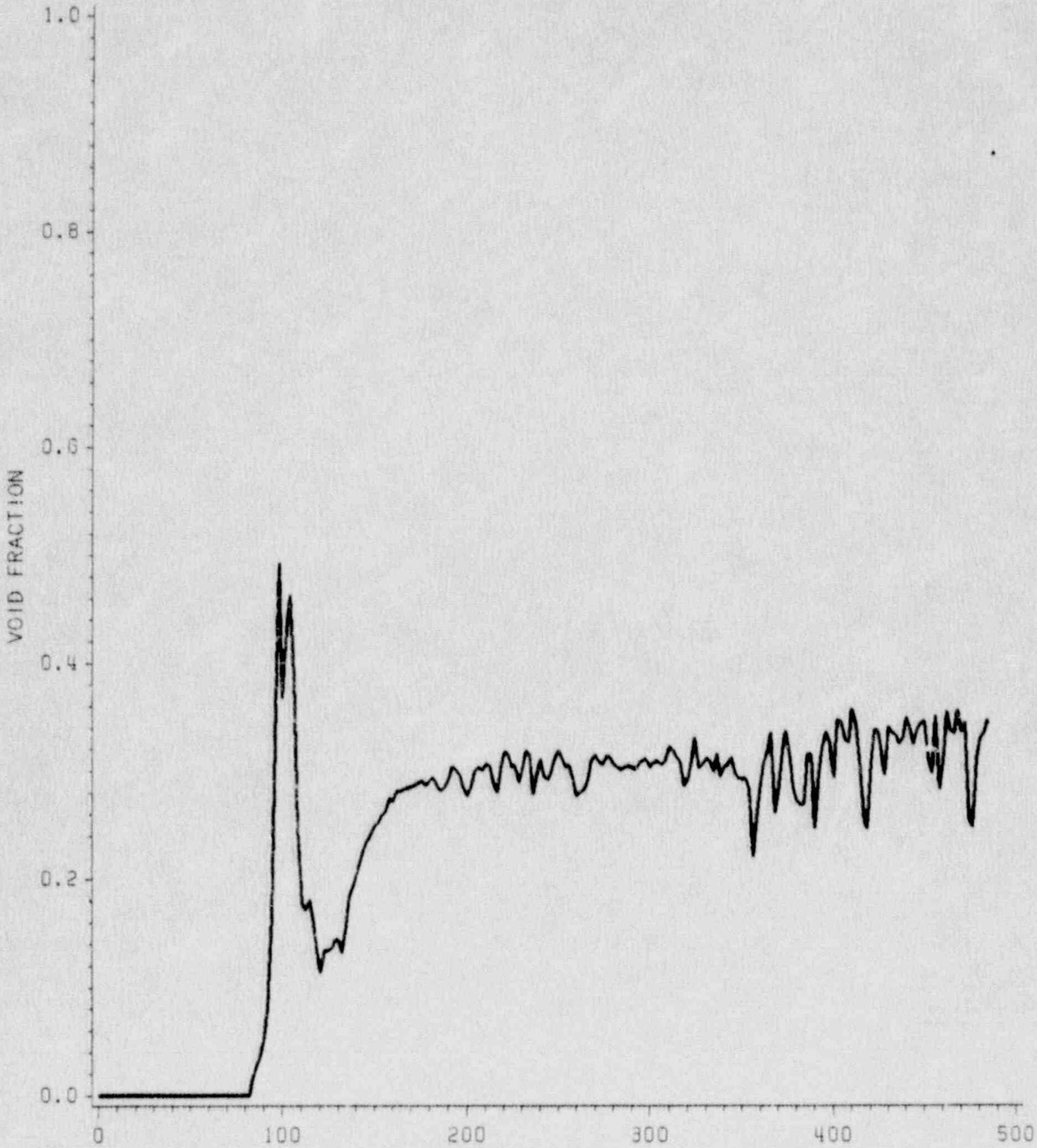


FIGURE 7-11

HADDAM NECK PLANT ZIRCALOY SBLOCA
0.4 FT2 DISCHARGE LEG BREAK

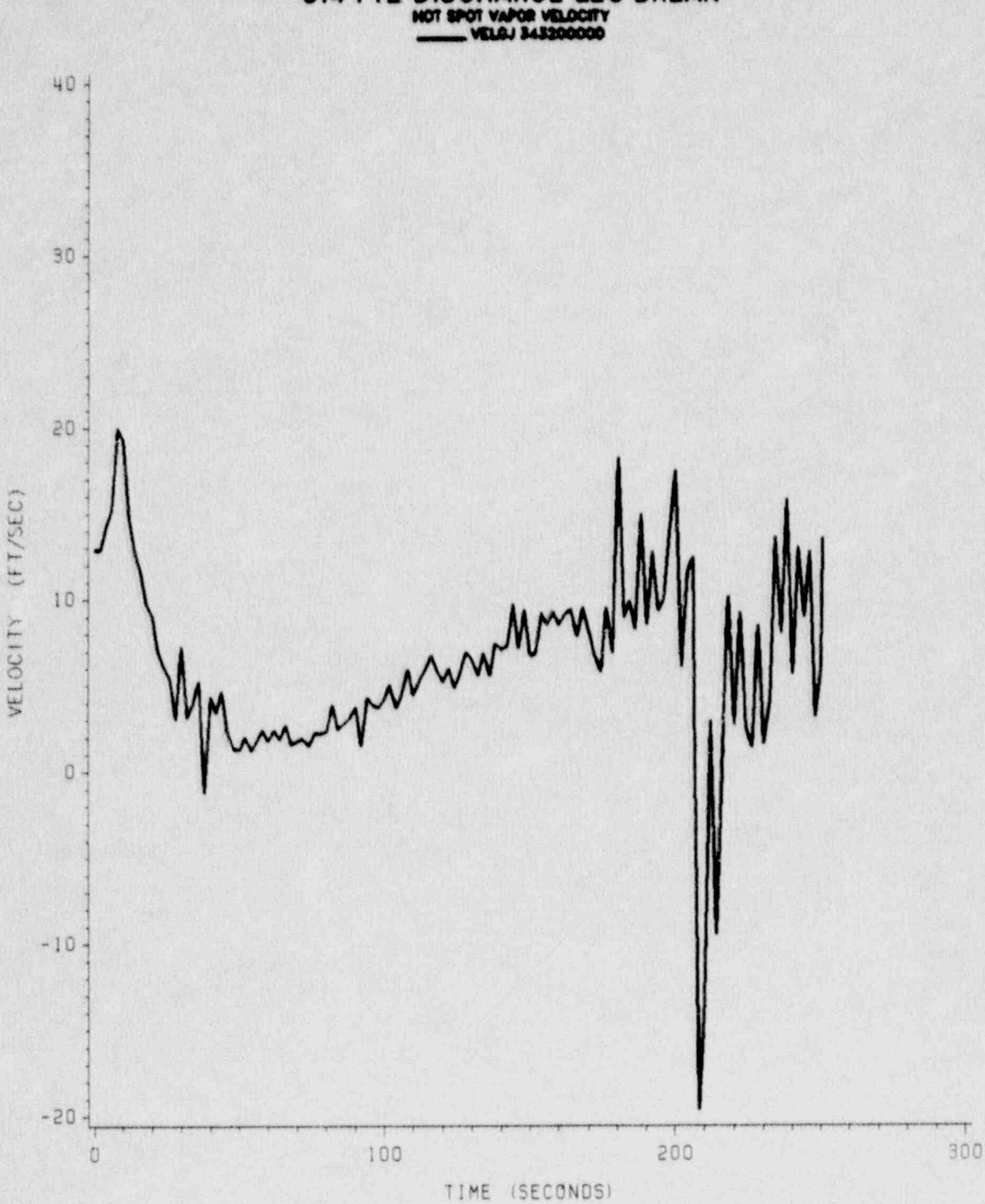
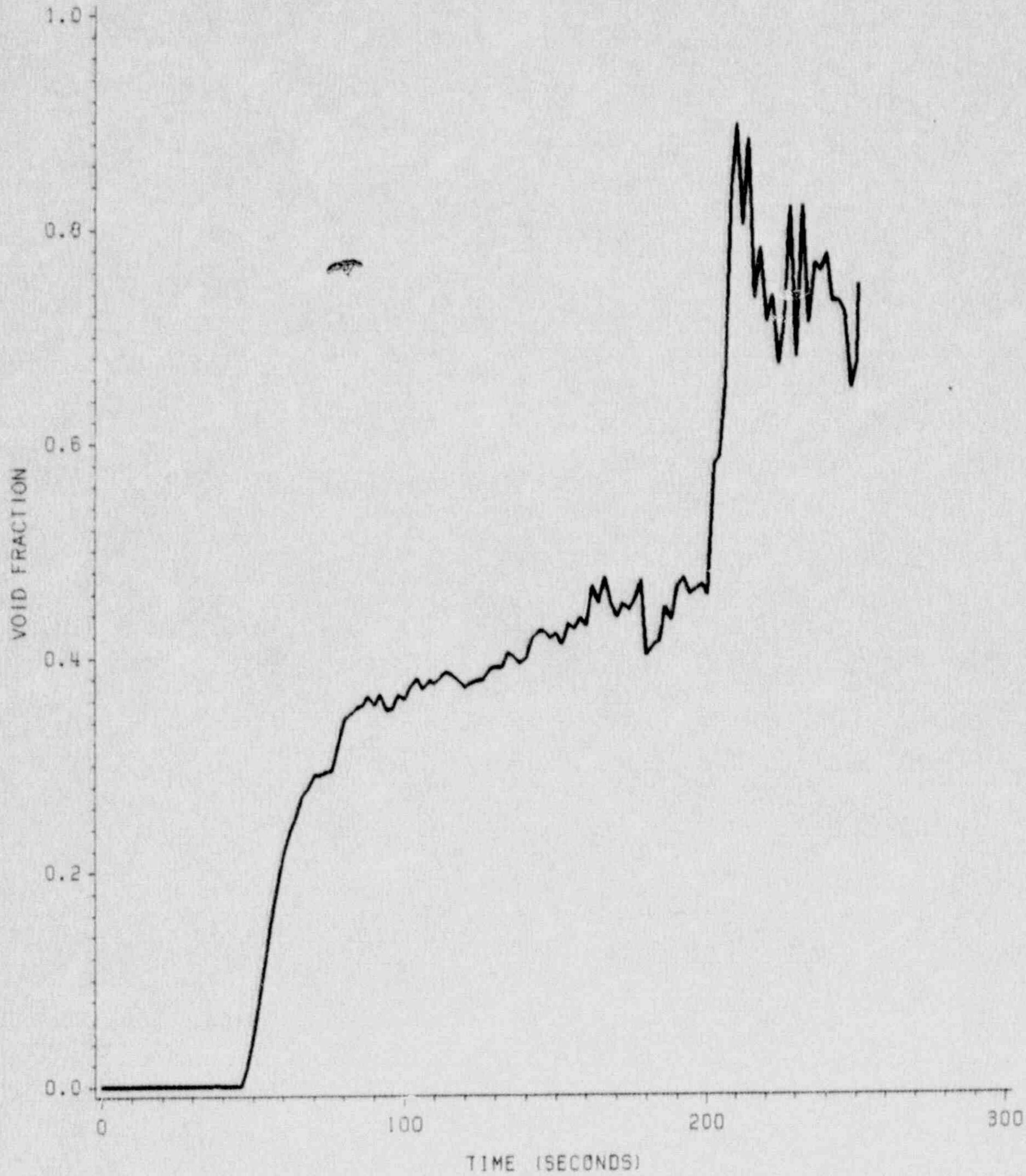


FIGURE 7-12

HADDAM NECK PLANT ZIRCALOY SBLOCA
0.4 FT2 DISCHARGE LEG BREAK

VOID FRACTION – VOLUME 33501

——— VOIDG 335010000



Question 8

With regard to Figures A.15 through F.15, define two-phase level and discuss its use as part of your evaluation methodology. We have also noticed a possible inconsistency in the relation between the two-phase level and the collapsed liquid level. Specifically, in Figure E.15, an initial depression of the two-phase level occurs when the collapsed liquid level shows a significant increase. Also in Figure F.15 at the end of the transient, the two-phase level is about 90% and the liquid mass is less than 5%, while earlier, at about 90 seconds, the liquid mass is about 25% with a corresponding two-phase level of about 55%. Please explain in detail the relation between the two-phase level and collapsed water level indicated in this Figure as well as Figures A thru F.15.

Response

For the zircaloy clad fuel analyses, the two-phase level provided on Figures A.15 through F.15 is defined as the normalized elevation within the active fuel region of a volume node just below the first node exhibiting a void fraction of 1.0. Since NULAP5 neither explicitly calculates a two-phase level nor uses it in any calculation, this definition was chosen arbitrarily to facilitate the determination and plotting of two-phase level. The two-phase level was provided for information only.

The inconsistency in the relation between the two-phase level and collapsed level is due to an error in plotting the two-phase level. The two-phase level plots shown on Figures A.15 through F.15 are actually the two-phase levels for the 121 outer assemblies core channel. The collapsed levels are correctly plotted. Figures 8-1 through 8-6 provide the correct curves for collapsed and two-phase level for the 36 center assemblies. It is easily seen that the correlation between two levels is improved.

We agree that there appears to be an inconsistency between collapsed and two-phase water level toward the end of the transient for the 0.4 ft2 break (Figures F.15 and 8-6). This particular break is relatively large and exhibits some of the phenomena associated with medium to large break LOCA's. During the rapid blowdown, there was insufficient time for a well defined two-phase level to develop. Within the NULAP5 Code there is no direct relation between the collapsed and two-phase levels. Both are calculated based on the void fraction distribution in the core channels. As discussed above, the determination of two-phase level is somewhat subjective and can lead to confusing results when applied to highly transient conditions as is the case for the 0.4 ft2 break. We suspect that for a more stable, quasi-steady conditions that would occur during a long term uncovery/recovery period, the consistency between collapsed and two-phase level would be significantly better. Since no long term uncovery was predicted due to the large capacity of the ECCS, this effect could not be shown.

It should be noted that for the 0.4 ft2 break, the data beyond approximately 140 seconds is not representative of the actual plant response since RCS pressure is below 300 ps and LPSI would have injected. LPSI was not modeled for this small break spectrum.

FIGURE 8-1

HADDAM NECK PLANT ZIRCALOY SBLOCA
0.01 FT2 DISCHARGE LEG BREAK
COLLAPSED AND TWO-PHASE WATER LEVEL
IN 36 CENTER ASSEMBLIES
NORMALIZED TO ACTIVE CORE LENGTH
______CNTRLVAR 041
----TWO PHASE LEVEL

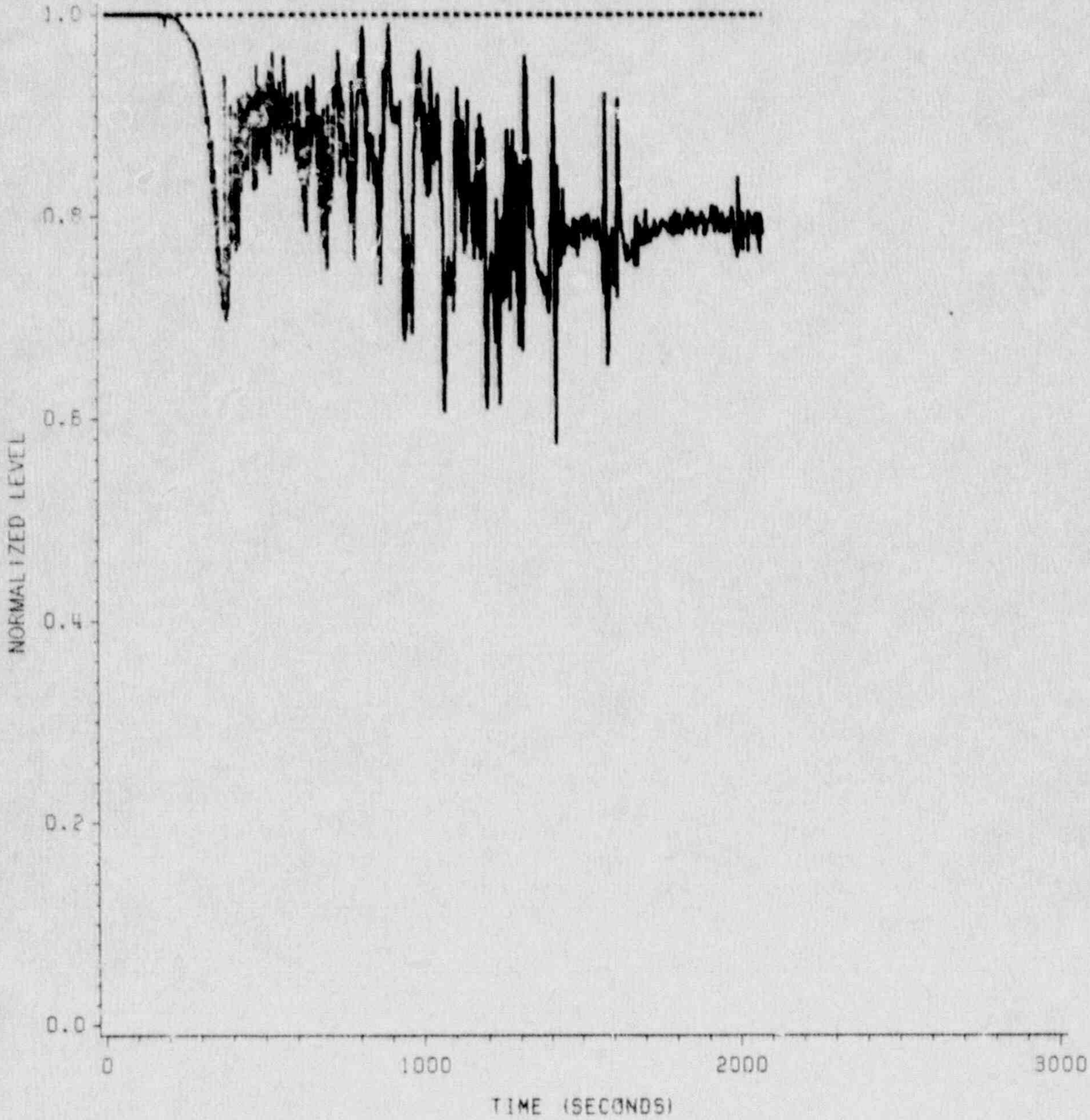


FIGURE 8-2

HADDAM NECK PLANT ZIRCALOY SBLOCA
0.02 FT2 DISCHARGE LEG BREAK
COLLAPSED AND TWO-PHASE WATER LEVEL
IN 36 CENTER ASSEMBLIES
NORMALIZED TO ACTIVE CORE LENGTH
———CNTRLVAR 041
----TWO PHASE LEVEL

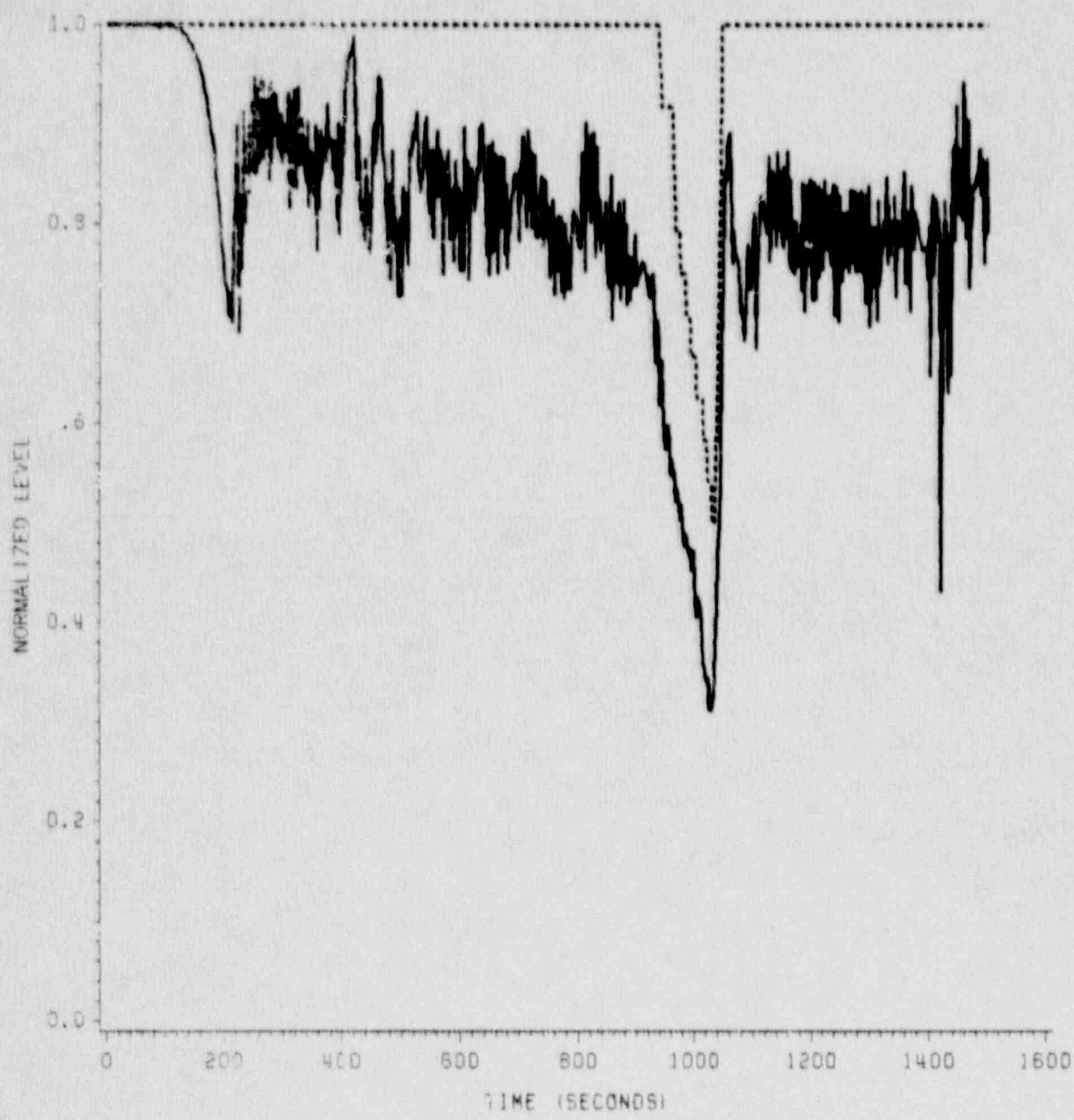


FIGURE 8-3

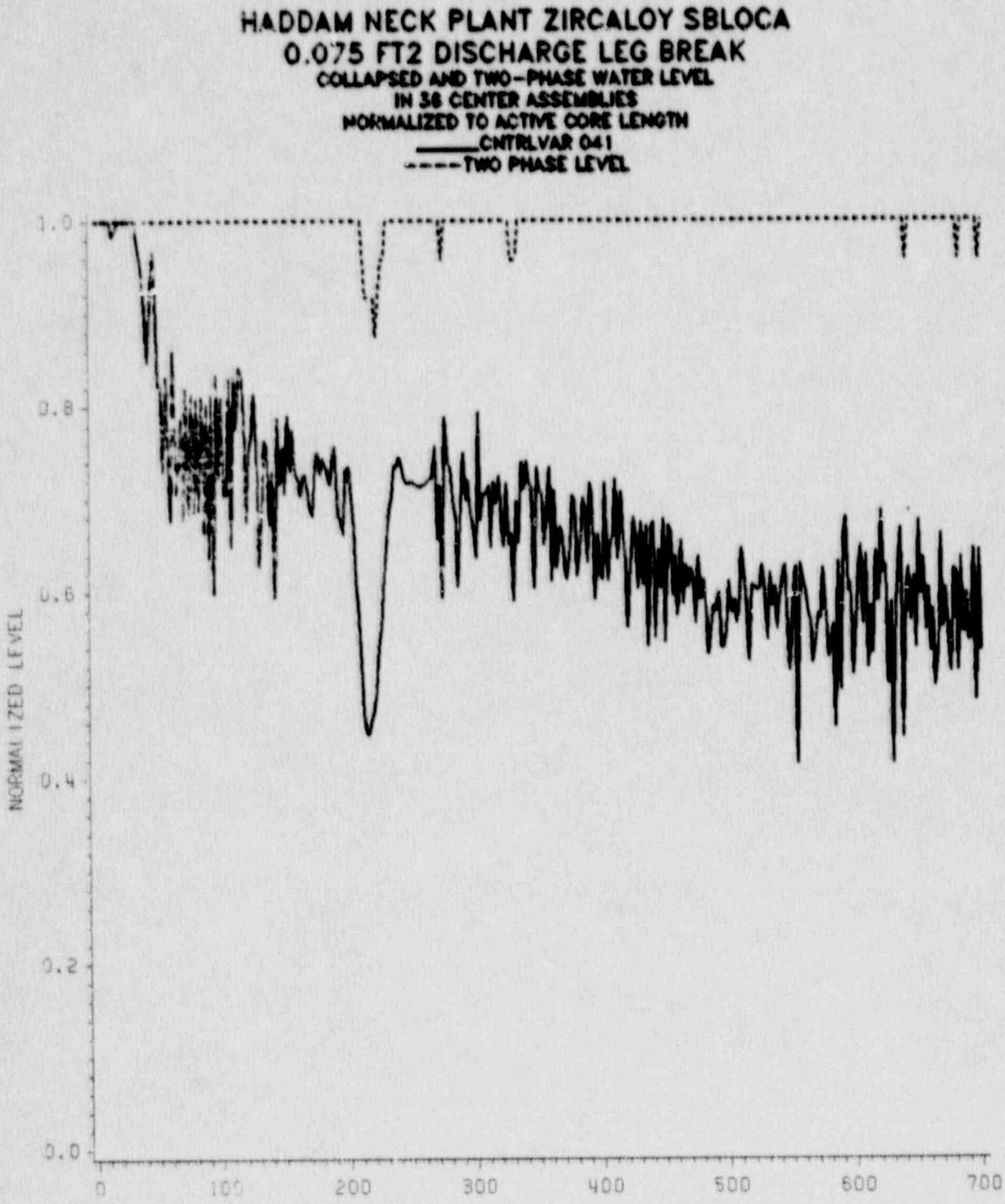

HADDAM NECK PLANT ZIRCALOY SBLOCA
0.075 FT2 DISCHARGE LEG BREAK
COLLAPSED AND TWO-PHASE WATER LEVEL
IN 36 CENTER ASSEMBLIES
NORMALIZED TO ACTIVE CORE LENGTH
CNTRLVAR 041
TWO PHASE LEVEL
NORMALIZED LEVEL
1.0
0.8
0.6
0.4
0.2
0.0
0
100
200
300
400
500
600
700
TIME (SECONDS)

FIGURE 8-4

HADDAM NECK PLANT ZIRCALOY SBLOCA
0.1 FT2 DISCHARGE LEG BREAK
COLLAPSED AND TWO-PHASE WATER LEVEL
IN 36 CENTER ASSEMBLIES
NORMALIZED TO ACTIVE CORE LENGTH
______CNTRLVAR 041
----TWO PHASE LEVEL

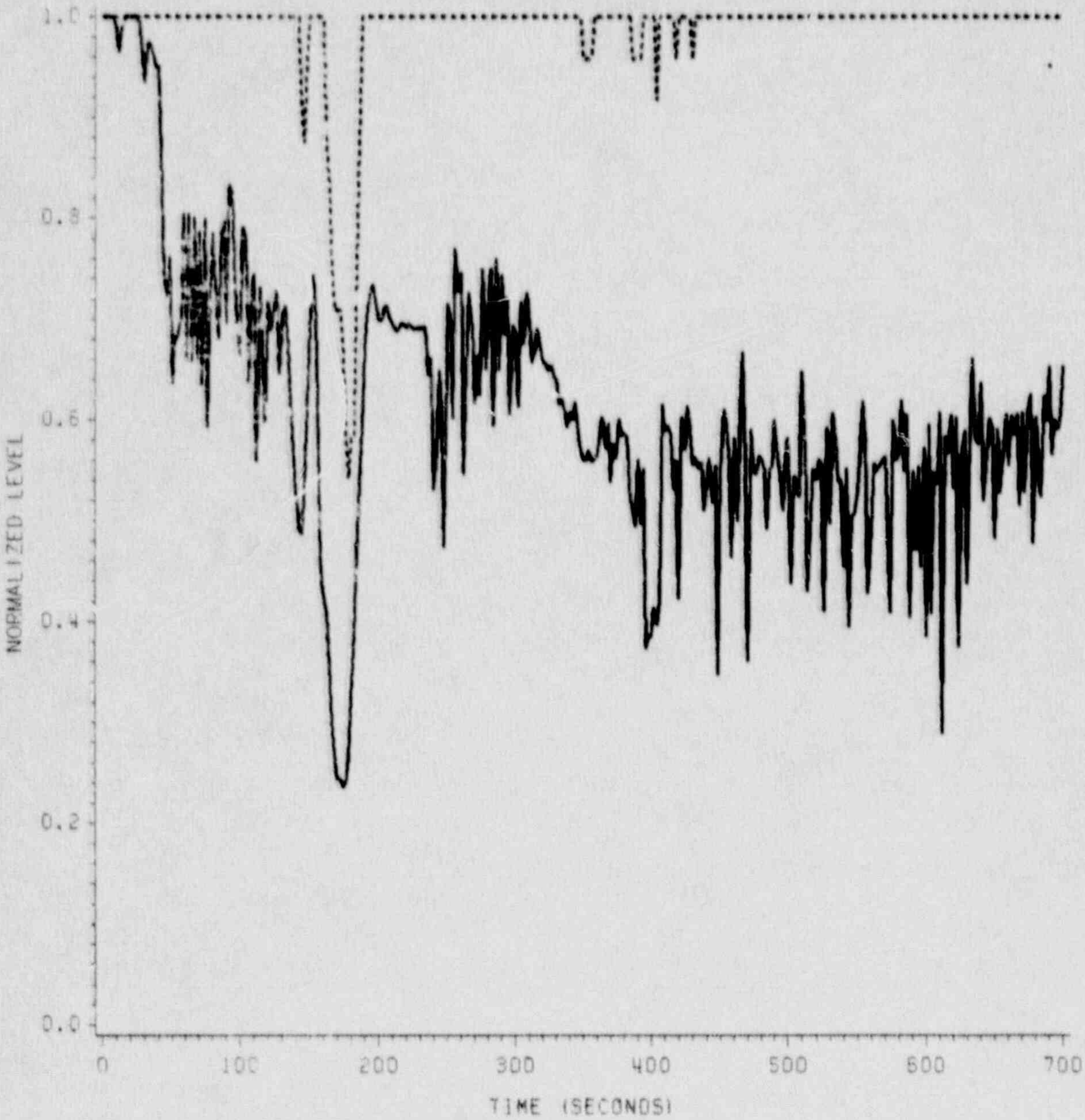


FIGURE 8-5

HADDAM NECK PLANT ZIRCALOY SBLOCA
0.2 FT2 DISCHARGE LEG BREAK
COLLAPSED AND TWO-PHASE WATER LEVEL
IN 38 CENTER ASSEMBLIES
NORMALIZED TO ACTIVE CORE LENGTH
______CNTRLVAR 041
----TWO PHASE LEVEL

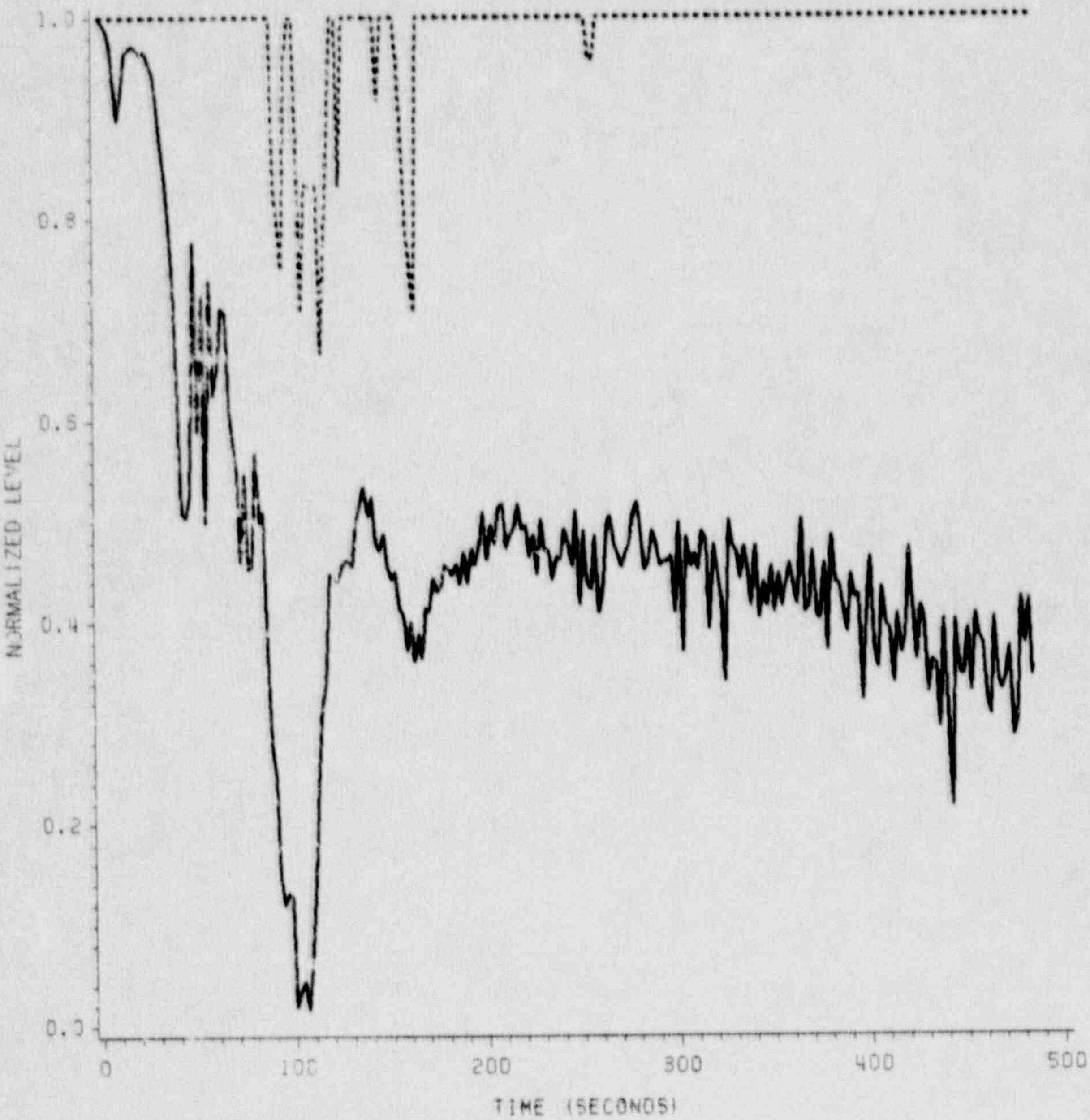
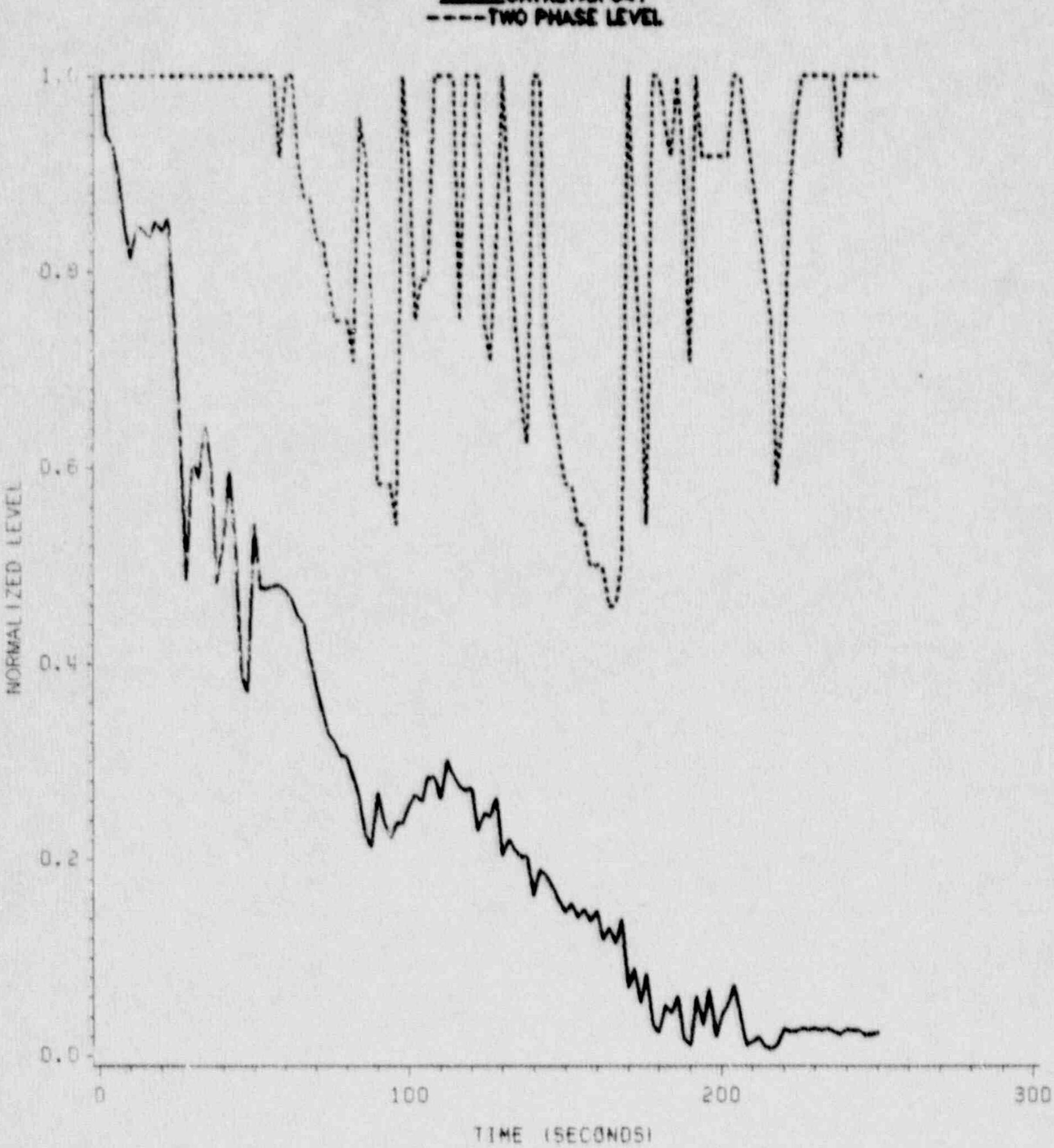


FIGURE 8-6

HADDAM NECK PLANT ZIRCALOY SBLOCA
0.4 FT2 DISCHARGE LEG BREAK
COLLAPSED AND TWO-PHASE WATER LEVEL
IN 36 CENTER ASSEMBLIES
NORMALIZED TO ACTIVE CORE LENGTH



Question 9.

What causes the clad temperature increase in Figure E.14 when the core is covered with two-phase flow?

Response

The sudden clad temperature increase which occurs at approximately 50 seconds is due to the fact that NULAP5 predicted a DNB condition at that hot rod location. The sudden drop in surface heat transfer coefficient at 50 seconds is seen on Figure E.24. Since NULAP5 does not allow a return to nucleate boiling heat transfer, the surface heat transfer coefficient remains low and the clad surface temperature continues to increase. At 90 seconds the loop seal clearing phenomenon results in additional core level depression and the clad surface temperature continues to rise until level is recovered. Typically, the sudden drop in heat transfer coefficient coincides with the initiation of the loop seal clearing phenomena. For this break, however, the drop in heat transfer coefficient was predicted to occur slightly ahead of loop seal clearing.

Question 10.

Explain the large oscillations in the two-phase level in Figure F.15.

Response

The response to Question 8 provides a description of the relation between collapsed and two-phase level. Basically, the oscillations are a result of the highly transient nature of this relatively large break and the method of quantifying two-phase level from the predicted void fraction distribution in the center core channel.

Question 12.

The heat transfer coefficient in Figures 24 is difficult to interpret at values below 500 Btu/hr/sq. ft./F. Please provide an additional plot or tabulated data (0-500) so that the variation of the heat transfer coefficient for the latter portion of the transient, particularly when steam cooling governs the heatup of the hot rod, may be reviewed.

Response

Figures 12-1 through 12-6 provide the surface heat transfer coefficient at the hot spot plotted on a log scale for each of the breaks provided in NUSCO 163.

FIGURE 12-1

HADDAM NECK PLANT ZIRCALOY SBLOCA
0.01 FT2 DISCHARGE LEG BREAK
HEAT TRANS. COEFF. - HOT SPOT

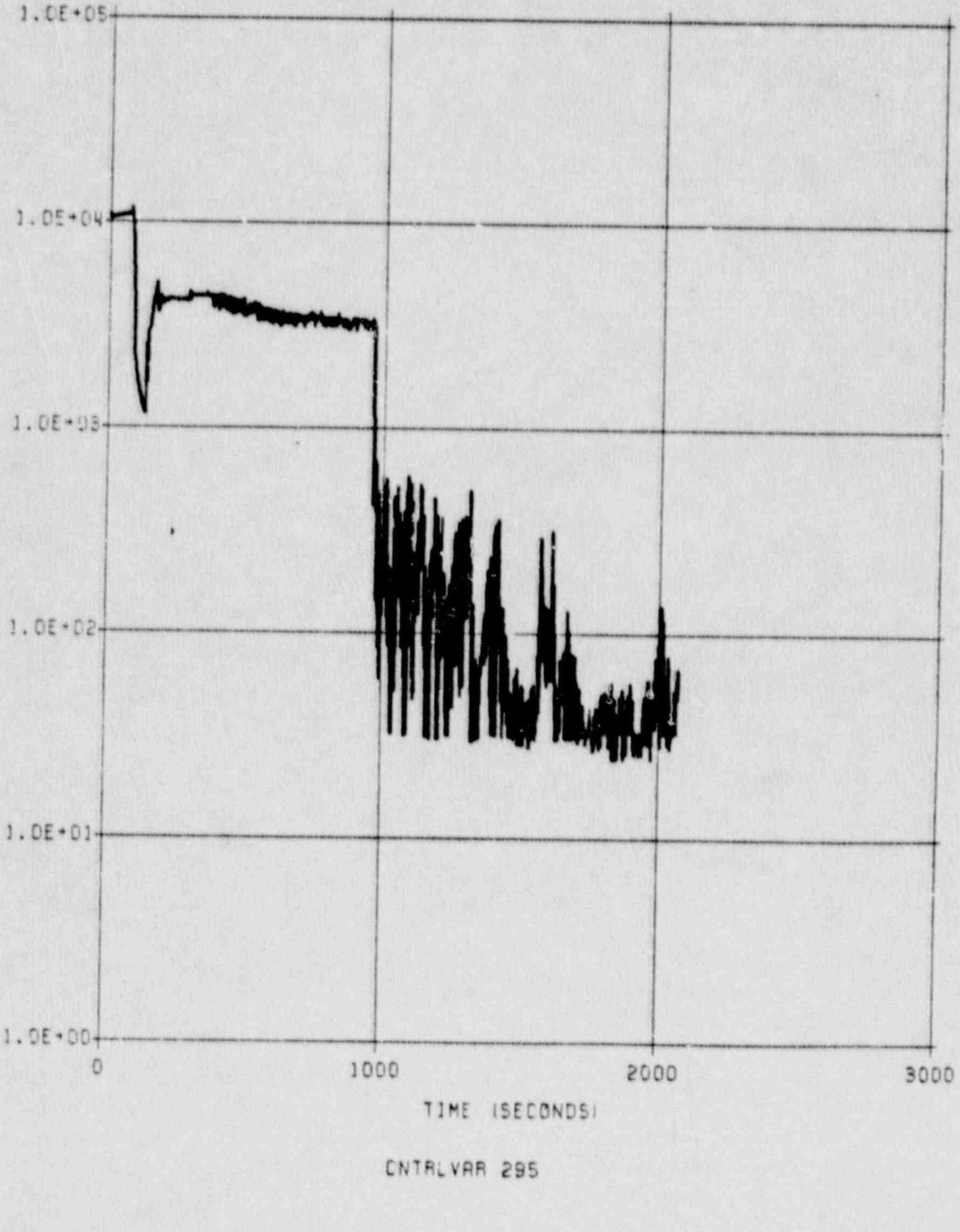
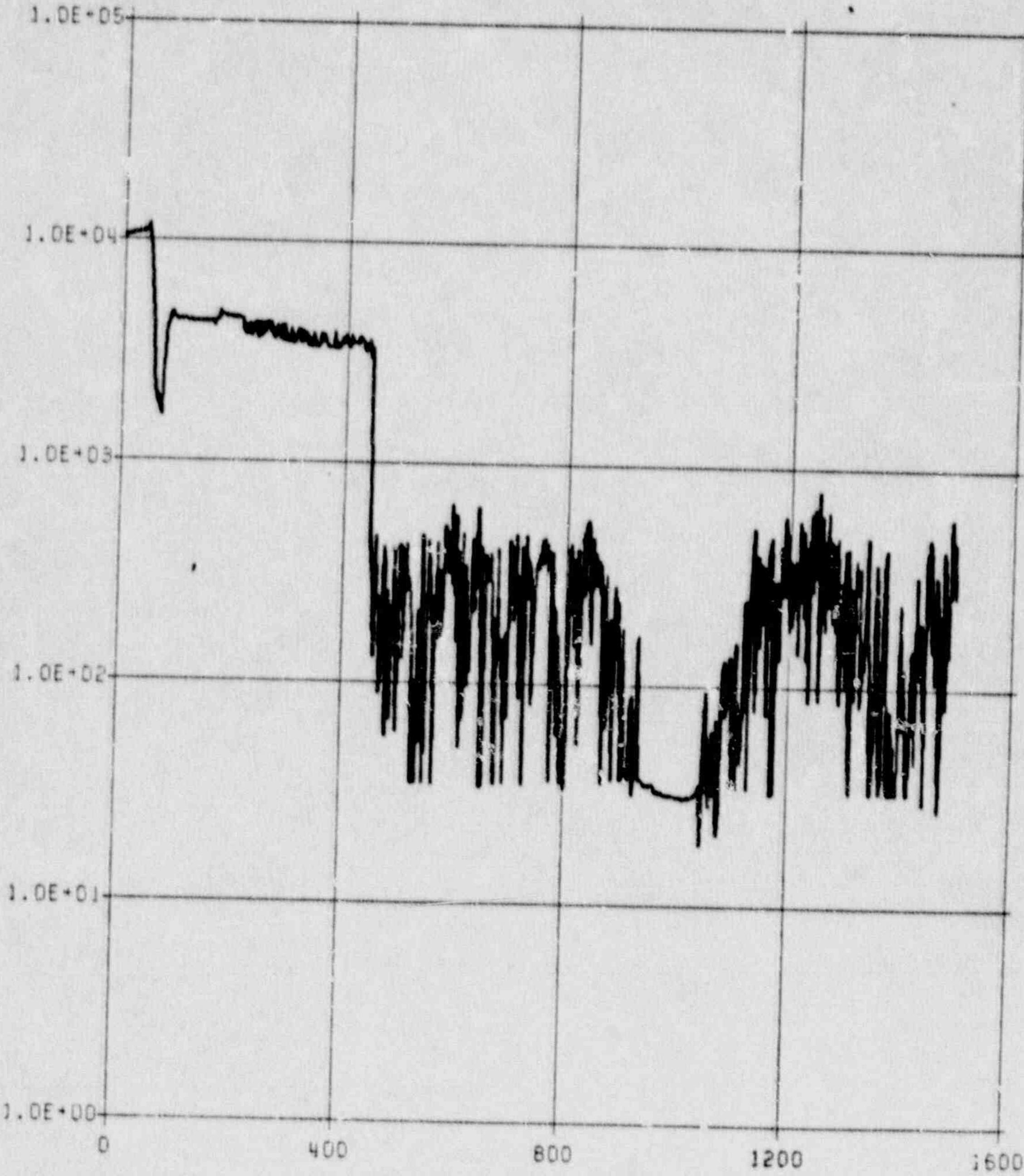


FIGURE 12-2

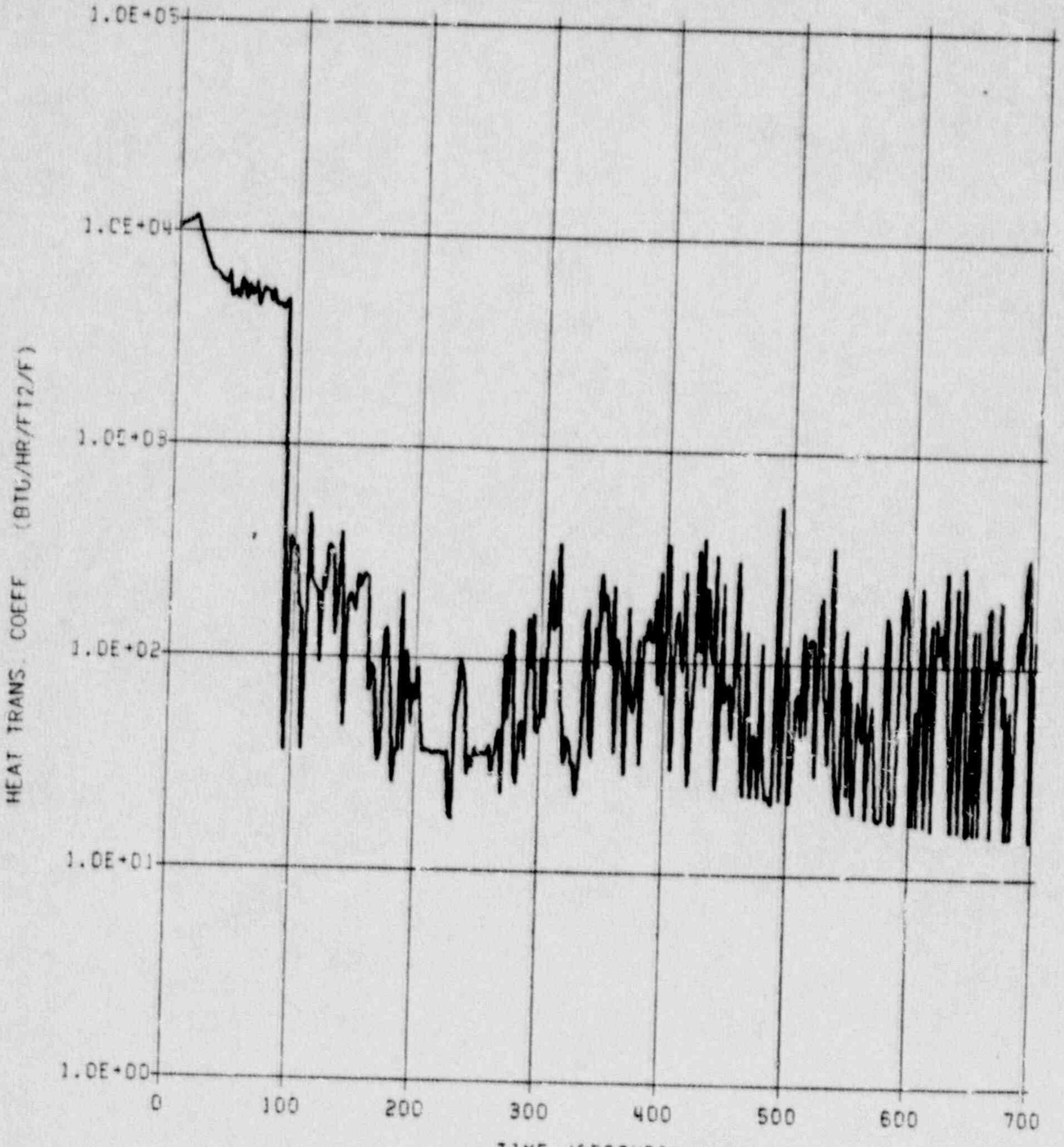
HADDAM NECK PLANT ZIRCALOY SBLOCA
0.02 FT2 DISCHARGE LEG BREAK
HEAT TRANS. COEFF. – HOT SPOT



CNTRLVAR 296

FIGURE 12-3

HADDAM NECK PLANT ZIRCALOY SBLOCA
0.075 FT2 DISCHARGE LEG BREAK
HEAT TRANS. COEFF. – HOT SPOT



CNTRLVAR 296

FIGURE 12-4

HADDAM NECK PLANT ZIRCALOY SBLOCA
0.1 FT2 DISCHARGE LEG BREAK
HEAT TRANS. COEFF. -- HOT SPOT

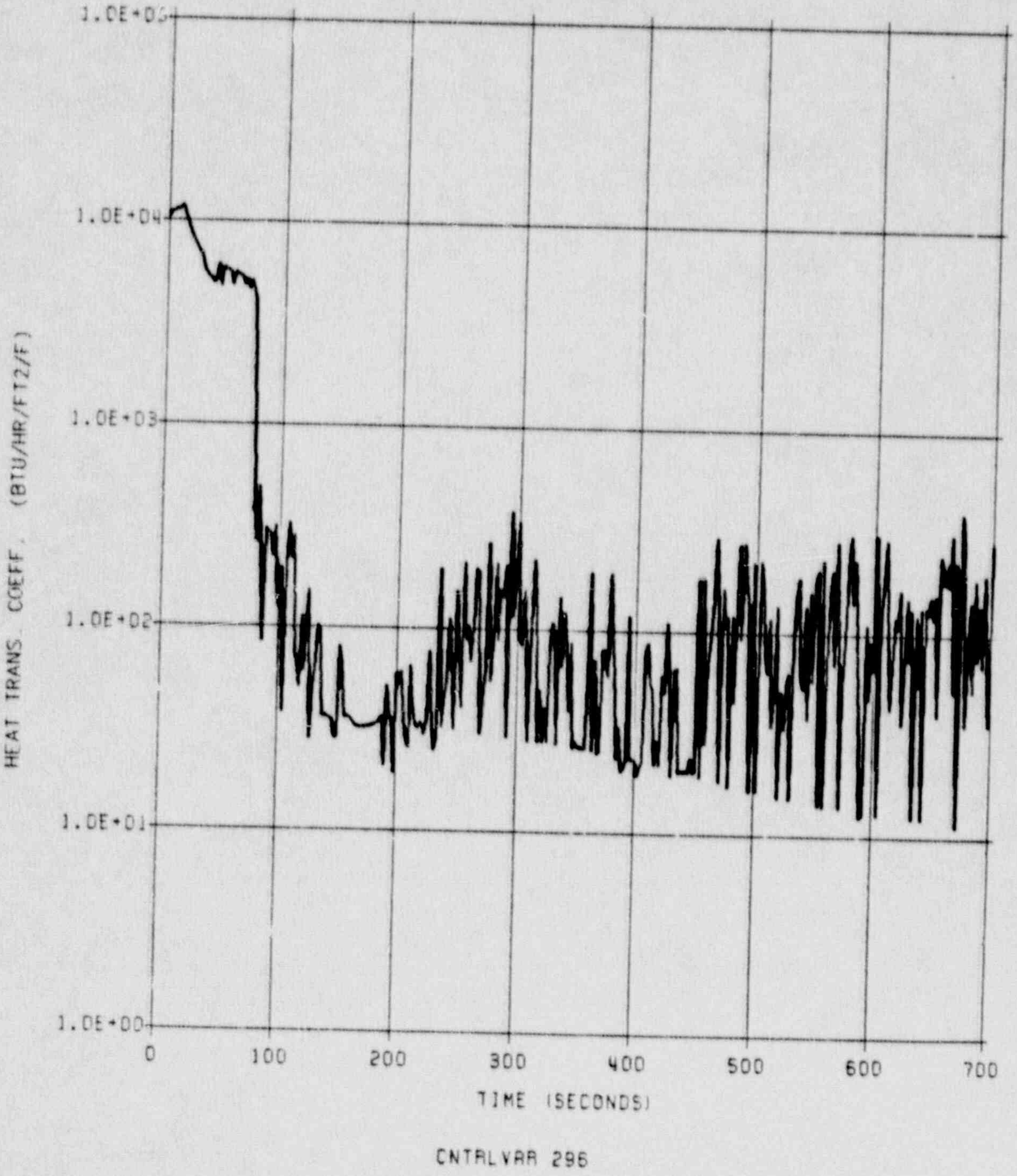
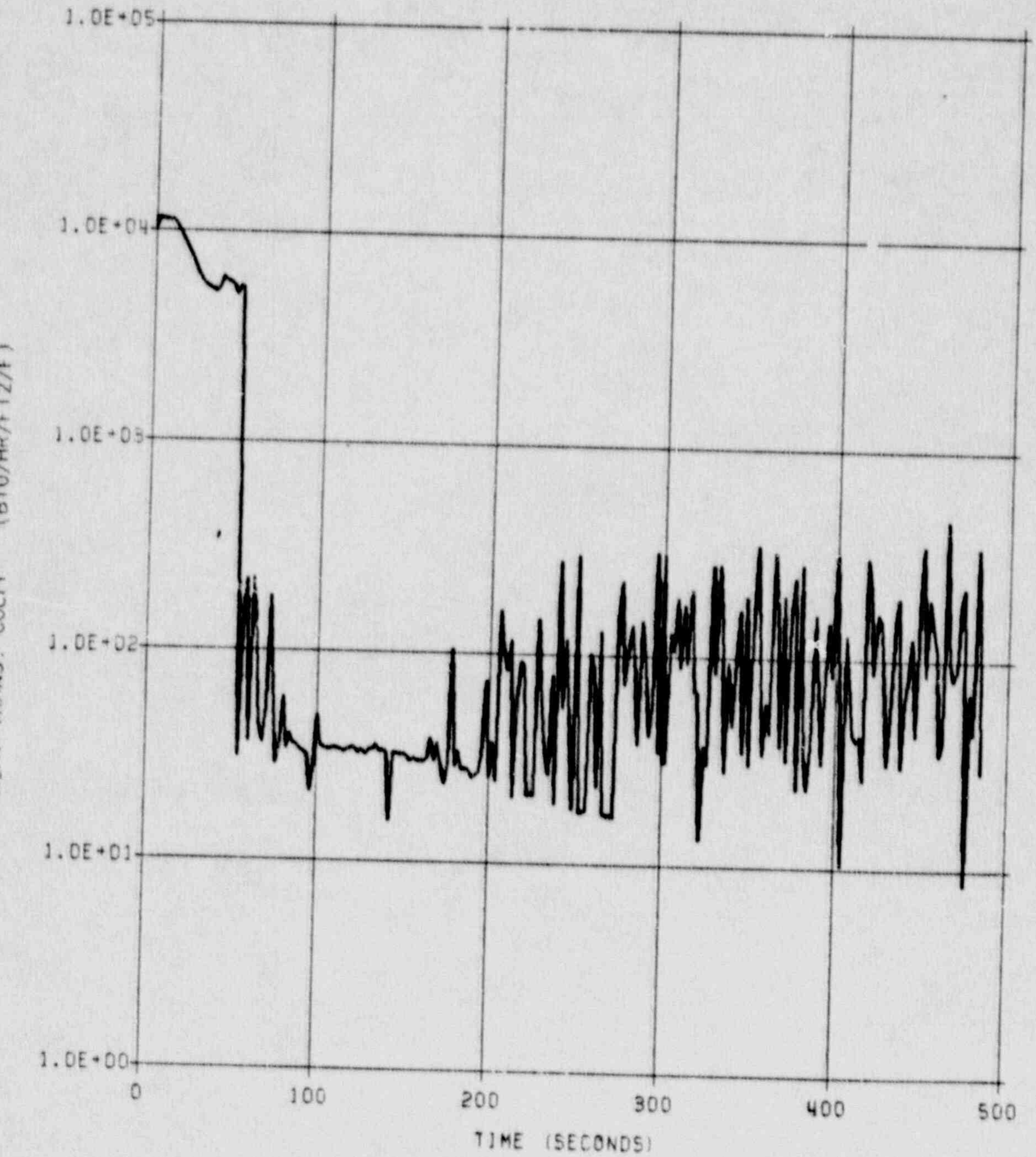


FIGURE 12-5

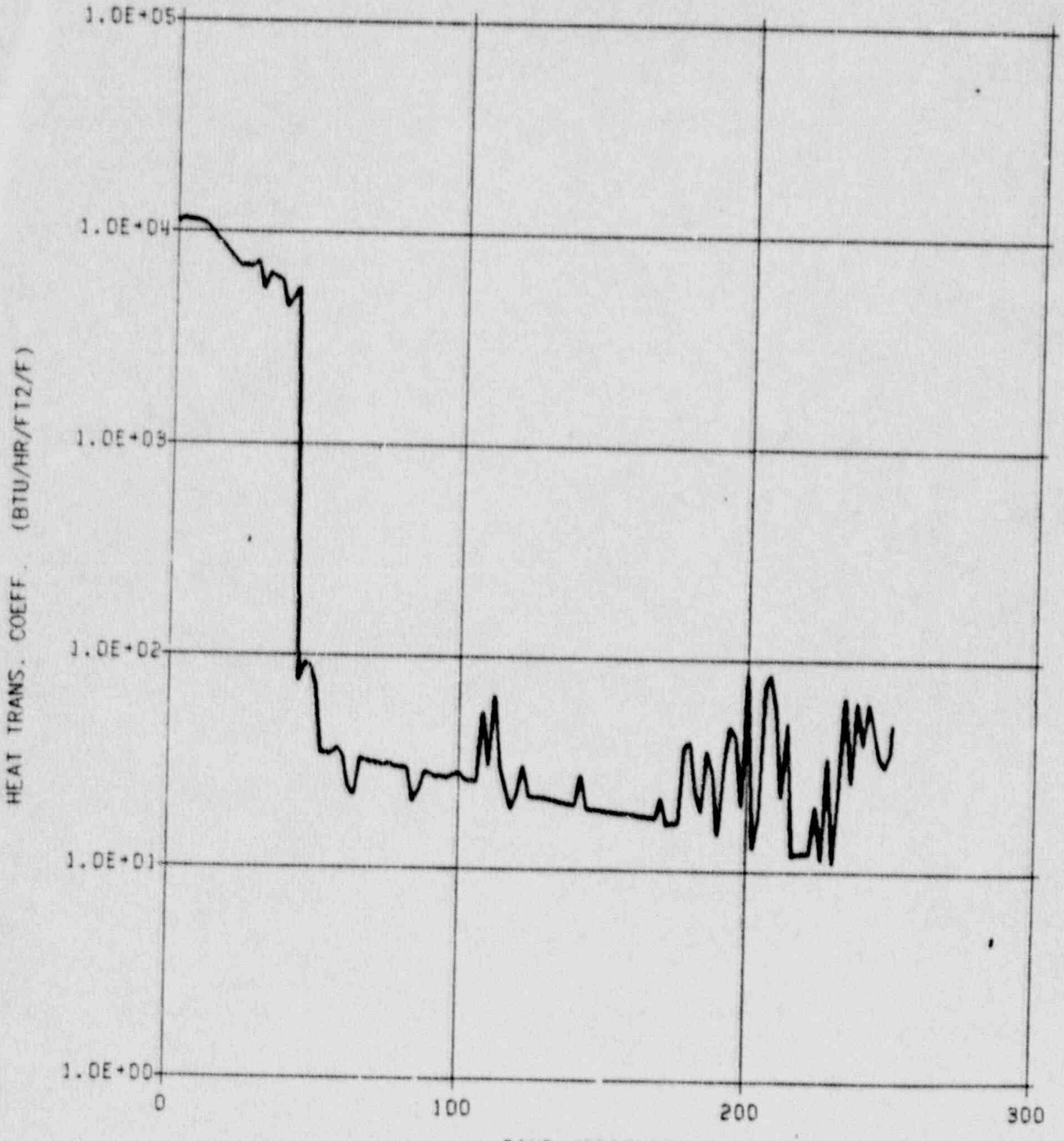
HADDAM NECK PLANT ZIRCALOY SBLOCA
0.2 FT2 DISCHARGE LEG BREAK
HEAT TRANS. COEFF. – HOT SPOT



CNTRLVAR 296

FIGURE 12-6

HADDAM NECK PLANT ZIRCALOY SBLOCA
0.4 FT2 DISCHARGE LEG BREAK
HEAT TRANS. COEFF. – HOT SPOT



CNTRLVAR 295