# REVISED RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

**APR1400 Design Certification**

**Korea Electric Power Corporation / Korea Hydro & Nuclear Power Co., LTD**

**Docket No. 52-046**

| | |
|---|---|
| **RAI No.:** | **318-8337** |
| **SRP Section:** | **15.06.05 – Loss of Coolant Accidents Resulting From Spectrum of Postulated Piping Breaks Within the Reactor Coolant Pressure Boundary** |
| **Application Section:** | **15.6.5** |
| **Date of RAI Issue:** | **11/24/2015** |

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## Question No. 15.06.05-2

**SBLOCA Break Spectrum Analysis & Core Two-Phase Level**

General Design Criterion (GDC) 35, "Emergency Core Cooling," in 10 CFR Part 50, Appendix A, mandates the requirements for the emergency core cooling system (ECCS) that need to be satisfied by conforming to the ECCS acceptance criteria for light-water reactors given in 10 CFR 50.46, "Acceptance Criteria for Emergency Core Cooling Systems for Light-water Nuclear Power Reactors." 10 CFR 50.46(b)(1) identifies the peak cladding temperature (PCT) requirement; and 10 CFR 50.46(b)(5) requires that after any calculated successful initial operation of the ECCS, the calculated core temperature shall be maintained at an acceptably low value and decay heat shall be removed for the extended period of time to prevent the core from being uncovered. These requirements, along with 10 CFR 50.46(a)(1), specify the need to calculate the ECCS cooling performance using an acceptable evaluation model for a number of postulated loss-of-coolant accidents (LOCAs) of different sizes, locations, and other properties sufficient to provide assurance that the most severe LOCAs have been evaluated.

The staff's review of the small-break LOCA (SBLOCA) analysis results presented in the APR1400 DCD Section 15.6.5, "Loss-of-Coolant Accidents Resulting from the Spectrum of Postulated Piping Breaks within the Reactor Coolant Pressure Boundary," and the referenced Technical Report (TeR) APR1400-F-A-NR-14001-P, Rev.0,"Small Break LOCA Evaluation Model," has raised three questions, as submitted in the current RAI.

The break spectrums presented in Table 15.6.5-10 of the DCD are insufficient to ensure that the limiting SBLOCA has been identified. Both the direct vessel injection (DVI) and the pump discharge leg (PDL) break spectrums show a trend of increasing PCT for decreasing break size. It is therefore possible that a break smaller than the smallest break analyzed could be more limiting. The SRP Section 15.6.5 notes that in the analysis of small breaks, evaluating integer diameter break sizes (i.e., 1, 2, 3, 4-inch, etc.) is considered insufficient to determine

the worst break because the break areas associated with these integer diameters are too coarse to adequately identify the highest PCT. The applicant is requested to provide the results of a finer break spectrum for both the DVI line and PDL breaks to establish that the ECCS will function to meet acceptance criteria specified in 10 CFR 50.46. The results must include the PCT as well as the number of loop seals clearing for each SBLOCA break size in the following table.

| ID, in | A, $ft^2$ | A, $cm^2$ | ID, in | A, $ft^2$ | A, $cm^2$ |
|---|---|---|---|---|---|
| 0.5 | 0.0014 | 1.3 | 5.5 | 0.1650 | 153.3 |
| 1 | 0.0055 | 5.1 | 6 | 0.1963 | 182.4 |
| 1.5 | 0.0123 | 11.4 | 6.5 | 0.2304 | 214.1 |
| 2 | 0.0218 | 20.3 | 7 | 0.2673 | 248.3 |
| 2.5 | 0.0341 | 31.7 | 7.5 | 0.3068 | 285.0 |
| 3 | 0.0491 | 45.6 | 8 | 0.3491 | 324.3 |
| 3.5 | 0.0668 | 62.1 | 8.5 | 0.4006 | 372.2 |
| 4 | 0.0873 | 81.1 | 9 | 0.4418 | 410.4 |
| 4.5 | 0.1104 | 102.6 | 9.5 | 0.4922 | 457.3 |
| 5 | 0.1364 | 126.7 | 10 | 0.5454 | 506.7 |

## Response – (Rev. 1)

According to the proposed finder break size table, the dense break spectrum analysis for small break LOCA of APR1400 are performed for the DVI line break and PDL break. The results of dense break spectrum are shown in the Table 8337-1~3 and Figure 8337-1~33, respectively.

Table 8337-1 Summary of DVI line break spectrum analysis results

TS

Table 8337-2 Summary of Pump Discharge Leg break spectrum analysis results

TS

Table 8337-3 Summary of evaluation results for minimum break sizes

TS

Figure 8337-1 DVI Line Break - 0.0123 $ft^2$

TS

Figure 8337-2 DVI Line Break - 0.0218 ft$^2$

TS

Figure 8337-3 DVI Line Break - 0.0341 $ft^2$

Figure 8337-4 DVI Line Break - 0.0491 ft$^2$

Figure 8337-5 DVI Line Break - 0.0668 ft$^2$

TS

Figure 8337-6 DVI Line Break - 0.0873 $ft^2$

**Non-Proprietary**



TS

Figure 8337-7 DVI Line Break - 0.1104 $ft^2$

Figure 8337-8 DVI Line Break - 0.1364 $ft^2$

**TS**

Figure 8337-9 DVI Line Break - 0.1650 $ft^2$

Non-Proprietary



TS

Figure 8337-10 DVI Line Break - 0.1963 $ft^2$

TS

Figure 8337-11 DVI Line Break - 0.2304 $ft^2$

TS

Figure 8337-12 DVI Line Break - 0.2673 $ft^2$

TS

Figure 8337-13 DVI Line Break - 0.3068 $ft^2$

Figure 8337-14 DVI Line Break - 0.3491 $ft^2$

Figure 8337-15 DVI Line Break - 0.4006 $ft^2$

TS

Figure 8337-16 PDL Break - 0.0218 $ft^2$

Figure 8337-17 PDL Break - 0.0341 $ft^2$

TS

Figure 8337-18 PDL Break - 0.0491 $ft^2$

Figure 8337-19 PDL Break - 0.0668 $ft^2$

TS

Figure 8337-20 PDL Break - 0.0873 $ft^2$

TS

Figure 8337-21 PDL Break - 0.1104 $ft^2$

TS

Figure 8337-22 PDL Break - 0.1364 $ft^2$

Figure 8337-23 PDL Break - 0.1650 ft$^2$

Figure 8337-24 PDL Break - 0.1963 $ft^2$

Figure 8337-25 PDL Break - 0.2304 ft$^2$

Figure 8337-26 PDL Break - 0.2673 $ft^2$

Figure 8337-27 PDL Break - 0.3068 $ft^2$

Figure 8337-28 PDL Break - 0.3491 ft$^2$

TS

Figure 8337-29 PDL Break - 0.4006 $ft^2$

TS

Figure 8337-30 PDL Break - 0.4418 $ft^2$

Figure 8337-31 PDL Break - 0.4922 ft$^2$

Figure 8337-32 PDL Break - 0.5454 $ft^2$

TS

Figure 8337-33 Peak Cladding Temperature vs. Break Size

**Impact on DCD**

DCD Tier 2 Section 15.6.5 will be revised as indicated on the attachment 1.

**Impact on PRA**

There is no impact on the PRA.

**Impact on Technical Specifications**

There is no impact on the Technical Specifications.

**Impact on Technical/Topical/Environmental Reports**

There is an impact on Technical Report (APR1400-F-NR-14001-P, Rev.0). The markup for part of Technical Report modified by RAI 15.06.05-2 response is attached as the attachment 2.

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126.7cm$^2$ (0.1364ft$^2$)

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Uncertainties from sources other than code models or plant operation conditions, such as automatic time step control function and data reading frequency of RELAP5/MOD3.3, are considered of maximum 10 °C. The hot rod average oxidation is calculated lower than one percent. The final PCT, maximum cladding oxidation, and core-wide hydrogen generation combining all the biases are as follows:

Peak cladding temperature = 991.3 °C + 10 °C
= 1,001.3 °C (1,834.3 °F)
= 1,274.5 K < 1,477.15 K (2,200 °F)

Maximum cladding oxidation = 3.09 % < 17 %

Maximum hydrogen generation << 1 %

The highest cladding temperature in the large breaks analyzed is 1,001.3 °C (1,834.3 °F), which is 202.7 °C (365.7 °F) lower than the acceptance criterion of 1,204 °C (2,200 °F).

The final PCT considering the effect of thermal conductivity degradation is still satisfied the acceptance criteria. Details are given in Reference 78. The PCT increase is ended when the core is maintaining a coolable geometry. The heat generated from the fuel is able to be removed properly for a long period.

Based on the results of this analysis, it is concluded that the APR1400 SIS satisfies the all SRP acceptance criteria of References 62 and 64 (Subsection 15.0.5) for a complete spectrum of large break LOCAs and is adequate to perform its intended function of maintaining the integrity of the core, thereby limiting radiation release to the environment.

33 Small Break Loss-of-Coolant Accident Analysis Results

The ~~nine~~ breaks analyzed at 4,062.66 MWt, 102 percent of nominal, include reactor coolant pump discharge leg breaks ranging in size from ~~465 cm² (0.5 ft²)~~ 506.69 cm² (0.5454 ft²) to ~~46.5 cm² (0.05 ft²)~~ 20.25 cm² (0.0218 ft²) and DVI line breaks from 372 cm² (0.4 ft²) to ~~18.6 cm² (0.02 ft²)~~ 11.43 cm² (0.0123 ft²). One break, equal in area to a fully open POSRV, 27.9 cm² (0.03 ft²), is postulated to occur in the top of the pressurizer. The 465 cm² (0.5 ft²) discharge leg break is also analyzed for the large break spectrum and is defined as the transition break size (Reference 67). Table 15.6.5-8 lists the various break sizes and locations examined for this analysis.

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126.7 cm$^2$ (0.1364 ft$^2$)

The transient behavior of important NSSS parameters is shown in the figures listed in Table 15.6.5-9. Table 15.6.5-10 summarizes the important results of this analysis. Times of interest for the various breaks analyzed are presented in Table 15.6.5-11. A plot of PCT versus break size is presented in Figure 15.6.5-33. The 372 ft$^2$ (0.4 ft$^2$) DVI break results in the highest cladding temperature 624 °C (1,156 °F) of the small breaks analyzed, which is 580 °C (1,044 °F) lower than the acceptance criteria of 1,204 °C (2,200 °F). Of the pump discharge leg and DVI line break locations, the DVI line break is limiting due to the assumed loss of all safety injection flow to the broken line.

286 °C (516 °F)
918 °C (1684 °F)

For the DVI line break location, as the break size becomes progressively smaller than 372 cm$^2$ (0.4 ft$^2$), the inner vessel two phase level follows a definite pattern:

a. The time of initial core uncovery is later.

b. The depth of core uncovery is less.

c. The rate of level decrease and increase becomes slower.

b

This trend continues until the core does not uncover at all. These trends predictably affect the PCT.

The core uncover does not occur less than the 31.68 cm$^2$ (0.0341 ft$^2$)

As the break size decreases, both the later time of the initial core uncovery and the shallower depth of uncovery tend to mitigate the temperature transient. This trend continues until the core does not uncover as typified by the 18.6 cm$^2$ (0.02 ft$^2$) break. By analyzing several break sizes over this range, the behavior of PCT versus break size is adequately determined.

dense break spectrum
62 cm$^2$ (0.0668 ft$^2$)

The above behavior of core uncovery with break size results from the design characteristics of the SIS. For DVI break sizes below 93 cm$^2$ (0.1 ft$^2$), the RCS pressure remains above the SIT pressure and coolant flow injection to the reactor vessel is accomplished entirely by one SIP. For break sizes greater than 93 cm$^2$ (0.1 ft$^2$), the transient is terminated by the action of both the SITs and SI pumps.

62 cm$^2$ (0.0668 ft$^2$)

For the cold leg breaks, the additional SIS flow resulting from being able to credit two SIPs precludes core uncovery to break sizes up to 93 cm$^2$ (0.1 ft$^2$). In addition, the core

153 cm$^2$ (0.1650 ft$^2$)

153 $cm^2$ (0.1650 $ft^2$)

uncovery for break sizes greater than 93 $ft^2$ (0.1 $ft^2$) is delayed, and the depth and duration of uncovery decreased relative to DVI breaks, which credit only one SIP. This more favorable behavior results in lower cladding temperatures relative to breaks in a DVI line.

and very small break size of DVI and cold leg are considered as shown in Table 15.6.5-12.

In addition to the break locations described above, the rupture of an in-core instrument tube is considered. A break equal in size to a completely severed instrument tube (2.8 $cm^2$ [0.003 $ft^2$]) is postulated to occur in the reactor vessel bottom head.

In the very small break LOCA, following

$kg/cm^2A$

Following rupture, the primary system depressurizes until a reactor scram signal and safety injection actuation signal (SIAS) are generated due to low pressurizer pressure at 109.3 $g/cm^2A$ (1,555 psia). The assumed LOOP causes the primary coolant pumps and the feedwater pumps to coast down. After the 40-second delay, required to actuate the emergency diesel and the SIPs following the SIAS, safety injection flow is initiated to the RCS. Four SITs are available but do not inject due to the high RCS pressure.

for the cold leg break and the rupture of an in-core instrument tube

The typical phenomena of small break LOCA such as the core uncovery and loop seal clearing are not shown for the very small break size.

The primary side depressurization continues accompanied by a rise in secondary side pressure until the secondary side pressure reaches the lowest setpoint of the steam generator safety valves. The primary system pressure continues to fall until it is just slightly greater than the secondary side pressure. At this point, the flow from the two operating SIPs (63 kg/sec [139 lbm/sec]) exceeds the leak flow (12 kg/sec [26 lbm/sec]). Therefore, the RCS fills. The decay heat generated in the core is removed in the SGs by steam flow through the secondary side safety valves. The core remains covered and cooled in this condition.

The flow from the one operating SIP for DVI break exceeds the leak flow. Comparison of leaking flow and charging flow by SIPs are summarized in the Table 15.6.5-12.

Based on the results of this analysis, it is concluded that the APR1400 SIS satisfies the all SRP acceptance criteria of References 1 and 62 (Subsection 15.0.5) for small break LOCAs.

Post Loss-of-Coolant Accident Long-term Cooling Evaluation Results

An evaluation of the various break locations showed that the double-ended (9,104.5 $cm^2$ [9.8 $ft^2$]) cold leg break was confirmed to be the limiting break geometry for the boric acid precipitation analysis (Reference 73). The long-term loop seal refilling with a slot break at the top of the cold leg does not significantly affect the boric acid precipitation analysis. For a cold leg break, the core flushing flow is the difference between the hot leg injection flow rate and the core boiloff rate. The initiation of a simultaneous hot leg and direct vessel SIP injection flow at 3 hours post-LOCA provides a substantial and time-increasing

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Table 15.6.5-10

Peak Cladding Temperature and Oxidation Percentage
for the Small Break Spectrum

| Break | Peak Cladding Temperature, °C (°F) | Maximum Cladding Oxidation, % | Maximum Core-Wide Oxidation, % |
|---|---|---|---|
| 465 $cm^2$/PD | 498 (929) | 0.0017 | < 0.0003 |
| 325 $cm^2$/PD | 492 (917) | 0.0015 | < 0.0002 |
| 93 $cm^2$/PD | 565 (1,049) | 0.0010 | < 0.0001 |
| 46.5 $cm^2$/PD | 568 (1,054) | 0.0008 | < 0.0002 |
| 372 $cm^2$/DVI | 624 (1,156) | 0.0195 | < 0.0029 |
| 93 $cm^2$/DVI | 569 (1,056) | 0.0069 | < 0.0009 |
| 46.5 $cm^2$/DVI | 571 (1,059) | 0.0018 | < 0.0003 |
| 18.6 $cm^2$/DVI | 616 (1,140) | 0.0029 | < 0.0006 |
| 27.9 $cm^2$/HL | 568 (1,055) | 0.0006 | < 0.0002 |

Replace with A
(Next 3pages)

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A

Peak Cladding Temperature and Oxidation Percentage

for the Small Break Spectrum (1 of 3)

| Case | Direct Vessel Injection Line Break size | | Peak Cladding Temperature (˚F) | Maximum Cladding Oxidation (%) | Maximum Core-Wide Oxidation (%) |
|---|---|---|---|---|---|
| | Diameter (in) | Area ($ft^2$) | | | |
| 1 | 1.5 | 0.0123 | 1045.6 | 0.00096 | <0.00033 |
| 2 | 2 | 0.0218 | 1042.6 | 0.00107 | <0.00039 |
| 3 | 2.5 | 0.0341 | 1040.7 | 0.00129 | <0.00035 |
| 4 | 3 | 0.0491 | 1053.6 | 0.00420 | <0.00050 |
| 5 | 3.5 | 0.0668 | 1056.8 | 0.00111 | <0.00019 |
| 6 | 4 | 0.0873 | 1060.3 | 0.01541 | <0.00178 |
| 7 | 4.5 | 0.1104 | 1527.9 | 0.22653 | <0.02017 |
| 8 | 5 | 0.1364 | 1683.9 | 0.55474 | <0.05679 |
| 9 | 5.5 | 0.1650 | 1319.1 | 0.05786 | <0.00558 |
| 10 | 6 | 0.1963 | 1229.9 | 0.02875 | <0.00284 |
| 11 | 6.5 | 0.2304 | 1195.6 | 0.02019 | <0.00206 |
| 12 | 7 | 0.2673 | 850.1 | 0.00081 | <0.00010 |
| 13 | 7.5 | 0.3068 | 877.6 | 0.00099 | <0.00017 |
| 14 | 8 | 0.3491 | 1015.2 | 0.00391 | <0.00060 |
| 15 | 8.5 | 0.4006 | 1104.2 | 0.01106 | <0.00133 |

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Peak Cladding Temperature and Oxidation Percentage
for the Small Break Spectrum (2 of 3)

| Case | Pump Discharge Leg Break size | | Peak Cladding Temperature (°F) | Maximum Cladding Oxidation (%) | Maximum Core-Wide Oxidation (%) |
|---|---|---|---|---|---|
| | Diameter (in) | Area ($ft^2$) | | | |
| 1 | 2 | 0.0218 | 1050.5 | 0.00114 | <0.00030 |
| 2 | 2.5 | 0.0341 | 1040.9 | 0.00113 | <0.00027 |
| 3 | 3 | 0.0491 | 1055.2 | 0.00111 | <0.00024 |
| 4 | 3.5 | 0.0668 | 1061.1 | 0.00101 | <0.00016 |
| 5 | 4 | 0.0873 | 1044.1 | 0.00098 | <0.00015 |
| 6 | 4.5 | 0.1104 | 1050.6 | 0.00091 | <0.00013 |
| 7 | 5 | 0.1364 | 1037.2 | 0.00087 | <0.00012 |
| 8 | 5.5 | 0.1650 | 725.0 | 0.00008 | <0.00005 |
| 9 | 6 | 0.1963 | 725.0 | 0.00017 | <0.00006 |
| 10 | 6.5 | 0.2304 | 782.1 | 0.00029 | <0.00008 |
| 11 | 7 | 0.2673 | 794.0 | 0.00033 | <0.00008 |
| 12 | 7.5 | 0.3068 | 872.1 | 0.00095 | <0.00015 |
| 13 | 8 | 0.3491 | 899.1 | 0.00121 | <0.00021 |
| 14 | 8.5 | 0.4006 | 920.8 | 0.00245 | <0.00039 |
| 15 | 9 | 0.4418 | 921.7 | 0.00192 | <0.00032 |
| 16 | 9.5 | 0.4922 | 944.2 | 0.00196 | <0.00029 |
| 17 | 10 | 0.5454 | 958.2 | 0.00225 | <0.00032 |

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Peak Cladding Temperature and Oxidation Percentage
for the Small Break Spectrum (3 of 3)

| Case | Top of Pressurizer | | Peak Cladding Temperature (˚F) | Maximum Cladding Oxidation (%) | Maximum Core-Wide Oxidation (%) |
|---|---|---|---|---|---|
| | Diameter (in) | Area ($ft^2$) | | | |
| 1 | 2.3 | 0.03 | 1055.2 | 0.0004 | <0.0002 |

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Table 15.6.5-11

Times of Interest for the Small Break Spectrum
(Seconds after Break)

| Break | SI Pump Flow Delivered to RCS | SI Tank Flow Delivered to RCS | Hot Spot Peak Cladding Temperature Occurs |
|---|---|---|---|
| 465 $cm^2$/PD | 57 | 150 | 167 |
| 325 $cm^2$/PD | 62 | 218 | 105 |
| 93 $cm^2$/PD | 138 | 1,128 | 100 |
| 46.5 $cm^2$/PD | 248 | 2,984 | 208 |
| 372 $cm^2$/DVI | 60 | 192 | 239 |
| 93 $cm^2$/DVI | 138 | 1,092 | 100 |
| 46.5 $cm^2$/DVI | 250 | N/A (1) | 210 |
| 18.6 $cm^2$/DVI | 624 | N/A (1) | 1,184 |
| 27.9 $cm^2$/HL | 795 | N/A (1) | 750 |

(1) Calculation terminated before initiation of SI tank discharge

Replace with A
(Next 3pages)
Supplement with B

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A

Times of Interest for the Small Break Spectrum
(Seconds after Break 1 of 3)

| Case | Direct Vessel Injection Line Break size | | SIP Flow Delivered to RCS (sec) | SIT Flow Delivered to RCS (sec) | Hot Spot Peak Clad Temperature Occurs (sec) |
|---|---|---|---|---|---|
| | Diameter (in) | Area ($ft^2$) | | | |
| 1 | 1.5 | 0.0123 | 905.2 | N/A[1] | 786.0 |
| 2 | 2 | 0.0218 | 582.8 | N/A | 455.3 |
| 3 | 2.5 | 0.0341 | 396.8 | N/A | 297.7 |
| 4 | 3 | 0.0491 | 290.0 | N/A | 215.3 |
| 5 | 3.5 | 0.0668 | 195.0 | 2189.2 | 151.2 |
| 6 | 4 | 0.0873 | 155.0 | 1232.4 | 115.3 |
| 7 | 4.5 | 0.1104 | 129.0 | 872.2 | 936.0 |
| 8 | 5 | 0.1364 | 114.0 | 621.2 | 686.5 |
| 9 | 5.5 | 0.1650 | 93.0 | 524.8 | 562.1 |
| 10 | 6 | 0.1963 | 81.0 | 429.0 | 462.1 |
| 11 | 6.5 | 0.2304 | 75.0 | 356.8 | 378.1 |
| 12 | 7 | 0.2673 | 69.0 | 305.2 | 322.0 |
| 13 | 7.5 | 0.3068 | 66.0 | 261.2 | 275.9 |
| 14 | 8 | 0.3491 | 63.0 | 223.6 | 102.8 |
| 15 | 8.5 | 0.4006 | 60.0 | 191.9 | 219.0 |

[1] N/A : calculation terminated before initiation of SIT discharge

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Times of Interest for the Small Break Spectrum
(Seconds after Break 2 of 3)

| Case | Pump Discharge Leg Break size | | SIP Flow Delivered to RCS (sec) | SIT Flow Delivered to RCS (sec) | Hot Spot Peak Clad Temperature Occurs (sec) |
|---|---|---|---|---|---|
| | Diameter (in) | Area ($ft^2$) | | | |
| 1 | 2 | 0.0218 | 568.0 | N/A | 471.6 |
| 2 | 2.5 | 0.0341 | 396.0 | N/A | 301.0 |
| 3 | 3 | 0.0491 | 292.0 | N/A | 212.5 |
| 4 | 3.5 | 0.0668 | 192.0 | 2046.2 | 152.1 |
| 5 | 4 | 0.0873 | 156.0 | 1475.3 | 113.0 |
| 6 | 4.5 | 0.1104 | 129.0 | 1005.5 | 90.4 |
| 7 | 5 | 0.1364 | 114.0 | 634.0 | 73.4 |
| 8 | 5.5 | 0.1650 | 93.0 | 532.1 | 0.0 |
| 9 | 6 | 0.1963 | 81.0 | 419.0 | 0.0 |
| 10 | 6.5 | 0.2304 | 75.0 | 340.3 | 385.2 |
| 11 | 7 | 0.2673 | 69.0 | 286.1 | 321.1 |
| 12 | 7.5 | 0.3068 | 66.0 | 245.0 | 271.1 |
| 13 | 8 | 0.3491 | 62.0 | 212.8 | 102.7 |
| 14 | 8.5 | 0.4006 | 60.0 | 184.1 | 102.0 |
| 15 | 9 | 0.4418 | 58.0 | 166.7 | 89.9 |
| 16 | 9.5 | 0.4922 | 57.0 | 152.3 | 174.5 |
| 17 | 10 | 0.5454 | 55.5 | 138.7 | 160.1 |

Times of Interest for the Small Break Spectrum
(Seconds after Break 3 of 3)

| Case | Top of Pressurizer | | SIP Flow Delivered to RCS (sec) | SIT Flow Delivered to RCS (sec) | Hot Spot Peak Clad Temperature Occurs (sec) |
|---|---|---|---|---|---|
| | Diameter (in) | Area ($ft^2$) | | | |
| 1 | 2.3 | 0.03 | 800.0 | N/A | 750.0 |

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B

The Evaluation Results for the Very Small Break LOCA Spectrum

| Case | Break Location | Break Size | | Break flowrate | | ECCS flowrate | |
|---|---|---|---|---|---|---|---|
| | | Diameter (In) | Area ($ft^2$) | lbm/sec | kg/sec | lbm/sec | kg/sec |
| 1 | DVI | 0.5 | 0.0014 | 12.25 | 5.56 | 62.82 | 28.9 |
| 2 | | 1 | 0.0055 | 48.13 | 21.80 | 62.82 | 28.9 |
| 3 | PDL | 0.5 | 0.0014 | 12.25 | 5.56 | 127.6 | 57.9 |
| 4 | | 1 | 0.0055 | 48.13 | 21.80 | 127.6 | 57.9 |
| 5 | | 1.5 | 0.0123 | 107.64 | 48.80 | 127.6 | 57.9 |
| 6 | In-core Instrument tube | 0.75 | 0.003 | 26.25 | 11.9 | 127.6 | 57.9 |

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Replace with A
From Figure 15.6.5-24A
to Figure 15.6.5-25H
(Next 16pages)
Delete From Figure 15.6.5-26A
to Figure15.6.5-32H

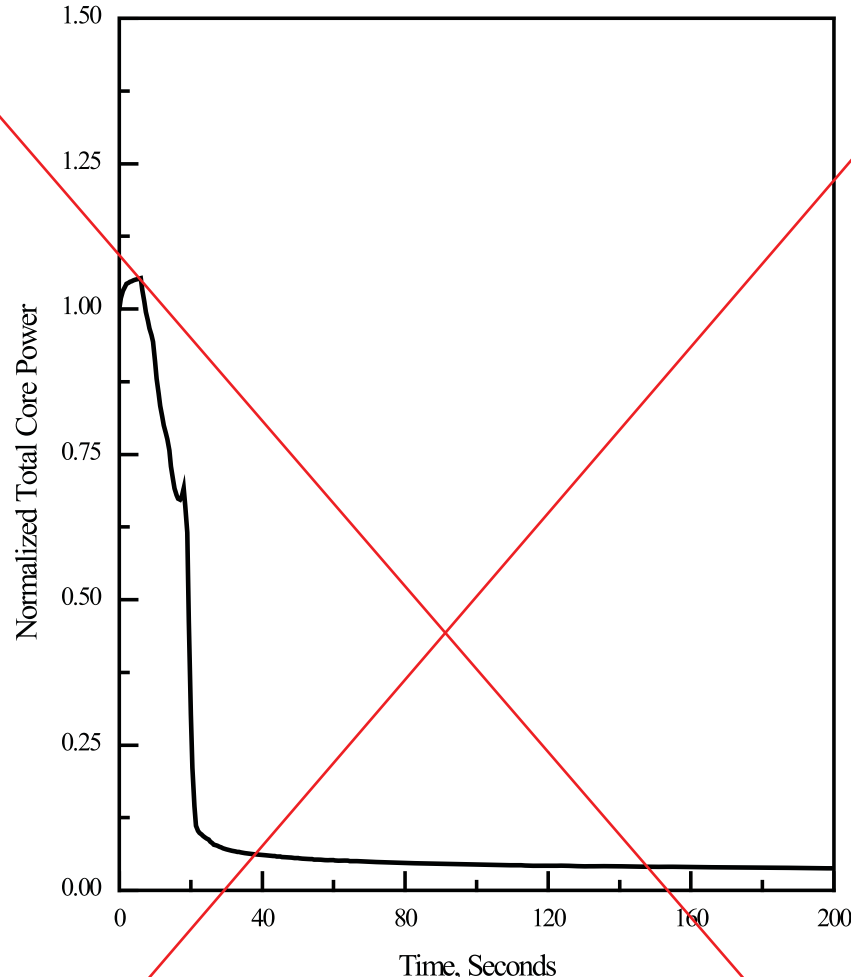


**Figure 15.6.5-24A 465 cm$^2$ (0.5 ft$^2$) Break in Pump Discharge Leg: Normalized Total Core Power**

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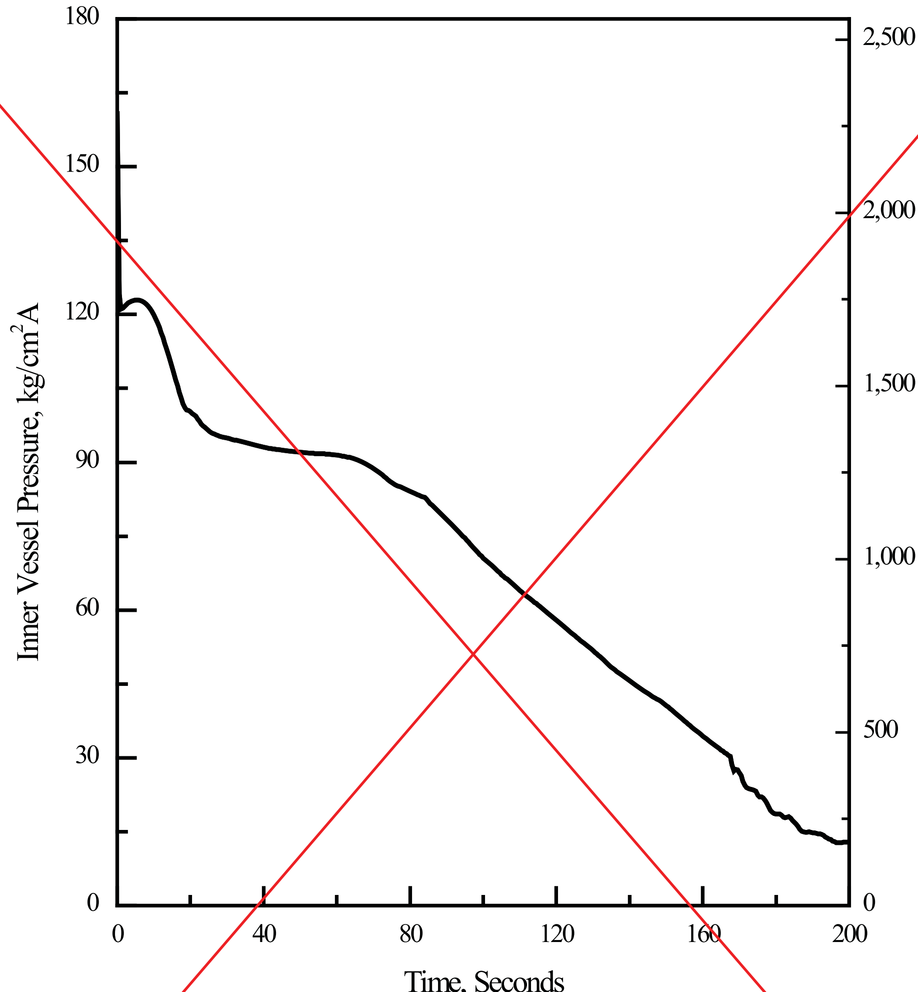


**Figure 15.6.5-24B    465 cm$^2$ (0.5 ft$^2$) Break in Pump Discharge Leg: Inner Vessel Pressure**

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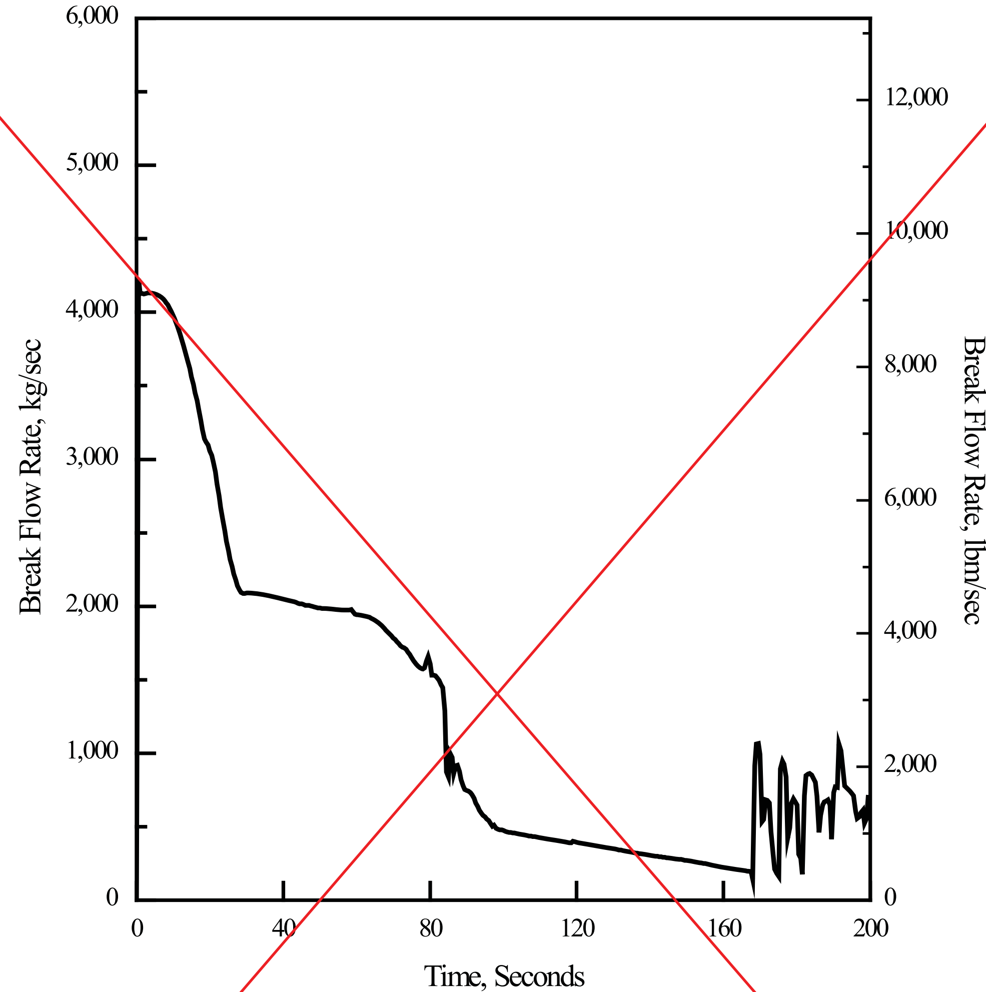


**Figure 15.6.5-24C 465 cm$^2$ (0.5 ft$^2$) Break in Pump Discharge Leg: Break Flow Rate**

RAI 318-8337 - Question 15.06.05-2_Rev.1

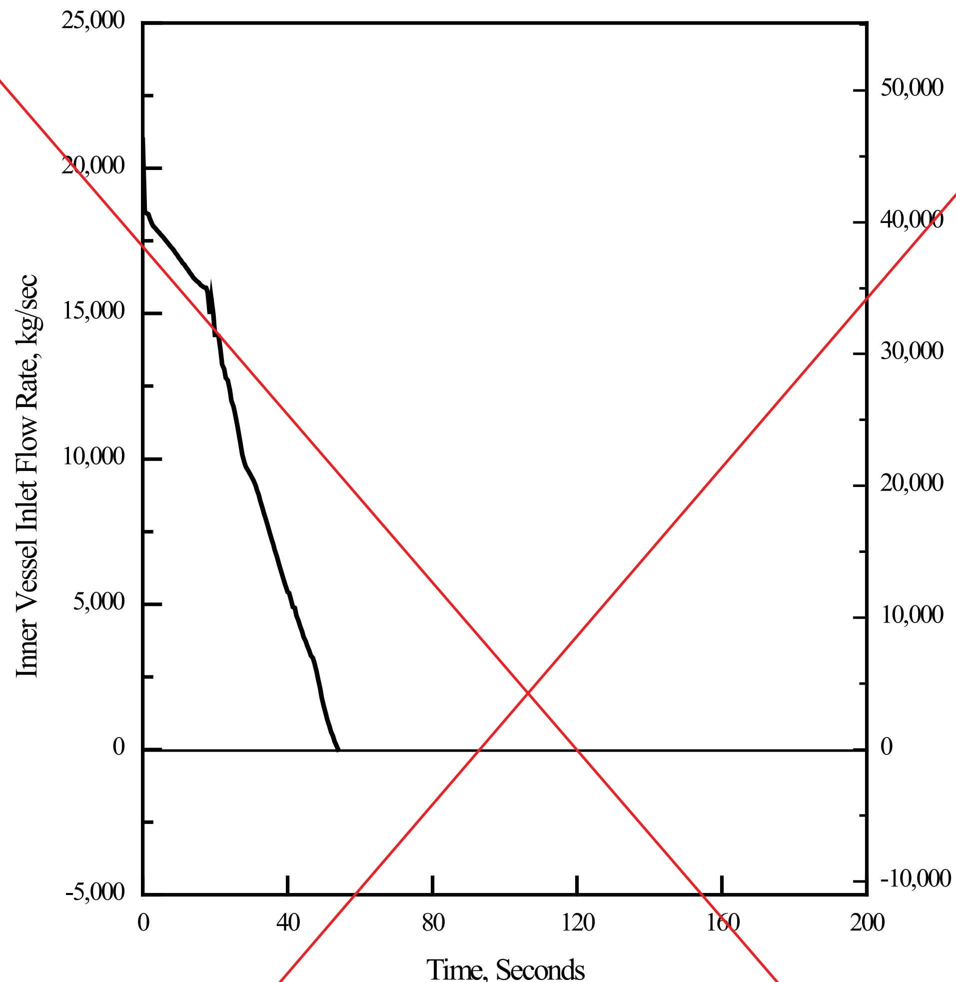


**Figure 15.6.5-24D 465 cm$^2$ (0.5 ft$^2$) Break in Pump Discharge Leg: Inner Vessel Inlet Flow Rate**

RAI 318-8337 - Question 15.06.05-2_Rev.1

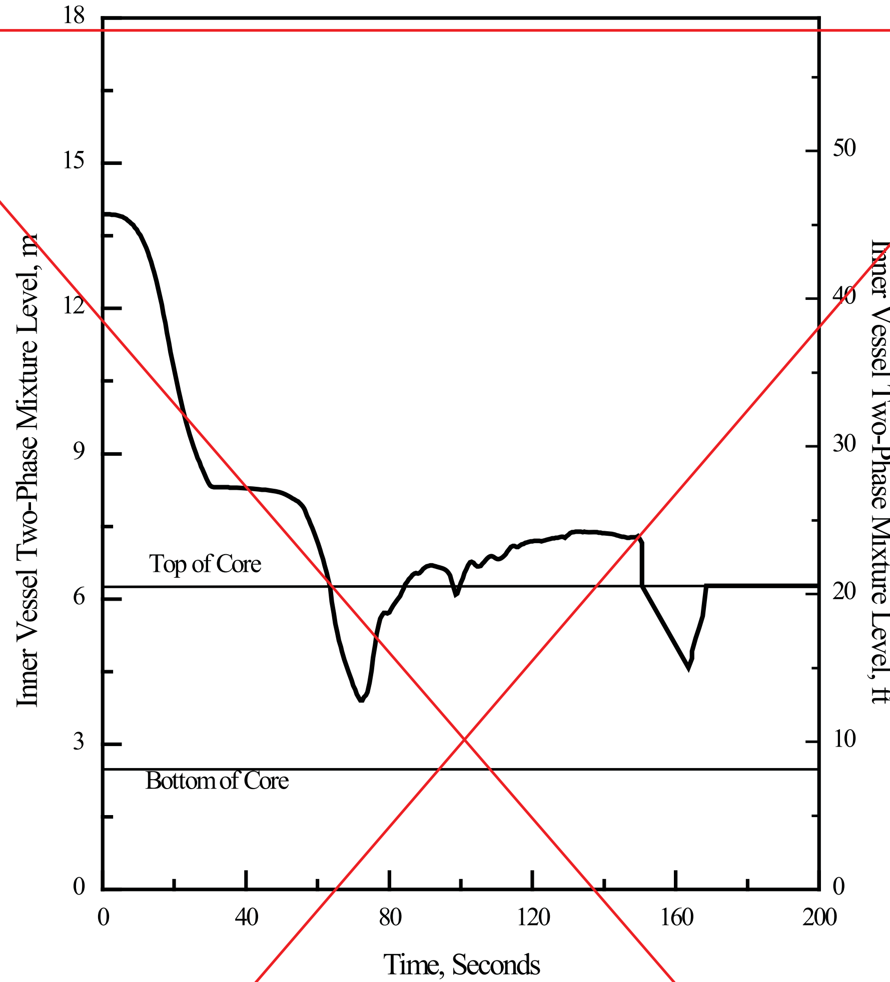


**Figure 15.6.5-24E 465 $cm^2$ (0.5 $ft^2$) Break in Pump Discharge Leg: Inner Vessel Two-Phase Mixture Level**

RAI 318-8337 - Question 15.06.05-2_Rev.1

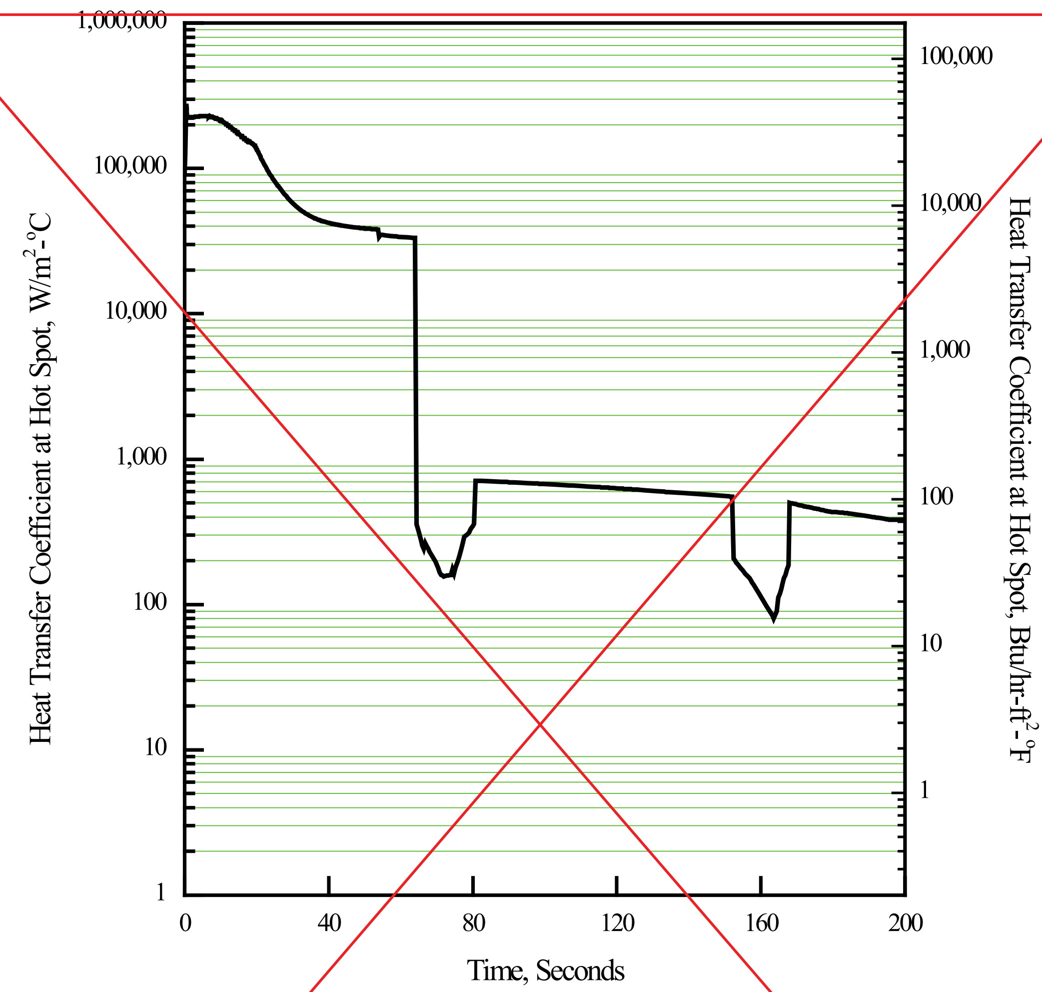


**Figure 15.6.5-24F 465 cm$^2$ (0.5 ft$^2$) Break in Pump Discharge Leg: Heat Transfer Coefficient at Hot Spot**

RAI 318-8337 - Question 15.06.05-2_Rev.1

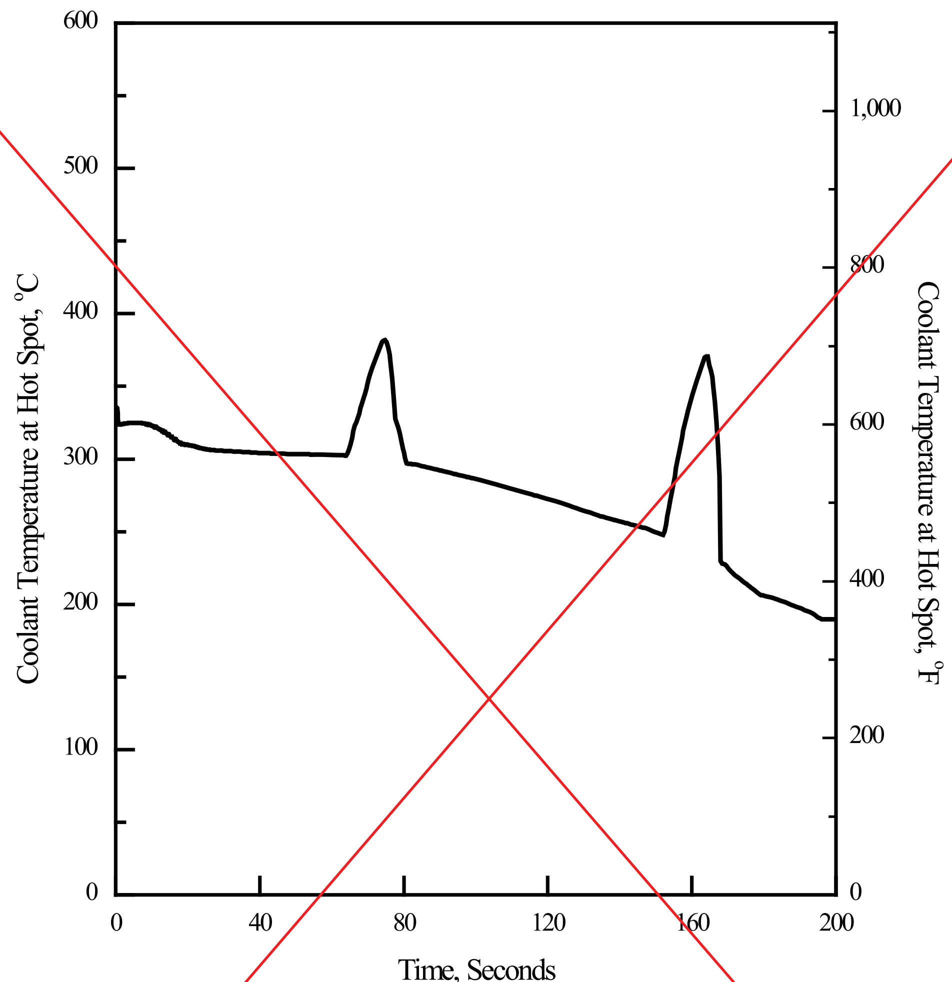


**Figure 15.6.5-24G 465 cm$^2$ (0.5 ft$^2$) Break in Pump Discharge Leg: Coolant Temperature at Hot Spot**

RAI 318-8337 - Question 15.06.05-2_Rev.1

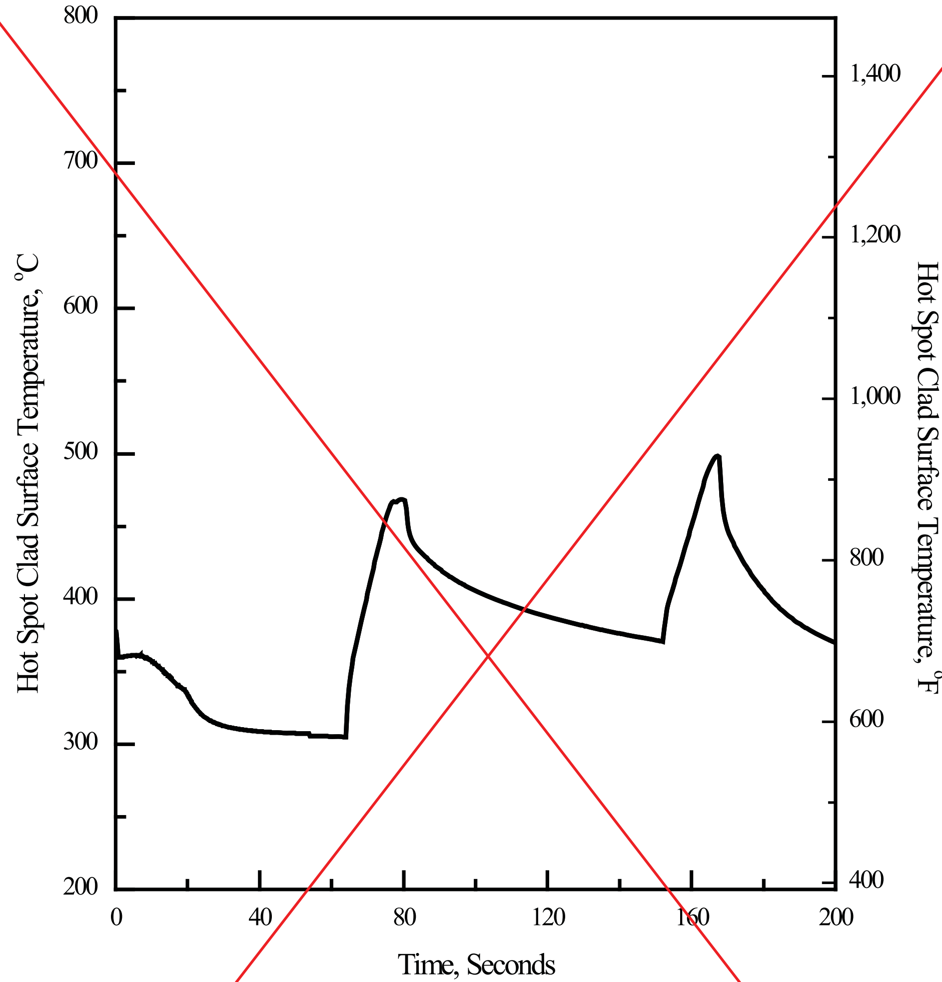


**Figure 15.6.5-24H 465 $cm^2$ (0.5 $ft^2$) Break in Pump Discharge Leg: Hot Spot Clad Surface Temperature**

RAI 318-8337 - Question 15.06.05-2_Rev.1

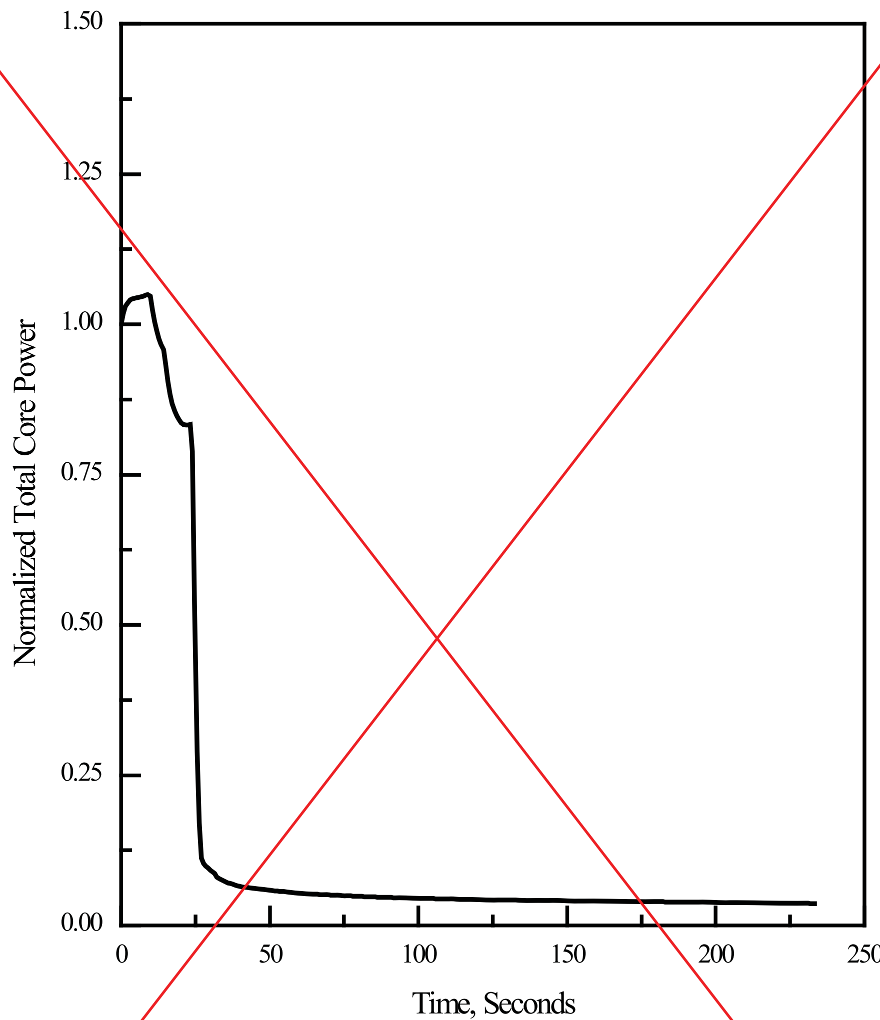


**Figure 15.6.5-25A 325 $cm^2$ (0.35 $ft^2$) Break in Pump Discharge Leg: Normalized Total Core Power**

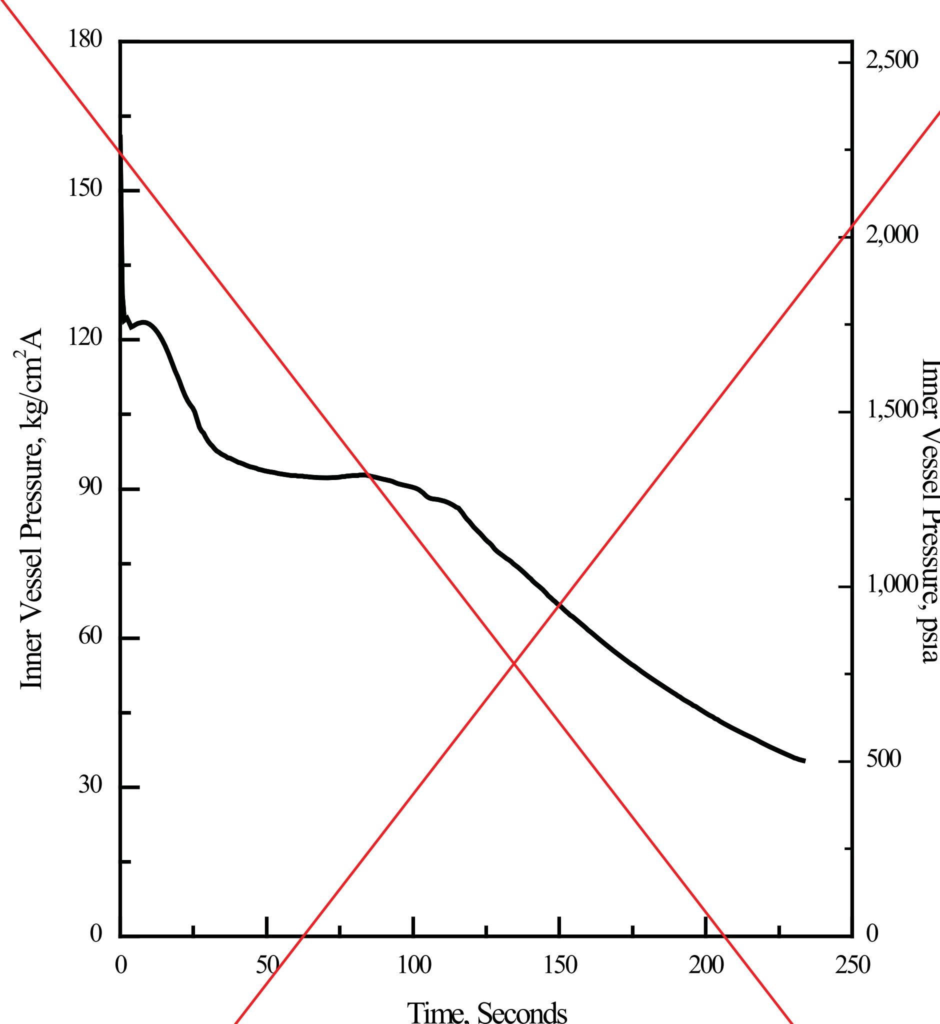


**Figure 15.6.5-25B 325 cm$^2$ (0.35 ft$^2$) Break in Pump Discharge Leg: Inner Vessel Pressure**

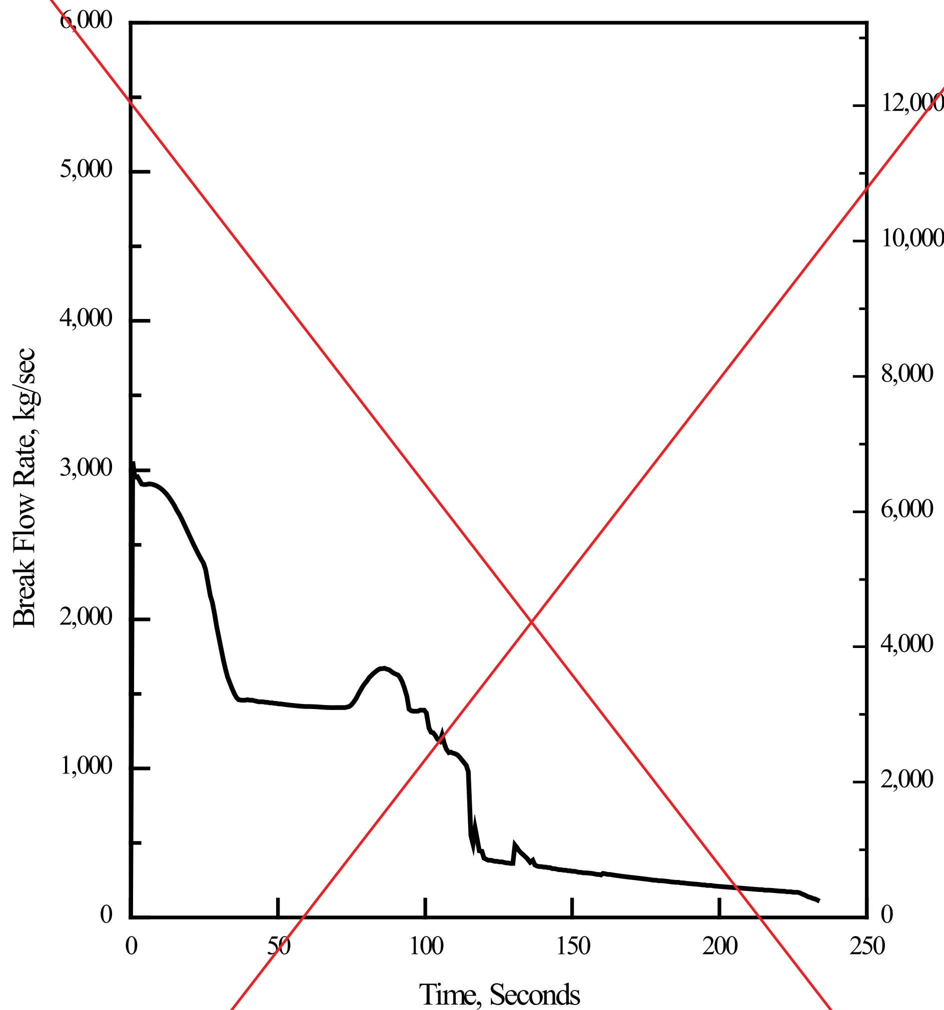


**Figure 15.6.5-25C 325 cm$^2$ (0.35 ft$^2$) Break in Pump Discharge Leg: Break Flow Rate**

RAI 318-8337 - Question 15.06.05-2_Rev.1

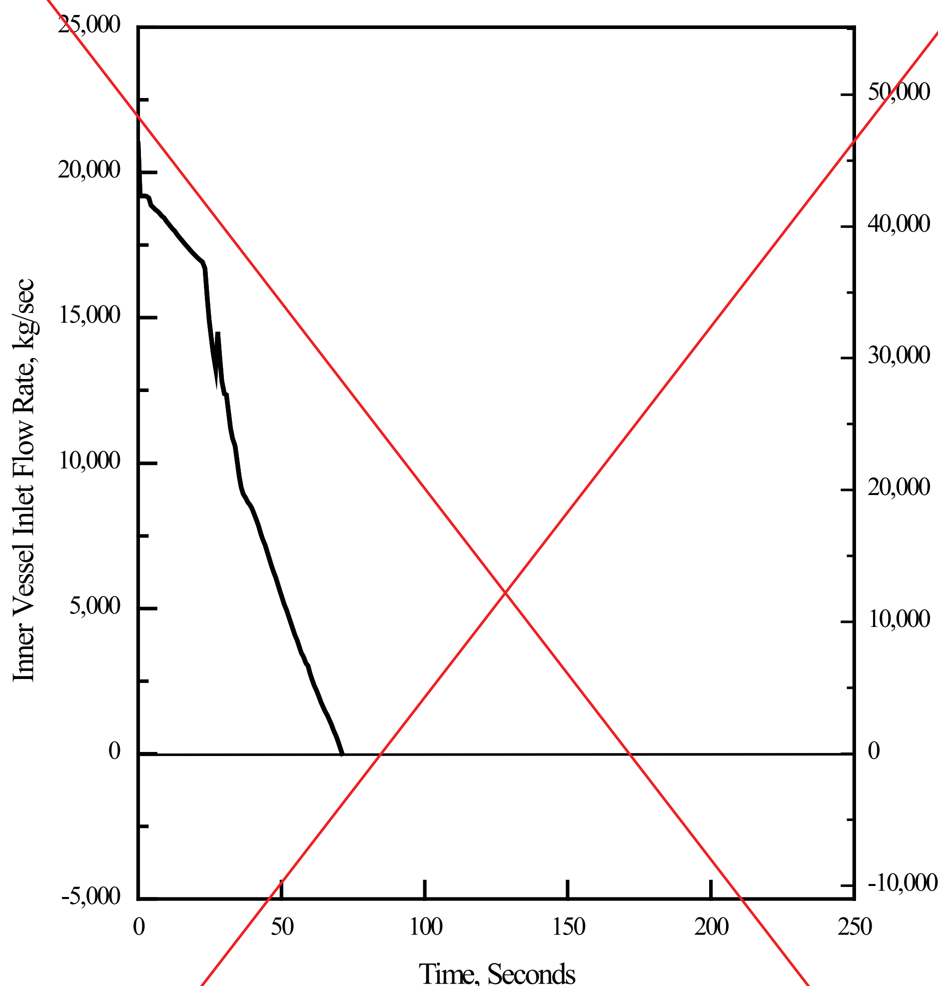


**Figure 15.6.5-25D 325 cm$^2$ (0.35 ft$^2$) Break in Pump Discharge Leg: Inner Vessel Inlet Flow Rate**

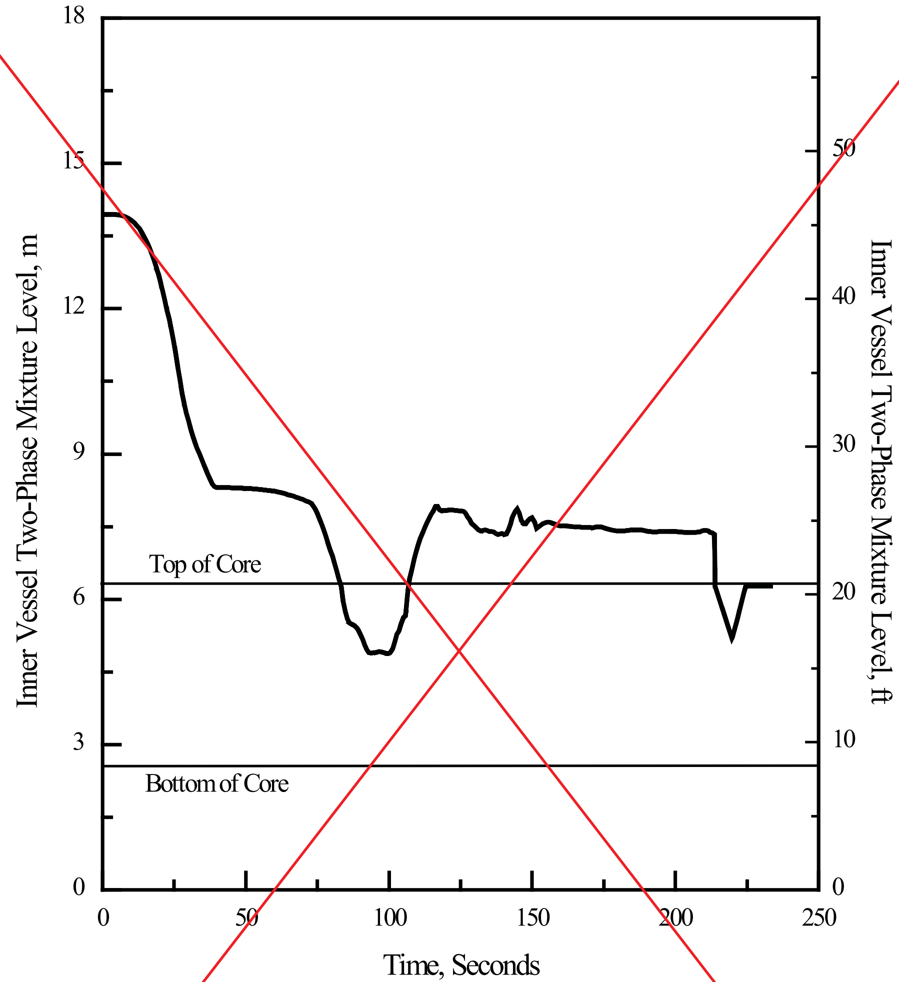


**Figure 15.6.5-25E 325 cm² (0.35 ft²) Break in Pump Discharge Leg: Inner Vessel Two-Phase Mixture Level**

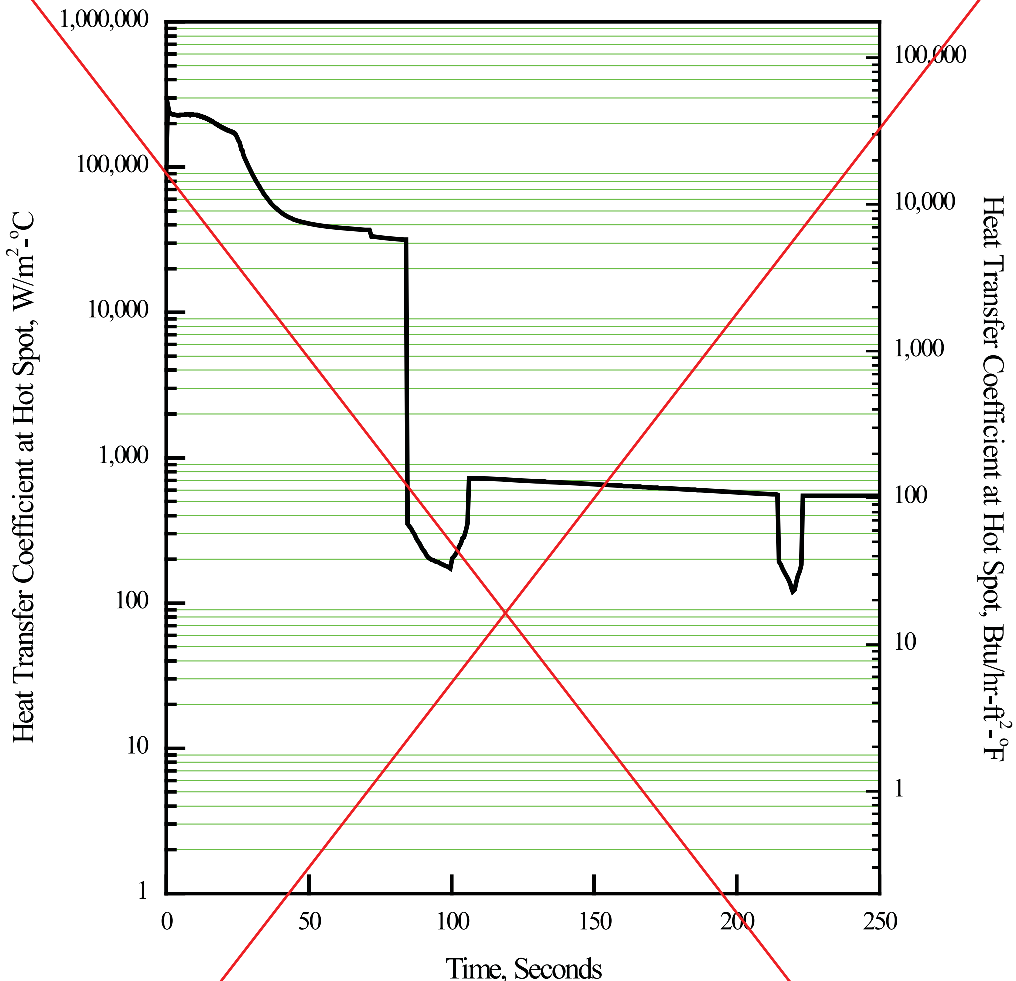


**Figure 15.6.5-25F 325 cm² (0.35 ft²) Break in Pump Discharge Leg: Heat Transfer Coefficient at Hot Spot**

RAI 318-8337 - Question 15.06.05-2_Rev.1

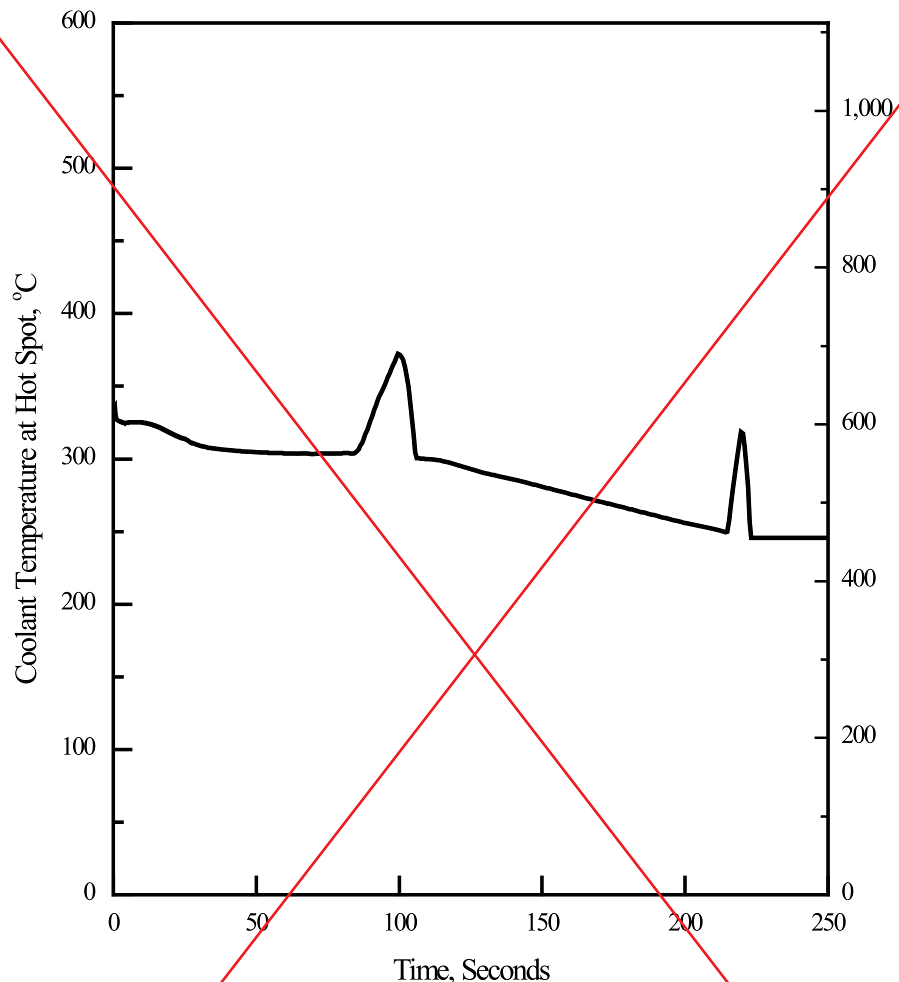


**Figure 15.6.5-25G 325 cm² (0.35 ft²) Break in Pump Discharge Leg: Coolant Temperature at Hot Spot**

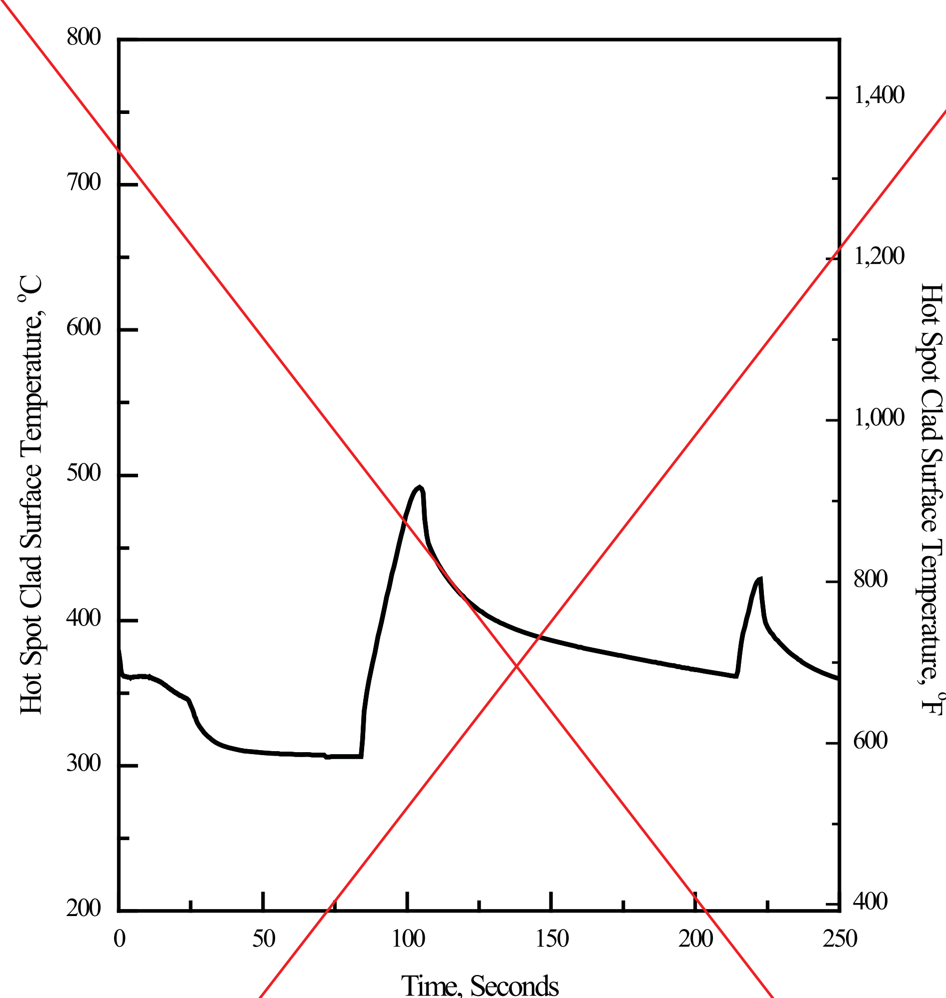


**Figure 15.6.5-25H 325 cm$^2$ (0.35 ft$^2$) Break in Pump Discharge Leg: Hot Spot Clad Surface Temperature**

RAI 318-8337 - Question 15.06.05-2_Rev.1

A

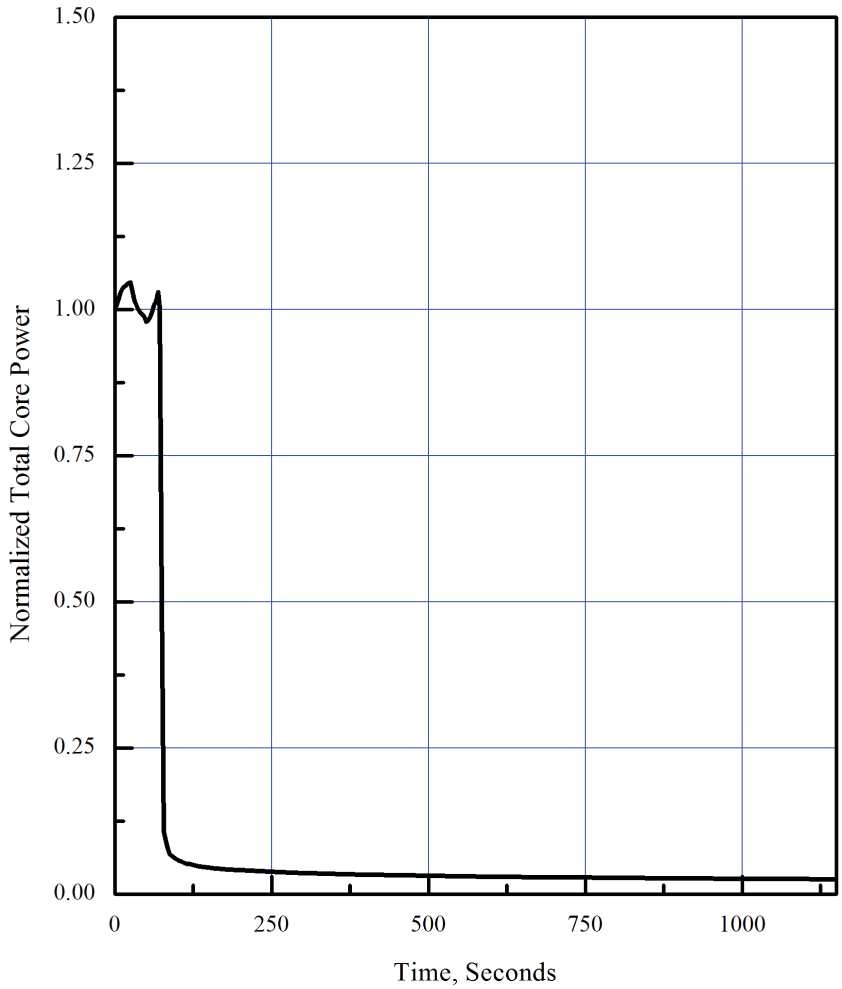


Figure 15.6.5-24A 126.7 $cm^2$ (0.1364 $ft^2$) Break in DVI Line: Normalized Total Core Power

RAI 318-8337 - Question 15.06.05-2_Rev.1

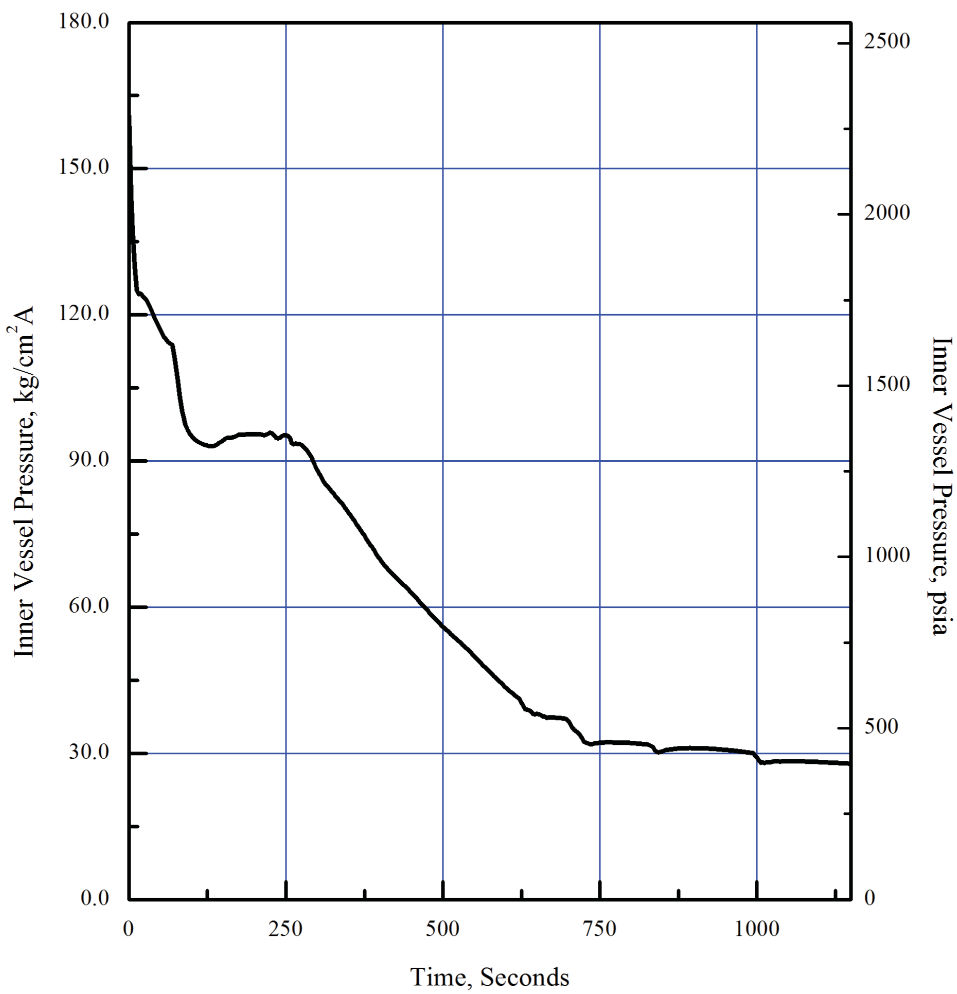


Figure 15.6.5-24B 126.7 $cm^2$ (0.1364 $ft^2$) Break in DVI Line: Inner Vessel Pressure

RAI 318-8337 - Question 15.06.05-2_Rev.1

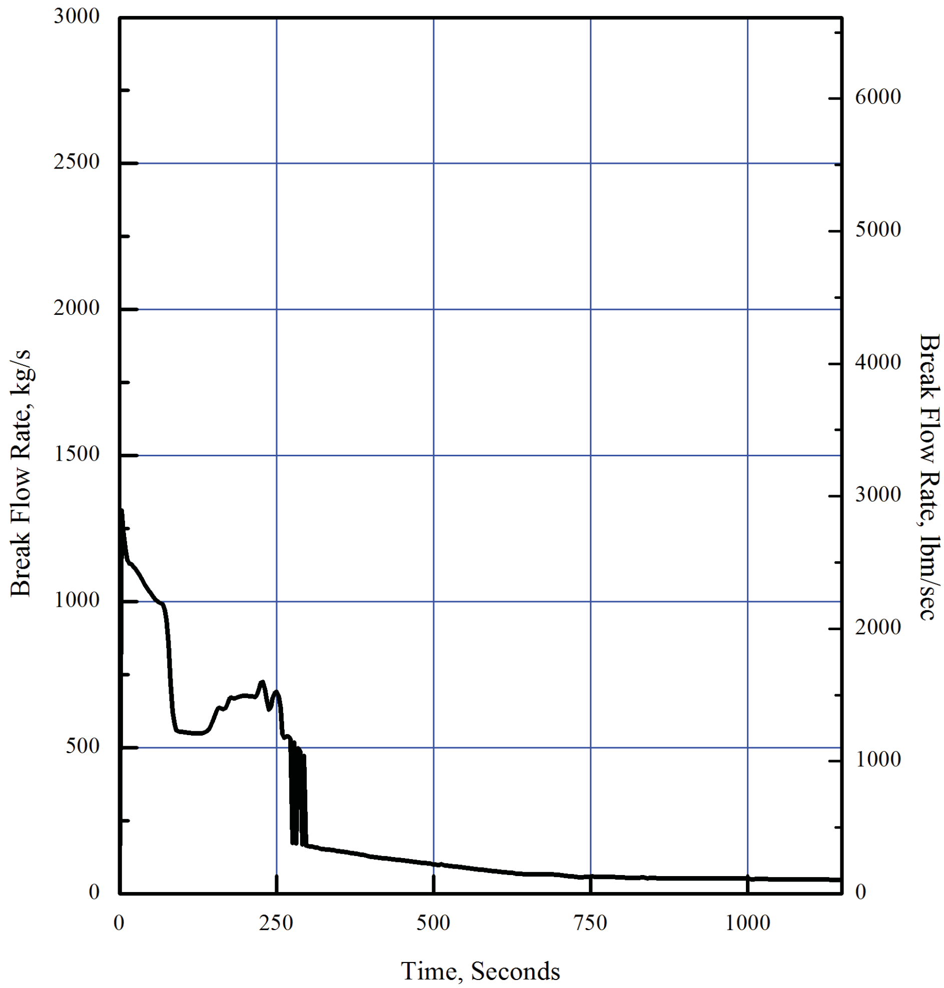


Figure 15.6.5-24C 126.7 $cm^2$ (0.1364$ft^2$) Break in DVI Line: Break Flow Rate

RAI 318-8337 - Question 15.06.05-2_Rev.1

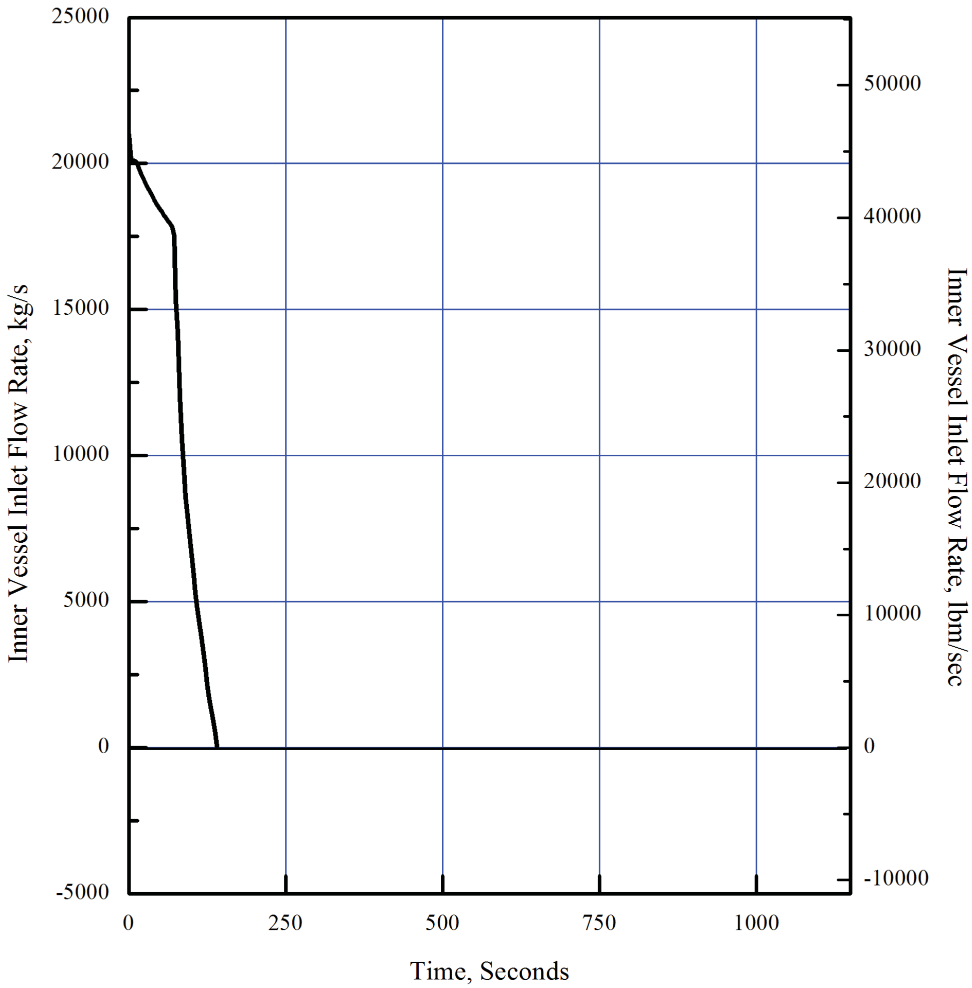


Figure 15.6.5-24D 126.7 cm$^2$ (0.1364ft$^2$) Break in DVI Line: Inner Vessel Inlet Flow

RAI 318-8337 - Question 15.06.05-2_Rev.1

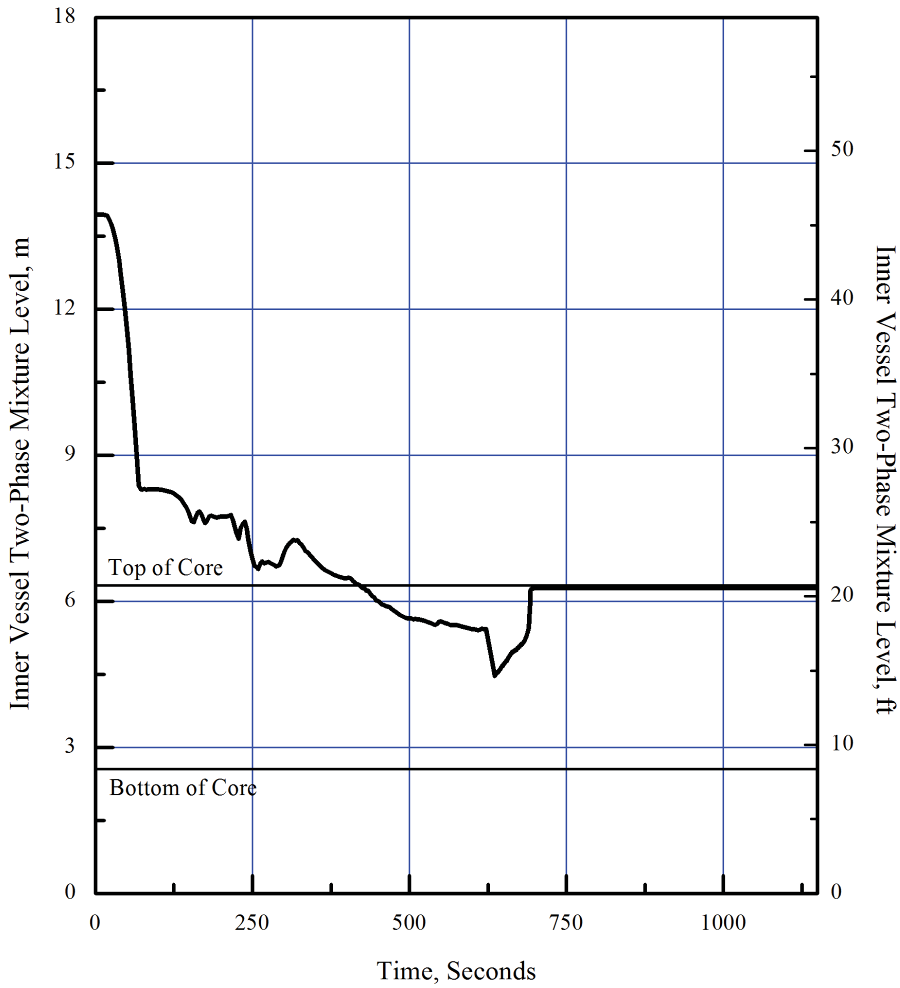


Figure 15.6.5-24E 126.7 cm$^2$ (0.1364ft$^2$) Break in DVI Line: Inner Vessel Two-Phase Mixture Level

RAI 318-8337 - Question 15.06.05-2_Rev.1

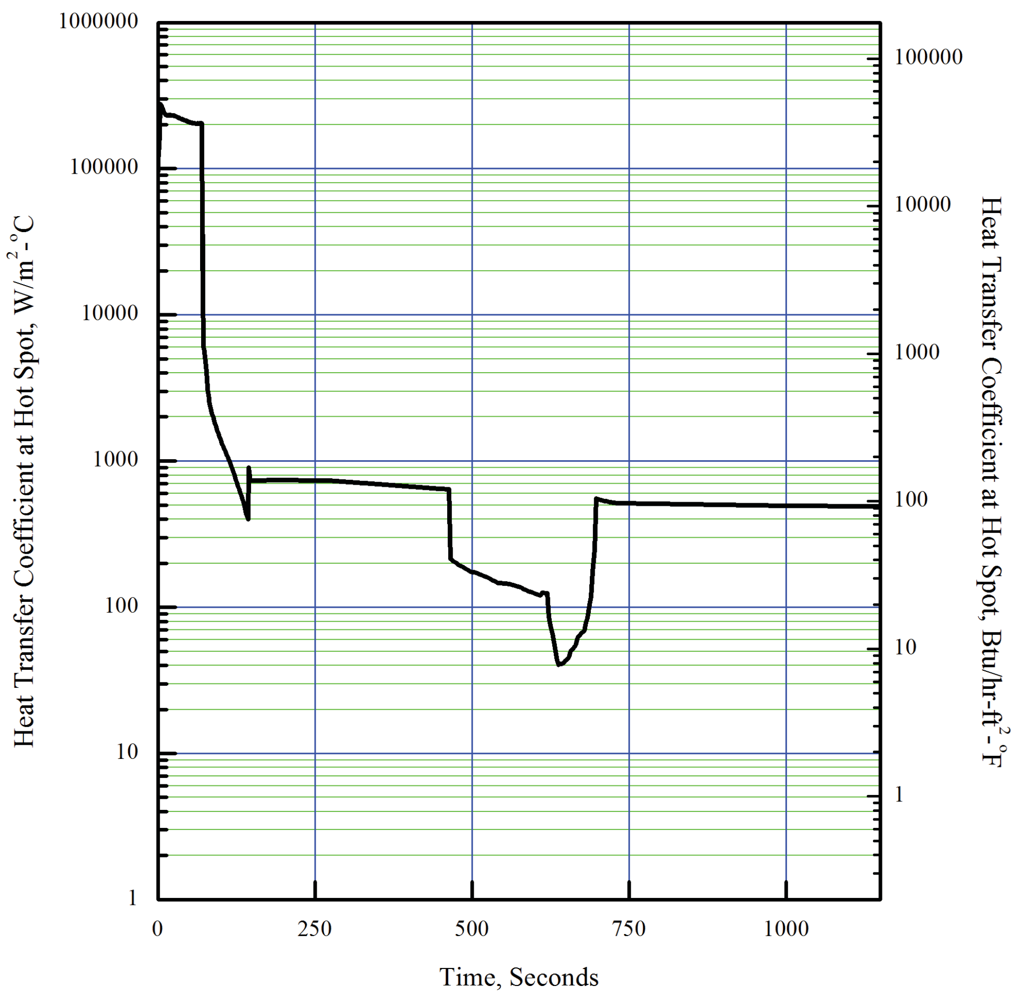


Figure 15.6.5-24F 126.7 $cm^2$ (0.1364$ft^2$) Break in DVI Line: Heat Transfer Coefficient at Hot Spot

RAI 318-8337 - Question 15.06.05-2_Rev.1

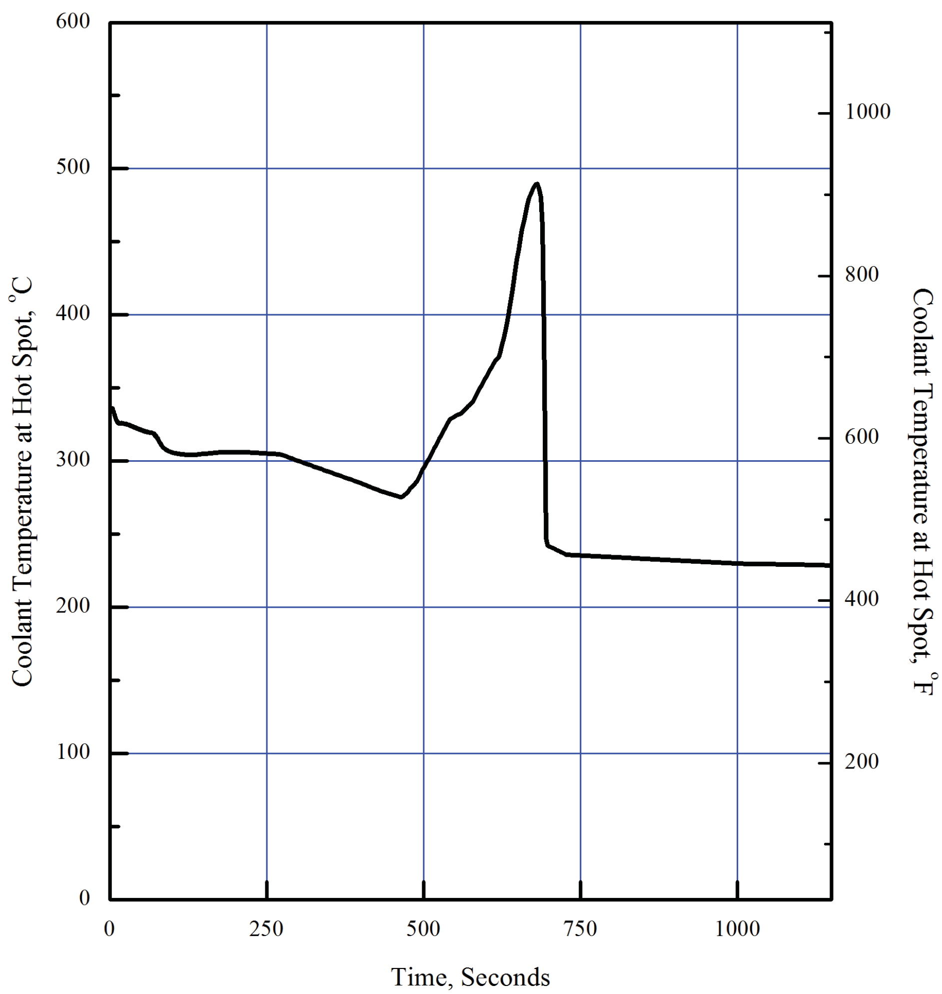


Figure 15.6.5-24G 126.7 cm$^2$ (0.1364ft$^2$) Break in DVI Line: Coolant Temperature at Hot Spot

RAI 318-8337 - Question 15.06.05-2_Rev.1

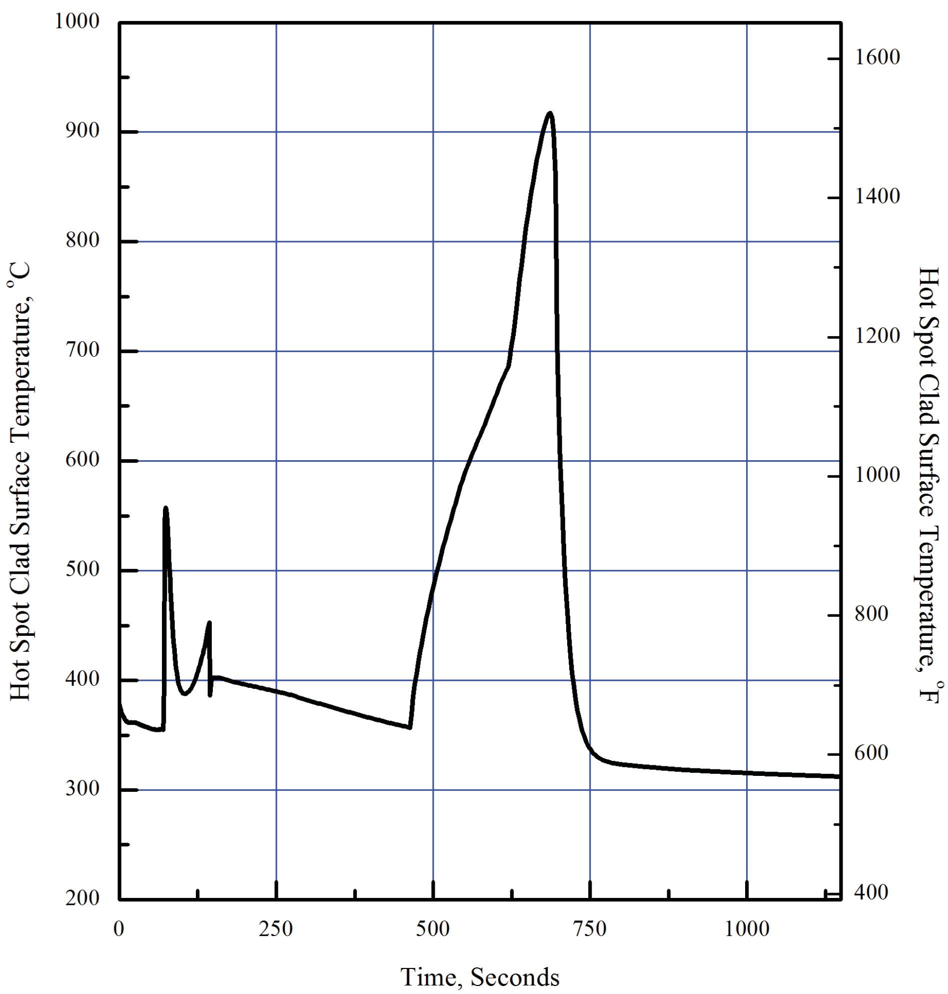


Figure 15.6.5-24H 126.7 $cm^2$ (0.1364$ft^2$) Break in DVI Line: Hot Spot Clad Surface Temperature

RAI 318-8337 - Question 15.06.05-2_Rev.1

A

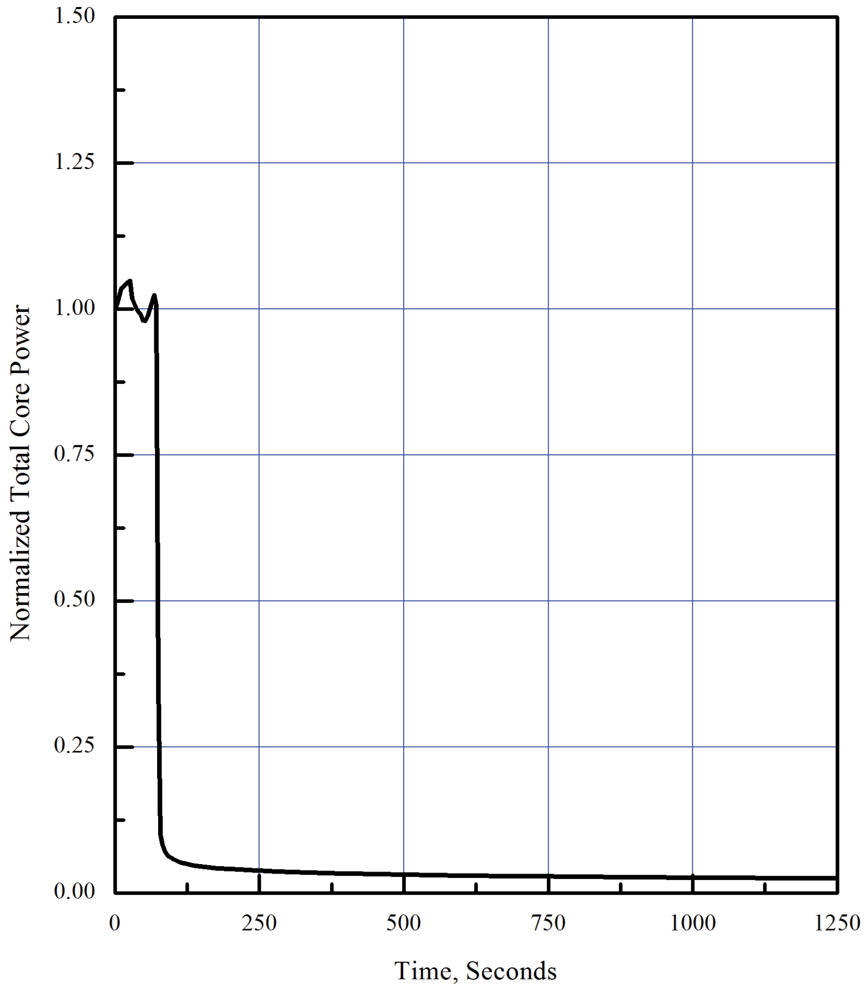


Figure 15.6.5-25A 126.7cm$^2$ (0.1364ft$^2$) Break in Pump discharge Leg: Normalized Total Core Power

RAI 318-8337 - Question 15.06.05-2_Rev.1

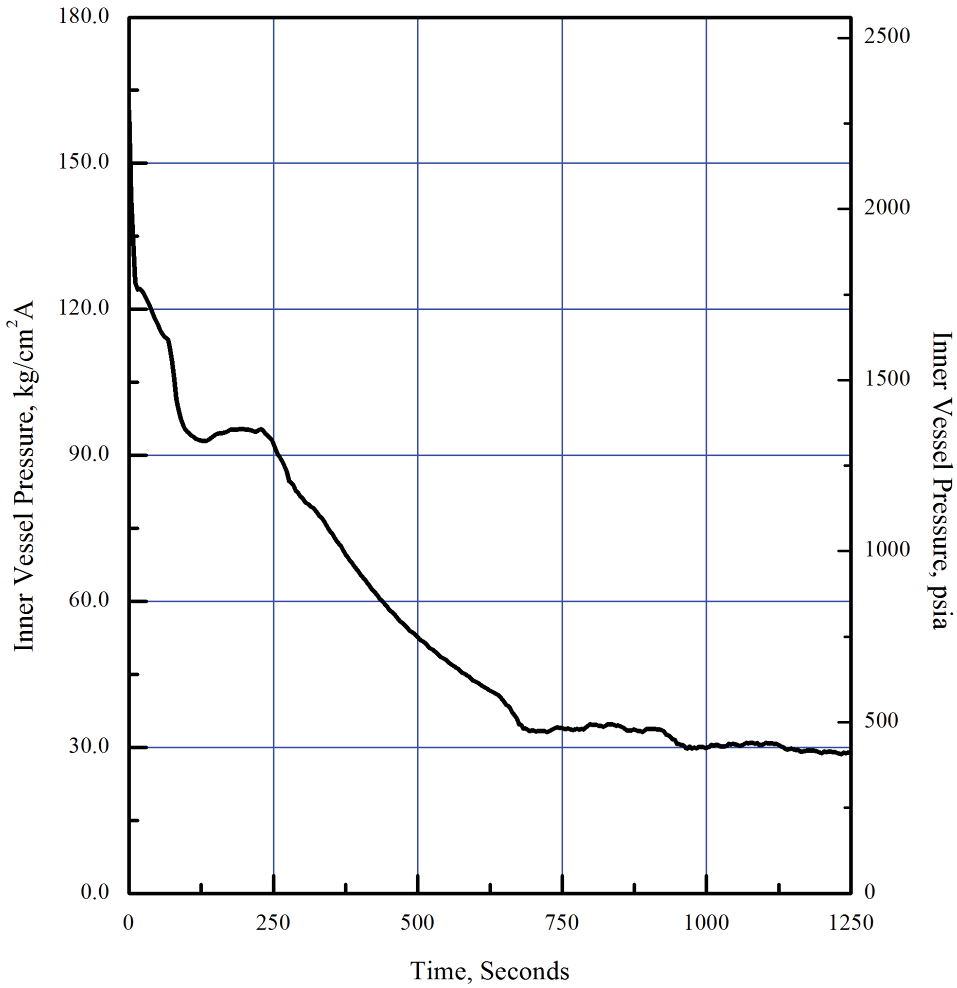


Figure 15.6.5-25B 126.7cm$^2$ (0.1364ft$^2$) Break in Pump discharge Leg: Inner Vessel Pressure

**Non-Proprietary**



RAI 318-8337 - Question 15.06.05-2_Rev.1

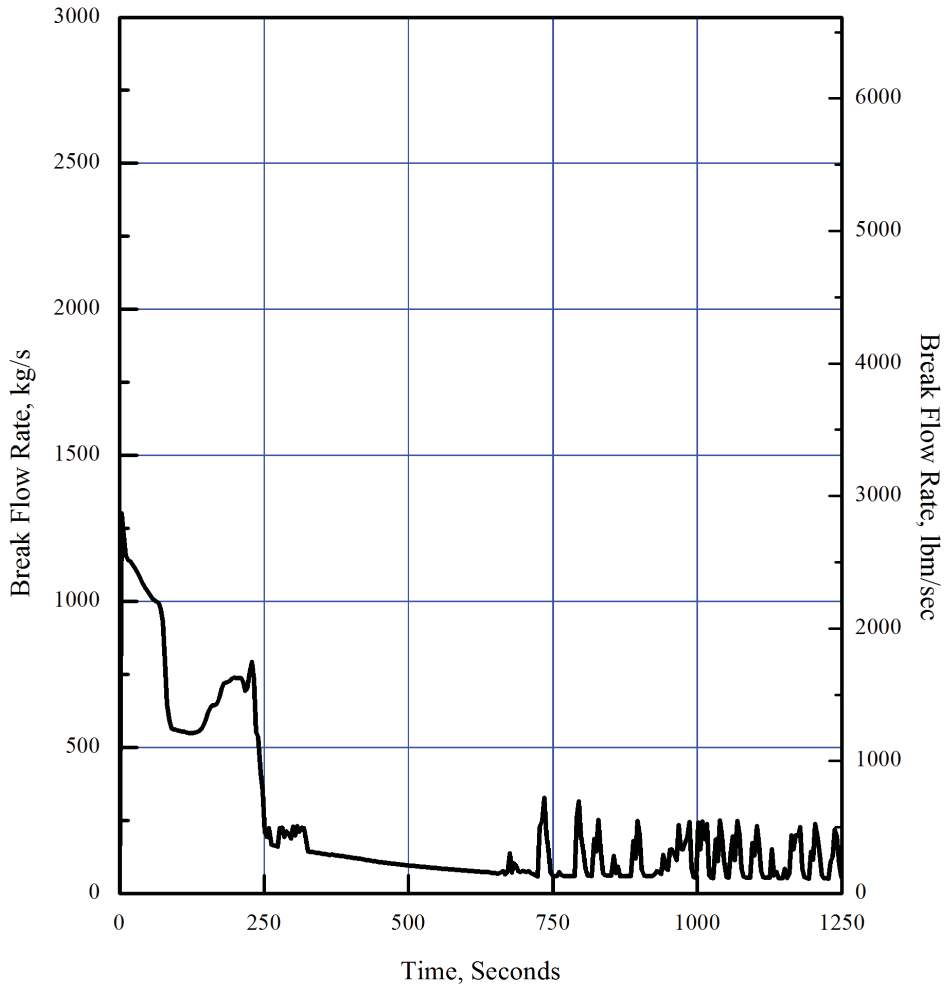


Figure 15.6.5-25C 126.7cm$^2$ (0.1364ft$^2$) Break in Pump discharge Leg: Break Flow Rate

RAI 318-8337 - Question 15.06.05-2_Rev.1

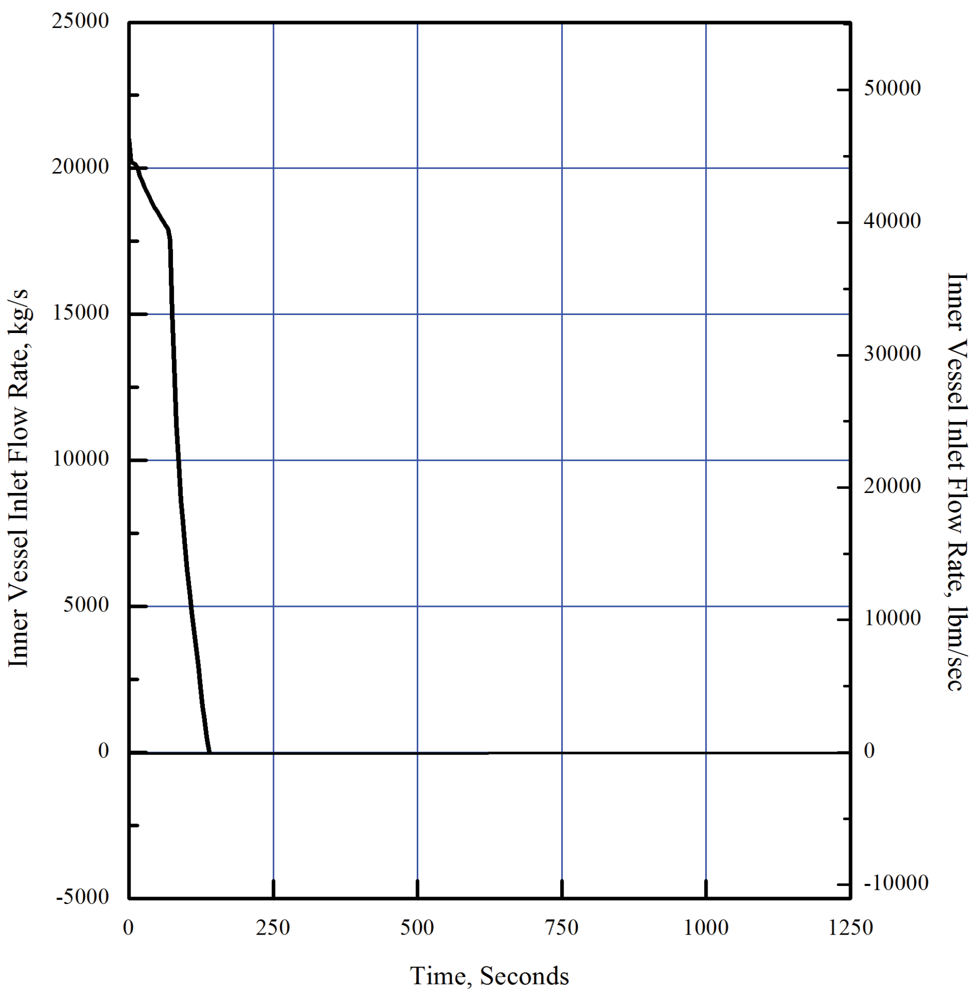


Figure 15.6.5-25D 126.7cm$^2$ (0.1364ft$^2$) Break in Pump discharge Leg: Inner Vessel Inlet Flow

RAI 318-8337 - Question 15.06.05-2_Rev.1

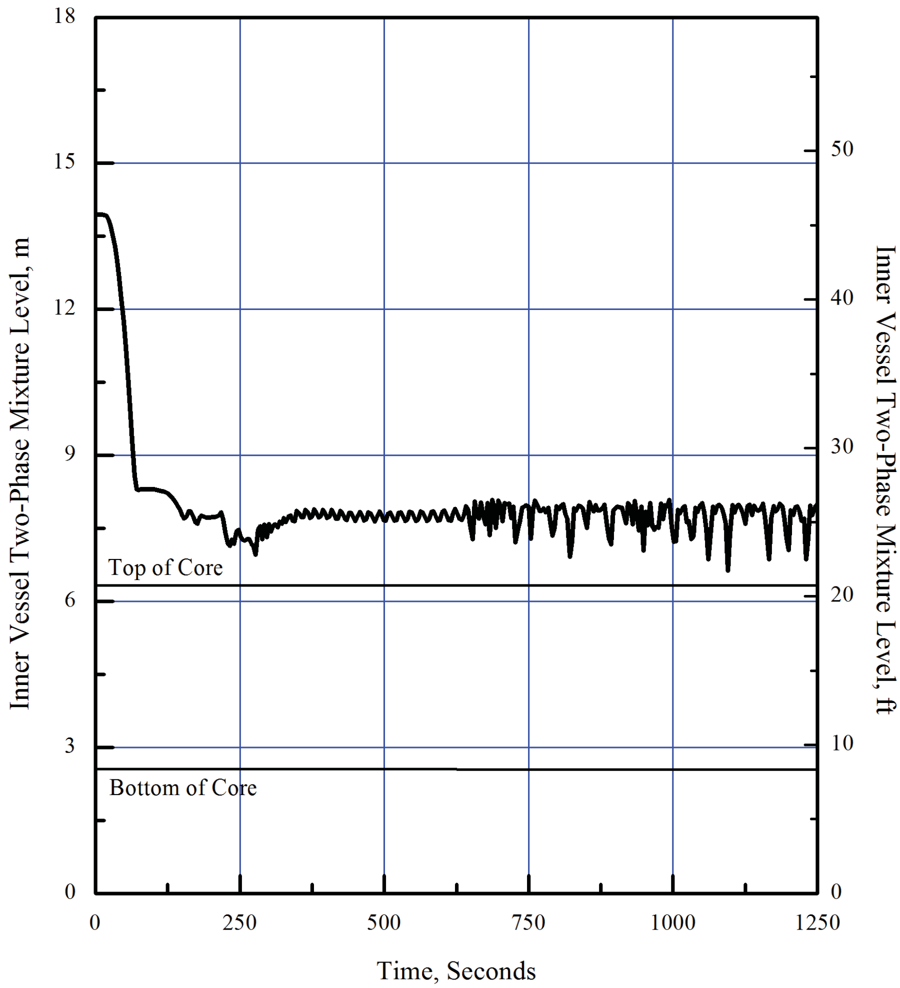


Figure 15.6.5-25E 126.7cm$^2$ (0.1364ft$^2$) Break in Pump discharge Leg: Inner Vessel Two-Phase Mixture Level

RAI 318-8337 - Question 15.06.05-2_Rev.1

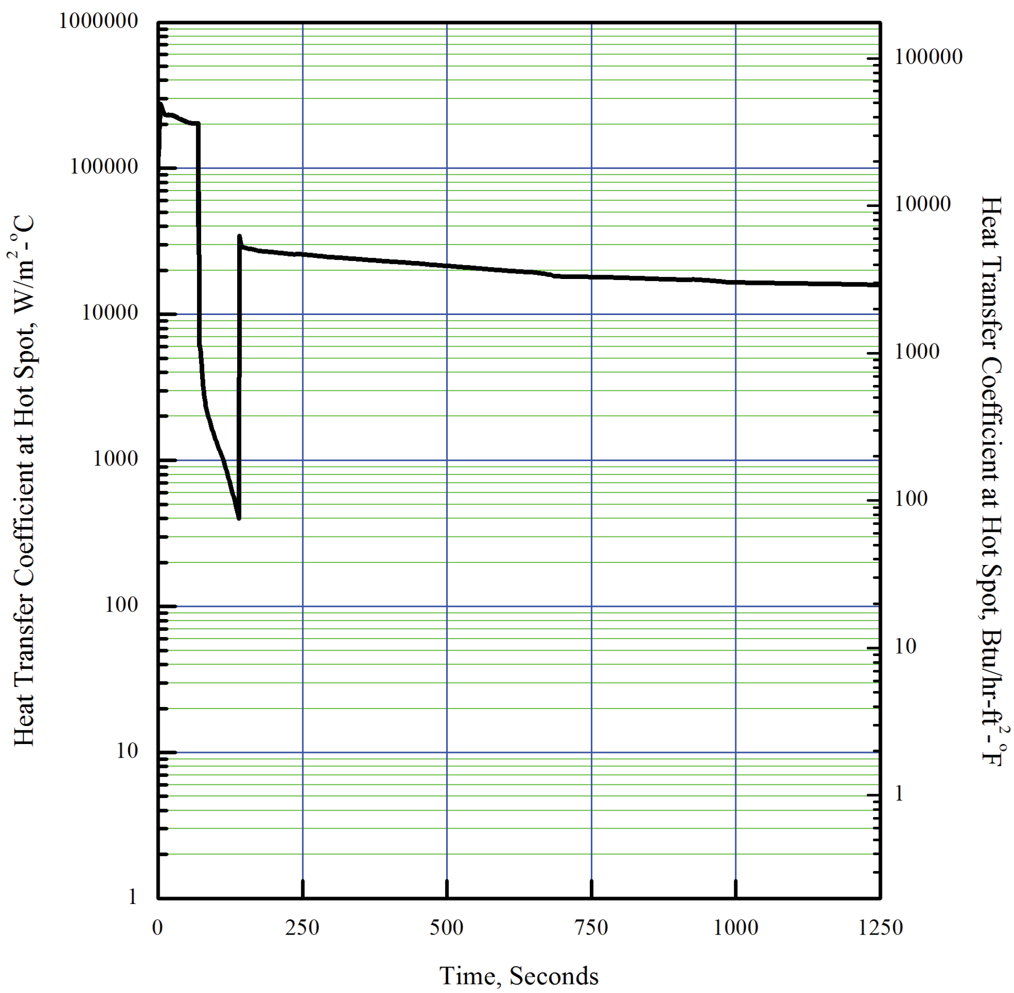


Figure 15.6.5-25F 126.7cm$^2$ (0.1364ft$^2$) Break in Pump discharge Leg: Heat Transfer Coefficient at Hot Spot

RAI 318-8337 - Question 15.06.05-2_Rev.1

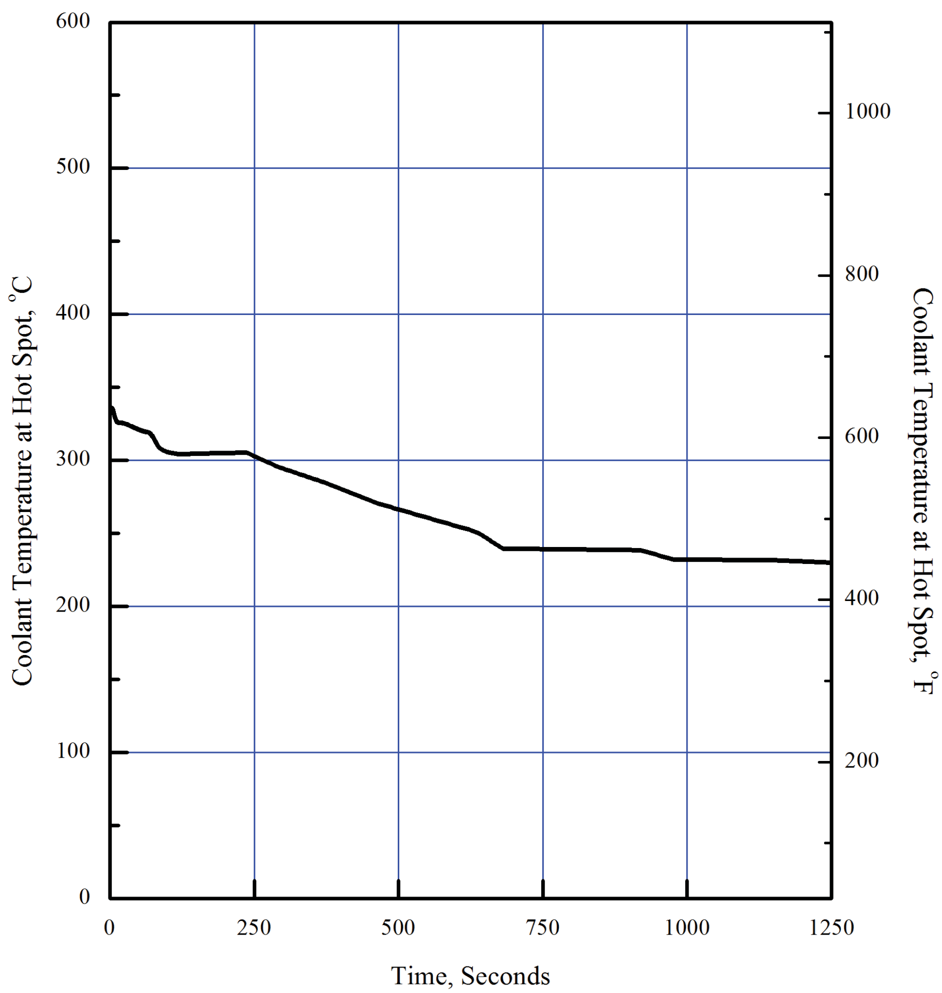


Figure 15.6.5-25G 126.7cm$^2$ (0.1364ft$^2$) Break in Pump discharge Leg: Coolant Temperature at Hot Spot

RAI 318-8337 - Question 15.06.05-2_Rev.1

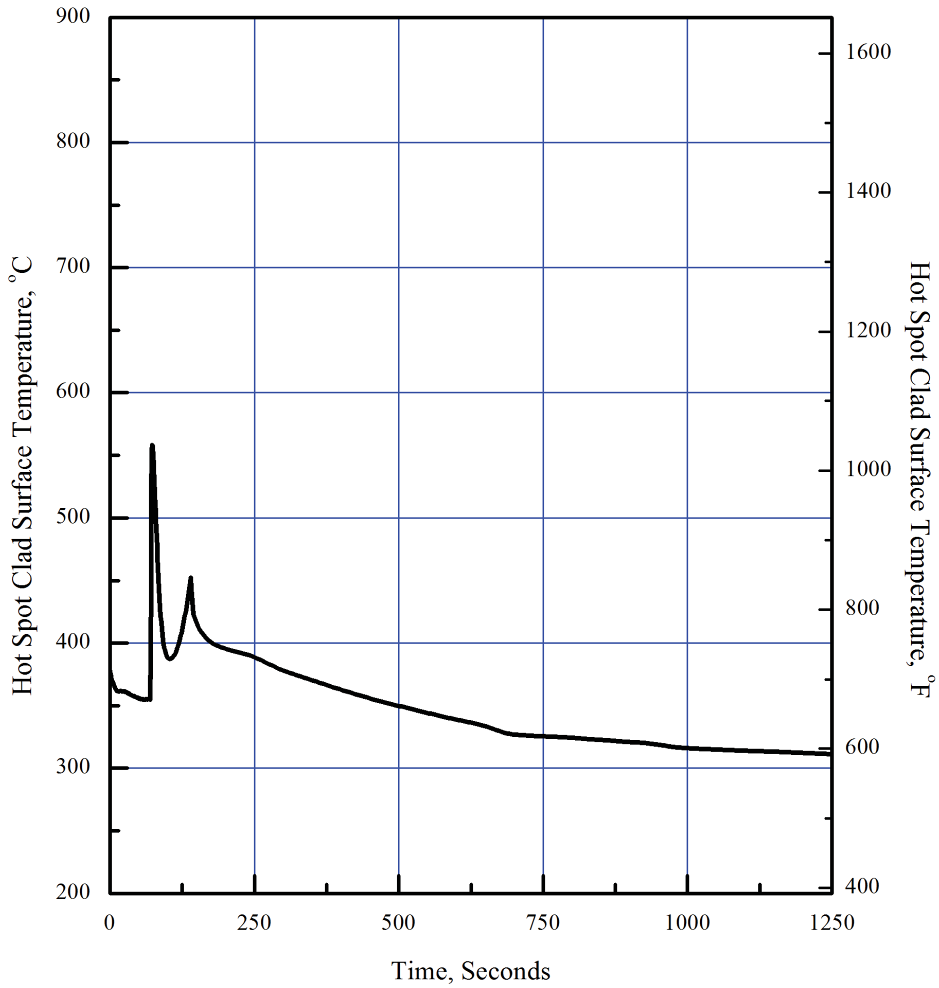


Figure 15.6.5-25H 126.7cm$^2$ (0.1364ft$^2$) Break in Pump discharge Leg: Hot Spot Clad Surface Temperature

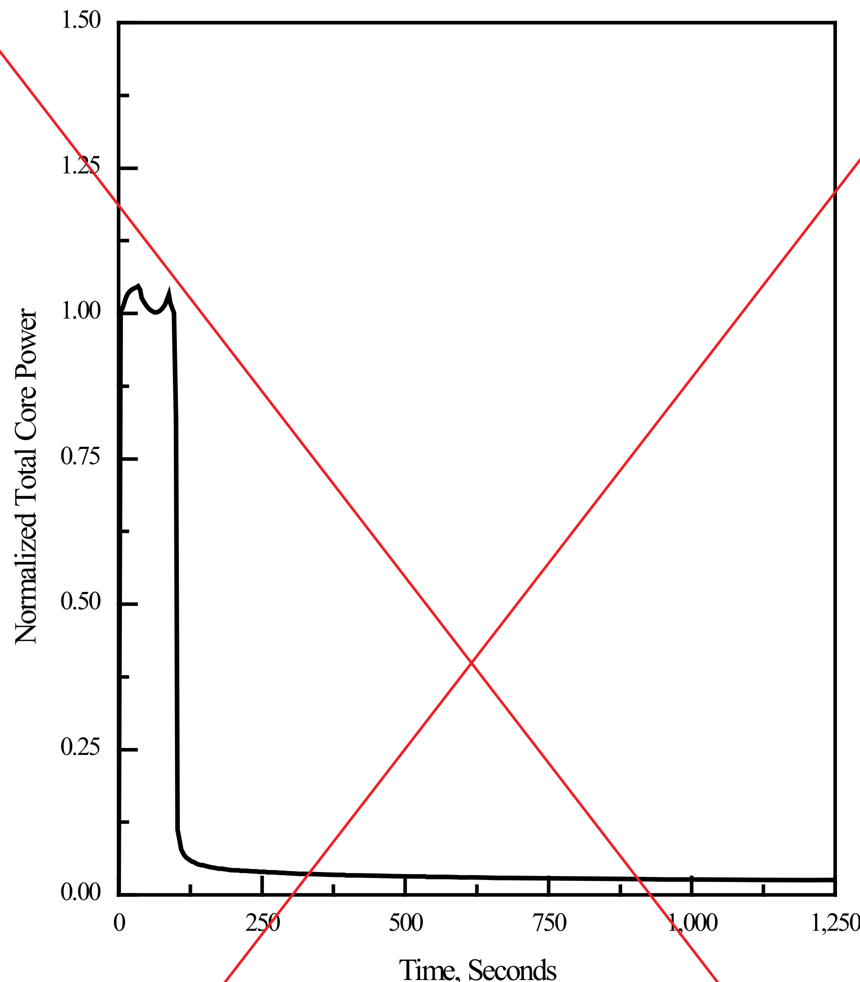


**Figure 15.6.5-26A 93 $cm^2$ (0.1 $ft^2$) Break in Pump Discharge Leg: Normalized Total Core Power**

RAI 318-8337 - Question 15.06.05-2_Rev.1

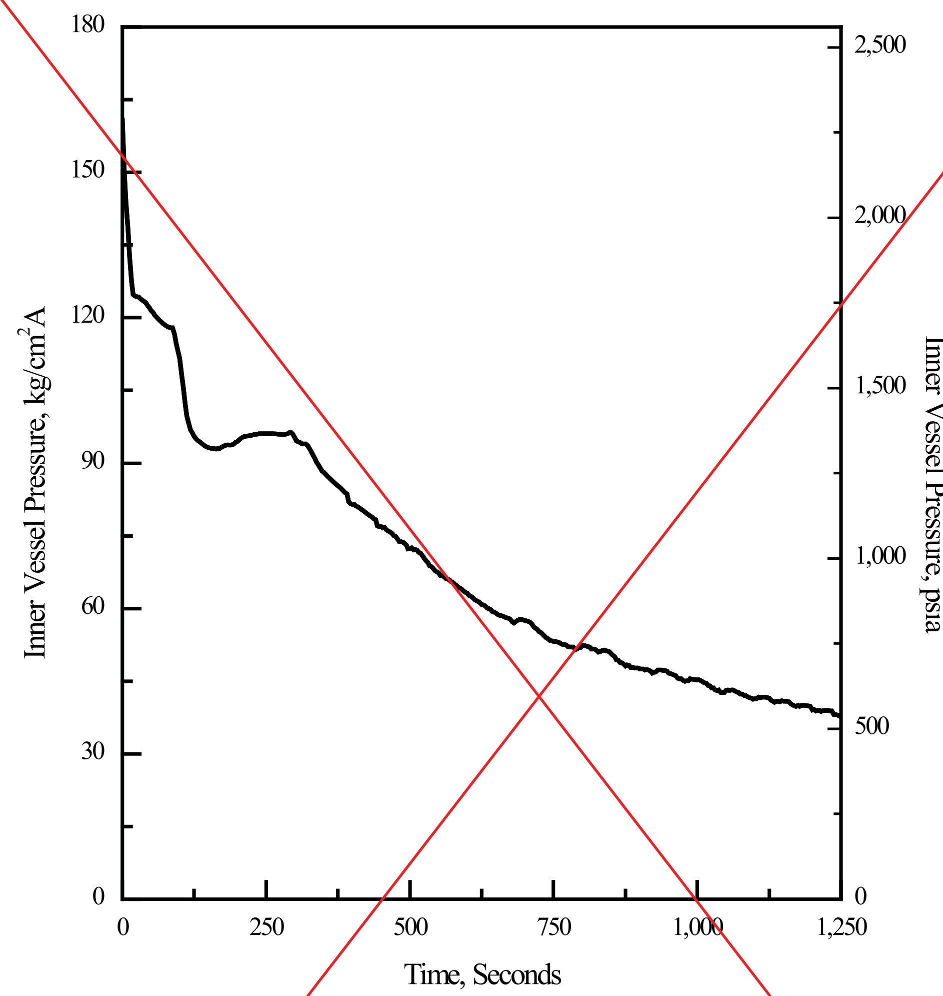


**Figure 15.6.5-26B 93 $cm^2$ (0.1 $ft^2$) Break in Pump Discharge Leg: Inner Vessel Pressure**

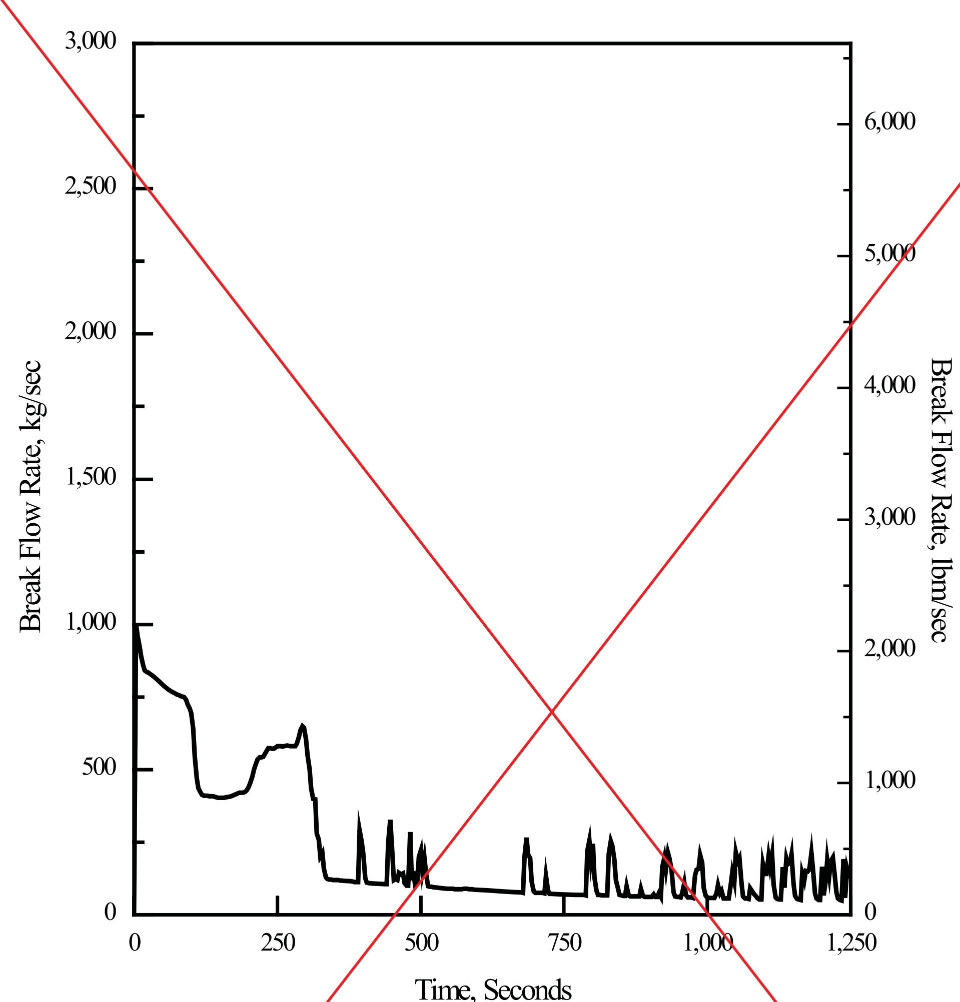


**Figure 15.6.5-26C 93 $cm^2$ (0.1 $ft^2$) Break in Pump Discharge Leg: Break Flow Rate**

RAI 318-8337 - Question 15.06.05-2_Rev.1

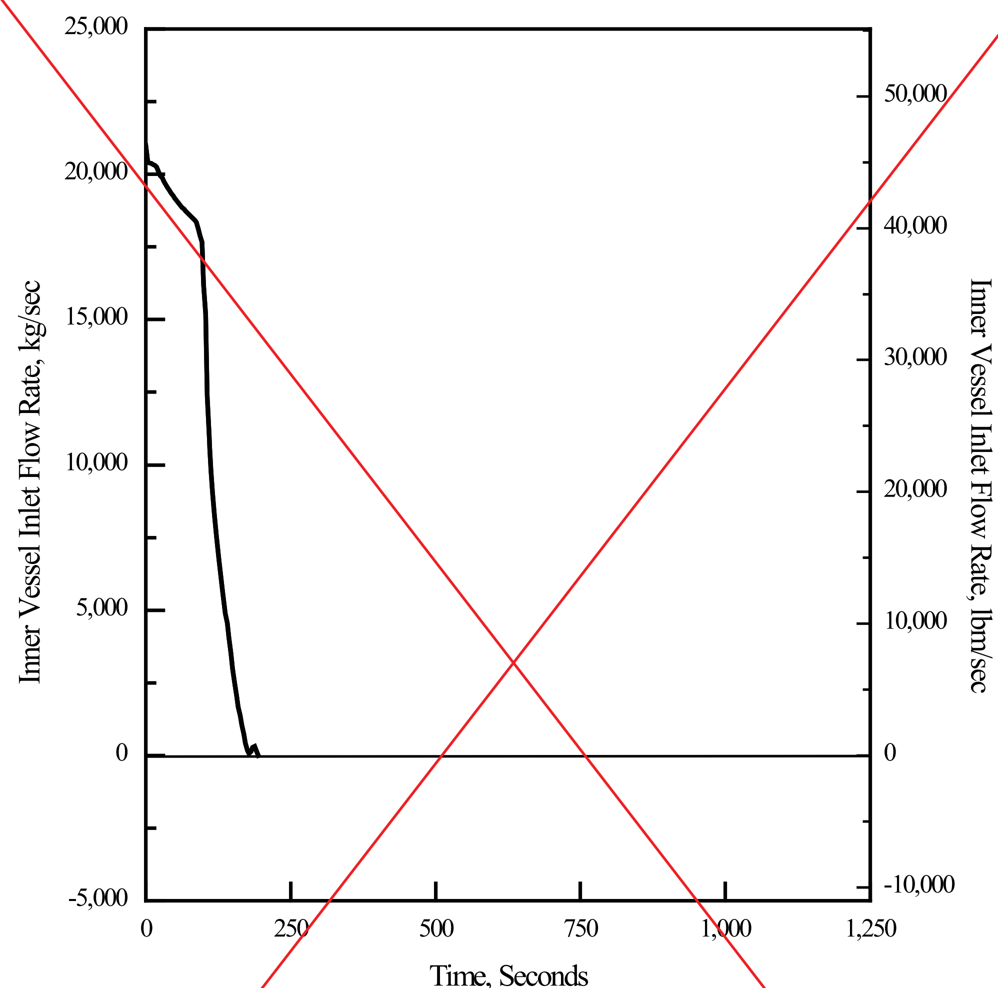


**Figure 15.6.5-26D 93 $cm^2$ (0.1 $ft^2$) Break in Pump Discharge Leg: Inner Vessel Inlet Flow Rate**

RAI 318-8337 - Question 15.06.05-2_Rev.1

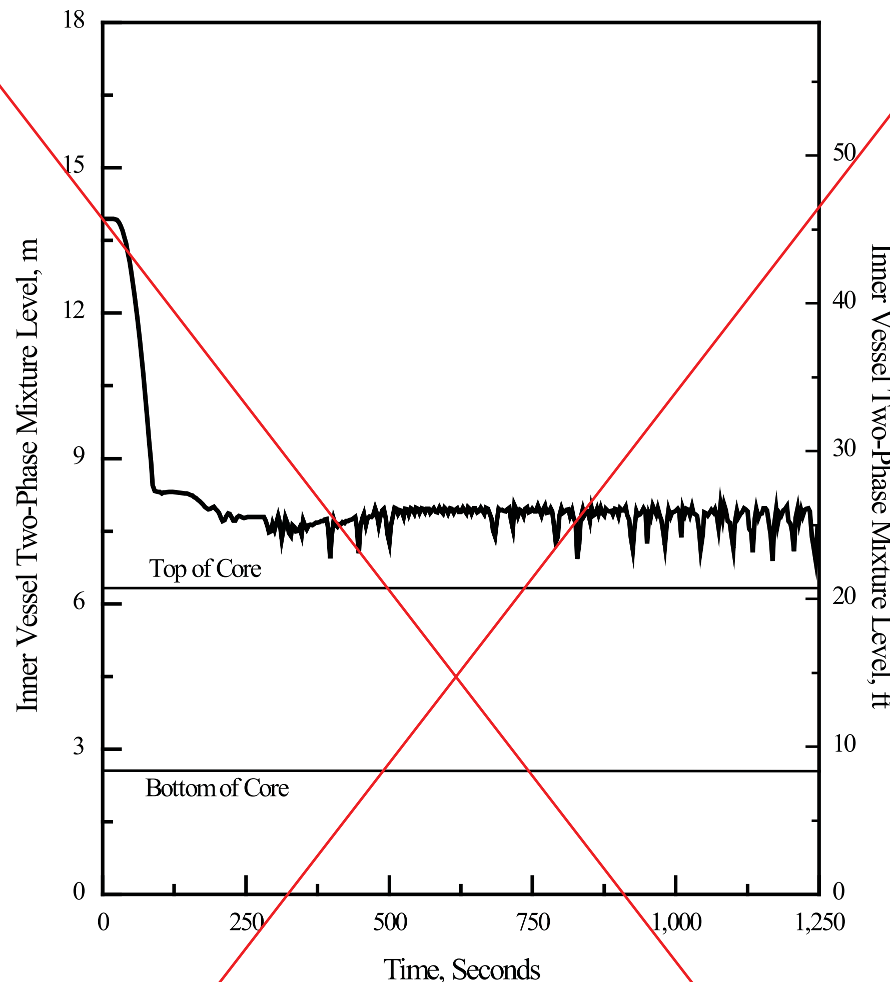


**Figure 15.6.5-26E 93 cm² (0.1 ft²) Break in Pump Discharge Leg: Inner Vessel Two-Phase Mixture Level**

RAI 318-8337 - Question 15.06.05-2_Rev.1

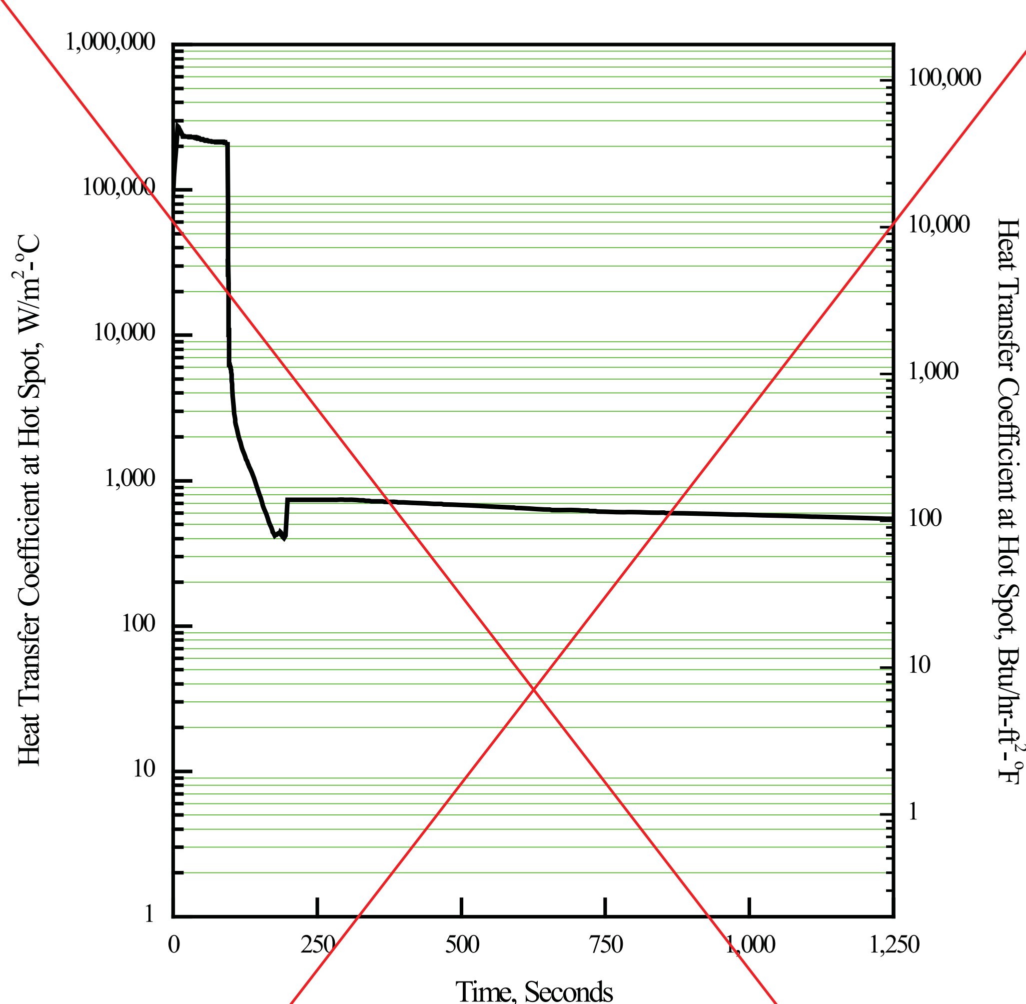


**Figure 15.6.5-26F 93 cm$^2$ (0.1 ft$^2$) Break in Pump Discharge Leg: Heat Transfer Coefficient at Hot Spot**

RAI 318-8337 - Question 15.06.05-2_Rev.1

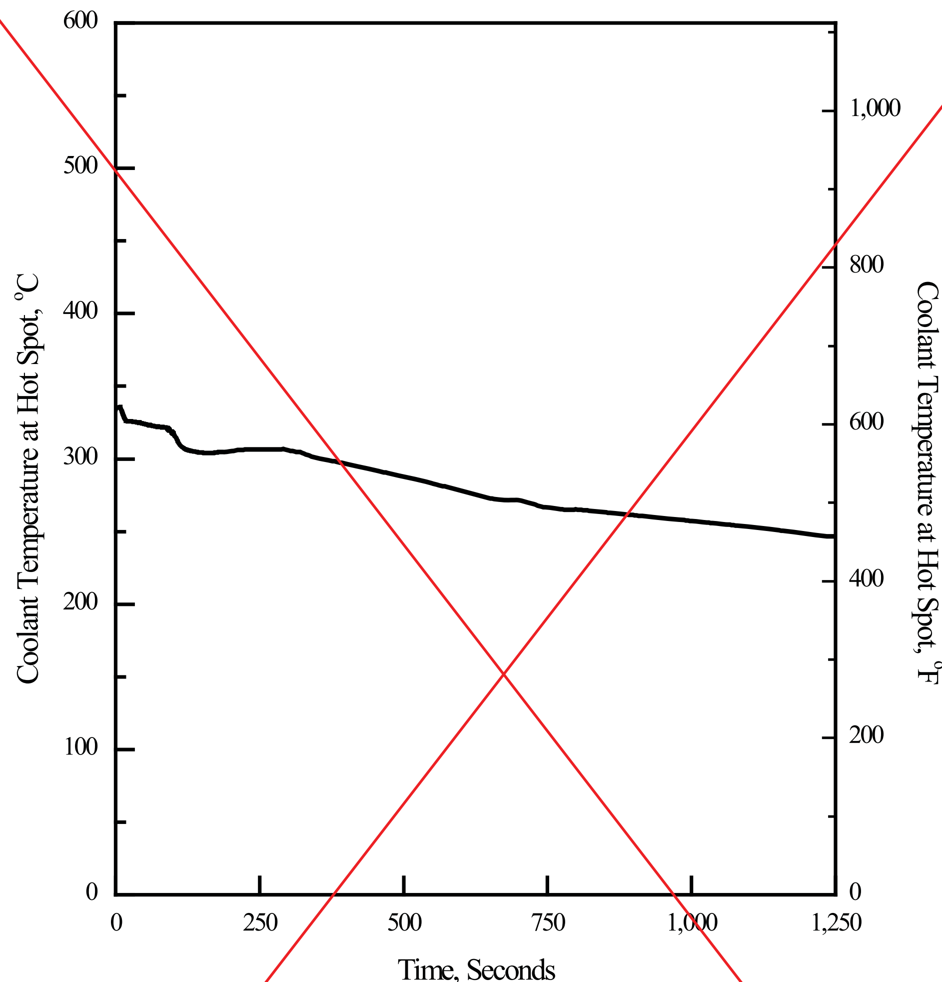


**Figure 15.6.5-26G 93 cm² (0.1 ft²) Break in Pump Discharge Leg: Coolant Temperature at Hot Spot**

RAI 318-8337 - Question 15.06.05-2_Rev.1

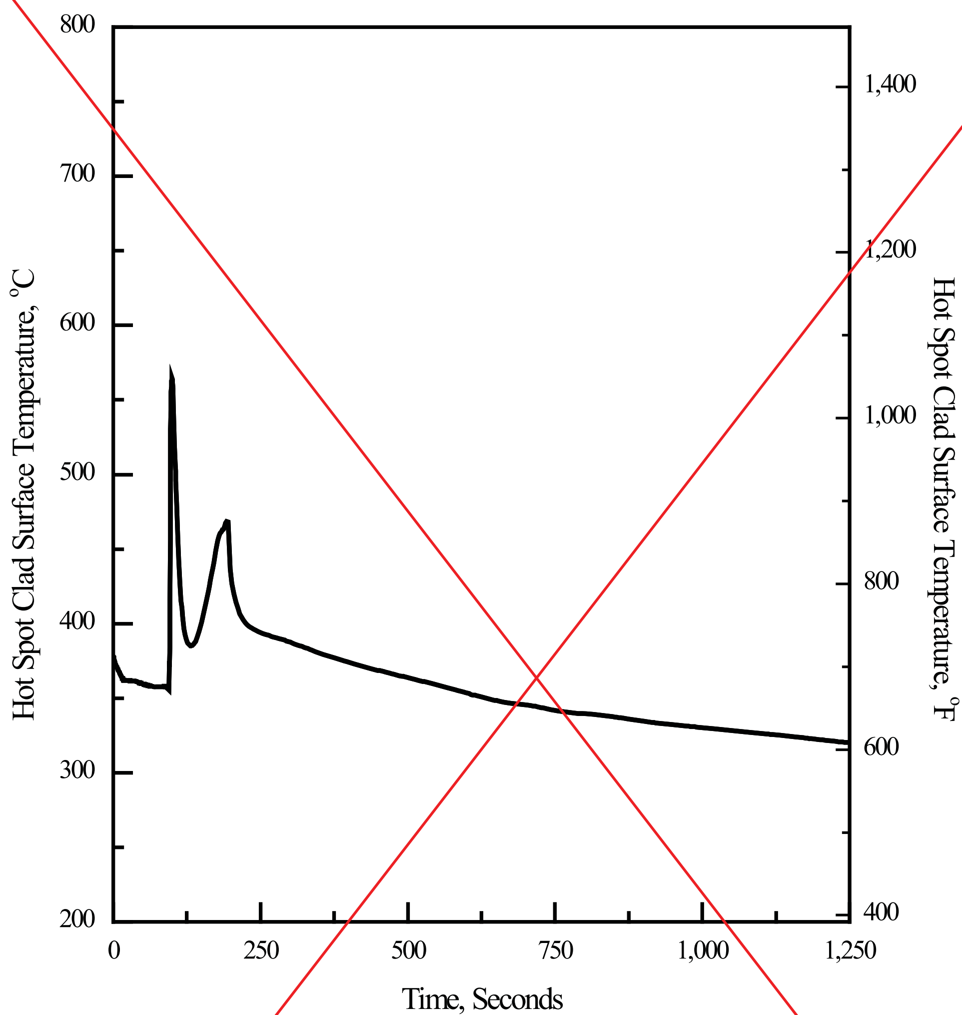


**Figure 15.6.5-26H 93 cm² (0.1 ft²) Break in Pump Discharge Leg: Hot Spot Clad Surface Temperature**

RAI 318-8337 - Question 15.06.05-2_Rev.1

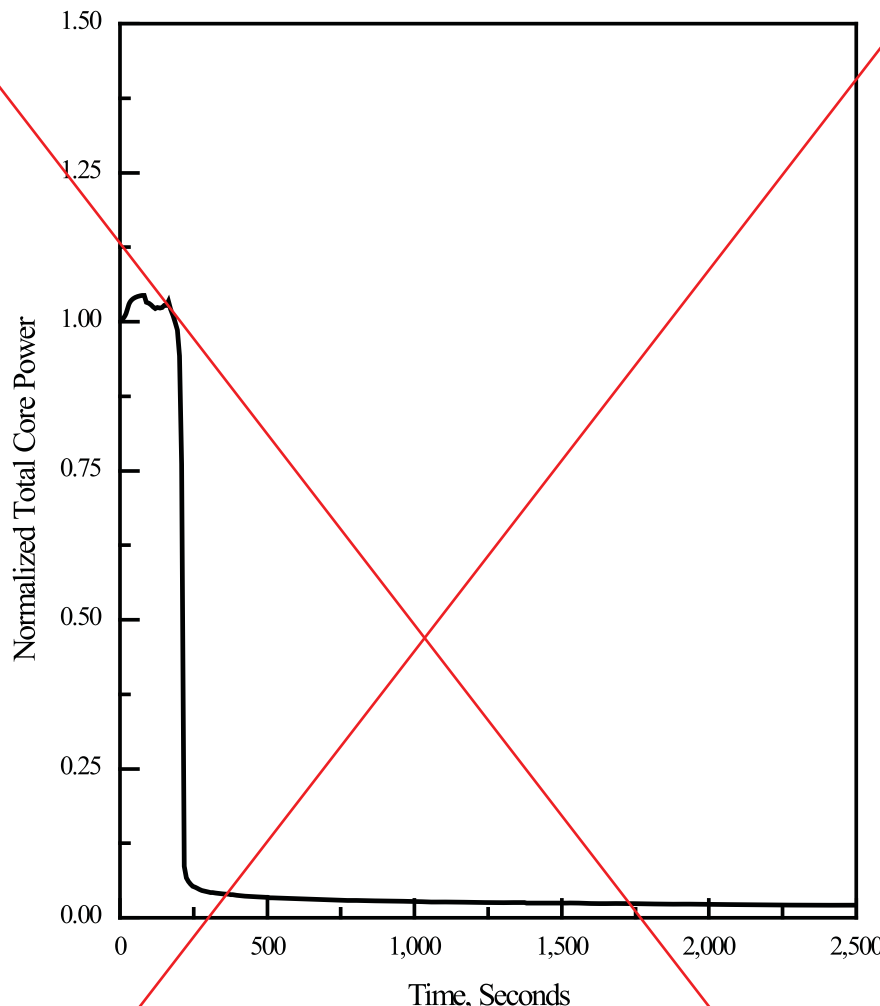


**Figure 15.6.5-27A 46.5 cm$^2$ (0.05 ft$^2$) Break in Pump Discharge Leg: Normalized Total Core Power**

RAI 318-8337 - Question 15.06.05-2_Rev.1

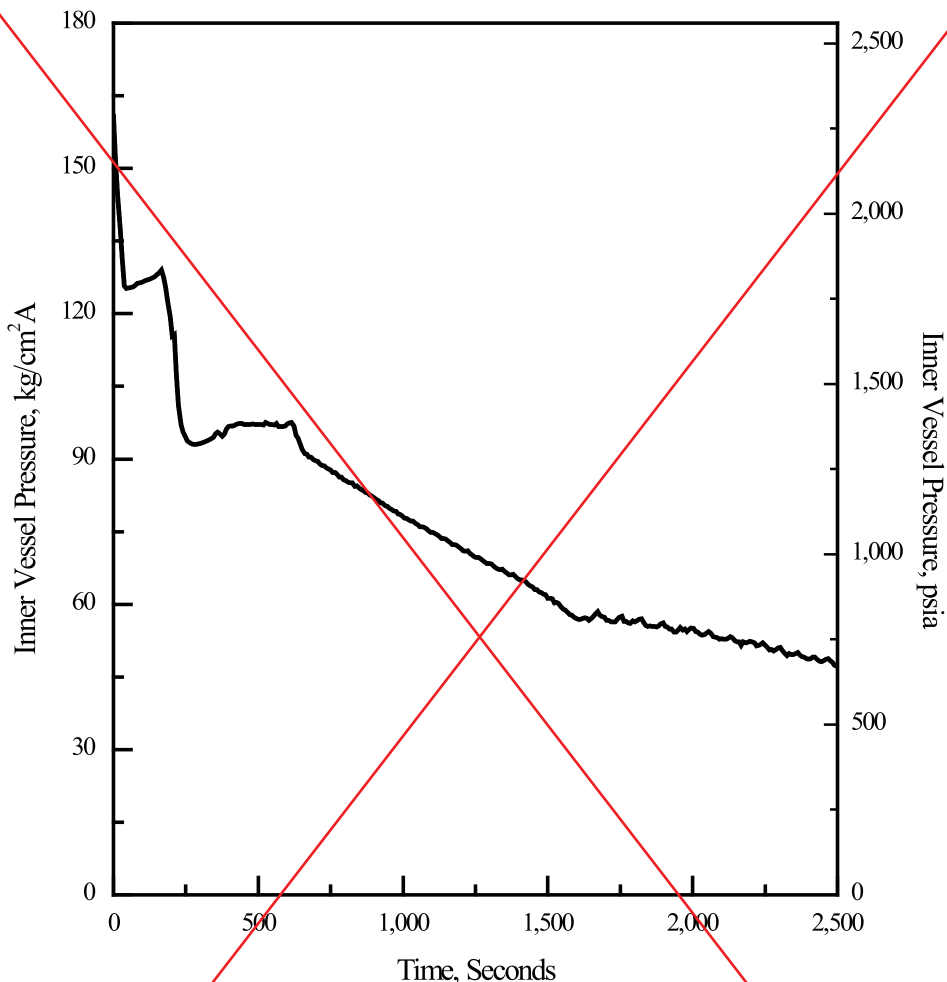


**Figure 15.6.5-27B 46.5 $cm^2$ (0.05 $ft^2$) Break in Pump Discharge Leg: Inner Vessel Pressure**

RAI 318-8337 - Question 15.06.05-2_Rev.1

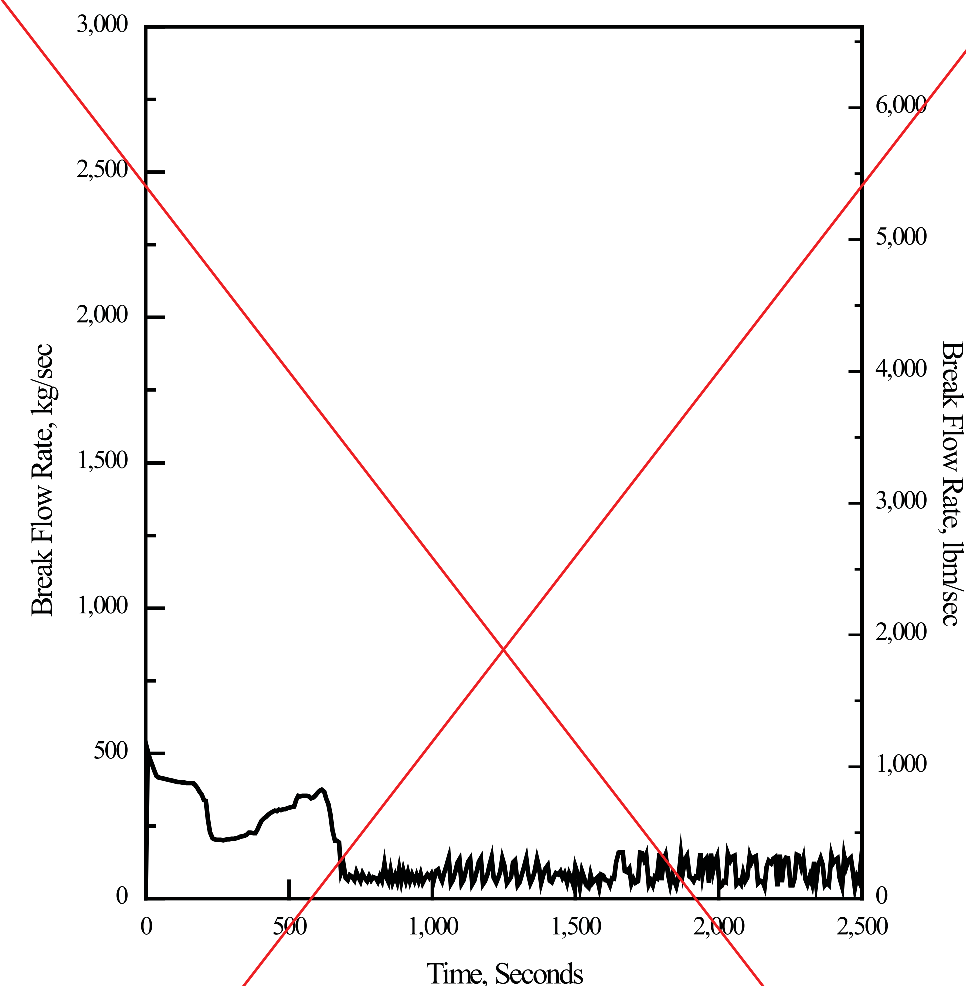


**Figure 15.6.5-27C 46.5 cm$^2$ (0.05 ft$^2$) Break in Pump Discharge Leg: Break Flow Rate**

RAI 318-8337 - Question 15.06.05-2_Rev.1

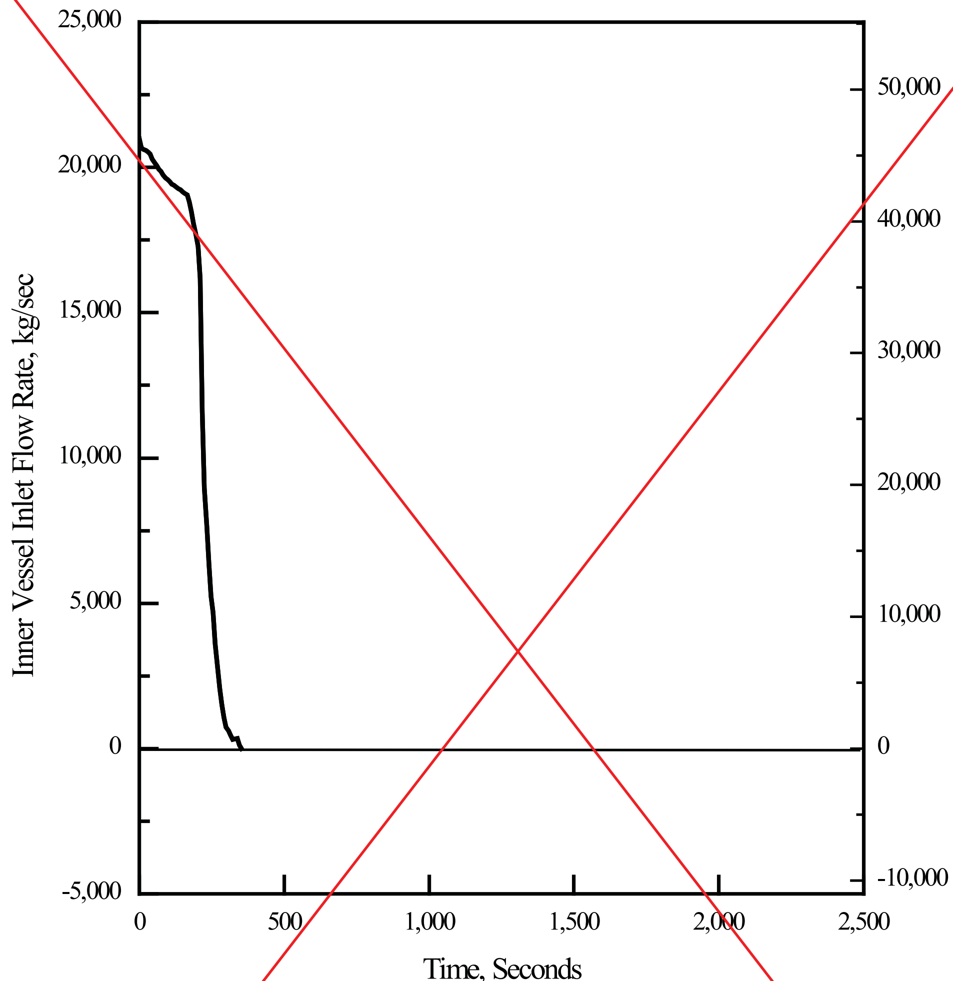


**Figure 15.6.5-27D 46.5 cm$^2$ (0.05 ft$^2$) Break in Pump Discharge Leg: Inner Vessel Inlet Flow Rate**

RAI 318-8337 - Question 15.06.05-2_Rev.1

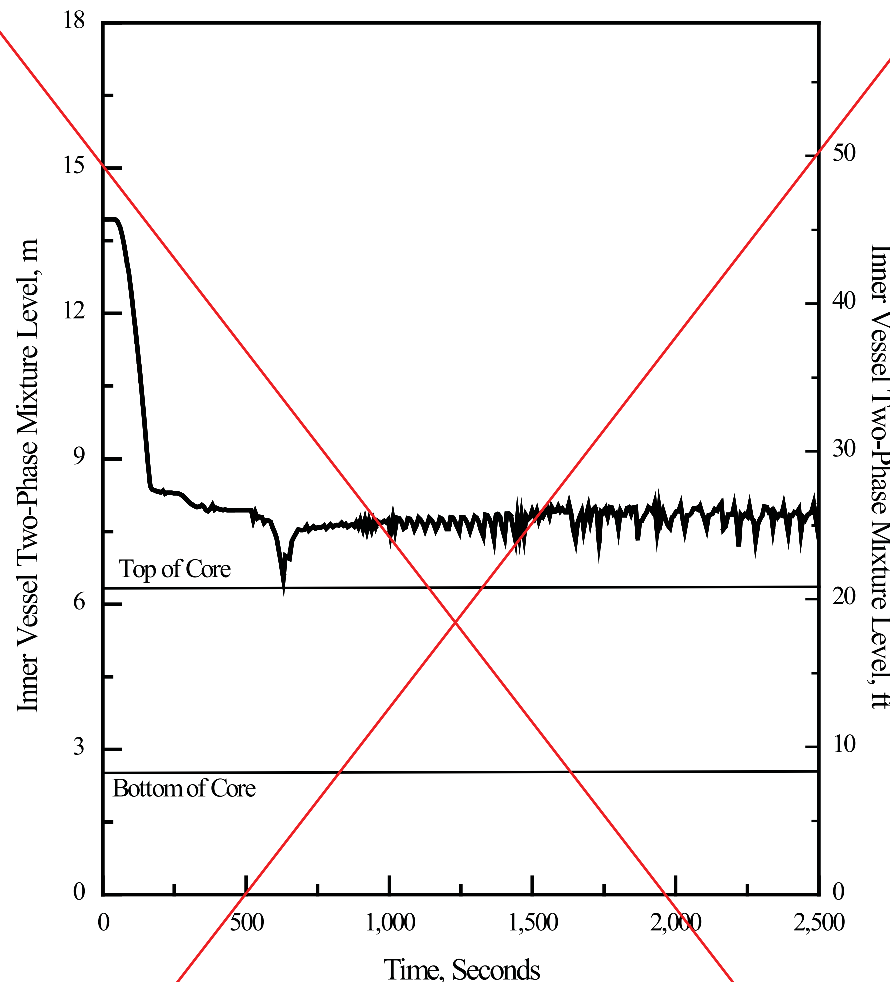


**Figure 15.6.5-27E 46.5 cm$^2$ (0.05 ft$^2$) Break in Pump Discharge Leg: Inner Vessel Two-Phase Mixture Level**

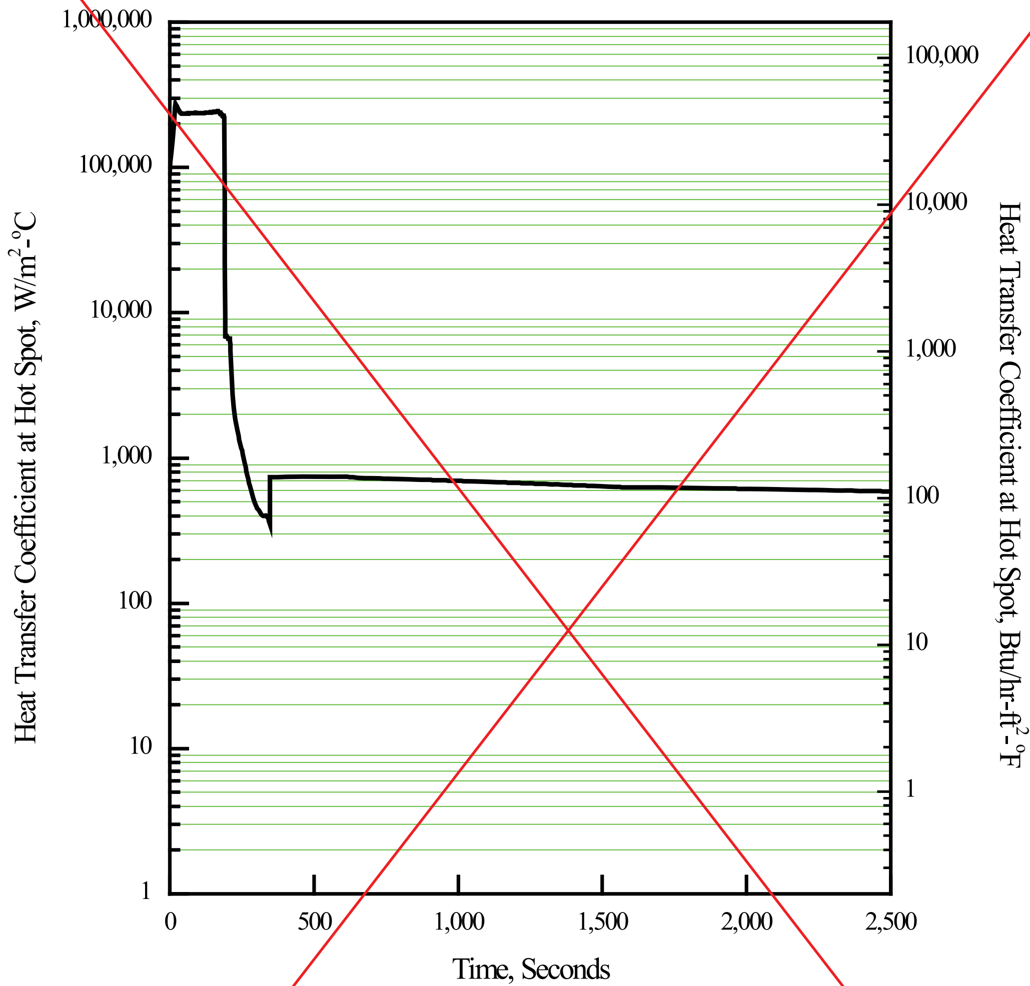


**Figure 15.6.5-27F 46.5 cm$^2$ (0.05 ft$^2$) Break in Pump Discharge Leg: Heat Transfer Coefficient at Hot Spot**

RAI 318-8337 - Question 15.06.05-2_Rev.1

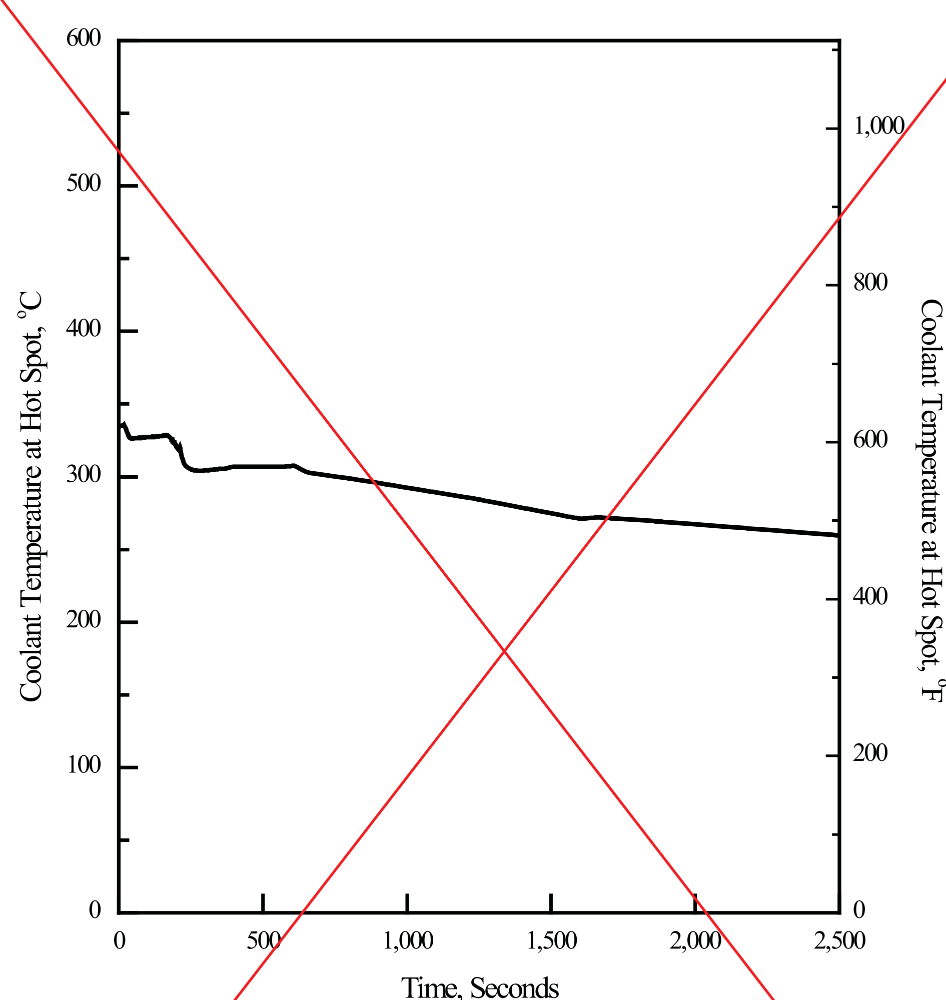


**Figure 15.6.5-27G 46.5 cm$^2$ (0.05 ft$^2$) Break in Pump Discharge Leg: Coolant Temperature at Hot Spot**

RAI 318-8337 - Question 15.06.05-2_Rev.1

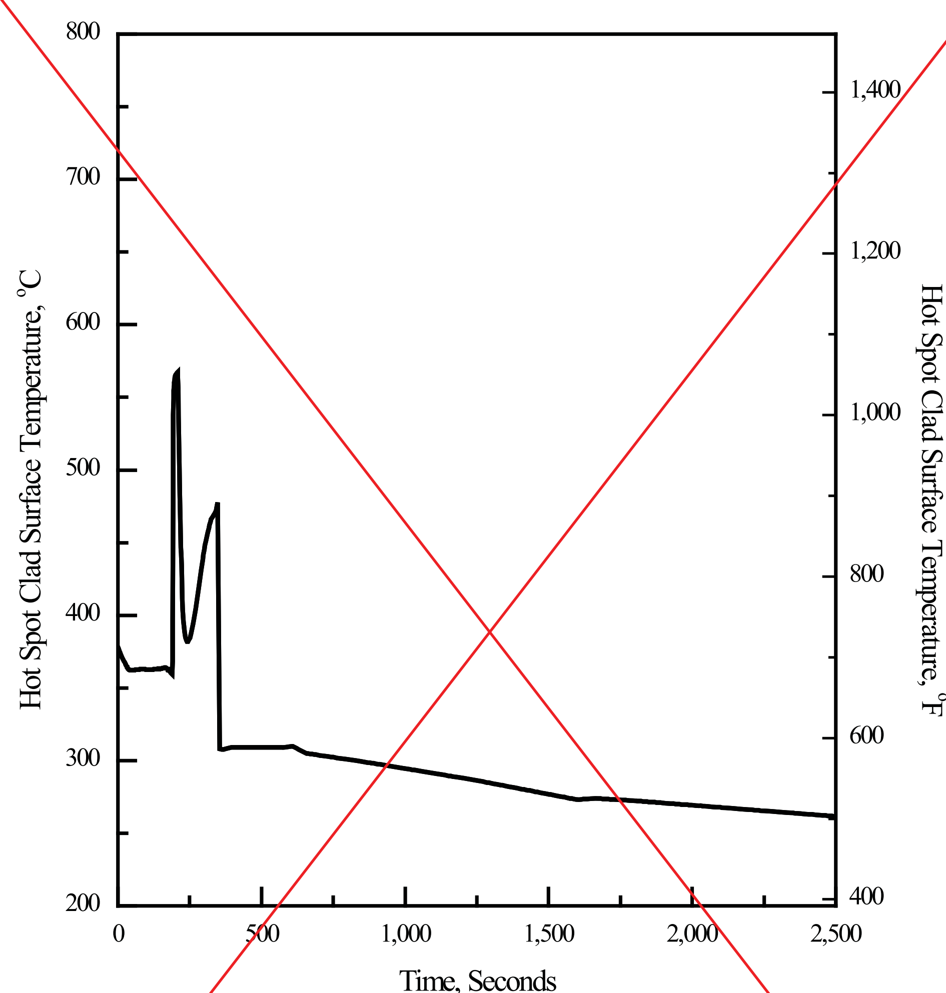


**Figure 15.6.5-27H 46.5 cm² (0.05 ft²) Break in Pump Discharge Leg: Hot Spot Clad Surface Temperature**

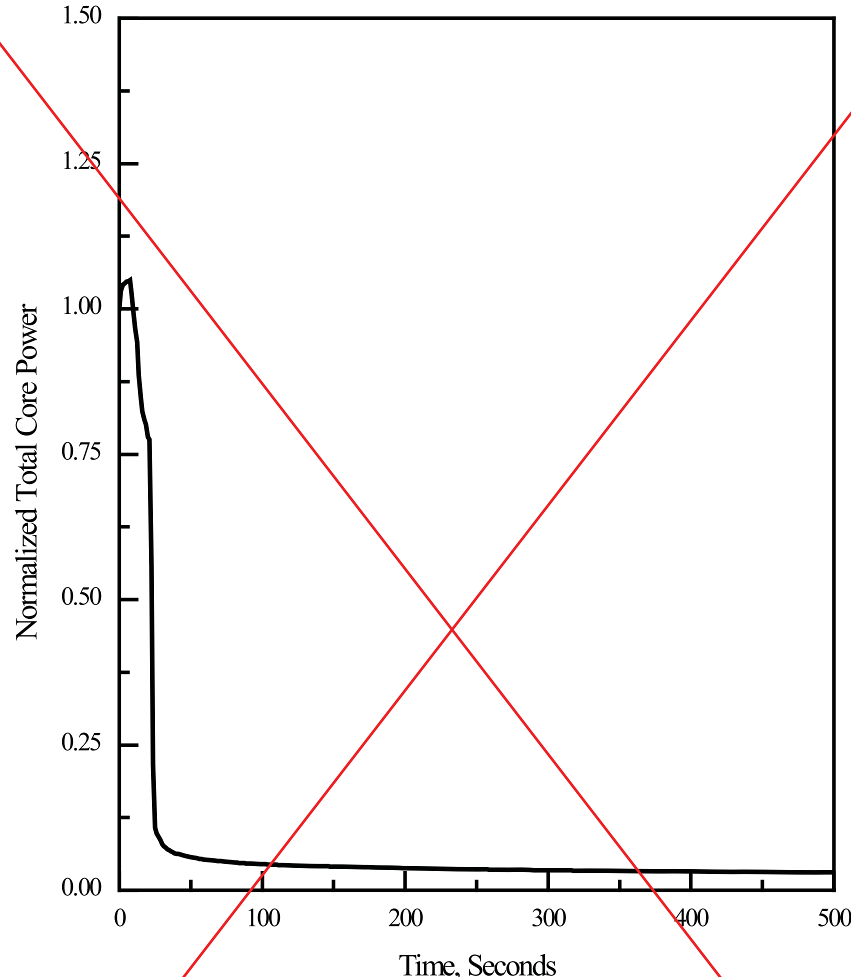


**Figure 15.6.5-28A 372 $cm^2$ (0.4 $ft^2$) Break in DVI Line: Normalized Total Core Power**

RAI 318-8337 - Question 15.06.05-2_Rev.1

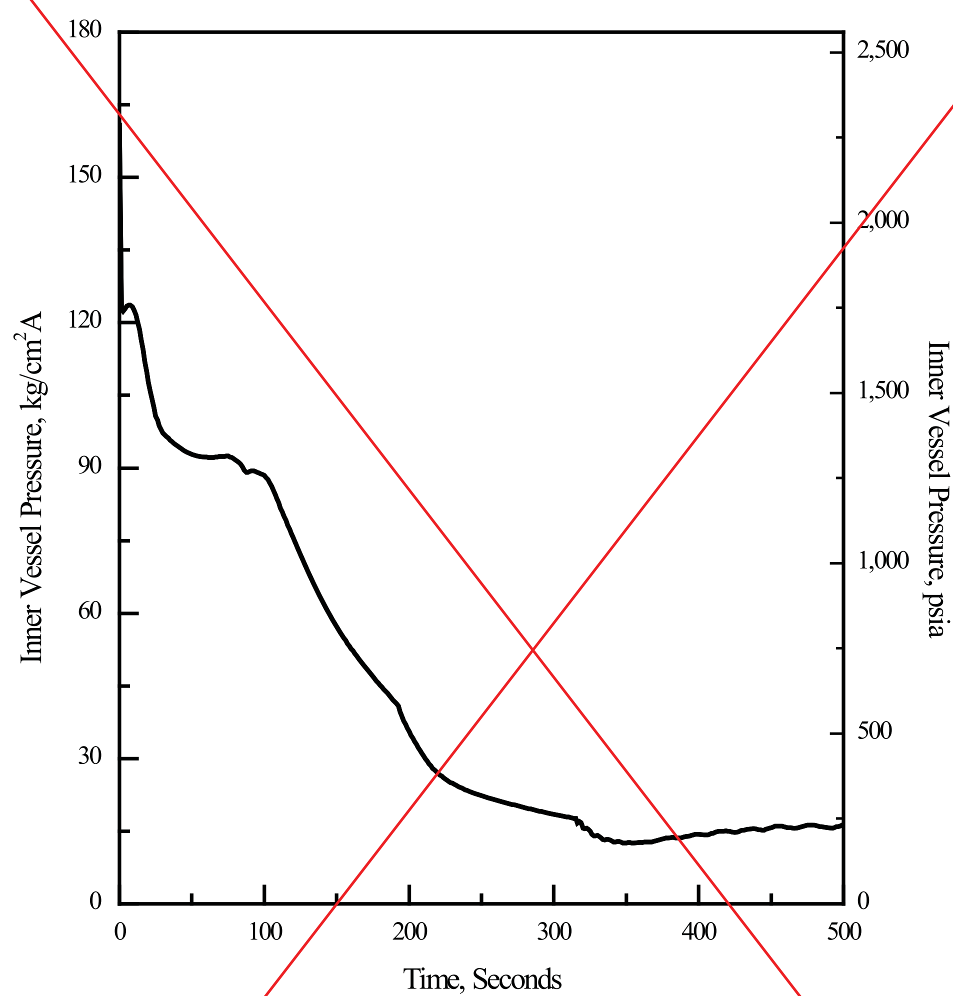


**Figure 15.6.5-28B 372 cm$^2$ (0.4 ft$^2$) Break in DVI Line: Inner Vessel Pressure**

RAI 318-8337 - Question 15.06.05-2_Rev.1

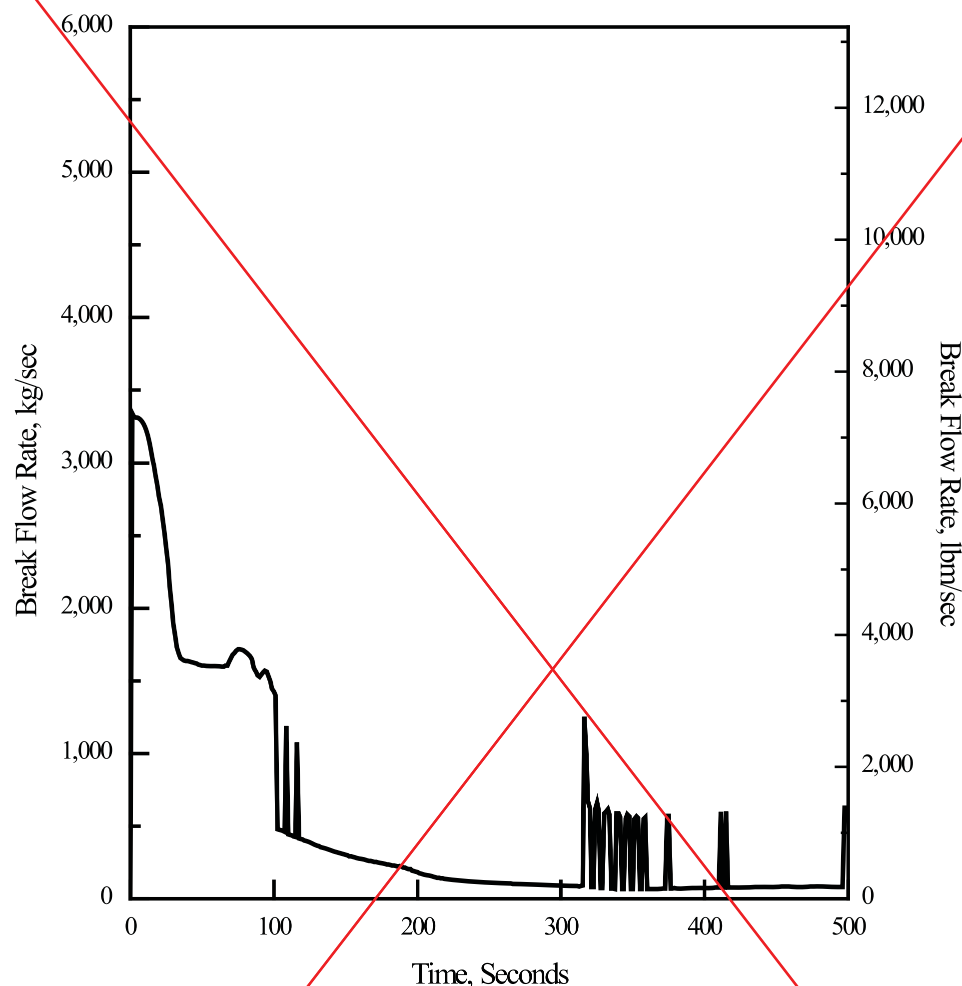


**Figure 15.6.5-28C 372 cm$^2$ (0.4 ft$^2$) Break in DVI Line: Break Flow Rate**

RAI 318-8337 - Question 15.06.05-2_Rev.1

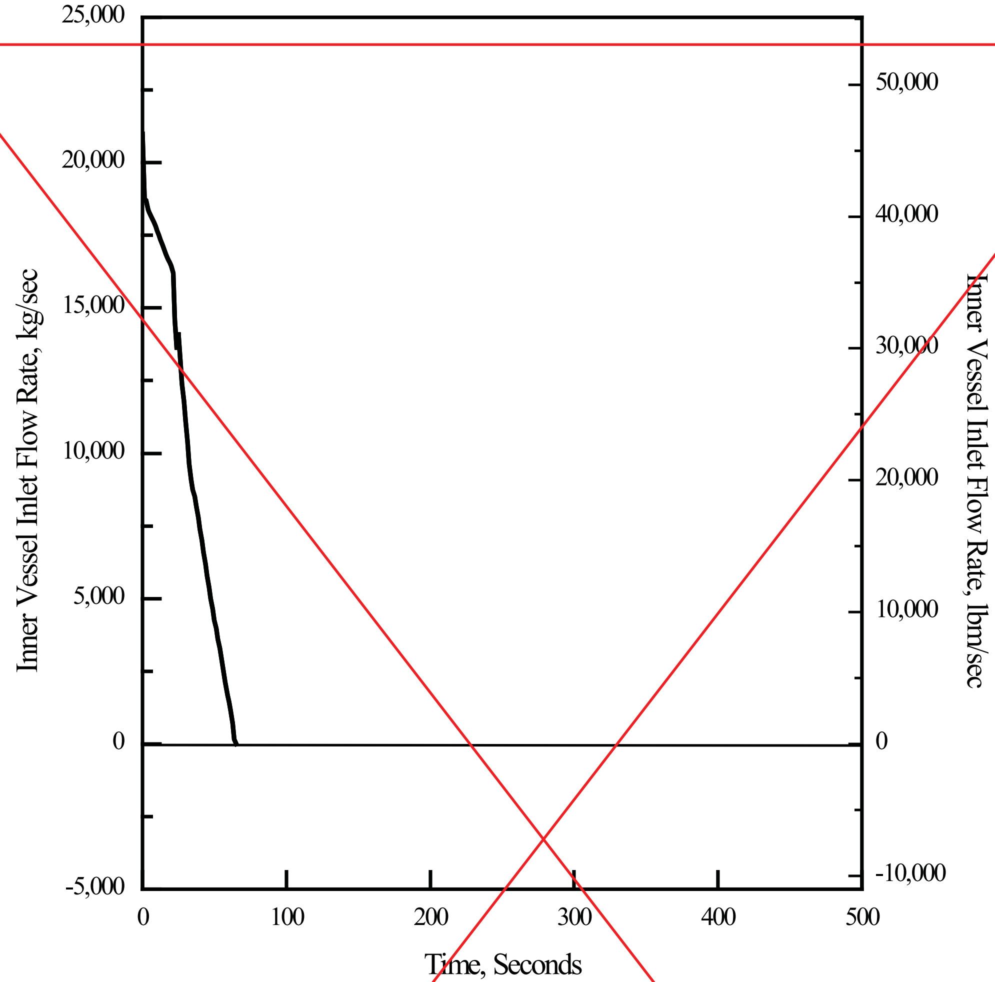


**Figure 15.6.5-28D 372 cm$^2$ (0.4 ft$^2$) Break in DVI Line: Inner Vessel Inlet Flow Rate**

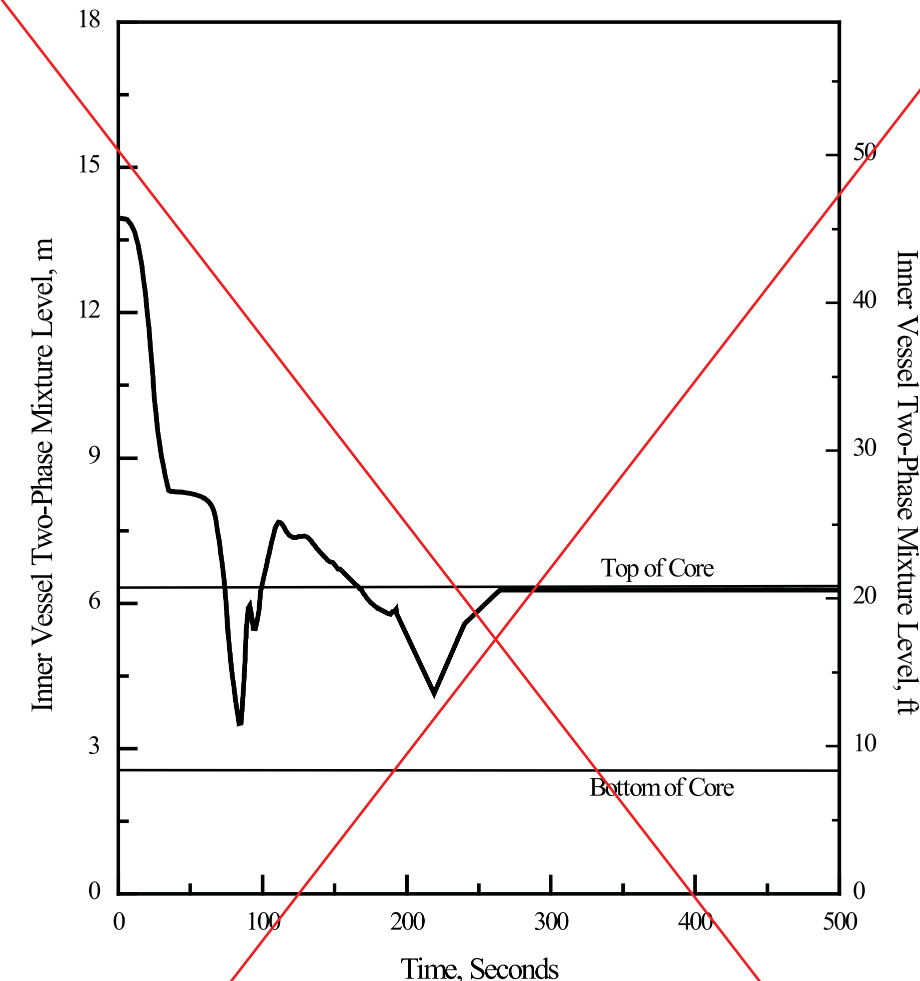


**Figure 15.6.5-28E 372 cm$^2$ (0.4 ft$^2$) Break in DVI Line: Inner Vessel Two-Phase Mixture Level**

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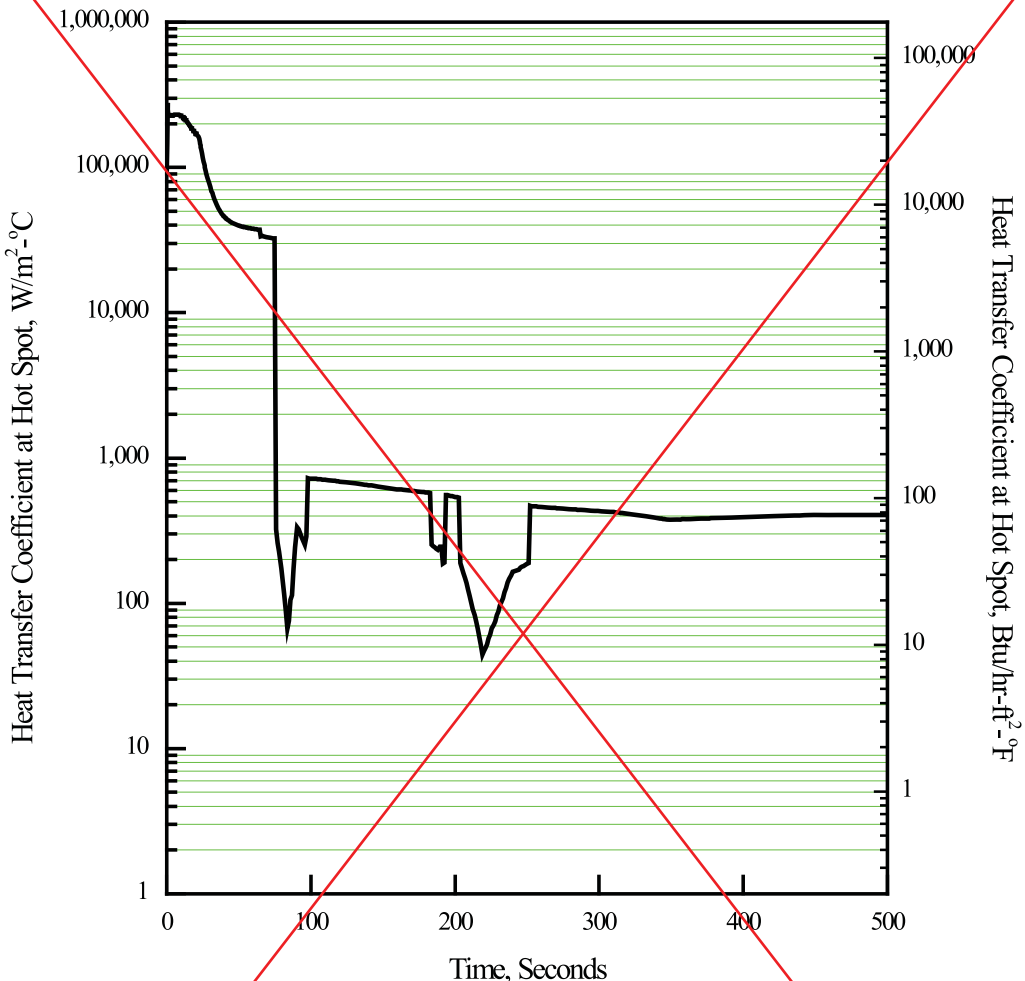


**Figure 15.6.5-28F 372 cm$^2$ (0.4 ft$^2$) Break in DVI Line: Heat Transfer Coefficient at Hot Spot**

RAI 318-8337 - Question 15.06.05-2_Rev.1

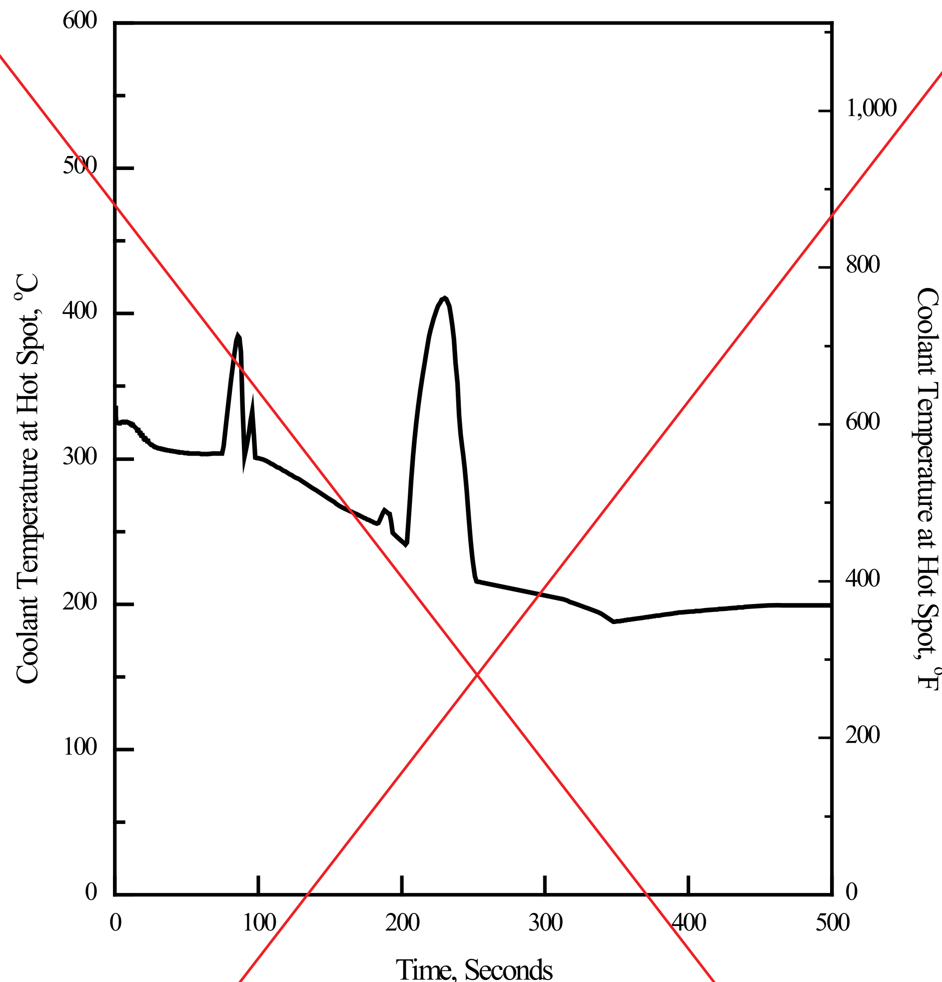


**Figure 15.6.5-28G 372 $cm^2$ (0.4 $ft^2$) Break in DVI Line: Coolant Temperature at Hot Spot**

RAI 318-8337 - Question 15.06.05-2_Rev.1

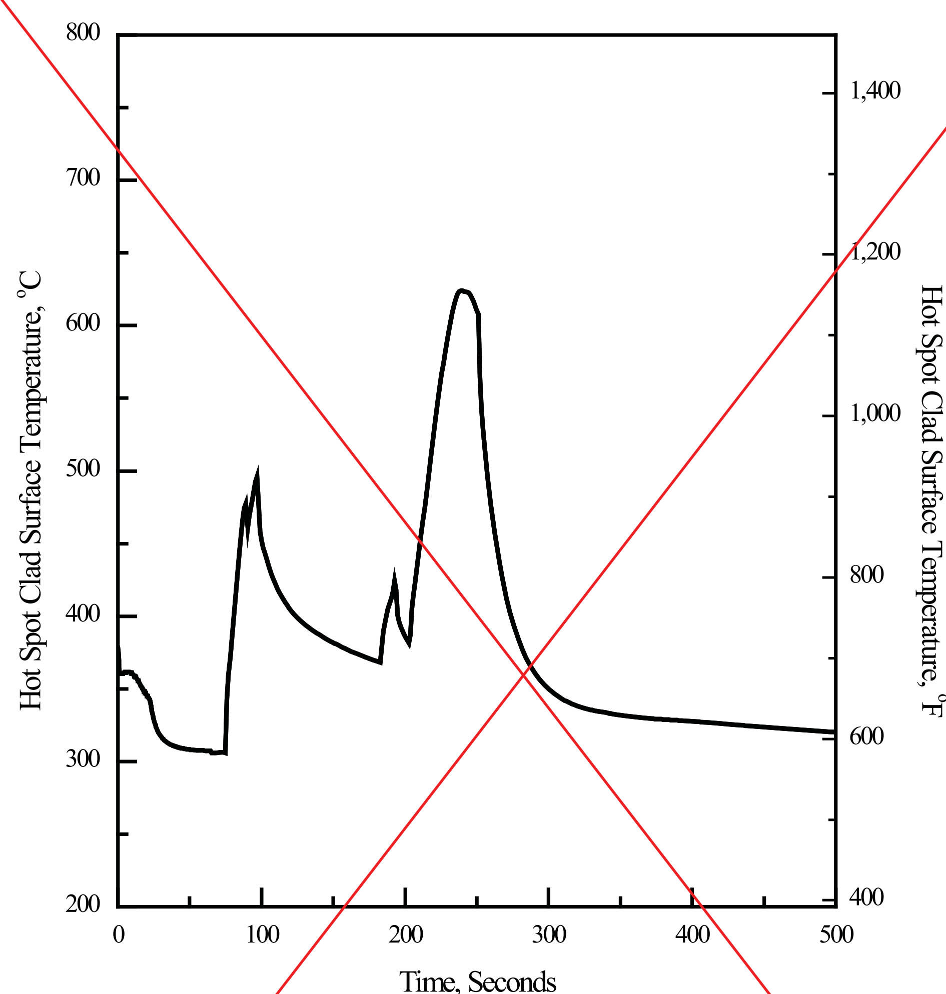


Figure 15.6.5-28H 372 $cm^2$ (0.4 $ft^2$) Break in DVI Line: Hot Spot Clad Surface Temperature

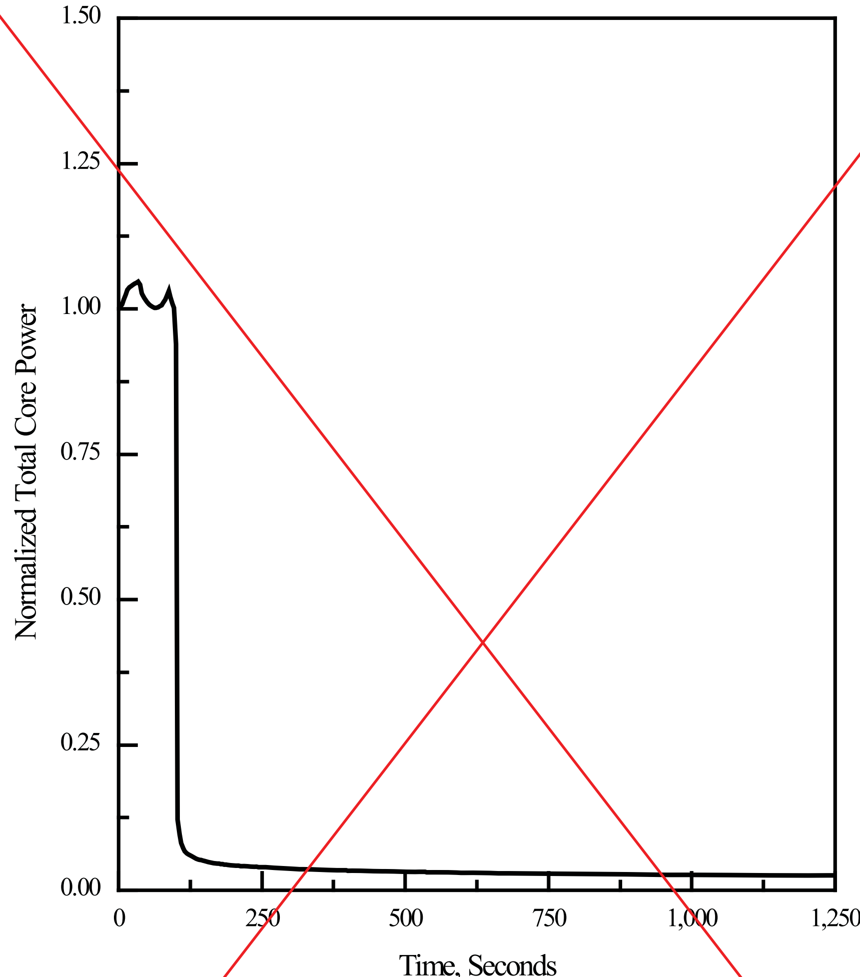


**Figure 15.6.5-29A 93 $cm^2$ (0.1 $ft^2$) Break in DVI Line: Normalized Total Core Power**

RAI 318-8337 - Question 15.06.05-2_Rev.1

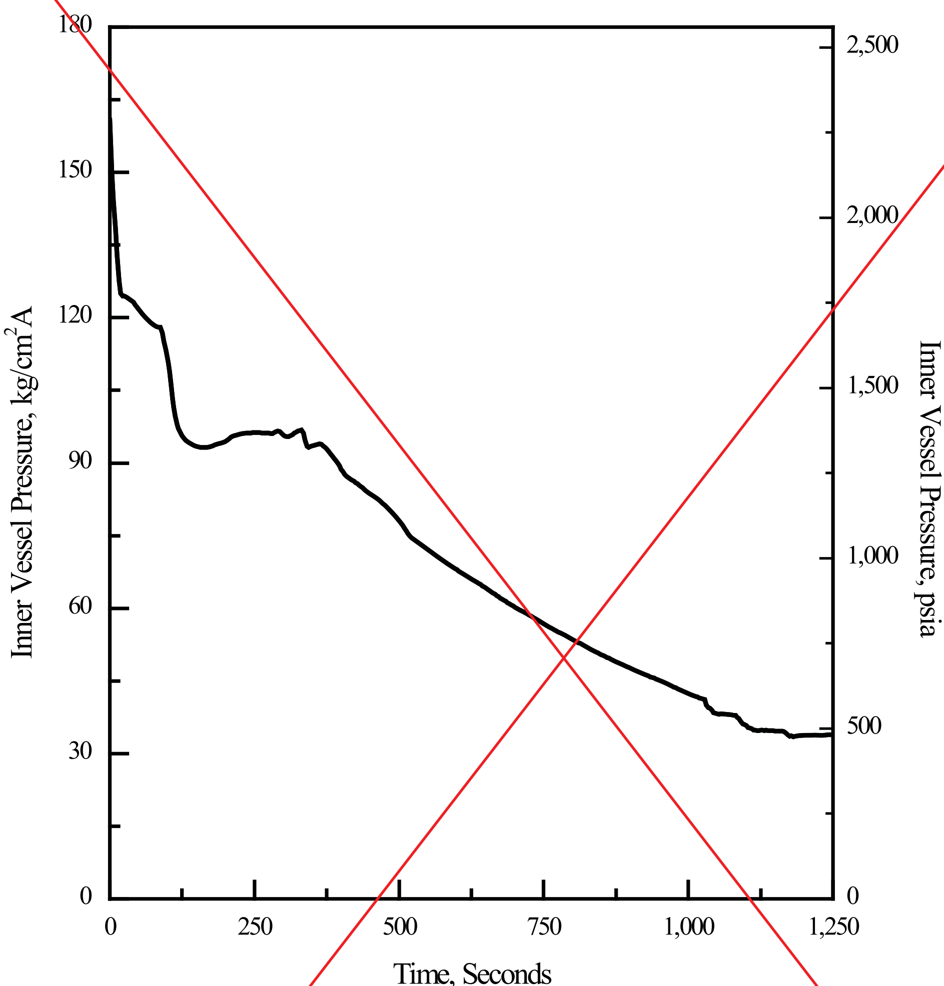


**Figure 15.6.5-29B 93 cm$^2$ (0.1 ft$^2$) Break in DVI Line: Inner Vessel Pressure**

RAI 318-8337 - Question 15.06.05-2_Rev.1

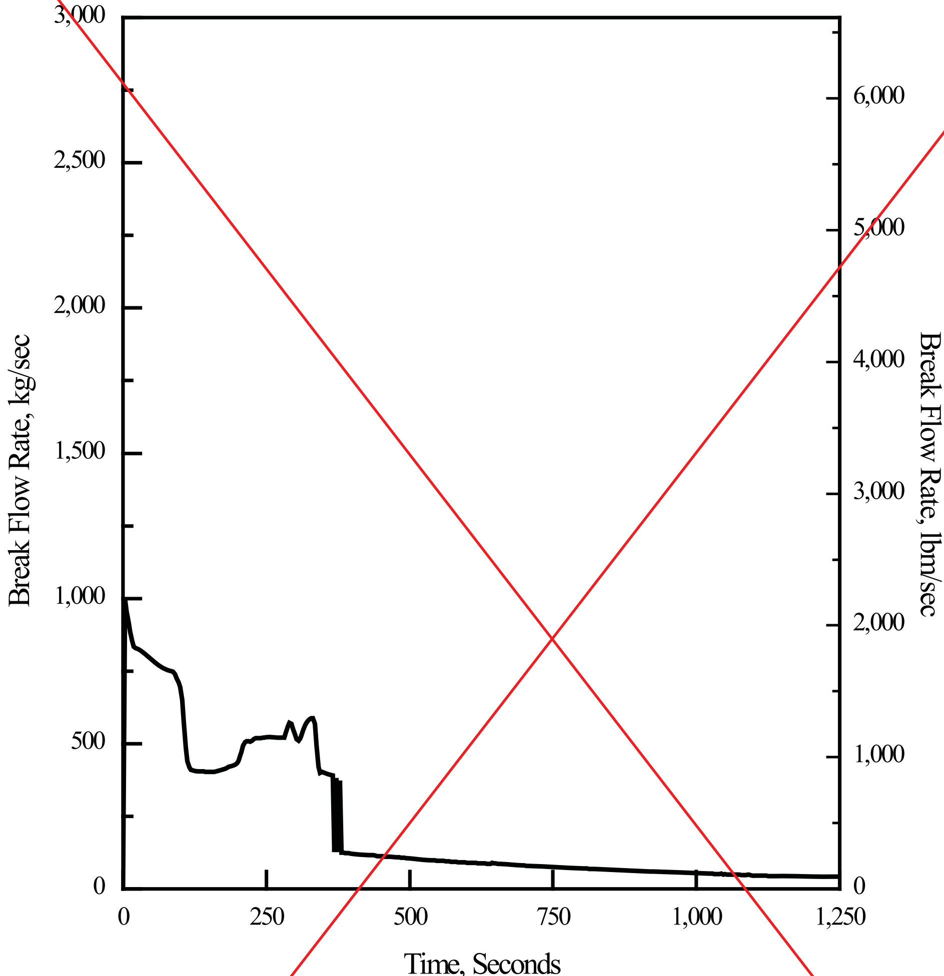


**Figure 15.6.5-29C 93 cm² (0.1 ft²) Break in DVI Line: Break Flow Rate**

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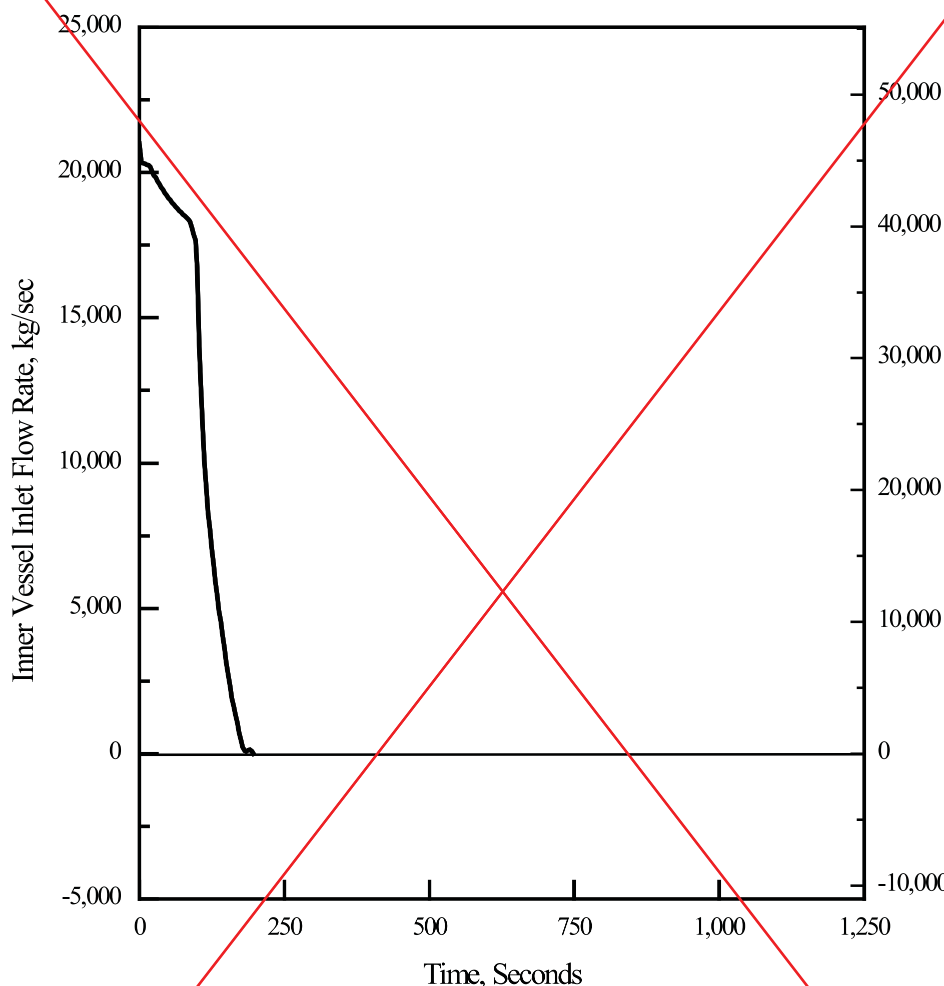


**Figure 15.6.5-29D 93 $cm^2$ (0.1 $ft^2$) Break in DVI Line: Inner Vessel Inlet Flow Rate**

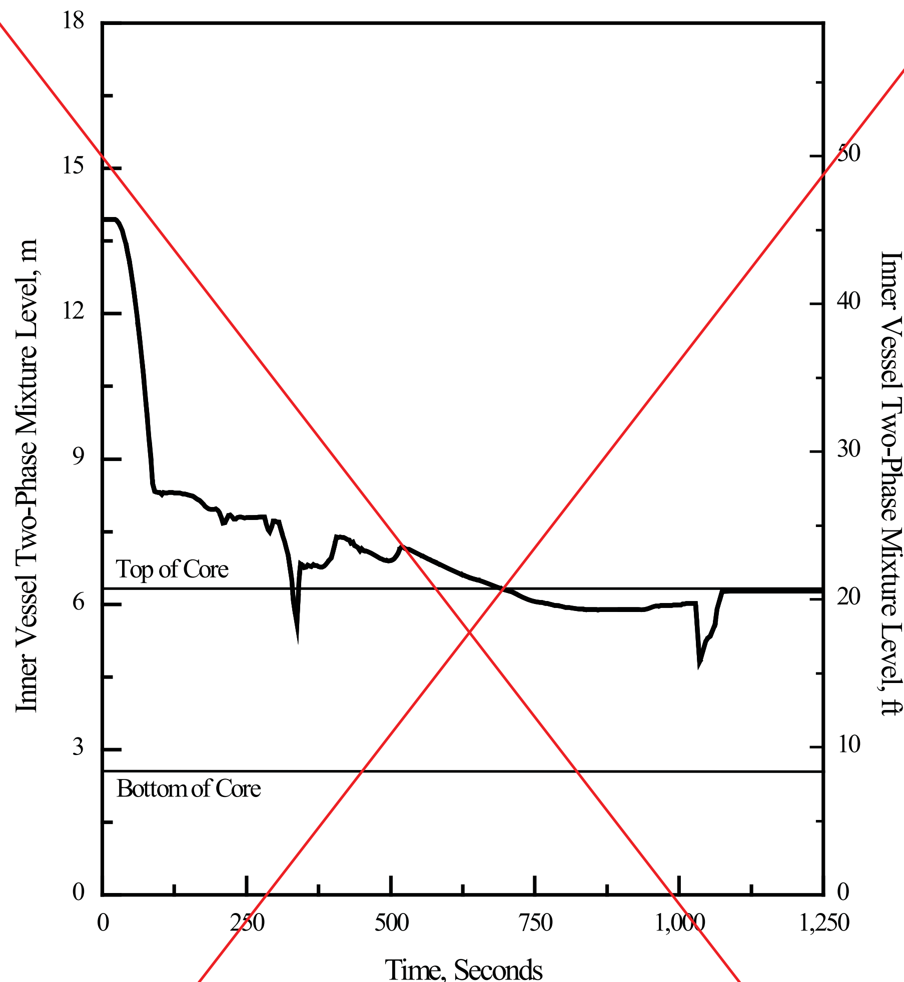


**Figure 15.6.5-29E 93 cm² (0.1 ft²) Break in DVI Line: Inner Vessel Two-Phase Mixture Level**

RAI 318-8337 - Question 15.06.05-2_Rev.1

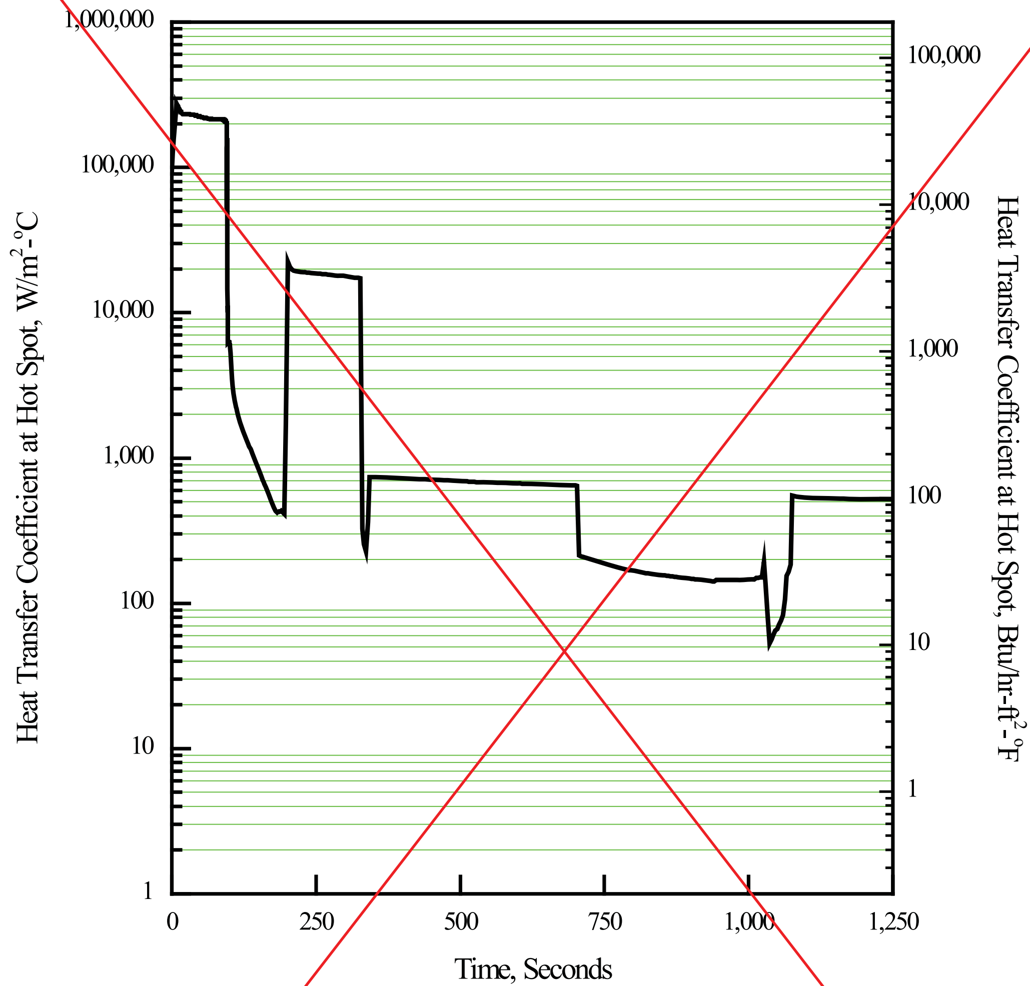


**Figure 15.6.5-29F 93 $cm^2$ (0.1 $ft^2$) Break in DVI Line: Heat Transfer Coefficient at Hot Spot**

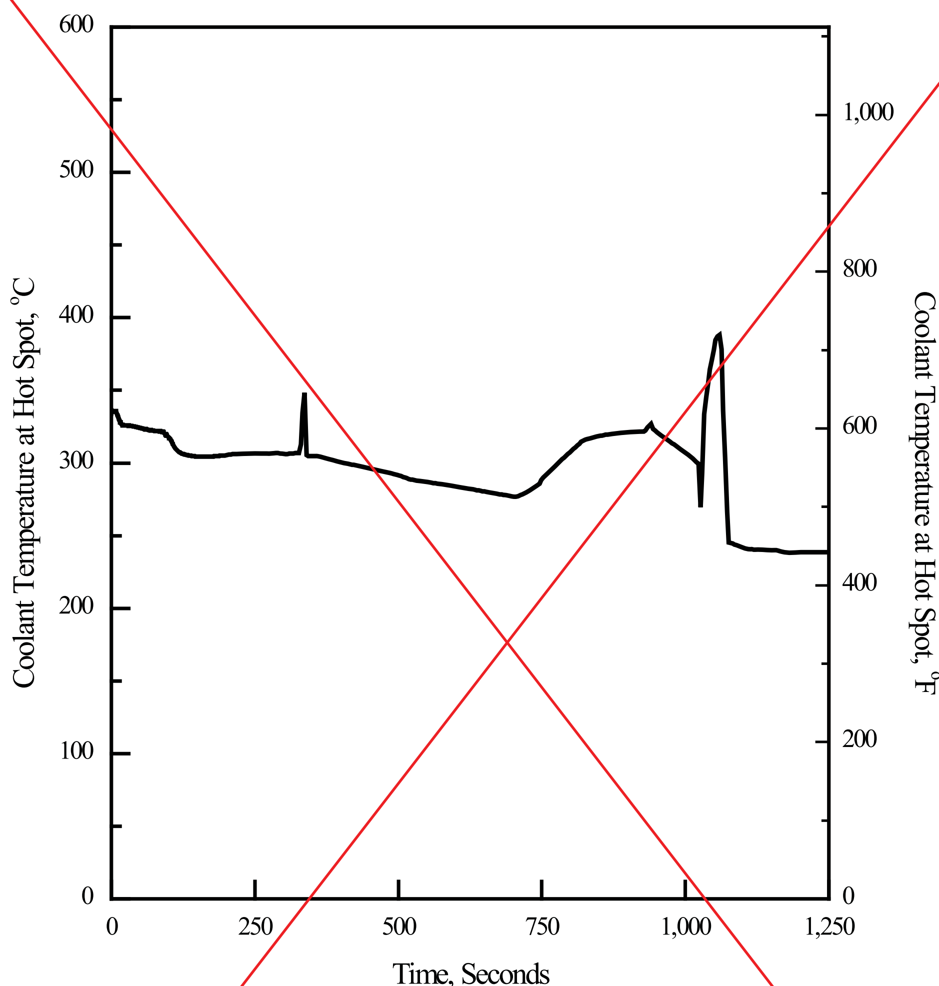


**Figure 15.6.5-29G 93 cm$^2$ (0.1 ft$^2$) Break in DVI Line: Coolant Temperature at Hot Spot**

RAI 318-8337 - Question 15.06.05-2_Rev.1

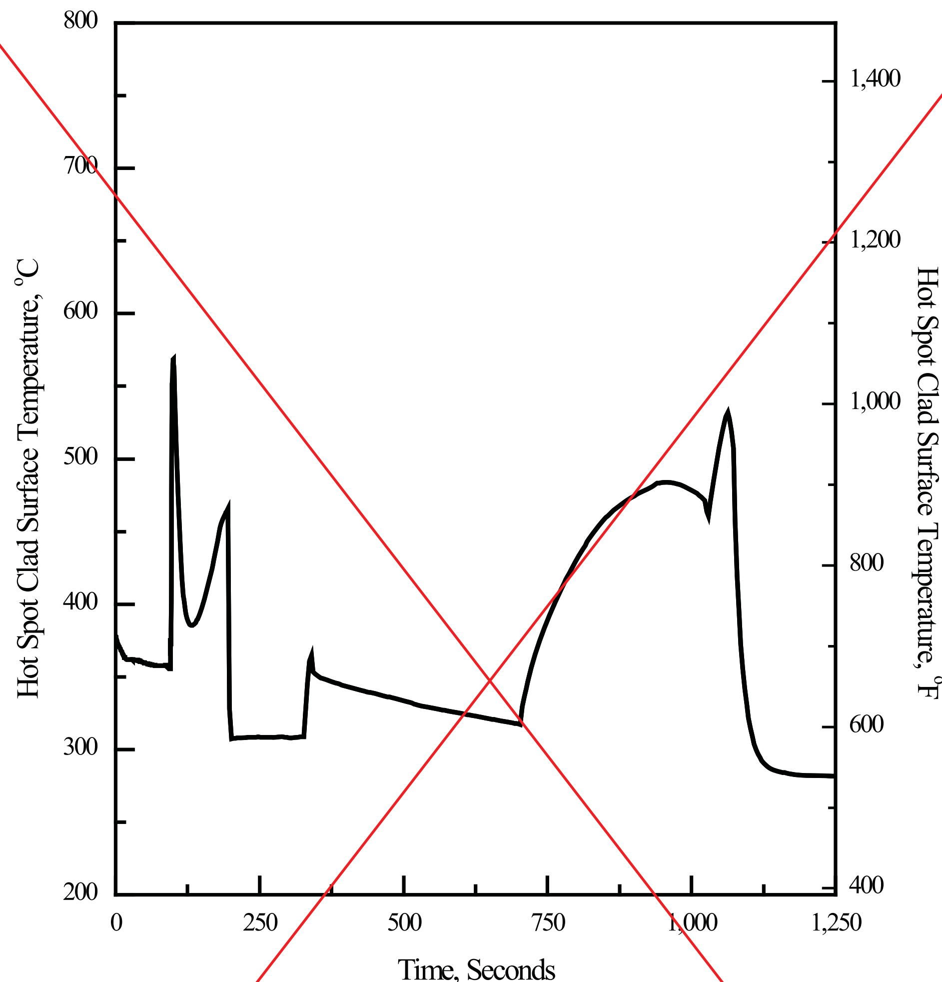


**Figure 15.6.5-29H 93 cm$^2$ (0.1 ft$^2$) Break in DVI Line: Hot Spot Clad Surface Temperature**

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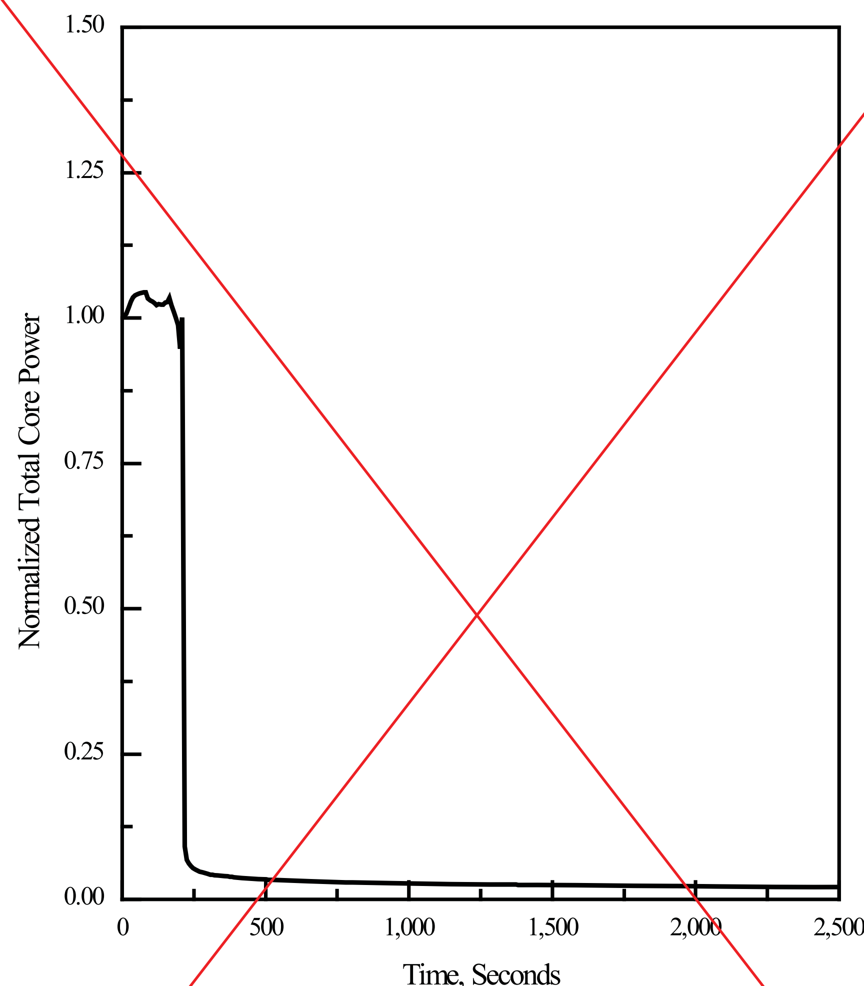


**Figure 15.6.5-30A 46.5 cm² (0.05 ft²) Break in DVI Line: Normalized Total Core Power**

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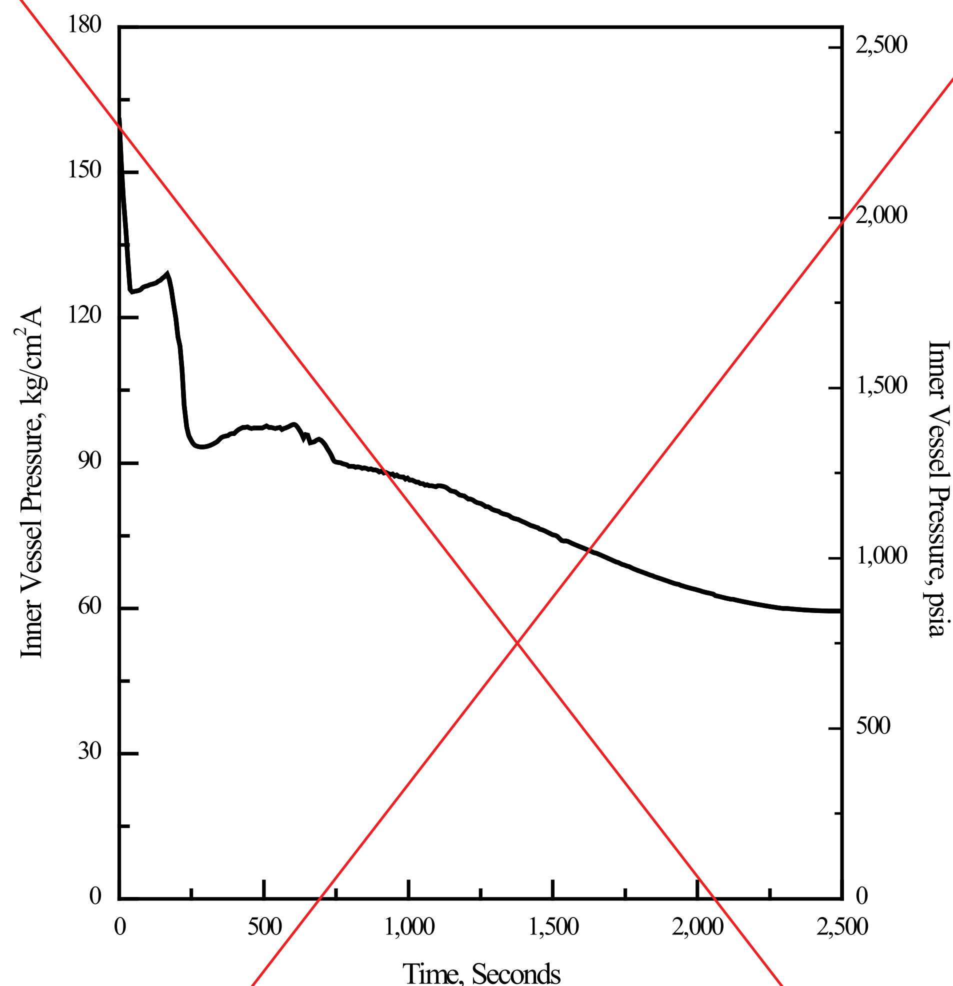


**Figure 15.6.5-30B 46.5 cm$^2$ (0.05 ft$^2$) Break in DVI Line: Inner Vessel Pressure**

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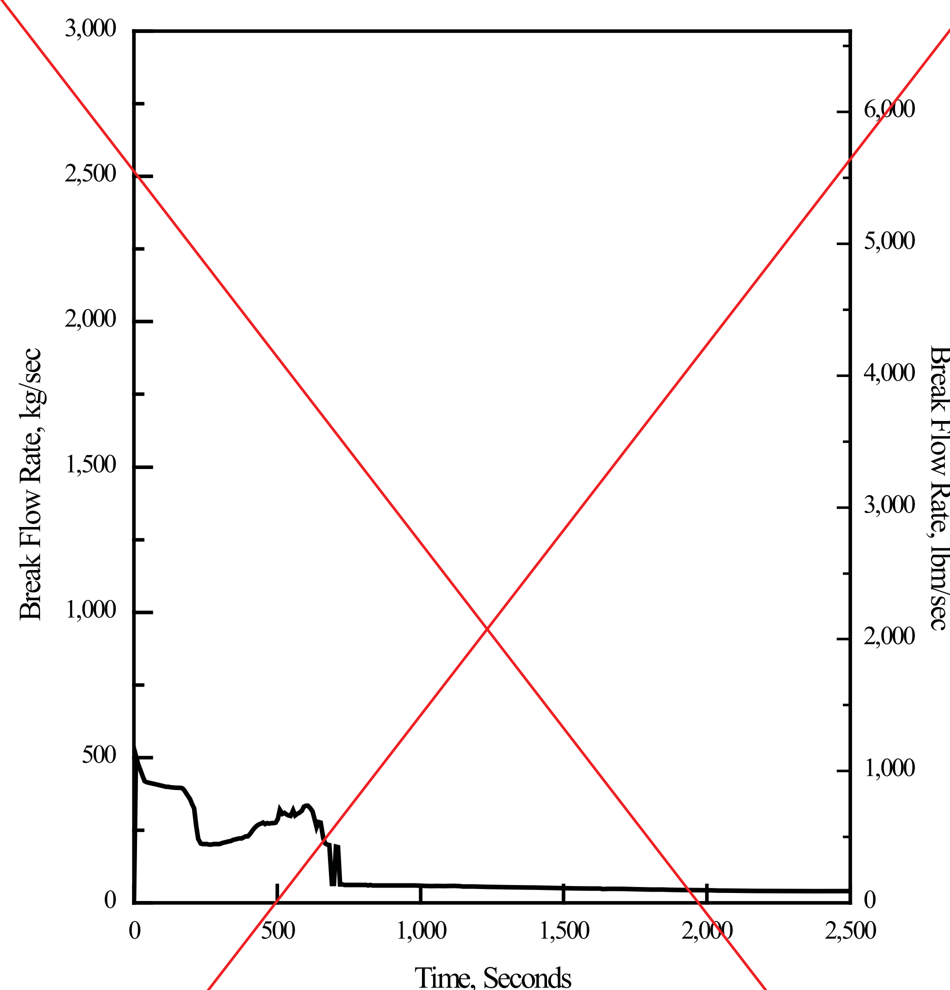


**Figure 15.6.5-30C 46.5 cm$^2$ (0.05 ft$^2$) Break in DVI Line: Break Flow Rate**

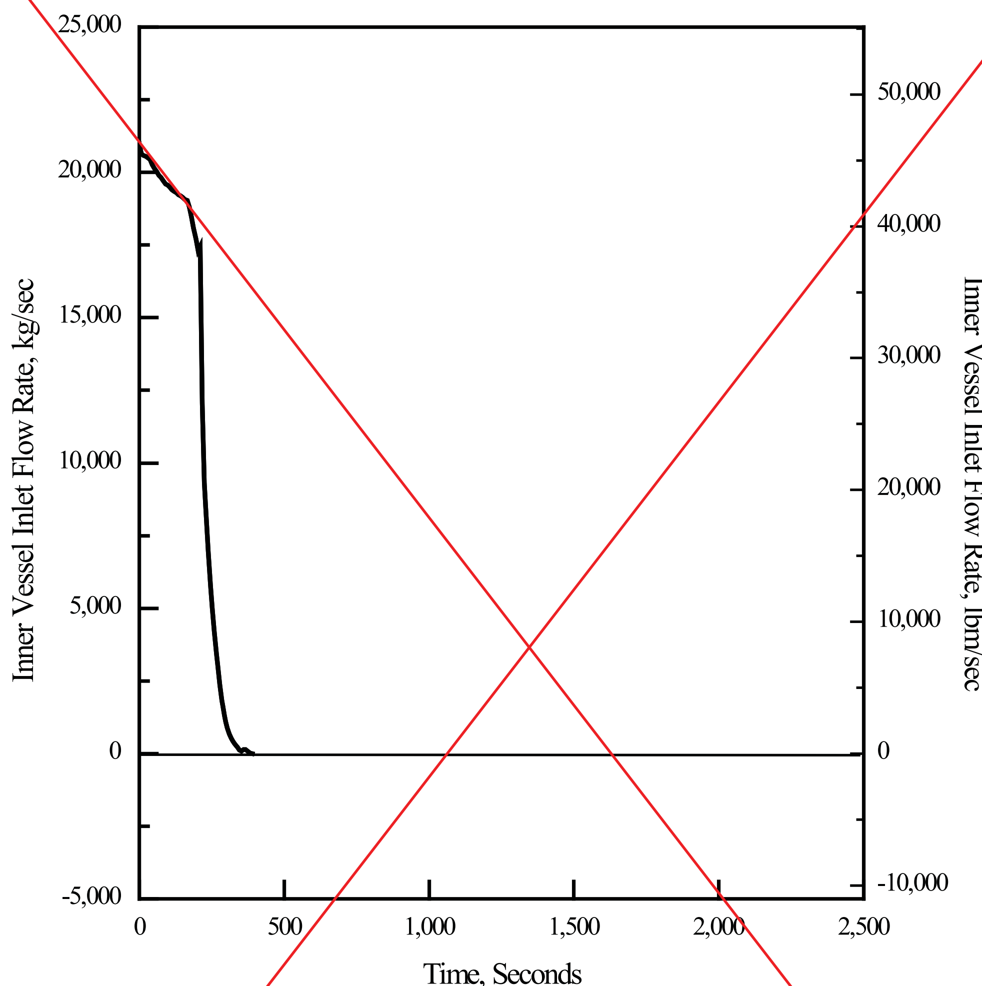


**Figure 15.6.5-30D 46.5 cm$^2$ (0.05 ft$^2$) Break in DVI Line: Inner Vessel Inlet Flow Rate**

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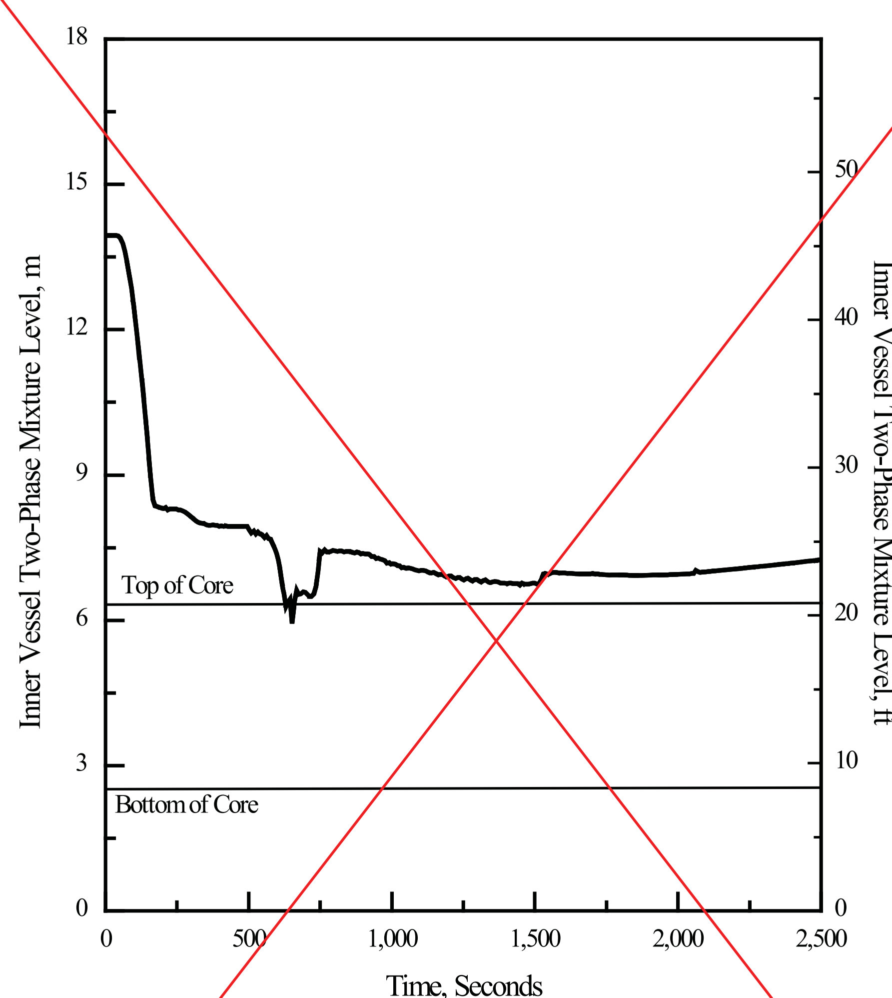


**Figure 15.6.5-30E 46.5 cm$^2$ (0.05 ft$^2$) Break in DVI Line: Inner Vessel Two-Phase Mixture Level**

RAI 318-8337 - Question 15.06.05-2_Rev.1

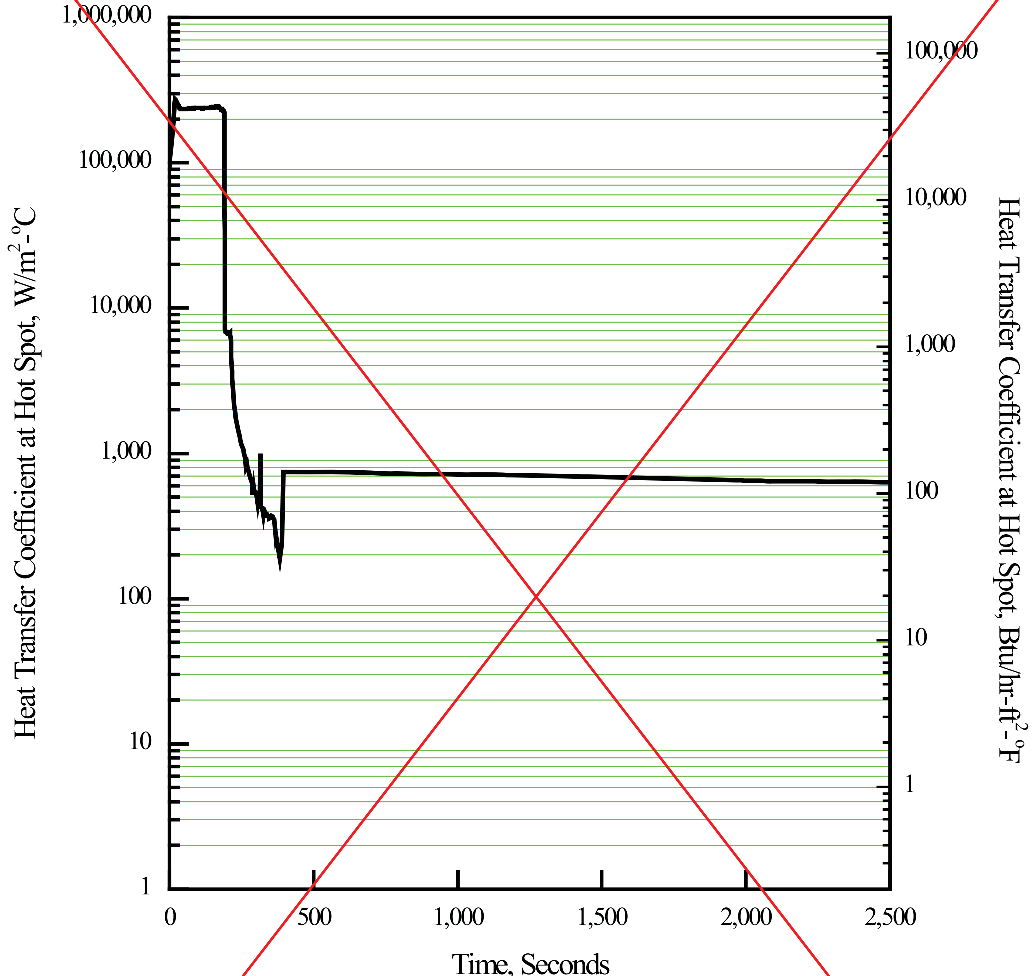


**Figure 15.6.5-30F 46.5 cm$^2$ (0.05 ft$^2$) Break in DVI Line: Heat Transfer Coefficient at Hot Spot**

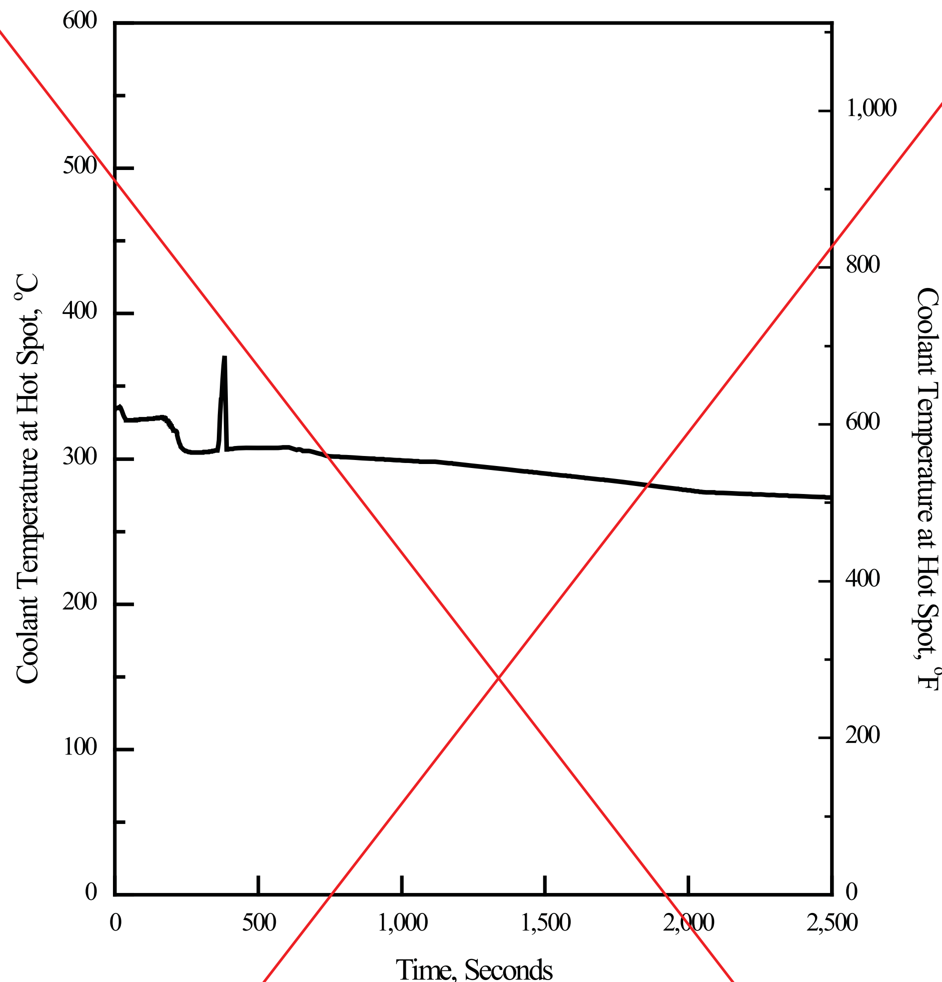


**Figure 15.6.5-30G 46.5 cm$^2$ (0.05 ft$^2$) Break in DVI Line: Coolant Temperature at Hot Spot**

RAI 318-8337 - Question 15.06.05-2_Rev.1

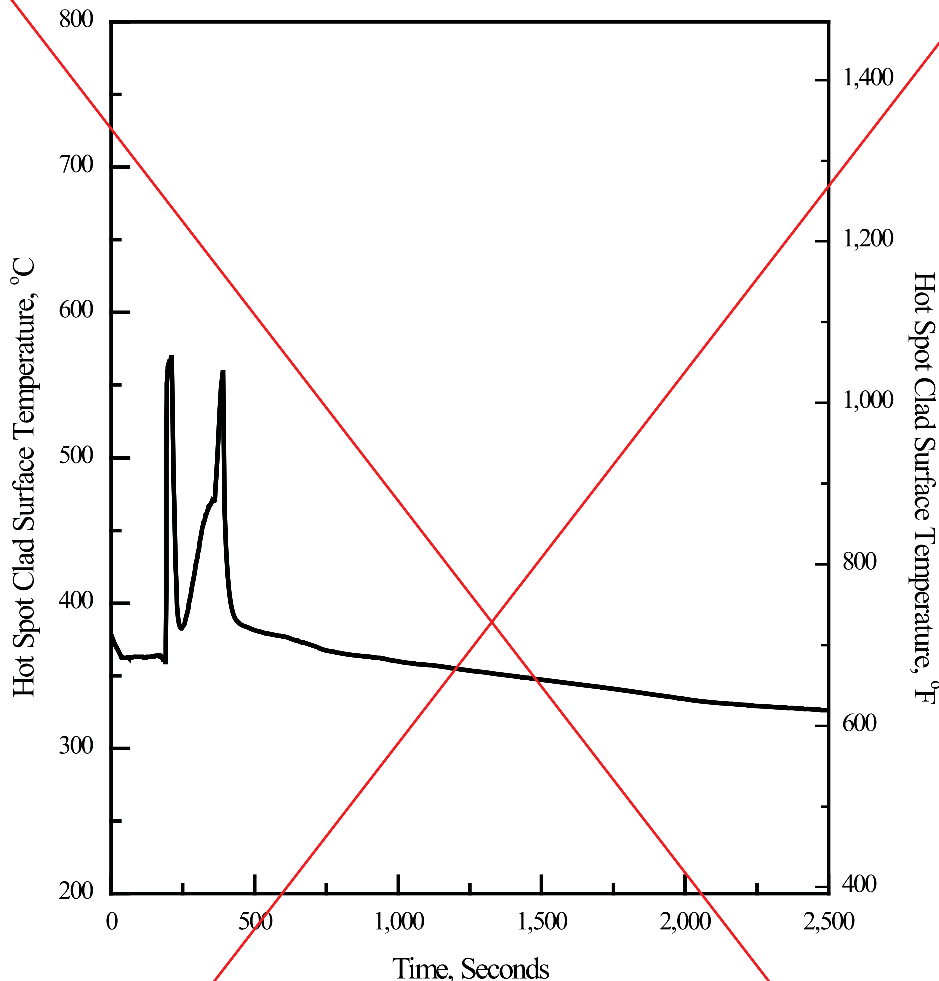


**Figure 15.6.5-30H 46.5 cm² (0.05 ft²) Break in DVI Line: Hot Spot Clad Surface Temperature**

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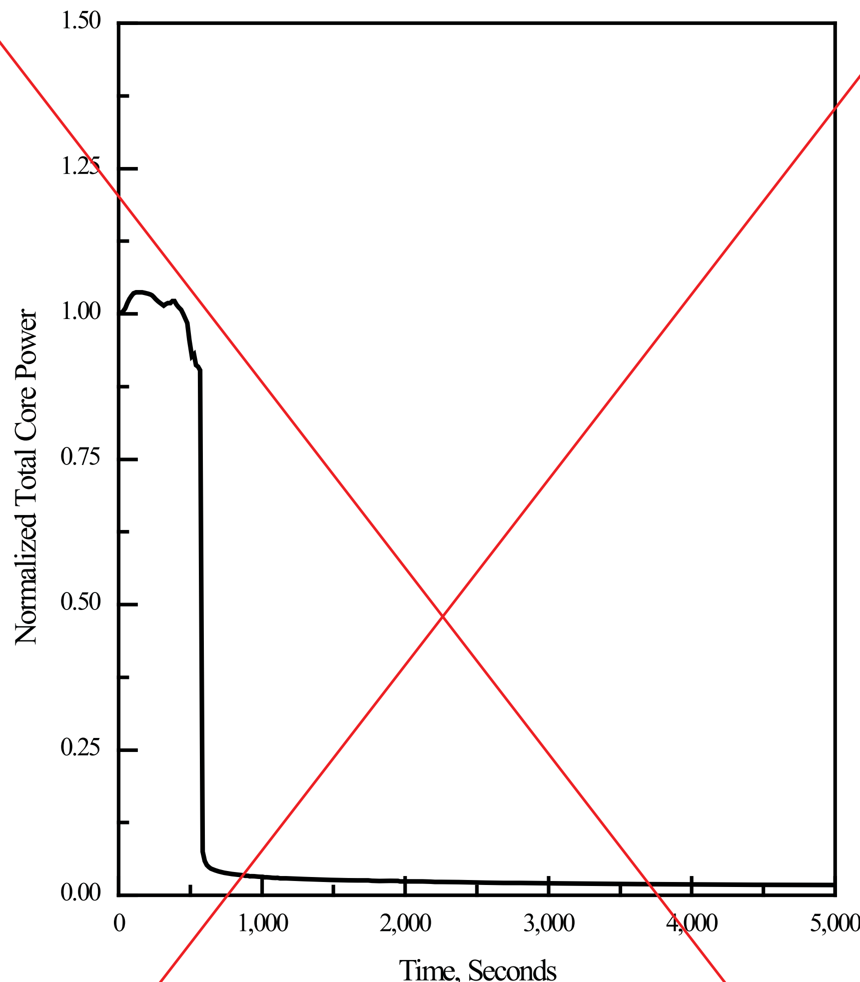


**Figure 15.6.5-31A 18.6 $cm^2$ (0.02 $ft^2$) Break in DVI Line: Normalized Total Core Power**

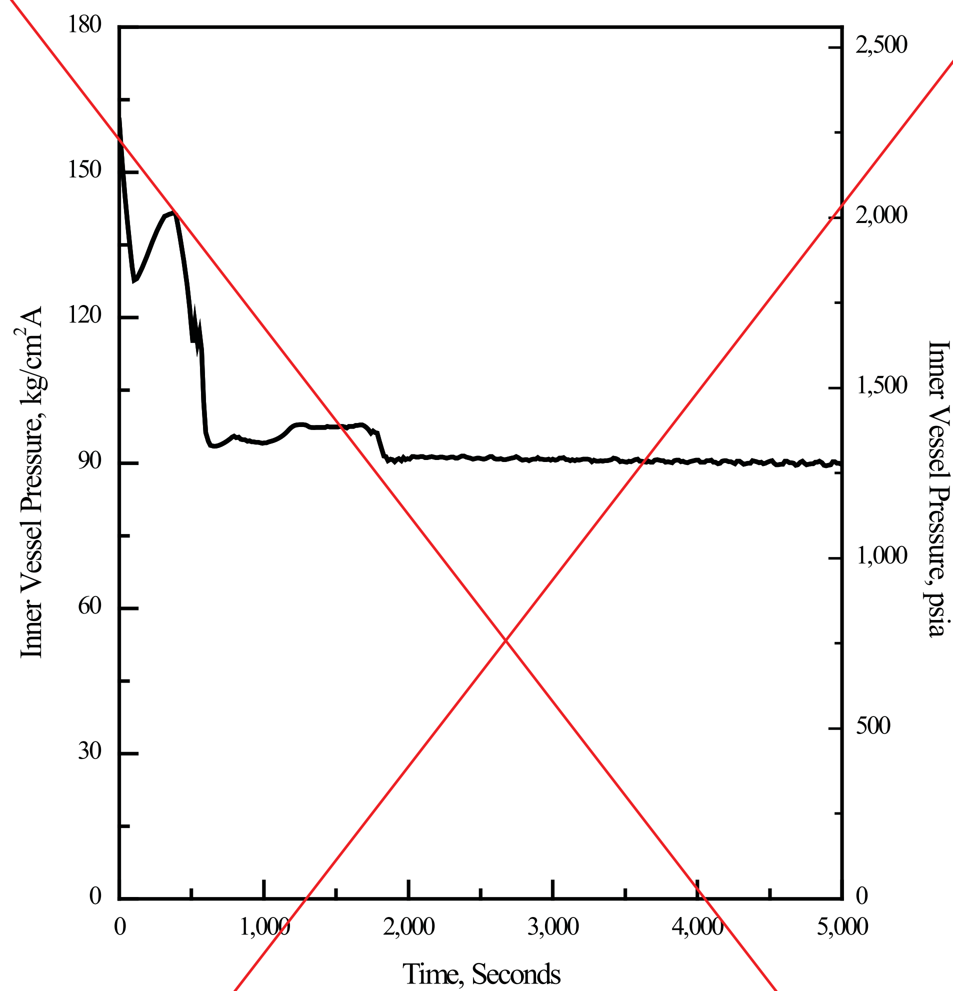


**Figure 15.6.5-31B 18.6 cm$^2$ (0.02 ft$^2$) Break in DVI Line: Inner Vessel Pressure**

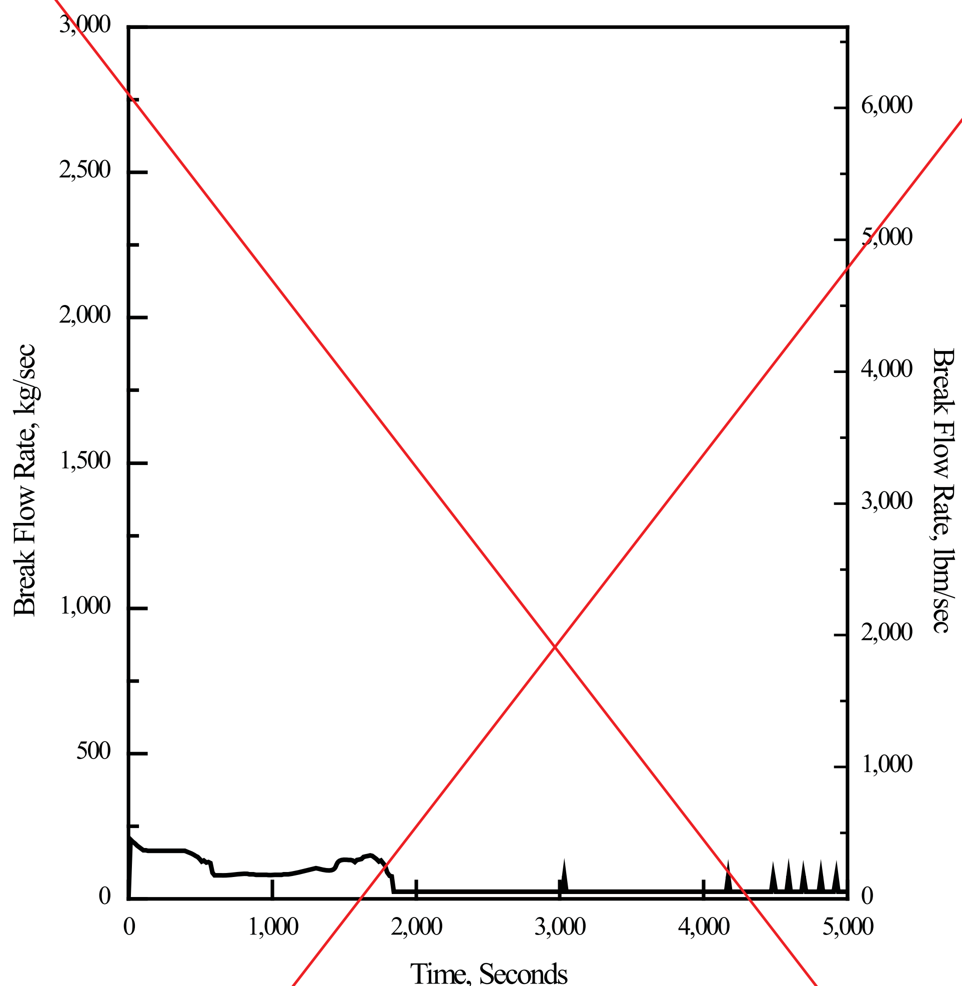


**Figure 15.6.5-31C 18.6 cm$^2$ (0.02 ft$^2$) Break in DVI Line: Break Flow Rate**

RAI 318-8337 - Question 15.06.05-2_Rev.1

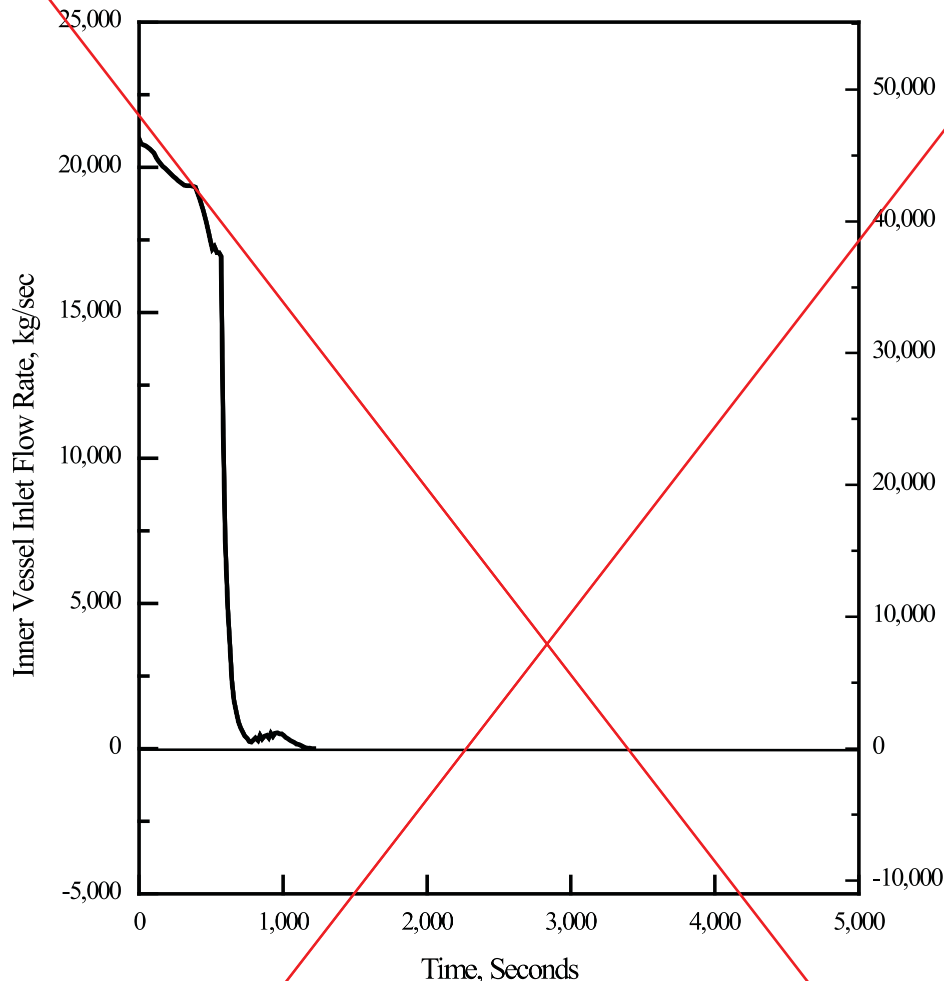


**Figure 15.6.5-31D 18.6 cm$^2$ (0.02 ft$^2$) Break in DVI Line: Inner Vessel Inlet Flow Rate**

RAI 318-8337 - Question 15.06.05-2_Rev.1

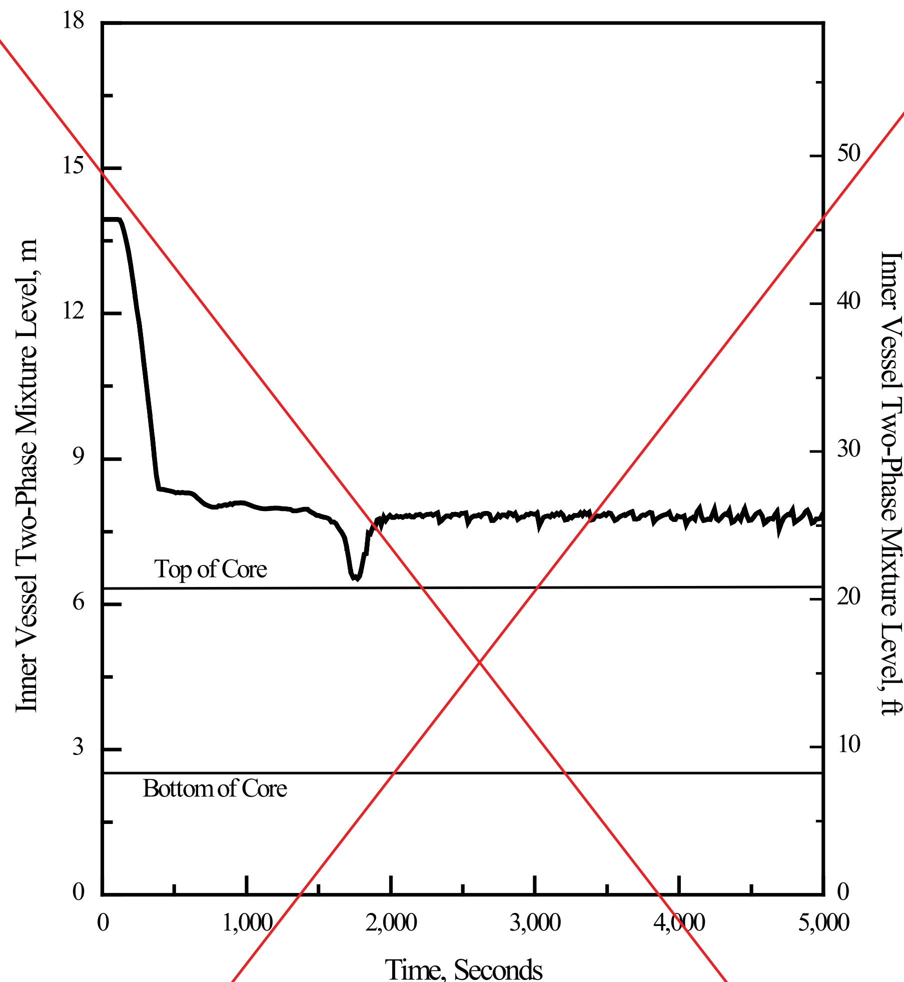


**Figure 15.6.5-31E 18.6 cm$^2$ (0.02 ft$^2$) Break in DVI Line: Inner Vessel Two-Phase Mixture Level**

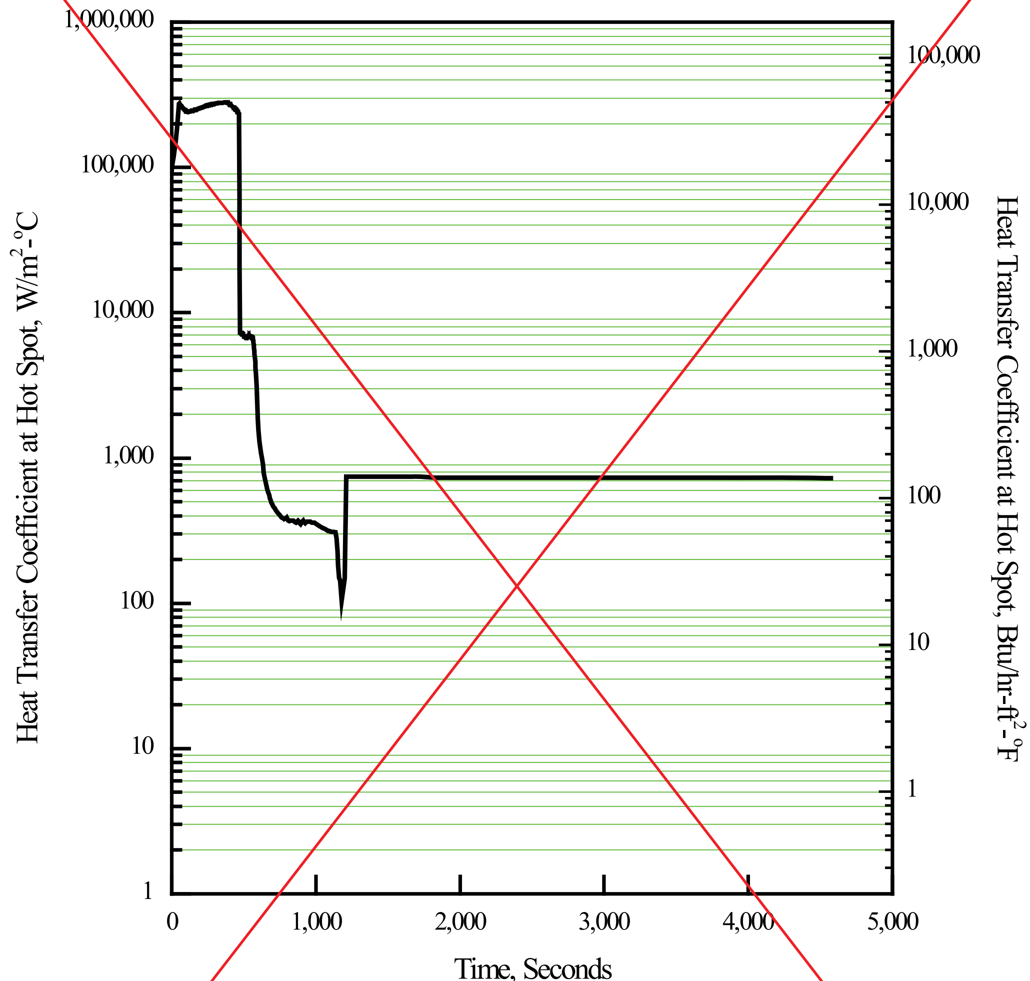


**Figure 15.6.5-31F 18.6 cm$^2$ (0.02 ft$^2$) Break in DVI Line: Heat Transfer Coefficient at Hot Spot**

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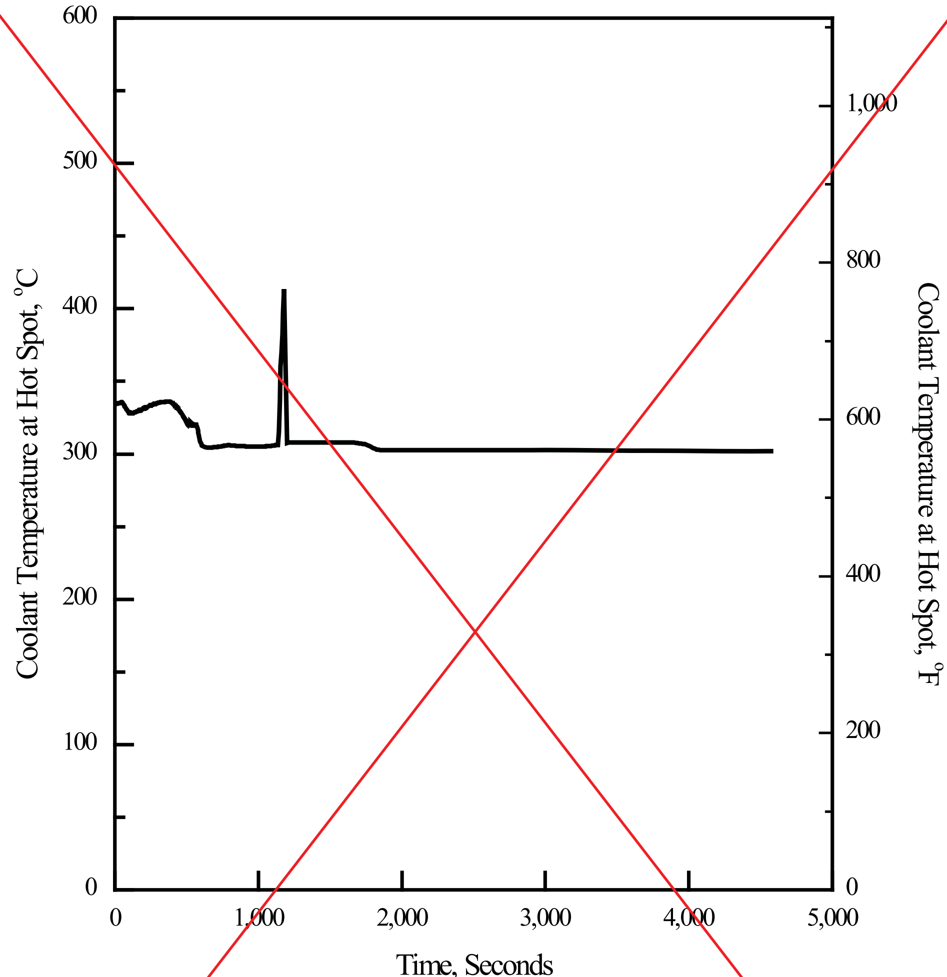


**Figure 15.6.5-31G 18.6 cm$^2$ (0.02 ft$^2$) Break in DVI Line: Coolant Temperature at Hot Spot**

RAI 318-8337 - Question 15.06.05-2_Rev.1

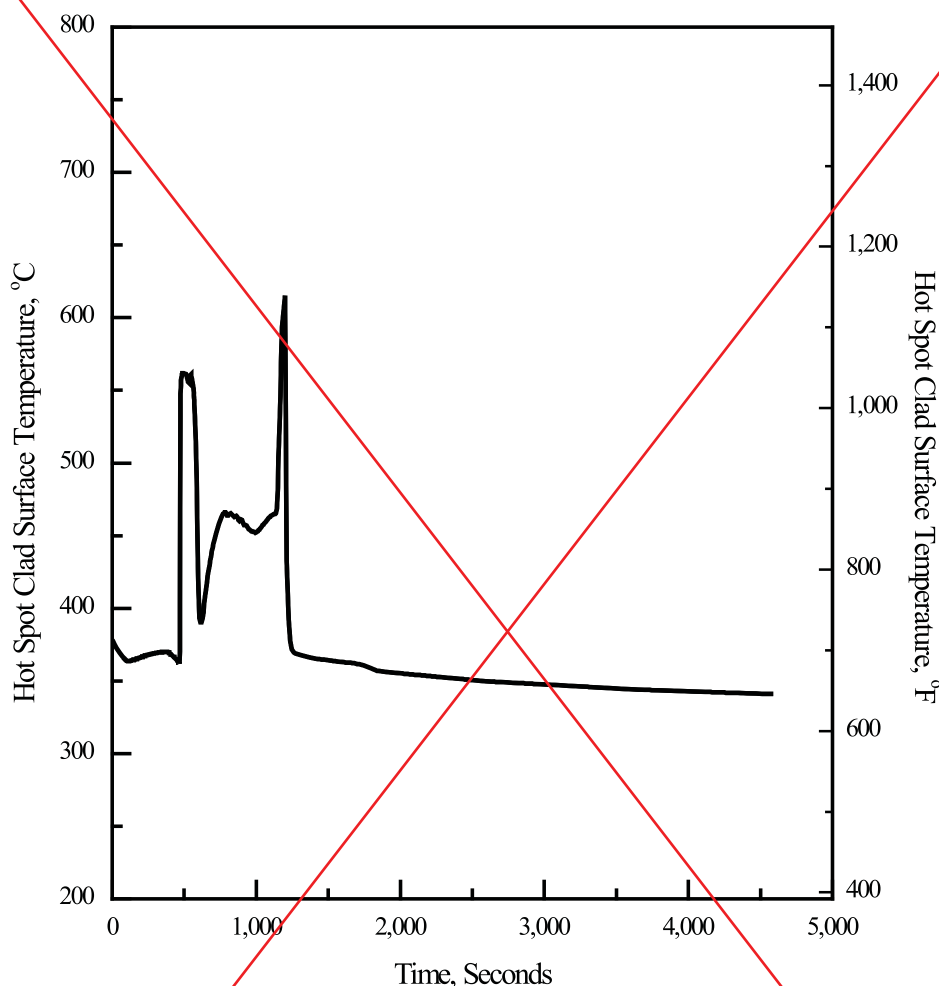


**Figure 15.6.5-31H 18.6 cm$^2$ (0.02 ft$^2$) Break in DVI Line: Hot Spot Clad Surface Temperature**

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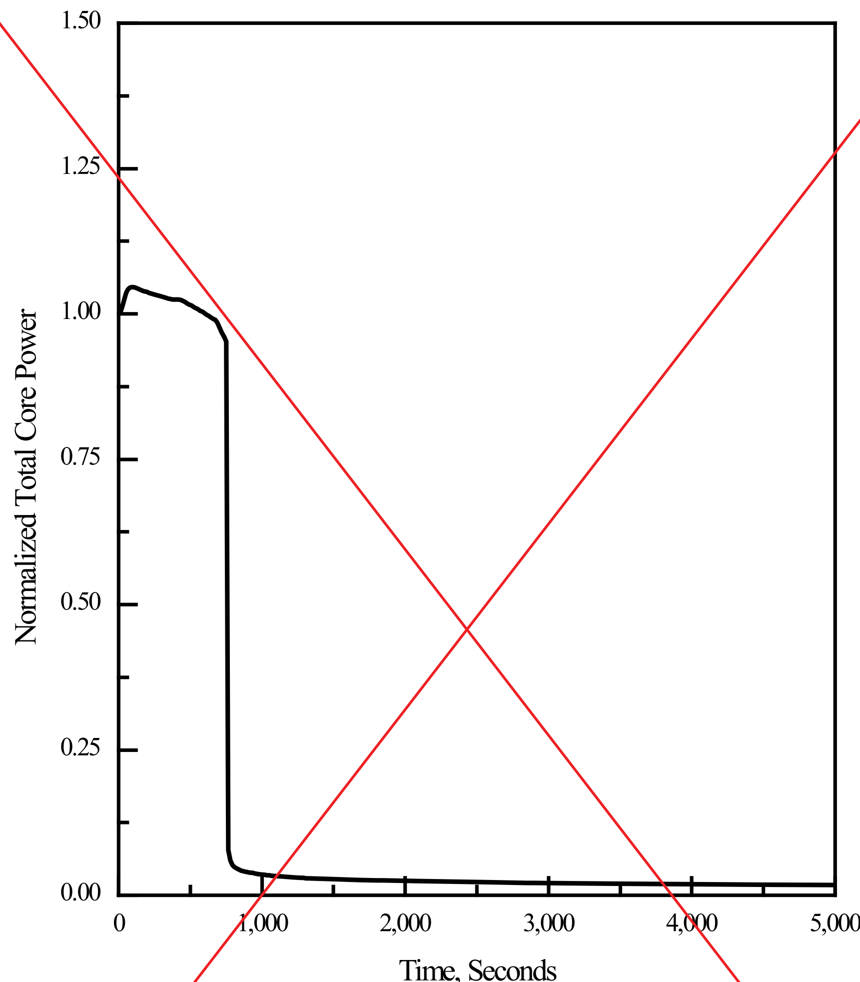


**Figure 15.6.5-32A 27.9cm$^2$ (0.03 ft$^2$) Break in Top of Pressurizer: Normalized Total Core Power**

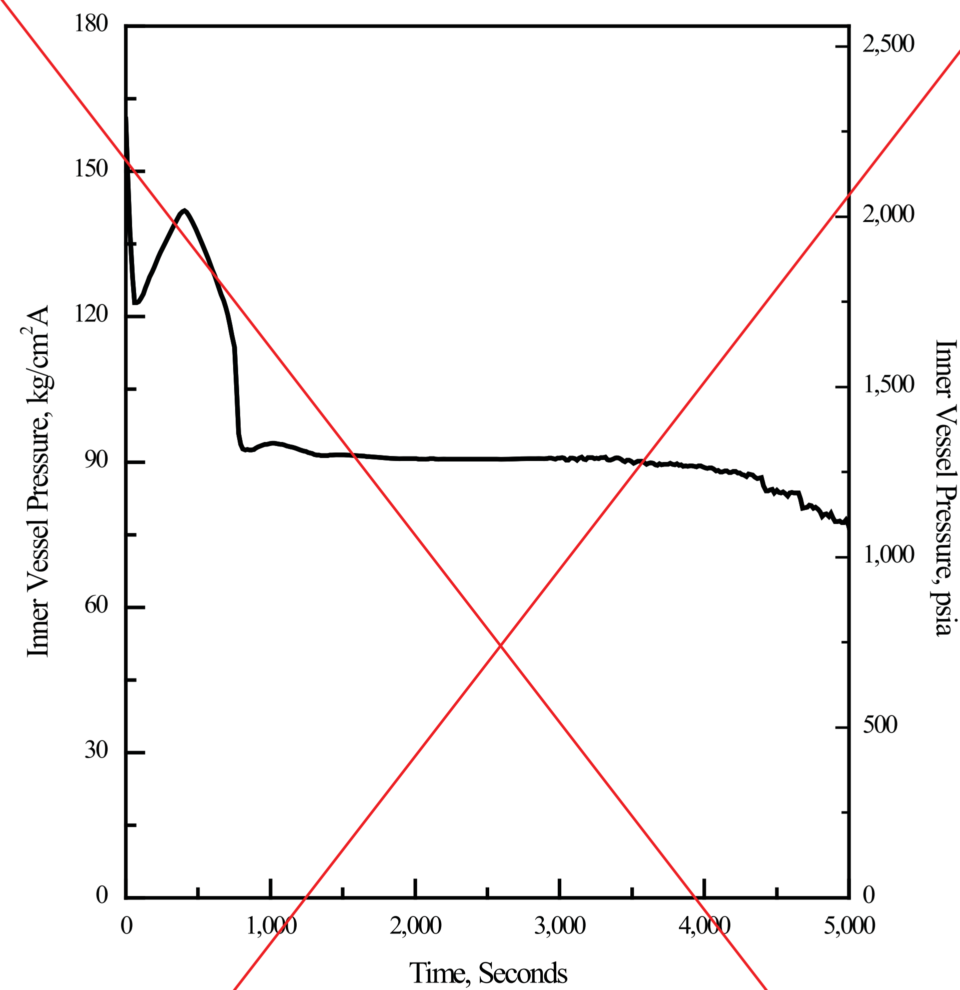


Figure 15.6.5-32B 27.9 $cm^2$ (0.03 $ft^2$) Break in Top of Pressurizer: Inner Vessel Pressure

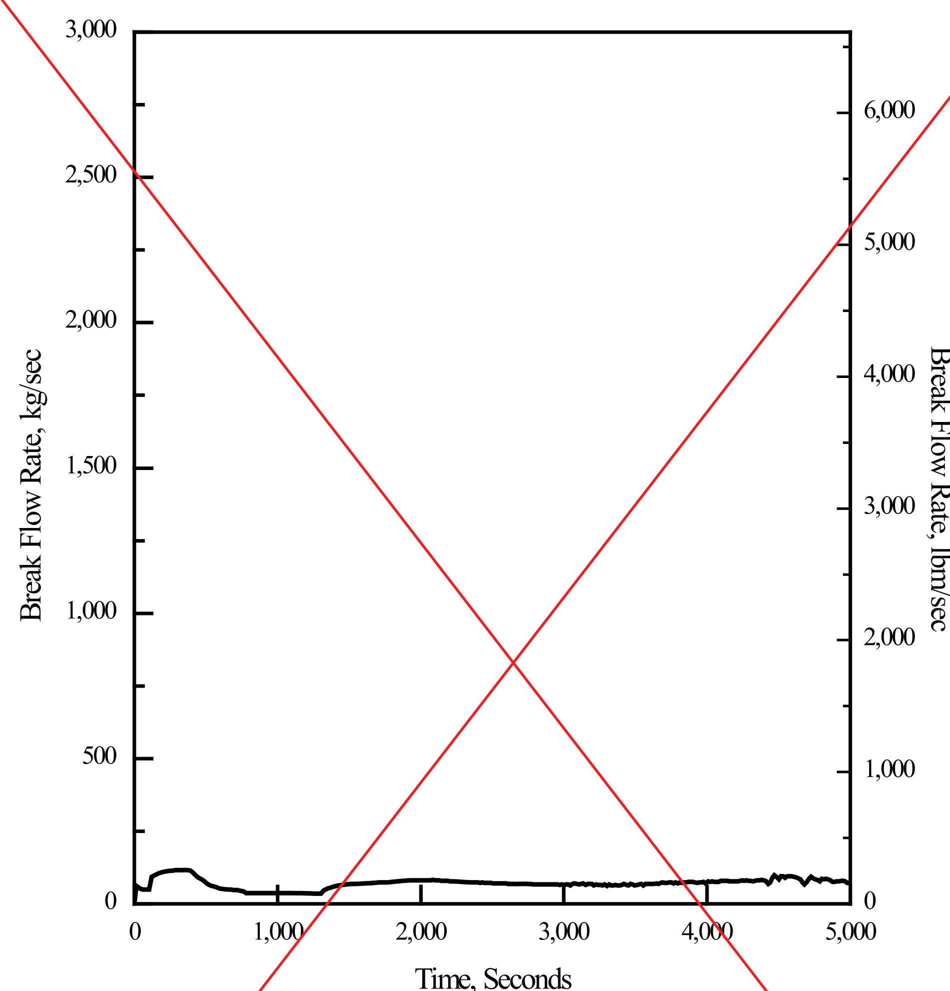


**Figure 15.6.5-32C 27.9 cm$^2$ (0.03 ft$^2$) Break in Top of Pressurizer: Break Flow Rate**

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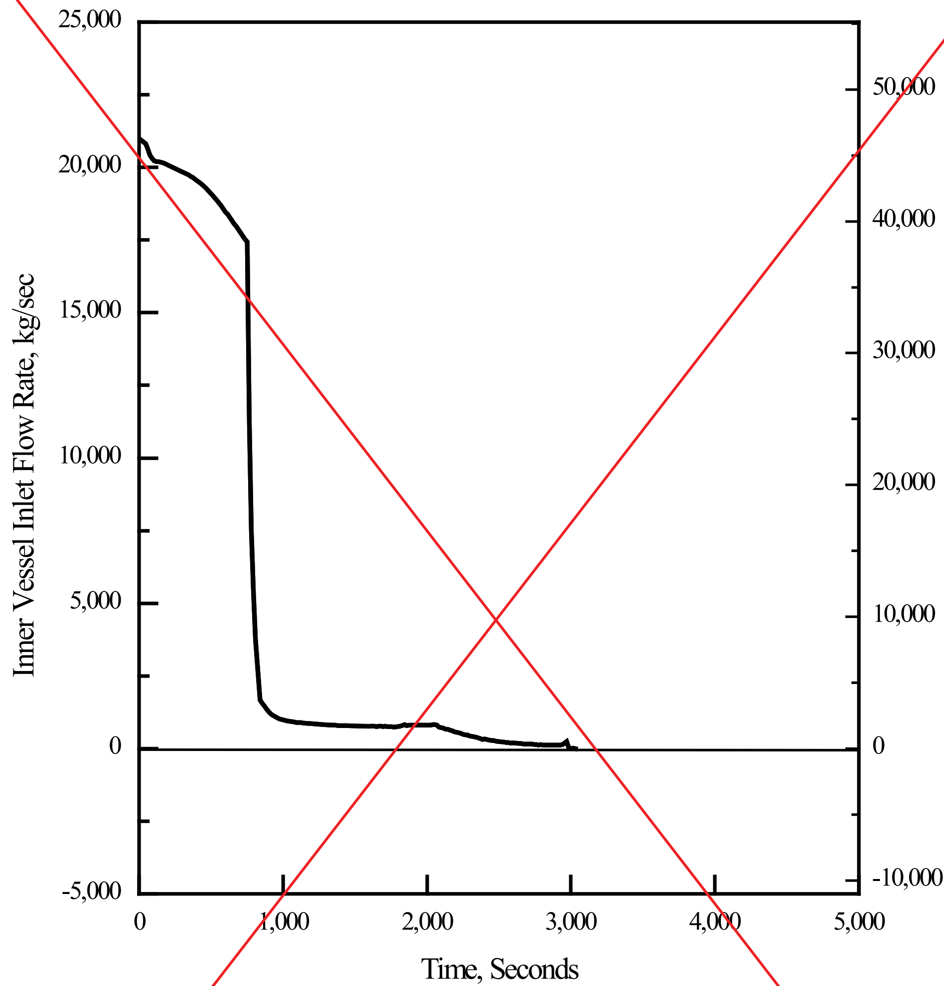


**Figure 15.6.5-32D 27.9 cm$^2$ (0.03 ft$^2$) Break in Top of Pressurizer: Inner Vessel Inlet Flow Rate**

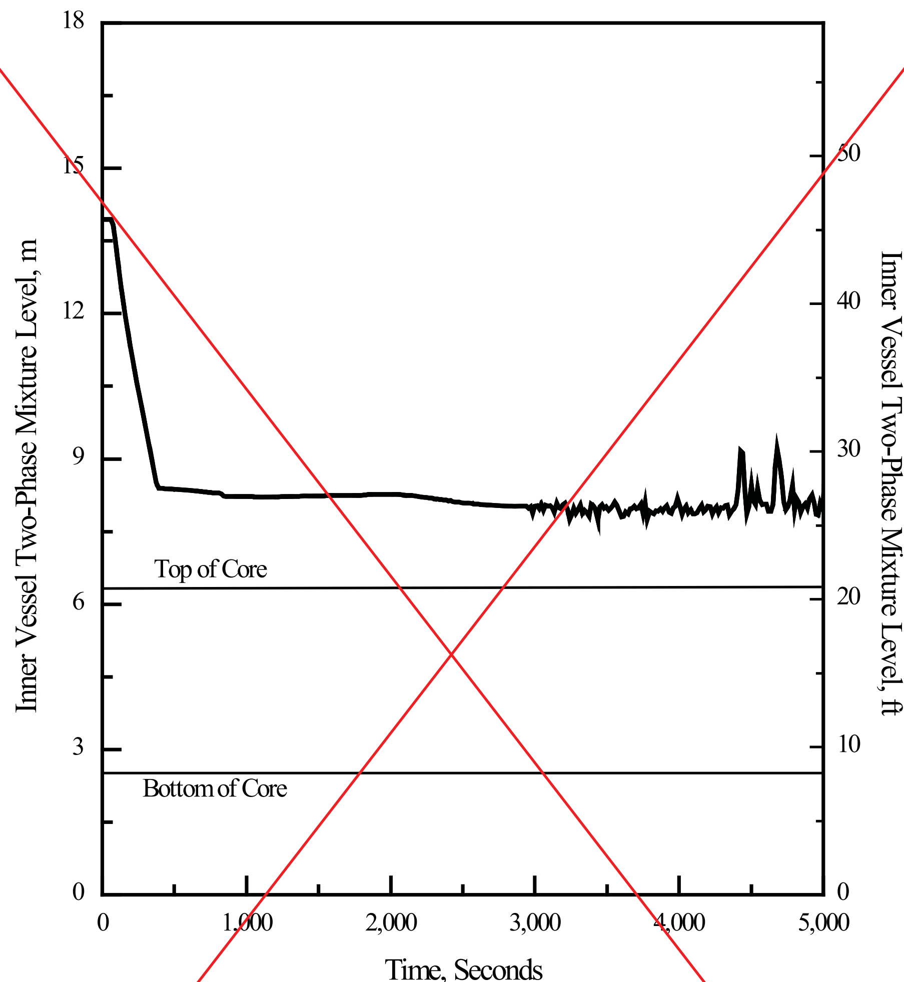


**Figure 15.6.5-32E 27.9 $cm^2$ (0.03 $ft^2$) Break in Top of Pressurizer: Inner Vessel Two-Phase Mixture Level**

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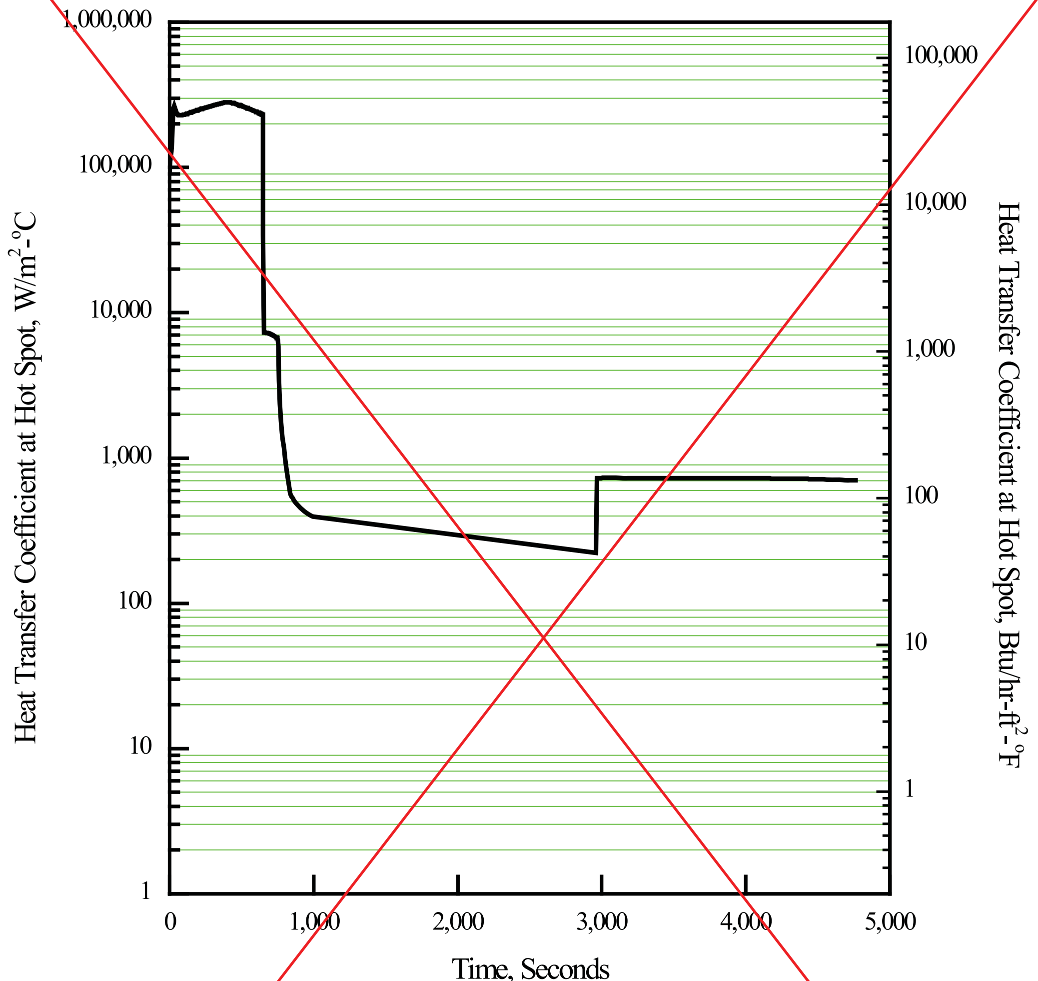


**Figure 15.6.5-32F 27.9 $cm^2$ (0.03 $ft^2$) Break in Top of Pressurizer: Heat Transfer Coefficient at Hot Spot**

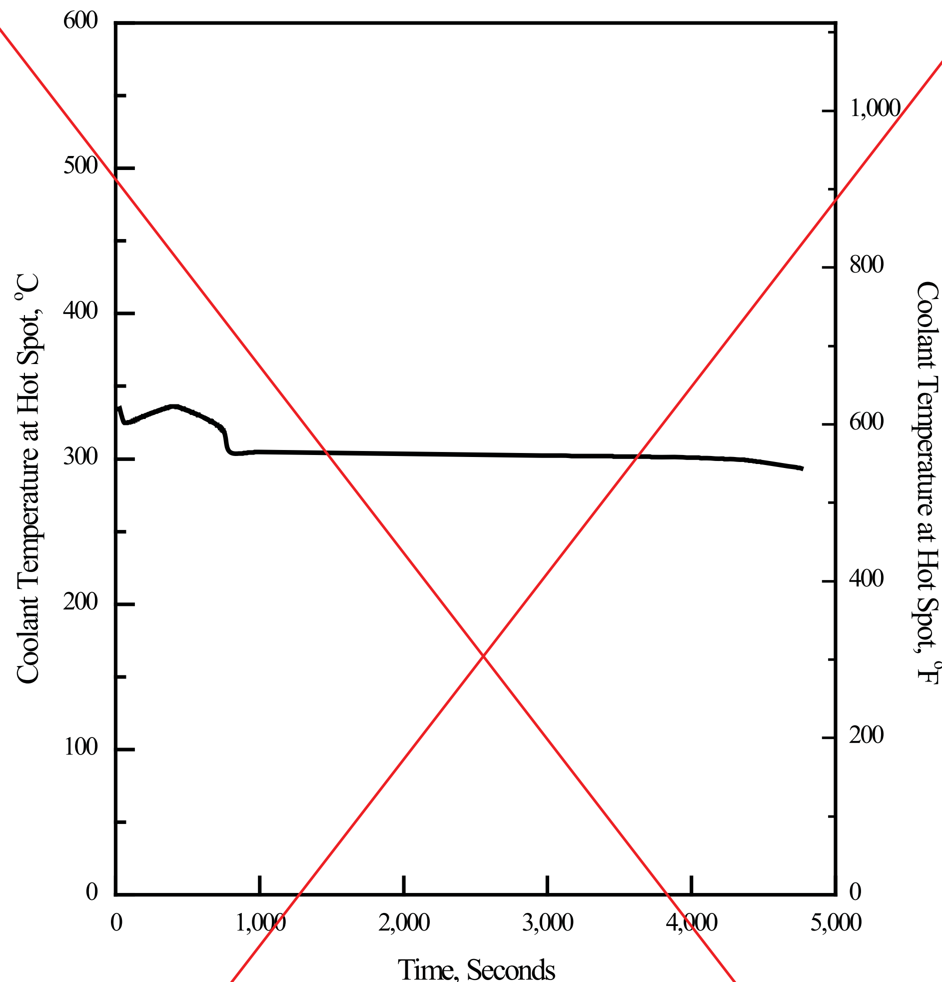


**Figure 15.6.5-32G 27.9 cm$^2$ (0.03 ft$^2$) Break in Top of Pressurizer: Coolant Temperature at Hot Spot**

RAI 318-8337 - Question 15.06.05-2_Rev.1

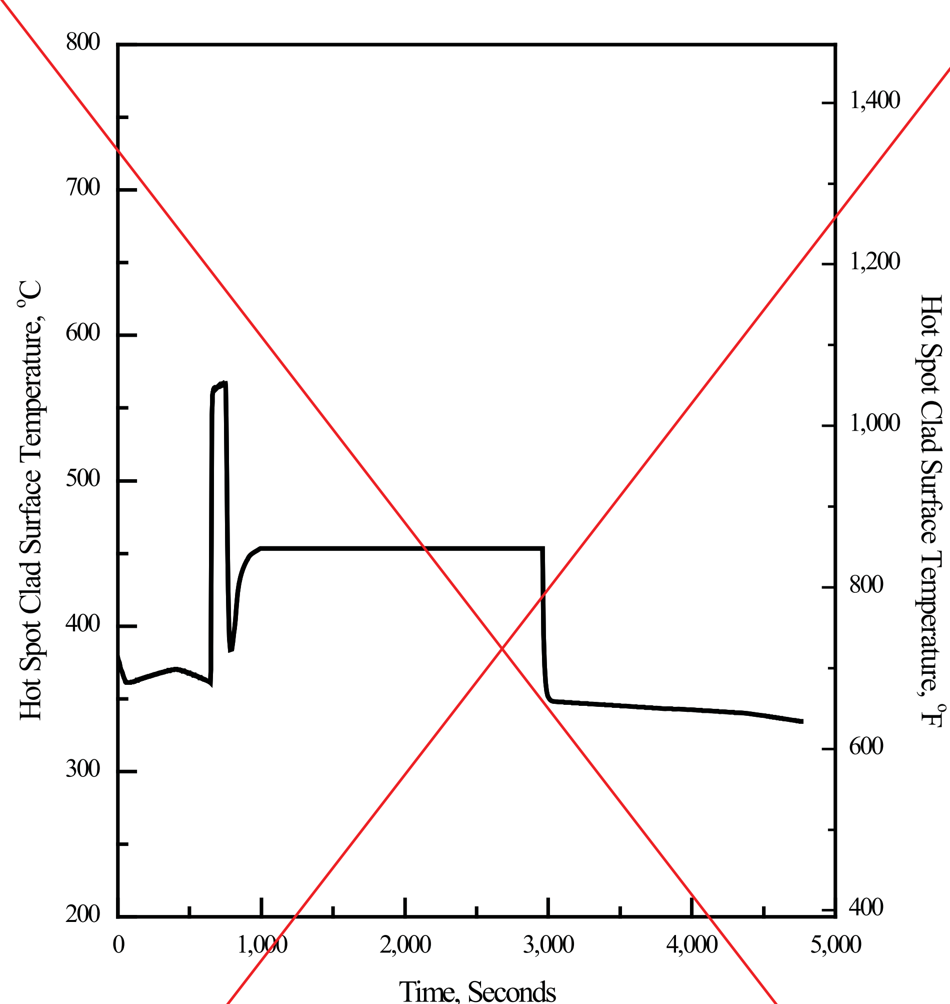


**Figure 15.6.5-32H 27.9 cm$^2$ (0.03 ft$^2$) Break in Top of Pressurizer: Hot Spot Clad Surface Temperature**

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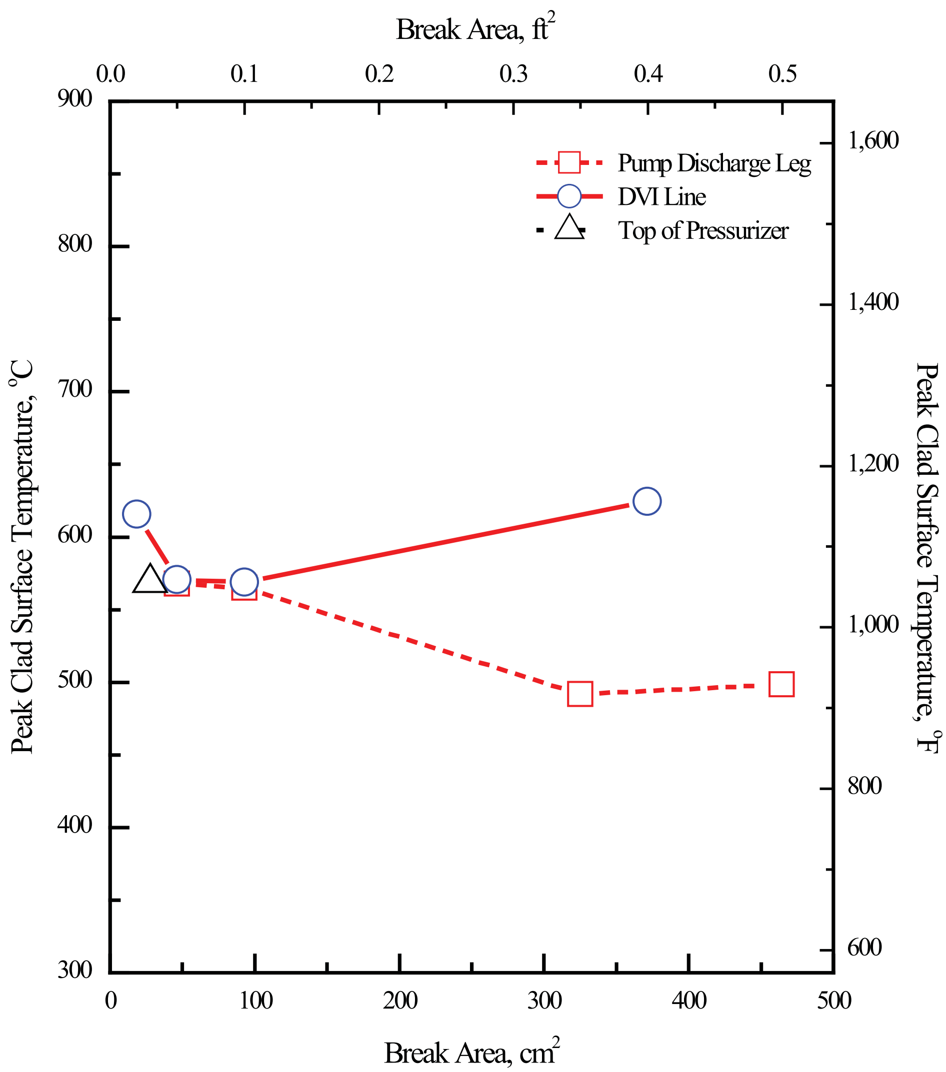


Figure 15.6.5-26

~~Figure 15.6.5-33~~ **Peak Cladding Temperature vs. Break Size**

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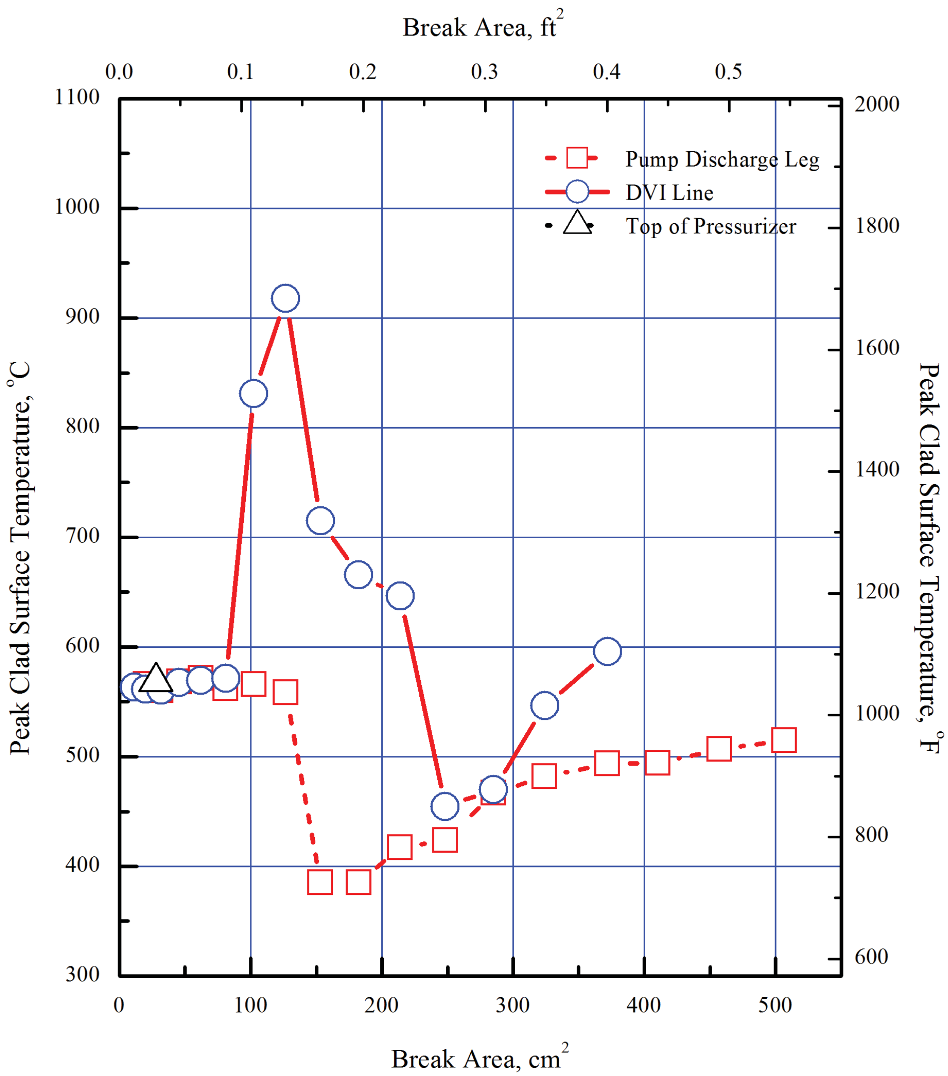


**Figure 15.6.5-26 Peak Cladding Temperature vs. Break Size**

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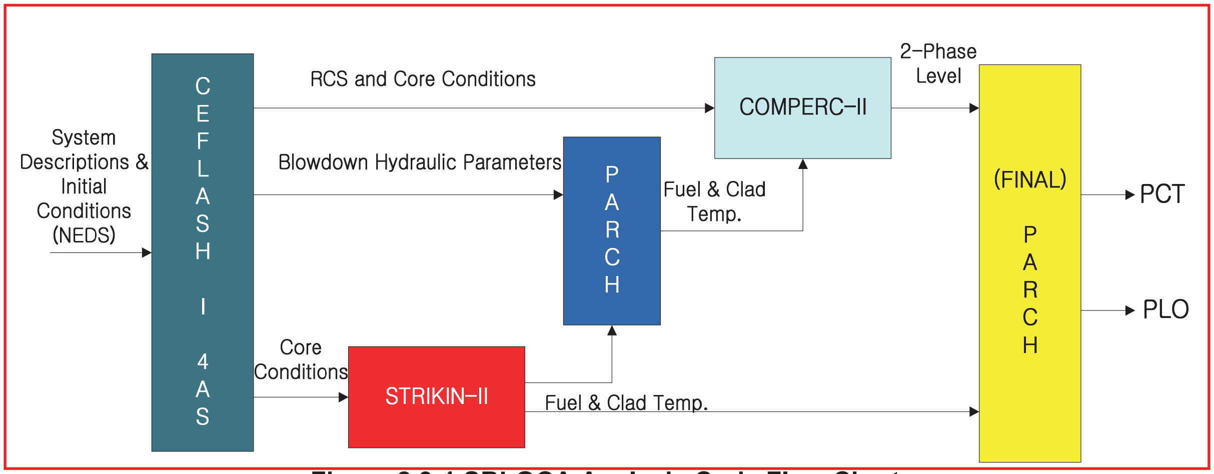


**Figure 2.3-1 SBLOCA Analysis Code Flow Chart**

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## 4.2 Calculation Results

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The nine breaks analyzed at 4,062.66 MWt (102 % of nominal) include reactor coolant pump discharge leg breaks ranging in size from [ ]TS and DVI line breaks ranging in size from [ .]TS One break, equal in area to a fully open pressurizer safety valve, [ ]TS , is postulated to occur at the top of the pressurizer. The 465 $cm^2$ discharge leg break is also analyzed for the large break spectrum and is defined as the transition break size (Reference 1).

The transient behavior of important NSSS parameters is shown in the figures listed in DCD Tier2 section 15.6.5. Table 4.2-1 summarizes the main results of this analysis. Times of interest for the various breaks analyzed are presented in Table 4.2-2. A plot of peak cladding temperature (PCT) versus break size is presented in Figure 4.2-1. The [ ]TS DVI break results in the highest cladding temperature [ ]TS of the small breaks analyzed. Of the two break locations (pump discharge leg and DVI line), the DVI location is limiting due to the assumed loss of all safety injection flow to the broken line.

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For the DVI line break location, as the break size becomes progressively smaller than 372 $cm^2$, the inner vessel two phase level follows a definite pattern:

- The time of initial core uncovery is delayed.
- The depth of core uncovery is lower.
- The rate of level decrease and increase becomes slower.

The core uncover does not occur less than the 31.68$cm^2$.

This trend continues until the core does not uncover at all. These trends affect PCT.

As the break size decreases, both the later time of initial core uncovery and the shallower depth of uncovery tend to mitigate the temperature transient. This trend continues until the core does not uncover as typified by the 18.6 $cm^2$ break. Thus, by analyzing several break sizes over this range, the behavior of PCT versus break size is adequately determined.

dense break spectrum

The above behavior of core uncovery according to break size results from the design characteristics of the SIS. For DVI break sizes below [ ]TS, the RCS pressure remains above SIT pressure and coolant flow injection to the reactor vessel is accomplished entirely by one SI pump. For break sizes greater than [ ]TS, the transient is terminated by the SITs and the SI pump.

and very small break size of DVI and cold leg are considered as shown in Table 4.2-3.

For cold leg breaks, the additional SIS flow resulting from being able to credit two SI pumps precludes core uncovery for break sizes up to [ ]TS. In addition, core uncovery for break sizes greater than [ ]TS is delayed and the depth and duration of uncovery decreases relative to DVI breaks that credit one SI pump. This more favorable behavior results in lower cladding temperatures relative to breaks in a DVI line.

In addition to the break locations discussed above, the rupture of an in-core instrument tube is considered. A break equal in size to a completely severed instrument tube (2.8 $cm^2$) is postulated to occur in the reactor vessel bottom head.

The typical phenomena of small break LOCA such as the core uncovery and loop seal clearing are not shown for the very small break size.

In the very small break LOCA, following

Following rupture, the primary system depressurizes until a reactor scram signal and SIAS are generated due to low pressurizer pressure at 109.3 kg/ $cm^2$A. The assumed loss of offsite power causes the primary coolant pumps and the feedwater pumps to coast down. After the 40 second delay required to actuate the EDGs and the SI pumps following SIAS, safety injection flow is initiated. Due to the assumed failure of one EDG, only two SI pumps are available. (Four SITs are available but do not inject due to the high RCS pressure.)

for the cold leg break and the rupture of an in-core instrument tube

The primary side depressurization continues accompanied by a rise in the secondary side pressure until the secondary side pressure reaches the lowest set point of the steam generator safety valves. The primary system pressure continues to fall until it is just slightly higher than the secondary side pressure. At this point, the flow from the two operating SI pumps ~~(62 kg/sec)~~ exceeds the leak flow ~~(35 kg/sec)~~. Therefore, the RCS will fill. The decay heat generated in the core is removed from the steam generators by steam flow through the secondary side safety valves. Thus, the core will remain covered and cooled in this condition.

The flow from the one operating SIP for DVI break exceeds the leak flow. Comparison of leaking flow and charging flow by SIPs are summarized in the Table 4.2-3.

**Table 4.2-1 Results of SBLOCA Break Spectrum Analysis**

| Break | Peak Cladding Temperature (℃) | Maximum Cladding Oxidation (%) | Maximum Core-Wide Oxidation (%) |
|---|---|---|---|
| 465 $cm^2$/PD[1)] | 498 | 0.0017 | < 0.0003 |
| 325 $cm^2$/PD | 492 | 0.0015 | < 0.0002 |
| 93 $cm^2$/PD | 565 | 0.0010 | < 0.0001 |
| 46.5 $cm^2$/PD | 568 | 0.0008 | < 0.0002 |
| 372 $cm^2$/DVI[2)] | 624 | 0.0195 | < 0.0029 |
| 93 $cm^2$/DVI | 569 | 0.0069 | < 0.0009 |
| 46.5 $cm^2$/DVI | 571 | 0.0018 | < 0.0003 |
| 18.6 $cm^2$/DVI | 616 | 0.0029 | < 0.0006 |
| 27.9 $cm^2$/HL[3)] | 568 | 0.0006 | < 0.0002 |

1) PD : Pump Discharge Leg Break,

2) DVI : DVI Line Break,

3) HL : Hot Leg Break



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Table 4.2-1 Results of SBLOCA Break Spectrum Analysis (1 of 3)

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Table 4.2-1 Results of SBLOCA Break Spectrum Analysis (2 of 3)

TS

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Table 4.2-1 Results of SBLOCA Break Spectrum Analysis (3 of 3)

TS

**Table 4.2-2 Time Sequence of SBLOCA Break Spectrum Analysis**

**(Seconds)**

| Break | SI Pump Flow Delivered to RCS | SI Tank Flow Delivered to RCS | Hot Spot Peak Clad Temperature Occurs |
|---|---|---|---|
| 465 $cm^2$/PD | 57 | 152 | 167 |
| 325 $cm^2$/PD | 62 | 218 | 105 |
| 93 $cm^2$/PD | 138 | 1,128 | 100 |
| 46.5 $cm^2$/PD | 248 | 2,984 | 208 |
| 372 $cm^2$/DVI | 60 | 192 | 239 |
| 93 $cm^2$/DVI | 138 | 1,096 | 100 |
| 46.5 $cm^2$/DVI | 250 | N/A[4)] | 210 |
| 18.6 $cm^2$/DVI | 624 | N/A | 1,184 |
| 27.9 $cm^2$/HL | 795 | N/A | 750 |

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4) N/A : calculation terminated before initiation of SIT discharge

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Table 4.2-2 Time Sequence of SBLOCA Break Spectrum Analysis ( 1 of 3)

**TS**

[1] N/A : calculation terminated before initiation of SIT discharge

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Table 4.2-2 Time Sequence of SBLOCA Break Spectrum Analysis ( 2 of 3)

TS

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Table 4.2-2 Time Sequence of SBLOCA Break Spectrum Analysis ( 3 of 3)

TS

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B

Table 4.2-3 The Evaluation Results for the Very Small Break LOCA Spectrum

TS

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C

TS

Figure 4.2-1A 102.5 cm$^2$ (0.1104 ft$^2$) Break in DVI Line: Normalized Total Core Power

Non-Proprietary



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TS

Figure 4.2-1B 102.5 cm$^2$ (0.1104 ft$^2$) Break in DVI Line: Inner Vessel Pressure

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TS

Figure 4.2-1C 102.5 $cm^2$ (0.1104 $ft^2$) Break in DVI Line: Break Flow Rate

Non-Proprietary



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TS

Figure 4.2-1D 102.5 $cm^2$ (0.1104 $ft^2$) Break in DVI Line: Inner Vessel Inlet Flow Rate

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TS

Figure 4.2-1E 102.5 cm$^2$ (0.1104 ft$^2$) Break in DVI Line: Inner Vessel Two-Phase Mixture Level

Non-Proprietary



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TS

Figure 4.2-1F 102.5 $cm^2$ (0.1104 $ft^2$) Break in DVI Line: Heat Transfer Coefficient at Hot Spot

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TS

Figure 4.2-1G 102.5 $cm^2$ (0.1104 $ft^2$) Break in DVI Line: Coolant Temperature at Hot Spot

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TS

Figure 4.2-1H 102.5 $cm^2$ (0.1104 $ft^2$) Break in DVI Line: Hot Spot Clad Surface Temperature

**Non-Proprietary**



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TS

Figure 4.2-2A 126.7 $cm^2$ (0.1364 $ft^2$) Break in DVI Line: Normalized Total Core Power

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TS

Figure 4.2-2B 126.7 $cm^2$ (0.1364 $ft^2$) Break in DVI Line: Inner Vessel Pressure

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TS

Figure 4.2-2C 126.7 $cm^2$ (0.1364 $ft^2$) Break in DVI Line: Break Flow Rate

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**TS**

Figure 4.2-2D 126.7 $cm^2$ (0.1364 $ft^2$) Break in DVI Line: Inner Vessel Inlet Flow Rate

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TS

Figure 4.2-2E 126.7 $cm^2$ (0.1364 $ft^2$) Break in DVI Line: Inner Vessel Two-Phase Mixture Level

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TS

Figure 4.2-2F 126.7 $cm^2$ (0.1364 $ft^2$) Break in DVI Line: Heat Transfer Coefficient at Hot Spot

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TS

Figure 4.2-2G 126.7 $cm^2$ (0.1364 $ft^2$) Break in DVI Line: Coolant Temperature at Hot Spot

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TS

Figure 4.2-2H 126.7 $cm^2$ (0.1364 $ft^2$) Break in DVI Line: Hot Spot Clad Surface Temperature

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TS

Figure 4.2-3A 153.3 $cm^2$ (0.1650 $ft^2$) Break in DVI Line: Normalized Total Core Power

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**TS**

Figure 4.2-3B 153.3 $cm^2$ (0.1650 $ft^2$) Break in DVI Line: Inner Vessel Pressure

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TS

Figure 4.2-3C 153.3 $cm^2$ (0.1650 $ft^2$) Break in DVI Line: Break Flow Rate

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TS

Figure 4.2-3D 153.3 $cm^2$ (0.1650 $ft^2$) Break in DVI Line: Inner Vessel Inlet Flow Rate

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TS

Figure 4.2-3E 153.3 $cm^2$ (0.1650 $ft^2$) Break in DVI Line: Inner Vessel Two-Phase Mixture Level

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TS

Figure 4.2-3F 153.3 $cm^2$ (0.1650 $ft^2$) Break in DVI Line: Heat Transfer Coefficient at Hot Spot

RAI 318-8337 - Question 15.06.05-2_Rev.1

TS

Figure 4.2-3G 153.3 $cm^2$ (0.1650 $ft^2$) Break in DVI Line: Coolant Temperature at Hot Spot

RAI 318-8337 - Question 15.06.05-2_Rev.1

TS

Figure 4.2-3H 153.3 $cm^2$ (0.1650 $ft^2$) Break in DVI Line: Hot Spot Clad Surface Temperature

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TS

Figure 4.2-4A 102.5 cm$^2$ (0.1104 ft$^2$) Break in Pump discharge Leg:
Normalized Total Core Power

RAI 318-8337 - Question 15.06.05-2_Rev.1

TS

Figure 4.2-4B 102.5 $cm^2$ (0.1104 $ft^2$) Break in Pump discharge Leg: Inner Vessel Pressure

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TS

Figure 4.2-4C 102.5 $cm^2$ (0.1104 $ft^2$) Break in Pump discharge Leg: Break Flow Rate

RAI 318-8337 - Question 15.06.05-2_Rev.1

TS

Figure 4.2-4D 102.5 $cm^2$ (0.1104 $ft^2$) Break in Pump discharge Leg: Inner Vessel Inlet Flow Rate

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TS

Figure 4.2-4E 102.5c m$^2$ (0.1104 ft$^2$) Break in Pump discharge Leg: Inner Vessel Two-Phase Mixture Level

**Non-Proprietary**



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**TS**

Figure 4.2-4F 102.5 $cm^2$ (0.1104 $ft^2$) Break in Pump discharge Leg: Heat Transfer Coefficient at Hot Spot

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TS

Figure 4.2-4G 102.5 cm$^2$ (0.1104 ft$^2$) Break in Pump discharge Leg: Coolant Temperature at Hot Spot

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TS

Figure 4.2-4H 102.5 $cm^2$ (0.1104 $ft^2$) Break in Pump discharge Leg: Hot Spot Clad Surface Temperature

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TS

Figure 4.2-5A 126.7 $cm^2$ (0.1364 $ft^2$) Break in Pump discharge Leg:
Normalized Total Core Power

 **Non-Proprietary** 

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**TS**

Figure 4.2-5B 126.7 $cm^2$ (0.1364 $ft^2$) Break in Pump discharge Leg: Inner Vessel Pressure

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TS

Figure 4.2-5C 126.7 $cm^2$ (0.1364 $ft^2$) Break in Pump discharge Leg: Break Flow Rate

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TS

Figure 4.2-5D 126.7 $cm^2$ (0.1364 $ft^2$) Break in Pump discharge Leg: Inner Vessel Inlet Flow Rate

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TS

Figure 4.2-5E 126.7 $cm^2$ (0.1364 $ft^2$) Break in Pump discharge Leg: Inner Vessel Two-Phase Mixture Level

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TS

Figure 4.2-5F 126.7 $cm^2$ (0.1364 $ft^2$) Break in Pump discharge Leg: Heat Transfer Coefficient at Hot Spot

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**TS**

Figure 4.2-5G 126.7 $cm^2$ (0.1364 $ft^2$) Break in Pump discharge Leg: Coolant Temperature at Hot Spot

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TS

Figure 4.2-5H 126.7 $cm^2$ (0.1364 $ft^2$) Break in Pump discharge Leg: Hot Spot Clad Surface Temperature

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TS

Figure 4.2-6A 153.3 $cm^2$ (0.1650 $ft^2$) Break in Pump discharge Leg:
Normalized Total Core Power

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TS

Figure 4.2-6B 153.3 $cm^2$ (0.1650 $ft^2$) Break in Pump discharge Leg: Inner Vessel Pressure

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TS

Figure 4.2-6C 153.3 $cm^2$ (0.1650 $ft^2$) Break in Pump discharge Leg: Break Flow Rate

Non-Proprietary



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TS

Figure 4.2-6D 153.3 $cm^2$ (0.1650 $ft^2$) Break in Pump discharge Leg: Inner Vessel Inlet Flow Rate

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TS

Figure 4.2-6E 153.3 $cm^2$ (0.1650 $ft^2$) Break in Pump discharge Leg: Inner Vessel Two-Phase Mixture Level

Non-Proprietary



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TS

Figure 4.2-6F 153.3 $cm^2$ (0.1650 $ft^2$) Break in Pump discharge Leg: Heat Transfer Coefficient at Hot Spot

Non-Proprietary



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TS

Figure 4.2-6G 153.3 cm$^2$ (0.1650 ft$^2$) Break in Pump discharge Leg: Coolant Temperature at Hot Spot

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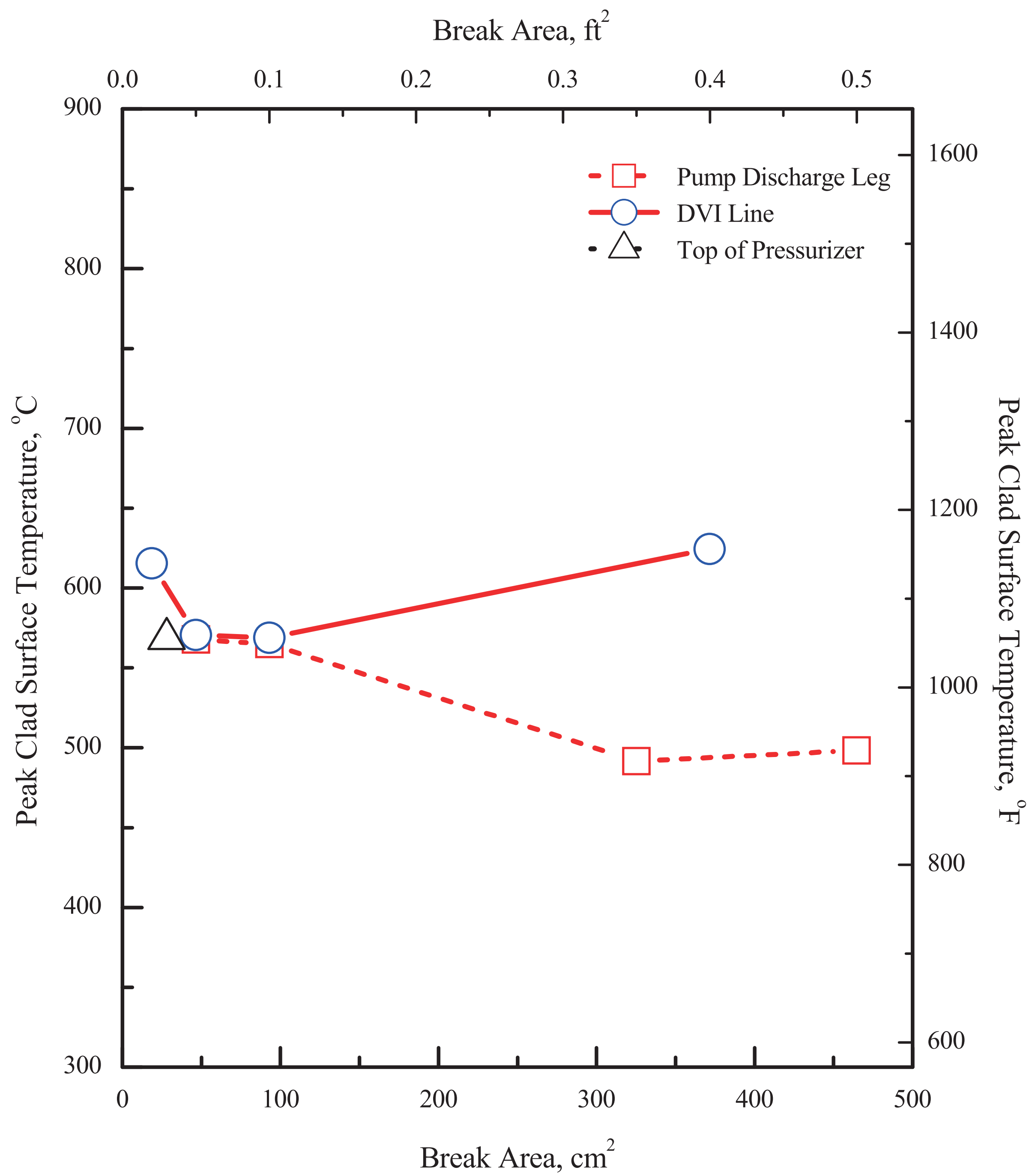
TS

Figure 4.2-6H 153.3 $cm^2$ (0.1650 $ft^2$) Break in Pump discharge Leg: Hot Spot Clad Surface Temperature




~~Figure 4.2-1~~ **Peak Cladding Temperature vs. Break Area**

Replace with A
(Next 1page)

Figure 4.2−7

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A

TS