REVISED
FEASIBILITY REPORT FOR
BIT ELIMINATION
FOR
INDIAN POINT UNIT 3

July, 1988

INTRODUCTION

Westinghouse has developed improved analytical techniques which allow a reduction in the Boron Injection Tank (BIT) concentration and, in some cases, removal of the BIT. These analytical techniques have been applied to demonstrate the feasibility of the elimination of the BIT at Indian Point Unit 3 while continuing to meet applicable safety criteria. This report provides background information on the Indian Point Unit 3 BIT design basis, reasons why tank removal may be desirable, plant design features which allow the change to be proposed, as well as a summary of analytical results which demonstrate the feasibility of BIT removal for Indian Point Unit 3. Potential difficulties unfavorably affecting plant availability, operability, and maintainability can be eliminated or reduced in severity by elimination of the BIT entirely or by isolating the BIT system.

BACKGROUND

The BIT is a component of the Safety Injection System whose sole function is to provide concentrated boric acid to the reactor coolant to mitigate the consequences of postulated steamline break accidents.

The basis for the Technical Specifications regarding the minimum boric acid concentration which must be maintained in the plant, is that sufficient boron must be available in the BIT/RWST to meet the design criteria for borating the reactor coolant system following a steamline break. Existing design criteria are as follows:

- The radiation releases for the hypothetical steamline break, i.e., double-ended rupture of a main steamline, must remain within the requirements of 10CFR Part 100. This is the ANS criterion for Class IV events.

- There is no return to criticality on the credible steamline break, i.e., a steam generator safety or relief valve failing open with offsite power available. This is a conservative Westinghouse criterion for Class II events.

Under the existing Technical Specifications, the minimum boron concentration that must be maintained in the BIT is 20,000 ppm. To maintain this high concentration in solution (see Figure 1), the tank and associated piping are heat traced (with Technical Specification limits on the solution temperature) and are fitted with low-temperature alarms to alert the operator of temperature deviations. Furthermore, the safety-related nature of the BIT system requires that the heat-tracing system be redundant.

The required solubility temperature imposes a continuous load on the heaters. Low-temperature alarm actuation and heater burnout have occurred in some plants. Violation of the Technical Specification on concentration in the BIT poses availability problems in that recovery is required within a very short time. If the concentration is not restored within the time required by the Technical Specification, the plant must be shutdown. In addition to the Technical Specification limits on the BIT temperature and concentration, the tank pressure must be within range and the level channels and isolation valve interlocks must be operable in order to consider the subsystem as "available". Thus, the above requirements have a potentially serious impact on plant availability.

Additionally, to prevent cold spots and ensure homogeneity of solution within the BIT, the contents are continually recirculated to the 20,000 ppm boron Boric Acid Tanks. With the reduction in BIT concentration or complete elimination, the need to continue recirculation and the need to maintain elevated boron concentrations within the BAT may be eliminated. Basically the BAT concentration can only be reduced to the concentration level in the BIT with the limiting constraint that sufficient volumes and concentrations must be retained in the BAT to meet its design basis. More explicitly, if the BIT concentration can be reduced to only 6% then the BAT can potentially be reduced to only 6%. However, if the BIT can be eliminated then there remains no need to recirculate BIT contents and the only limiting factors imposed on BAT concentration reduction are those associated with meeting its design basis independent of the BIT. On Indian Point 3 it has been determined that the BIT can be eliminated and thus the boric acid concentration within the BAT can be reduced to the 4 weight percent demonstrated in the BAT reduction report.

DESCRIPTION OF THE ANALYSES

Definition of Cases

The only postulated accident analyses affected by BIT removal are the Steamline Break and Mass and Energy Release/Containment Pressure analyses. These transients are affected with respect to both core integrity and mass and energy release to containment.

CORE INTEGRITY ANALYSIS

Five Steamline Break cases are presented in the Indian Point Unit 3 FSAR. Each case was reanalyzed assuming removal of the BIT, to assure core integrity.

The five cases are:

- o Hypothetical Steam Breaks

  1) Steampipe severance, upstream of the flow restrictor, with offsite power available,

  2) Steampipe severance, upstream of the flow restrictor, without offsite power available,

  3) Steampipe severance, downstream of the flow restrictor, with offsite power available,

  4) Steampipe severance, downstream of the flow restrictor, without offsite power available,

- o Credible Steamline Break

  5) A failed secondary safety or relief valve, with offsite power available.

The BIT removal analysis assumed 24% uniform steam generator tube plugging.

Criteria

For the hypothetical break analyses, the same criteria was applied to the BIT elimination analyses as is applied in the FSAR. That is, for the most severe Condition IV break, the radiation releases should be within the requirements of 10CFR Part 100 by demonstrating that the DNB design basis is met.

The credible steamline break analysis was performed using a revised criterion whereby the plant may return to criticality but no damage may occur to the fuel. This constitutes a relaxation of the conservative internal Westinghouse criterion for Class II events. This criterion is in compliance with the criteria used by the NRC and ANS, which require that releases during steamline break accidents remain within the limits set forth in 10CFR Part 20. This limit could be met with a return to criticality if it is assured that there is no consequential fuel damage.

Analysis Methods

In the Indian Point 3 steamline break analysis, the system transient parameters, i.e., RCS pressure, temperatures, steam flow, core boron concentration and core power were calculated using the LOFTRAN (1) system transient analysis computer code. This computer code includes models of the reactor core, steam generators, pressurizer, primary piping, protection systems and engineered safeguards systems.

The changes in safety injection system volumes, initial concentrations, and temperatures corresponding to an elimination of the BIT are introduced into the analyses in the LOFTRAN code.

For the hypothetical breaks, the plant is initially assumed to be at hot zero power at the minimum required shutdown margin. Following the break, the RCS temperature and pressure decrease rapidly, and in the presence of a large End of Life (EOL) moderator coefficient of reactivity, the reactor returns critical with the rods inserted, assuming the most reactive Rod cluster Control Assembly (RCCA) in the fully withdrawn position. The reactor power

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1. WCAP-7907, T.W.T. Burnett, et. al., "LOFTRAN Code Description," October, 1972.

increases at a decreasing rate until boron from the safety injection system reaches the core and begins to offset the positive reactivity insertion caused by the cooldown. The core is subsequently brought subcritical with boron injection, aided by the abatement and eventual termination of steam flow from the faulted steam generator. The cooldown will terminate when steam flow from the faulted steam generator is stopped, and auxiliary feedwater will be available to the intact steam generators to perform a normal shutdown.

Figures 2 through 9 show the transient behavior for the Hypothetical Breaks. A comparison of the FSAR cases with these figures reveals only small changes in reactor coolant system parameters, with the exception of core power, which is understandably higher for the cases without the BIT. The effect of the boron on the total reactivity is both delayed and damped in Figures 2 through 9 because the safety injection system must purge more water before injecting boron into the cold leg and the boron source (RWST) is both colder ($T_{RWST} < 40^{o}F$ assumed) and contains a lower boron concentration than the BIT. This causes the power to initially rise to a higher peak due to the delay and to subsequently decay at a slower rate after the boron reaches the core. The BIT elimination analyses assumed the safety injection system piping downstream of the RWST to contain no boron. It also assumed the BIT was present containing no boron. This assumption conservatively delays boron injection to the RCS. These pipes in reality will contain boron.

Departure from Nucleate Boiling (DNB) analyses were performed using the same design verification procedure as is used for the FSAR cases. The DNB analyses show that the DNB design basis is met, and that no consequential fuel failures are anticipated.

Figures 10 and 11 show transient parameters for the credible steamline break. The DNB design basis must still be met in order to meet the 10CFR Part 20 dose requirements. Figure 10 shows that criticality is attained for the assumed no BIT condition. DNB analyses for this case show that the DNB design basis is met and no fuel failures are predicted. This conclusion is also consistent with the conclusion drawn for the Hypothetical breaks, since no violation of the DNB design basis was calculated for the more extreme double ended ruptures.

In conclusion, calculations have been performed for Indian Point Unit 3 which show that, if the FSAR criterion prohibiting a return to criticality for the credible break is relaxed to the present NRC criterion for Condition II accidents, the BIT can be isolated or eliminated. The same criteria for the Hypothetical steamline breaks as was used in the FSAR can be met with the BIT eliminated.

MASS AND ENERGY RELEASE

The impact of BIT elimination on the Mass and Energy/Containment Pressure analysis was addressed to assure the containment pressure remains below its design pressure (47 psig). The LOFTRAN computer code was used to generate the mass and energy release to the containment for a large double-ended rupture. The steam break at the steam generator nozzle with offsite power case was analyzed as specified in the Indian Point Unit 3 FSAR assuming 24% uniform steam generator tube plugging. This "uniform" analysis bounds the previously performed asymmetric tube plugging analysis.

The Indian Point Unit No. 3 Containment heat removal system consists of two separate, full capacity, engineered safety feature systems. Adequate containment heat removal capability is provided by 2 spray systems or 5 containment fan cooler units (other combinations are possible). At containment design temperature, 271^{o}F, the total heat absorption capability of each of the spray systems is 218 x 10^6 Btu/hr. At this design temperature, each of the present 3 fan cooler units was designed for removing heat from the containment at a rate of 81.00 x 10^6 Btu/hr. For this evaluation, we are however using the original conservative FSAR Fan Cooler heat removal rate of 76.32 x 10^6 Btu/hr per fan cooler.

The fan cooler system is actuated on a Safety Injection signal, which is reached within 2 seconds of the accident. An additional 60 second delay is assumed for the fan coolers to be fully operational. The spray system actuates at a Hi-Hi Containment Pressure Setpoint 24.6 psig. By considering the break flow into the containment and assuming no heat removal from the containment safeguards system, it would take approximately 160 seconds to reach this setpoint.

The containment pressure and temperature responses shown on Figures 12 and 13 were determined using the COCO computer code. The initial containment temperature assumed in the BIT removal containment analysis was 130°F. This will allow the increase of initial maximum containment temperature from 120°F to 130°F with the BIT removed. The peak containment pressure is 42.93 psig, which remains below the 47 psig containment design pressure and it occured at 1455 seconds during the transient. The peak containment temperature is 262°F and it occurred at 1538 seconds during the transient. Based on this case analyzed, which assumes that the non-return valve in the faulted main steam line functions as intended, the BIT removal is acceptable from the standpoint of peak pressure and temperature for this break size.

CONCLUSIONS

Plant specific analyses have been performed for Indian Point Unit 3 and have shown that the Boron Injection Tank may be bypassed, eliminated, or the boric acid concentration reduced. Since the analyses consider a BIT containing no boric acid solution (e.g., only water), dilution of the boric acid concentration to a level below that requiring heat tracing is permitted.

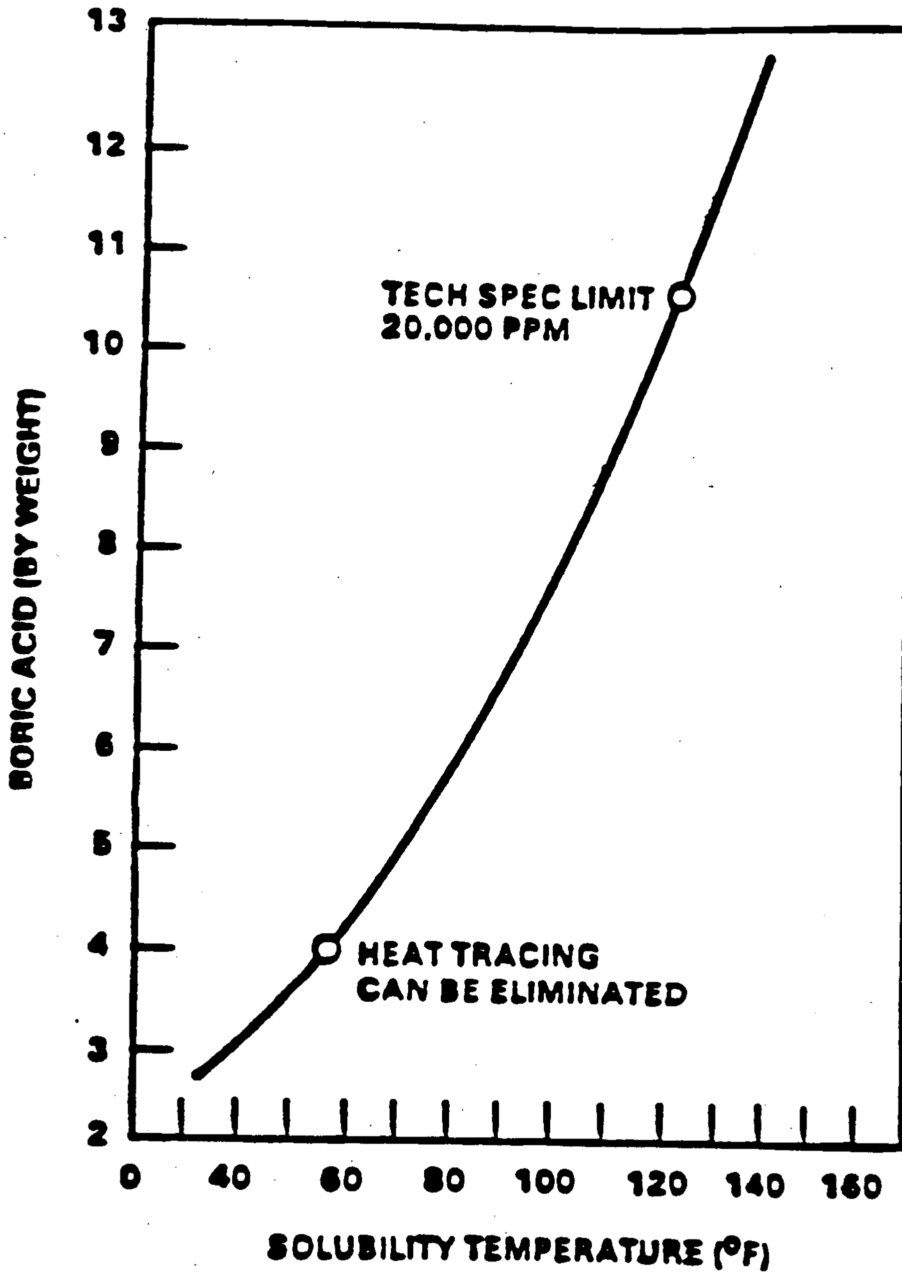

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Figure 1.

Boric Acid Concentration Versus Solubility Temperature

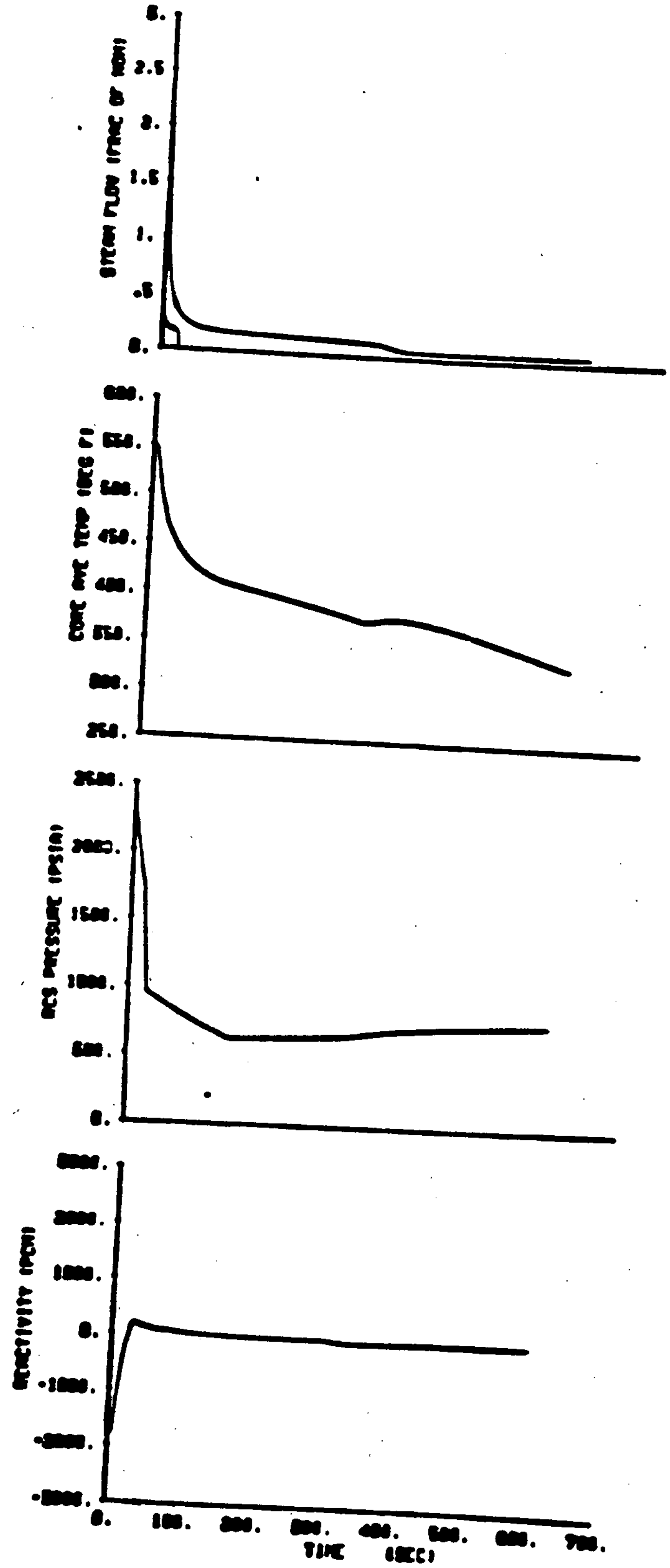

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Figure 2

Steam line break at exit of steam generator with safety injection and offsite power available.

Steam flow, Temperature, Pressure, & Reactivity vs Time

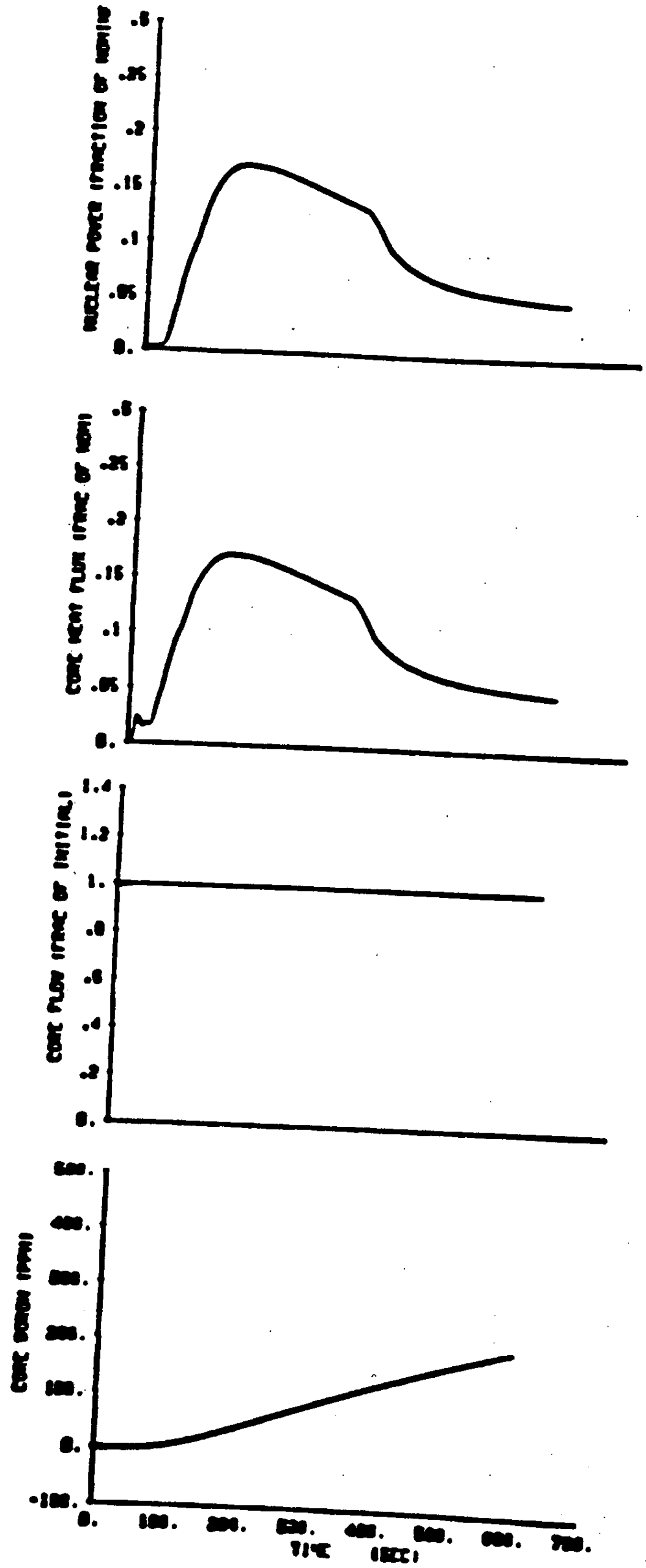

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Figure 3

Steam line break at exit of steam generator with safety injection and offsite power available.

Core power, core heat flux, core flow, and core boron vs time

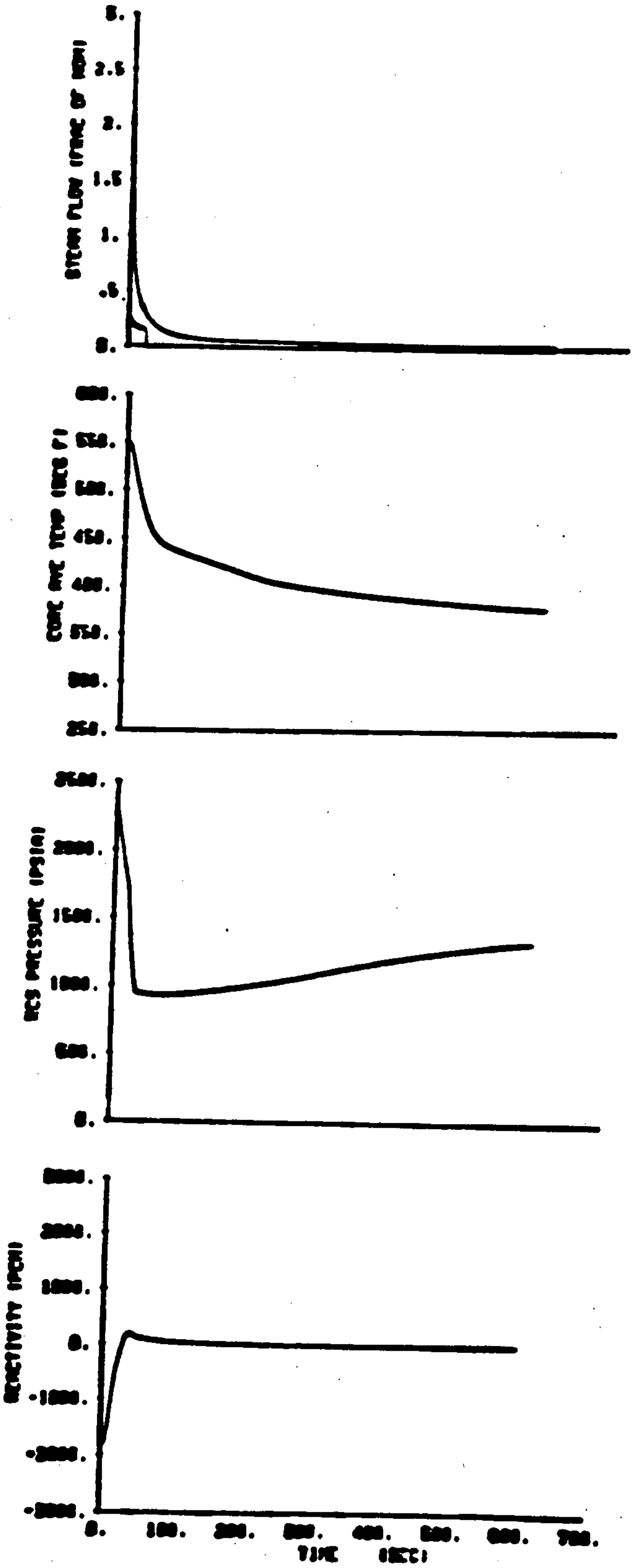

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Figure 4

Steam line break at exit of steam generator with safety injection and loss of offsite power

Steam flow, Temperature, Pressure, & Reactivity vs Time

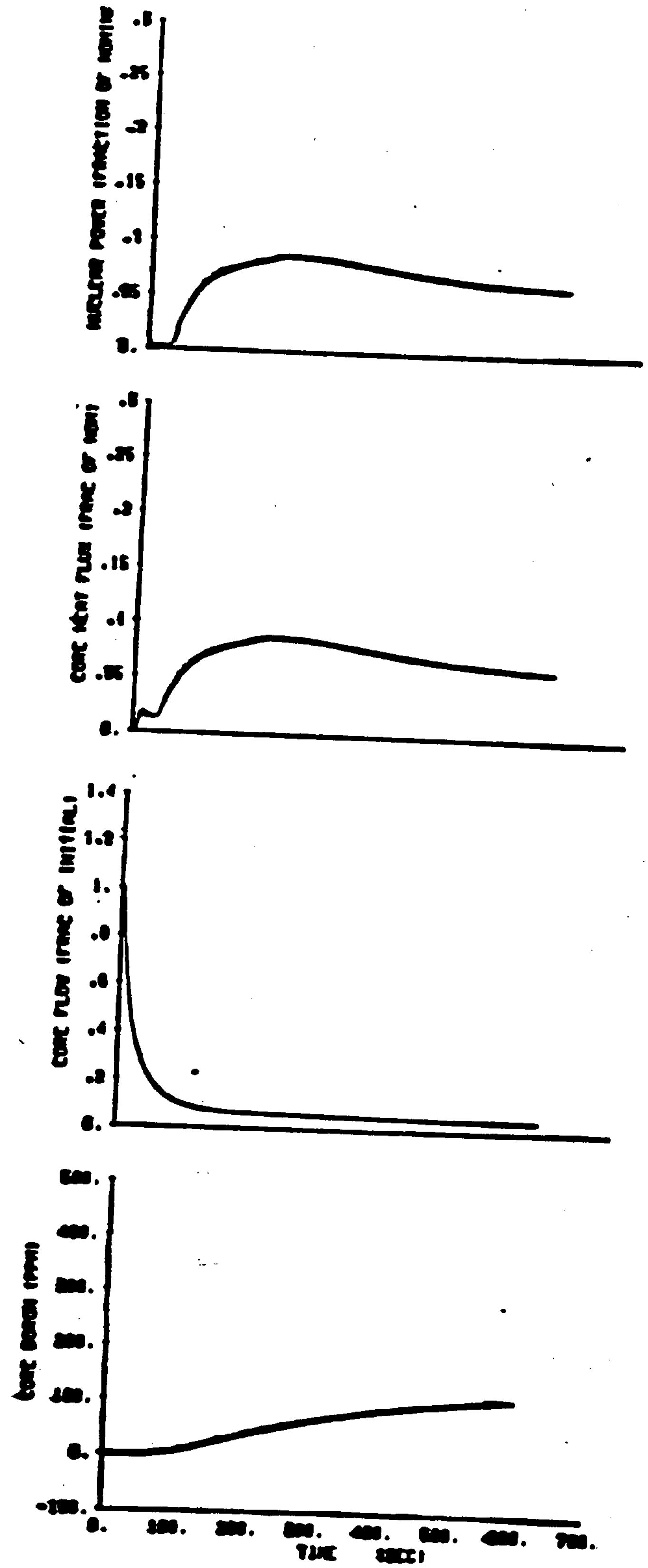

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Figure 5

Steam line break at exit of steam generator with safety injection and loss of offsite power

Core power, core heat flux, core flow, & core boron vs time

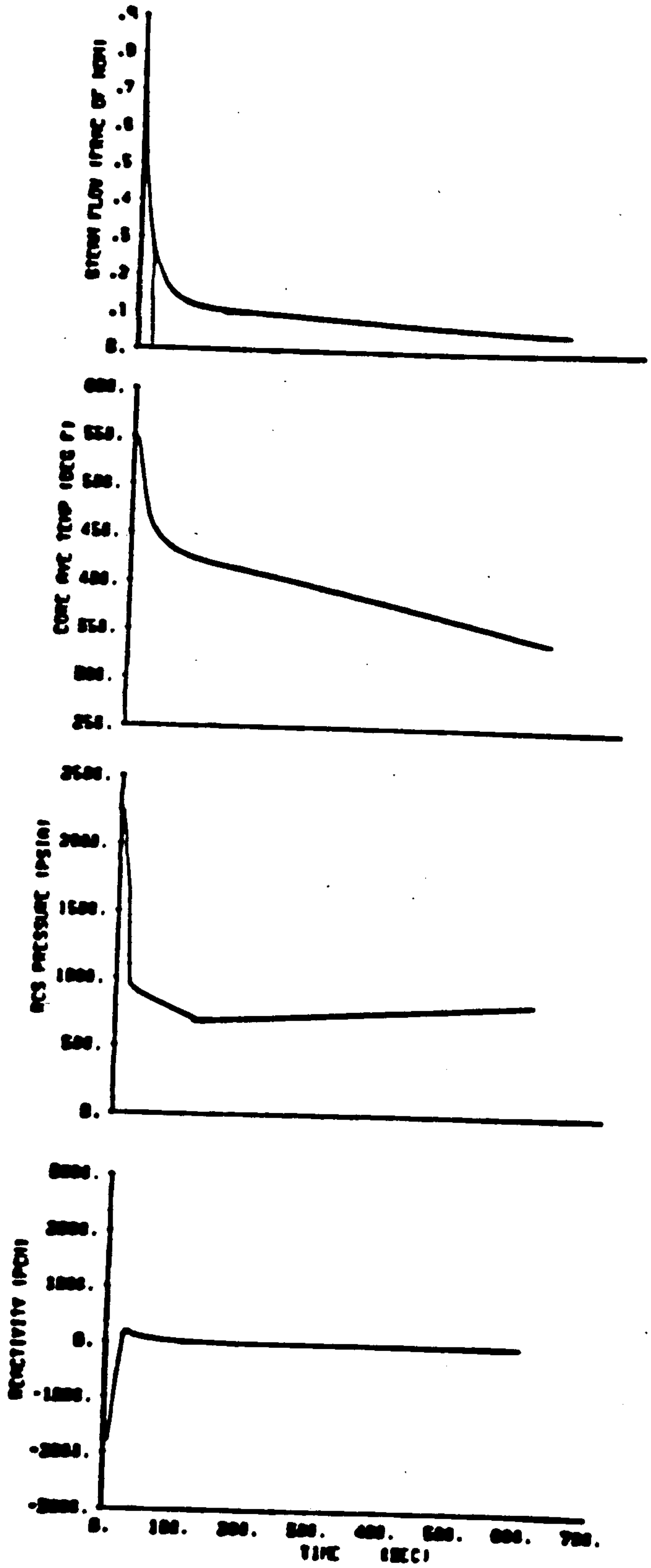

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Figure 6

Steam line break downstream of flow measuring nozzle with safety injection and offsite power available

Steam flow, Temperature, Pressure, and Reactivity vs time

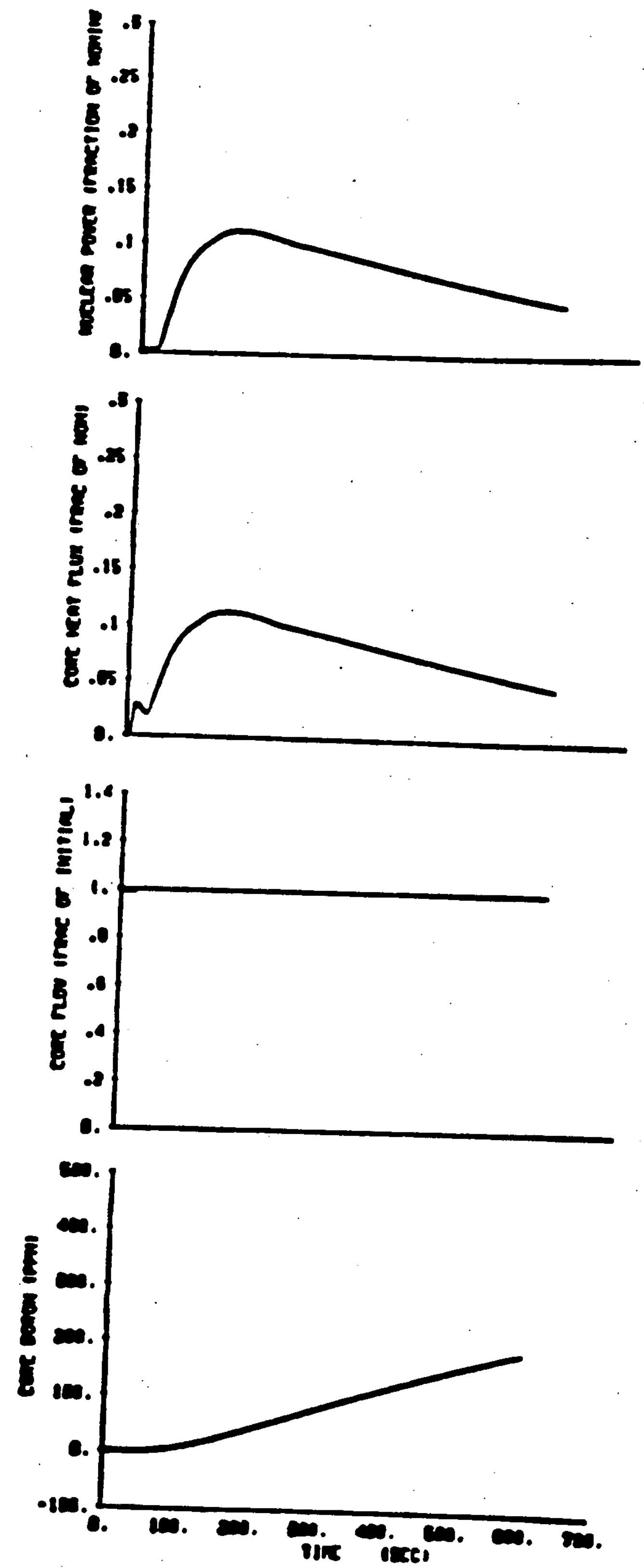

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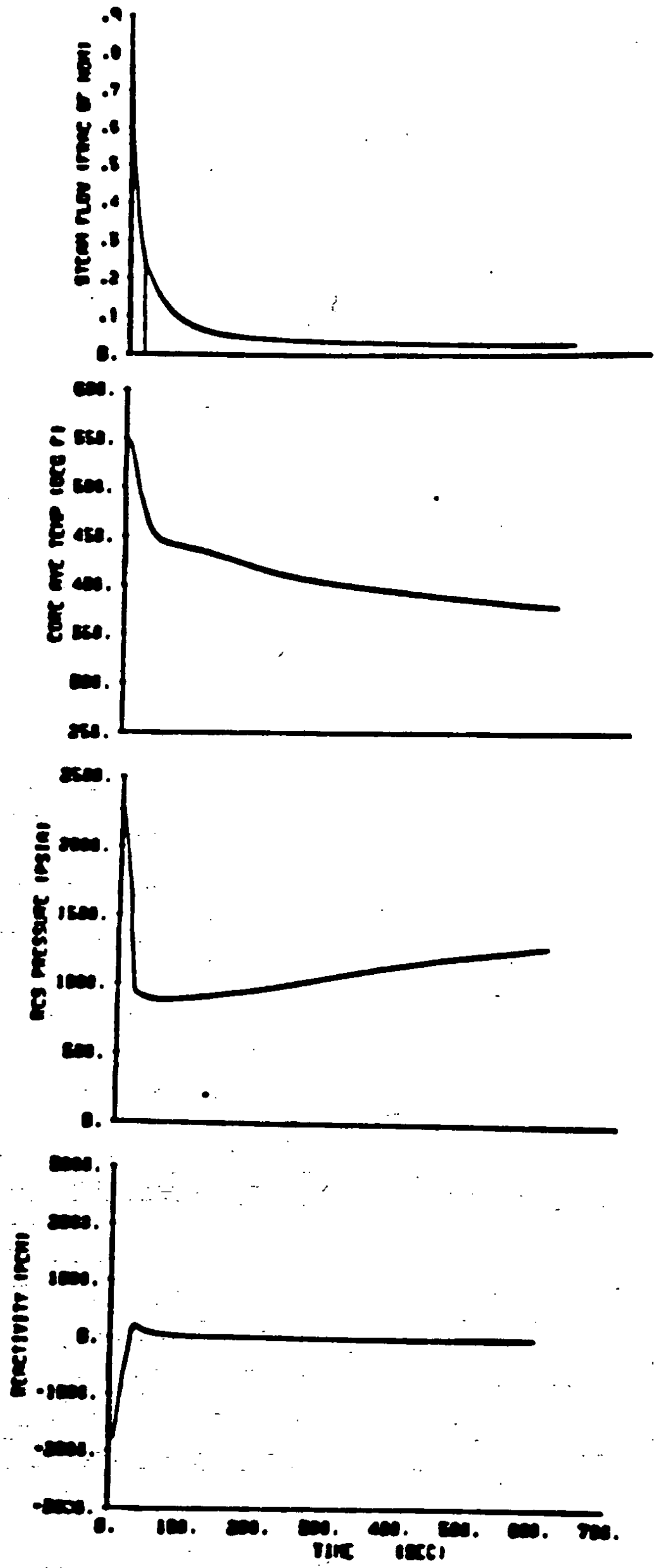
Figure 7

Steam line break downstream of flow measuring nozzle with safety injection and offsite power available

Core power, core heat flux, core flow, & core boron vs time



INDIAN POINT 3 BIT REMOVAL STUDY	Figure 8 Steam line break downstream of flow measuring nozzle with safety injection and loss of offsite power Steam flow, Temperature, Pressure, & Reactivity vs Time

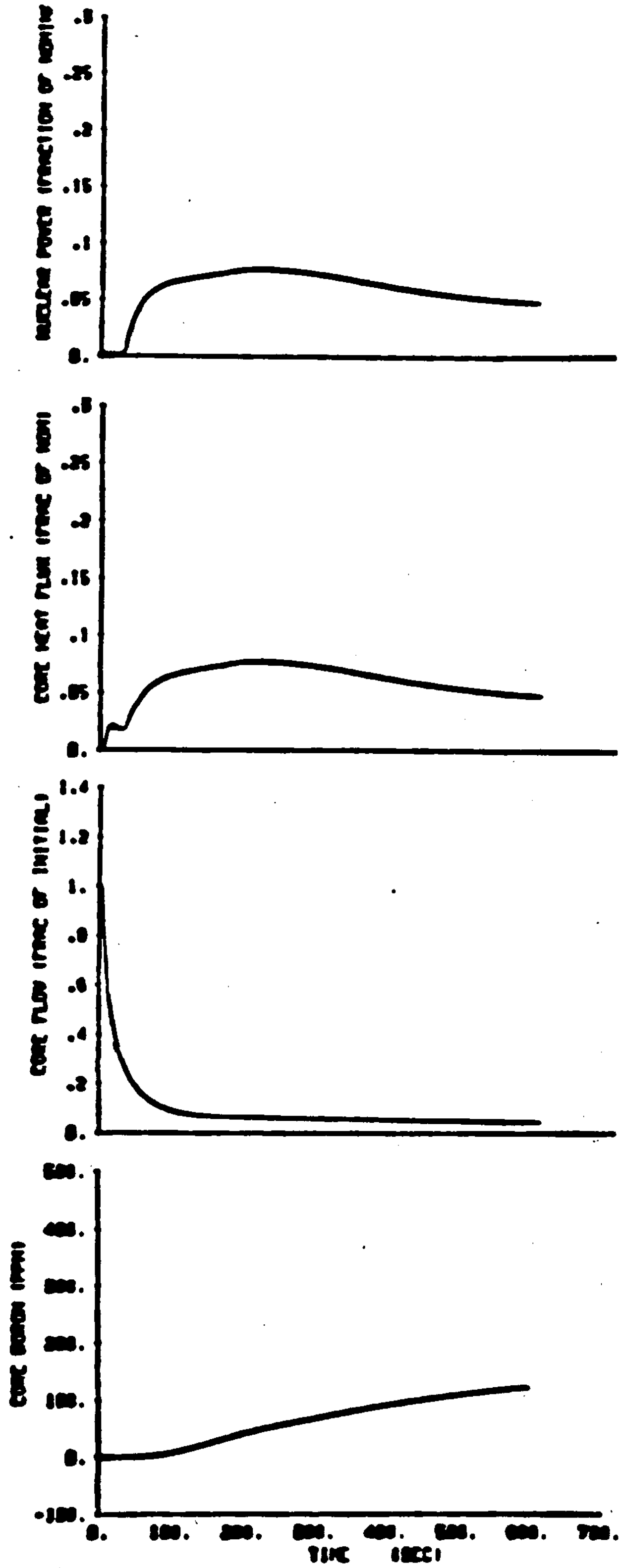


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Figure 9

Steam line break downstream of flow measuring nozzle with safety injection and loss of offsite power

Core power, core heat flux, core flow, & core boron vs time

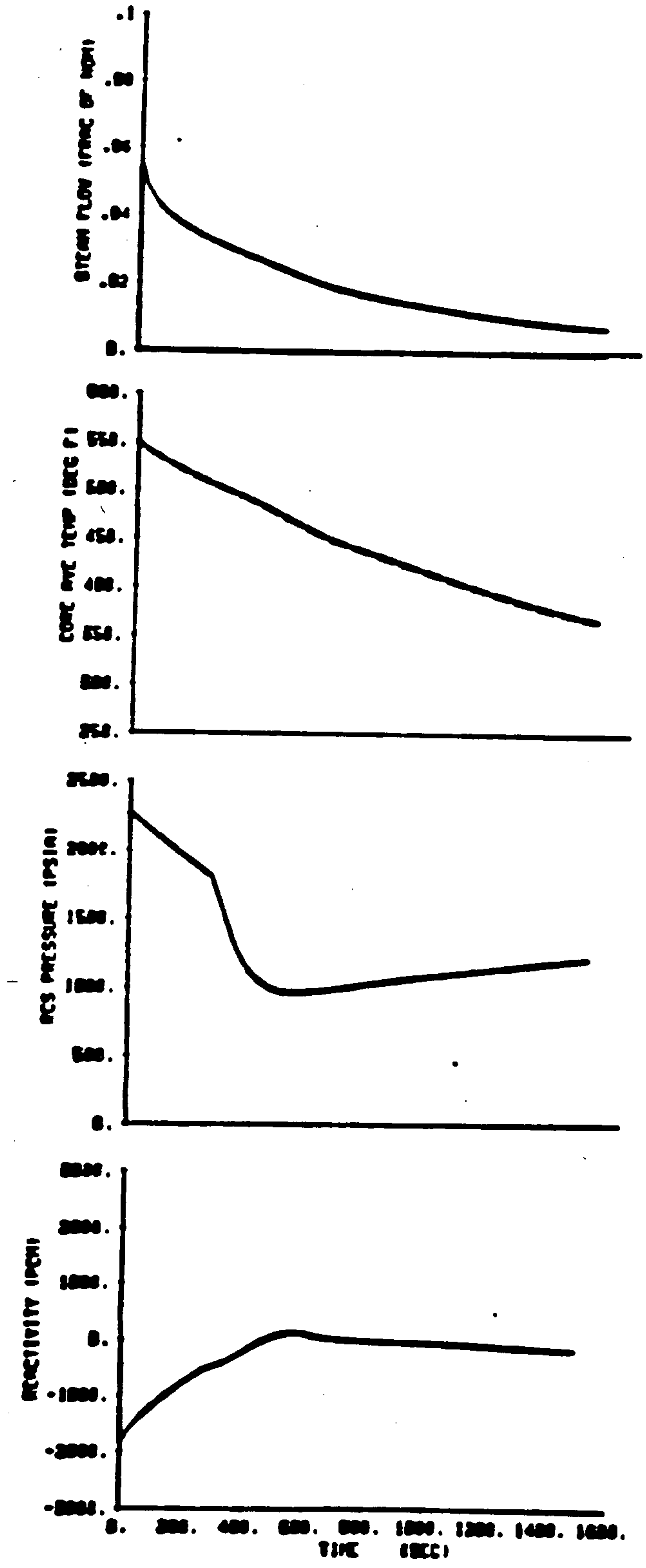

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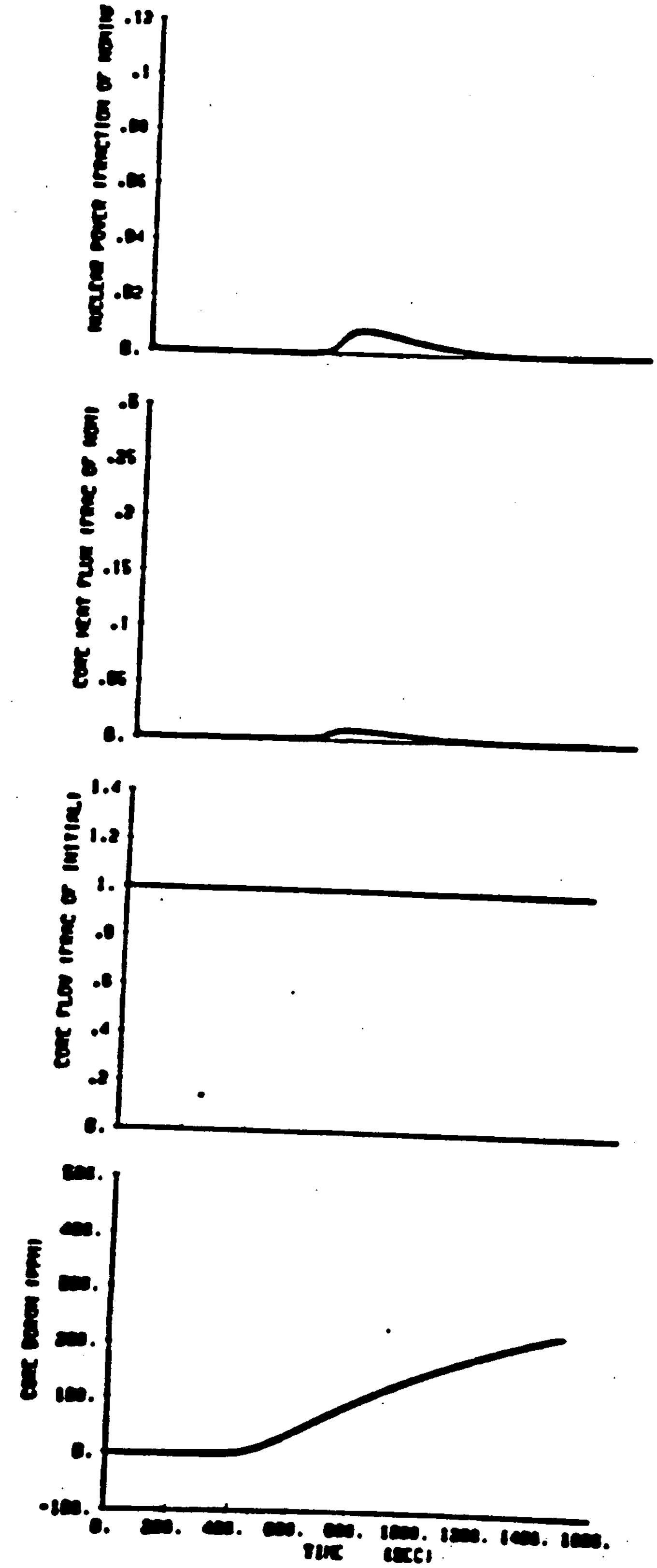
Figure 10

Steam line break equivalent to opening one steam generator safety valve with offsite power available

Steam flow, Temperature, Pressure, & Reactivity vs Time



INDIAN POINT 3 BIT REMOVAL STUDY	Figure 11 Steam line break equivalent to opening one steam generator safety valve with offsite power available Core Power, Core Heat Flux, Core Flow, & Core Boron vs Time

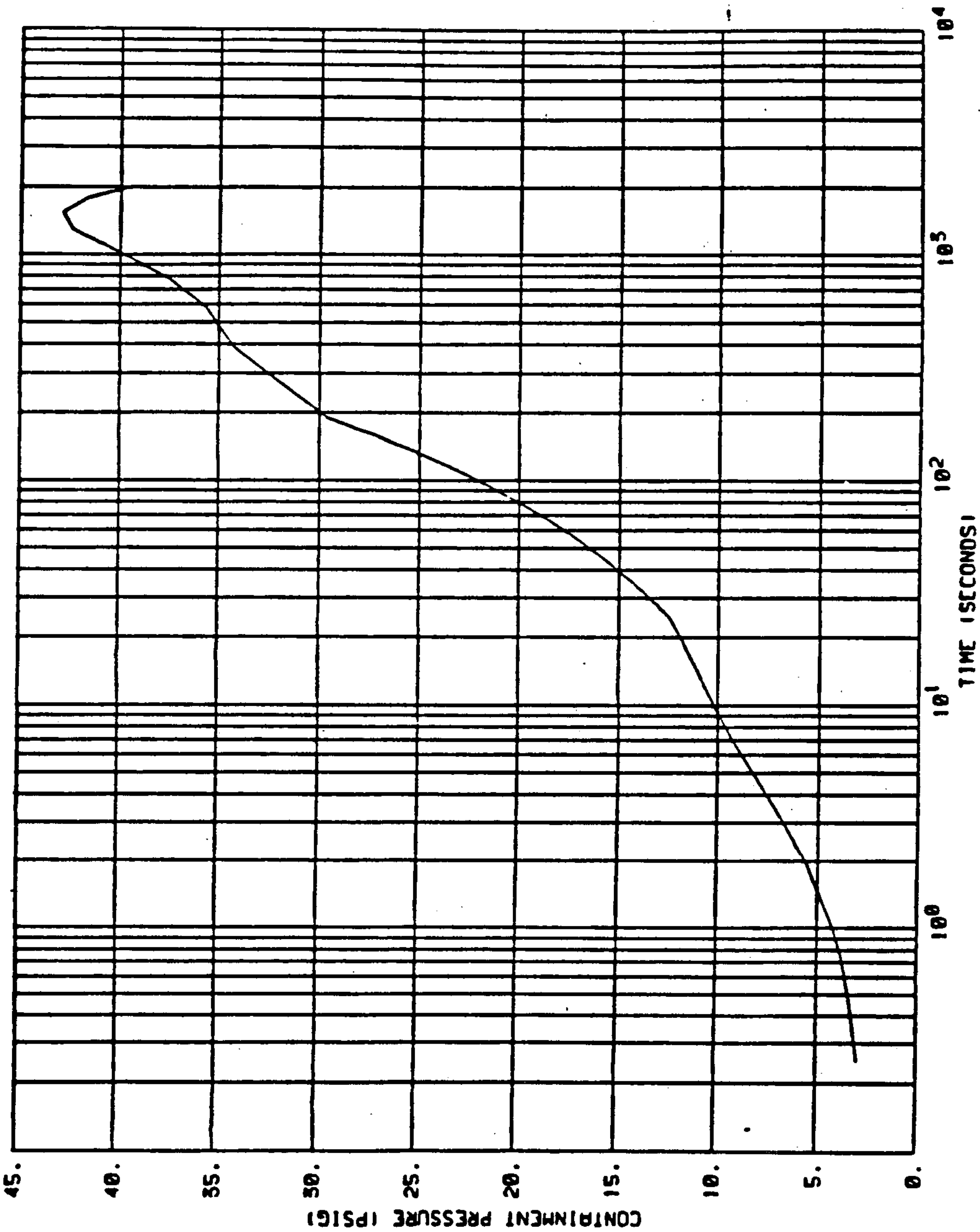


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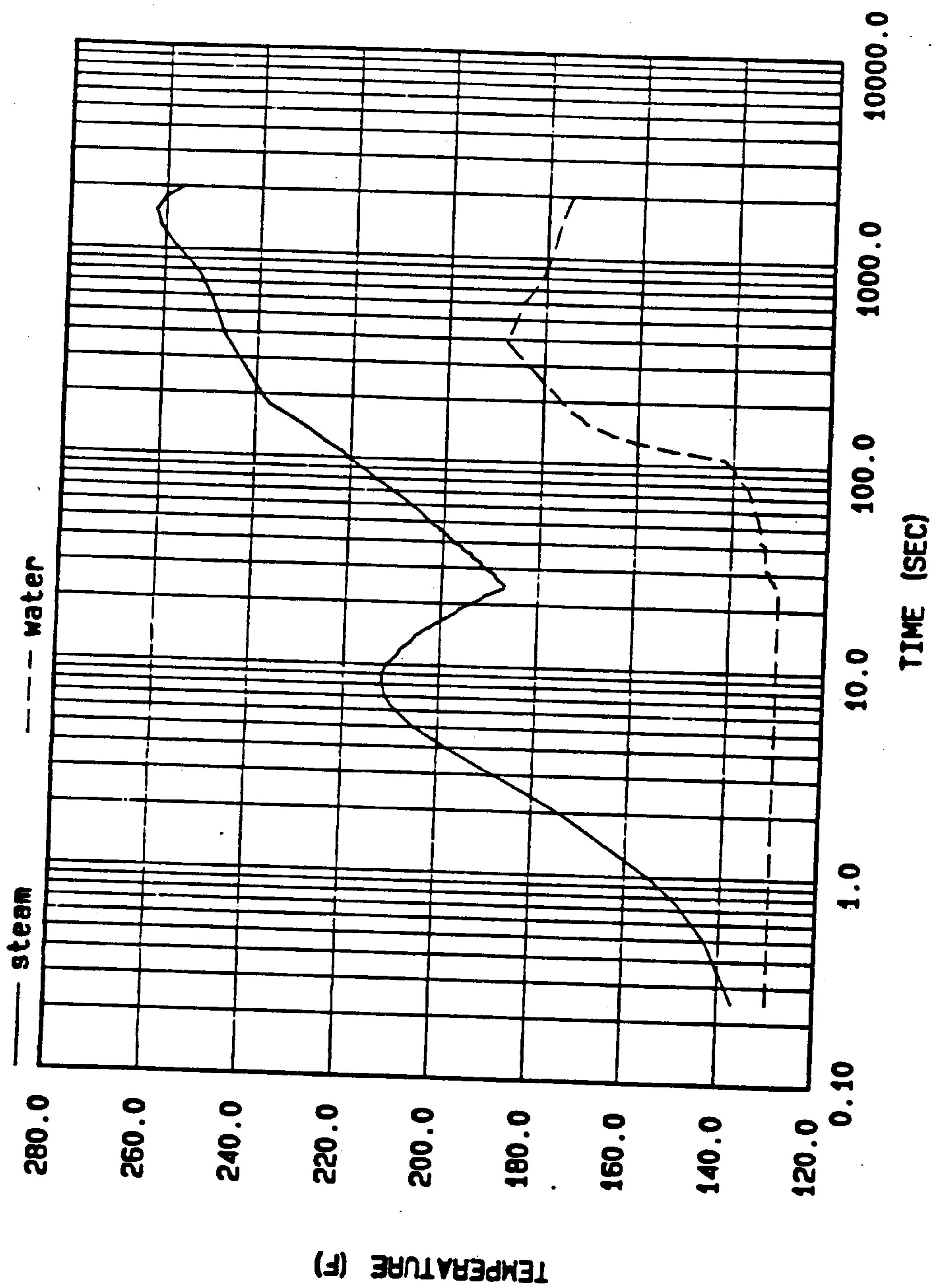
FIGURE 12

CONTAINMENT PRESSURE RESPONSE



INDIAN POINT 3 BIT REMOVAL STUDY	FIGURE 13 CONTAINMENT TEMPERATURE RESPONSE