PROPOSED CHANGE NO. 8

FOR THE

SOUTHWEST EXPERIMENTAL FAST OXIDE REACTOR

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GENERAL ELECTRIC COMPANY

310 DeGuigne Drive

Sunnyvale, California 94086

Proposed Change No. 8

for the

Southwest Experimental Fast Oxide Reactor

I. Introduction

Under the authority of License DR-15, General Electric operates the Southwest Experimental Fast Oxide Reactor at a site near Strickler, Arkansas.

A revision of the current Technical Specifications is desired as described herein. The applicable revised pages of the Technical Specifications are also included as Attachment A.

II. Proposed Changes

Pursuant to the provisions of 10 CFR 50.59, General Electric requests that the SEFOR Technical Specifications be changed by substituting Pages 3.3-2, 3.3-7, 3.10-2, 3.12-1, 3.12-1.1, 3.12-3, 3.12-3.1, 3.12-5, 4.3-1, and 4.4-2.1 in Attachment A of this document for the corresponding pages of the current Technical Specifications and adding pages 3.3-7.1 and 3.12-6.

III. Purpose of the Proposed Change

The changes described in this submittal will accomplish the following purposes:

A. Permit initiation of the Core II transient test program after completing static tests at 10 MW; revise the limit for the maximum allowable poison slug worth for transient tests, so that a linear interpolation for slug worth as a function of Doppler coefficient can be used for Core II transient tests;and remove the mandatory requirement for DRL approval to initiate the super-prompt tests in Core II.

B. Reduce the frequency of fuel surveillance and sodium sampling required during the super-prompt critical test program, based on th experience gained during Core I testing.

C. Clarify the requirements for static and oscillator tests during the Core II test program.

D. Remove an inconsistency in the requirements for reactor operation with the head removed.

IV. Discussion

The proposed Technical Specification changes are discussed individually as follows:

A. Section 3.12, Excursion Tests

1. Initiation of Transient Test Program after completing Static Tests at 10 MWt.

The Technical Specifications as originally written for the SEFOR program reflected the conservative approach to reactor operations considered prudent for the safe "first time through" operation of this test facility. The initial power ascension program and transient tests demonstrated that the reactor performance is predictable, stable, and as expected.(1,2,3) The satisfactory completion of the Core I test program and the excellent agreement between predicted and measured reactor performance has demonstrated that the Doppler coefficient, the power coefficient of reactivity, the isothermal temperature coefficient of reactivity at zero power, and reactor stability can be accurately determined from operation at power levels of 10 MWt and below. Therefore, the static and oscillator tests at power levels up to 10 MWt on Core II will provide a sufficient amount of data to demonstrate that the requirements of Sections 3.3 and 3.12 B.1 have been met. These measurements at power levels up to 10 MWt will enable reactor response during subprompt and superprompt transient tests to be accurately predicted without requiring measurements to full power. If the reactor is to be operated at steady state power levels greater than 10 MWt, additional static tests will be performed as called for in Section 3.10.

2. Adjustment of Permissible Core II Slug Worth

The limits specified for the maximum ejectable poison slug wort were previously set at 1.30\$ for a Doppler coefficient of $T\frac{dk}{dT} = -0.008$, and 1.20\$ for $T\frac{dk}{dT} = -0.005$. The maximum permissible reactivity insertion rate and initial power level for these tests are 20\$/sec and 11 MWt. These limits were based on the analysis of effects resulting from the maximum planned transient with a Doppler coefficient of $T\frac{dk}{dT} = -0.004$.[4] The following table shows the assumed values for this transient and other transients used to establish the present limits in th Technical Specifications.

Table 1

Comparison of Superprompt Critical Transients Analyzed and Technical Specification Limits

	Design* Transient	Maximum Planned Transients*		Tech. Spec. Limits	
Doppler Coefficient ($T\frac{dk}{dT}$)	-0.004	-0.0085	-0.004	-0.008	-0.005
Reactivity Inserted (\$)	1.5	1.3	1.2	1.3	1.2
Reactivity Rate (\$/sec)	50	20	20	20	20
Initial Power (MWt)	7	11.5	9	11	11
Core Coolant Flow (%)	100	100	100	90	90

* Transients Analyzed in Ref. (4).

By comparing values in the above table and referring to the discussion on pages 1-42 and 1-43 of Ref. (4), it can be determined that the transients permitted by the Technical Specifications are comparable to the planned transients previously analyzed.

The value of the Doppler coefficient was determined to be -0.0081 for Core I.[3] Thus, the maximum permissible poison slug worth was 1.3\$. For Core II, the Doppler coefficient will be reduced by approximately 15% to about -0.0069. The actual value will be determined from the results of the static tests prior to initiation of the transient test program for Core II. It is desirable from an experimental viewpoint to perform the superprompt critical transients with the maximum permissible poison slug worth consistent with safety considerations. Therefore, it is proposed that the present limit of 1.2$ for any Doppler coefficient with a magnitude of less than 0.008, be changed to permit a linear interpolation between the present values for the limiting slug worth as a function of Doppler coefficient. This would result in a limiting slug worth of 1.26$ for a Doppler coefficient of -.0069. This method of determining the limit will provide equivalent margins with respect to the design transient for any acceptable value of the Doppler coefficient, as discussed below. The observed values of the dynamic slug worth will be used for comparison to the limits as discussed on page 3 of Ref. (3).

Figure 1 compares the proposed limits for slug worth to the present limits.

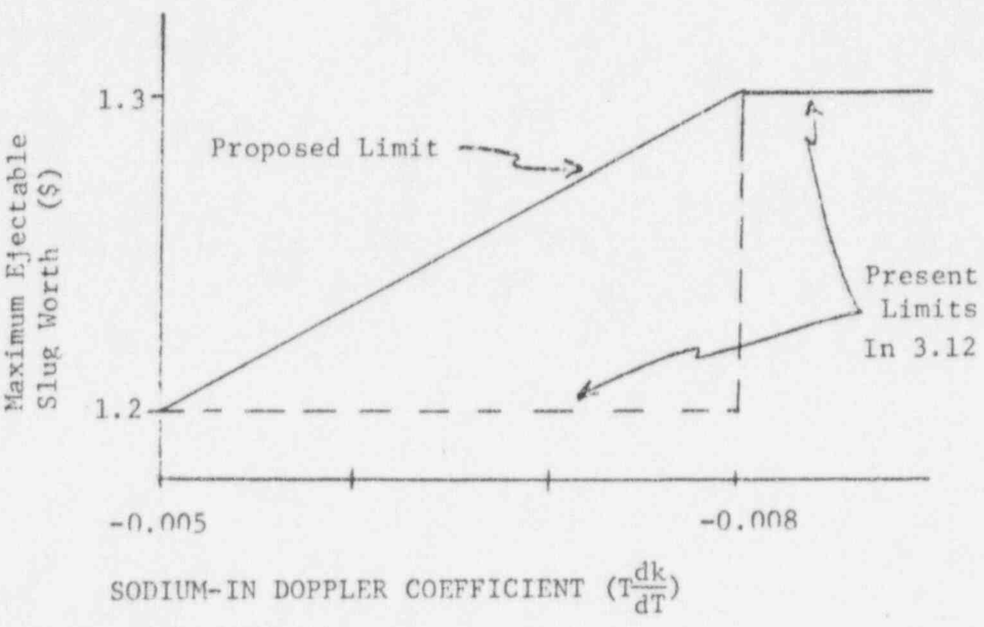

Figure 1. Limits for Poison Slug Worths

The calculated values of power and increase of the average fuel temperature are given in Figures 2 and 3 for transients with Doppler coefficient values of -0.005, -0.006, -0.007, and -0.008, and with reactivity insertion values corresponding to the proposed limit.

From these figures it can be seen that the proposed limits for intermediate values of the Doppler coefficient provide an envelope for transient tests which is consistent with the present limits for Doppler coefficients of -0.005 and -0.008.

It should be noted that the values obtained from Figures 2 and 3 represent the maximum values since they are based on the maximum initial power level consistent with the core loading limit of .50$ and on start of reflector movement (scram) at 0.600 seconds. Thus the proposed limits provide margins with respect to the design transient which are equivalent to the margins provided by the present Technical Specifications for Doppler coefficients of -0.005 and -0.008.

This conclusion is further supported by the excellent agreement between measured and calculated values of reactor power for the superprompt transient tests with Core I.

The data for superprompt transient No. 2 are plotted in Figure 4. Non-Doppler feedback coefficients contribute about 12 percent of the total feedback during the transient. This comparison provides assurance that the results of transient tests for Core II can be accurately predicted by use of the available analytical tools and test data.

Analysis of the superprompt transients for Core I has provided further verification that the value of the Doppler coefficient is $T\frac{dk}{dT} = -0.0081$, as indicated by the comparison of values in Tables 2, 3, 4 and 5.

Eight superprompt critical transients were performed at three different initial power levels using reactivity insertion up to 1.28$. Initial and peak power levels and energy release at 0.3 sec (just prior to scram) are compared with predicted values in Table 2.

The energy release during transients can be determined from the flux measurements of the two U-238 chambers (combined in two instances - Test 1 & 2 - with gamma chambers), and from two energy probes, which are essentially calorimetric devices. A comparison of the energy determined from these four instruments is shown in Table 3.

To obtain an initial estimate of the Doppler effect during the superprompt transients, only the data during the time after ($t \gtrsim 140$ msec) the FRED reactivity insertion has ceased, but prior to the time ($t \gtrsim 300$ msec) of reactor scram, was analyzed. During this time, the only changes in reactivity are those resulting from feedback. Analysis of the complete power trace requires an accurate knowledge of the time-dependent reactivity characteristics of the FRED, while this procedure does not. For the appropriate time interval, the observed time-dependent reactivity change, as determined from the kinetics inversion equation, was plotted against the time-dependent energy release obtained from analysis of the fission chamber data.

Over the limited energy range, the data demonstrated essentially a linear dependence of reactivity upon energy release. The slope of this linear relationship, which is the energy coefficient, as well as the approximate energy interval over which the analysis was performed, is shown in Table 4.

The coefficients in Table 4 were corrected for the calculated non-Doppler (i.e., the fuel and clad axial expansion, sodium and structure effects, etc.) reactivity effect of about 12 percent and they were corrected for the fact that only (0.932)(0.943) = 0.88 of the total energy produced is actually absorbed in the fuel during the short time interval under consideration.[5]

The resultant averaged Doppler energy coefficients, in units of cents per MW-sec of energy absorbed in the fuel, are compared in Table 5 with the results obtained from the subprompt tests, and with results calculated for the energy range and initial power level (see Table 4) used for the measurement. As the data of Table 5 indicate, all transient Doppler results show good agreement with a Doppler $T\frac{dk}{dT}$ of -0.0081, which verifies the previously determined value of -0.0081 obtained during the power ascension tests.

3. Removal of the Mandatory Requirement for DRL Approval to Initiate Superprompt Critical Tests in Core II

The requirement that the prompt critical test program cannot be initiated until DRL completes a review of all test information up through the subprompt critical tests and determines if additional specifications are required was based on a lack of sufficient experimental data prior to Core I testing to support the adequacy of the Technical Specification limits. The successful completion of the Core I experimental program as discussed above has demonstrated the adequacy of these limits and the ability to predict the performance of Core II, which represents only a small extrapolation from Core I. Further, the license requires reporting of anomalous behavior, which assures prompt reporting of any observed deviations during Core II tests from that predicted. As a result, a mandatory review and approval by DRL should not be necessary prior to initiation of the Core II superprompt tests.

B. Paragraphs 4.3C and 4.4O - Fuel Surveillance and Sodium Sample Analysis for Superprompt Tests

Data obtained from fuel surveillance and sodium sample analysis during Core I superprompt transient tests showed no effects resulting from the transient tests. In the unlikely event that fuel failure occurred during a transient test, the cover gas monitor and spectral analysis of cover gas samples (required before and after each transient above 90¢ by Paragraph 4.4P) would provide the most sensitive means of detecting the failure. The fuel rod examination and sodium sample analysis provide back-up information. Therefore, it can be concluded that fuel rod examinations and sodium sample analysis performed after every other prompt critical transient when combined with on-line cover gas monitor measurements and cover gas spectral analysis performed after each prompt critical transient will provide reasonable assurance that Specification 3.12 B.10 will be complied with.

In addition, the consequences of performing a transient test with a failed fuel rod which admits sodium have been evaluated[6] and it was determined that such a condition would not lead to gross clad rupture.

C. Section 3.10 - Approach to Power

The results for conventional oscillator tests performed on Core I have been presented previously in Refs. (1) and (2). These results have demonstrated the stability of the reactor. The change to Core II is estimated to reduce the magnitude of the negative Doppler coefficient from the Core I value of .0081 to a value of .0069 (a change of 15 percent). Analysis has shown that a change in the Doppler coefficient of ± 20 percent from a value of -0.0085 will yield minimal changes in the SEFOR core transfer function.[7] For Core I the phase margin at the point where the Nyquist plot crosses the unit circle was measured to be between 73° and 83.5° for power levels from 2 MWt to 17.5 MWt.[8] The estimated change in the Doppler coefficient for Core II will have a minimal effect on the phase margin determined for Core I, and thus for Core II the phase margin will be substantially greater than the required minimum of 30°.

D. Specification 3.3M - Inoperable Gross Gamma Cover Gas Monitor

The change to Specification 3.3M and the basis for Section 3.3 will remove an inconsistency which requires that the reactor be shut down if the gross gamma monitor is inoperable (Para. 3.3M) but permits operation with the reactor head removed (Section 3.9). Operation with the reactor head removed results in dilution of the reactor cover gas which significantly reduces the effectiveness of the gross gamma monitor.

The proposed change will eliminate this inconsistency by excepting operations with the reactor head removed from the requirements of Paragraph 3.3M. Section 3.9 limits the reactor power to less than 500 KWt with the reactor head removed, and the planned tests are performed at power levels of 100 KWt or less. At this low power there is no need for on-line monitoring of the reactor cover gas for fission gases since the low fuel and clad temperatures preclude the possibility of anomalous fuel rod performance.

References

1. General Electric Breeder Reactor Development Operation, "SEFOR Reactivity Coefficients - as Determined from Tests Through 10 MW," submitted to the AEC-DRL on December 2, 1970, pages 8-10.

2. General Electric Breeder Reactor Development Operation, "Results for Core I of Power Ascension and Conventional Oscillator Tests to 20 MWt," submitted to the AEC-DRL on June 16, 1971, pages 55-111.

3. General Electric Breeder Reactor Department, "Results of the Familiarization and Sub-Prompt Critical Transients for Core I," submitted to the AEC-DRL on July 16, 1971, page 3.

4. SEFOR-FDSAR, Supplement 10, Section 1.3, pp. 1-42 through 1-70.

5. Op. cit., Ref. 3, page 22.

6. General Electric Breeder Reactor Development Operation, "Additional Information Regarding Sodium Logging of SEFOR Fuel Rods," submitted to AEC-DRL on February 1, 1971.

7. Noble, L. D., and Wilkinson, C. D., "Final Specifications for the SEFOR Experimental Program," General Electric Advanced Products Operation, January, 1968, (GEAP 5576), pages 5-67 through 5-73.

8. General Electric Breeder Reactor Development Operation, "Revision No. 1 of Proposed Change No. 4 for the Southwest Experimental Fast Oxide Reactor," submitted to the AEC-DRL on December 11, 1970, pp. 4, 5.

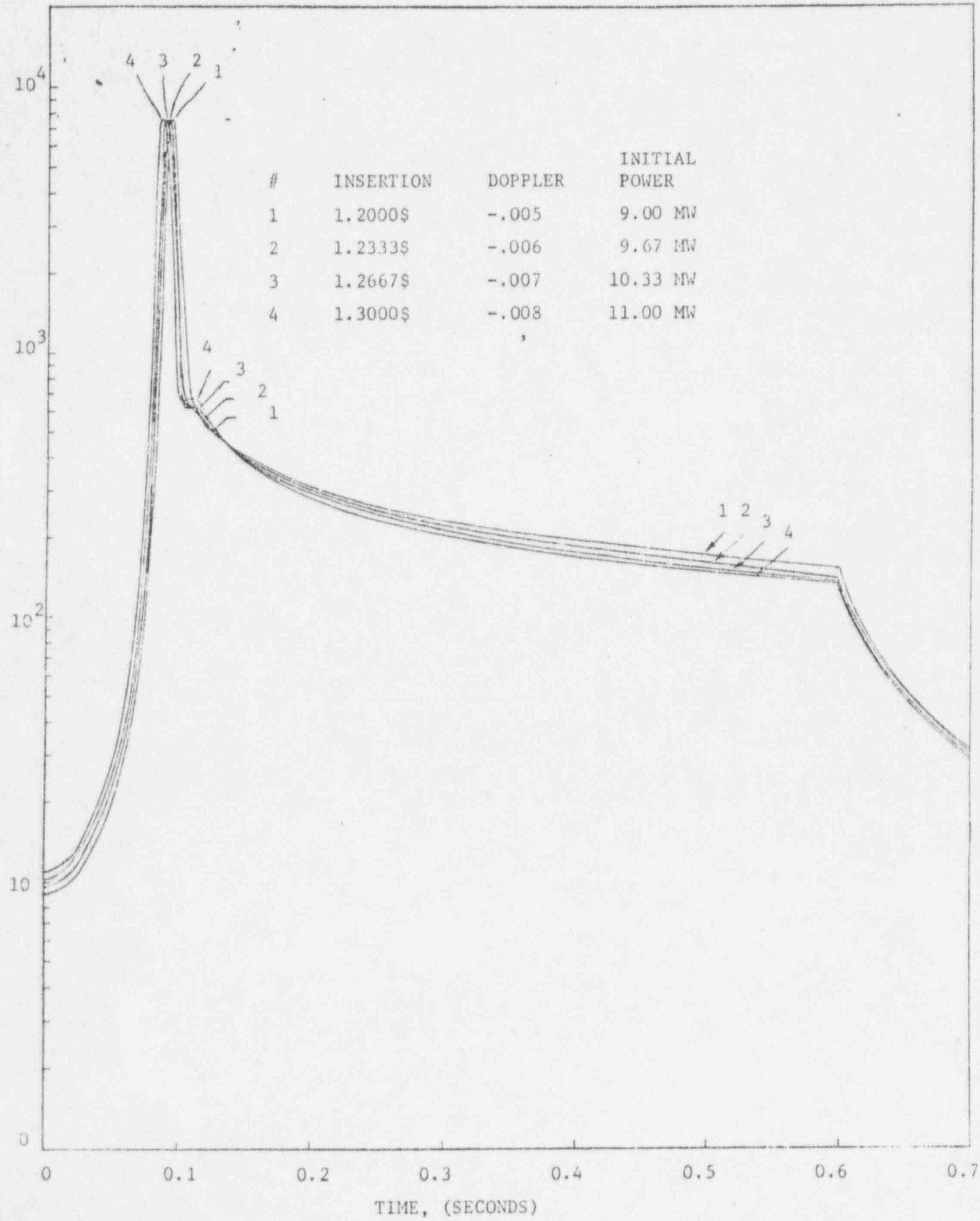

FIGURE 2: POWER DURING SUPER-PROMPT CRITICAL TRANSIENTS

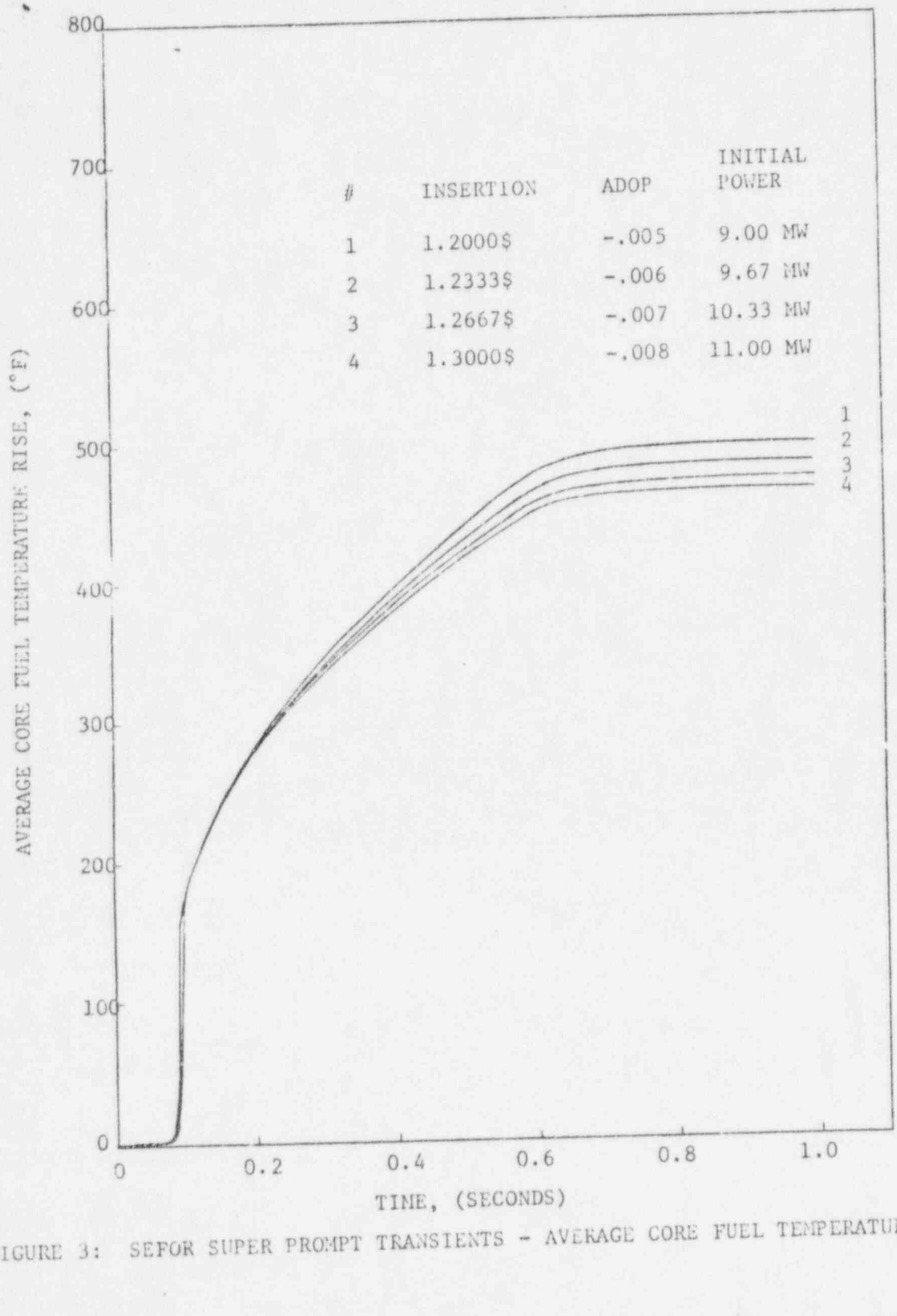

FIGURE 3: SEFOR SUPER PROMPT TRANSIENTS - AVERAGE CORE FUEL TEMPERATURE RISE

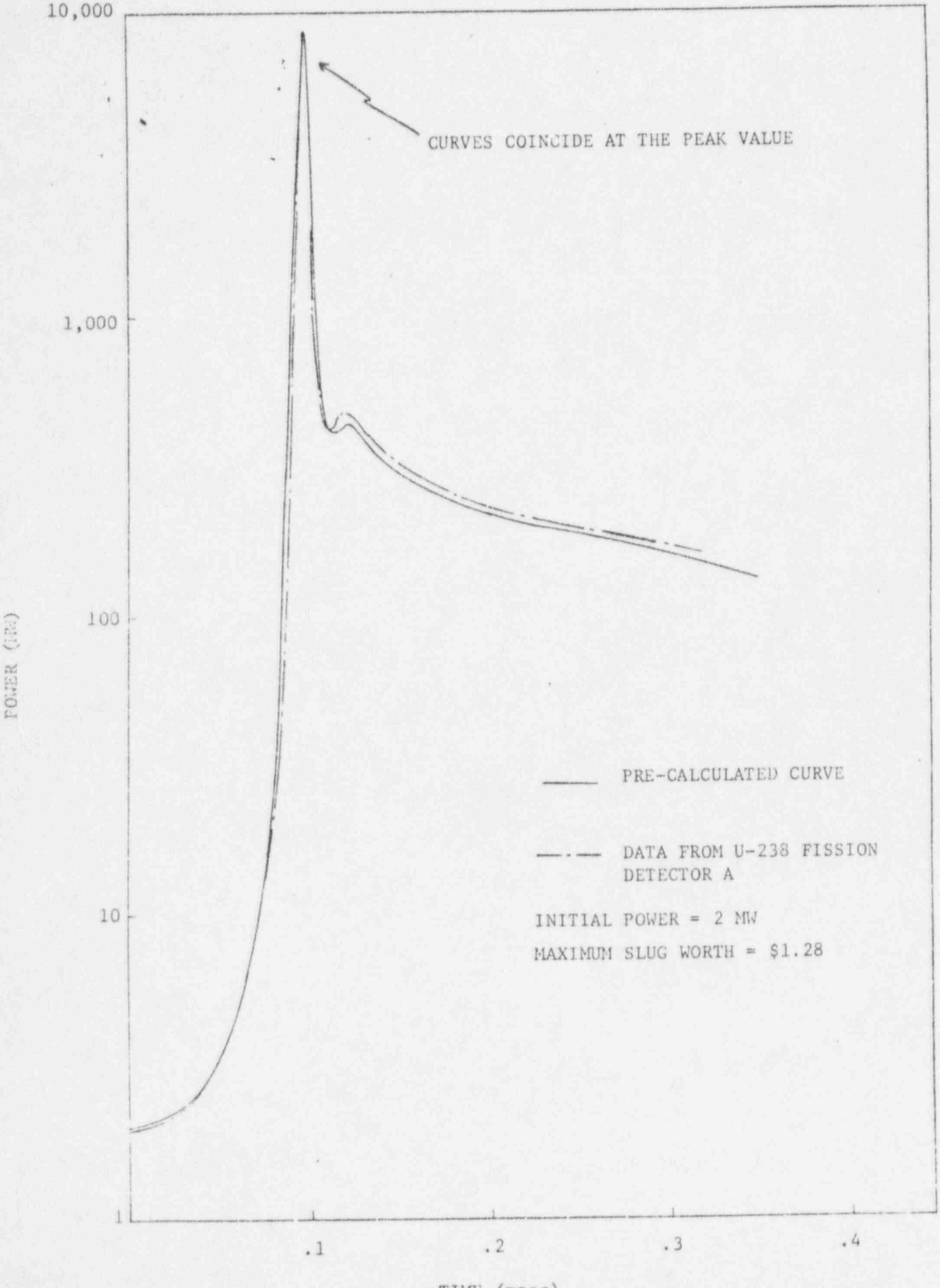
10,000
1,000
100
10
1
POWER (MW)
CURVES COINCIDE AT THE PEAK VALUE
PRE-CALCULATED CURVE
DATA FROM U-238 FISSION DETECTOR A
INITIAL POWER = 2 MW
MAXIMUM SLUG WORTH = $1.28
.1
.2
.3
.4
TIME (msec)

TABLE 2

Test	Initial Power (MW)	Slug Worth ($)	Peak Power Level Measured (MW)	Peak Power Level Predicted* (MW)	Energy Release to 0.3 sec. Measure (MW-sec)	Energy Release to 0.3 sec. Predicted* (MW-sec)
1	2.0	1.18	5300	5400	82	80
2	2.0	1.28	9000	8800	108	105
3	2.0	1.28	8800	8800	106	105
4	5.0	1.18	4900	5300	93	95
5	5.0	1.28	8200	8600	120	125
6	8.0	1.18	5100	5300	108	110
7	8.0	1.28	8300	8500	135	140
8	8.0	1.28	8400	8500	136	140

* For a Doppler Coefficient $(T\frac{dk}{dT}) = -0.0081$.

TABLE 3

COMPARISON OF MEASURED ENERGY RELEASE
FOR SUPER-PROMPT TRANSIENTS

Test	ENERGY RELEASE* (MW-sec)			
	SEFOR Energy Probe #1	SEFOR Energy Probe #2	Fission Detector A	Fission Detector B
1	43	47	46	43
2	62	65	62	64
3	58	65	60	59
4	50	56	49	48
5	69	77	66	64
6	62	64	56	56
7	75	84	73	70
8	73	78	74	70

* At 120 msec after lift-off.

TABLE 4

SUPER-PROMPT TRANSIENT ENERGY COEFFICIENTS

Test	Initial Power (MW)	Slug Worth (\$)	Energy Range (MW-sec)	Measured Energy Coefficient (¢/MW-sec)
1	2	1.18	50→75	-0.47
2	2	1.28	70→110	-0.45
3	2	1.28	70→110	-0.45
4	5	1.18	60→90	-0.42
5	5	1.28	75→115	-0.42
6	8	1.18	70→100	-0.39
7	8	1.28	90→125	-0.39
8	8	1.28	90→125	-0.38

TABLE 5

TRANSIENT TEST RESULTS

Initial Power (MW)	Slug Worth ($)	Measured Doppler Energy Coefficient (¢/MW-sec)	*Calculated Doppler Energy Coefficient (¢/MW-sec)
2	0.97	-0.56	-0.54
2	1.18	-0.47	-0.49
2	1.28	-0.45	-0.46
5	0.97	-0.45	-0.45
5	1.18	-0.42	-0.42
5	1.28	-0.42	-0.40
8	1.18	-0.39	-0.37
8	1.28	-0.38	-0.36
10	0.97	-0.35	-0.37

* Calculated with $T\frac{dk}{dT} = -0.0081$.