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KINETICS CALCULATIONS FOR RIA EXPERIMENTS IN THE POWER BURST FACILITY

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SUMMARY

The Reactivity Initiated Accident (RIA) test series is being conducted in the Power Burst Facility (PBF) to provide information on nuclear fuel rod behavior during postulated accidents involving sudden rapid transients in power reactors. During a typical RIA experiment the PBF is operated in the "natural burst" mode, exposing one or more commercial-type fuel rods located in the central experiment space to a large, rapid and nearly adiabatic deposition of fission energy. This prompt energy deposition is followed by an extended (several-minute) period of delayed energy deposition caused by the release of delayed neutrons into the subcritical PBF core after the control rods are inserted to terminate the transient. The delayed component of the deposited energy can be as much as 15-25% of the total. Some of the techniques used to measure energy deposition in the test fuel during RIA experiments do not distinguish between the prompt and delayed components. Others do not, for various reasons, give reliable results for the delayed component. Accordingly, reactor physics calculations have been completed to compute the delayed fraction of both the total fissions and the total energy deposition in the test fuel rods for five RIA experiments conducted in the recent past. The calculated delayed fractions should be useful in correctly interpreting results obtained from the various measurements of the energy deposited in the test fuel during each RIA experiment.

Two independent techniques were used to compute the delayed fractions; 1) a method based on steady-state neutronics calculations for the PBF core and experiment space, and 2) space-time kinetics calculations. Due to geometric limitations inherent in the computer program used for the "steady-state" approach, the space-time kinetics results are more physically realistic. They are given below:

Experiment	Post Burst Fraction of Total Fissions Occurring in the Test Fuel	Post Burst Fraction of Total Energy Deposited in the Test Fuel
RIA ST-1 PB-1	0.150	0.193
RIA ST-1 PB-2	0.147	0.190
RIA ST-2	0.148	0.191
RIA ST-3	0.152	0.195
RIA 1-1	0.140	0.184

Finally, since space-time kinetics calculations were employed, it has been incidentally possible to obtain information concerning the speed with which the spatial neutron flux distribution in the PBF shifts to a new asymptotic shape in response to a change in reactor conditions, particularly a change due to control or transient rod motion. The calculations have shown that, for transients with periods of interest to the RIA test program, the time required for a shape change to occur is insignificant compared to the total length of the prompt portion of the burst. This is as expected and simply verifies the usual assumption that the spatial power shape in the PBF is in an asymptotic mode for the entire significant portion of the burst.

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1.0 INTRODUCTION

The Reactivity Initiated Accident (RIA)[1] test series is being conducted in the Power Burst Facility (PBF) to provide information on nuclear fuel rod behavior during postulated accidents involving unexpected rapid transients in power reactors. The data obtained will be used for evaluation and possible revision of, a) current reactor licensing criteria and, b) computational models used to predict reactor fuel thermal and mechanical behavior during normal and off-normal conditions. Several RIA experiments, listed in Table I, have already been completed. Others are planned for the future.

During a typical RIA experiment the PBF is operated in the "natural burst"[2] mode, exposing one or more commercial-type fuel rods located in the central experiment space to a large, rapid, and nearly adiabatic deposition of fission energy. This prompt energy deposition is followed by an extended (several-minute) period of delayed energy deposition caused by the release of delayed neutrons into the subcritical PBF core after the control rods are inserted to terminate the transient. The delayed component of the deposited energy can be as much as 15-25% of the total. It is of central importance to each of the RIA experiments that the relative and absolute magnitudes of both the prompt and delayed energy deposition be well-known. Several independent measurement techniques have been employed for this purpose. Flux wires, self powered neutron detectors (SPND's), ion chambers, and post-test burnup analysis of the RIA fuel rods have all been employed. Details are given in Appendix B. The results of these measurements have not always been acceptably in agreement with each other for a given experiment. To resolve these discrepancies it is important (among other things) to correctly account for post-burst delayed neutron multiplication in the PBF since such a significant portion of the total energy deposition in an RIA test fuel rod can occur after termination of the burst. This energy might not be accurately measured by the SPND's

TABLE I

RIA EXPERIMENTS CONDUCTED TO DATE

Test	Description	Reactor Period (ms)	Pre-Test Target Energy (cal/g UO2)
RIA ST1 PB1	RIA Scoping Test 1, Power Burst 1 (Single Rod)	5.7	200
RIA ST1 PB2	RIA Scoping Test 1, Power Burst 2 (Single Rod)	4.4	245
RIA ST2	RIA Scoping Test 2 (Single Rod)	4.6	250
RIA ST3	RIA Scoping Test 3 (Single Rod)	5.2	215
RIA ST4*	RIA Scoping Test 4 (Single Rod)	3.85*	475
RIA 1-1	RIA 1-1 (Four Rods, 2 Fresh, 2 Depleted)	3.1	215-220
RIA 1-2*	RIA 1-2 (Four Rods, All Depleted)	4.3*	180

*Kinetics calculations not done for RIA ST4 and RIA 1-2.

and core chambers, but would be included in the burnup-based energy measurements (and also in the flux wire data). Accordingly, this report is primarily a description of calculations done to provide estimates of post-burst test fuel energy deposition for each of five RIA experiments conducted to date. Also, since this effort has involved space-time reactor kinetics calculations, the report includes incidentally obtained information verifying the usual assumption that the neutron distribution in the PBF core and test space assumes an asymptotic spatial shape appropriate to each RIA transient before any significant sensible power is generated in the test fuel. This assumption has always been made during design and performance analysis of the various RIA test assemblies in the PBF since one can then compute the power distribution in the core and test fuel during the burst using inexpensive static neutronic analysis techniques rather than more costly space-and time-dependent kinetics calculations.

2.0 METHODS FOR COMPUTING THE POST-BURST ENERGY DEPOSITION IN RIA EXPERIMENTS

Consider the following extremely simplified, but illustrative case of an infinitely large, subcritical reactor. The multiplication factor for this reactor is given by:

$$K = \frac{\nu\Sigma_f}{\Sigma_a} < 1.0 \qquad (2.1)$$

where $\nu\Sigma_f$ and Σ_a have the usual definitions. Using intuitive arguments, suppose that at time t = 0, the reactor momentarily becomes supercritical and exactly one fission takes place, producing $(1-\beta)\nu$ prompt and $\beta\nu$ delayed neutrons, where β is the delayed fraction for the reactor. These $\beta\nu$ delayed neutrons cause $\beta\nu\Sigma_f/\Sigma_a = \beta K$ fissions, producing $\nu\beta K$ more neutrons (prompt + delayed). These $\nu\beta K$ neutrons cause $\nu\beta K\Sigma_f/\Sigma_a = \beta K^2$ fissions, producing $\nu\beta K^2$ more neutrons. These $\nu\beta K^2$ neutrons cause $\nu\beta K^2/\Sigma_f/\Sigma_a = \beta K^3$ fissions and so forth. The total number of fissions that will result from the introduction of $\nu\beta$ delayed neutrons (which came from 1 original fission) is given by

*For simplicity, the K for the delayed neutrons is assumed equal to the K for the prompt neutrons. This is not true because the prompt and delayed neutron energy emission distributions differ and cause differences in Σ_f and Σ_a. However it is nearly the case for an infinite thermal reactor in which Σ_f and Σ_a differ insignificantly with fast neutron energy spectrum changes.

$$\text{Total Delayed Fissions} = F_t = \sum_{n=1}^{\infty} \beta K^n = \frac{\beta K}{1-K} \qquad (2.2)$$

If for example we assume that K = 0.95, (typical for the PBF with the control rods full-in and the transient rods full-out) Equation (2.2) gives a delayed fission ratio of 0.14 for the PBF effective delayed fraction of β= 0.0072. Thus, each fission during a transient will eventually be followed by .14 more fissions during the delayed tail after the control rods are inserted to terminate the burst, according to this simple model. Actually, the situation for the PBF is considerably more complex since spatial effects will be present, and the multiplication during the burst and tail is constantly changing due to temperature feedback. The most realistic way to compute the delayed multiplication in the RIA experiment fuel is to do full multi-dimensional space-time kinetics calculations with thermal feedback for the PBF core and test space. This is the approach ultimately taken in this work. However, it is also possible to approximately account for spatial effects on the delayed multiplication by using static neutronic codes, at considerable savings in computer expense. Section 2.1 describes this approach, while Section 2.2 documents the space-time kinetics methods by which the delayed neutron multiplication was actually computed for the RIA experiments.

2.1 An Approximate Steady-State Method for Computing Delayed Neutron Multiplication in the PBF

If it is assumed that the power shape in the PBF during a short burst is constant, then the fission density during the burst can be written:

$$F_b(\bar{r},t) = f_b(\bar{r})\, T_b(t) \qquad (2.3)$$

where the spatial fission distribution $f_b(\bar{r})$ can be computed adequately by solving the steady-state problem for the reactor condition existing during the burst. The function $T_b(t)$ is simply a unitless function of time that accounts for the relative change in power density at any point $\bar{r}$ with respect to time.

The time-integrated fission density for the burst is then:

$$F_b(\bar{r}) = \int_0^{t_b} F_b(\bar{r},t)dt = f_b(\bar{r}) \int_0^{t_b} T_b(t)dt \qquad (2.4)$$

where t_b is the burst duration time. Since $T_b(t)$ is arbitrary in magnitude, its time integral in Equation (2.4) can be set to unity (one second) so that:

$$F_b(\bar{r}) = f_b(\bar{r}) \quad \text{fissions/cm}^3 \qquad (2.5)$$

The neutron source distribution $s_b(\bar{r})$ (neutrons/cm^3-sec), calculated in the steady-state solution for $f_b(\bar{r})$ is consistent with $f_b(\bar{r})$ such that the total number of prompt neutrons and delayed neutron precursors per cm^3 produced during the burst at r is:

$$S_b(\bar{r}) = s_b(\bar{r}) \int_0^{t_b} T_b(t)\, dt = s_b(\bar{r}) \quad \text{neutrons/cm}^3 \qquad (2.6)$$

If β_i is the fraction of the total number of neutrons that are produced by the i'th delayed neutron precursor with decay constant λ_i (sec^{-1}), then the delayed source distribution in the subcritical scrammed reactor after the burst can be written as

$$S_d(\bar{r},E,t) = s_b(\bar{r})\ \chi_d(E)\ T_d(t) \qquad (2.7)$$

where $\chi_d(E)$ is the spectrum of delayed neutron emission normalized such that

$$\int_0^{\infty} \chi_d(E)\, dE = 1.0 \qquad (2.8)$$

and

$$T_d(t) = \sum_i \beta_i\, \lambda_i\, e^{-\lambda_i(t-t_p)}* \qquad (2.9)$$

If the $\bar{r}$ and E-dependent part of the delayed neutron source $S_d(r,E,t)$ (that is, $s_b(\bar{r})$ and $\chi_d(E)$) is input as a fixed-volume source to a steady-state calculation that represents the subcritical reactor after the burst, then the fission distribution that results is actually the $\bar{r}$ distribution of

*Since the burst duration t_b is small compared to the lifetimes of the precursors it is reasonable to simplify the expression for $T_d(t)$ by assuming that all precursors are formed at the time t_p, of peak burst power.

total fissions $f_d(\bar{r})$* (fissions/cm^3) that will result from the release of $s_b(\bar{r})$ neutrons/cm^3 with spectrum $\chi_d(E)$ in the subcritical reactor. The magnitude, distribution and time rate of occurrence of the fissions caused in the subcritical reactor by the appearance of the delayed neutrons generated during the burst is then given by the product of $f_d(\bar{r})$ and $T_d(t)$; hence:

$$F_d(\bar{r},t) = f_d(\bar{r})\, T_d(t) = f_d(\bar{r}) \sum_i \beta_i\, \lambda_i\, e^{-\lambda_i(t-t_p)} \qquad (2.10)$$

To obtain the total number of fissions at any point $\bar{r}$ occurring during the post-burst tail we integrate Equation (2.10) over time, starting at t_b.

$$\begin{aligned} F_d(\bar{r}) &= \int_{t_b}^{\infty} f_d(\bar{r}) \sum_i \beta_i\, \lambda_i\, e^{-\lambda_i(t-t_p)}\, dt \\ &= f_d(\bar{r}) \sum_i \beta_i e^{-\lambda_i(t_b-t_p)} = f_d(\bar{r})\beta_{t_b} \end{aligned} \qquad (2.11)$$

At any point $\bar{r}$ the ratio of fissions occurring after the burst to fissions occurring during the burst is then simply the ratio of the two fission distributions $F_d(\bar{r})$ and $F_b(\bar{r})$, obtained from the two coupled steady-state calculations - corrected for the decay of precursors during the burst, that is

$$R(\bar{r}) = \frac{F_d(\bar{r})}{F_b(\bar{r})} = \frac{f_d(\bar{r})}{f_b(\bar{r})} \sum_i \beta_i e^{-\lambda_i(t_b-t_p)} = \frac{f_d(\bar{r})}{f_b(\bar{r})}\beta_{t_b} \qquad (2.12)$$

This ratio accounts for the fact that, for example, the neutron multiplication near the experiment space may be different than the average neutron multiplication for the overall core after the burst. The numerator and denominator of Equation (2.12) can be integrated over any reactor region of interest, in our case, the test fuel. The resulting ratio will be the ratio of fissions occurring after the burst to fissions occurring during the burst for that region, independent of the rest of the reactor.

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* In the PBF, the changes in coolant and fuel temperatures after the burst produce so small a change in the fission distribution with respect to $\bar{r}$ that it is reasonable to assume a time dependent $\bar{r}$ distribution, $f_d(\bar{r})$ for the fissions occurring after the burst. The space-time kinetics calculations have verified this assumption.

This derivation, while accounting for spatial effects to any degree of detail required (1-D, 2-D, 3-D, coarse or fine mesh, etc.) does not account for time-dependent-multiplication; i.e., one average subcritical K is assumed for the reactor after the burst. This K will be the eigenvalue associated with the subcritical reactor condition assumed when solving the fixed-source problem to obtain $f_d(\bar{r})$. Also, in writing the time dependence for the tail fission rate in Equations (2.9) and (2.10), it is assumed for simplicity that delayed neutrons produced during the tail are emitted simultaneously with the prompt neutrons. Although the time dependence in Equations (2.9) and (2.10) is not strictly correct, the time integrals appearing in Equations (2.11) and (2.12) are correct.

To apply this method to RIA experiments in the PBF, we use the SCAMP* S_n transport program. The PBF is modeled in one-dimensional radial geometry for the case where a single 20%-enriched fuel rod, surrounded by water, is located in the central experiment space. Figure 1 shows the actual PBF core and experiment space, looking down from the top. A standard, 32-group cross section library[4] provided neutron constants for all materials assumed to be present. Details of the SCAMP model are given in Appendix C. An eigenvalue calculation is first run for the reactor condition assumed to exist during the burst, i.e., with hot core fuel and enough boron concentration in the control rod ring to represent a reactor configuration that is just critical on prompt neutrons alone at the top of the burst. This provides the fission distribution and corresponding fission neutron source and delayed precursor distribution for the burst. These are $f_b(\bar{r})$ and $s_b(\bar{r})$ in Equations (2.3) and (2.6). The pointwise fission neutron source (normalized by SCAMP such that its volume-energy integral over the entire reactor is 1.0 neutrons/second) is punched out on cards. A simple computer program, listed in Appendix C reads these cards, assigns a delayed spectrum ($X_d(E)$) at each space point and punches out the results on cards in a format suitable for input to SCAMP as a pointwise, energy-dependent fixed source. The total

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*SCAMP is not documented for outside use. In radial geometry it is a multigroup version of the TOPIC[3] program.

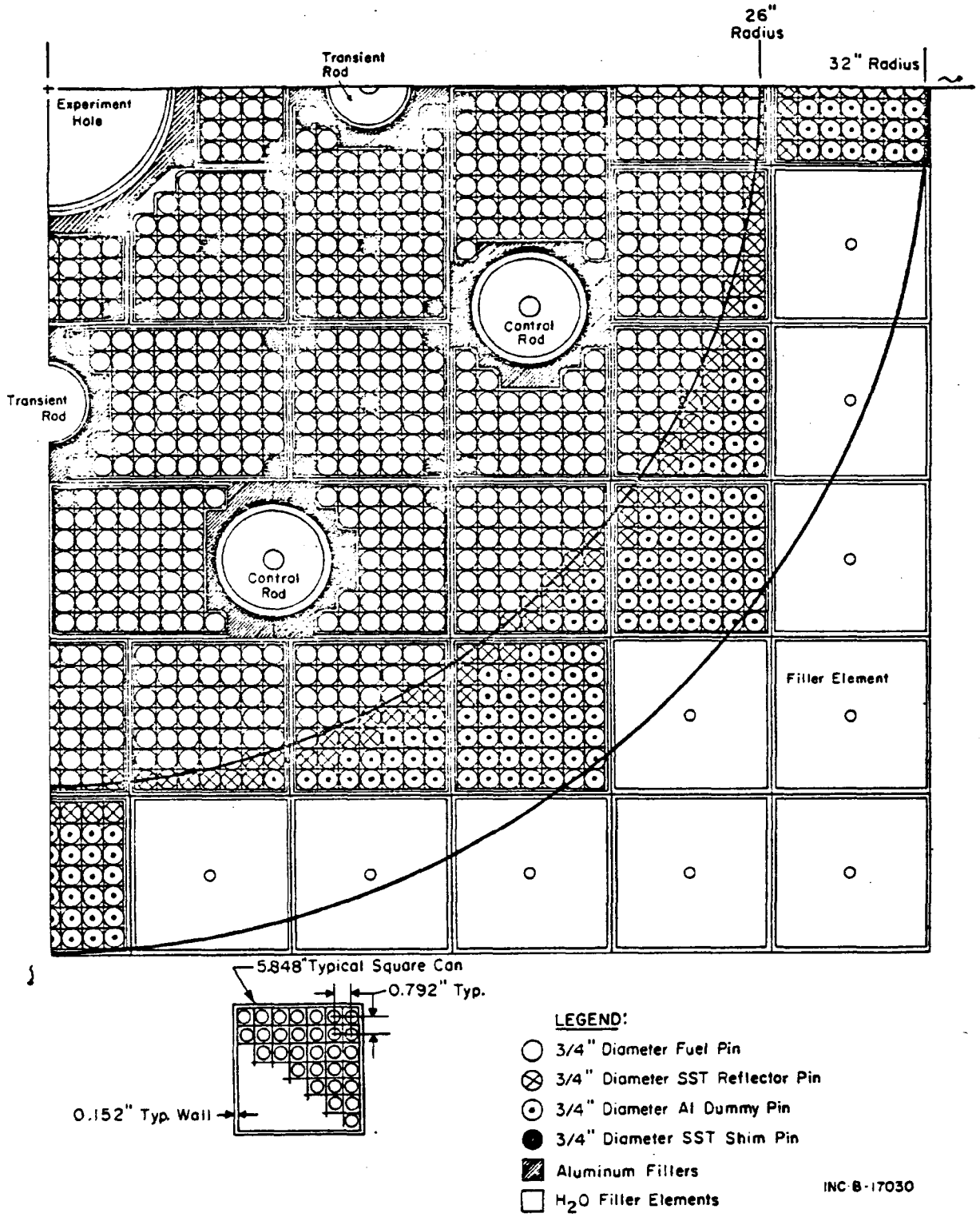

Figure 1. Quarter core plan view of the finalized PBF core design.

volume- and energy-integrated magnitude of this fixed source is still normalized to 1.0 neutrons/second. This fixed source corresponds to the product of $s_b(\bar{r})$ and $\chi_d(E)$ in Equation (2.7).

The delayed, fixed source is then input to a second SCAMP "Fixed Source with Fissions" calculation, set up to represent the subcritical reactor configuration after the burst. The fuel is still assumed to be hot and enough boron poison is included in the control rod region to produce the desired degree of subcriticality. This calculation produces the fission distribution $f_d(\bar{r})$ fissions/cm^3-sec corresponding to a fixed source of $s_b(\bar{r})\ \chi_d(E)$ delayed neutrons/cm^3-sec introduced into the subcritical reactor. It also represents the <u>total</u> number of fissions/cm^3 that would occur at each point if <u>one</u> neutron (with distribution $s_b(\bar{r})$ and spectrum $\chi_d(E)$) were suddenly to appear in the subcritical reactor at zero power and fissions were counted until the power decayed back to zero. This is true since SCAMP can be thought of as solving for either flux or fluence, depending on whether the fixed source is assumed to be neutrons/cm^3-sec or just neutrons/cm^3. This type of calculation can take hundreds of outer iterations to converge, depending on how close the reactor is to criticality. It will obviously never converge if the reactor is just critical or above. It should be mentioned that only the <u>source</u> spectrum $\chi_d(E)$ in the subcritical SCAMP should be a delayed neutron spectrum. The <u>fission</u> spectrum in both the burst SCAMP and the subcritical SCAMP should be that corresponding to total neutron emission.

Given $f_d(\bar{r})$ and $f_b(\bar{r})$ computed as described above, where $f_d(\bar{r})$ is consistent with a fixed source of 1.0 delayed neutrons and $f_b(\bar{r})$ is consistent with a total prompt plus delayed fission source of 1.0 neutrons, Equation (2.12) can be evaluated upon computing delayed fraction as corrected for delayed precursor decay during the burst. In our case it is more appropriate to compute the ratios of selected volume integrals of $f_d(\bar{r})$ and $f_b(\bar{r})$ using the SCAMP regionwise fission rate (power) edits and then apply the decay-corrected delayed fraction. Typical SCAMP input decks for the burst and tail calculations are shown in Appendix C. Section 3.1 gives a detailed demonstration of this method for one case.

2.2 Space-Time Kinetics Calculations for Delayed Neutron Multiplication in the PBF

The "steady-state" model described previously will yield a computed delayed fission fraction that is extremely sensitive to the assumed degree of subcriticality (shutdown margin) after termination of the burst. This is a consequence of Equation (2.2). In the physical situation, the shutdown margin changes during a few-minute period following a burst, primarily because the core fuel is cooling off. Also, the shutdown margin following a burst is dependent upon the total energy released during the burst (and thus on the burst period). If cross sections are computed to reflect the true core temperature (or perhaps some time average) for the time period after a given burst then the steady-state model can be made to approximately account for these effects. Another, more realistic (and expensive) approach is to model the entire transient (burst and tail) using space-time kinetics calculations for the core and test space, accounting explicitly for changes in control rod position and for space- and time-dependent fuel temperatures. One can then directly obtain the fraction of fissions occurring in the test fuel during the tail or any other arbitrary segment of time during the transient since the power-time history and the power-time integral as a function of time for any region of interest are computed directly.

To do this, we employ a modified version of the TWIGL[5] program. TWIGL solves the coupled space- and time-dependent neutron diffusion and thermal-hydraulic equations for a reactor in two-dimensional rectangular (X-Y) or cylindrical (R-Z) geometry. The thermal-hydraulic treatment in TWIGL is somewhat limited, but still applicable to the PBF where the primary reactivity feedback mechanism due to thermal effects is Doppler broadening of the fuel absorption resonances with increasing fuel temperature.

The PBF-TWIGL model is in X-Y geometry. This geometry choice allows the control rod geometry to be more correctly represented than in the cylindrical SCAMP model. This should allow a more accurate accounting for the effect of the control rods (after they are inserted to terminate the burst) on the local neutron multiplication near the experiment space.

The TWIGL representation of the PBF geometry is illustrated in Figure 2. Originally a somewhat more detailed (57 x 57 mesh rather than 28 x 28) model was developed. This fine mesh model proved unacceptably expensive to run. Cross sections for all core materials in the TWIGL model were obtained from a standard 69 x 69 mesh interval, four-group PDQ diffusion theory model of the PBF[6,7]. The top three groups of the four-group data were combined into one fast group for TWIGL. The fourth, or thermal group data remained the same. The PDQ cross sections, were not only collapsed by group but were also flux-volume weighted over selected PDQ region sets that corresponded to the coarse regions in TWIGL. Cross sections for the materials inside the experiment space were flux-volume weighted data obtained from the SCAMP model described previously. The number of neutrons per fission in the TWIGL fuel cross sections has been adjusted so that the model has the correct rods-out cold core excess reactivity. The control and transient rod poison cross sections have been adjusted to give the correct integral control and transient rod reactivity worths. These adjustments were made using a PDQ steady-state version of the TWIGL model with identical geometry. This PDQ model also provides starting pointwise flux guesses for TWIGL. We always assume that a burst begins at time t = 0 with the control rods and transient rods full-out (in the X-Y model). The actual starting reactivity is controlled by an input parameter as will be described later.

Core fuel cross sections are fit to the local fuel temperature in TWIGL by the formula:

$$\Sigma(T_f,\bar{r}) = \Sigma^* + \frac{\partial\Sigma}{\partial T_f^{\frac{1}{2}}} \left[\sqrt{T_f(\bar{r}) + T_{fa}} - \sqrt{T_f^*(\bar{r}) + T_{fa}} \right] \qquad (2.13)$$

where $T_f(\bar{r})$ is the local fuel temperature, Σ^* is a reference value of some particular cross section Σ, corresponding to $T^*(\bar{r})$ and T_{fa} is a fitting parameter set by the user in the modified version of TWIGL. The partial derivative of a given cross section with respect to square root of the fuel temperature is computed by:

$$\frac{\partial\Sigma(T_f,\bar{r})}{\partial T_f^{\frac{1}{2}}} = \frac{\Sigma(T_1) - \Sigma(T_0)}{\sqrt{T_1 + T_{fa}} - \sqrt{T_0 + T_{fa}}} \qquad (2.14)$$

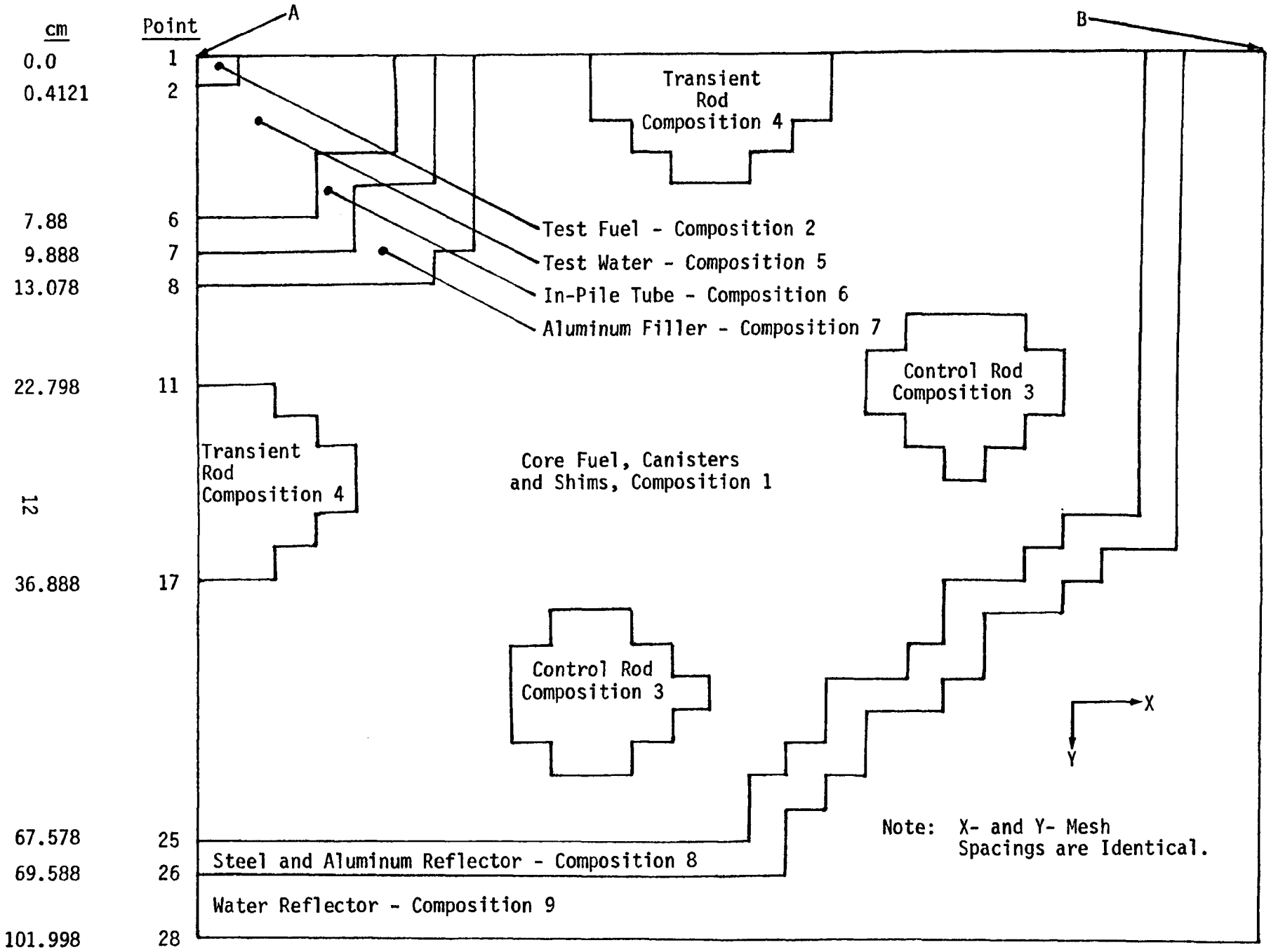

Figure 2. TWIGL representation of the PBF geometry.

where in our case, $T_0 = T^* = 68°F$ and $T_1 = 1772°F$. Some experimentation with the value of T_{fa} showed that the PBF doppler reactivity curve is adequately represented in the TWIGL model by setting $T_{fa} = 100.0°F$ in Equations (2.13) and (2.14).

The modified version of TWIGL allows a temperature-dependent local fuel heat capacity (second degree polynomial fit). This is important for accurate calculations of doppler feedback in the PBF.

A summary description of the various input parameters for the PBF TWIGL model is given in Appendix D along with a listing of the TWIGL input for a typical problem (RIA ST-3, the 5.2 ms burst shown in Table I).

With the control rods out, the cold TWIGL model has an eigenvalue of 1.03694 and an approximate generation time of 26.81 microseconds. To input a reactivity to TWIGL at time t = 0 (assuming the correct control-rods-out starting flux guess) we use the input parameter EGV, which divides all the fission cross sections at all times throughout the problem. For reactivities above prompt critical the time dependent power (assuming no flux shape change or feedback) in a reactor is given by:

$$\frac{P(t)}{P_o} = e^{\frac{\rho-\beta}{\ell} t} = e^{t/T} \qquad (2.15)$$

where $T = \ell/(\rho-\beta)$ and ℓ = the generation time, ρ = the reactivity and β = the effective delayed neutron fraction. ($\rho > \beta$)

In the TWIGL PBF model, the initial reactivity is given in absolute units by:

$$\rho = \frac{\frac{1.03694}{EGV} - 1.0}{\frac{1.03694}{EGV}}$$

$$= 1.0 - EGV/1.03694 \qquad (2.16)$$

For $\beta = .0072$ and $\ell = 26.81 \times 10^{-6}$ s we find from Equations (2.15) and (2.16) that the relationship between the no-feedback prompt reactor period that the TWIGL model will exhibit and the input parameter EGV is given by (for $\rho > \beta$):

$$EGV = 1.029474 - (2.780036 \times 10^{-5}/T) \tag{2.17}$$

When the control rods are inserted to terminate the burst (by an explicit time-dependent cross section variation in the control rod regions), the model is representative of a control-rods-full-in configuration and EGV must be changed back to 1.0 so that the correct shutdown reactivity is obtained. This is done by an explicit linear change in $\nu\Sigma_f$ from $\nu\Sigma_f^*$ to $\nu\Sigma_f^* + \delta\nu\Sigma_f$ for all fuel materials at the same time as the control rod region cross sections are being changed from the rods-out to the rods-in values. For all regions containing fuel, TWIGL divides the input values of both $\nu\Sigma_f$ and $\delta\nu\Sigma_f$ by EGV throughout a given TWIGL run, i.e.,

$$\nu\Sigma_f(t) = \frac{\nu\Sigma_f^*}{EGV} + \frac{\delta\nu\Sigma_f}{EGV} \quad f(t) \tag{2.18}$$

where $f(t)$ goes from 0 to 1 in a time interval specified by the input data. Thus the correct way to effectively ramp out EGV while the control rods go in is to set:

$$\delta\nu\Sigma_f = (EGV - 1.0)\ \nu\Sigma_f^* \tag{2.19}$$

Thus for the five TWIGL cases to be run we have the data given in Table II.

TABLE II

REACTIVITY PARAMETERS FOR THE RIA TWIGL CALCULATIONS

Case	Description	Period (ms)	EGV	$\delta\nu\Sigma_f$ Ramp Factor
1	RIA ST-3	5.2	1.02413	0.02413
2	RIA ST-2	4.6	1.02343	0.02343
3	RIA 1-1	3.1	1.02051	0.02051
4	RIA ST1 - PB1	5.7	1.02460	0.02460
5	RIA ST1 - PB2	4.4	1.02316	0.02316

Since $\nu\Sigma_f$ for group 1 has a weak temperature dependence in the TWIGL model, equations 2.18 and 2.19 are not strictly exact. An exact treatment would require changing the code so that the input values of $\delta\nu\Sigma_f$ could have a functional dependence on the local fuel temperature throughout the TWIGL calculation.

The initial PBF power in the TWIGL model is set to 0.4 MW (0.1 MW/quarter). This starting power should be as high as possible so that the program does not waste time computing through decades of increasing power that make no significant contribution to the total energy released during the transient. The starting power cannot be arbitrarily high, however, since TWIGL assumes that the burst begins with an equilibrium delayed neutron precursor population corresponding to the starting power. Accordingly the starting power must be small enough so that the equilibrium delayed precursor population is small compared to the number of delayed precursors produced during the transient. For the 6 delay groups in the model we require:

$$P_s \sum_{i=1}^{6} \frac{\beta_i}{\lambda_i} \quad << \quad \sum_{i=1}^{6} \beta_i E_b \qquad (2.20)$$

where P_s is the starting power, E_b is the energy produced during the burst (before the control rods are inserted) and β_i and λ_i are the 6 delayed precursor fractions and decay constants in the model (See Appendix D).

The delayed tail is defined to begin at the time the control rods begin to move into the core to fully terminate the burst. Therefore it is important that the control rods in the TWIGL model begin to be ramped in at the same time after the occurrence of peak power as the actual rods did during the experiment. The time interval between peak power and initiation of control rod movement is easily determined from the power-time histories recorded during the experiment by the SPND's and the core chambers. The sudden change in core multiplication that occurs when the rods begin to move shows up as an obvious inflection in these curves. Each TWIGL case accounts for the correct (measured) delay time between peak power and initiation of control rod movement. The rod worth is then linearly inserted over an interval of 100 ms by an explicit change in the control rod region cross sections.

The Figure of Merit, or ratio of test fuel linear power density to PBF core power, is not calculated exactly by TWIGL since the test fuel cross sections are not necessarily correct for each RIA experiment and diffusion theory would not give the right test fuel power even if they were. The RIA experiments to date have consisted of either one or four widely separated low-enriched rods, surrounded by water. We assume complete decoupling of the test and core, i.e., the flux in the test space depends only on the core power and is not significantly affected by the test fuel. Accordingly we can simply modify the TWIGL-calculated test powers to conform to the true figure of merit and the calculated delayed fraction of total fissions in the test fuel will still be the same as the value that would have resulted if the test fuel cross sections had been adjusted in TWIGL to give the correct FOM for each case. For later RIA experiments involving large bundles of rods this procedure will probably no longer be valid.

A simple program, TPLOT, described in Appendix E was written to process the TWIGL output for each case into a form suitable for reporting. TPLOT reads time-dependent region powers from the TWIGL output tape (TAPE8), does the required test power renormalization to obtain the correct figure of merit, and (for each time point) prints out core and test power and their accumulated time integrals for use in determining the tail fission fraction. The data are also punched on cards for reading by machine plot programs.

TWIGL assumes a constant energy per fission (the transient value in our case). Accordingly, the edited powers are really more analogous to the time-dependent fission rate for the system before equilibrium, as is the case for the RIA transients. From the TPLOT calculations we obtain F_f, the fraction of total fissions occurring in the test fuel after scram. Therefore $(1-F_f)$ will be the fraction of total fissions occurring during the burst. Further, we assume that the equilibrium energy per fission in the test fuel differs from the prompt energy per fission by a factor $(1 + \alpha)$, where α is typically between .05 and .07. Since the time-integrated energy per fission for the entire transient (burst plus tail) must equal the

equilibrium value (eventually all of the energy from a fission will appear, regardless of whether it occurs during the burst or tail) we find that each fission that deposits one unit of energy during the burst effectively contributes another α units of energy during the tail. All fissions in the tail can be considered to eventually contribute $(1 + \alpha)$ units of energy. Thus the fraction of <u>energy</u> after scram is given by

$$F_e = \frac{(1+\alpha)\ F_f + \alpha(1-F_f)}{1 + \alpha} = \frac{F_f + \alpha}{(1 + \alpha)} \qquad (2.21)$$

Equation (2.21) also applies to the SCAMP-calculated results for the tail fission fraction.

3.0 RESULTS

Results of the SCAMP calculations described in Section 2.1 were not ultimately used in the RIA energy measurements. They are included here for the sake of completeness and to provide a demonstration of the method. The TWIGL results for each of the RIA experiments examined are given in detail.

3.1 Results of a Typical SCAMP Steady-State Calculation for the Post-Burst Energy Deposition in RIA Test Fuel Rods

The SCAMP model is for the case where a 20% enriched single PWR-type fuel rod, surrounded by water is located in the PBF central experiment space. This corresponds to the RIA 1-4 experiment listed in Table I. If decoupling of core and test fuel is assumed, the results for this case will be valid for the other RIA experiments as well.

A steady-state SCAMP eigenvalue calculation for the reactor condition presumed to exist during the burst gives the following region power edits in arbitrary units (normalized to a total integrated fission neutron source in the entire reactor of 1.0 neutron/second):

$$\begin{aligned} \text{Test Power} &= 4.7692 \times 10^{-14} \quad (a) \\ \text{Core Power} &= 1.3002 \times 10^{-11} \quad (b) \\ \hline \text{Total Power} &= 1.3049 \times 10^{-11} \quad (c) \end{aligned} \tag{3.1}$$

A fixed source with fission calculation for the subcritical reactor after the burst, using the pointwise fission source from the previous problem (with a delayed neutron spectrum) yields the following region powers, in the same arbitrary units:

$$\begin{aligned} \text{Test Power} &= 2.0408 \times 10^{-12} \quad (a) \\ \text{Core Power} &= 4.9976 \times 10^{-10} \quad (b) \\ \hline \text{Total Power} &= 5.0180 \times 10^{-10} \quad (c) \end{aligned} \tag{3.2}$$

The nominal multiplication factor for the reactor configuration assumed for the subcritical fixed source calculation is K = 0.9739, obtained by simply removing the fixed source and running an eigenvalue calculation for the subcritical reactor. To compute the exponentials in Equation (2.12) we assume that the burst begins at time t = 0, peak power occurs after 50 ms and the burst terminates at time t_b = 120 ms. Using the delayed neutron data from Appendix D, we obtain a decay-corrected delayed fraction:

$$\beta_{tb} = 0.0063 \tag{3.3}$$

This is slightly smaller than the true delayed fraction of 0.0065, as expected. Note that the effective delayed fraction for PBF ($\beta^* = 0.0072$) does not apply here since spectrum effects are accounted for automatically in the multigroup SCAMP calculations.

To obtain the delayed fission fractions, we simply combine Equations (3.1), (3.2), and (3.3):

$$\frac{\text{Delayed Fissions}}{\text{Burst Fissions}} \Big/ \text{Overall Core + Test} = \frac{(0.0063)(5.0180\text{-}10)}{(1.3049\text{-}11)} = 0.2423 \tag{3.4}$$

$$\left.\frac{\text{Delayed Fissions}}{\text{Burst Fissions}}\right/_{\text{Test Fuel Only}} = \frac{(0.0063)(2.0408\text{-}12)}{(4.7692\text{-}14)} = 0.2696 \qquad (3.5)$$

For K = 0.9739, Equation (2.2) gives:

$$\left.\frac{\text{Delayed Fissions}}{\text{Burst Fissions}}\right/_{\substack{\text{Infinite}\\ \text{Reactor Model}}} = \frac{\beta K}{1\text{-}K} = \frac{(0.0063)(0.9739)}{1-\ 0.9739} = 0.2351 \qquad (3.6)$$

The SCAMP calculations show that the multiplication near the experiment space is higher than the overall average, causing the delayed fraction in the test fuel to be higher than the average delayed fraction.

Rerunning the delayed SCAMP calculation with a lowered nominal K = 0.96303 (obtained by adding more boron poison to the control rod ring) yields:

$$\left.\frac{\text{Delayed Fissions}}{\text{Burst Fissions}}\right/_{\text{Overall Core + Test}} = 0.1670 \qquad (3.7)$$

$$\left.\frac{\text{Delayed Fissions}}{\text{Burst Fissions}}\right/_{\text{Test Fuel Only}} = 0.1959 \qquad (3.8)$$

$$\left.\frac{\text{Delayed Fissions}}{\text{Burst Fissions}}\right/_{\substack{\text{Infinite}\\ \text{Reactor Model}}} = \frac{\beta K}{1\text{-}K} = 0.1641 \qquad (3.9)$$

It is generally more convenient to express the delayed fissions as a fraction of total fissions. This is easily done. If:

$$\frac{D}{B} = \frac{\text{Delayed Fissions}}{\text{Burst Fissions}} \qquad (3.10)$$

then

$$\frac{D}{T} = \frac{D}{D+B} = \frac{\text{Delayed Fissions}}{\text{Total Fissions}} = \frac{D/B}{1 + D/B} \qquad (3.11)$$

substituting the data from Equations (3.5) and (3.8) into Equation (3.11) gives the final results shown in Table III.

TABLE III

DELAYED FISSION FRACTIONS COMPUTED BY SCAMP

FOR THE RIA EXPERIMENTS IN THE PBF

Nominal Shutdown K	Delayed Fissions in Test Fuel / Total Fissions in Test Fuel
.9739	0.2124
.9630	0.1638

As mentioned previously, the major drawback to this calculational procedure is that one constant K is assumed for the entire subcritical portion of the transient. These SCAMP calculations were run with the PBF fuel assumed to be at the same temperature (1212 K) during both the burst and the tail. The reactivity was controlled solely by changing the concentration of boron poison in the control rod region. Also, since in one-dimensional cylindrical geometry the control rods are represented as an annular ring, the radial power shape (and importance function) may well be unrealistically peaked near the experiment space in the subcritical, post-burst SCAMP calculations, making the local multiplication in this region higher than really is the case. The TWIGL calculations should avoid both of these problems. All of the above results are reported for illustrative purposes only and are not used for actual RIA experiments.

3.2 Results of the TWIGL Calculations for Post-Burst Energy Deposition in RIA Fuel Rods

The TWIGL-calculated results for the post-burst fraction of fissions and energy deposition in the RIA test fuel are summarized in Table IV for each of the five tests considered. We use a value of $\alpha = 0.0537$[8] in Equation (2.21) to convert the post-burst fission fractions to energy fractions. This is more realistic than the value of $\alpha = 0.07$ that was used in some earlier reports of these data.

TABLE IV

TWIGL-CALCULATED RESULTS FOR POST-BURST FISSIONS
AND ENERGY DEPOSITION IN PBF-RIA TEST FUEL

Case	Period (ms)	F_f(1)	F_e(2)
RIA ST1,PB1	5.7	0.150	0.193
RIA ST1,PB2	4.4	0.147	0.190
RIA ST2	4.6	0.148	0.191
RIA ST3	5.2	0.152	0.195
RIA 1-1	3.1	0.140	0.184

NOTES:

(1) $F_f = \dfrac{\text{Fissions in the Test Fuel During the Tail (At the Axial Peak)}}{\text{Fissions in the Test Fuel for All Time (At the Axial Peak)}}$

(2) $F_e = \dfrac{\text{Energy Deposited in the Test Fuel During the Tail (At the Axial Peak)}}{\text{Energy Deposited in the Test Fuel for All Time (At the Axial Peak)}}$

$= (F_f + \alpha)/(1 + \alpha)$ where $\alpha = 0.0537$

(3) The tail is defined to begin at the time the control rods start moving into the core and the inflection in the measured power data indicates the change in the neutron multiplication properties of the PBF.

Appendix F contains plots of computed core and test power for all RIA experiments examined, along with listings of the actual calculated power-time data. The accumulated power-time (energy) integrals used to compute the data in Table IV are also given. It should again be noted that all TWIGL-computed data are based on a constant (transient) energy per fission. This is corrected for in the energy data given in Table IV through the use of Equation (2.21).

We note from the power-time integrals given in Appendix F that the fraction of the total energy deposited in the test fuel during the tail is larger than the fraction of the energy deposited in the core fuel during the same time. This is another indication of the higher local neutron multiplication near the experiment space.

3.3 Spatial Flux Shape Changes in the PBF During a Transient

When the PBF is operated in the natural burst mode, the transient rods are initially fully inserted and the control rods are set at the position that will give the desired reactivity for the burst when the transient rods are fully removed from the core. The transient rods are then rapidly driven out, the burst occurs and, finally, the control rods drop fully into the core to maintain the reactor in a shutdown condition as it cools off. The initial fission power for a burst is generally quite small, less than 1 watt. When the transient rods are removed to initiate the burst, the spatial flux shape in the core must adjust from the shape appropriate to a subcritical configuration with the transient rods in to that shape appropriate to some supercritical configuration with the transient rods out. The usual assumption has been that this shape change is completed long before any sensible power is generated anywhere in the reactor. In fact, it is this assumption that allows us to begin the TWIGL calculations described in Section 3.2 with a flux guess corresponding to a transient-rods-out configuration. To demonstrate that this is a reasonable procedure, a TWIGL calculation was run for the RIA 1-1 (3.1 ms) burst using an approximate starting flux guess appropriate to a transient-rods-in configuration. The calculational model was supercritical, with the transient rods fully out,

as before. Thus, this calculation models the assumed situation where the transient rods are instantly removed at time t = 0. TWIGL then computes the time-dependent X-Y flux shape and shows how this shape adjusts to the transient-rods-out configuration that exists during the burst.

Figure 3 shows a plot of the time-dependent thermal flux along traverse AB (the X-axis) in Figure 2. After 150 microseconds (about six prompt generations) the shape is quite close to that which would be obtained from a steady-state calculation of the flux shape for the reactor conditions assumed to exist during the burst. This is shown in Figure 4, where the 150 μs thermal flux shape (from Figure 3) is compared to the asymptotic transient-rods-out shape computed for traverse AB by PDQ and normalized to the same reactor power. Note that the overall reactor power rises from 33.17 to only 34.87 kW in the TWIGL calculation between 0 and 150 μs. In the real reactor the time for the shape change to take place would be the same as in the calculation, but the power that exists while the shape is changing would be much lower and would rise by the same fraction as in the calculation. Thus, we can conclude that the shape change takes place in the PBF long before any sensible power (a few kilowatts) is measured and even longer before the power gets to the point (a few megawatts) where significant contributions to the total burst energy are beginning to accumulate.

4.0 CONCLUSIONS

Appendix B shows some measured values for the fraction of fissions occurring after scram, as obtained by the SPND data for each RIA experiment. As is stated in this appendix, these fractions should be considered only approximate since the magnitude of the gamma flux contribution to the SPND current is unknown. They are repeated in Table V along with the calculated corrections from Table IV for comparison:

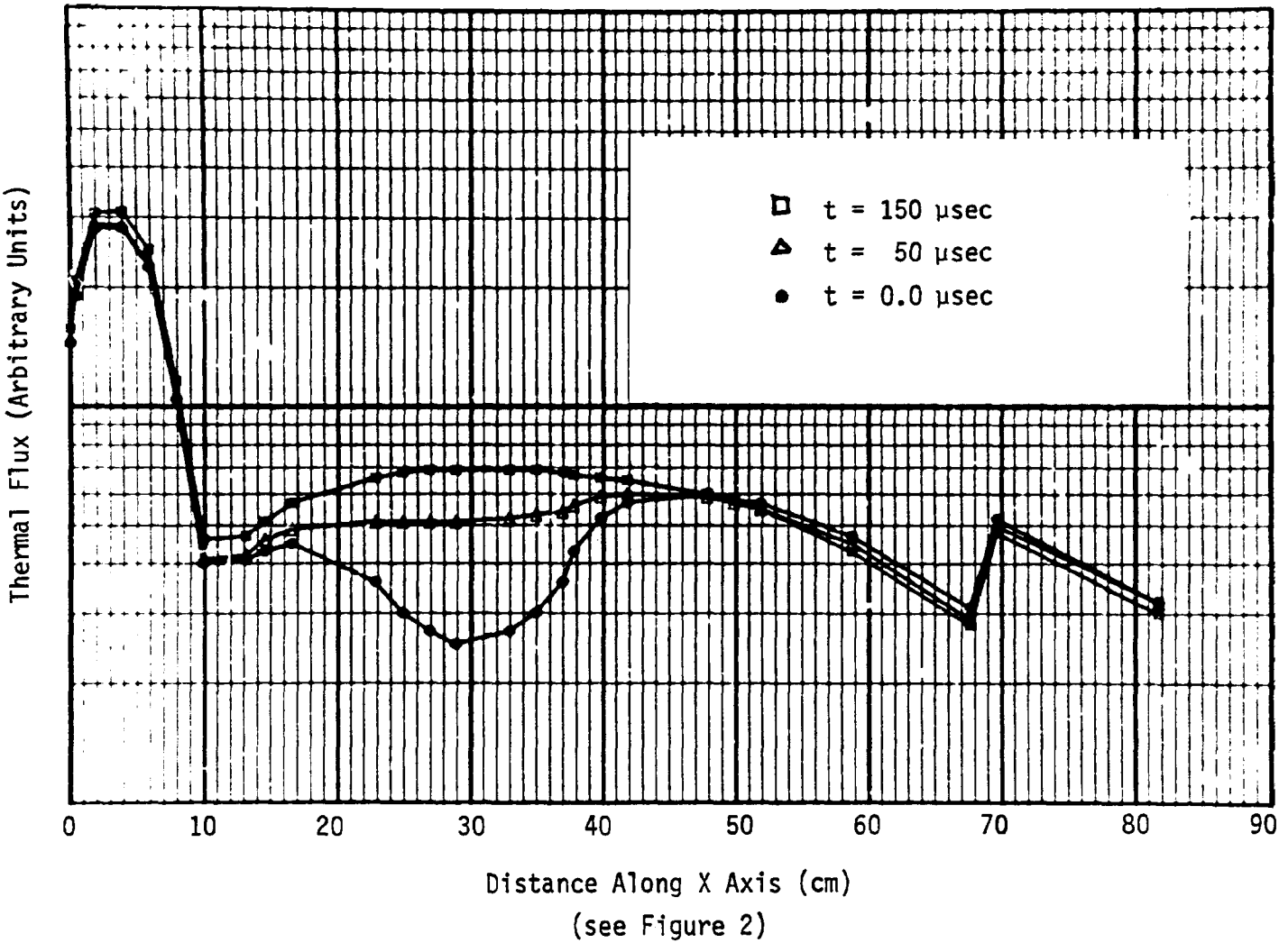

Figure 3. TWIGL X-Y results for the time dependent thermal flux in the power burst facility following an instant removal of the transient rods at time t = 0 (control rods out).

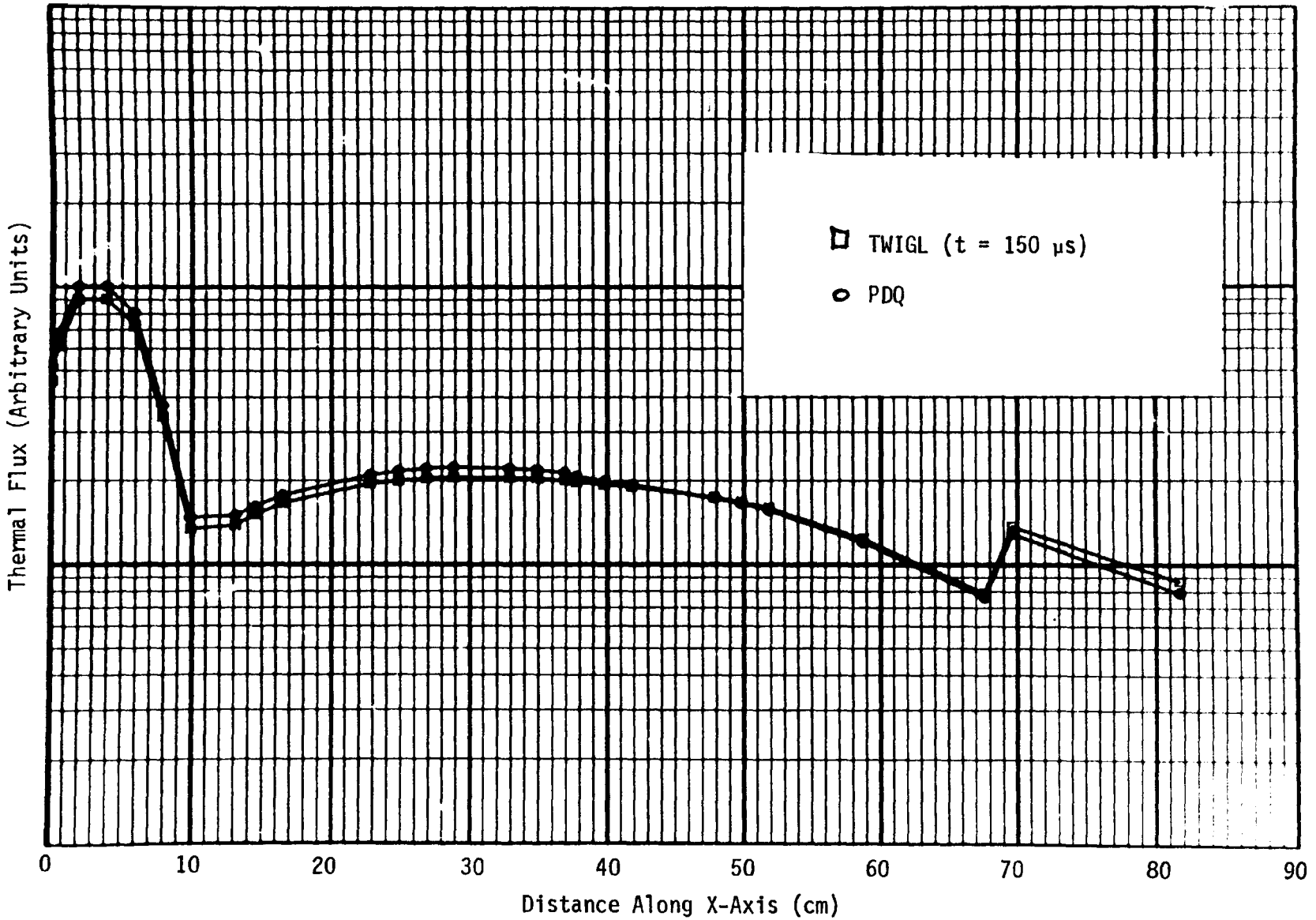

Figure 4. Comparison of the PDQ computed asymptotic transient rods out PBF thermal flux profile with the TWIGL-computed flux profile 150 μs after an instant removal of the transient rods (see Figure 3).

TABLE V

MEASURED AND CALCULATED TEST FUEL DELAYED FISSION FRACTIONS FOR RIA EXPERIMENTS IN THE PBF

Case	Period (ms)	$f_{f,measured}$	$f_{f,calculated}$	$\frac{Calculated}{Measured}$
RIA ST1,PB1	5.7	0.164	0.150	0.915
RIA ST1,PB2	4.4	0.154	0.147	0.955
RIA ST2	4.6	0.153	0.148	0.967
RIA ST3	5.2	0.116	0.152	1.310
RIA 1-1	3.1	0.101	0.140	1.386

For the first three cases we find agreement to within 10%, with the TWIGL calculations giving results consistently lower than the corresponding measurements. It is not apparent why the last two measured tail fractions (RIA ST3 and RIA 1-1) are neither in better agreement with the calculations than they are nor more consistent with the other measurements. We recommend that the calculated values be used for at least these two cases, if not for all cases when accounting for fissions occurring in the test fuel after the prompt portion of each burst.

A special committee[9], formed to review the methods of measuring deposited energy in the PBF-RIA experiments has recommended that calculations of the post-burst energy be completed for each RIA experiment conducted in the future. Accordingly this report should prove useful as an aid to doing these future calculations.

Finally, it should be noted that under some circumstances, the "steady-state" method of calculating the delayed fissions may be superior to the TWIGL two-group diffusion theory method. Such circumstances could occur if the reactor were represented in two- or three-dimensional geometry, using transport theory rather than diffusion theory. This would allow for better representation of the control rod geometry, as in TWIGL, but would retain the accuracy of transport theory, as in the one-dimensional SCAMP calculations. This approach would also allow a finer mesh representation of the reactor than is feasible with TWIGL and more than two neutron groups could be used.

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APPENDIX A

COMPUTER DATA SETS AND PERMANENT RECORDS FOR THE RIA KINETICS CALCULATIONS

Data Set	Historical File Number
SCAMP Program	H00029IB
SCAMP Library	H000125IB
PDQ Program	H00400IB
TWIGL Program	H00997IB
Detailed Notes of the Calculations	INEL NBU-496

APPENDIX B

SUMMARY DESCRIPTION OF THE RIA ENERGY MEASUREMENTS BASED ON QUALIFIED DATA

EG&G Idaho

INTEROFFICE CORRESPONDENCE

date April 16, 1979

to P. E. MacDonald

from Z. R. Martinson

subject RIA FUEL ROD ENERGIES BASED ON QUALIFIED DATA - ZRM-10-79

The RIA fuel rod energy measurements have been calculated using DARS qualified data. Corrections based on self-powered neutron detectors have been applied to account for the fission energy deposited after the time of control rod scram following the power burst. The measurements are summarized in Table I.

The fuel energy data based on radiochemical analysis are about 30% higher than data based on the PBF core power chamber data, and about 10% higher than corresponding data based on the SPNDs. The probable reasons for the discrepancies in energy measurements are believed to include the following:

(1) Errors in fuel rod power calibration measurements, such as coolant flow rate and coolant temperature rise, will result in errors in power burst energy values based on core chambers and SPND data.

(2) Variations in corresponding data values were noted between narrow band and wide band DARS channels of the same instrument. Since the power calibration employed only the narrow band DARS channels, the observed relationships between fuel rod powers, core chambers, and SPND outputs are probably not accurate for wide band data channels of the same instruments.

(3) Different amplifer gain settings for the core chambers had to be used for the power burst than for the power calibration. The observed relationships between fuel rod powers, core chambers, and SPND outputs are probably not accurate for different electronic gain settings.

(4) Energy values based on radiochemical analysis of fuel rods irradiated only during a single power burst will be higher than the actual energy deposited prior to control rod scram due to delayed neutron contribution after reactor shutdown. A correction was applied to the data, but should only be regarded as an approximation. Reactor physics calculations are underway to better define the correction.

The procedures used for calculating the energy data given in Table I and observed problems are discussed below.

1.1 Steady-State Rod Energy

1.1.1 Radiochemical Analysis - Sections of fuel rods irradiated during steady-state operation were radiochemically analyzed. Analysis of the RIA-ST-1 and RIA 1-1 (Rod 801-4) have been completed, while the rod sectioning of a RIA 1-2 fuel rod has not been completed yet. Analytical results are given in terms of fission per gram of uranium. This analysis is then converted to total rod energy generated at the axial flux peak during the test in terms of $\left(\frac{kW \cdot s}{m}\right)$ using a calculated energy per fission for steady-state operation and the flux profile obtained from a cobalt wire installed on each flow shroud. This data is summarized in Table II.

1.1.2 On-Line Data Integration - Integration of the output current of an SPND in terms of Ampere·second over the steady-state portion of the test (power calibration and preconditioning) was completed using qualified DARS data. This total integrated output was then multiplied by the ratio of fuel rod peak power to SPND output current in terms of kW/m per Ampere of SPND output current. This ratio was obtained from data taken during the calorimetric power calibration. The on-line data agrees with the burnup analysis results for ST-1 within 2%, but is about 12% lower than the burnup analysis results for RIA 1-1.

1.2 Steady-State Ratio of Test Rod Power to PBF Reactor Power

1.2.1 Measured - The measured ratio of test rod power at the axial flux peak to total PBF reactor power during the steady-state power calibration is listed in this column. The test rod power was determined calorimetrically by measuring the coolant pressure, coolant inlet temperature, coolant inlet flow rate and coolant temperature rise over the length of the flow shroud. The reactor power was measured by the average of the neutron detecting chambers: EV-1, EV-2, TR-1, and TR-2.

1.2.2 Calculated - The calculated ratio of test rod power at the axial flux peak to total PBF reactor power during the steady-state power calibration is listed in this column. Calculated steady-state energy per fission values were used for the test rod and PBF core fuel rods.

1.3 Power Burst Radially Averaged Fuel Rod Energy

All of the columns under this heading refer to the radially-averaged fuel energy at the axial power peak. The values given refer to the total fuel energy due to the power burst deposition plus the energy equivalent for initiating the power burst at 538 K, or 15.3 cal/g UO_2.

1.3.1 Pretest Energy Target - This column lists the total fuel energy sought prior to conducting the power burst.

1.3.2 Core Chamber Data - This column lists the total fuel energy based on the core power chamber data from EV-1, EV-2, TR-1, and TR-2. The fuel energies were obtained by integrating each chamber current output (in terms of MW·s) during each power burst to the time of control rod scram. The total reactor energy was then multiplied by (a) the ratio of test rod peak power to reactor power, (kW/m/MW), as measured by each core power chamber during the steady-state power calibration, and (b) by the ratio of

$$\frac{\text{Test rod energy per fission during a power burst}}{\text{Test rod energy per fission during steady-state operation.}}$$

The test rod energy thus obtained in terms of $\left(\frac{kW \cdot s}{m}\right)$ was converted to cal/g UO_2 using appropriate conversion factors of 238.89 $\left(\frac{cal}{kW \cdot s}\right)$ and number of grams of UO_2 per metre length of fuel pellets for each type of fuel rod. The calculated energy was increased by 15.3 cal/g UO_2 to account for an ambient temperature of 538 K.

As shown in Table III, there is a large scatter in the core chamber data for the four rod tests, RIA 1-1 and RIA 1-2, where separate data from each of the four core chambers for each of the four rods was processed. The average fuel energy for RIA 1-1 is 254 cal/g UO_2 with a standard deviation of 31 cal/g UO_2. The average of the four core power chambers for Test RIA 1-2 is 192 cal/g with a standard deviation of 15 cal/g UO_2.

Large differences were noted between narrow band and wide band DARS channels of the core chamber data on the 50 MW ranges prior to the power burst and several seconds after the power burst. The narrow band and wide band data could not be compared during the power burst due to the time response limits of narrow band channels. Since only the narrow band data was available

for the power calibration, part of the discrepancy in core chamber data and other data is probably due to errors in using wide band power burst data with a full-scale range of 50,000 MW, while the power calibration narrow-band data had a full-scale range of 50 MW.

1.3.3 SPND Data - This column lists the total fuel energy based on the cobalt SPNDs mounted on each test train. Three cobalt SPNDs were installed on the RIA Scoping test train and ten SPNDs on the test train used for RIA 1-1 and RIA 1-2. Data from only two of the ten SPNDs was qualified for Test RIA 1-1 due to a DARS recording problem. For the other tests all of the SPND data was qualified. The fuel energies were obtained by integrating a SPND current output (in terms of Ampere·seconds) during each power burst to the time of control rod scram. This integrated SPND current output was multiplied by (a) the ratio of test rod peak power to SPND current, $\left(\frac{kW/m}{A}\right)$ as measured by each SPND during the steady-state power calibration, (b) by:

$$\frac{\text{Test rod energy per fission during a power burst}}{\text{Test rod energy per fission during steady-state}},$$

and, (c) 0.95 to account for the lack of delayed gammas and neutrons during a power burst. The calculated relative SPND current is about 5% higher during a power burst than during steady-state operation. The test rod energy thus obtained in terms of $\left(\frac{kW\cdot s}{m}\right)$ was then converted to cal/g UO_2 as explained in previous sections and then increased by 15.3 cal/g UO_2 to account for the ambient temperature of 538 K.

Analysis of the RIA 1-2 power burst data indicated that the axial power profile calculated from the wide band SPND DARS channels was erroneous with a peak-to-average value of about 1.6. The SPND data for the power calibration phase of the test indicated a normal power profile with a peak-to-average of about 1.35. Scan data of the cobalt flux wires mounted on each flow shroud indicated peak-to-average power ratios of about 1.35 for both the power calibration and during the power burst. Further examination revealed that the SPND data recorded on the narrow band DARS channels indicated a normal power profile with a peak-to-average ratio of 1.35 during the power burst.

It was therefore concluded that the wide band channel SPND data were erroneous. Fuel energies based on the SPNDs for Test RIA 1-2 also had a large scatter (see Table III) with values ranging from 162 to 311 cal/g UO_2 due to the erroneous high readings from the wide band SPND channels. Similar peaking problems were observed for the 0.457 m SPND on the scoping test hardware. For this reason, data from the SPND at 0.457 m was not included in computing an average energy from the SPNDs.

1.3.4 Shroud Flux Wire Data - This column lists the total fuel energy based on the cobalt flux wires located on the outer surface of each shroud.

The fuel energy for each power burst was obtained in the following manner:

(a) For RIA-ST-2, RIA-ST-3, and RIA 1-1 the total steady-state fuel rod energy determend from burnup analysis that is given in column 1.1.1 was divided by the peak nvt determined from the 0.51% cobalt-99.49% aluminum flux wire mounted on each flow shroud during steady-state operation.

For RIA-ST-4 and RIA 1-2 the total steady-state fuel rod energy at the axial flux peak given in 1.1.2 was divided by the peak nvt determined from the 0.51% cobalt-99.49% aluminum flux wire mounted on each flow shroud during only the steady-state operation.

(b) The ratio of $\left(\frac{\frac{kW\cdot s}{m}}{nvt}\right)$ at the test rod axial flux peak was multiplied by the peak nvt determined from a pure cobalt flux wire mounted on the flow shroud during power burst operation only.

(c) The resulting fuel rod peak energy in terms of $\left(\frac{kW\cdot s}{m}\right)$ was multiplied by the ratio of test rod energy per fission during a power burst to test rod energy per fission during steady-state operation.

(d) The fuel rod peak energy was converted to cal/g UO_2 by the appropriate conversion factors.

(e) The fuel rod energy was corrected for the small contribution (about 8 cal/g UO_2) from the steady-state reactor operation done prior to the power

burst which consists of checking reactor neutron chamber operability and determining control rod withdrawal position for criticality.

(f) The fuel rod was corrected for energy deposited after the time of control rod scram. A separate correction for each power burst was derived from the SPNDs.

The SPND data traces were integrated over the time span from 100 ms prior to the power burst to the time of control rod scram and also to 15 minutes after the time of scram.

The ratio of:

$$\frac{\text{Integrated SPND current to time of scram}}{\text{Integrated SPND current to ten minutes after scram}}$$

was used to correct the energy deposited after the scram. Data from all SPNDs available was averaged to determine the correction used for the energy after scram for each power burst. These corrections are: 0.836 for ST-1, PB-1; 0.846 for ST-1, PB-2; 0.847 for ST-2; 0.884 for ST-3; 0.912 for ST-4; 0.899 for RIA 1-1; and, 0.850 for RIA 1-2. These corrections must be considered only approximate since the magnitude of the gamma flux contribution to the SPND current after scram is unknown. Detailed reactor physics calculations are underway to better define this correction factor.

(g) The fuel rod energy was corrected for the ambient temperature of 538 K.

1.3.5 Core Flux Wire Data - This column lists the total fuel energy based on the cobalt flux wires located on the periphery of the PBF core. The fuel energy for each power burst was obtained in the following manner:

(a) For Tests RIA 1-1 and RIA 1-2, the total steady-state fuel rod energy at the axial flux peak derived from the burnup analysis given in 1.1.1 was divided by the peak nvt determined from a cobalt flux wire installed only during steady-state operation in a holder located on the periphery of the core. RIA 1-1 data was used to calibrate the RIA 1-2 core flux wire.

For ST-1, ST-2, ST-3, and ST-4, the calorimetric steady-state fuel rod energy at the axial flux peak was used to calibrate the core flux wire irradiated during steady-state operation.

(b) The peak nvt determined from a cobalt flux wire installed only during power burst operation in the same position on the core periphery was multiplied by the ratio of $\left(\frac{\frac{kW \cdot s}{m}}{nvt}\right)$ determined in (a).

(c) The resulting fuel rod peak energy in terms of $\left(\frac{kW \cdot s}{m}\right)$ was multiplied by the ratio of test rod energy per fission during a power burst to test rod energy per fission during steady-state.

(d) The fuel rod peak energy was converted to cal/g UO_2 by the appropriate conversion factors.

(e) The fuel rod energy was corrected for the small contribution from steady-state operation just prior to the power burst.

(f) The fuel rod energy was corrected in the same manner as the shroud flux wire data for the contribution of energy generated after the time of control rod scram.

(g) The fuel rod energy was corrected for ambient temperature of 538 K.

1.3.6 Burnup Analysis Data - This column lists the total fuel rod energy based on radiochemical analysis of fuel samples taken from rods tested only during a single power burst. These fuel rods are from ST-2, ST-3, and Rod 801-5 from RIA 1-1. The fuel energy for each test was obtained in the following manner:

(a) Fuel samples about 13 mm long were sectioned from known elevations of the three rods. Radiochemical analysis at ICPP was performed using isotopes: Zr^{95}, Ce^{141}, and Ce^{144}. The results, given in terms of fission per gram uranium, are listed in Table IV.

The shroud flux wire scan data was used to adjust the sample location burnup to that at the axial

flux peak. The average of the three isotope values was converted to cal/g UO_2 using appropriate conversion factors and the reactor physics calculated energy per fission during a power burst. The total power burst energy was calculated by correcting for the small contribution from steady-state operation just prior to the power burst. The energy deposited after scram was corrected in the same manner as that described for the shroud wires. A correction of 15.3 cal/g UO_2 was also included for an initial temperature of 538 K. The rod energy values listed in the table are the average of the samples taken from each rod.

Discussion

I would judge the fuel rod energy values based on the shroud flux wire data to be the most accurate of the various measurements used. The relationship between shroud flux wire activation and fuel rod energy deposition was established by radiochemical burnup analysis of a fuel rod irradiated during just steady-state operation and flux wire nvt measurements. Both of these measurements were based on activations about a factor of 1000 larger than the activations associated with a power burst. Fuel rod energies from shroud flux wire data and from power burst burnup analysis data for Test RIA 1-1 are in excellent agreement, while for ST-2 and ST-3, the shroud flux wire data is about 20% less than the burnup analysis results.

Examination of the ST-2 and ST-3 power burst data indicates consistency between the burnup analysis measurements and the other data as shown in Table V. Normalizing the ratio of each instrument output for ST-2 and ST-3 to that of the burnup analysis shows that all of the instruments increase nearly the same relative amount. The difference in indicated fuel energy values from the different instruments, therefore, is probably due to errors in the power calibration measurements used to calibrate each instrument, errors in relating narrow band power calibration data to the wide band data during a power burst, and possible contamination of the burnup analysis fuel samples in the hot cell.

Recommendations

(1) Wide band data during power calibration should be used to determine relationships between test rod power, core chambers, and SPNDs. This would eliminate errors in relating narrow band DARS power calibration data to wide band DARS power burst data.

(2) The possible errors in relating power calibration data to power burst data due to different amplifier gain settings used for power calibration than for power burst operation should be further evaluated.

(3) Errors in calorimetric power calibration measurements may require that on-line power burst data from SPNDs and core chambers be used only for power shape and the burnup analysis results be used for final energy values. SPND and core chamber data would also be used for preliminary fuel rod energy values for quick look reports.

(4) Future RIA tests should include at least one rod that is tested solely during the power burst. This could be accomplished by either replacing one of the fuel rods after the calibration and preconditioning phases are completed or by foregoing the power calibration and preconditioning phases of the test entirely. The latter procedure would necessitate using only reactor physics figure-of-merit calculations to determine the reactor period required to achieve a given fuel rod energy. The disadvantage of not establishing an inventory of short half-life fission gases prior to the power burst would also have to be considered.

(5) Inclusion of other on-line instrumentation such as fission chambers may not provide data any better than data from SPNDs or core chambers. I would expect similar errors would be experienced in relating the fuel rod power to instrument output during the power calibration to determine fuel rod energy during the power burst.

(6) Use of uranium-zircaloy flux monitors should be considered to relate steady-state fuel rod power to power fuel energy. This recommendation is based primarily on the discrepancy between the energy values based on cobalt flux wire steady-state burnup analysis and the energy values based on power burst burnup analysis. Use of uranium-zircaloy flux monitors would require special fabrication of such monitors for PBF used due to the large activation generated during power calibration and preconditioning phases of the test. Presently available EG&G uranium-aluminum flux monitors are 10 weight percent, fully enriched uranium-90% aluminum. TREAT uses 3.5 weight percent fully enriched uranium-96.5% zircaloy. I would anticipate that neither of these flux monitors would be suitable for typical steady-state operating times for TFBP tests.

(7) As already planned, additional burnup samples from ST-2, ST-3, and RIA 1-1 (Rod 801-5) should be analyzed independently. Extreme care should be taken to avoid any cross-contamination of samples. An unirradiated control fuel sample should also be included to determine the magnitude of hot cell background contamination.

(8) Actual reactor measurements may be required to derive accurate corrections for the energy deposited after scram. This could be accomplished by remote removal of a flux wire(s) at the time of scram and comparing its activation to that of wires left on the test train.

klm

Attachments:
As stated

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TABLE I

Summary of Preliminary Radially-Averaged Fuel Rod Energy Data

Test Designation	1.1 Steady-State Total Rod Energy		1.2 Steady-State Ratio of $\left(\frac{\text{Test Rod Power}}{\text{PBF Reactor Power}}\right)$		1.3 Power Burst Radially Averaged Fuel Rod Energy					
	1.1.1 Burnup Analysis (kW·s/m)	1.1.2 On-line Calorimetric Data (kW·s/m)	1.2.1 Measured $\left(\frac{kW/m}{MW}\right)$	1.2.2 Calculated $\left(\frac{kW/m}{MW}\right)$	1.3.1 Pre-Test Energy Target (cal/g UO_2)	1.3.2 Core Chamber Data (Cal/g UO_2)	1.3.3 SPND Data (cal/g UO_2)	1.3.4 Shroud Flux Wire Data (cal/g UO_2)	1.3.5 Core Flux Wire Data (cal/g UO_2)	1.3.6 Burnup Analysis Data (cal/g UO_2)
ST-1, PB-1	9.93×10^5	9.74×10^5	2.5	2.3	200	201	211	[a]	201	---
ST-1, PB-2	9.93×10^5	9.74×10^5	2.5	2.3	245	252	281	[a]	258	---
ST-2	No SS Op.	No SS Op.	---	---	250	256	280	259	265	320
ST-3	No SS Op.	No SS Op.	--	---	215	217	233	232	233	274
ST-4	Rod Destroyed	1.98×10^5	5.8	5.6	475	549	535	Wire Destroyed	646	---
RIA 1-1 MAPI Rods	Not Planned	1.4×10^6	1.7	1.70	215	254	341	---	---	---
RIA 1-1 SAXTON Rods	1.62×10^6	1.43×10^6	1.7	1.72	220	254	341	323	311	311
RIA 1-2 MAPI Rods	Not Completed	1.25×10^6	1.7	1.70	180	192	224	204	201	---

[a] As planned, the shroud fluxwire was not changed after steady-state operation.

TABLE II

Steady-State Burnup Analysis Data

Test	Sample No.	Sample Location (m)	Relative Flux at Sample	Zr^{95} Burnup (f/gU)	Ce^{141} Burnup (f/gU)	Ce^{144} Burnup (f/gU)	Average Isotopic Burnup (f/gU)	Rod Energy Adjusted To Flux Peak (kw·s/m)
ST-1	R1 B1	0.229	0.8236	6.20 + 16	6.14 + 16	6.06 + 16	6.133 + 16	1.046 + 6
ST-1	R1 B2	0.635	0.8637	5.65 + 16	5.81 + 16	5.84 + 16	6.677 + 16	9.379 + 5
ST-1	800-2A	0.208	0.7892	5.69 + 16	4.88 + 16	6.27 + 16	7.096 + 16	9.966 + 5
RIA 1-1	B-1	0.1448	0.6646	7.32 + 16	7.14 + 16	6.96 + 16	7.14 + 16	1.661 + 6
RIA 1-1	B-2	0.295	0.9161	1.00 + 17	9.70 + 16	1.00 + 17	9.90 + 16	1.671 + 6
RIA 1-1	B-3	0.455	0.9983	1.08 + 17	1.07 + 17	1.05 + 17	1.07 + 17	1.658 + 6
RIA 1-1	B-4	0.615	0.8794	9.64 + 16	9.44 + 16	9.22 + 16	9.43 + 16	1.658 + 6
RIA 1-1	B-5	0.765	0.6133	6.90 + 16	6.73 + 16	6.57 + 16	6.73 + 16	1.589 + 6

TABLE III

Variation in Preliminary Energy Data

Test Designation	Range of Radially Averaged Fuel Rod Energy from Various Instruments					
	Pre-Test Energy Target (cal/g UO_2)	Core Chamber Data (cal/g UO_2)	SPND Data (cal/g UO_2)	Shroud Flux Wire Data (cal/g UO_2)	Core Flux Wire Data (cal/g UO_2)	Burnup Analysis Data (cal/g UO_2)
ST-1, PB-1	200	189 - 213	209 - 269	[a]	193 - 209	---
ST-1, PB-2	245	244 - 272	273 - 359	[a]	248 - 268	---
ST-2	250	242 - 277	277 - 324	245 - 273	255 - 276	306 - 334
ST-3	215	204 - 235	230 - 274	220 - 244	224 - 242	264 - 289
ST-4	475	530 - 583	508 - 678	Wire Destroyed	646	---
RIA 1-1 MAPI Rods	215	209 - 295	310 - 371	---	---	---
RIA 1-1 SAXTON Rods	220	207 - 303	307 - 378	319 - 326	311	326 - 336
RIA 1-2 MAPI Rods	180	164 - 218	162 - 219	192 - 219	201	---

[a] As planned, the shroud fluxwire was not changed after steady-state operation.

TABLE IV

Power Burst Burnup Analysis Data

Test	Sample No.	Sample Location (m)	Relative Flux at Sample	Zr^{95} Burnup (f/gU)	Ce^{141} Burnup (f/gU)	Ce^{144} Burnup (f/gU)	Average Isotopic Burnup (f/gU)	Cal/g UO_2 Adjusted to Flux Peak
ST-2	R2 B2	0.635	0.835	5.59 + 13	5.43 + 13	5.63 + 13	5.55 + 13	339
ST-2	800-2B	0.6145	0.862	5.20 + 13	5.69 + 13	4.93 + 13	5.24 + 13	310
ST-3	R3 B1	0.228	0.839	4.35 + 13	4.22 + 13	4.27 + 13	4.28 + 13	271
ST-3	R3 B2	0.381	0.999	5.55 + 13	5.33 + 13	5.60 + 13	5.49 + 13	291
ST-3	R3 B3	0.635	0.830	4.38 + 13	4.28 + 13	4.23 + 13	4.30 + 13	275
ST-3	800-3A	0.3645	0.995	5.10 + 13	5.43 + 13	4.75 + 13	4.98 + 13	266
ST-3	800-3B	0.4335	0.980	5.08 + 13	5.31 + 13	4.87 + 13	5.11 + 13	277
RIA 1-1	801-5A	0.183	0.758	4.80 + 13	4.74 + 13	4.49 + 13	4.73 + 13	338
RIA 1-1	801-5B	0.677	0.809	4.97 + 13	4.97 + 13	4.63 + 13	4.87 + 13	327

[a] Separate isotopic burnup not received.

TABLE V

Comparison of ST-2 and ST-3 Data

Instrument	ST-2 Instrument Output	ST-3 Instrument Output	ST-2 Output / ST-3 Output	Ratio Normalized to Burnup Data
Burnup Analysis	6.363×10^{13} f/gU	5.199×10^{13} f/gU	1.224	1.0
Shroud Flux Wire	9.8508×10^{14} nvt	8.444×10^{14} nvt	1.1667	0.953
Core Flux Wire	6.772×10^{13} nvt	5.667×10^{13} nvt	1.1950	0.976
0.229 SPND	0.20231×10^{-5} A·s	0.16618×10^{-5} A·s	1.2174	0.995
0.457 SPND	0.23896×10^{-5} A·s	0.20860×10^{-5} A·s	1.194	0.975
0.686 SPND	0.19539×10^{-5} A·s	0.16223×10^{-5} A·s	1.204	0.984
EV-1	229. MW·s	192. MW·s	1.193	0.974
EV-2	242. MW·s	203. MW·s	1.192	0.974
TR-1	226. MW·s	190. MW·s	1.190	0.972
TR-2	226. MW·s	189. MW·s	1.196	0.977

APPENDIX C

DATA FOR CONSTRUCTING SCAMP MODELS OF THE PBF

Table C-I shows the SCAMP radial region descriptions. Table C-II gives the material descriptions. Table C-III shows the energy group boundaries for the 32-group model and the groupwise delayed neutron spectrum. Table C-IV is a listing of the simple program written to read the SCAMP fission source output cards and construct an input pointwise delayed neutron source in SCAMP format using the delayed spectrum data given in Table C-III. Finally, Table C-V is an actual listing of a typical SCAMP deck. The deck shown is a fixed source (delayed) problem with a nominal K = .9739. This is shutdown case 1 in section 3.1. One can run an eigenvalue problem by simply removing the fixed source data cards and changing the boron concentration (isotope 130) in material 7 to the value necessary to obtain the desired eigenvalue for the problem. This was done both to obtain the nominal eigenvalues for the shutdown cases and to run the original problem for the conditions existing during the burst.

TABLE C-I

SCAMP MODEL OF THE PBF CORE AND EXPERIMENT SPACE

Region	Material	Material ID	Outer Radius (cm)
1	Test Fuel	16	0.093
2	Test Fuel	16	0.186
3	Test Fuel	16	0.279
4	Test Fuel	16	0.372
5	Test Fuel	16	0.465
6	Cladding + Gap	17	0.535
7	Water	12	0.815
8	Shroud	14	1.130
9	Water (bypass)	12	6.035
10	Flow Divider	11	6.350
11	Water (downcomer	13	7.750
12	Inconel In-Pile Tube	3	10.004
13	Gas Gap	2	10.479
14	Aluminum Filler	4	13.665
15	Canister Plates (Al)	5	14.689
16	Core Fuel	1	19.903
17	Canister Plates (Al)	5	20.591
18	Core Fuel	1	24.584
19	Canister Plates (Al)	5	25.223
20	Core Fuel + Steel Shims	18	28.666
21	Transient Rod Region	6	31.151
22	Core Fuel + Steel Shims	18	37.184
23	Canister Plates (Al)	5	38.050
24	Core Fuel + Steel Shims	18	43.247
25	Canister Plates	5	43.857
26	Core Fuel	1	47.469
27	Control Rod Region	7	51.817
28	Core Fuel	1	56.934
29	Canister Plates	5	57.687
30	Core Fuel	1	61.117
31	Canister Plates	5	62.873
32	Core Fuel	1	66.109
33	Steel Reflector Region	9	68.558
34	Aluminum Reflector Region	8	74.674
35	Water Reflector Region	15	94.674

TABLE C-II

SCAMP MATERIAL DESCRIPTIONS

Material ID	Isotopes[1]	Density Factor
16	289	1.0
17	246	3.71478×10^{-2}
12	10	1.0
14	246	4.291×10^{-2}
11	246	4.291×10^{-2}
13	10	1.0
3	3	1.0
2	3	0.0
4	4	1.0
5	5	1.0
1	1	1.0
18	1	0.884
	9	0.116
6	7	1.0
7	8	1.0
	130	1.7×10^{-5}[2]
	130	6.7×10^{-5}[3]
	130	1.18×10^{-4}[4]
9	9	1.0
8	4	0.7107
	6	0.2891
15	15	1.0

Notes: (1) see Reference (4)
(2) for K = 0.9981 (Burst Calculation for Delayed Source Shape)
(3) for K = 0.9739 (Shutdown Case 1)
(4) for K = 0.9630 (Shutdown Case 2)

TABLE C-III

32-GROUP ENERGY STRUCTURE AND DELAYED NEUTRON SPECTRUM

Group		Upper Energy (eV)	Lower Energy (eV)	$\chi_d(g)$
1		10.0+6	6.07+6	0.0
2		6.07+6	3.68+6	0.0
3		3.68+6	2.23+6	0.0015
4		2.23+6	1.35+6	0.0226
5		1.35+6	8.21+5	0.1017
6		8.21+5	4.98+5	0.1982
7		4.98+5	3.02+5	0.2264
8		3.02+5	1.83+5	0.1839
9		1.83+5	1.11+5	0.121
10		1.11+5	6.74+4	0.07
11	TWIGL Group 1	6.74+4	4.09+4	0.0373
12		4.09+4	2.48+4	0.0191
13		2.48+4	1.50+4	0.0094
14		1.50+4	9.12+3	0.0046
15		9.12+3	5.53+3	0.0022
16		5.53+3	2.04+3	0.0015
17		2.04+3	7.485+2	0.003
18		7.485+2	2.754+2	0.0
19		2.754+2	1.013+2	0.0
20		1.013+2	3.73+1	0.0
21		3.73+1	1.37+1	0.0
22		1.37+1	5.04	0.0
23		5.04	1.86	0.0
24		1.86	8.76-1	0.0
25		8.76-1	5.32-1	0.0
26		5.32-1	4.14-1	0.0
27		4.14-1	1.80-1	0.0
28	TWIGL Group 2	1.80-1	6.50-2	0.0
29		6.50-2	3.0-2	0.0
30		3.00-2	1.50-2	0.0
31		1.50-2	4.00-2	0.0
32		4.0-3	0.0	0.0

TABLE C-IV

PROGRAM FOR GENERATING SCAMP INPUT FIXED SOURCE CARDS
FROM SCAMP OUTPUT FISSION SOURCE CARDS,
ASSIGNING A NEW GROUP SPECTRUM

```
SRSGEN      76/76    OPT=1                                    FTN 4.6+452

      PROGRAM SRSGEN(INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT,PUNCH)
      DIMENSION SJS(5),SRS(5),CHI(18)
      READ (5,4) CHI
    4 FORMAT (6E12.8)
      DO 40 I=1,42
      READ (5,3) (I1,I2,I3,I4,I5,I6,(SRS(J),J=1,5))
    3 FORMAT (I1,2I2,I3,2I2,5E12.8)
      J1=0
      J2=9
      K=I4
      DO 24 J=1,17
      DO 20 K1=1,I6
   20 SJS(K1)=CHI(J)*SRS(K1)
      PUNCH 30, (J1,J2,J,K,I5,I6,(SJS(K2),K2=1,I6))
   24 WRITE(6,30)(J1,J2,J,K,I5,I6,(SJS(K2),K2=1,I6))
   30 FORMAT (I1,2I2,I3,2I2,1P5E12.5)
   40 CONTINUE
      STOP
      END
```

TABLE C-V

TYPICAL SCAMP CARD INPUT

```
SCAMP 2 GROUP SIGMA   DELAY SOURCE K=.974                                                                    2
          1   15      35   32    1    1    1    1 200          1    0    0    4    2
          1   15      39   32    0    1    1    1 200          1    0    0    4    2
          1   15      39   32    1    1    1    1 200          1    0    0    4
         11    1    1
         18    1    0
         19    2   32
         22    1    2
         22    1    1
         23    1    0
         23    1    2
         24    1    0
         24    1    2
      1   1   15   16   16   16   16   16   17   12   14   12   11   13    3    2    4    5
      1  16   15    1    5    1    5   18    6   18    5   18    5    1    7    1    5    1
      1  16   15    1    5    1   19    1    6   18    6   18    5   18    5    1    7    1
      1  31    5    5    1    9    8   15
      1  31    5    5    1    6    1   19    1    9    8   15
      2   1   15    2    2    3    3    3    2    5    3   15    3    5   10    1    4    2
      2  16   15   15    1    6    1    4    2    5    1    5    1    4    3    6    1    5
      2  16   15   15    1    6    1    6    1    4    2    5    1    5    1    4    3    6
      2  31    5    2    7    5   13   25
      2  31    5    1    6    2    7    1    7    5   10   25
         31    1    1
         34    1    2
         34    1    0
      9   1   12   25   32
     10   1   15    5   11   12   14   18   19   22   23   28   29   34   35   36   37   38
     10  16    1   39
   1   1   1    1  271
   1   1   1    1    1
   1   2   1    1    3
   1   3   1    1    3
   1   4   1    1    4
   1   5   1    1    5
   1   6   1    1    7
   1   7   1    2    8  130
   1   8   1    2    4    6
   1   9   1    1    9
  110   1    1    4
  111   1    1    2
  112   1    1   10
  113   1    1   10
  114   1    1    2
  115   1    1   15
  116   1    1  288
  117   1    1  246
  118   1    2    9  271
  118   1    2    1    9
  119   1    1  999
         2    1  0.005
         2    1  0.001
         6    2  .37966890+06 3.17     -11
         8    1   .5
         9    1   .5
   1  1   1    5  1.0          1.0          1.0          1.0          1.0
```

TABLE C-V (cont'd)

1	1	6	5	1.0			1.0			1.0			1.0			1.0	
1	1	11	5	1.0			1.0			1.0			1.0			1.0	
1	1	16	5	1.0			1.0			1.0			1.0			1.0	
1	1	21	5	1.0			1.0			1.0			1.0			1.0	
1	1	26	5	1.0			1.0			1.0			1.0			1.0	
1	1	31	2	1.0			1.0			1.0							
5	1	1	5	2.3717		-02	1.04356		-01	2.00501		-01	2.2631		-01	1.82704	-01
5	1	6	5	1.19799		-01	6.9116		-02	3.6872		-02	1.8754		-02	9.2654	-03
5	1	11	5	4.4975		-03	2.15994		-03	1.03056		-03	4.8977		-04	2.32204	-04
5	1	16	4	1.6193		-04	3.62009		-05	8.0831		-06	1.80405		-06		
516	1		5	2.3717		-02	1.04356		-01	2.00501		-01	2.2631		-01	1.82704	-01
516	6		5	1.19799		-01	6.9116		-02	3.6872		-02	1.8754		-02	9.2654	-03
516	11		5	4.4975		-03	2.15994		-03	1.03056		-03	4.8977		-04	2.32204	-04
516	16		4	1.6193		-04	3.62009		-05	8.0831		-06	1.80405		-06		
518	1		5	2.3717		-02	1.04356		-01	2.00501		-01	2.2631		-01	1.82704	-01
518	6		5	1.19799		-01	6.9116		-02	3.6872		-02	1.8754		-02	9.2654	-03
518	11		5	4.4975		-03	2.15994		-03	1.03056		-03	4.8977		-04	2.32204	-04
518	16		4	1.6193		-04	3.62009		-05	8.0831		-06	1.80405		-06		
6	1	1	1	0.87		-03											
9	1	1	5	0.			0.			0.			0.			0.	
9	2	1	5	0.			0.			0.			0.			0.	
9	3	1	5	6.22503E		-06	6.24357E		-06	6.28494E		-06	6.35283E		-06	6.35283E	-06
9	4	1	5	9.37905E		-05	9.40698E		-05	9.46931E		-05	9.57160E		-05	9.57160E	-05
9	5	1	5	4.22057E		-04	4.23314E		-04	4.26119E		-04	4.30722E		-04	4.30722E	-04
9	6	1	5	8.22534E		-04	8.24984E		-04	8.30450E		-04	8.39421E		-04	8.39421E	-04
9	7	1	5	9.39565E		-04	9.42363E		-04	9.48607E		-04	9.58854E		-04	9.58854E	-04
9	8	1	5	7.63189E		-04	7.65462E		-04	7.70534E		-04	7.78857E		-04	7.78857E	-04
9	9	1	5	5.02152E		-04	5.03648E		-04	5.06985E		-04	5.12462E		-04	5.12462E	-04
910	1	0	5	2.90501E		-04	2.91367E		-04	2.93297E		-04	2.96465E		-04	2.96465E	-04
911	1	0	5	1.54796E		-04	1.55257E		-04	1.56286E		-04	1.57974E		-04	1.57974E	-04
912	1	0	5	7.92654E		-05	7.95015E		-05	8.00282E		-05	8.08927E		-05	8.08927E	-05
913	1	0	5	3.90102E		-05	3.91264E		-05	3.93856E		-05	3.98111E		-05	3.98111E	-05
914	1	0	5	1.90501E		-05	1.91469E		-05	1.92738E		-05	1.94820E		-05	1.94820E	-05
915	1	0	5	9.13004E		-06	9.15724E		-06	9.21791E		-06	9.31748E		-06	9.31748E	-06
916	1	0	5	6.22563E		-06	6.24357E		-06	6.28494E		-06	6.35283E		-06	6.35283E	-06
917	1	0	5	1.24501E		-06	1.24871E		-06	1.25699E		-06	1.27057E		-06	1.27057E	-06
9	1	6	5	0.			0.			0.			0.			0.	
9	2	6	5	0.			0.			0.			0.			0.	
9	3	6	5	6.44922E		-06	6.57651E		-06	6.73772E		-06	6.73772E		-06	6.93675E	-06
9	4	6	5	9.71682E		-05	9.90861E		-05	1.01515E		-04	1.01515E		-04	1.04514E	-04
9	5	6	5	4.37257E		-04	4.45887E		-04	4.56817E		-04	4.56817E		-04	4.70312E	-04
9	6	6	5	8.52157E		-04	8.68976E		-04	8.90277E		-04	8.90277E		-04	9.16576E	-04
9	7	6	5	9.73402E		-04	9.92615E		-04	1.01695E		-03	1.01695E		-03	1.04699E	-03
9	8	6	5	7.90674E		-04	8.06280E		-04	8.26044E		-04	8.26044E		-04	8.50444E	-04
9	9	6	5	5.20237E		-04	5.30505E		-04	5.43509E		-04	5.43509E		-04	5.59565E	-04
910	6	0	5	3.00984E		-04	3.06904E		-04	3.14427E		-04	3.14427E		-04	3.23715E	-04
911	6	0	5	1.60371E		-04	1.63536E		-04	1.67545E		-04	1.67545E		-04	1.72494E	-04
912	6	0	5	8.21201E		-05	8.37409E		-05	8.57936E		-05	8.57936E		-05	8.83280E	-05
913	6	0	5	4.04151E		-05	4.12128E		-05	4.22230E		-05	4.22230E		-05	4.34703E	-05
914	6	0	5	1.97776E		-05	2.01680E		-05	2.06623E		-05	2.06623E		-05	2.12727E	-05
915	6	0	5	9.45886E		-06	9.64555E		-06	9.88198E		-06	9.88198E		-06	1.01739E	-05
916	6	0	5	6.44922E		-06	6.57651E		-06	6.73772E		-06	6.73772E		-06	6.93675E	-06
917	6	0	5	1.28984E		-06	1.31530E		-06	1.34754E		-06	1.34754E		-06	1.38735E	-06
9	1	11	5	0.			0.			0.			0.			0.	
9	2	11	5	0.			0.			0.			0.			0.	
9	3	11	5	7.17848E		-06	7.46925E		-06	7.46925E		-06	7.81748E		-06	8.23590E	-06
9	4	11	5	1.04156E		-04	1.12537E		-04	1.12537E		-04	1.17783E		-04	1.24088E	-04
9	5	11	5	4.47721E		-04	5.04185E		-04	5.04185E		-04	5.30025E		-04	5.58394E	-04

TABLE C-V (cont'd)

9	6	11	0	5	9.455166E-04	9.866937E-04	9.866937E-04	1.032295E-03	1.088224E-03
9	7	11	0	5	1.053475E-03	1.127366E-03	1.127366E-03	1.179922E-03	1.243076E-03
9	8	11	0	5	8.600816E-04	9.157306E-04	9.157306E-04	9.584226E-04	1.009726E-03
9	9	11	0	5	5.790646E-04	6.025206E-04	6.025206E-04	6.306106E-04	6.643636E-04
9	10	11	0	5	3.349966E-04	3.485656E-04	3.485656E-04	3.648316E-04	3.843426E-04
9	11	11	0	5	1.795056E-04	1.857356E-04	1.857356E-04	1.943956E-04	2.047996E-04
9	12	11	0	5	9.140596E-05	9.510856E-05	9.510856E-05	9.954256E-05	1.048706E-04
9	13	11	0	5	4.498516E-05	4.680736E-05	4.680736E-05	4.898956E-05	5.161166E-05
9	14	11	0	5	2.201406E-05	2.290576E-05	2.290576E-05	2.397366E-05	2.525686E-05
9	15	11	0	5	1.052346E-05	1.095496E-05	1.095496E-05	1.146566E-05	1.207936E-05
9	16	11	0	5	7.178486E-06	7.469256E-06	7.469256E-06	7.817486E-06	8.235906E-06
9	17	11	0	5	1.435706E-06	1.493856E-06	1.493856E-06	1.563506E-06	1.647186E-06
9	1	16	0	5	0.	0.	0.	0.	0.
9	2	16	0	5	0.	0.	0.	0.	0.
9	3	16	0	5	8.746206E-06	8.746206E-06	9.399176E-06	1.031966E-05	1.204706E-05
9	4	16	0	5	1.317766E-04	1.317766E-04	1.416146E-04	1.554836E-04	1.815086E-04
9	5	16	0	5	5.929926E-04	5.929926E-04	6.372636E-04	6.996726E-04	8.167866E-04
9	6	16	0	5	1.155666E-03	1.155666E-03	1.241946E-03	1.363576E-03	1.591816E-03
9	7	16	0	5	1.320096E-03	1.320096E-03	1.418656E-03	1.557586E-03	1.818296E-03
9	8	16	0	5	1.072286E-03	1.072286E-03	1.152346E-03	1.265196E-03	1.476966E-03
9	9	16	0	5	7.055276E-04	7.055276E-04	7.581996E-04	8.324516E-04	9.717916E-04
9	10	16	0	5	4.081566E-04	4.081566E-04	4.386286E-04	4.815836E-04	5.621936E-04
9	11	16	0	5	2.174896E-04	2.174896E-04	2.337266E-04	2.566156E-04	2.995696E-04
9	12	16	0	5	1.113686E-04	1.113686E-04	1.196836E-04	1.314036E-04	1.533986E-04
9	13	16	0	5	5.480956E-05	5.480956E-05	5.890146E-05	6.466976E-05	7.549456E-05
9	14	16	0	5	2.682176E-05	2.682176E-05	2.882416E-05	3.164696E-05	3.694416E-05
9	15	16	0	5	1.282786E-05	1.282786E-05	1.378546E-05	1.513556E-05	1.766896E-05
9	16	16	0	5	8.746206E-06	8.746206E-06	9.399176E-06	1.031966E-05	1.204706E-05
9	17	16	0	5	1.749246E-06	1.749246E-06	1.879836E-06	2.063936E-06	2.409406E-06
9	1	81	0	5	0.	0.	0.	0.	0.
9	2	81	0	5	0.	0.	0.	0.	0.
9	3	81	0	5	1.957396E-07	2.024796E-07	2.053506E-07	2.077176E-07	2.099326E-07
9	4	81	0	5	3.009266E-06	3.050666E-06	3.093946E-06	3.129606E-06	3.161476E-06
9	5	81	0	5	1.354176E-05	1.372616E-05	1.392276E-05	1.408326E-05	1.422666E-05
9	6	81	0	5	2.639096E-05	2.675426E-05	2.713366E-05	2.744636E-05	2.772586E-05
9	7	81	0	5	3.014586E-05	3.056086E-05	3.099426E-05	3.135146E-05	3.167066E-05
9	8	81	0	5	2.448686E-05	2.482396E-05	2.517596E-05	2.546616E-05	2.572546E-05
9	9	81	0	5	1.611156E-05	1.633336E-05	1.656496E-05	1.675586E-05	1.692646E-05
9	10	81	0	5	9.320716E-06	9.449026E-06	9.583006E-06	9.693466E-06	9.792166E-06
9	11	81	0	5	4.936616E-06	5.034596E-06	5.106376E-06	5.165236E-06	5.217826E-06
9	12	81	0	5	2.543226E-06	2.578236E-06	2.614796E-06	2.644936E-06	2.671866E-06
9	13	81	0	5	1.251646E-06	1.268876E-06	1.286866E-06	1.301696E-06	1.314956E-06
9	14	81	0	5	6.125046E-07	6.209366E-07	6.297406E-07	6.369996E-07	6.434856E-07
9	15	81	0	5	2.982376E-07	3.023696E-07	3.066806E-07	3.102526E-07	3.134546E-07
9	16	81	0	5	1.937306E-07	2.024796E-07	2.053506E-07	2.077176E-07	2.099326E-07
9	17	81	0	5	3.994596E-08	4.049586E-08	4.107006E-08	4.154346E-08	4.176646E-08
9	1	86	0	5	0.	0.	0.	0.	0.
9	2	86	0	5	0.	0.	0.	0.	0.
9	3	86	0	5	2.117796E-07	2.136276E-07	2.154326E-07	2.172036E-07	2.190096E-07
9	4	86	0	5	3.190836E-06	3.218656E-06	3.245836E-06	3.272536E-06	3.299746E-06
9	5	86	0	5	1.435866E-05	1.448396E-05	1.460636E-05	1.472646E-05	1.484886E-05
9	6	86	0	5	2.798316E-05	2.822726E-05	2.846576E-05	2.869986E-05	2.893846E-05
9	7	86	0	5	3.196456E-05	3.224346E-05	3.251586E-05	3.278326E-05	3.305586E-05
9	8	86	0	5	2.596416E-05	2.619076E-05	2.641196E-05	2.662916E-05	2.685056E-05
9	9	86	0	5	1.706356E-05	1.723266E-05	1.737816E-05	1.752106E-05	1.766676E-05
9	10	86	0	5	9.883026E-06	9.969266E-06	1.005356E-05	1.013616E-05	1.022046E-05
9	11	86	0	5	5.236246E-06	5.312196E-06	5.357066E-06	5.401116E-06	5.446026E-06
9	12	86	0	5	2.695666E-06	2.723196E-06	2.743166E-06	2.765726E-06	2.788716E-06

TABLE C-V (cont'd)

913	86	0	5	1.327155E-06	1.338736-06	1.35004E-06	1.36114E-06	1.37246E-06
914	86	0	5	6.494565E-07	6.551232-07	6.60657E-07	6.660895-07	6.71628E-07
915	86	0	5	3.106096-07	3.13320E-07	3.15966E-07	3.18564E-07	3.21213E-07
916	86	0	5	2.117796-07	2.13627E-07	2.15432E-07	2.172035-07	2.19009E-07
917	86	0	5	4.235586-08	4.27254E-08	4.30863E-08	4.34406E-08	4.38018E-08
9	1	91	0	5	0.	0.	0.	0.
9	2	91	0	5	0.	0.	0.	0.
9	3	91	0	5	2.20803E-07	2.22756E-07	2.24664E-07	2.27171E-07	2.29230E-07
9	4	91	0	5	3.32677E-06	3.35619E-06	3.38494E-06	3.42270E-06	3.45373E-06
9	5	91	0	5	1.49704E-05	1.51029E-05	1.52322E-05	1.54022E-05	1.55418E-05
9	6	91	0	5	2.91754E-05	2.94335E-05	2.96856E-05	3.00168E-05	3.02889E-05
9	7	91	0	5	3.33206E-05	3.36213E-05	3.39093E-05	3.42876E-05	3.45984E-05
9	8	91	0	5	2.70704E-05	2.73099E-05	2.75438E-05	2.78511E-05	2.81036E-05
9	9	91	0	5	1.78114E-05	1.79690E-05	1.81229E-05	1.83251E-05	1.84912E-05
9	10	91	0	5	1.03041E-05	1.03953E-05	1.04843E-05	1.06013E-05	1.06974E-05
9	11	91	0	5	5.49063E-06	5.53920E-06	5.58664E-06	5.64897E-06	5.70019E-06
9	12	91	0	5	2.81156E-06	2.83643E-06	2.86072E-06	2.89264E-06	2.91886E-06
9	13	91	0	5	1.38370E-06	1.39594E-06	1.40789E-06	1.42360E-06	1.43651E-06
9	14	91	0	5	6.77129E-07	6.83118E-07	6.88970E-07	6.96656E-07	7.02972E-07
9	15	91	0	5	3.23844E-07	3.26709E-07	3.29507E-07	3.33183E-07	3.36204E-07
9	16	91	0	5	2.20803E-07	2.22756E-07	2.24664E-07	2.27171E-07	2.29230E-07
9	17	91	0	5	4.41606E-08	4.45512E-08	4.49328E-08	4.54341E-08	4.58460E-08
9	1	96	0	5	0.	0.	0.	0.	0.
9	2	96	0	5	0.	0.	0.	0.	0.
9	3	96	0	5	2.36008E-07	0.	0.	2.35143E-07	2.32460E-07
9	4	96	0	5	3.55582E-06	0.	0.	3.54282E-06	3.50239E-06
9	5	96	0	5	1.60012E-05	0.	0.	1.59427E-05	1.57608E-05
9	6	96	0	5	3.11842E-05	0.	0.	3.10702E-05	3.07156E-05
9	7	96	0	5	3.56211E-05	0.	0.	3.54909E-05	3.50859E-05
9	8	96	0	5	2.89343E-05	0.	0.	2.88285E-05	2.84995E-05
9	9	96	0	5	1.90378E-05	0.	0.	1.89682E-05	1.87517E-05
9	10	96	0	5	1.10136E-05	0.	0.	1.09733E-05	1.08481E-05
9	11	96	0	5	5.86867E-06	0.	0.	5.84722E-06	5.78049E-06
9	12	96	0	5	3.00514E-06	0.	0.	2.99415E-06	2.95999E-06
9	13	96	0	5	1.47897E-06	0.	0.	1.47356E-06	1.45675E-06
9	14	96	0	5	7.23750E-07	0.	0.	7.21105E-07	7.12876E-07
9	15	96	0	5	3.46141E-07	0.	0.	3.44876E-07	3.40941E-07
9	16	96	0	5	2.36008E-07	0.	0.	2.35143E-07	2.32460E-07
9	17	96	0	5	4.72011E-08	0.	0.	4.70286E-08	4.64919E-08
9	1	101	0	5	0.	0.	0.	0.	0.
9	2	101	0	5	0.	0.	0.	0.	0.
9	3	101	0	5	2.31749E-07	2.31488E-07	2.31560E-07	2.31813E-07	2.32248E-07
9	4	101	0	5	3.49168E-06	3.48775E-06	3.48883E-06	3.49265E-06	3.49920E-06
9	5	101	0	5	1.57125E-05	1.56994E-05	1.56997E-05	1.57169E-05	1.57464E-05
9	6	101	0	5	3.06217E-05	3.05872E-05	3.05967E-05	3.06302E-05	3.06877E-05
9	7	101	0	5	3.49786E-05	3.49392E-05	3.49500E-05	3.49883E-05	3.50540E-05
9	8	101	0	5	2.84124E-05	2.83804E-05	2.83892E-05	2.84203E-05	2.84736E-05
9	9	101	0	5	1.86944E-05	1.86733E-05	1.86791E-05	1.86996E-05	1.87347E-05
9	10	101	0	5	1.08149E-05	1.08028E-05	1.08061E-05	1.08179E-05	1.08382E-05
9	11	101	0	5	5.76281E-06	5.75532E-06	5.75811E-06	5.76442E-06	5.77523E-06
9	12	101	0	5	2.95093E-06	2.94761E-06	2.94852E-06	2.95175E-06	2.95729E-06
9	13	101	0	5	1.45229E-06	1.45066E-06	1.45111E-06	1.45269E-06	1.45542E-06
9	14	101	0	5	7.10695E-07	7.09895E-07	7.10116E-07	7.10893E-07	7.12227E-07
9	15	101	0	5	3.39496E-07	3.39515E-07	3.39621E-07	3.39992E-07	3.40630E-07
9	16	101	0	5	2.31749E-07	2.31488E-07	2.31560E-07	2.31813E-07	2.32248E-07
9	17	101	0	5	4.63497E-08	4.62975E-08	4.63119E-08	4.63626E-08	4.64496E-08
9	1	106	0	5	0.	0.	0.	0.	0.
9	2	106	0	5	0.	0.	0.	0.	0.

TABLE C-V (cont'd)

3	5106	0	5	0.	0.	2.32248E-07	2.32794E-07	2.33568E-07
3	4106	0	5	0.	0.	3.49920E-06	3.50743E-06	3.51909E-06
9	5106	0	5	0.	0.	1.57464E-05	1.57834E-05	1.58359E-05
3	6106	0	5	0.	0.	3.06877E-05	3.07598E-05	3.08621E-05
9	7106	0	5	0.	0.	3.50540E-05	3.51364E-05	3.52532E-05
3	8106	0	5	0.	0.	2.84736E-05	2.85405E-05	2.86354E-05
9	9106	0	5	0.	0.	1.87347E-05	1.87787E-05	1.88412E-05
9101	06	0	5	0.	0.	1.08382E-05	1.08637E-05	1.08998E-05
9111	06	0	5	0.	0.	5.77523E-06	5.78881E-06	5.80806E-06
9121	06	0	5	0.	0.	2.95729E-06	2.96424E-06	2.97410E-06
9131	06	0	5	0.	0.	1.45542E-06	1.45884E-06	1.46369E-06
9141	06	0	5	0.	0.	7.12227E-07	7.13902E-07	7.14275E-07
9151	06	0	5	0.	0.	3.40630E-07	3.41431E-07	3.42566E-07
9161	06	0	5	0.	0.	2.32248E-07	2.32794E-07	2.33568E-07
9171	06	0	5	0.	0.	4.64496E-08	4.65588E-08	4.67136E-08
3	1111	0	5	0.	0.	0.	0.	0.
3	2111	0	5	0.	0.	0.	0.	0.
9	3111	0	5	2.34401E-07	2.35842E-07	2.37008E-07	2.42733E-07	0.
9	4111	0	5	3.53163E-06	3.55335E-06	3.57091E-06	3.65718E-06	0.
9	5111	0	5	1.58924E-05	1.59901E-05	1.60691E-05	1.64573E-05	0.
9	6111	0	5	3.09721E-05	3.11626E-05	3.13166E-05	3.20731E-05	0.
9	7111	0	5	3.53788E-05	3.55964E-05	3.57723E-05	3.66365E-05	0.
9	8111	0	5	2.87375E-05	2.89142E-05	2.90571E-05	2.97591E-05	0.
9	9111	0	5	1.89083E-05	1.90246E-05	1.91166E-05	1.95805E-05	0.
9101	11	0	5	1.08387E-05	1.09060E-05	1.10604E-05	1.13275E-05	0.
9111	11	0	5	5.82676E-06	5.86460E-06	5.89359E-06	6.03596E-06	0.
9121	11	0	5	2.98470E-06	3.00305E-06	3.01790E-06	3.09080E-06	0.
9131	11	0	5	1.46891E-06	1.47794E-06	1.48525E-06	1.52113E-06	0.
9141	11	0	5	7.18828E-07	7.23249E-07	7.26823E-07	7.44381E-07	0.
9151	11	0	5	3.43787E-07	3.45902E-07	3.47611E-07	3.56009E-07	0.
9161	11	0	5	2.34401E-07	2.35842E-07	2.37008E-07	2.42733E-07	0.
9171	11	0	5	4.68801E-08	4.71684E-08	4.74015E-08	4.85466E-08	0.
3	1116	0	5	0.	0.	0.	0.	0.
9	2116	0	5	0.	0.	0.	0.	0.
9	3116	0	5	0.	2.13690E-07	2.07830E-07	2.08386E-07	2.06277E-07
3	4116	0	5	0.	3.21960E-06	3.13130E-06	3.13968E-06	3.10791E-06
9	5116	0	5	0.	1.44862E-05	1.40908E-05	1.41286E-05	1.39856E-05
9	6116	0	5	0.	2.82356E-05	2.74612E-05	2.75347E-05	2.72561E-05
9	7116	0	5	0.	3.22529E-05	3.13684E-05	3.14524E-05	3.11341E-05
9	8116	0	5	0.	2.61984E-05	2.54799E-05	2.55481E-05	2.52896E-05
9	9116	0	5	0.	1.72377E-05	1.67645E-05	1.68098E-05	1.66397E-05
9101	16	0	5	0.	9.97220E-06	9.69871E-06	9.72458E-06	9.62626E-06
9111	16	0	5	0.	5.31376E-06	5.16803E-06	5.18187E-06	5.12942E-06
9121	16	0	5	0.	2.72994E-06	2.64636E-06	2.65345E-06	2.62659E-06
9131	16	0	5	0.	1.33912E-06	1.30240E-06	1.30589E-06	1.29267E-06
9141	16	0	5	0.	6.55316E-07	6.37344E-07	6.39050E-07	6.32583E-07
9151	16	0	5	0.	3.13412E-07	3.04817E-07	3.05633E-07	3.02540E-07
9161	16	0	5	0.	2.13690E-07	2.07830E-07	2.08386E-07	2.06277E-07
9171	16	0	5	0.	4.27380E-08	4.15659E-08	4.16772E-08	4.12554E-08
3	1121	0	5	0.	0.	0.	0.	0.
9	2121	0	5	0.	0.	0.	0.	0.
9	3121	0	5	2.13303E-07	0.	0.	0.	2.11499E-07
9	4121	0	5	3.21377E-06	0.	0.	0.	3.18658E-06
9	5121	0	5	1.44619E-05	0.	0.	0.	1.43396E-05
9	6121	0	5	2.81844E-05	0.	0.	0.	2.79460E-05
9	7121	0	5	3.21945E-05	0.	0.	0.	3.19222E-05
9	8121	0	5	2.61509E-05	0.	0.	0.	2.59297E-05
9	9121	0	5	1.72064E-05	0.	0.	0.	1.70609E-05

TABLE C-V (cont'd)

9101 21	0 5	9.95414E-06	0.	0.	0.	0.	9.86993E-06
9111 21	0 5	5.39413E-06	0.	0.	0.	0.	5.25926E-06
9121 21	0 5	2.71606E-06	0.	0.	0.	0.	2.69308E-06
9131 21	0 5	1.33670E-06	0.	0.	0.	0.	1.32539E-06
9141 21	0 5	6.54129E-07	0.	0.	0.	0.	6.48595E-07
9151 21	0 5	3.12844E-07	0.	0.	0.	0.	3.10198E-07
9161 21	0 5	2.13303E-07	0.	0.	0.	0.	2.11499E-07
9171 21	0 5	4.25606E-08	0.	0.	0.	0.	4.22997E-08
9 1126	0 5	0.	0.	0.	0.	0.	0.
9 2126	0 5	0.	0.	0.	0.	0.	0.
9 3126	0 5	2.009361E-07	1.96230E-07	1.93944E-07	1.88147E-07	0.	1.93356E-07
9 4126	0 5	3.027435E-06	2.95653E-06	2.92209E-06	2.83474E-06	0.	2.91323E-06
9 5126	0 5	1.36234E-05	1.33044E-05	1.31494E-05	1.27563E-05	0.	1.31095E-05
9 6126	0 5	2.65503E-05	2.59285E-05	2.56265E-05	2.48604E-05	0.	2.55488E-05
9 7126	0 5	3.03279E-05	2.96176E-05	2.92726E-05	2.83976E-05	0.	2.91939E-05
9 8126	0 5	2.46347E-05	2.40578E-05	2.37775E-05	2.30668E-05	0.	2.37054E-05
9 9126	0 5	1.62088E-05	1.58292E-05	1.56448E-05	1.51772E-05	0.	1.55974E-05
9101 26	0 5	9.37699E-06	9.15740E-06	9.05072E-06	8.78017E-06	0.	9.02328E-06
9111 26	0 5	4.99666E-06	4.87959E-06	4.82274E-06	4.67858E-06	0.	4.80812E-06
9121 26	0 5	2.55858E-06	2.49866E-06	2.46955E-06	2.39573E-06	0.	2.46207E-06
9131 26	0 5	1.25920E-06	1.22971E-06	1.21538E-06	1.17905E-06	0.	1.21170E-06
9141 26	0 5	6.16202E-07	6.01772E-07	5.94762E-07	5.76993E-07	0.	5.92958E-07
9151 26	0 5	2.34705E-07	2.29204E-07	2.26451E-07	2.19548E-07	0.	2.25899E-07
9161 26	0 5	2.00936E-07	1.96230E-07	1.93944E-07	1.88147E-07	0.	1.93356E-07
9171 26	0 5	4.01871E-08	3.92460E-08	3.87888E-08	3.76293E-08	0.	3.86712E-08
9 1131	0 5	0.	0.	0.	0.	0.	0.
9 2131	0 5	0.	0.	0.	0.	0.	0.
9 3131	0 5	0.	0.	1.90893E-07	1.79303E-07	0.	1.72662E-07
9 4131	0 5	0.	0.	2.87612E-06	2.70149E-06	0.	2.60144E-06
9 5131	0 5	0.	0.	1.29425E-05	1.21567E-05	0.	1.17065E-05
9 6131	0 5	0.	0.	2.52233E-05	2.36918E-05	0.	2.28144E-05
9 7131	0 5	0.	0.	2.88121E-05	2.70627E-05	0.	2.60605E-05
9 8131	0 5	0.	0.	2.34035E-05	2.19825E-05	0.	2.11684E-05
9 9131	0 5	0.	0.	1.53987E-05	1.44637E-05	0.	1.39281E-05
9101 31	0 5	0.	0.	8.90834E-06	8.36745E-06	0.	8.05756E-06
9111 31	0 5	0.	0.	4.74687E-06	4.45866E-06	0.	4.29353E-06
9121 31	0 5	0.	0.	2.43070E-06	2.28312E-06	0.	2.19856E-06
9131 31	0 5	0.	0.	1.19626E-06	1.12363E-06	0.	1.08202E-06
9141 31	0 5	0.	0.	5.85405E-07	5.49861E-07	0.	5.29497E-07
9151 31	0 5	0.	0.	2.79976E-07	2.62977E-07	0.	2.53239E-07
9161 31	0 5	0.	0.	1.90893E-07	1.79303E-07	0.	1.72662E-07
9171 31	0 5	0.	0.	3.91786E-08	3.58605E-08	0.	3.45324E-08
9 1136	0 5	0.	0.	0.	0.	0.	0.
9 2136	0 5	0.	0.	0.	0.	0.	0.
9 3136	0 5	1.66997E-07	1.59420E-07	1.57233E-07	0.	0.	0.
9 4136	0 5	2.51606E-06	2.40193E-06	2.36896E-06	0.	0.	0.
9 5136	0 5	1.13224E-05	1.08087E-05	1.06604E-05	0.	0.	0.
9 6136	0 5	2.20565E-05	2.10647E-05	2.07757E-05	0.	0.	0.
9 7136	0 5	2.52053E-05	2.40618E-05	2.37317E-05	0.	0.	0.
9 8136	0 5	2.04738E-05	1.95449E-05	1.92768E-05	0.	0.	0.
9 9136	0 5	1.34711E-05	1.28599E-05	1.26835E-05	0.	0.	0.
9101 36	0 5	7.79317E-06	7.43960E-06	7.33754E-06	0.	0.	0.
9111 36	0 5	4.15265E-06	3.96424E-06	3.90966E-06	0.	0.	0.
9121 36	0 5	2.12642E-06	2.02995E-06	2.00210E-06	0.	0.	0.
9131 36	0 5	1.04651E-06	9.99132E-07	9.85327E-07	0.	0.	0.
9141 36	0 5	5.12123E-07	4.89056E-07	4.82181E-07	0.	0.	0.
9151 36	0 5	2.44928E-07	2.33816E-07	2.30606E-07	0.	0.	0.
9161 36	0 5	1.66997E-07	1.59420E-07	1.57233E-07	0.	0.	0.

	9 7136	0	5	3.33993E-08	3.13646E-08	3.14466E-08	0.	0.
	9 1141	0	5	0.	0.	0.	0.	0.
	9 2141	0	5	0.	0.	0.	0.	0.
	9 3141	0	5	1.75178E-07	1.63083E-07	1.51140E-07	1.40961E-07	1.14494E-07
	9 4141	0	5	2.63934E-06	2.45712E-06	2.27716E-06	2.12381E-06	1.72504E-06
	9 5141	0	5	1.18770E-05	1.10570E-05	1.02473E-05	9.55715E-06	7.76268E-06
	9 6141	0	5	2.31468E-05	2.15487E-05	1.99706E-05	1.86256E-05	1.51284E-05
	9 7141	0	5	2.64401E-05	2.46147E-05	2.28121E-05	2.12757E-05	1.72809E-05
	9 8141	0	5	2.14768E-05	1.99940E-05	1.85298E-05	1.72818E-05	1.40369E-05
	9 9141	0	5	1.41310E-05	1.31554E-05	1.21920E-05	1.13708E-05	9.23583E-06
	9101 41	0	5	8.17495E-06	7.61054E-06	7.05320E-06	6.57817E-06	5.34304E-06
	9111 41	0	5	4.35608E-06	4.05533E-06	3.75835E-06	3.50523E-06	2.84708E-06
	9121 41	0	5	2.23059E-06	2.07659E-06	1.92452E-06	1.79490E-06	1.45789E-06
	9131 41	0	5	1.09778E-06	1.02199E-06	9.47144E-07	8.83355E-07	7.17494E-07
	9141 41	0	5	5.37211E-07	5.00121E-07	4.63496E-07	4.32280E-07	3.51114E-07
	9151 41	0	5	2.56927E-07	2.39188E-07	2.21672E-07	2.06743E-07	1.67924E-07
	9161 41	0	5	1.75178E-07	1.63083E-07	1.51140E-07	1.40961E-07	1.14494E-07
	9171 41	0	5	3.50355E-08	3.26166E-08	3.02280E-08	2.81922E-08	2.28988E-08
	9 1146	0	5	0.	0.	0.	0.	0.
	9 2146	0	5	0.	0.	0.	0.	0.
	9 3146	0	5	0.	0.	0.	0.	1.12296E-07
	9 4146	0	5	0.	0.	0.	0.	1.69193E-06
	9 5146	0	5	0.	0.	0.	0.	7.61370E-06
	9 6146	0	5	0.	0.	0.	0.	1.48361E-05
0	9 7146	0	5	0.	0.	0.	0.	1.69493E-05
0	9 8146	0	5	0.	0.	0.	0.	1.37675E-05
0	9 9146	0	5	0.	0.	0.	0.	9.05858E-06
0	9101 46	0	5	0.	0.	0.	0.	5.24050E-06
0	9111 46	0	5	0.	0.	0.	0.	2.79244E-06
0	9121 46	0	5	0.	0.	0.	0.	1.42951E-06
0	9131 46	0	5	0.	0.	0.	0.	7.03724E-07
0	9141 46	0	5	0.	0.	0.	0.	3.44376E-07
0	9151 46	0	5	0.	0.	0.	0.	1.64701E-07
0	9161 46	0	5	0.	0.	0.	0.	1.12296E-07
0	9171 46	0	5	0.	0.	0.	0.	2.24593E-08
0	9 1151	0	5	0.	0.	0.	0.	0.
0	9 2151	0	5	0.	0.	0.	0.	0.
0	9 3151	0	5	1.23430E-07	1.24381E-07	1.23168E-07	1.21372E-07	1.17357E-07
0	9 4151	0	5	1.85967E-06	1.87400E-06	1.85574E-06	1.82867E-06	1.76817E-06
0	9 5151	0	5	8.36853E-06	8.43304E-06	8.35081E-06	8.22904E-06	7.95677E-06
0	9 6151	0	5	1.63092E-05	1.64346E-05	1.62746E-05	1.60373E-05	1.55067E-05
0	9 7151	0	5	1.86296E-05	1.87732E-05	1.85902E-05	1.83191E-05	1.77130E-05
0	9 8151	0	5	1.51325E-05	1.52491E-05	1.51004E-05	1.48802E-05	1.43879E-05
0	9 9151	0	5	9.95665E-06	1.00334E-05	9.93558E-06	9.79069E-06	9.46676E-06
0	9101 51	0	5	5.76005E-06	5.80443E-06	5.74785E-06	5.66404E-06	5.47664E-06
0	9111 51	0	5	3.06926E-06	3.09293E-06	3.06279E-06	3.01812E-06	2.91827E-06
0	9121 51	0	5	1.57167E-06	1.58378E-06	1.56834E-06	1.54547E-06	1.49434E-06
0	9131 51	0	5	7.73492E-07	7.79452E-07	7.71855E-07	7.60599E-07	7.35434E-07
0	9141 51	0	5	3.76517E-07	3.81434E-07	3.77716E-07	3.72206E-07	3.59893E-07
0	9151 51	0	5	1.81030E-07	1.82425E-07	1.80647E-07	1.78013E-07	1.72123E-07
0	9161 51	0	5	1.23430E-07	1.24381E-07	1.23168E-07	1.21372E-07	1.17357E-07
0	9171 51	0	5	2.46859E-08	2.46761E-08	2.46337E-08	2.42744E-08	2.34713E-08
0	9 1156	0	5	0.	0.	0.	0.	0.
0	9 2156	0	5	0.	0.	0.	0.	0.
0	9 3156	0	5	1.17815E-07	0.	0.	1.15875E-07	1.07693E-07
0	9 4156	0	5	1.77508E-06	0.	0.	1.74585E-06	1.62257E-06
0	9 5156	0	5	7.96786E-06	0.	0.	7.85634E-06	7.30158E-06
0	9 6156	0	5	1.55673E-05	0.	0.	1.53110E-05	1.42298E-05
0	9 7156	0	5	1.77892E-05	0.	0.	1.74894E-05	1.62545E-05

TABLE C-V (cont'd)

0	9	8156	0	5	1.44441E-05	0.	0.	1.42063E-05	1.32632E-05
0	9	9156	0	5	9.50375E-06	0.	0.	9.34726E-06	8.68723E-06
0	9	10156	0	5	5.49804E-06	0.	0.	5.40751E-06	5.02567E-06
0	9	11156	0	5	2.92967E-06	0.	0.	2.88143E-06	2.67796E-06
0	9	12156	0	5	1.50018E-06	0.	0.	1.47548E-06	1.37129E-06
0	9	13156	0	5	7.36308E-07	0.	0.	7.26151E-07	6.74876E-07
0	9	14156	0	5	3.61303E-07	0.	0.	3.55350E-07	3.30259E-07
0	9	15156	0	5	1.72795E-07	0.	0.	1.69950E-07	1.57950E-07
0	9	16156	0	5	1.17815E-07	0.	0.	1.15875E-07	1.07693E-07
0	9	17156	0	5	2.35630E-08	0.	0.	2.31750E-08	2.15386E-08
0	9	1161	0	5	0.	0.	0.	0.	0.
0	9	2161	0	5	0.	0.	0.	0.	0.
0	9	3161	0	5	1.01886E-07	9.69320E-08	9.14379E-08	9.00492E-08	0.
0	9	4161	0	5	1.53508E-06	1.46044E-06	1.37766E-06	1.35674E-06	0.
0	9	5161	0	5	6.90787E-06	6.57199E-06	6.19949E-06	6.10534E-06	0.
0	9	6161	0	5	1.34625E-05	1.28079E-05	1.20820E-05	1.18985E-05	0.
0	9	7161	0	5	1.53786E-05	1.46303E-05	1.38010E-05	1.35914E-05	0.
0	9	8161	0	5	1.24912E-05	1.18839E-05	1.12103E-05	1.10400E-05	0.
0	9	9161	0	5	8.21880E-06	7.81918E-06	7.37599E-06	7.26397E-06	0.
0	9	10161	0	5	4.75468E-06	4.52349E-06	4.26710E-06	4.20230E-06	0.
0	9	11161	0	5	2.53357E-06	2.41037E-06	2.27376E-06	2.23922E-06	0.
0	9	12161	0	5	1.29735E-06	1.23427E-06	1.16431E-06	1.14663E-06	0.
0	9	13161	0	5	6.36486E-07	6.07440E-07	5.73011E-07	5.64309E-07	0.
0	9	14161	0	5	3.12450E-07	2.97258E-07	2.80410E-07	2.76151E-07	0.
0	9	15161	0	5	1.49433E-07	1.42167E-07	1.34109E-07	1.32072E-07	0.
0	9	16161	0	5	1.01886E-07	9.69320E-08	9.14379E-08	9.00492E-08	0.
0	9	17161	0	5	2.03772E-08	1.93864E-08	1.82876E-08	1.80098E-08	0.
0	9	1166	0	5	0.	0.	0.	0.	0.
0	9	2166	0	5	0.	0.	0.	0.	0.
0	9	3166	0	5	0.	0.	8.84067E-08	8.61173E-08	8.43561E-08
0	9	4166	0	5	0.	0.	1.33199E-06	1.29750E-06	1.27097E-06
0	9	5166	0	5	0.	0.	5.99397E-06	5.83875E-06	5.71934E-06
0	9	6166	0	5	0.	0.	1.16815E-05	1.13790E-05	1.11463E-05
0	9	7166	0	5	0.	0.	1.33435E-05	1.29980E-05	1.27321E-05
0	9	8166	0	5	0.	0.	1.09387E-05	1.05580E-05	1.03421E-05
0	9	9166	0	5	0.	0.	7.13147E-06	6.94679E-06	6.80473E-06
0	9	10166	0	5	0.	0.	4.12565E-06	4.01881E-06	3.93662E-06
0	9	11166	0	5	0.	0.	2.19838E-06	2.14145E-06	2.09766E-06
0	9	12166	0	5	0.	0.	1.12571E-06	1.09650E-06	1.07413E-06
0	9	13166	0	5	0.	0.	5.54015E-07	5.39668E-07	5.28632E-07
0	9	14166	0	5	0.	0.	2.71114E-07	2.64093E-07	2.58692E-07
0	9	15166	0	5	0.	0.	1.29663E-07	1.26305E-07	1.23722E-07
0	9	16166	0	5	0.	0.	8.84067E-08	8.61173E-08	8.43561E-08
0	9	17166	0	5	0.	0.	1.76813E-08	1.72235E-08	1.68712E-08
0	9	1171	0	5	0.	0.	0.	0.	0.
0	9	2171	0	5	0.	0.	0.	0.	0.
0	9	3171	0	5	8.28242E-08	8.14625E-08	8.02433E-08	7.91586E-08	7.82103E-08
0	9	4171	0	5	1.24788E-06	1.22737E-06	1.20900E-06	1.19266E-06	1.17837E-06
0	9	5171	0	5	5.61548E-06	5.52315E-06	5.44049E-06	5.36695E-06	5.30266E-06
0	9	6171	0	5	1.09438E-05	1.07639E-05	1.06028E-05	1.04595E-05	1.03342E-05
0	9	7171	0	5	1.25009E-05	1.22954E-05	1.21114E-05	1.19477E-05	1.18045E-05
0	9	8171	0	5	1.01542E-05	9.98730E-06	9.83782E-06	9.70484E-06	9.58858E-06
0	9	9171	0	5	6.68115E-06	6.57130E-06	6.47296E-06	6.38546E-06	6.30896E-06
0	9	10171	0	5	3.86513E-06	3.80158E-06	3.74469E-06	3.69407E-06	3.64981E-06
0	9	11171	0	5	2.05956E-06	2.02570E-06	1.99538E-06	1.96841E-06	1.94483E-06
0	9	12171	0	5	1.05463E-06	1.03729E-06	1.02176E-06	1.00795E-06	9.95879E-07
0	9	13171	0	5	5.19031E-07	5.10498E-07	5.02858E-07	4.96061E-07	4.90119E-07
0	9	14171	0	5	2.53994E-07	2.49818E-07	2.46079E-07	2.42753E-07	2.39845E-07
0	9	15171	0	5	1.21475E-07	1.19478E-07	1.17690E-07	1.16099E-07	1.14708E-07

TABLE C-V (cont'd)

```
 0  9161 71  0  5  8.28242E-08  8.14625E-08  8.02433E-08  7.91586E-08  7.82103E-08
 0  9171 71  0  5  1.65648E-08  1.62925E-08  1.60487E-08  1.58317E-08  1.56421E-08
 0  9  11 76  0  5  0.           0.           0.           0.           0.
 0  9  21 76  0  5  0.           0.           0.           0.           0.
 0  9  31 76  0  5  0.           0.           7.82103E-08  7.74215E-08  7.67861E-08
 0  9  41 76  0  5  0.           0.           1.17837E-06  1.16648E-06  1.15691E-06
 0  9  51 76  0  5  0.           0.           5.30266E-06  5.24917E-06  5.20609E-06
 0  9  61 76  0  5  0.           0.           1.03342E-05  1.02300E-05  1.01460E-05
 0  9  71 76  0  5  0.           0.           1.18045E-05  1.16855E-05  1.15896E-05
 0  9  81 76  0  5  0.           0.           9.58858E-06  9.49187E-06  9.41397E-06
 0  9  91 76  0  5  0.           0.           6.30896E-06  6.24533E-06  6.19407E-06
 0  9101 76  0  5  0.           0.           3.64981E-06  3.61300E-06  3.58335E-06
 0  9111 76  0  5  0.           0.           1.94483E-06  1.92521E-06  1.90941E-06
 0  9121 76  0  5  0.           0.           9.95678E-07  9.85933E-07  9.77742E-07
 0  9131 76  0  5  0.           0.           4.90118E-07  4.85174E-07  4.81193E-07
 0  9141 76  0  5  0.           0.           2.39845E-07  2.37426E-07  2.35477E-07
 0  9151 76  0  5  0.           0.           1.14708E-07  1.13551E-07  1.12620E-07
 0  9161 76  0  5  0.           0.           7.82103E-08  7.74215E-08  7.67861E-08
 0  9171 76  0  5  0.           0.           1.56421E-08  1.54943E-08  1.53572E-08
 0  9  11 81  0  5  0.           0.           0.           0.           0.
 0  9  21 81  0  5  0.           0.           0.           0.           0.
 0  9  31 81  0  5  7.63188E-08  7.60572E-08  7.60209E-08  7.63160E-08  7.70318E-08
 0  9  41 81  0  5  1.14987E-06  1.14593E-06  1.14536E-06  1.14983E-06  1.16061E-06
 0  9  51 81  0  5  5.17441E-06  5.15668E-06  5.15422E-06  5.17422E-06  5.22275E-06
 0  9  61 81  0  5  1.00843E-05  1.00497E-05  1.00449E-05  1.00839E-05  1.01785E-05
 0  9  71 81  0  5  1.15191E-05  1.14796E-05  1.14741E-05  1.15186E-05  1.16267E-05
 0  9  81 81  0  5  9.35668E-06  9.32461E-06  9.32016E-06  9.35634E-06  9.44409E-06
 0  9  91 81  0  5  6.15638E-06  6.13528E-06  6.13235E-06  6.15615E-06  6.21389E-06
 0  9101 81  0  5  3.56154E-06  3.54934E-06  3.54764E-06  3.56141E-06  3.59482E-06
 0  9111 81  0  5  1.89779E-06  1.89129E-06  1.89039E-06  1.89772E-06  1.91552E-06
 0  9121 81  0  5  9.71793E-07  9.68462E-07  9.67999E-07  9.71756E-07  9.80871E-07
 0  9131 81  0  5  4.78264E-07  4.76625E-07  4.76398E-07  4.78247E-07  4.82732E-07
 0  9141 81  0  5  2.34044E-07  2.33242E-07  2.33131E-07  2.34036E-07  2.36231E-07
 0  9151 81  0  5  1.11934E-07  1.11551E-07  1.11497E-07  1.11930E-07  1.12980E-07
 0  9161 81  0  5  7.63188E-08  7.60572E-08  7.60209E-08  7.63160E-08  7.70318E-08
 0  9171 81  0  5  1.52638E-08  1.52114E-08  1.52042E-08  1.52632E-08  1.54064E-08
  11  1   1     1  1.0
  11  2   1     1  0.0
  11  3   1     1  1.0
  11  4   1     1  1.0
  11  5   1     1  1.0
  11  6   1     1    1.0
  11  7   1     2    1.0          .000118
  11  7   1     2    1.0          .000017
  11  7   1     2    1.0          .000067
  11  8   1     2   .7107          .2891
  11  9   1     1  1.0
 1110  1   1     1  1.0
 1111  1   1     1  1.0
 1112  1   1     1  1.0
 1113  1   1     1  1.0
 1114  1   1     1  1.0
 1115  1   1     1  1.0
 1116  1   1     1  1.0
 1117  1   1     1  0.86571
 1118  1   1     2  0.116         0.884
 1118  1   1     2   .884          .116
 1119  1   1     1  1.0
 1119  1   1     1  1.0       -10
```

TABLE C-V (cont'd)

```
      1   1    5  0.093          [illegible]        0.093          0.093          0.093
      1   6    5  0.070          [illegible]          0.315          4.905          0.315
      1  11    4  1.46             2.25425          .47498         3.18556
      1  15    5  1.02421          5.21428          0.686          3.99259        0.63917
      1  15    5  1.02421          5.21428          0.686          1.99258        .00001
      1  20    5  3.442565         2.485485         6.03274        0.86602        5.1976
      1  20    5  2.0              .63917           3.442565       2.485485       6.03274
      1  25    5  0.61             3.6112           4.34803        5.11737        0.7532
      1  25    5  .86602           5.1976             .61            3.6112       4.34803
      1  30    5  4.4301           0.7553           3.236          2.4493         6.1165
      1  30    5  5.11737          .7532              4.4301         .7553        1.63599
1     1  35    5  .00001             1.5              2.4493         6.1165         20.0
   0  0499                    1/V VALUES FOR GE 3.2: ENR ROD
      1    1  2  5  2.67200E-05  3.37529E-05  4.32325E-05  5.52399E-05  7.02798E-05
      1    6  2  5  8.97080E-05  1.17005E-04  1.46939E-04  1.91252E-04  2.453545-04
      1   11  2  5  3.15416E-04  4.05915E-04  5.24352E-04  6.66413E-04  8.60532E-04
      1   16  2  5  1.25651E-03  2.05330E-03  3.43336E-03  5.66694E-03  9.28726E-03
      1   21  2  5  1.53867E-02  2.53385E-02  4.16095E-02  6.46291E-02  8.74724E-02
      1   26  2  5  1.06431E-01  1.49556E-01  2.23546E-01  3.37390E-01  4.83835E-01
1     1   31  2  2  7.37774E-01  1.47179E+00
```

APPENDIX D

SUMMARY DESCRIPTION OF THE PBF TWIGL MODEL

This appendix will document the TWIGL PBF model, going through the input data in the order given in the revised TWIGL manual[5]. Explanations of the data will be provided where appropriate. A card listing for a typical problem (RIA ST-3) then follows.

Card 1) Title Card

Self-explanatory.

Card 2) δ, θ, FNORM, EPF

FNORM = 4.35849×10^{9} multiplies all input fluxes to obtain the desired starting power of 0.4 MW (0.1 MW per quarter). EPF = 2.946×10^{-11} w-s per fission is the energy per fission, assumed constant throughout the problem. This assumption requires that the tail energy be corrected, using Equation 2.2.1.

Card 3) General Integer Input Data

Most of this is self-explanatory. The model is quarter-core, X-Y geometry with 28 x 28 mesh intervals. There are six delayed neutron groups.

Card 4) General Input Data

EGV divides all fission cross sections throughout a run (including the time and temperature-dependent components). It is used to control the starting reactivity in the model. This is explained in detail in Section 2.2. The inverse neutron speeds were obtained by collapsing appropriate 32-group (1/v) data over a PBF fuel spectrum computed during the SCAMP "steady-state" calculations for the delayed source multiplication. The input fluxes for the TWIGL model are generated by PDQ and read in on cards. We set NMORE = 2 to obtain a recording of output data on unit 8 for every other time point for later use in the plotting program described in Appendix E.

Card 5-6) Time Step Data

Self-explanatory.

Card 7) Edit Requests

Self-explanatory.

Card 8) General Floating Point Input Data

The number of neutrons per fission, ν has been set in the model (both on this card and in the cross section data) to obtain the correct rods-out excess reactivity. The Y-dimension is set to the core height, 91.44 cm. Thus the model always computes one-fourth of the actual power, with the correct volumetric power density. This is necessary in order to obtain the correct fuel temperatures in the thermal feedback model. The coolant flow rate is set arbitrarily large. This has the effect of making the PBF coolant a constant-temperature heat sink. Moderator feedback is thus (justifiably for PBF) ignored. This device is necessary since the thermal-hydraulic equations solved by TWIGL are not strictly applicable to our problem. T_{fa} is the input parameter affecting the functional dependence of certain cross sections (Σ_{t1}, Σ_{R1}, $\nu\Sigma_{f1}$) on the core fuel temperature. See also equations 2.13 and 2.14, with accompanying discussion.

Card 9) Delayed Neutron Data

We use six delayed neutron groups. The required data are obtained from Reference 10, page 100.

Card 10) Explicit Time-Dependent Ramp Data

This card is used to move the control rods into the core to terminate a burst. See the discussion in Section 2.2.

Card(s) 11) Flux Edit Requests

Self-explanatory.

Card(s) 12-15) Mesh Interval Data

Self-explanatory.

Card(s) 16) Material Overlay

The region-material data given on these cards is overridden by the information given on cards 22. It must be provided, nevertheless.

Card(s) 17) Reference Cross Sections

These are the basic values of the two-group cross sections for each composition. The basic cross sections may be altered by the time- and temperature-dependent data given later.

Card(s) 18) Explicit Time Dependence on the Cross Sections

These cards are used along with card 10 in the model to represent control rod insertion, i.e., the time-dependent change of the control rod region cross sections from the values appropriate to a rods-out configuration to the values appropriate to a rods-in configuration. They are also used to change the effective value of the input reactivity parameter EGV, for the purpose outlined in section 2.2.

Cards 19-22) Thermal-Hydraulic Overlay Data

These data override the information given on Card(s) 16. Normally they provide exactly the same information.

Card(s) 23) General Thermal-Hydraulic Data

The PBF fuel cell has the following volume fractions:

29% water
39.27% fuel
31.73% cladding, void, and insulator

TWIGL assumes that a given fueled region is all fuel and water. To force TWIGL to get the correct fuel and water volumes for the thermal feedback routines we proceed as follows:

1) The true fuel cell volume in the PBF is 2432.66 cm^3/cm-quarter (see Reference 7). Thus:

True Coolant Volume - (0.29)(2432.66) = 705.47
True Fuel Volume = (0.3927)(2432.66) = 955.31

Therefore:

$$\frac{V_c}{V_f + V_c} = \frac{705.47}{2892.51} = 0.2439 \qquad \text{(D-1)}$$

since in TWIGL the fueled region of the core has volume = 2892.51 cm^3/cm-quarter because the shims and side plates are homogenized into the fueled region. Also:

$$\frac{V_f}{V_c} = \frac{955.31}{705.47} = 1.3541 \qquad \text{(D-2)}$$

The Heat Transfer Area per unit volume is given by

$$A_h = \frac{\text{Heat Transfer Area}}{\text{Unit Fuel Volume}} \times \frac{\text{Unit Fuel Volume}}{\text{Unit Coolant Volume}}$$

$$= \frac{2\pi R_p}{\pi R_{eq}} \times \frac{1}{0.29} = 156.07 \text{ ft}^{-1} \qquad \text{(D-3)}$$

where R_p and R_{eq} are the fuel rod radius and the equivalent fuel cell radius, respectively. From Reference 7 $2\pi R_p/\pi R_{eq}^2 = 45.26$ ft^{-1}. Also from Reference 7:

$$U_n = 40 \text{ Btu/hr-ft}^2\text{-°F} \qquad \text{(D-4)}$$

and

$$H_o = 2000 \text{ Btu/hr-ft}^2\text{-°F} \qquad \text{(D-5)}$$

The heat capacity of the PBF is temperature-dependent. The modified version of TWIGL will allow this. We use the RELAP4 PBF model data for volumetric heat capacity and do a least squares fit to a parabola. The final heat capacity function is given by

$$\left(\rho_f \frac{V_f}{V_c} C_f\right) = 46.395 + (7.3653 \times 10^{-3})\,T - (2.9159 \times 10^{-8})T^2 \qquad \text{(D-6)}$$

where V_f/V_c is from Equation D-2 and T is in °F and the heat capacity is in Btu/ft^3°F.

Card(s) 24) Temperature Dependent Cross Section Data

These cards are used to account for the dependence of the core cross sections on fuel temperature. Moderator feedback is ignored. See Equation 2.14 with accompanying discussion.

Card(s) 25) Flow Rate Fractions

These are all set to 1.0 since moderator feedback is not used, and the total flow rate has been set arbitrarily high.

Card(s) 27-28) Reference Fuel and Coolant Temperatures

See Equations 2.13 and 2.14.

Card(s) 29) Initial Fuel and Moderator Temperatures

Self-explanatory.

Card(s) 30-31) Initial Fluxes

These are calculated by PDQ using a rods-out reactor model with geometry and cold cross sections identical to the TWIGL model.

Card 32) NTIMES

This card must be present, although it does nothing. It can be blank.

TABLE D-I

TWIGL INPUT LISTING FOR RIA ST-3

```
 COARSE TWIGL 5.2 45 BURST
0.005      1.0          4.35849+092.946  -11
    39    29   581    23    23    11    10     4    38     6    68     2     0     1
 .03413     5.999     -82.576    -6    -1     1   310                 2
0.00005     0.0001      0.00025     0.0004     0.0005     0.0025     0.1
0.5         1.0          5.0          25.0
    21    61   101   301   391   471   491   501   541   581   621
     0     0     0     1     1     1
2.3593      1.0         91.44        1.0       101.0       +80.0        68.0
 1.0       +80.0        100.0
 .000238  0.0124
0.001577  0.0305
0.001411  .1111
0.002844  0.301
0.000828  1.14
0.000302  3.01
0.120       0.220
     2     3     4     5     6    10    11    21    31    41    51    61    71    81
    91   101   111   121   131   141   151   161   171   181   191   201   211   221
   231   241   251   261   271   281   291   301   311   321   331   341   351   361
   371   381   391   401   411   421   431   441   451   461   471   481   491   501
   511   521   531   541   551   561   571   581   591   601   611   621
1.0         0.4121      1.435       2.011       2.008       3.190       1.420
2.010       6.290       2.020       2.010       4.020       2.020       2.010
0.840       2.010       6.040       2.010       6.880       8.890       2.010
12.07      20.34
     2     3     4     7     8     9    10    11    12    13    15    16    17    18
    19    21    22    24    25    26    27    28    29
 1.0         0.4121      1.435       2.011       2.008       3.190       1.420
2.010       6.290       2.020       2.010       4.020       2.020       2.010
0.840       2.010       6.040       2.010       6.880       8.890       2.010
12.07      20.34
     2     3     4     7     8     9    10    11    12    13    15    16    17    18
    19    21    22    24    25    26    27    28    29
     9     2    29     2    29
     8     2    17     2    27
     6     2    27     2    17
     8     2    18     2    25
     8     2    25     2    18
     8     2    19     2    24
     8     2    24     2    19
     8     2    21     2    22
     8     2    22     2    21
     1     2    16     2    26
     1     2    26     2    16
     1     2    17     2    24
     1     2    24     2    17
     1     2    18     2    23
     1     2    23     2    18
     1     2    20     2    21
     1     2    21     2    20
     7     2     8     2     9
     7     2     9     2     8
     6     2     6     2     8
     6     2     8     2     6
     5     2     5     2     7
     5     2     7     2     5
     2     2     3     2     3
     3    10    14    20    23
     3    20    23    10    14
     3    11    13    19    24
     3    19    24    11    13
```

TABLE D-I (cont'd)

3	14	15	21	22									
3	21	22	14	15									
4	2	4	12	18									
4	12	18	2	4									
4	4	5	13	17									
4	13	17	4	5									
4	5	6	14	16									
4	14	16	5	6									
10	1	29	1	2									
10	1	2	1	29									
1.09 7		5.3040	-11.7958		-21.0321	-11.0830		-25.6684	-31.5412	-1			
1.3258		1.9720	-15.2921		-21.4604	5.5047		-46.9610	-22.8553				
2.0035		2.1813	3 1426		-36.1233	-31 1715		-30.0	0.0				
2.0340		1.6587	3.5543		-37.1146	-31.5933		-30.0	0.0				
1.3278		2.8890	-14.3733		-29.3537	-34.2117		-20.0	0.0				
7.7886		-12.6870	-19.2873		-31.6189	-10.0		0.0	0.0				
2.3671		1.7732	2.3541		-38.1380	-30.0		0.0	0.0				
9.258		-12.6360	-11.8633		-21.1720	-11.3623		-20.0	0.0				
1.3534		4.0370	-11.5214		-21.5937	-21.3525		-20.0	0.0				
0.0		0.0	0.0		0.0	0.0		0.0	0.0				
0.0		0.0	0.0		0.0	0.0		0.0	0.0				
0.0		0.0	0.0		0.0	0.0		0.0	0.0				
0.0		0.0	0.0		0.0	0.0		0.0	0.0				
0.0		0.0	0.0		0.0	0.0		0.0	0.0				
0.0		0.0	0.0		0.0	0.0		1.3678	-43.7189	-3			
0.0		0.0	0.0		0.0	0.0		1.6797	-36.8898	-2			
-7.988		-1-6.624	-12.2577		-26.5053	-2-1.1694		-30.0	0.0				
0.0		0.0	0.0		0.0	0.0		0.0	0.0				
28	28												
2	3	4	5	6	7	8	9	10	11	12	13	14	15
16	17	18	19	20	21	22	23	24	25	26	27	28	29
2	3	4	5	6	7	8	9	10	11	12	13	14	15
16	17	18	19	20	21	22	23	24	25	26	27	28	29
10	10	10	10	10	10	10	10	10	10	10	10	10	10
10	10	10	10	10	10	10	10	10	10	10	10	10	10
10	2	5	5	5	5	6	7				4	4	4
4	4	4	1	1	1	1	1				8	9	9
10	5	5	5	5	5	6	7				4	4	4
4	4	4	1	1	1	1	1				8	9	9
10	5	5	5	5	5	6	7				1	4	4
4	4	1	1	1	1	1	1				8	9	9
10	5	5	5	6	6	6	7				1	1	4
4	1	1	1	1	1	1	1				8	9	9
10	5	5	5	6	7	7	7				1	1	1
1	1	1	1	1	1	1	1				8	9	9
10	6	6	6	6	7	7	7				1	1	1
1	1	1	1	1	1	1	1				8	9	9
10	7	7	7	7	7	7					1	1	1
1	1	1	1	1	1	1	1				8	9	9
10	1	1	1	1	1	1	1				1	1	1
1	1	1	1	1	1	1	1				8	9	9
10	1	1	1	1	1	1	1				1	1	1
1	1	1	1	1	3	3	3				8	9	9
10	1	1	1	1	1	1	1	1	1	1	1	1	1
1	1	1	1	3	3	3	3	3	1	1	8	9	9
10	4	4	1	1	1	1	1	1	1	1	1	1	1
1	1	1	1	3	3	3	3	3	1	1	8	9	9
10	4	4	4	1	1	1	1	1	1	1	1	1	1
1	1	1	1	1	3	3	3	1	1	1	8	9	9
10	4	4	4	4	1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	3	1	1	1	1	8	9	9
10	4	4	4	1	1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1	1	1	8	9	9
10	4	4	4	1	1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1	8	8	8	9	9
10	4	4	1	1	1	1	1	1	1	1	1	1	1

TABLE D-I (cont'd)

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  1    1    1    1    1    1    1    1    8    8    9    9    9    9
 10    1    1    1    1    1    1    1    1    1    1    1    1    1
  1    1    1    1    1    1    8    8    8    9    9    9    9    9
 10    1    1         1    1    1    1    1    1    3    3    1    1
  1    1    1    1    1    1    8    9    9    9    9    9    9    9
 10    1    1    1    1    1    1    1    1    3    3    3    3    1
  1    1    1    1    1    8    8    9    9    9    9    9    9    9
 10    1    1    1    1    1    1    1    1    3    3    3    3    3
  1    1    1    8    8    8    9    9    9    9    9    9    9    9
 10    1    1    1    1    1    1    1    1    3    3    3    3    1
  1    1    1    8    9    9    9    9    9    9    9    9    9    9
 10    1    1    1    1    1    1    1    1    1    3    3    1    1
  1    1    8    8    9    9    9    9    9    9    9    9    9    9
 10    1    1    1    1    1    1    1    1    1    1    1    1    1
  1    8    8    9    9    9    9    9    9    9    9    9    9    9
 10    1    1    1    1    1    1    1    1    1    1    1    1    1
  1    8    9    9    9    9    9    9    9    9    9    9    9    9
 10    8    8    8    8    8    8    8    8    8    8    8    8    8
  8    8    9    9    9    9    9    9    9    9    9    9    9    9
 10    9    9    9    9    9    9    9    9    9    9    9    9    9
  9    9    9    9    9    9    9    9    9    9    9    9    9    9
 10    9    9    9    9    9    9    9    9    9    9    9    9    9
  9    9    9    9    9    9    9    9    9    9    9    9    9    9
0.2439  62.4      156.07  40.0      2000.0  0.03      46.395  7.3653-3-2.916-8
0.2439  62.4      156.07  40.0      2000.0  0.03      46.395  7.3653-3-2.916-8
0.2439  62.4      156.07  40.0      2000.0  0.03      46.395  7.3653-3-2.916-8
0.2439  62.4      156.07  40.0      2000.0  0.03      46.395  7.3653-3-2.916-8
0.2439  62.4      156.07  40.0      2000.0  0.03      46.395  7.3653-3-2.916-8
0.2439  62.4      156.07  40.0      2000.0  0.03      46.395  7.3653-3-2.916-8
0.2439  62.4      156.07  40.0      2000.0  0.03      46.395  7.3653-3-2.916-8
0.2439  62.4      156.07  40.0      2000.0  0.03      46.395  7.3653-3-2.916-8
0.2439  62.4      156.07  40.0      2000.0  0.03      46.395  7.3653-3-2.916-8
0.2439  62.4      156.07  40.0      2000.0  0.03      46.395  7.3653-3-2.916-8
0.0      0.0      0.0      1.750-60.0      0.0      -9.18-60.0      -4.41-70.0
0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
1.0      1.0      1.0      1.0      1.0      1.0      1.0      1.0      1.0      1.0
1.0      1.0      1.0      1.0      1.0      1.0      1.0      1.0      1.0      1.0
1.0      1.0      1.0      1.0      1.0      1.0      1.0      1.0
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TABLE D-I (cont'd)

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TABLE D-I (cont'd)

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TABLE D-I (cont'd)

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TABLE D-I (cont'd)

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TABLE D-I (cont'd)

.23632E-03	.22576E+03	.19257E+03	.18664E+03	.20197E+03	.23360E+03
.30332E+03	.33590E+03	.36183E+03	.39226E+03	.44011E+03	.44018E+03
.43952E+03	.43875E+03	.43809E+03	.43873E+03	.43976E+03	.44017E+03
.43643E+03	.42848E+03	.38637E+03	.36816E+03	.34797E+03	.26449E+03
.12715E+03	.87952E+02	.21900E+02	.22576E+03	.21986E+03	.19211E+03
.18671E+03	.20220E+03	.23385E+03	.30345E+03	.33599E+03	.36191E+03
.39232E+03	.44018E+03	.44026E+03	.43958E+03	.43881E+03	.43814E+03
.43878E+03	.43980E+03	.44019E+03	.43647E+03	.42845E+03	.38632E+03
.36811E+03	.34793E+03	.26446E+03	.12713E+03	.87942E+02	.21898E+02
.19257E+03	.19212E+03	.18610E+03	.18828E+03	.20649E+03	.23871E+03
.30586E+03	.33772E+03	.36336E+03	.39357E+03	.44153E+03	.44178E+03
.44085E+03	.43991E+03	.43910E+03	.43985E+03	.44069E+03	.44049E+03
.43606E+03	.42778E+03	.38550E+03	.36732E+03	.34719E+03	.26395E+03
.12689E+03	.87780E+02	.21857E+02	.18666E+03	.18673E+03	.18830E+03
.19822E+03	.22409E+03	.25854E+03	.31412E+03	.34362E+03	.36838E+03
.39787E+03	.44600E+03	.44705E+03	.44522E+03	.44374E+03	.44237E+03
.44314E+03	.44228E+03	.44078E+03	.43456E+03	.42530E+03	.38255E+03
.36450E+03	.34457E+03	.26215E+03	.12605E+03	.87200E+02	.21714E+02
.20203E+03	.20226E+03	.20655E+03	.22413E+03	.27332E+03	.30031E+03
.32574E+03	.35272E+03	.37643E+03	.40482E+03	.45198E+03	.45505E+03
.45288E+03	.45011E+03	.44754E+03	.44645E+03	.44212E+03	.43947E+03
.43120E+03	.42066E+03	.37741E+03	.35965E+03	.34012E+03	.25910E+03
.12462E+03	.86215E+02	.21470E+02	.23372E+03	.23397E+03	.23883E+03
.25864E+03	.30036E+03	.31805E+03	.33634E+03	.36417E+03	.38707E+03
.41402E+03	.45860E+03	.46259E+03	.46255E+03	.46038E+03	.45291E+03
.44731E+03	.43963E+03	.43582E+03	.42535E+03	.41338E+03	.36988E+03
.35270E+03	.33387E+03	.25486E+03	.12262E+03	.84830E+02	.21126E+02
.30360E+03	.30372E+03	.30613E+03	.31436E+03	.32590E+03	.33643E+03
.34886E+03	.37908E+03	.40056E+03	.42512E+03	.46515E+03	.46884E+03
.46882E+03	.46603E+03	.45405E+03	.44510E+03	.43424E+03	.42925E+03
.41637E+03	.40290E+03	.35970E+03	.34360E+03	.32593E+03	.24949E+03
.12005E+03	.83052E+02	.20686E+02	.33631E+03	.33640E+03	.33811E+03
.34398E+03	.35304E+03	.36443E+03	.37927E+03	.41436E+03	.42833E+03
.44542E+03	.47427E+03	.47577E+03	.47378E+03	.46860E+03	.44938E+03
.43546E+03	.41912E+03	.41186E+03	.39403E+03	.37813E+03	.33719E+03
.32462E+03	.31033E+03	.23882E+03	.11487E+03	.79438E+02	.19790E+02
.36242E+03	.36250E+03	.36394E+03	.36893E+03	.37692E+03	.38749E+03
.40089E+03	.42846E+03	.43975E+03	.45376E+03	.47726E+03	.47755E+03
.47443E+03	.46804E+03	.44565E+03	.42937E+03	.40987E+03	.40099E+03
.37895E+03	.36265E+03	.32347E+03	.31443E+03	.30292E+03	.23334E+03
.11213E+03	.77521E+02	.19318E+02	.39310E+03	.39317E+03	.39440E+03
.39866E+03	.40555E+03	.41468E+03	.42566E+03	.44574E+03	.45396E+03
.46416E+03	.48011E+03	.47859E+03	.47380E+03	.46568E+03	.43912E+03
.41957E+03	.39505E+03	.38274E+03	.36496E+03	.35032E+03	.31210E+03
.30206E+03	.29268E+03	.22486E+03	.10782E+03	.74491E+02	.18574E+02
.44182E+03	.44189E+03	.44322E+03	.44764E+03	.45354E+03	.46007E+03
.46649E+03	.47537E+03	.47823E+03	.48088E+03	.47662E+03	.46995E+03
.46060E+03	.44837E+03	.41467E+03	.39218E+03	.36534E+03	.35238E+03
.33525E+03	.31936E+03	.28016E+03	.26989E+03	.26076E+03	.19250E+03
.90907E+02	.62568E+02	.15704E+02	.44202E+03	.44210E+03	.44362E+03
.44889E+03	.45683E+03	.46428E+03	.47041E+03	.47710E+03	.47875E+03
.47959E+03	.47019E+03	.46236E+03	.45210E+03	.43921E+03	.40515E+03
.38355E+03	.35895E+03	.34768E+03	.32739E+03	.31050E+03	.27057E+03
.26062E+03	.24808E+03	.17900E+03	.84169E+02	.57926E+02	.14653E+02
.44151E+03	.44158E+03	.44284E+03	.44722E+03	.45486E+03	.46446E+03
.47062E+03	.47535E+03	.47588E+03	.47505E+03	.46110E+03	.45236E+03
.44144E+03	.42816E+03	.39427E+03	.37383E+03	.35172E+03	.34231E+03
.32015E+03	.30177E+03	.26100E+03	.24882E+03	.23059E+03	.16374E+03
.76787E+02	.52935E+02	.13557E+02	.44088E+03	.44093E+03	.44203E+03
.44587E+03	.45223E+03	.46246E+03	.46802E+03	.47038E+03	.46969E+03
.46714E+03	.44910E+03	.43970E+03	.42840E+03	.41495E+03	.38137E+03
.36175E+03	.34104E+03	.33235E+03	.31186E+03	.29312E+03	.24895E+03
.22970E+03	.21047E+03	.14650E+03	.68673E+02	.47626E+02	.12431E+02
.44054E+03	.44059E+03	.44154E+03	.44482E+03	.44999E+03	.45537E+03
.45642E+03	.45154E+03	.44769E+03	.44097E+03	.41586E+03	.40611E+03
.39499E+03	.38186E+03	.34875E+03	.32928E+03	.30857E+03	.29974E+03

TABLE D-I (cont'd)

.27842E+03	.25760E+03	.20120E+03	.18129E+03	.16102E+03	.10530E+03
.49796E+02	.36362E+02	.10147E+02	.44136E+03	.44141E+03	.44247E+03
.44529E+03	.44912E+03	.44995E+03	.44764E+03	.43777E+03	.43153E+03
.42156E+03	.39354E+03	.38470E+03	.37475E+03	.36244E+03	.32943E+03
.30953E+03	.28798E+03	.27868E+03	.25596E+03	.23344E+03	.17367E+03
.15314E+03	.13030E+03	.80540E+02	.38907E+02	.31219E+02	.90649E+01
.44259E+03	.44264E+03	.44354E+03	.44518E+03	.44500E+03	.44244E+03
.43604E+03	.42155E+03	.41216E+03	.39714E+03	.36686E+03	.36029E+03
.35284E+03	.34193E+03	.30898E+03	.28818E+03	.26525E+03	.25521E+03
.23031E+03	.20497E+03	.14344E+03	.12340E+03	.10267E+03	.65336E+02
.32930E+02	.26982E+02	.80545E+01	.44314E+03	.44316E+03	.44347E+03
.44377E+03	.44242E+03	.43870E+03	.43200E+03	.41433E+03	.40330E+03
.38484E+03	.35395E+03	.34909E+03	.34349E+03	.33330E+03	.30022E+03
.27895E+03	.25528E+03	.24484E+03	.21877E+03	.19071E+03	.12845E+03
.11051E+03	.95086E+02	.60710E+02	.30723E+02	.25336E+02	.76536E+01
.43966E+03	.43964E+03	.43928E+03	.43776E+03	.43433E+03	.42838E+03
.41925E+03	.39656E+03	.38129E+03	.36709E+03	.33687E+03	.32887E+03
.32148E+03	.31297E+03	.27906E+03	.25639E+03	.23054E+03	.21893E+03
.19028E+03	.15955E+03	.10368E+03	.91606E+02	.80076E+02	.51007E+02
.26071E+02	.21724E+02	.67502E+01	.43790E+03	.43786E+03	.43718E+03
.42865E+03	.42393E+03	.41652E+03	.40586E+03	.38070E+03	.36500E+03
.35249E+03	.32102E+03	.31202E+03	.30317E+03	.29436E+03	.25838E+03
.23400E+03	.20533E+03	.19099E+03	.15967E+03	.13020E+03	.85703E+02
.76313E+02	.67328E+02	.42892E+02	.22126E+02	.18567E+02	.59262E+01
.39004E+03	.39000E+03	.38916E+03	.38615E+03	.38090E+03	.37322E+03
.36285E+03	.33991E+03	.32595E+03	.31435E+03	.28195E+03	.27222E+03
.26252E+03	.25034E+03	.20216E+03	.17441E+03	.14398E+03	.12889E+03
.10397E+03	.85874E+02	.56120E+02	.48781E+02	.42403E+02	.26478E+02
.13797E+02	.11660E+02	.39377E+01	.37181E+03	.37176E+03	.37095E+03
.36808E+03	.36312E+03	.35603E+03	.34674E+03	.32737E+03	.31697E+03
.30438E+03	.27172E+03	.26232E+03	.25039E+03	.23109E+03	.18224E+03
.15388E+03	.12392E+03	.11095E+03	.91915E+02	.76520E+02	.48819E+02
.42127E+02	.36400E+02	.22514E+02	.11740E+02	.99343E+01	.34110E+01
.35157E+03	.35153E+03	.35078E+03	.34811E+03	.34356E+03	.33717E+03
.32907E+03	.31312E+03	.30554E+03	.29506E+03	.26263E+03	.24981E+03
.23215E+03	.21184E+03	.16195E+03	.13099E+03	.10315E+03	.95511E+02
.80391E+02	.67553E+02	.42465E+02	.36430E+02	.31302E+02	.19158E+02
.99833E+01	.84544E+01	.29470E+01	.26756E+03	.26753E+03	.26701E+03
.26517E+03	.26206E+03	.25772E+03	.25224E+03	.24135E+03	.23576E+03
.22712E+03	.19426E+03	.18058E+03	.16515E+03	.14772E+03	.10610E+03
.81110E+02	.65762E+02	.61093E+02	.51301E+02	.43115E+02	.26572E+02
.22579E+02	.19200E+02	.11417E+02	.58790E+01	.49723E+01	.17830E+01
.12868E+03	.12867E+03	.12843E+03	.12757E+03	.12611E+03	.12406E+03
.12145E+03	.11617E+03	.11338E+03	.10900E+03	.91830E+02	.85002E+02
.77529E+02	.69318E+02	.50232E+02	.39229E+02	.33189E+02	.30961E+02
.26261E+02	.22278E+02	.13874E+02	.11800E+02	.10029E+02	.58958E+01
.38002E+01	.25313E+01	.92078E+00	.89009E+02	.89000E+02	.88833E+02
.88241E+02	.87236E+02	.85824E+02	.84015E+02	.80336E+02	.78389E+02
.75309E+02	.63213E+02	.58510E+02	.53457E+02	.48084E+02	.36692E+02
.31492E+02	.27207E+02	.25545E+02	.21894E+02	.18706E+02	.11731E+02
.99904E+01	.84975E+01	.49871E+01	.25321E+01	.21354E+01	.77969E+00
.22154E+02	.22152E+02	.22110E+02	.21964E+02	.21716E+02	.21367E+02
.20919E+02	.20010E+02	.19531E+02	.18776E+02	.15867E+02	.14802E+02
.13694E+02	.12553E+02	.10243E+02	.91499E+01	.81283E+01	.77235E+01
.68097E+01	.59772E+01	.39680E+01	.34364E+01	.29676E+01	.17933E+01
.92431E+00	.78226E+00	.29004E+00			
.11858E+03	.15584E+03	.23049E+03	.23142E+03	.18505E+03	.85736E+02
.33758E+02	.34386E+02	.37222E+02	.40713E+02	.48200E+02	.49831E+02
.50852E+02	.51355E+02	.50955E+02	.50154E+02	.49011E+02	.47734E+02
.45955E+02	.44589E+02	.40030E+02	.38135E+02	.36054E+02	.27630E+02
.17370E+02	.29523E+02	.18141E+02	.15584E+03	.17087E+03	.23129E+03
.23075E+03	.18417E+03	.85364E+02	.33721E+02	.34377E+02	.37222E+02
.40717E+02	.48186E+02	.49828E+02	.50847E+02	.51348E+02	.50947E+02
.50145E+02	.48991E+02	.47722E+02	.45949E+02	.44584E+02	.40026E+02
.38131E+02	.36059E+02	.27628E+02	.17368E+02	.29520E+02	.18139E+02
.23050E+03	.23129E+03	.23944E+03	.21729E+03	.16706E+03	.78126E+02

TABLE D-I (cont'd)

.33007E+03	.34215E+02	.37239E+02	.40792E+02	.47916E+02	.49771E+02
.50760E+02	.51245E+02	.50815E+02	.49989E+02	.48610E+02	.47489E+02
.45836E+02	.44499E+02	.39941E+02	.38050E+02	.35974E+02	.27574E+02
.17336E+02	.29465E+02	.18106E+02	.23144E+03	.23076E+03	.21730E+03
.15175E+03	.90680E+02	.46869E+02	.30985E+02	.33870E+02	.37372E+02
.41088E+02	.47409E+02	.49342E+02	.50432E+02	.50875E+02	.50345E+02
.49348E+02	.47418E+02	.46770E+02	.45459E+02	.44193E+02	.39637E+02
.37762E+02	.35707E+02	.27387E+02	.17221E+02	.29270E+02	.17988E+02
.18508E+03	.18420E+03	.16709E+03	.90690E+02	.36487E+02	.31143E+02
.31188E+02	.34276E+02	.37945E+02	.41687E+02	.47428E+02	.48600E+02
.49759E+02	.50225E+02	.49478E+02	.47892E+02	.46625E+02	.46120E+02
.44930E+02	.43672E+02	.39117E+02	.37274E+02	.35258E+02	.27071E+02
.17026E+02	.28940E+02	.17787E+02	.85761E+02	.85388E+02	.78149E+02
.46881E+02	.31147E+02	.31693E+02	.32529E+02	.35419E+02	.38999E+02
.42586E+02	.47771E+02	.48537E+02	.48977E+02	.49024E+02	.48067E+02
.47048E+02	.45935E+02	.45446E+02	.44219E+02	.42911E+02	.38380E+02
.36593E+02	.34639E+02	.26632E+02	.16752E+02	.28475E+02	.17504E+02
.33781E+02	.33743E+02	.33030E+02	.31004E+02	.31201E+02	.32536E+02
.33710E+02	.37222E+02	.40518E+02	.43748E+02	.48273E+02	.48793E+02
.48935E+02	.48738E+02	.47440E+02	.46393E+02	.45173E+02	.44629E+02
.43270E+02	.41886E+02	.37444E+02	.35752E+02	.33886E+02	.26080E+02
.16403E+02	.27880E+02	.17742E+02	.34419E+02	.34410E+02	.34248E+02
.33909E+02	.34303E+02	.35442E+02	.37241E+02	.42169E+02	.43944E+02
.45975E+02	.49125E+02	.49321E+02	.49151E+02	.48639E+02	.46653E+02
.45216E+02	.43559E+02	.42841E+02	.41130E+02	.39725E+02	.35693E+02
.34288E+02	.32569E+02	.24995E+02	.15696E+02	.26667E+02	.16409E+02
.37278E+02	.37279E+02	.37290E+02	.37425E+02	.37993E+02	.39041E+02
.40551E+02	.43957E+02	.45289E+02	.46886E+02	.49420E+02	.49471E+02
.49167E+02	.48520E+02	.46221E+02	.44572E+02	.42645E+02	.41797E+02
.39794E+02	.38766E+02	.35136E+02	.34033E+02	.32168E+02	.24448E+02
.15325E+02	.26026E+02	.16023E+02	.40801E+02	.40805E+02	.40878E+02
.41169E+02	.41761E+02	.42654E+02	.43804E+02	.46009E+02	.46906E+02
.48011E+02	.49705E+02	.49556E+02	.49068E+02	.48237E+02	.45524E+02
.43579E+02	.41225E+02	.40106E+02	.39210E+02	.38365E+02	.34843E+02
.33548E+02	.32007E+02	.23607E+02	.14738E+02	.25013E+02	.15419E+02
.48393E+02	.48379E+02	.48104E+02	.47584E+02	.47591E+02	.47923E+02
.48410E+02	.49240E+02	.49519E+02	.49784E+02	.49343E+02	.48656E+02
.47693E+02	.46439E+02	.43034E+02	.40896E+02	.38599E+02	.37686E+02
.36970E+02	.36060E+02	.32500E+02	.31090E+02	.29516E+02	.20302E+02
.12450E+02	.21074E+02	.13114E+02	.50049E+02	.50046E+02	.49988E+02
.49554E+02	.48793E+02	.48715E+02	.48956E+02	.49459E+02	.49595E+02
.49659E+02	.48681E+02	.47872E+02	.46813E+02	.45490E+02	.42038E+02
.39972E+02	.37854E+02	.37076E+02	.36014E+02	.35016E+02	.31483E+02
.30159E+02	.27966E+02	.18923E+02	.11587E+02	.19631E+02	.12296E+02
.51086E+02	.51081E+02	.50993E+02	.50663E+02	.49983E+02	.49179E+02
.49122E+02	.49312E+02	.49314E+02	.49195E+02	.47743E+02	.46839E+02
.45711E+02	.44345E+02	.40893E+02	.38902E+02	.36902E+02	.36160E+02
.34791E+02	.33788E+02	.30316E+02	.28680E+02	.25242E+02	.17411E+02
.10684E+02	.18165E+02	.11459E+02	.51605E+02	.51600E+02	.51495E+02
.51121E+02	.50466E+02	.49246E+02	.48945E+02	.48823E+02	.48689E+02
.48387E+02	.46514E+02	.45540E+02	.44370E+02	.42981E+02	.39544E+02
.37594E+02	.35628E+02	.34863E+02	.33256E+02	.32371E+02	.28638E+02
.25447E+02	.22821E+02	.15885E+02	.98316E+01	.16767E+02	.10617E+02
.51231E+02	.51224E+02	.51090E+02	.50616E+02	.49744E+02	.48323E+02
.47685E+02	.46875E+02	.46430E+02	.45714E+02	.43156E+02	.42137E+02
.40968E+02	.39594E+02	.36170E+02	.34198E+02	.32144E+02	.31289E+02
.29280E+02	.27407E+02	.22217E+02	.20466E+02	.18899E+02	.13537E+02
.88290E+01	.14706E+02	.89731E+01	.50441E+02	.50433E+02	.50274E+02
.49530E+02	.48172E+02	.47321E+02	.46655E+02	.45453E+02	.44795E+02
.43784E+02	.41041E+02	.40096E+02	.39000E+02	.37667E+02	.34220E+02
.32208E+02	.30101E+02	.29221E+02	.27151E+02	.25251E+02	.20321E+02
.19397E+02	.18367E+02	.15972E+02	.12088E+02	.15122E+02	.82217E+01
.49309E+02	.49289E+02	.48909E+02	.47718E+02	.46923E+02	.46225E+02
.45451E+02	.43809E+02	.42880E+02	.41444E+02	.38768E+02	.38004E+02
.37024E+02	.35724E+02	.32188E+02	.30122E+02	.27975E+02	.27095E+02
.25095E+02	.23573E+02	.19729E+02	.20878E+02	.23315E+02	.21726E+02

TABLE D-I (cont'd)

.15801E+03	.15840E+02	.75168E+01	.48042E+02	.48030E+02	.47797E+02
.47078E+03	.46424E+02	.45741E+02	.44911E+02	.43095E+02	.42037E+02
.40330E+03	.37870E+02	.37243E+02	.36294E+02	.34967E+02	.31340E+02
.29249E+03	.27102E+02	.26234E+02	.24311E+02	.22921E+02	.20641E+02
.25233E+02	.27629E+02	.24250E+02	.16628E+02	.15928E+02	.72306E+01
.46285E+03	.46279E+02	.46164E+02	.45785E+02	.45250E+02	.44529E+02
.43563E+02	.41390E+02	.40035E+02	.39439E+02	.37160E+02	.36191E+02
.34949E+03	.33382E+02	.29348E+02	.27197E+02	.25121E+02	.24328E+02
.22811E+02	.22012E+02	.23267E+02	.31005E+02	.33468E+02	.27336E+02
.17269E+02	.15657E+02	.65645E+01	.44937E+02	.44932E+02	.44844E+02
.44534E+02	.44004E+02	.43230E+02	.42188E+02	.39989E+02	.39011E+02
.38600E+02	.36257E+02	.35199E+02	.33956E+02	.32520E+02	.27491E+02
.25312E+02	.23615E+02	.22954E+02	.22027E+02	.26553E+02	.30713E+02
.34596E+02	.35730E+02	.28002E+02	.16892E+02	.14916E+02	.59243E+01
.40401E+02	.40397E+02	.40310E+02	.40001E+02	.39470E+02	.38719E+02
.37763E+02	.35970E+02	.35390E+02	.35087E+02	.32704E+02	.31674E+02
.30493E+02	.28799E+02	.22322E+02	.20406E+02	.19801E+02	.20709E+02
.23321E+02	.30771E+02	.34059E+02	.32985E+02	.31215E+02	.22334E+02
.12760E+02	.11058E+02	.41789E+01	.38501E+02	.38497E+02	.38414E+02
.38121E+02	.37622E+02	.36927E+02	.36069E+02	.34567E+02	.34291E+02
.33794E+02	.31294E+02	.30350E+02	.28855E+02	.25599E+02	.20570E+02
.19486E+02	.20961E+02	.25325E+02	.31102E+02	.34686E+02	.33005E+02
.31152E+02	.28934E+02	.20186E+02	.11381E+02	.98268E+01	.36834E+01
.36419E+02	.36415E+02	.36338E+02	.36066E+02	.35607E+02	.34975E+02
.34205E+02	.32854E+02	.32437E+02	.32253E+02	.29718E+02	.28154E+02
.25409E+02	.22967E+02	.19007E+02	.18460E+02	.23416E+02	.27742E+02
.33588E+02	.35840E+02	.31254E+02	.28955E+02	.26499E+02	.18066E+02
.10066E+02	.86666E+01	.32321E+01	.27946E+02	.27943E+02	.27889E+02
.27697E+02	.27374E+02	.26926E+02	.26363E+02	.25255E+02	.24697E+02
.23841E+02	.20484E+02	.19088E+02	.17558E+02	.16014E+02	.13637E+02
.16077E+02	.21855E+02	.24388E+02	.27479E+02	.28136E+02	.22406E+02
.20240E+02	.18104E+02	.11733E+02	.63455E+01	.54288E+01	.20201E+01
.17576E+02	.17574E+02	.17541E+02	.17424E+02	.17225E+02	.16946E+02
.16590E+02	.15871E+02	.15493E+02	.14897E+02	.12575E+02	.11694E+02
.10785E+02	.99221E+01	.89043E+01	.12183E+02	.15918E+02	.13748E+02
.17388E+02	.17001E+02	.12826E+02	.11434E+02	.10108E+02	.63611E+01
.33627E+01	.28622E+01	.10647E+01	.29879E+02	.29876E+02	.29820E+02
.29622E+02	.29285E+02	.28812E+02	.28205E+02	.26972E+02	.26320E+02
.25291E+02	.21294E+02	.19831E+02	.18345E+02	.16929E+02	.14837E+02
.15249E+02	.15966E+02	.16051E+02	.15771E+02	.15018E+02	.11121E+02
.98793E+01	.87092E+01	.54458E+01	.28641E+01	.24349E+01	.90587E+00
.18352E+02	.18350E+02	.18316E+02	.18195E+02	.17991E+02	.17704E+02
.17337E+02	.16592E+02	.16201E+02	.15588E+02	.13252E+02	.12423E+02
.11575E+02	.10722E+02	.90589E+01	.82984E+01	.75850E+01	.72955E+01
.66216E+01	.59742E+01	.42103E+01	.37099E+01	.32541E+01	.20313E+01
.10686E+01	.90867E+00	.34062E+00			
0					

APPENDIX E

TPLOT - A PROGRAM TO PROCESS TWIGL OUTPUT TAPES

TPLOT, listed in Table E-I reads the TWIGL output tape and processes the data into various more useful forms. As an example of the computations performed, we use the case of RIA ST-3. The correct Figure of Merit (FOM) for this experiment is 2.4 kW/m-MW at the axial flux peak. The TWIGL FOM is different, as discussed in Section 2.2, and must be renormalized. From TWIGL, the unnormalized power in the test fuel region at time t = 0 is 1253.42 Btu/hr = .036725 kW. The total power is 0.1 MW = 100 kW. Therefore:

$$\text{FOM (Rods Out)} = \frac{0.36725}{(0.9144)(0.1-0.36725\times10^{-3})} = 4.0311 \text{ kW/m-MW} \quad \text{(E-1)}$$

From a similar calculation we find that the control-rods-in FOM is 5.5442 kW/m-MW. Since the correct rods-out FOM is 2.4 kW/m-MW, the TWIGL rods-out results should be corrected by a factor of:

$$CF = \frac{2.4}{4.0311} = 0.59537 \quad \text{(E-2)}$$

This factor automatically includes a factor of 1.12 for an assumed control rod position during the burst of 12 inches inserted. Thus, to normalize the TWIGL test powers, which are in Btu/hr for 1/4 of the test fuel:

$$P_{test,norm} = \frac{(1.12)(0.53158)(P_{test,TWIGL})(4.0)}{(3413.0)(0.9144)}$$

$$= (1.12)(6.8133\times10^{-4})(P_{test,TWIGL})$$

$$= (1+RFAC)(TPCF)(P_{test,TWIGL}) \quad \text{(E-3)}$$

And the normalized core power is given by:

$$P_{core,norm} = (P_{total,TWIGL})(4.0)-(P_{test,norm})(0.9144)(.001)/(1.35) \quad \text{(E-4)}$$

where 1.35 is the axial peak to average power factor for the experiment fuel.

TABLE E-I

TPLOT SOURCE LISTING

```
PROGRAM TPLOT1   76/76  OPT=1                    FTN 4.6+452
      PROGRAM TPLOT1(INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT,TAPE7,TAPE8)
      DIMENSION TIME(1000),PTOTAL(1000),ETOTAL(1000),PTEST(1000),ETEST(
     1000),PCORE(1000),ECORE(1000),TITLE(10),INDEX(1000),QQ(70,70),CFRAC
     2(1000),TFRAC(1000),TFR(1000)
      READ(5,1) PZERO,RFAC,RTS,RTE,TPCF,TECF,PTZERO
    1 FORMAT(7E10.4)
      READ(5,2) IGEO,NTHC,NTHP,IFEED,IPLT
    2 FORMAT(5I5)
      READ(8) TITLE
      READ(8)
      WRITE(6,3) TITLE
    3 FORMAT(1H1,10A8)
      TIME(1)=0.0
      ETOTAL(1)=0.0
      PTEST(1)=(1.0+RFAC)*TPCF*PTZERO
      PTOTAL(1)=4.0*PZERO
      PCORE(1)=PTOTAL(1)-(PTEST(1)*0.9144/1.35)*0.001
      ECORE(1)=0.0
      ETEST(1)=0.0
      DO 100 I=2,IPLT
      J=I-1
      READ(8) INDEX(I),TIME(I),PTOTAL(I),ETOTAL(I)
      READ(8)
      READ(8)
      IF(IFEED.EQ.1) GO TO 25
      GO TO 50
   25 READ(8)
      READ(8)
      READ(8) ((QQ(IQ,JQ),IQ=1,NTHC),JQ=1,NTHP)
   50 CONTINUE
      IF((TIME(I).GE.RTS).AND.(TIME(I).LE.RTE)) GO TO 60
      XXX=RFAC
      IF(TIME(I).GT.RTE) XXX=0.0
      GO TO 70
   60 XXX=RFAC*((RTE-TIME(I))/(RTE-RTS))
   70 PTEST(I)=(1.0+XXX)*TPCF*QQ(2,2)
      PTOTAL(I)=4.0*PTOTAL(I)
      ETOTAL(I)=4.0*ETOTAL(I)
      PCORE(I)=PTOTAL(I)-(PTEST(I)*0.9144/1.35)*0.001
      DENOM=2.0/(TIME(I)-TIME(J))
      ECORE(I)=ECORE(J)+(PCORE(I)+PCORE(J))/DENOM
      ETEST(I)=ETEST(J)+(PTEST(I)+PTEST(J))/DENOM
C
C     FOLLOWING ARE TO FORCE AGREEMENT WITH TWIGA858
C     ON FIRST STEP POWER INTEGRATION
C
      IF(I.GT.2) GO TO 80
      ECORE(I)=ECORE(I)-PCORE(J)/DENOM
      ETEST(I)=ETEST(I)-PTEST(J)/DENOM
   80 CONTINUE
C
  100 CONTINUE
      WRITE(6,4)
    4 FORMAT(1H0,5X,"TIME",13X,"TOTAL",13X,"TOTAL",13X,"CORE",13X,"TEST"
     1,14X,"CORE",13X,"TEST")
      WRITE(6,5)
    5 FORMAT(1H ,4X," SEC",14X,"POWER",13X,"ENERGY",12X,"POWER",12X,"POW
```

BLE E-I (cont'd)

```
                                FTN 4.6+452
IX,"ENERGY")
4W ",13X,"MW SEC",13X," MW ",11X,"KWPM PEAK",9X,
%SPM PEAK")
,PTOTAL(I),ETOTAL(I),PCORE(I),PTEST(I),ECORE(I),
(,6(1PE12.5,6X))
:CORE(IPLT)
:TEST(IPLT)
:OTAL(IPLT)
', 13X,"CORE FRACTION  TEST FRACTION  TOTAL FRA
CFRAC(I),TFRAC(I),TFR(I)
IX,(1PE12.5,3X,1PE12.5,3X,(PE12.5)
,I=1,IPLT)
,I=1,IPLT)
,I=1,IPLT)
,I=1,IPLT)
```

-ing the time before the control
e control rods are ramped in the
the TWIGL X-Y model changes to a
nce of the rods is accounted
e moving in:

$$* \text{TPCF} * P_{test,TWIGL} \qquad \text{(E-5)}$$

lly ramped in at t_f. After the rods

$$P_{test,TWIGL} \qquad \text{(E-6)}$$

ıtered into TPLOT are given in

II
E RIA TWIGL RESULTS

CF	t_s	t_f
$5x10^{-4}$	0.172	0.272
$5x10^{-4}$	0.116	0.216
$3x10^{-4}$	0.120	0.220
$3x10^{-4}$	0.120	0.220
$1x10^{-4}$	0.065	0.165

ows:

ver for 1/4 of the reactor (MW)
E-3
ı E-5 (sec)
ı E-5 (sec)

Word 5: TPCF: see Equation E-3 (kW/m/Btu/hr)

Word 6: TECF: not used, set to 1.0

Word 7: PTZERO = test power as edited by TWIGL for time t = 0 (Btu/hr-quarter test)

Card 2 FORMAT (14I5)

Word 1: IGEO = 0 signifies X-Y geometry
= 1 signifies R-Z geometry

Word 2: NTHC = number of thermal hydraulic channels

Word 3: NTHP = number of thermal-hydraulic planes

Word 4: IFEED = 0 signifies no thermal feedback
= 1 signifies thermal feedback

Word 6: IPLT = number of time points to process, in order, starting with the first time point on the tape. IPLT must be less than or equal to the total number of time points written to the tape.

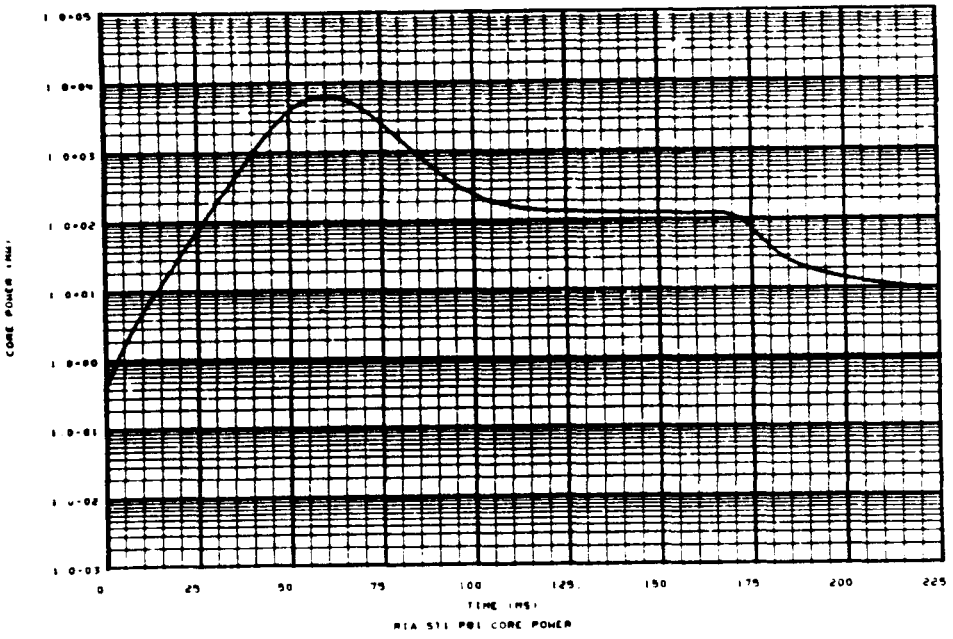
TPLOT output for a case consists of the time and, for the total reactor, the core and the test, an edit of both the power and the released energy as functions of time. Also, for each time point an edit is printed for the core, test and total reactor of the fraction of the total fissions accumulated by time point IPLT. This is used to compute the delayed fission fraction for a particular case.

Appendix F shows plotted and tabulated TPLOT output for each of the five RIA experiments calculated. To get the tail fraction in the test fuel for RIA ST-1, PB-1 as an example we note that the fraction of accumulated fissions in the test fuel at time t_s = 0.172 when the burst is defined to end is 0.85. The tail fraction of fissions is thus (1.0-0.85) = 0.15, as indicated in Table IV. (See also Page 88)

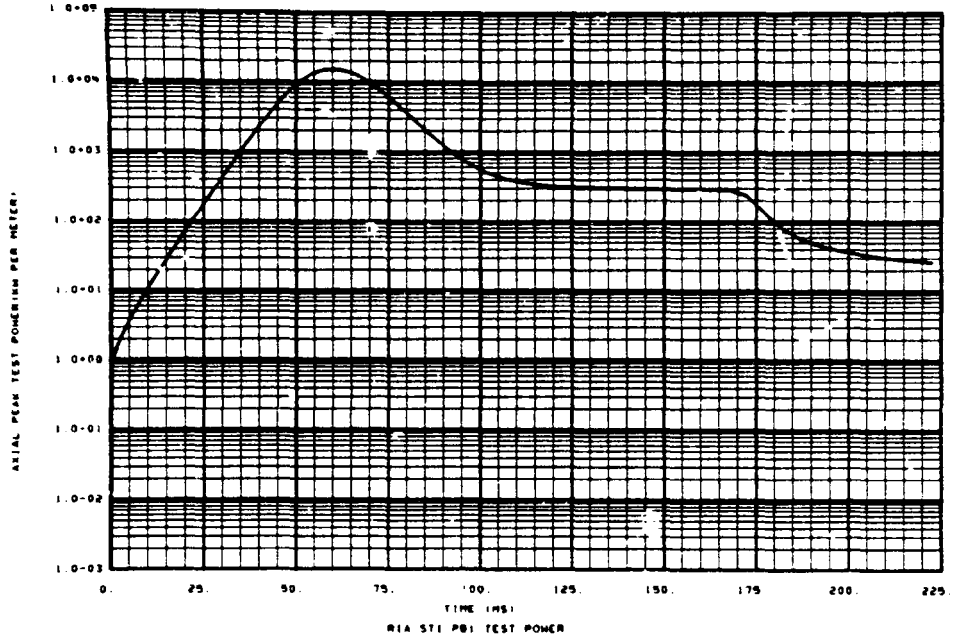
APPENDIX F

DETAILED TWIGL-TPLOT OUTPUT FOR THE RIA BURSTS CALCULATED

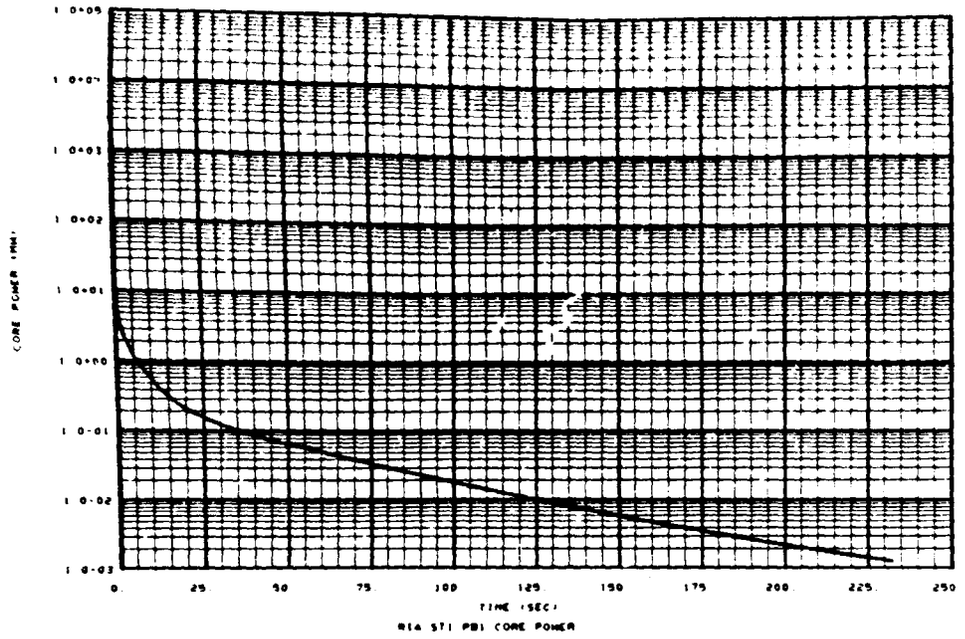
Each plot for either core power or test power for a given experiment is shown twice, once on a short time scale to show details of the burst and again on an expanded time scale out to 250 seconds to show the extended tail fissions. Each plot is slightly low on power during the tail due to the constant energy per fission assumed. This is discussed in detail and a correction factor is derived in Section 2.2. Following the core and test power plots for a given RIA experiment are complete listings of the core, test and total reactor power as functions of time for that experiment. Finally the accumulated fractions of the total fissions occurring in the core, test and total reactor are listed.



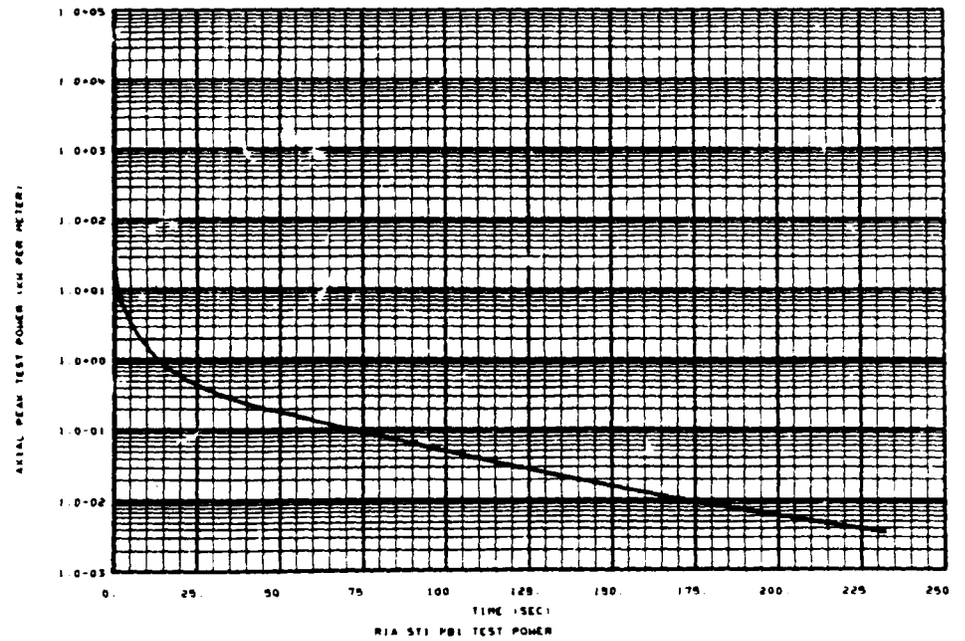
RIA ST1 PB1 CORE POWER



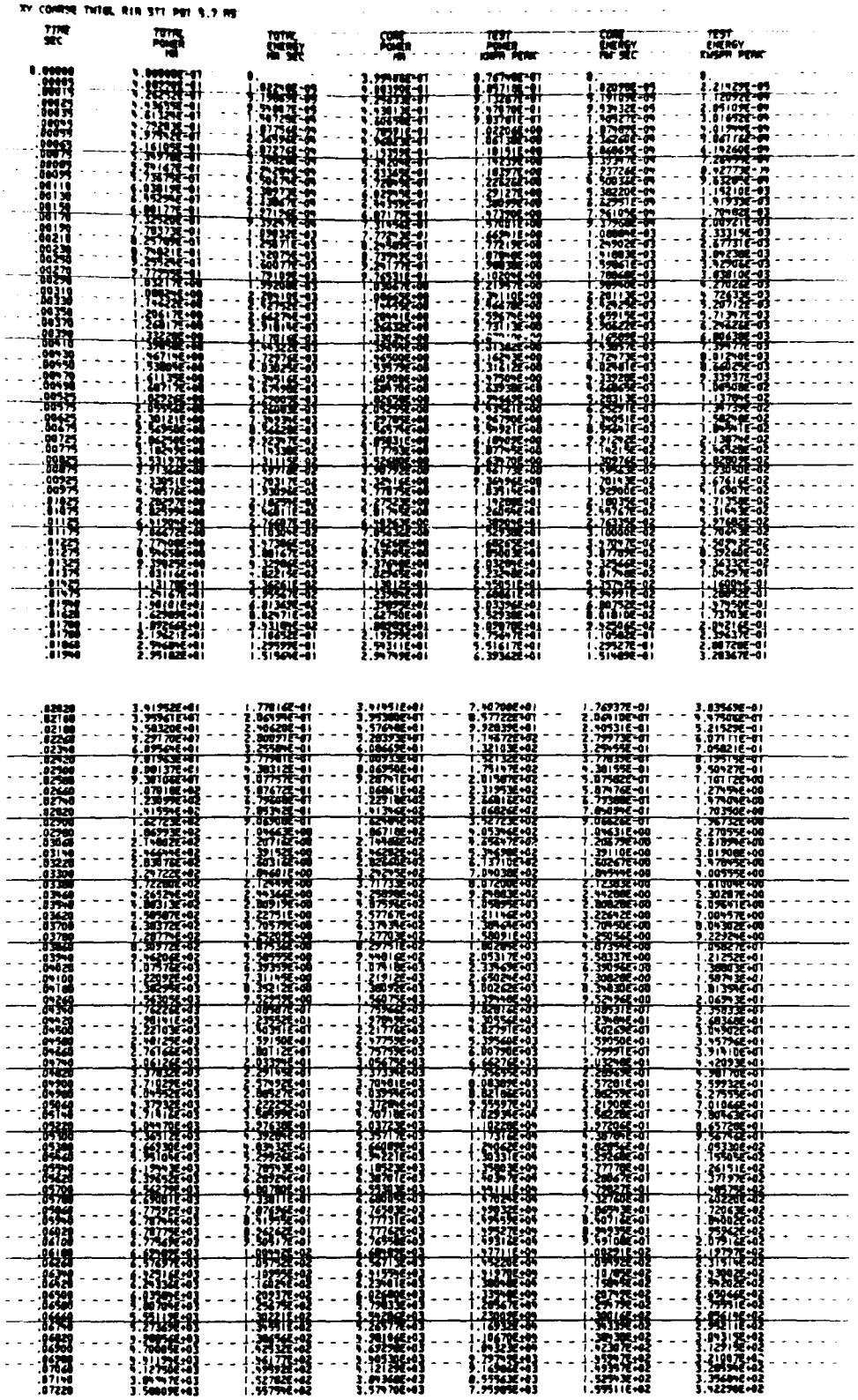
RIA ST1 PB1 TEST POWER

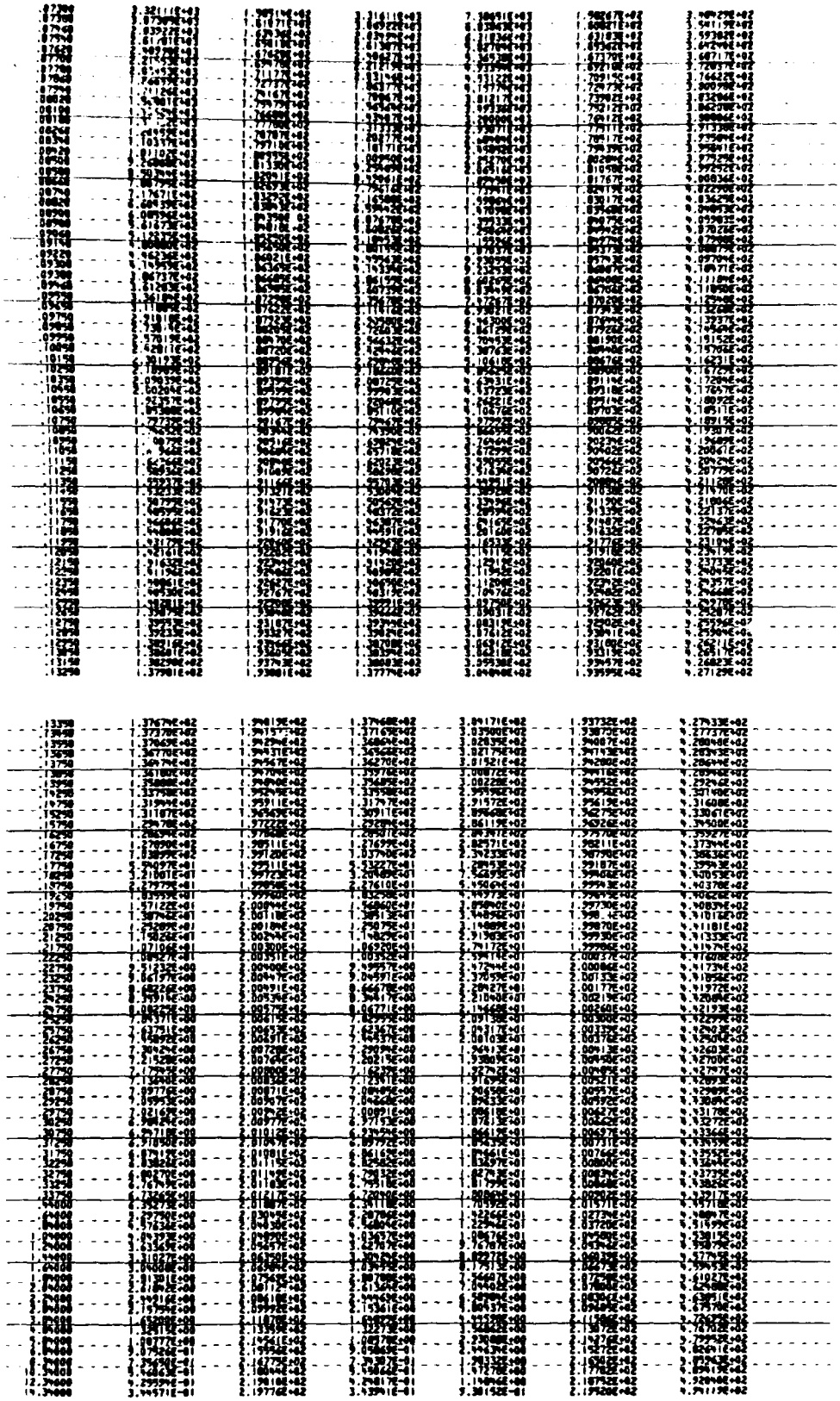


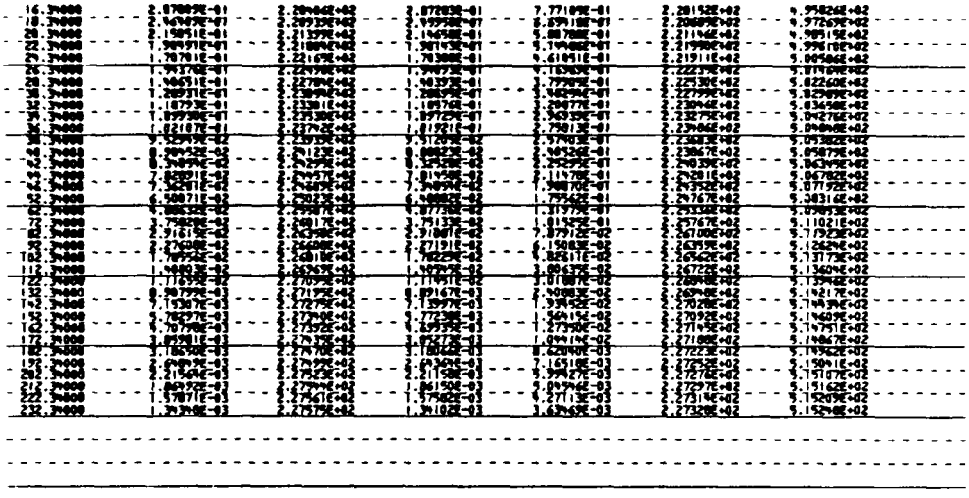
RIA STI PBI CORE POWER

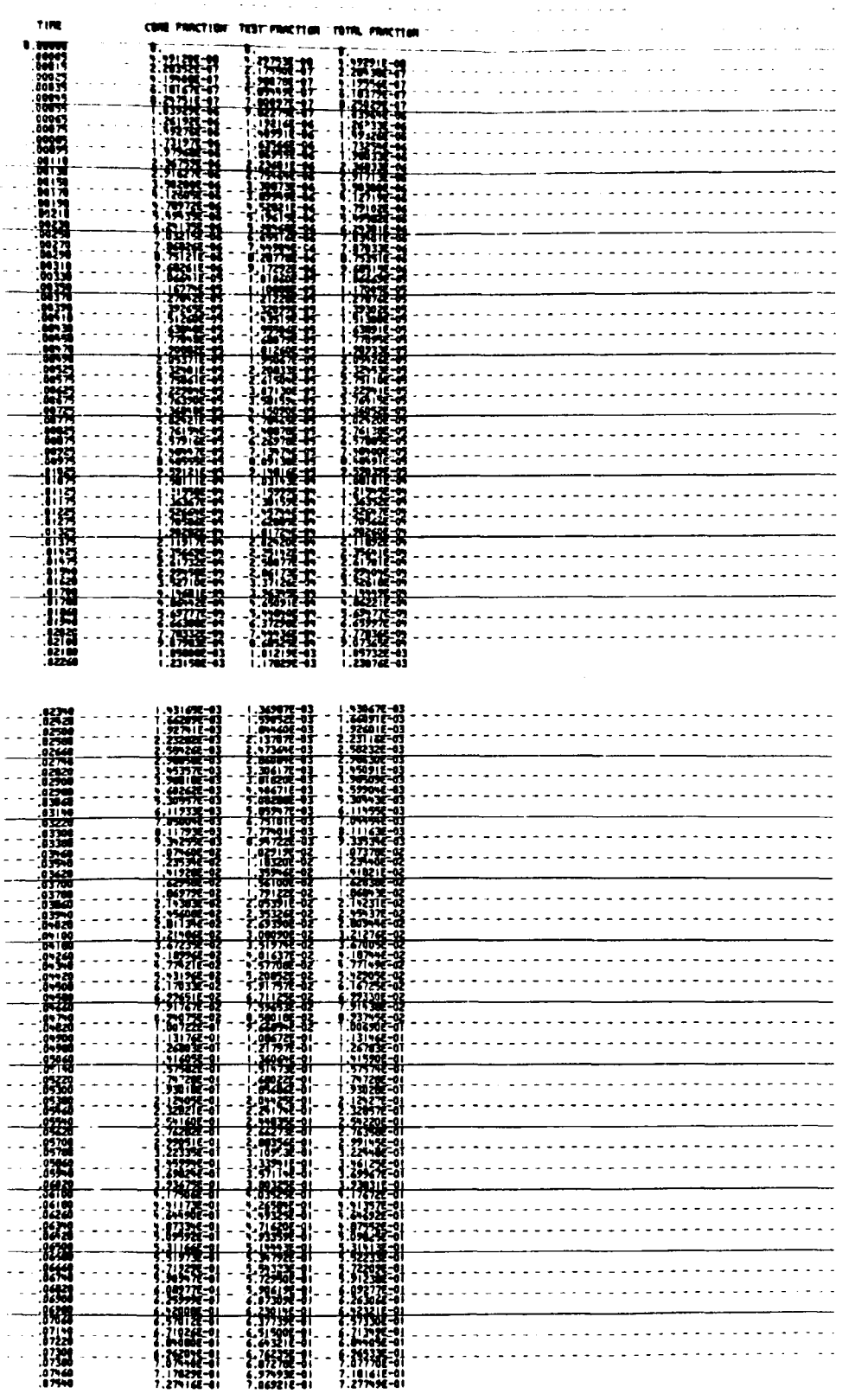


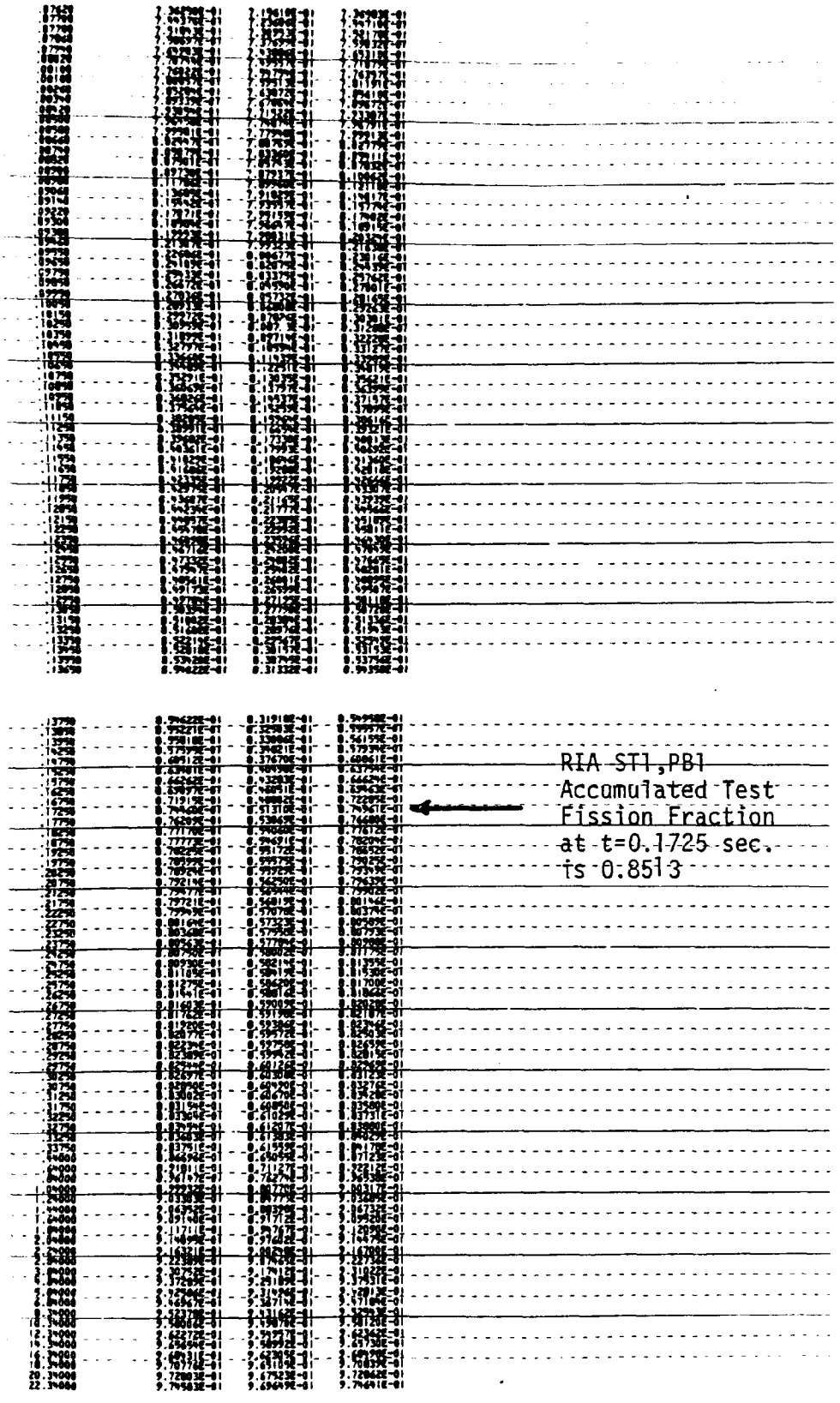
RIA STI PBI TEST POWER

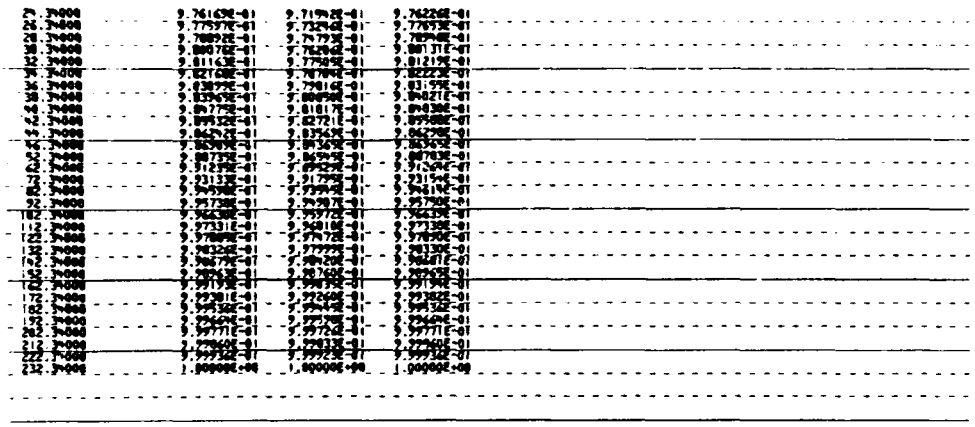


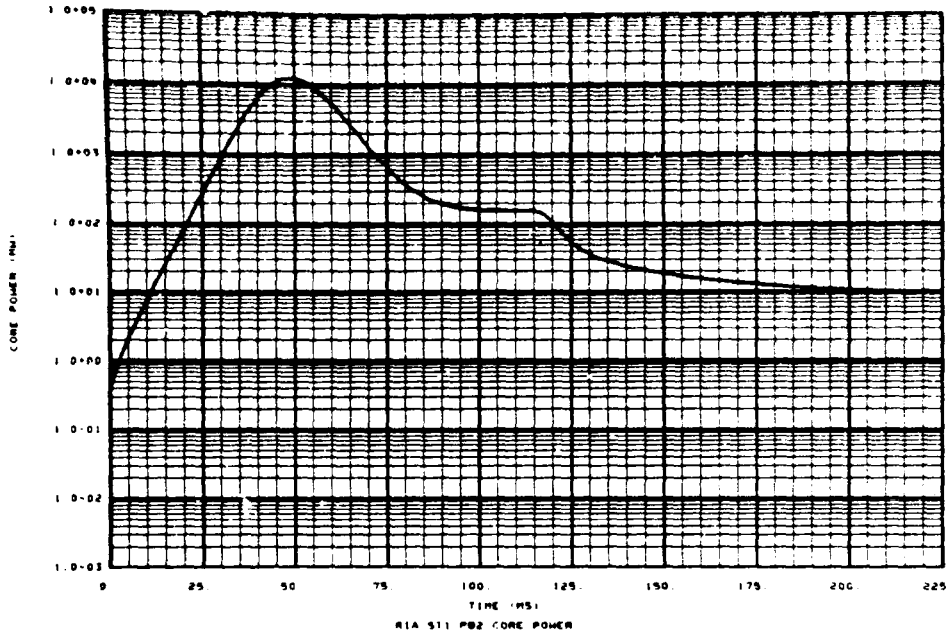





TIME
CORE FRACTION
TEST FRACTION
TOTAL FRACTION

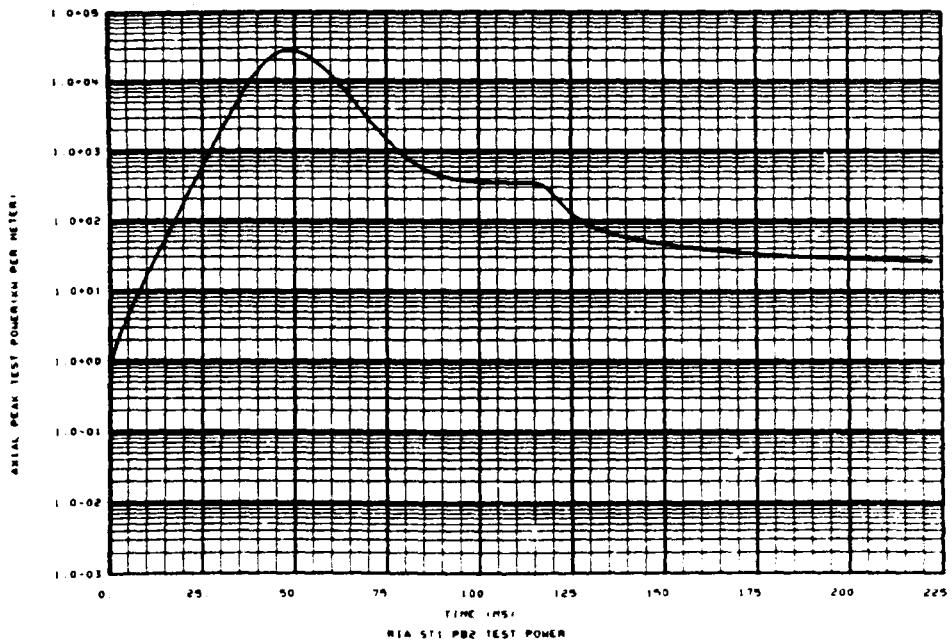

RIA ST1,PB1
Accumulated Test
Fission Fraction
at t=0.1725 sec.
is 0.8513



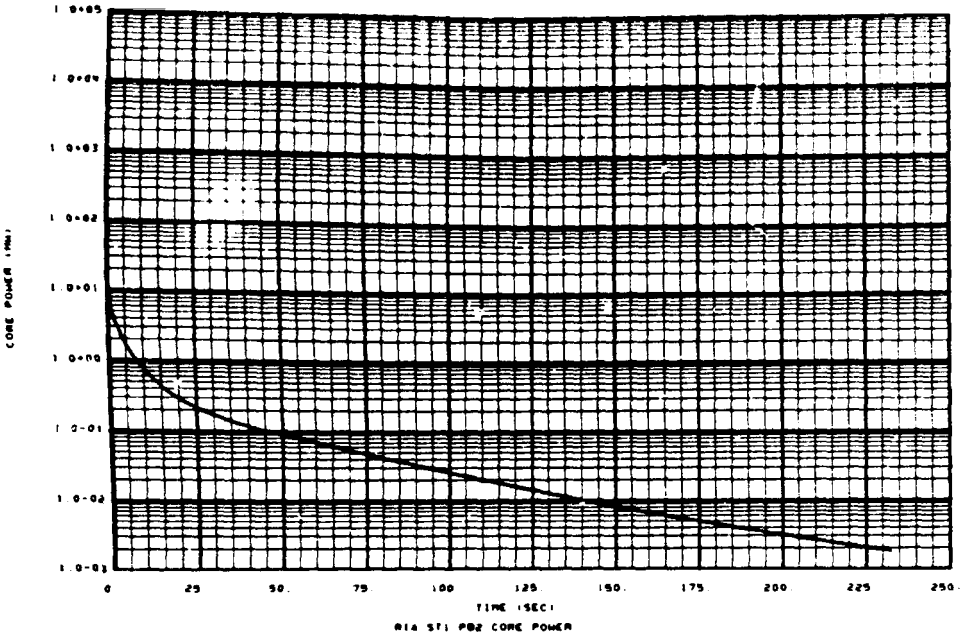


RIA 511 PB2 CORE POWER

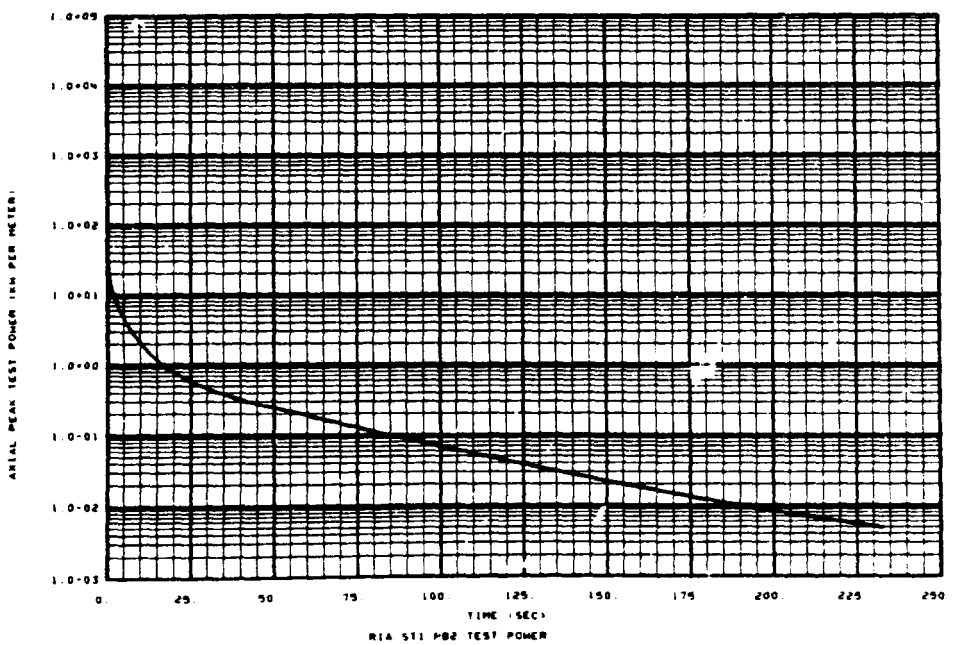
PAGE 20



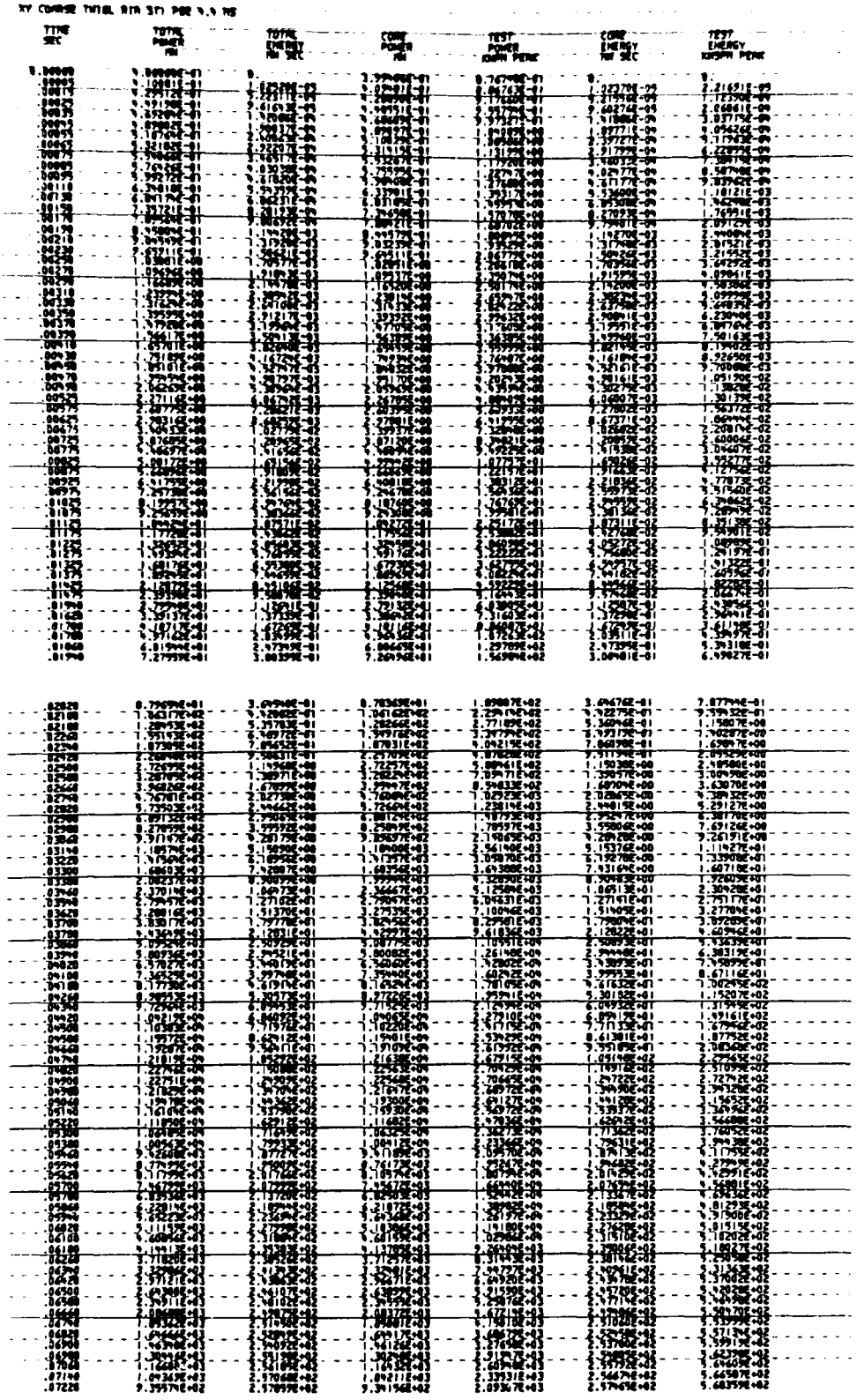
RIA 511 PB2 TEST POWER

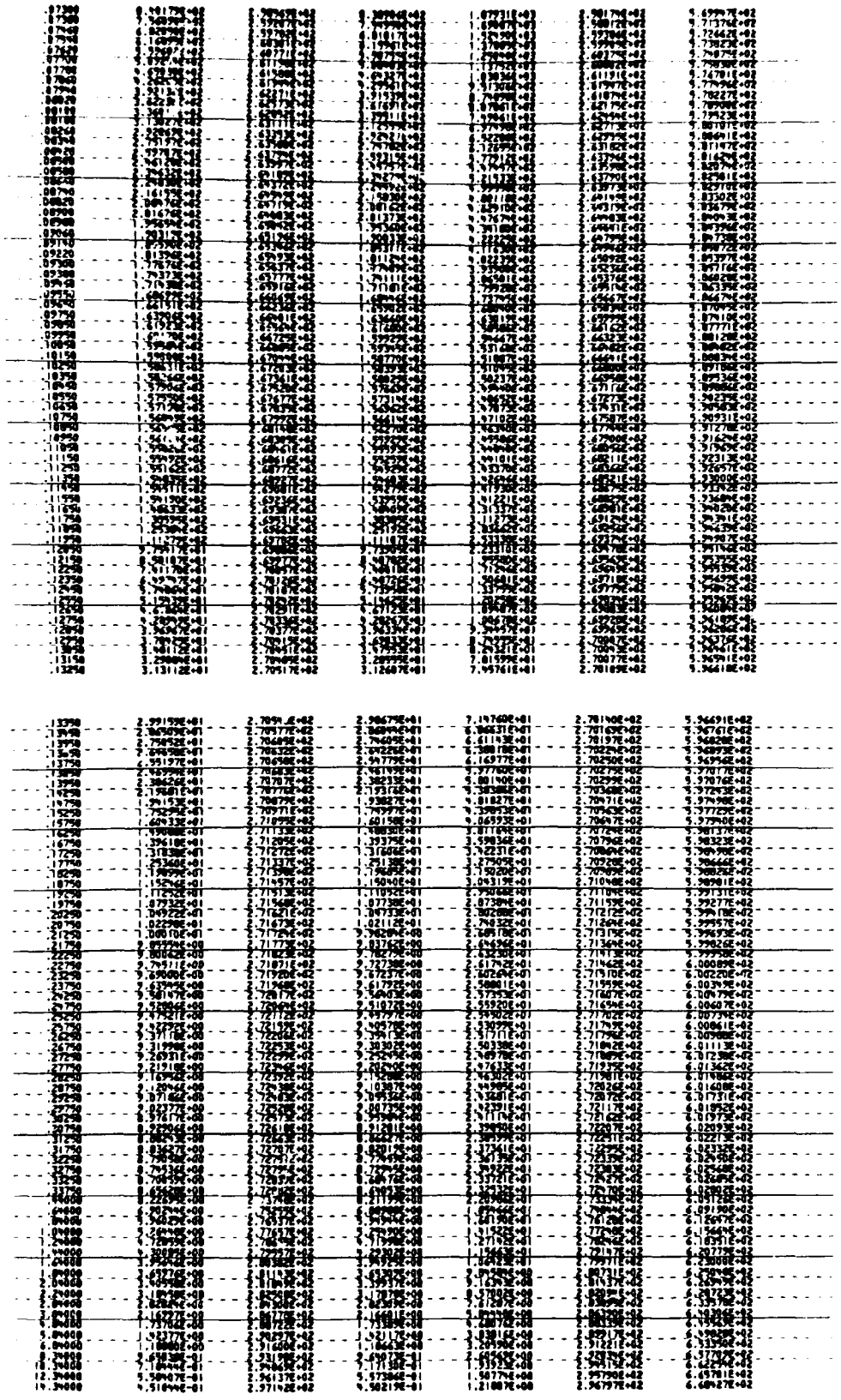


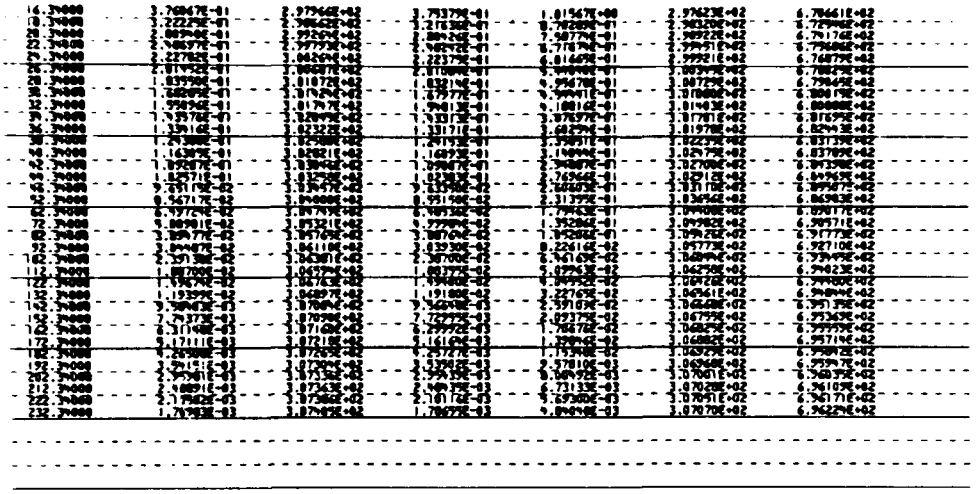
RIA ST1 PB2 CORE POWER

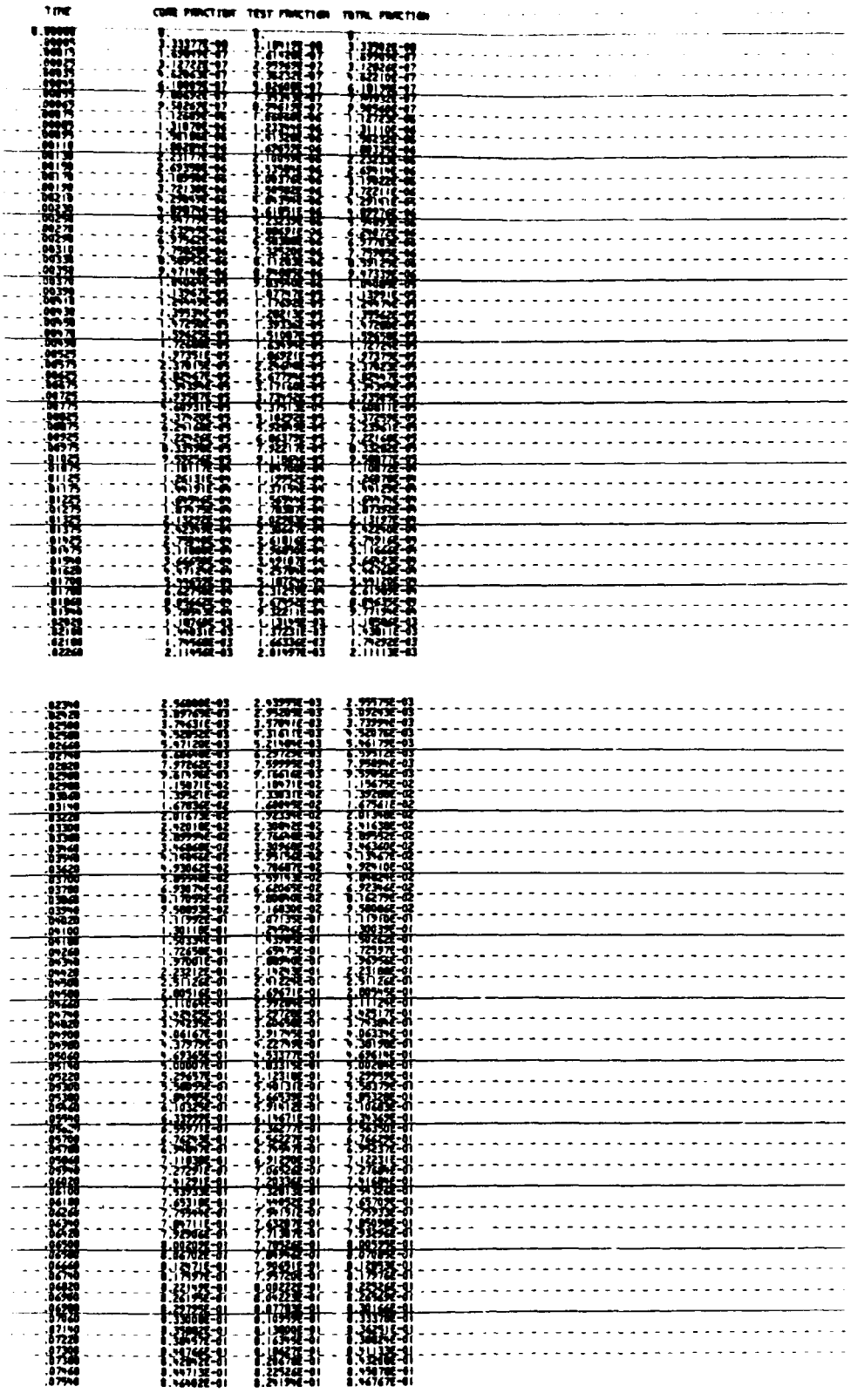


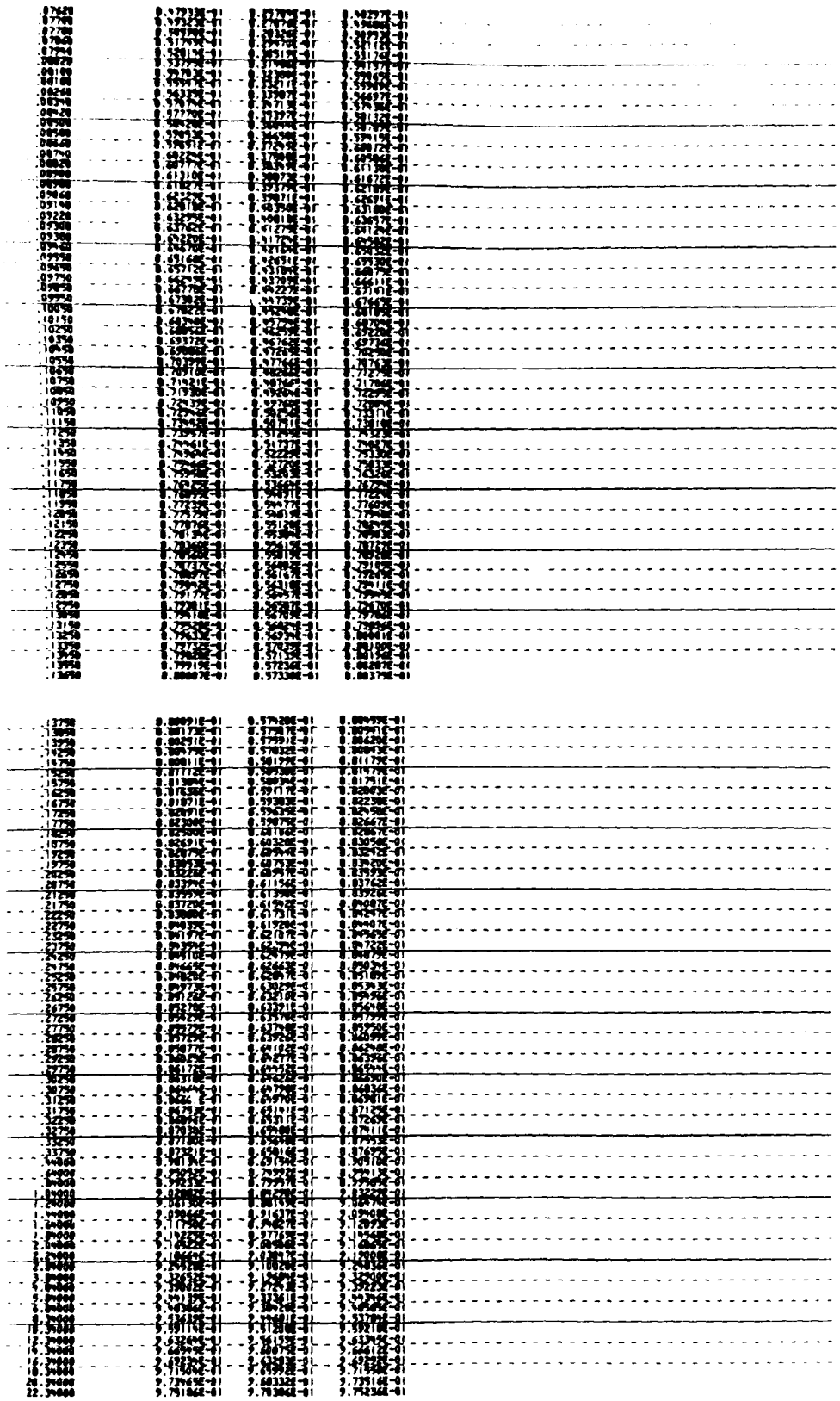
RIA ST1 PB2 TEST POWER

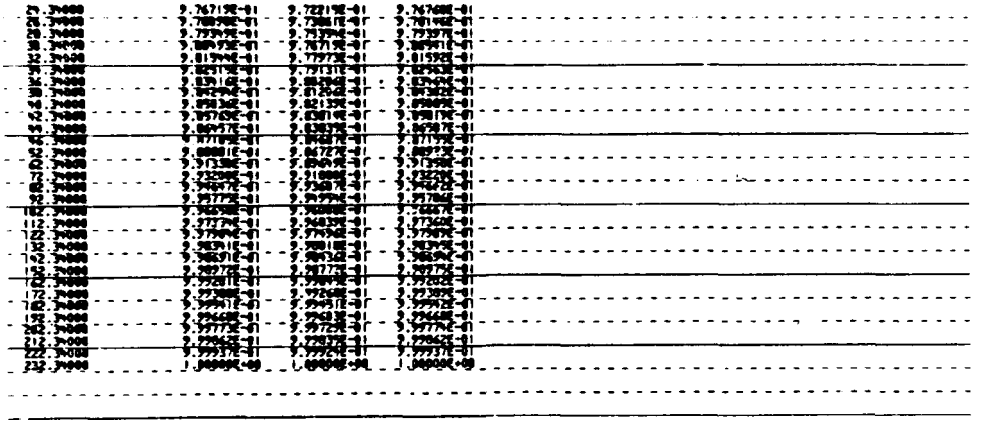


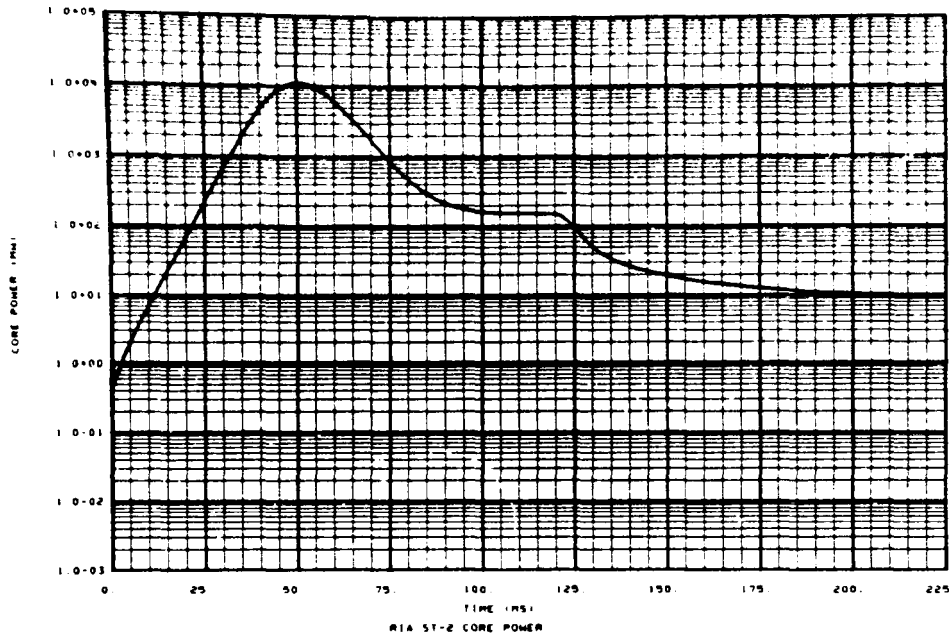





TIME
CORE FUNCTION
TEST FUNCTION
TOTAL FUNCTION






1.0+05
1.0+04
1.0+03
1.0+02
1.0+01
1.0+00
1.0-01
1.0-02
1.0-03
CORE POWER (MW)
0
25
50
75
100
125
150
175
200
225
TIME (MS)
RIA ST-2 CORE POWER

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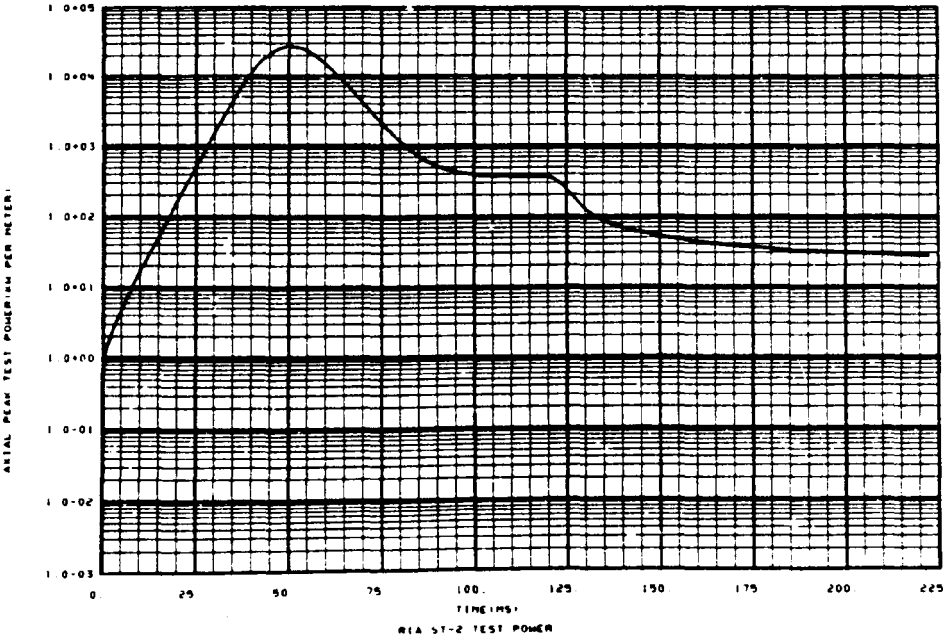
1.0+05
1.0+04
1.0+03
1.0+02
1.0+01
1.0+00
1.0-01
1.0-02
1.0-03
AXIAL PEAK TEST POWER(KW PER METER)
0
25
50
75
100
125
150
175
200
225
TIME(MS)
RIA ST-2 TEST POWER

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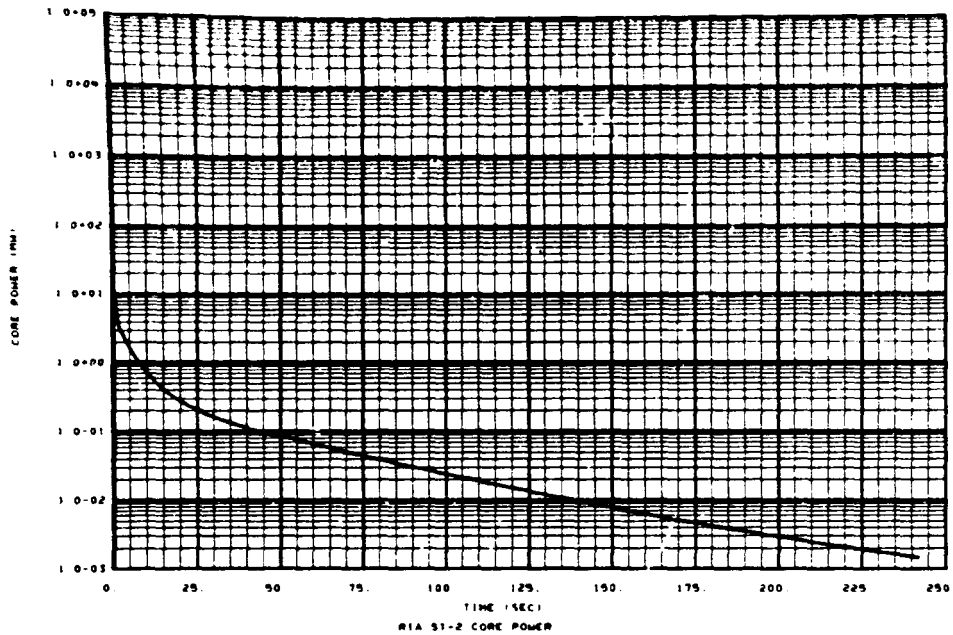
1.0+05
1.0+04
1.0+03
1.0+02
1.0+01
1.0+00
1.0-01
1.0-02
1.0-03
CORE POWER (MW)
0
25.
50.
75.
100.
125.
150.
175.
200.
225.
250.
TIME (SEC)
RIA 51-2 CORE POWER

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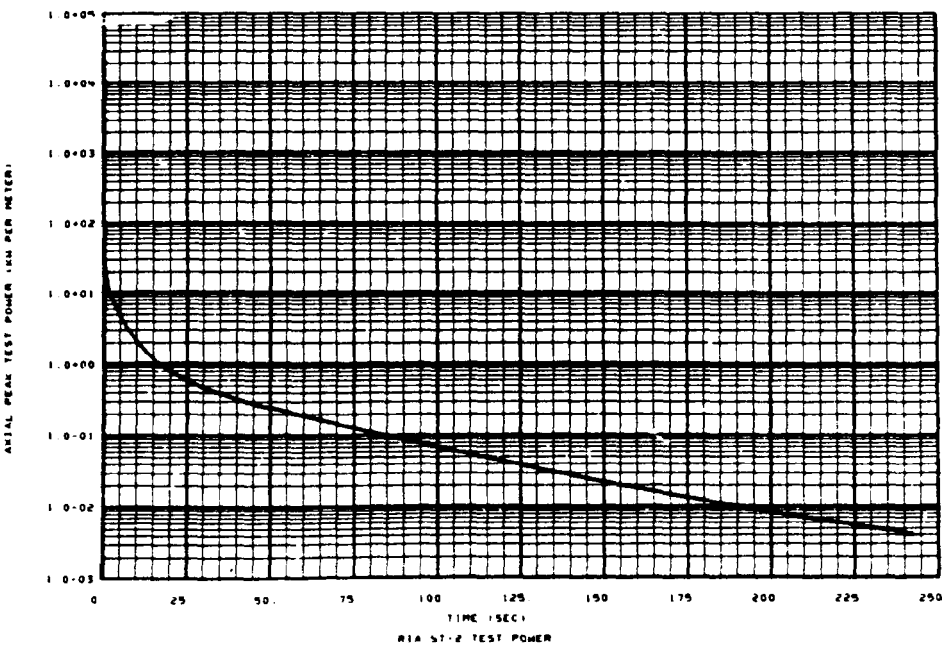
1.0+05
1.0+04
1.0+03
1.0+02
1.0+01
1.0+00
1.0-01
1.0-02
1.0-03
AXIAL PEAK TEST POWER (KW PER METER)
0
25
50.
75
100
125
150
175
200
225
250
TIME (SEC)
RIA 51-2 TEST POWER

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** COARSE TWIGL 9.6 MS BURST

TIME SEC	TOTAL POWER MW	TOTAL ENERGY MW SEC	CORE POWER MW	TEST POWER MWPH PEAK	COR ENERGY MW SEC	TEST ENERGY MWSPH PEAK
0.00000	9.000000E-07	0.	3.993312E-01	9.566957E-01	0.	0.
.00009	9.098774E-01	1.029668E-05	4.092229E-01	9.671702E-01	1.023064E-05	2.917922E-05
.00018	9.208790E-01	4.218452E-05	4.202211E-01	1.000199E+00	4.210227E-05	7.229847E-05
.00028	9.481153E-01	9.603976E-05	4.474408E-01	1.040866E+00	9.598641E-05	2.244998E-04
.00038	9.677794E-01	1.918308E-04	4.670849E-01	1.080427E+00	1.916161E-04	3.209903E-04
.00048	9.879099E-01	3.039407E-04	4.870942E-01	1.121349E+00	3.037114E-04	4.417745E-04
.00058	9.082748E-01	4.240407E-04	5.074485E-01	1.163991E+00	4.237991E-04	5.673202E-04
.00068	9.291294E-01	5.912732E-04	5.282492E-01	1.228058E+00	5.908827E-04	6.777707E-04
.00078	9.504259E-01	7.965298E-04	5.494862E-01	1.279876E+00	7.957220E-04	9.030794E-04
.00088	9.721755E-01	9.913376E-04	5.711749E-01	1.330816E+00	9.907662E-04	9.335123E-04
.00098	9.943779E-01	1.199700E-03	5.933639E-01	1.382356E+00	1.198799E-03	1.069136E-03
.00108	6.280869E-01	5.519277E-04	6.278870E-01	1.463256E+00	5.505956E-04	1.282545E-03
.00118	6.486884E-01	2.889967E-04	6.794216E-01	1.583579E+00	6.809452E-04	1.586495E-03
.00150	7.265327E-01	8.222552E-04	7.953180E-01	1.692117E+00	8.210458E-04	1.913394E-03
.00148	7.784902E-01	9.439224E-04	7.944240E-01	1.819649E+00	9.713099E-04	2.264222E-03
.00158	8.326655E-01	1.133081E-03	8.213499E-01	1.993359E+00	1.132178E-03	2.640128E-03
.00168	8.891146E-01	1.305997E-03	8.877440E-01	2.076498E+00	1.304908E-03	3.042108E-03
.00230	9.480316E-01	1.498369E-03	9.466531E-01	2.215299E+00	1.496791E-03	3.471288E-03
.00260	1.009942E+00	1.689537E-03	1.007782E+00	2.360008E+00	1.687452E-03	3.928811E-03
.00270	1.073935E+00	1.893362E-03	1.071736E+00	2.510898E+00	1.891590E-03	4.415590E-03
.00280	1.140016E+00	2.116944E-03	1.138359E+00	2.668188E+00	2.111190E-03	4.933808E-03
.00310	1.209272E+00	2.343989E-03	1.207816E+00	2.832108E+00	2.336652E-03	5.483844E-03
.00330	1.282226E+00	2.599206E-03	1.280233E+00	3.003196E+00	2.590533E-03	6.067377E-03
.00350	1.359789E+00	2.863033E-03	1.356573E+00	3.181411E+00	2.853622E-03	6.685638E-03
.00370	1.443673E+00	3.152945E-03	1.439645E+00	3.367226E+00	3.142794E-03	7.340705E-03
.00390	1.518935E+00	3.437709E-03	1.516525E+00	3.561035E+00	3.433304E-03	8.033535E-03
.00410	1.604432E+00	3.760249E-03	1.602098E+00	3.762044E+00	3.744930E-03	8.765953E-03
.00430	1.693308E+00	4.080010E-03	1.691129E+00	3.973666E+00	4.064723E-03	9.539604E-03
.00460	1.787114E+00	4.428166E-03	1.784930E+00	4.193295E+00	4.412779E-03	1.035463E-02
.00470	1.886226E+00	4.799525E-03	1.884126E+00	4.422219E+00	4.782835E-03	1.121708E-02
.00480	1.990552E+00	5.188218E-03	1.988236E+00	4.668088E+00	5.171671E-03	1.212461E-02
.00525	2.100.0E+00	5.595057E-03	2.097644E+00	4.925953E+00	5.579253E-03	1.308374E-02
.00545	5.993808E+00	7.077999E-03	5.988894E+00	9.893712E+00	7.060990E-03	1.698006E-02
.00625	2.839816E+00	8.409995E-03	2.835259E+00	6.670794E+00	8.399944E-03	1.971106E-02
.00675	3.227156E+00	9.925436E-03	3.222015E+00	7.583333E+00	9.916266E-03	2.327495E-02
.00725	3.655950E+00	1.164555E-02	3.652367E+00	8.601998E+00	1.163326E-02	2.732009E-02
.00775	4.142116E+00	1.359438E-02	4.135691E+00	9.739025E+00	1.356855E-02	3.190461E-02
.00825	4.690816E+00	1.577992E-02	4.683956E+00	1.102825E+01	1.576027E-02	3.709229E-02
.00875	5.305172E+00	1.825628E-02	5.297370E+00	1.247598E+01	1.824594E-02	4.294172E-02
.00925	5.995331E+00	2.103934E-02	5.987382E+00	1.410063E+01	2.101738E-02	4.955590E-02
.00975	6.702519E+00	2.425648E-02	6.694183E+00	1.577715E+01	2.423328E-02	5.700349E-02
.01025	7.538785E+00	2.781226E-02	7.526766E+00	1.771917E+01	2.778794E-02	6.538117E-02
.01075	8.472235E+00	3.181188E-02	8.458722E+00	1.994108E+01	3.178318E-02	7.480429E-02
.01125	9.511414E+00	3.624848E-02	9.497977E+00	2.239508E+01	3.622732E-02	8.538666E-02
.01175	1.067717E+01	4.115862E-02	1.065911E+01	2.513588E+01	4.113102E-02	9.726595E-02
.01225	1.197526E+01	4.708872E-02	1.195616E+01	2.819941E+01	4.705670E-02	1.106022E-01
.01275	1.342406E+01	5.335620E-02	1.340266E+01	3.160777E+01	5.330467E-02	1.255952E-01
.01325	1.504111E+01	6.044227E-02	1.501771E+01	3.541178E+01	6.041166E-02	1.423039E-01
.01375	1.684460E+01	6.842635E-02	1.681892E+01	3.967035E+01	6.837077E-02	1.610816E-01
.01425	1.886035E+01	7.737822E-02	1.883201E+01	4.443165E+01	7.728336E-02	1.821036E-01
.01475	2.111087E+01	8.733226E-02	2.107902E+01	4.973132E+01	8.718494E-02	2.056395E-01
.01548	2.445222E+01	1.021127E-01	2.441531E+01	5.762772E+01	1.020956E-01	2.405357E-01
.01620	2.847438E+01	1.236746E-01	2.843270E+01	2.891149E+01	1.234608E-01	2.913774E-01
.01700	3.348855E+01	1.495757E-01	3.343521E+01	8.332626E+01	1.493520E-01	3.525198E-01
.01780	4.241968E+01	1.860480E-01	4.234970E+01	1.861388E+02	1.858450E-01	4.385912E-01
.01860	4.102239E+01	2.180119E-01	4.094295E+01	1.201095E+02	2.177956E-01	5.140911E-01
.01940	6.121126E+01	2.628281E-01	6.111135E+01	1.441186E+02	2.628188E-01	6.197904E-01
.02020	7.394851E+01	3.165598E-01	7.382880E+01	1.729166E+02	3.165479E-01	7.466311E-01
.02100	8.779779E+01	3.809859E-01	8.765771E+01	2.052897E+02	3.810376E-01	8.987166E-01
.02180	1.054455E+02	4.582136E-01	1.052587E+02	2.489305E+02	4.582594E-01	1.081016E+00
.02260	1.263336E+02	5.507426E-01	1.261731E+02	2.976249E+02	5.508629E-01	1.299536E+00
.02340	1.512916E+02	6.615706E-01	1.510506E+02	3.564356E+02	6.617396E-01	1.561085E+00
.02420	1.811136E+02	7.956566E-01	1.808269E+02	4.267710E+02	7.959940E-01	1.879431E+00
.02500	2.167729E+02	9.530866E-01	2.163709E+02	5.106633E+02	9.533465E-01	2.249125E+00
.02580	2.592199E+02	1.143099E+00	2.588059E+02	6.107895E+02	1.143946E+00	2.697881E+00
.02660	3.098655E+02	1.370229E+00	3.093390E+02	7.302077E+02	1.370729E+00	3.234921E+00
.02740	3.702322E+02	1.641787E+00	3.696491E+02	8.726495E+02	1.642338E+00	3.875288E+00
.02820	4.420255E+02	1.966099E+00	4.413195E+02	1.041722E+03	1.966711E+00	4.640956E+00
.02900	5.273511E+02	2.353839E+00	5.264701E+02	1.242815E+03	2.355385E+00	5.554786E+00
.02980	6.289455E+02	2.814594E+00	6.279592E+02	1.481137E+03	2.815490E+00	6.644946E+00
.03060	7.498160E+02	3.364919E+00	7.484966E+02	1.763795E+03	3.365168E+00	7.942508E+00
.03140	8.889996E+02	4.018039E+00	8.873735E+02	2.092723E+03	4.019108E+00	9.486898E+00
.03220	1.055089E+03	4.799689E+00	1.053020E+03	2.482997E+03	4.796059E+00	1.132188E+01
.03300	1.251112E+03	5.716166E+00	1.249133E+03	2.950956E+03	5.717426E+00	1.349816E+01
.03380	1.479229E+03	6.808497E+00	1.476259E+03	3.489994E+03	6.807994E+00	1.607945E+01
.03460	1.744708E+03	8.094920E+00	1.741152E+03	4.117226E+03	8.095386E+00	1.911746E+01
.03540	2.051776E+03	9.610559E+00	2.048062E+03	4.843333E+03	9.611532E+00	2.270166E+01
.03620	2.404666E+03	1.139086E+01	2.400082E+03	5.678053E+03	1.139126E+01	2.691036E+01
.03705	2.807229E+03	1.347306E+01	2.802279E+03	6.632176E+03	1.347276E+01	3.183436E+01
.03780	3.255560E+03	1.589560E+01	3.250308E+03	7.697576E+03	1.589440E+01	3.756665E+01
.03860	3.749276E+03	1.865762E+01	3.743206E+03	8.870008E+03	1.865714E+01	4.419736E+01
.03940	4.293179E+03	2.191056E+01	4.286390E+03	1.014947E+04	2.190235E+01	5.180075E+01
.04020	4.886726E+03	2.558808E+01	4.878892E+03	1.151765E+04	2.556908E+01	6.050339E+01
.04100	5.523196E+03	2.957829E+01	5.515427E+03	1.309944E+04	2.957271E+01	7.037238E+01
.04180	6.179487E+03	3.364285E+01	6.170691E+03	1.465997E+04	3.440686E+01	8.174899E+01
.04260	6.850062E+03	3.966108E+01	6.839546E+03	1.623661E+04	3.963625E+01	9.391626E+01
.04340	7.539687E+03	4.594634E+01	7.528364E+03	1.786598E+04	4.591708E+01	1.076076E+02
.04420	8.266946E+03	5.173997E+01	8.254711E+03	1.966673E+04	5.175011E+01	1.222777E+02
.04500	8.997809E+03	5.864225E+01	8.985352E+03	2.130952E+04	5.860249E+01	1.391728E+02
.04580	9.748877E+03	6.602223E+01	9.735933E+03	2.264466E+04	6.594452E+01	1.566706E+02
.04660	1.007462E+04	7.382276E+01	9.998962E+03	2.392923E+04	7.373398E+01	1.752979E+02
.04740	1.044155E+04	8.201776E+01	1.042566E+04	2.498678E+04	8.190316E+01	1.948664E+02
.04820	1.076208E+04	9.050386E+01	1.074455E+04	2.578657E+04	9.037076E+01	2.151776E+02
.04900	1.098940E+04	9.920736E+01	1.096622E+04	2.635027E+04	9.905550E+01	2.360029E+02
.04980	1.108482E+04	1.080405E+02	1.106062E+04	2.659776E+04	1.078662E+02	2.572018E+02
.05060	1.107277E+04	1.168998E+02	1.105346E+04	2.662729E+04	1.167094E+02	2.789398E+02
.05140	1.100428E+04	1.257738E+02	1.098644E+04	2.643931E+04	1.255620E+02	2.999176E+02
.05220	1.088201E+04	1.344733E+02	1.086724E+04	2.608065E+04	1.342366E+02	3.207768E+02
.05300	1.056887E+04	1.430204E+02	1.055196E+04	2.545944E+04	1.427659E+02	3.413908E+02
.05380	1.020122E+04	1.513209E+02	1.018956E+04	2.456417E+04	1.510566E+02	3.614288E+02
.05460	9.772564E+03	1.593235E+02	9.756259E+03	2.363622E+04	1.590332E+02	3.807408E+02
.05540	9.276336E+03	1.669956E+02	9.261136E+03	2.243809E+04	1.666329E+02	3.991778E+02
.05620	8.774795E+03	1.741169E+02	8.759405E+03	2.123859E+04	1.738352E+02	4.166235E+02
.05700	8.285234E+03	1.807227E+02	8.272498E+03	1.885396E+04	1.805595E+02	4.330516E+02
.05780	7.816649E+03	1.869269E+02	7.804122E+03	1.869196E+04	1.868967E+02	4.483898E+02
.05860	7.052020E+03	1.931176E+02	7.040942E+03	1.712008E+04	1.927665E+02	4.626376E+02
.05940	6.649431E+03	1.985359E+02	6.638645E+03	1.578668E+04	1.981795E+02	4.758096E+02
.06020	6.256069E+03	2.035156E+02	6.245628E+03	1.448964E+04	2.031498E+02	4.879125E+02
.06100	5.433999E+03	2.080722E+02	5.423082E+03	1.322564E+04	2.076996E+02	4.990016E+02
.06180	5.491127E+03	2.122527E+02	5.479300E+03	1.199048E+04	2.118908E+02	5.091168E+02
.06260	5.492324E+03	2.160038E+02	5.480599E+03	1.079453E+04	2.156199E+02	5.183132E+02
.06340	5.065122E+03	2.192926E+02	5.054011E+03	2.203926E+03	2.189337E+02	5.266451E+02
.06420	3.670008E+03	2.221516E+02	3.663595E+03	8.344695E+03	2.218240E+02	5.341906E+02
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.06580	2.976708E+03	2.270176E+02	2.969795E+03	7.252883E+03	2.267406E+02	5.471176E+02
.06660	2.677835E+03	2.290776E+02	2.670881E+03	6.521715E+03	2.287962E+02	5.526425E+02
.06740	2.409966E+03	2.309101E+02	2.403993E+03	5.868945E+03	2.306284E+02	5.575958E+02
.06820	2.168972E+03	2.325410E+02	2.163734E+03	5.282787E+03	2.322591E+02	5.620108E+02
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.06980	1.757036E+03	2.370126E+02	1.752451E+03	4.216502E+03	2.366078E+02	5.695996E+02
.07060	1.581926E+03	2.383225E+02	1.446726E+03	3.779468E+03	2.379154E+02	5.727586E+02
.07140	1.389226E+03	2.394966E+02	1.386697E+03	3.389222E+03	2.390889E+02	5.756429E+02
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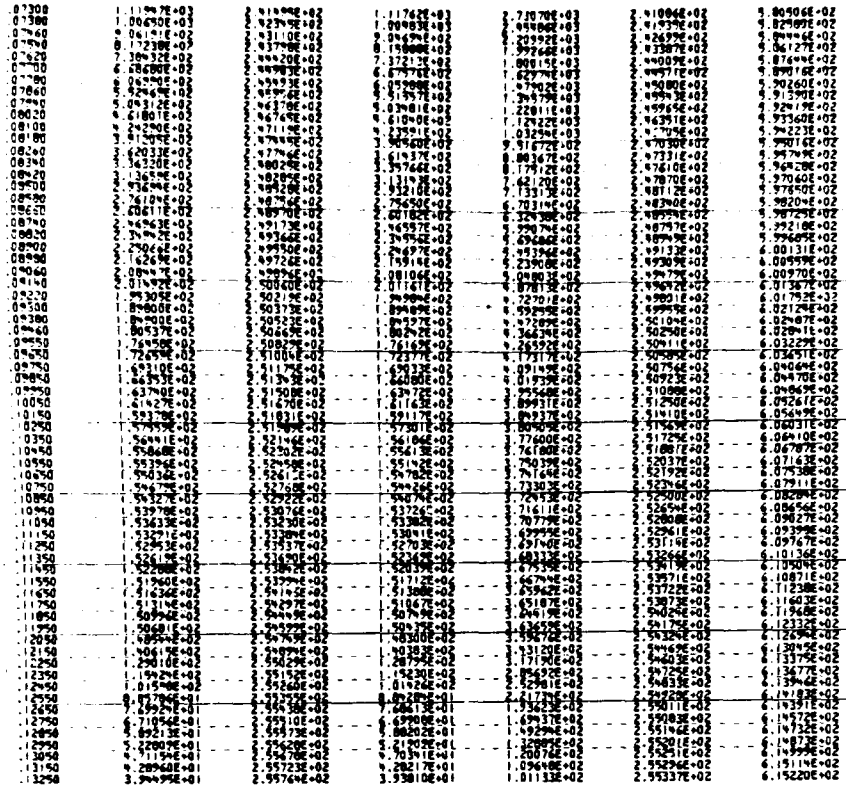

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18.34000	3.06793E-01	2.82479E+02	3.06180E-01	9.09494E-01	2.82319E+02	6.99439E+02
20.34000	2.67500E-01	2.83252E+02	2.66944E-01	7.88697E-01	2.82887E+02	6.96127E+02
22.34000	2.36809E-01	2.83795E+02	2.36337E-01	6.98189E-01	2.83291E+02	6.97819E+02
24.34000	2.12126E-01	2.84204E+02	2.11702E-01	6.25410E-01	2.83839E+02	6.98937E+02
26.34000	1.91807E-01	2.84607E+02	1.91429E-01	5.69499E-01	2.84242E+02	7.00128E+02
28.34000	1.74751E-01	2.84973E+02	1.74962E-01	5.15192E-01	2.84608E+02	7.01209E+02
30.34000	1.60204E-01	2.85308E+02	1.59884E-01	4.72294E-01	2.84942E+02	7.02196E+02
32.34000	1.47635E-01	2.85616E+02	1.47390E-01	4.35232E-01	2.85249E+02	7.03104E+02
34.34000	1.36659E-01	2.85900E+02	1.36388E-01	4.02853E-01	2.85533E+02	7.03942E+02
36.34000	1.26969E-01	2.86163E+02	1.26715E-01	3.74254E-01	2.85796E+02	7.04719E+02
38.34000	1.18572E-01	2.86409E+02	1.18335E-01	3.49508E-01	2.86041E+02	7.05443E+02
40.34000	1.10839E-01	2.86638E+02	1.10617E-01	3.26799E-01	2.86270E+02	7.06119E+02
42.34000	1.03807E-01	2.86852E+02	1.03600E-01	3.06259E-01	2.86484E+02	7.06752E+02
44.34000	9.75574E-02	2.87054E+02	9.73626E-02	2.87595E-01	2.86685E+02	7.07346E+02
46.34000	9.17810E-02	2.87243E+02	9.15970E-02	2.70567E-01	2.86874E+02	7.07904E+02
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72.34000	4.76121E-02	2.89671E+02	4.75170E-02	1.40405E-01	2.89305E+02	7.13163E+02
82.34000	3.70051E-02	2.89734E+02	3.69312E-02	1.09142E-01	2.89377E+02	7.14411E+02
92.34000	2.89201E-02	2.89766E+02	2.88623E-02	8.53096E-02	2.89406E+02	7.15383E+02
102.34000	2.27074E-02	2.89785E+02	2.26621E-02	6.69941E-02	2.89463E+02	7.16145E+02
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122.34000	1.42081E-02	2.89788E+02	1.41797E-02	4.19309E-02	2.89026E+02	7.17218E+02
132.34000	1.11335E-02	2.90513E+02	1.11310E-02	3.29514E-02	2.90154E+02	7.17599E+02
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152.34000	7.35030E-03	2.90697E+02	7.33561E-03	2.16994E-02	2.90338E+02	7.18139E+02
162.34000	5.97470E-03	2.90763E+02	5.96774E-03	1.76594E-02	2.90404E+02	7.18336E+02
172.34000	4.88950E-03	2.90811E+02	4.88071E-03	1.44621E-02	2.90458E+02	7.18497E+02
182.34000	4.04057E-03	2.90862E+02	4.03249E-03	1.19309E-02	2.90503E+02	7.18622E+02
192.34000	3.35945E-03	2.90899E+02	3.35075E-03	9.90768E-03	2.90540E+02	7.18738E+02
202.34000	2.80466E-03	2.90929E+02	2.79903E-03	8.28139E-03	2.90571E+02	7.18829E+02
212.34000	2.35872E-03	2.90955E+02	2.35400E-03	6.96462E-03	2.90596E+02	7.18905E+02
222.34000	1.99414E-03	2.90977E+02	1.99115E-03	5.89100E-03	2.90618E+02	7.18969E+02
232.34000	1.69659E-03	2.90996E+02	1.69320E-03	5.00990E-03	2.90637E+02	7.19026E+02
242.34000	1.44974E-03	2.91011E+02	1.44684E-03	4.28044E-03	2.90652E+02	7.19070E+02

TIME	CORE FRACTION	TEST FRACTION	TOTAL FRACTION
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.00004	3.512966E-08	3.362977E-08	3.521115E-08
.00014	1.772618E-07	1.709274E-07	1.749324E-07
.00024	3.299408E-07	3.122977E-07	3.300078E-07
.00034	4.872177E-07	4.681812E-07	4.873697E-07
.00044	6.513966E-07	6.343208E-07	6.515446E-07
.00054	8.229262E-07	7.993132E-07	8.226774E-07
.00064	1.000460E-06	9.929779E-07	1.000090E-06
.00074	1.186028E-06	1.116822E-06	1.186437E-06
.00084	1.378894E-06	1.290326E-06	1.377254E-06
.00094	1.574208E-06	1.486682E-06	1.574674E-06
.00104	1.807435E-06	1.781622E-06	1.807864E-06
.00114	2.342282E-06	2.206298E-06	2.343411E-06
.00124	2.829942E-06	2.660895E-06	2.825950E-06
.00134	3.376183E-06	3.198822E-06	3.374298E-06
.00144	3.895278E-06	3.671557E-06	3.895412E-06
.00210	4.806736E-06	4.230621E-06	4.687168E-06
.00230	5.117825E-06	4.827966E-06	5.118824E-06
.00260	5.790226E-06	5.463776E-06	5.791629E-06
.00270	6.505790E-06	6.191112E-06	6.507933E-06
.00280	7.266019E-06	6.861377E-06	7.267977E-06
.00310	8.073229E-06	7.646629E-06	8.079933E-06
.00330	8.943116E-06	8.437801E-06	8.931111E-06
.00350	9.836236E-06	9.297886E-06	9.838226E-06
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.00430	1.401766E-05	1.326666E-05	1.402046E-05
.00450	1.521338E-05	1.440232E-05	1.521649E-05
.00470	1.647456E-05	1.560058E-05	1.647726E-05
.00490	1.780388E-05	1.686342E-05	1.780762E-05
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.00875	6.285467E-05	5.973159E-05	6.283896E-05
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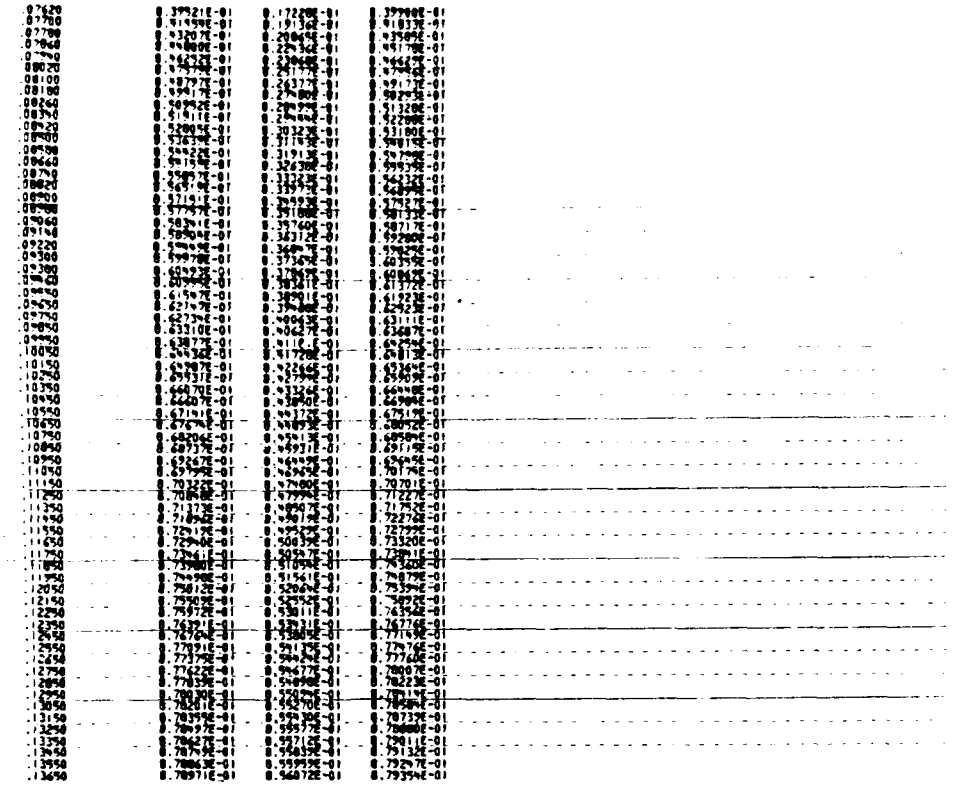
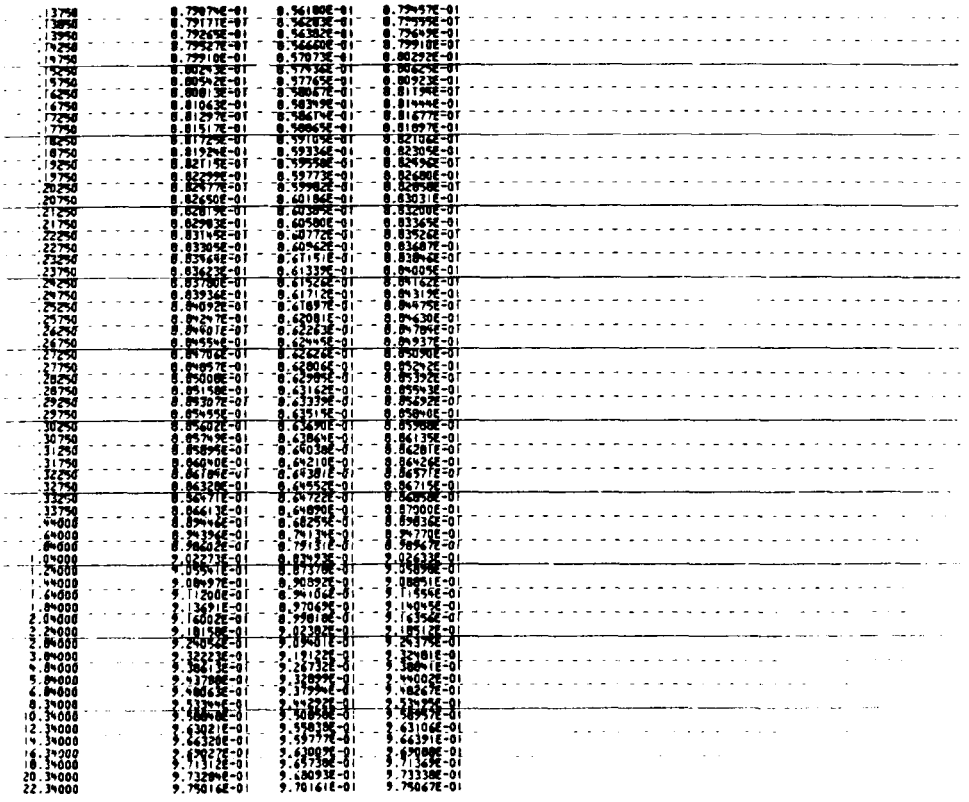
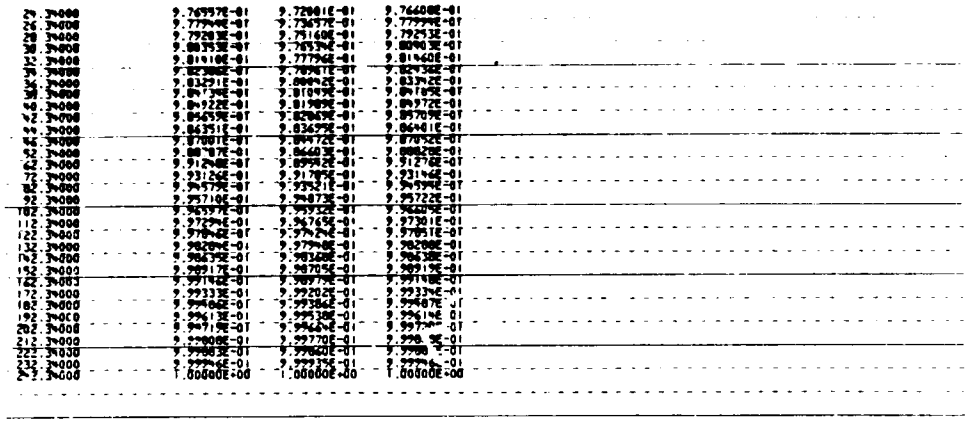
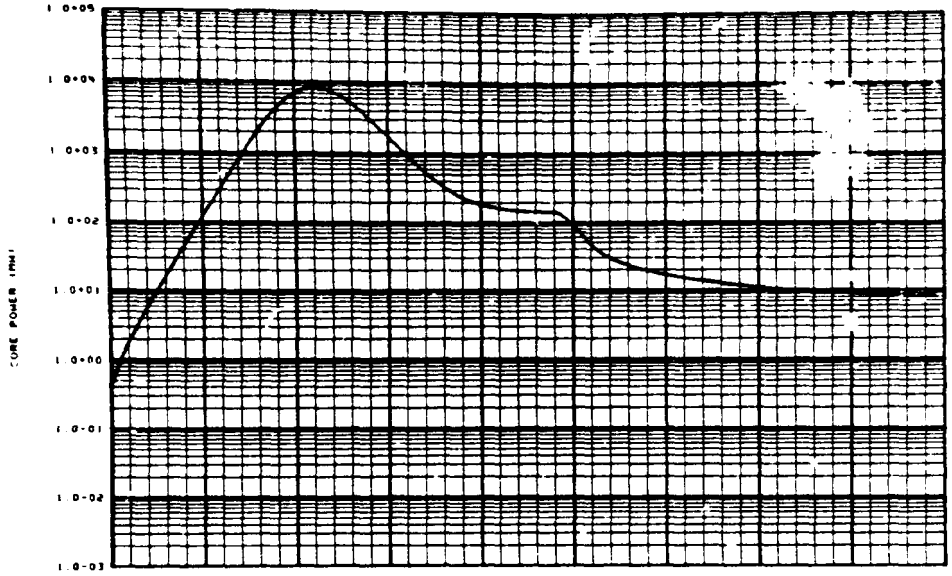
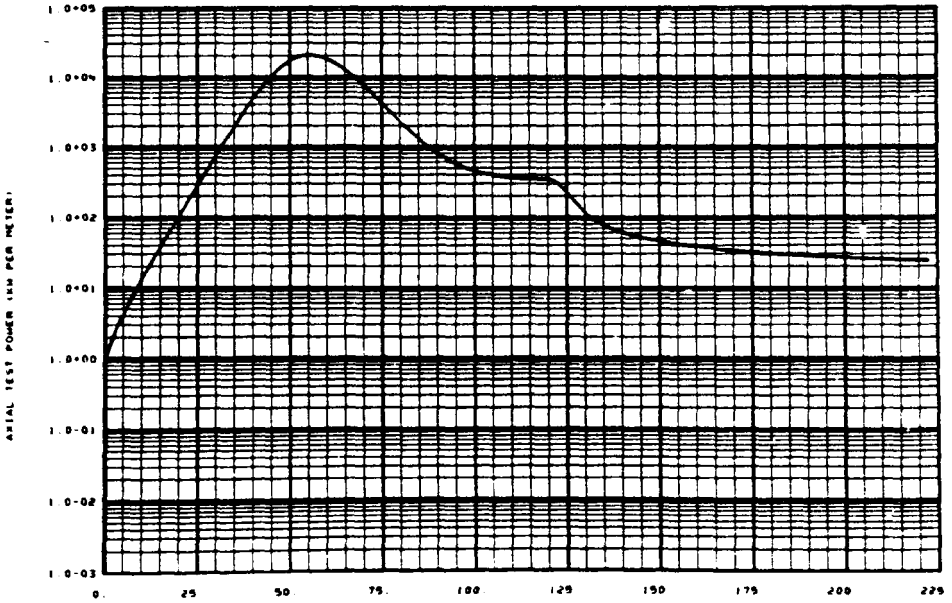








RIA ST-3 CORE POWER



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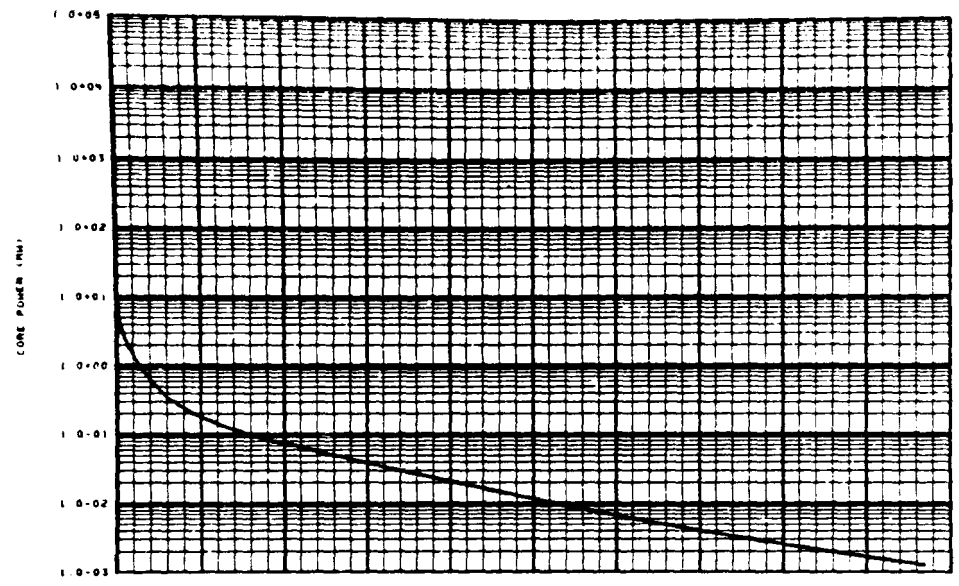

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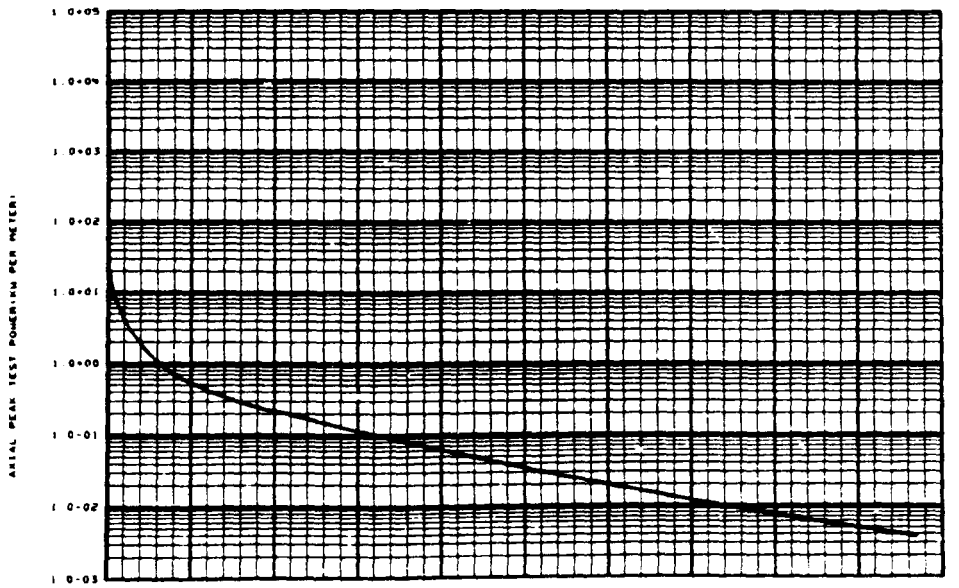

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YY COARSE TWIGL 5.2 MS BURST

TIME SEC	TOTAL POWER MW	TOTAL ENERGY MW SEC	CORE POWER MW	TEST POWER KWPR PEAK	CORE ENERGY MW SEC	TEST ENERGY KWSPR PEAK
0.00000	9.00000E-01	0.	3.99392E-01	9.56997E-01	0.	0.
.00005	9.09347E-01	1.92337E-05	9.08952E-01	9.66619E-01	1.02173E-05	2.41654E-05
.00010	9.27312E-01	5.20866E-05	9.26636E-01	9.97052E-01	5.19737E-05	7.22397E-05
.00025	9.45655E-01	9.67031E-05	9.44753E-01	1.03429E+00	9.59132E-05	2.24394E-04
.00035	9.63904E-01	1.41149E-04	9.63179E-01	1.10780E+00	1.40949E-04	3.29807E-04
.00045	9.82686E-01	1.88936E-04	9.81927E-01	1.12163E+00	1.88205E-04	4.39790E-04
.00055	9.01813E-01	2.37719E-04	9.01022E-01	1.16450E+00	2.37352E-04	5.54797E-04
.00065	9.21285E-01	2.88872E-04	9.20466E-01	1.21238E+00	2.88427E-04	6.73141E-04
.00075	9.41122E-01	3.41990E-04	9.40270E-01	1.25919E+00	3.41463E-04	7.96720E-04
.00085	5.61321E-01	3.91110E-04	5.60436E-01	1.30488E+00	3.96499E-04	9.25023E-04
.00096	5.81088E-01	4.59426E-04	4.80971E-01	1.35946E+00	4.53569E-04	1.05981E-03
.00110	6.43741E-01	5.43926E-04	6.42773E-01	1.43030E+00	5.43100E-04	1.26707E-03
.00130	6.57609E-01	6.71050E-04	6.56659E-01	1.53391E+00	6.70043E-04	1.56349E-03
.00150	7.03295E-01	8.07126E-04	7.02103E-01	1.69159E+00	8.05927E-04	1.88109E-03
.00170	7.50603E-01	9.52496E-04	7.49413E-01	1.79329E+00	9.51087E-04	2.22052E-03
.00190	7.99579E-01	1.10750E-03	7.98612E-01	1.86916E+00	1.10587E-03	2.58276E-03
.00210	8.50594E-01	1.27251E-03	8.49526E-01	1.98961E+00	1.27046E-03	2.96961E-03
.00230	9.03410E-01	1.44788E-03	9.01966E-01	2.11416E+00	1.44976E-03	3.37897E-03
.00250	9.58222E-01	1.63402E-03	9.56702E-01	2.23460E+00	1.63163E-03	3.81475E-03
.00270	1.01508E+00	1.83133E-03	1.01367E+00	2.37786E+00	1.82964E-03	4.27680E-03
.00290	1.07407E+00	2.04021E-03	1.07234E+00	2.51779E+00	2.03723E-03	4.76640E-03
.00310	1.13527E+00	2.26112E-03	1.13347E+00	2.66173E+00	2.25781E-03	5.28429E-03
.00330	1.19872E+00	2.49449E-03	1.19686E+00	2.81176E+00	2.49049E-03	5.83174E-03
.00350	1.26446E+00	2.74080E-03	1.26263E+00	2.96727E+00	2.73679E-03	6.40953E-03
.00370	1.33298E+00	3.00053E-03	1.33086E+00	3.12868E+00	2.99614E-03	7.01913E-03
.00390	1.40385E+00	3.27419E-03	1.40166E+00	3.29614E+00	3.26939E-03	7.66161E-03
.00410	1.47744E+00	3.56229E-03	1.47511E+00	3.46988E+00	3.55707E-03	8.33821E-03
.00430	1.55378E+00	3.86538E-03	1.55131E+00	3.65013E+00	3.85971E-03	9.05021E-03
.00450	1.63294E+00	4.18401E-03	1.63037E+00	3.83117E+00	4.17788E-03	9.79895E-03
.00470	1.71512E+00	4.51879E-03	1.71239E+00	4.03117E+00	4.51215E-03	1.05858E-02
.00490	1.80036E+00	4.87029E-03	1.79749E+00	4.23248E+00	4.86314E-03	1.14121E-02
.00525	1.9609 E+00	5.529 .2E-03	1.95782E+00	4.61091E+00	5.52032E-03	1.29597E-02
.00575	2.21878E+00	6.47253E-03	2.21525E+00	5.21781E+00	6.56359E-03	1.54169E-02
.00625	2.50113E+00	7.75165E-03	2.49714E+00	5.88039E+00	7.74169E-03	1.81924E-02
.00675	2.81219E+00	9.67906E-03	2.80771E+00	6.61865E+00	9.66799E-03	2.13182E-02
.00725	3.15489E+00	1.05699E-02	3.14986E+00	7.42765E+00	1.05573E-02	2.48299E-02
.00775	3.532 4E+00	1.22405E-02	3.52681E+00	8.31893E+00	1.22265E-02	2.87264E-02
.00825	3.94805E+00	1.41034E-02	3.94210E+00	9.30087E+00	1.40937E-02	3.31714E-02
.00875	4.40667E+00	1.61762E-02	4.39964E+00	1.03827E+01	1.61791E-02	3.80923E-02
.00925	4.91155E+00	1.85290E-02	4.90371E+00	1.15745E+01	1.85090E-02	4.35816E-02
.00975	5.46778E+00	2.11180E-02	5.45969E+00	1.28867E+01	2.10966E-02	4.96971E-02
.01025	6.08059E+00	2.40032E-02	6.07068E+00	1.43173E+01	2.39781E-02	5.65026E-02
.01075	6.75572E+00	2.72102E-02	6.74494E+00	1.59200E+01	2.71821E-02	6.40682E-02
.01125	7.49952E+00	3.07718E-02	7.48754E+00	1.76839E+01	3.07902E-02	7.24711E-02
.01175	8.31894E+00	3.47239E-02	8.30562E+00	1.96183E+01	3.46889E-02	8.17967E-02
.01225	9.22171E+00	3.91064E-02	9.20690E+00	2.17479E+01	3.90667E-02	9.21386E-02
.01275	1.02163E+01	4.39429E-02	1.01999E+01	2.40973E+01	4.39184E-02	1.03600E-01
.01325	1.13119E+01	4.93216E-02	1.12938E+01	2.66833E+01	4.92910E-02	1.16296E-01
.01375	1.25189E+01	5.52946E-02	1.24969E+01	2.95132E+01	5.52600E-02	1.30350E-01
.01425	1.38486E+01	6.18815E-02	1.38265E+01	3.26722E+01	6.18214E-02	1.45901E-01
.01475	1.53134E+01	6.91694E-02	1.52894E+01	3.61302E+01	6.91002E-02	1.63102E-01
.01550	1.79609E+01	7.98086E-02	1.79325E+01	4.12001E+01	7.97347E-02	1.88023E-01
.01620	2.05867E+01	9.50069E-02	2.05538E+01	4.85726E+01	9.49293E-02	2.24143E-01
.01700	2.42295E+01	1.12904E-01	2.41898E+01	5.71701E+01	1.12827E-01	2.66494E-01
.01780	2.84966E+01	1.33740E-01	2.84511E+01	6.72456E+01	1.33683E-01	3.16206E-01
.01860	3.34981E+01	1.58719E-01	3.34446E+01	7.90512E+01	1.58641E-01	3.74725E-01
.01940	3.93584E+01	1.87815E-01	3.92995E+01	9.28849E+01	1.87737E-01	4.43499E-01
.02020	4.62291E+01	2.21994E-01	4.61502E+01	1.09092E+02	2.21916E-01	5.24290E-01
.02100	5.42663E+01	2.62122E-01	5.41799E+01	1.28077E+02	2.62098E-01	6.19158E-01
.02180	6.36896E+01	3.09233E-01	6.35838E+01	1.50313E+02	3.09015E-01	7.30515E-01
.02260	7.47176E+01	3.64506E-01	7.45953E+01	1.76350E+02	3.64429E-01	8.61179E-01
.02340	8.76259E+01	4.293 1E-01	8.74858E+01	2.06830E+02	4.29257E-01	1.01449E+00
.02420	1.02734E+02	5.05367E-01	1.02572E+02	2.42509E+02	5.05280E-01	1.19418E+00
.02500	1.20619E+02	5.94488E-01	1.20221E+02	2.84420E+02	5.94337E-01	1.40488E+00
.02580	1.41887E+02	6.98927E-01	1.41484E+02	3.33850E+02	6.98830E-01	1.65188E+00
.02660	1.66925E+02	8.21279E-01	1.66408E+02	3.92170E+02	8.21170E-01	1.94106E+00
.02740	1.93884E+02	9.64550E-01	1.93317E+02	4.56779E+02	9.64435E-01	2.27987E+00
.02820	2.26446E+02	1.13227E+00	2.26089E+02	5.33613E+02	1.13214E+00	2.67637E+00
.02900	2.64982E+02	1.32851E+00	2.64478E+02	6.25439E+02	1.32836E+00	3.14039E+00
.02980	3.09730E+02	1.55802E+00	3.09234E+02	7.31312E+02	1.55785E+00	3.68309E+00
.03060	3.61931E+02	1.82429E+00	3.61392E+02	8.54621E+02	1.82408E+00	4.31744E+00
.03140	4.22699E+02	2.13966E+00	4.21972E+02	9.98063E+02	2.13941E+00	5.05053E+00
.03220	4.93773E+02	2.50597E+00	4.92385E+02	1.16470E+03	2.50516E+00	5.92369E+00
.03300	5.74960E+02	2.93212E+00	5.74040E+02	1.35790E+03	2.93173E+00	6.93271E+00
.03380	6.69629E+02	3.42927E+00	6.68658E+02	1.58175E+03	3.42876E+00	8.10861E+00
.03460	7.78974E+02	4.00793E+00	7.77728E+02	1.84020E+03	4.00728E+00	9.47742E+00
.03540	9.09499E+02	4.68062E+00	9.08350E+02	2.13821E+03	4.67977E+00	1.10668E+01
.03620	1.06968E+03	5.46198E+00	1.06801E+03	2.48058E+03	5.46037E+00	1.29163E+01
.03700	1.21277E+03	6.36458E+00	1.21083E+03	2.86749E+03	6.36239E+00	1.50956E+01
.03780	1.39567E+03	7.40881E+00	1.39336E+03	3.30078E+03	7.40561E+00	1.75229E+01
.03860	1.60254E+03	8.60613E+00	1.59997E+03	3.79099E+03	8.60257E+00	2.03579E+01
.03940	1.83538E+03	9.97996E+00	1.83244E+03	4.34304E+03	9.97594E+00	2.36132E+01
.04020	2.09599E+03	1.15511E+01	2.09263E+03	4.96130E+03	1.15496E+01	2.73349E+01
.04100	2.38579E+03	1.33423E+01	2.38197E+03	5.64935E+03	1.33358E+01	3.15772E+01
.04180	2.70579E+03	1.53770E+01	2.70114E+03	6.40960E+03	1.53692E+01	3.64027E+01
.04260	3.05600E+03	1.76806E+01	3.05117E+03	7.24283E+03	1.76702E+01	4.18637E+01
.04340	3.43612E+03	2.02760E+01	3.43060E+03	8.16470E+03	2.02629E+01	4.80199E+01
.04420	3.84409E+03	2.31860E+01	3.83791E+03	9.12025E+03	2.31703E+01	5.49271E+01
.04500	4.27689E+03	2.64340E+01	4.27001E+03	1.01539E+04	2.64139E+01	6.26268E+01
.04580	4.72997E+03	3.00359E+01	4.72236E+03	1.12367E+04	3.00104E+01	7.11927E+01
.04660	5.19726E+03	3.60063E+01	5.18889E+03	1.23560E+04	3.39749E+01	8.06298E+01
.04740	5.68069E+03	3.83766E+01	5.67253E+03	1.34963E+04	3.83613E+01	9.09977E+01
.04820	6.17963E+03	4.30932E+01	6.08711E+03	1.45227E+04	4.29970E+01	1.02136E+02
.04900	6.53237E+03	4.80750E+01	6.52182E+03	1.55735E+04	4.80406E+01	1.14175E+02
.04980	6.94618E+03	5.34082E+01	6.93395E+03	1.65720E+04	5.34229E+01	1.27033E+02
.05060	7.32542E+03	5.91983E+01	7.31357E+03	1.74960E+04	5.91219E+01	1.40661E+02
.05140	7.66439E+03	6.51962E+01	7.65108E+03	1.83223E+04	6.51077E+01	1.54909E+02
.05220	7.92781E+03	7.14252E+01	7.91495E+03	1.89773E+04	7.13311E+01	1.69707E+02
.05300	8.13864E+03	7.78604E+01	8.12584E+03	1.95204E+04	7.77952E+01	1.85300E+02
.05380	8.29175E+03	8.44339E+01	8.27728E+03	1.98895E+04	8.43114E+01	2.01054E+02
.05460	8.39356E+03	9.11058E+01	8.37999E+03	2.00644E+04	9.09583E+01	2.17036E+02
.05540	8.36122E+03	9.77925E+01	8.34764E+03	2.00956E+04	9.76433E+01	2.33078E+02
.05620	8.34952E+03	1.04478E+02	8.33593E+03	2.00745E+04	1.04307E+02	2.49167E+02
.05700	8.28003E+03	1.11138E+02	8.26652E+03	1.99231E+04	1.10976E+02	2.65170E+02
.05780	8.13061E+03	1.17705E+02	8.11733E+03	1.95918E+04	1.17520E+02	2.80980E+02
.05860	7.93876E+03	1.24132E+02	7.92619E+03	1.91267E+04	1.23915E+02	2.96467E+02
.05940	7.68666E+03	1.30381E+02	7.67409E+03	1.85153E+04	1.30152E+02	3.11539E+02
.06020	7.40512E+03	1.36419E+02	7.39301E+03	1.78079E+04	1.36179E+02	3.26116E+02
.06100	7.08022E+03	1.42217E+02	7.06862E+03	1.71205E+04	1.41964E+02	3.40119E+02
.06180	6.72003E+03	1.47738E+02	6.70924E+03	1.62618E+04	1.47475E+02	3.53472E+02
.06260	6.34612E+03	1.52965E+02	6.33577E+03	1.53422E+04	1.52692E+02	3.66122E+02
.06340	5.95946E+03	1.57886E+02	5.94908E+03	1.44048E+04	1.57599E+02	3.78013E+02
.06420	5.57350E+03	1.62495E+02	5.56351E+03	1.35125E+04	1.62211E+02	3.89095E+02
.06500	5.18947E+03	1.66809E+02	5.18139E+03	1.25809E+04	1.66509E+02	3.99265E+02
.06580	4.81673E+03	1.70860E+02	4.80868E+03	1.16854E+04	1.70540E+02	4.09375E+02
.06660	4.45114E+03	1.74511E+02	4.44408E+03	1.08086E+04	1.74204E+02	4.18375E+02
.06740	4.10281E+03	1.77932E+02	4.09404E+03	9.96619E+03	1.77621E+02	4.26683E+02
.06820	3.77110E+03	1.81081E+02	3.76599E+03	7.16378E+03	1.80764E+02	4.34394E+02
.06900	3.45776E+03	1.83971E+02	3.45205E+03	8.40459E+03	1.83652E+02	4.41362E+02
.06980	3.16365E+03	1.86613E+02	3.15894E+03	7.67250E+03	1.86294E+02	4.47801E+02
.07060	2.88919E+03	1.89035E+02	2.88453E+03	7.02632E+03	1.88715E+02	4.53689E+02
.07140	2.63439E+03	1.91248E+02	2.63000E+03	6.40890E+03	1.90919E+02	4.59063E+02
.07220	2.39878E+03	1.93260E+02	2.39402E+03	5.83694E+03	1.92929E+02	4.63961E+02

.07300	2.18191E+03	1.95091E+02	2.17831E+03	5.30962E+03	1.94758E+02	4.69417E+02
.07380	1.98297E+03	1.96796E+02	1.97970E+03	4.82611E+03	1.96421E+02	4.72473E+02
.07460	1.80105E+03	1.98269E+02	1.79008E+03	4.38380E+03	1.97932E+02	4.75157E+02
.07540	1.63517E+03	1.99643E+02	1.63248E+03	3.98033E+03	1.99305E+02	4.79507E+02
.07620	1.48430E+03	2.00890E+02	1.48186E+03	3.61326E+03	2.00550E+02	4.82541E+02
.07700	1.34780E+03	2.02022E+02	1.34518E+03	3.28006E+03	2.01681E+02	4.85298E+02
.07780	1.22342E+03	2.03050E+02	1.22140E+03	2.97823E+03	2.02708E+02	4.87901E+02
.07860	1.11139E+03	2.03983E+02	1.10991E+03	2.70532E+03	2.03640E+02	4.90075E+02
.07940	1.01019E+03	2.04831E+02	1.00853E+03	2.45896E+03	2.04487E+02	4.92140E+02
.08020	9.19036E+02	2.05602E+02	9.17521E+02	2.23690E+03	2.05258E+02	4.94019E+02
.08100	8.36991E+02	2.06304E+02	8.35611E+02	2.03700E+03	2.05959E+02	4.95729E+02
.08180	7.63232E+02	2.06944E+02	7.61974E+02	1.85727E+03	2.06598E+02	4.97284E+02
.08260	6.96941E+02	2.07528E+02	6.95842E+02	1.69583E+03	2.07181E+02	4.98707E+02
.08340	6.37556E+02	2.08061E+02	6.36506E+02	1.55096E+03	2.07714E+02	5.00006E+02
.08420	5.84272E+02	2.08550E+02	5.83310E+02	1.42107E+03	2.08202E+02	5.01195E+02
.08500	5.36538E+02	2.08998E+02	5.35654E+02	1.30470E+03	2.08650E+02	5.02289E+02
.08580	4.93803E+02	2.09410E+02	4.92990E+02	1.20050E+03	2.09061E+02	5.03287E+02
.08660	4.55565E+02	2.09789E+02	4.54815E+02	1.10727E+03	2.09440E+02	5.04210E+02
.08740	4.21370E+02	2.10140E+02	4.20677E+02	1.02388E+03	2.09790E+02	5.05063E+02
.08820	3.90804E+02	2.10464E+02	3.90161E+02	9.49342E+02	2.10115E+02	5.05852E+02
.08900	3.63492E+02	2.10766E+02	3.62894E+02	8.82734E+02	2.10416E+02	5.06585E+02
.08980	3.39096E+02	2.11047E+02	3.38538E+02	8.23234E+02	2.10696E+02	5.07267E+02
.09060	3.17311E+02	2.11309E+02	3.16790E+02	7.70104E+02	2.10959E+02	5.07904E+02
.09140	2.97864E+02	2.11555E+02	2.97374E+02	7.22670E+02	2.11204E+02	5.08502E+02
.09220	2.80506E+02	2.11787E+02	2.80045E+02	6.80331E+02	2.11435E+02	5.09063E+02
.09300	2.65016E+02	2.12005E+02	2.64580E+02	6.42547E+02	2.11653E+02	5.09592E+02
.09380	2.51194E+02	2.12211E+02	2.50781E+02	6.08833E+02	2.11859E+02	5.10093E+02
.09460	2.38862E+02	2.12407E+02	2.38470E+02	5.78752E+02	2.12055E+02	5.10568E+02
.09550	2.27550E+02	2.12617E+02	2.27177E+02	5.50967E+02	2.12264E+02	5.11076E+02
.09650	2.16544E+02	2.12839E+02	2.16189E+02	5.24130E+02	2.12486E+02	5.11613E+02
.09750	2.06068E+02	2.13050E+02	2.06529E+02	5.00550E+02	2.12698E+02	5.12126E+02
.09850	1.98361E+02	2.13253E+02	1.98034E+02	4.79819E+02	2.12900E+02	5.12616E+02
.09950	1.90879E+02	2.13447E+02	1.90567E+02	4.61588E+02	2.13094E+02	5.13087E+02
.10050	1.84588E+02	2.13635E+02	1.84284E+02	4.46169E+02	2.13282E+02	5.13541E+02
.10150	1.79257E+02	2.13817E+02	1.78963E+02	4.33183E+02	2.13463E+02	5.13980E+02
.10250	1.74506E+02	2.13994E+02	1.74220E+02	4.21618E+02	2.13640E+02	5.14408E+02
.10350	1.70271E+02	2.14166E+02	1.69992E+02	4.11309E+02	2.13812E+02	5.14824E+02
.10450	1.66493E+02	2.14335E+02	1.66221E+02	4.02114E+02	2.13980E+02	5.15231E+02
.10550	1.63122E+02	2.14499E+02	1.62855E+02	3.93908E+02	2.14145E+02	5.15629E+02
.10650	1.60111E+02	2.14661E+02	1.59849E+02	3.86579E+02	2.14306E+02	5.16019E+02
.10750	1.57419E+02	2.14820E+02	1.57162E+02	3.80028E+02	2.14464E+02	5.16402E+02
.10850	1.55011E+02	2.14976E+02	1.54757E+02	3.74168E+02	2.14620E+02	5.16779E+02
.10950	1.52853E+02	2.15130E+02	1.52603E+02	3.68919E+02	2.14774E+02	5.17151E+02
.11050	1.50919E+02	2.15282E+02	1.50672E+02	3.64213E+02	2.14926E+02	5.17519E+02
.11150	1.49182E+02	2.15432E+02	1.48938E+02	3.59987E+02	2.15075E+02	5.17880E+02
.11250	1.48104E+02	2.15580E+02	1.47862E+02	3.57190E+02	2.15224E+02	5.18238E+02
.11350	1.47546E+02	2.15726E+02	1.47305E+02	3.55814E+02	2.15371E+02	5.18595E+02
.11450	1.47003E+02	2.15875E+02	1.46763E+02	3.54503E+02	2.15518E+02	5.18950E+02
.11550	1.46556E+02	2.16022E+02	1.46317E+02	3.53423E+02	2.15665E+02	5.19304E+02
.11650	1.46214E+02	2.16168E+02	1.45975E+02	3.52592E+02	2.15811E+02	5.19657E+02
.11750	1.45875E+02	2.16314E+02	1.45637E+02	3.51775E+02	2.15957E+02	5.20009E+02
.11850	1.45539E+02	2.16460E+02	1.45302E+02	3.50966E+02	2.16102E+02	5.20360E+02
.11950	1.45207E+02	2.16606E+02	1.44970E+02	3.50164E+02	2.16248E+02	5.20711E+02
.12050	1.43083E+02	2.16750E+02	1.42849E+02	3.46187E+02	2.16391E+02	5.21059E+02
.12150	1.35318E+02	2.16890E+02	1.35094E+02	3.29950E+02	2.16530E+02	5.21397E+02
.12250	1.23938E+02	2.17019E+02	1.23731E+02	3.04519E+02	2.16660E+02	5.21714E+02
.12350	1.10556E+02	2.17137E+02	1.10371E+02	2.73498E+02	2.16777E+02	5.22004E+02
.12450	9.68019E+01	2.17240E+02	9.67186E+01	2.41143E+02	2.16880E+02	5.22261E+02
.12550	8.32603E+01	2.17331E+02	8.38100E+01	2.10122E+02	2.16971E+02	5.22486E+02
.12650	7.24355E+01	2.17409E+02	7.23121E+01	1.82144E+02	2.17049E+02	5.22683E+02
.12750	6.25964E+01	2.17476E+02	6.24093E+01	1.58051E+02	2.17115E+02	5.22853E+02
.12850	5.44653E+01	2.17535E+02	5.43718E+01	1.38008E+02	2.17175E+02	5.23001E+02
.12950	4.78752E+01	2.17586E+02	4.78120E+01	1.21740E+02	2.17226E+02	5.23131E+02
.13050	4.27475E+01	2.17631E+02	4.26737E+01	1.08933E+02	2.17271E+02	5.23246E+02
.13150	3.86736E+01	2.17672E+02	3.86067E+01	9.88339E+01	2.17312E+02	5.23350E+02
.13250	3.53732E+01	2.17709E+02	3.53118E+01	9.06561E+01	2.17349E+02	5.23445E+02

.13350	3.26833E+01	2.17743E+02	3.26264E+01	8.39990E+01	2.17383E+02	5.23532E+02
.13450	3.04665E+01	2.17774E+02	3.04133E+01	7.85268E+01	2.17414E+02	5.23613E+02
.13550	2.86134E+01	2.17804E+02	2.85633E+01	7.39648E+01	2.17444E+02	5.23689E+02
.13650	2.70402E+01	2.17832E+02	2.69927E+01	7.01033E+01	2.17471E+02	5.23761E+02
.13750	2.57245E+01	2.17858E+02	2.56792E+01	6.68768E+01	2.17498E+02	5.23830E+02
.13850	2.45784E+01	2.17883E+02	2.45347E+01	6.40945E+01	2.17523E+02	5.23895E+02
.13950	2.35406E+01	2.17907E+02	2.34989E+01	6.15740E+01	2.17547E+02	5.23958E+02
.14250	2.10955E+01	2.17974E+02	2.10577E+01	5.56659E+01	2.17614E+02	5.24134E+02
.14750	1.80763E+01	2.18072E+02	1.80436E+01	4.83540E+01	2.17711E+02	5.24394E+02
.15250	1.59998E+01	2.18156E+02	1.59705E+01	4.33172E+01	2.17796E+02	5.24623E+02
.15750	1.44174E+01	2.18232E+02	1.43907E+01	3.94664E+01	2.17872E+02	5.24830E+02
.16250	1.32092E+01	2.18301E+02	1.31795E+01	3.65039E+01	2.17941E+02	5.25020E+02
.16750	1.22799E+01	2.18365E+02	1.22567E+01	3.42436E+01	2.18005E+02	5.25197E+02
.17250	1.15089E+01	2.18424E+02	1.14870E+01	3.23512E+01	2.18064E+02	5.25364E+02
.17750	1.08758E+01	2.18480E+02	1.08549E+01	3.07907E+01	2.18120E+02	5.25521E+02
.18250	1.03491E+01	2.18533E+02	1.03291E+01	2.94869E+01	2.18173E+02	5.25672E+02
.18750	9.90539E+00	2.18584E+02	9.88616E+00	2.83823E+01	2.18224E+02	5.25817E+02
.19250	9.52795E+00	2.18633E+02	9.50937E+00	2.74375E+01	2.18272E+02	5.25956E+02
.19750	9.20442E+00	2.18679E+02	9.18639E+00	2.66221E+01	2.18319E+02	5.26091E+02
.20250	8.93421E+00	2.18725E+02	8.91664E+00	2.59406E+01	2.18364E+02	5.26223E+02
.20750	8.69343E+00	2.18769E+02	8.67628E+00	2.53251E+01	2.18408E+02	5.26351E+02
.21250	8.48249E+00	2.18812E+02	8.46571E+00	2.47789E+01	2.18451E+02	5.26476E+02
.21750	8.29931E+00	2.18854E+02	8.28205E+00	2.42992E+01	2.18493E+02	5.26599E+02
.22250	8.18278E+00	2.18895E+02	8.16659E+00	2.39836E+01	2.18534E+02	5.26720E+02
.22750	8.13738E+00	2.18936E+02	8.12123E+00	2.38515E+01	2.18575E+02	5.26839E+02
.23250	8.09132E+00	2.18976E+02	8.07525E+00	2.37168E+01	2.18615E+02	5.26958E+02
.23750	8.04556E+00	2.19017E+02	8.02959E+00	2.35829E+01	2.18655E+02	5.27076E+02
.24250	8.00027E+00	2.19057E+02	7.98438E+00	2.34502E+01	2.18695E+02	5.27194E+02
.24750	7.95545E+00	2.19097E+02	7.93965E+00	2.33190E+01	2.18735E+02	5.27311E+02
.25250	7.91110E+00	2.19136E+02	7.89539E+00	2.31892E+01	2.18775E+02	5.27427E+02
.25750	7.86722E+00	2.19176E+02	7.85160E+00	2.30607E+01	2.18814E+02	5.27543E+02
.26250	7.82381E+00	2.19215E+02	7.80827E+00	2.29336E+01	2.18853E+02	5.27658E+02
.26750	7.78085E+00	2.19254E+02	7.76540E+00	2.28079E+01	2.18892E+02	5.27772E+02
.27250	7.73834E+00	2.19293E+02	7.72297E+00	2.26835E+01	2.18931E+02	5.27886E+02
.27750	7.69627E+00	2.19332E+02	7.68099E+00	2.25603E+01	2.18969E+02	5.27999E+02
.28250	7.65464E+00	2.19370E+02	7.63945E+00	2.24384E+01	2.19008E+02	5.28112E+02
.28750	7.61345E+00	2.19408E+02	7.59833E+00	2.23170E+01	2.19046E+02	5.28223E+02
.29250	7.57268E+00	2.19446E+02	7.55765E+00	2.21984E+01	2.19084E+02	5.28335E+02
.29750	7.53234E+00	2.19484E+02	7.51738E+00	2.20803E+01	2.19121E+02	5.28445E+02
.30250	7.49240E+00	2.19522E+02	7.47753E+00	2.19634E+01	2.19159E+02	5.28556E+02
.30750	7.45288E+00	2.19559E+02	7.43809E+00	2.18477E+01	2.19196E+02	5.28665E+02
.31250	7.41377E+00	2.19596E+02	7.39909E+00	2.17332E+01	2.19233E+02	5.28774E+02
.31750	7.37505E+00	2.19633E+02	7.36041E+00	2.16199E+01	2.19270E+02	5.28882E+02
.32250	7.33673E+00	2.19670E+02	7.32217E+00	2.15077E+01	2.19307E+02	5.28990E+02
.32750	7.29880E+00	2.19707E+02	7.28431E+00	2.13966E+01	2.19343E+02	5.29097E+02
.33250	7.26126E+00	2.19743E+02	7.24684E+00	2.12867E+01	2.19380E+02	5.29204E+02
.33750	7.22409E+00	2.19779E+02	7.20975E+00	2.11779E+01	2.19416E+02	5.29310E+02
.44000	6.86003E+00	2.20501E+02	6.84641E+00	2.01087E+01	2.20136E+02	5.31426E+02
.64000	5.74024E+00	2.21757E+02	5.73682E+00	1.68945E+01	2.21395E+02	5.35123E+02
.84000	4.56175E+00	2.22825E+02	4.55189E+00	1.45523E+01	2.22463E+02	5.38263E+02
1.04000	4.38149E+00	2.23757E+02	4.37270E+00	1.28534E+01	2.23396E+02	5.41004E+02
1.24000	3.93596E+00	2.24588E+02	3.92714E+00	1.15661E+01	2.24222E+02	5.43444E+02
1.44000	3.57879E+00	2.25338E+02	3.57167E+00	1.05032E+01	2.24976E+02	5.45649E+02
1.64000	3.29210E+00	2.26025E+02	3.28556E+00	9.66376E+00	2.25661E+02	5.47665E+02
1.84000	3.04526E+00	2.26658E+02	3.03921E+00	8.94870E+00	2.26294E+02	5.49526E+02
2.04000	2.83384E+00	2.27246E+02	2.82823E+00	8.32137E+00	2.26881E+02	5.51252E+02
2.24000	2.65009E+00	2.27794E+02	2.64482E+00	7.78290E+00	2.27420E+02	5.52863E+02
2.84000	2.35220E+00	2.29204E+02	2.34752E+00	6.90944E+00	2.28926E+02	5.57270E+02
3.84000	1.80460E+00	2.31345E+02	1.80101E+00	5.30416E+00	2.31000E+02	5.63377E+02
4.84000	1.44531E+00	2.32962E+02	1.44243E+00	4.25029E+00	2.32622E+02	5.68154E+02
5.84000	1.18743E+00	2.34275E+02	1.18506E+00	3.49336E+00	2.33935E+02	5.72026E+02
6.84000	9.89792E-01	2.35360E+02	9.87819E-01	2.91306E+00	2.35022E+02	5.75229E+02
8.34000	8.04281E-01	2.36671E+02	8.02677E-01	2.36809E+00	2.36365E+02	5.79190E+02
10.34000	5.98331E-01	2.38082E+02	5.97137E-01	1.76261E+00	2.37764E+02	5.83321E+02
12.34000	4.65291E-01	2.39139E+02	4.64362E-01	1.37117E+00	2.38026E+02	5.86455E+02
14.34000	3.75954E-01	2.39976E+02	3.75204E-01	1.10814E+00	2.39666E+02	5.88934E+02

16.34000	3.19139E-01	2.94663E+02	3.13511E-01	9.26831E-01	2.94394E+02	5.99568E+02
18.34000	2.68784E-01	2.94294E+02	2.68847E-01	7.91789E-01	2.94033E+02	5.92886E+02
20.34000	2.39191E-01	2.91746E+02	2.33674E-01	6.90261E-01	2.91438E+02	5.99168E+02
22.34000	2.07226E-01	2.92780E+02	2.06812E-01	6.10911E-01	2.91878E+02	5.99569E+02
29.34000	1.85580E-01	2.92578E+02	1.85209E-01	5.47092E-01	2.92270E+02	5.96627E+02
26.34000	1.67754E-01	2.92931E+02	1.67419E-01	4.94935E-01	2.92623E+02	5.97869E+02
28.34000	1.52787E-01	2.93252E+02	1.52482E-01	4.50908E-01	2.92943E+02	5.98614E+02
30.34000	1.40022E-01	2.93544E+02	1.39776E-01	4.12777E-01	2.93235E+02	5.99477E+02
32.34000	1.28990E-01	2.93813E+02	1.28733E-01	3.80240E-01	2.93503E+02	6.00270E+02
34.34000	1.19353E-01	2.94061E+02	1.19114E-01	3.51839E-01	2.93751E+02	6.01002E+02
36.34000	1.10853E-01	2.94291E+02	1.10631E-01	3.26776E-01	2.93981E+02	6.01681E+02
38.34000	1.03293E-01	2.94505E+02	1.03087E-01	3.04497E-01	2.94195E+02	6.02312E+02
40.34000	9.65353E-02	2.94703E+02	9.63295E-02	2.84571E-01	2.94393E+02	6.02901E+02
42.34000	9.04290E-02	2.94892E+02	9.02484E-02	2.66477E-01	2.94582E+02	6.03452E+02
44.34000	8.50407E-02	2.95068E+02	8.48708E-02	2.50636E-01	2.94756E+02	6.03969E+02
46.34000	7.99778E-02	2.95233E+02	7.98187E-02	2.35772E-01	2.94921E+02	6.04456E+02
52.34000	7.10400E-02	2.95683E+02	7.08781E-02	2.09443E-01	2.95373E+02	6.05792E+02
62.34000	5.37306E-02	2.96302E+02	5.36233E-02	1.58936E-01	2.95992E+02	6.07631E+02
72.34000	4.13402E-02	2.96776E+02	4.12557E-02	1.21915E-01	2.96470E+02	6.09033E+02
82.34000	3.20393E-02	2.97147E+02	3.20267E-02	9.46530E-02	2.96838E+02	6.10116E+02
92.34000	2.50558E-02	2.97426E+02	2.50057E-02	7.39150E-02	2.97121E+02	6.10958E+02
102.34000	1.96598E-02	2.97649E+02	1.96205E-02	5.80064E-02	2.97344E+02	6.11618E+02
112.34000	1.55039E-02	2.97821E+02	1.54726E-02	4.57504E-02	2.97520E+02	6.12137E+02
122.34000	1.22922E-02	2.97962E+02	1.22680E-02	3.62801E-02	2.97659E+02	6.12547E+02
132.34000	9.80452E-03	2.98072E+02	9.78991E-03	2.89407E-02	2.97769E+02	6.12873E+02
142.34000	7.87000E-03	2.98168E+02	7.85427E-03	2.32330E-02	2.97857E+02	6.13134E+02
152.34000	6.35963E-03	2.98231E+02	6.34691E-03	1.87759E-02	2.97920E+02	6.13344E+02
162.34000	5.17470E-03	2.98289E+02	5.16436E-03	1.52786E-02	2.97968E+02	6.13516E+02
172.34000	4.24003E-03	2.98336E+02	4.23155E-03	1.25196E-02	2.98033E+02	6.13653E+02
182.34000	3.49832E-03	2.98374E+02	3.49133E-03	1.03279E-02	2.98071E+02	6.13767E+02
192.34000	2.90553E-03	2.98406E+02	2.90015E-03	8.58082E-03	2.98103E+02	6.13862E+02
202.34000	2.42997E-03	2.98433E+02	2.42572E-03	7.17423E-03	2.98130E+02	6.13943E+02
212.34000	2.04388E-03	2.98455E+02	2.03974E-03	6.03513E-03	2.98152E+02	6.14007E+02
222.34000	1.72923E-03	2.98479E+02	1.72577E-03	5.10608E-03	2.98177E+02	6.14063E+02
232.34000	1.47367E-03	2.98490E+02	1.47073E-03	4.35141E-03	2.98187E+02	6.14110E+02
242.34000	1.25952E-03	2.98504E+02	1.25700E-03	3.71897E-03	2.98201E+02	6.14150E+02

TIME	CORE FRACTION	TEST FRACTION	TOTAL FRACTION
0.00000	0.	0.	0.
.00005	9.11695E-08	3.97977E-08	1.11011E-08
.00015	2.09942E-07	1.99282E-07	2.09428E-07
.00025	3.09298E-07	3.61899E-07	3.09117E-07
.00035	4.67886E-07	5.37014E-07	4.68076E-07
.00045	7.53374E-07	7.16035E-07	7.18925E-07
.00055	9.54291E-07	9.02390E-07	9.54602E-07
.00065	1.16207E-06	1.03629E-06	1.16295E-06
.00075	1.37476E-06	1.29727E-06	1.37420E-06
.00085	1.59794E-06	1.50618E-06	1.57001E-06
.00095	1.82743E-06	1.72293E-06	1.82001E-06
.00110	2.18815E-06	2.26313E-06	2.18801E-06
.00130	2.69560E-06	2.59579E-06	2.70036E-06
.00150	3.29708E-06	3.06283E-06	3.29779E-06
.00170	3.83193E-06	3.61599E-06	3.81293E-06
.00190	4.45555E-06	4.20542E-06	4.45668E-06
.00210	5.11935E-06	4.83369E-06	5.12067E-06
.00230	5.85726E-06	5.50184E-06	5.82690E-06
.00250	6.57383E-06	6.21152E-06	6.57944E-06
.00270	7.36761E-06	6.96352E-06	7.36991E-06
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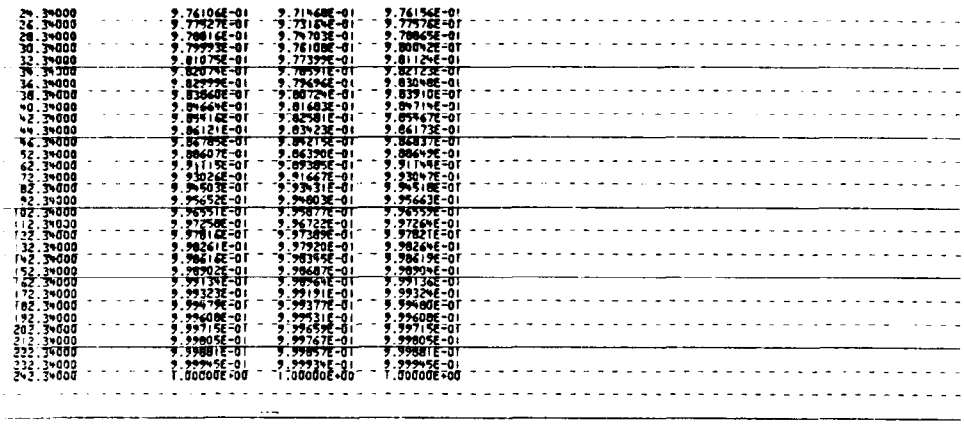

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222.3000	9.998818E-01	9.998857E-01	9.998818E-01
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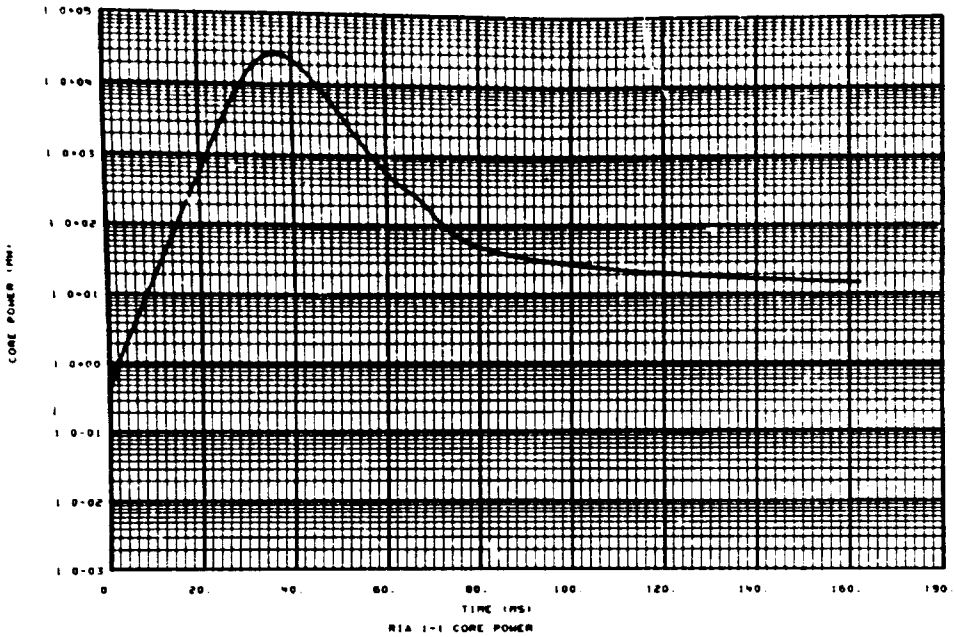
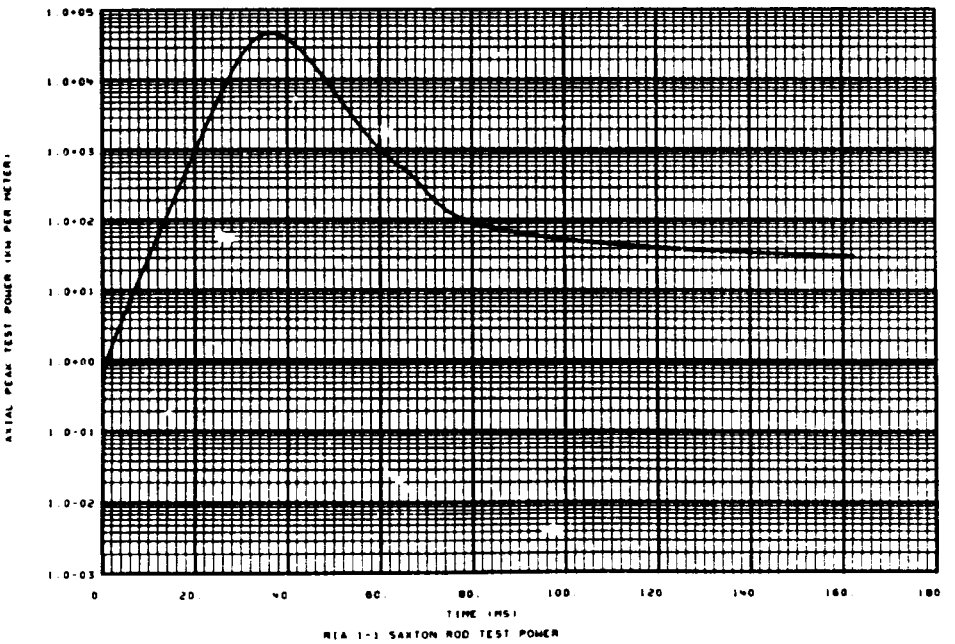
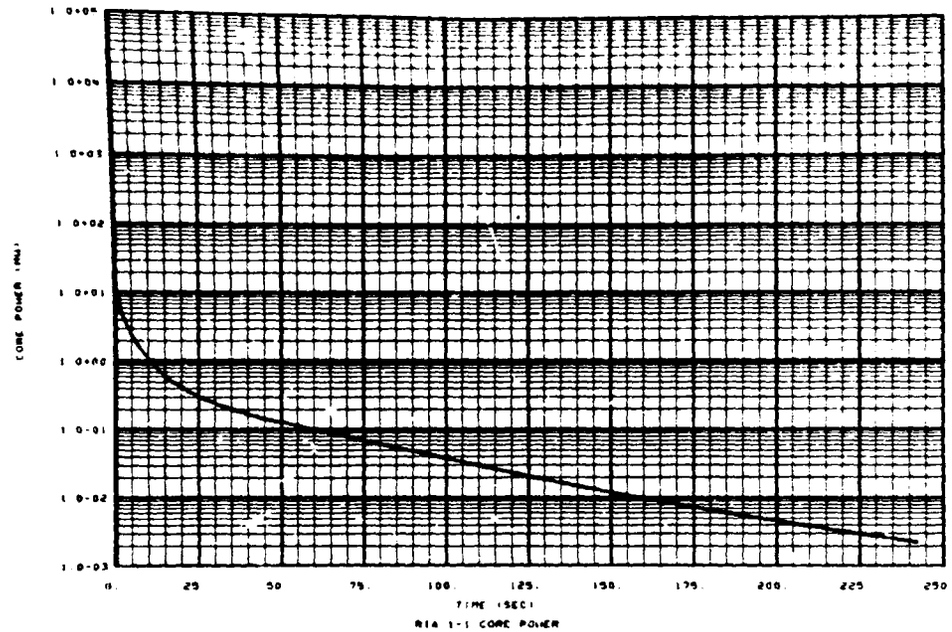
243.3000	1.000000E+00	1.000000E+00	1.000000E+00



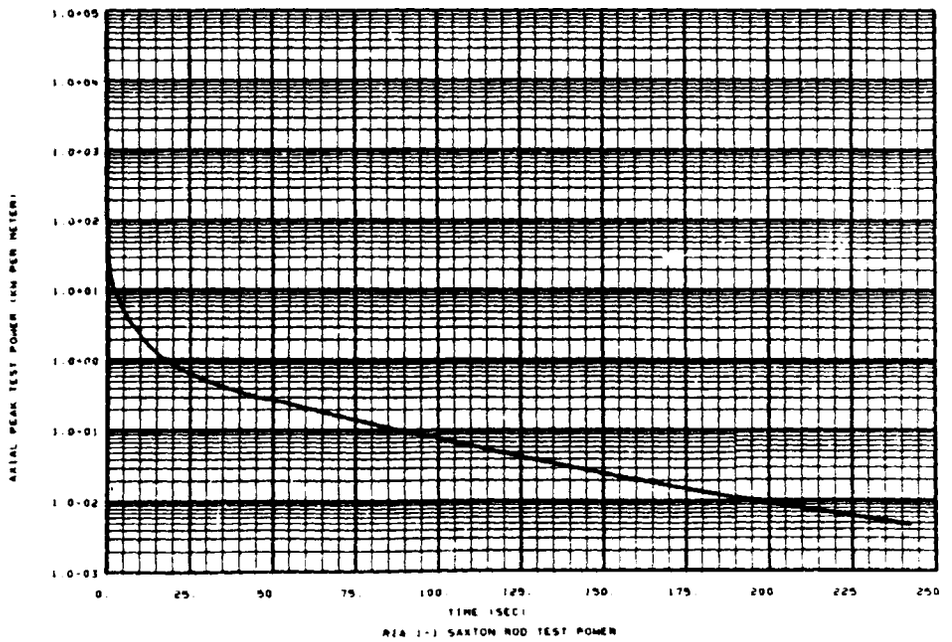
RIA 1-1 CORE POWER



RIA 1-1 SAXTON ROD TEST POWER



RIA 1-1 CORE POWER

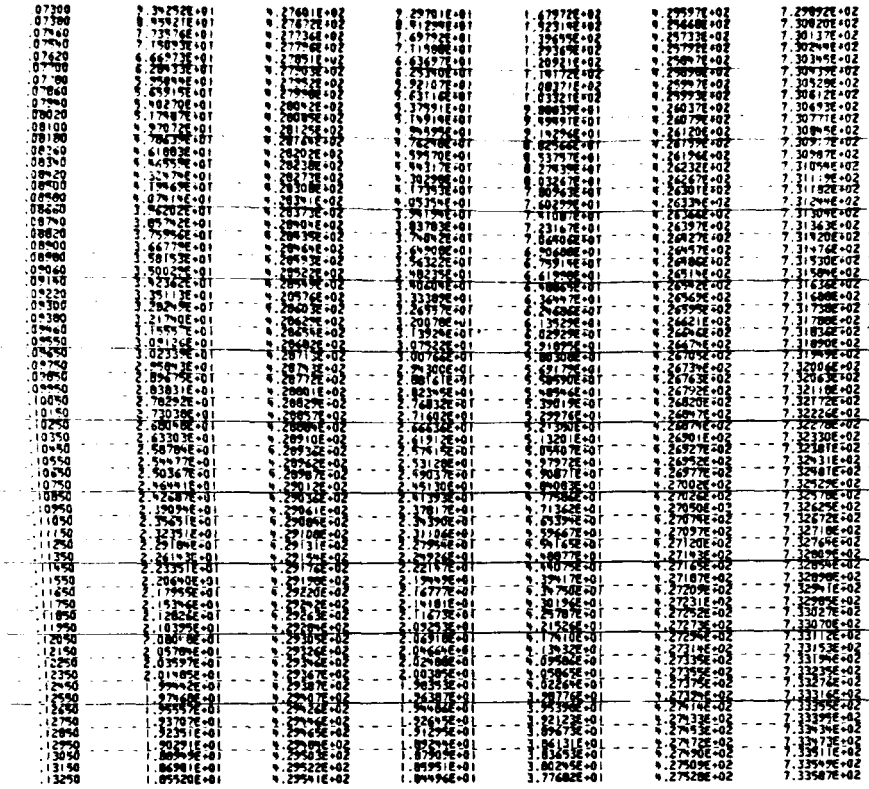


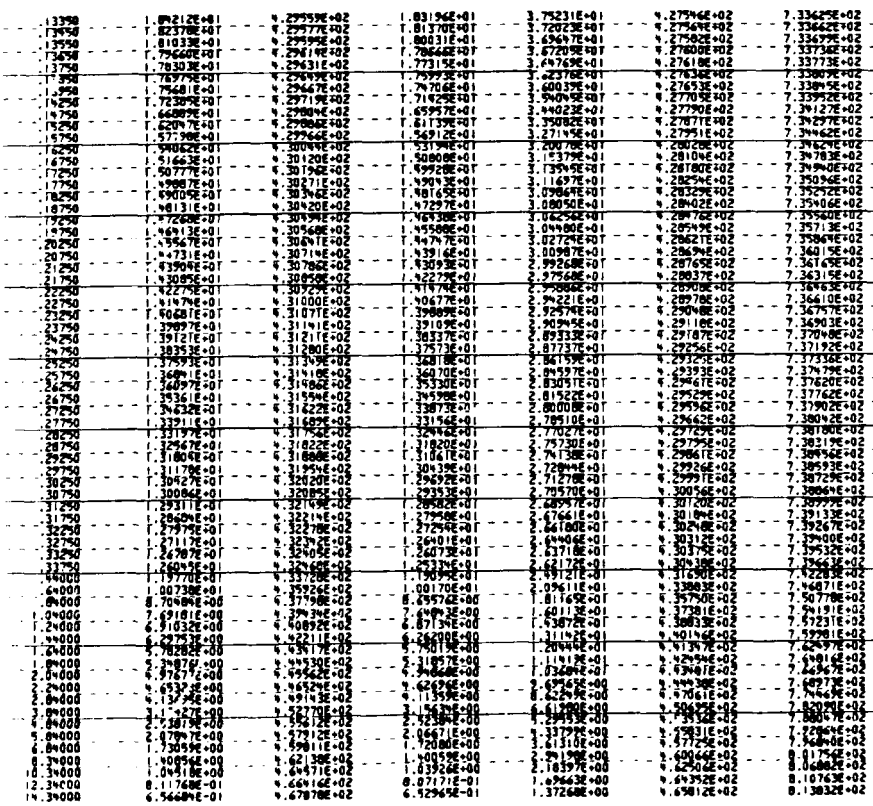
RIA 1-1 SAXTON ROD TEST POWER

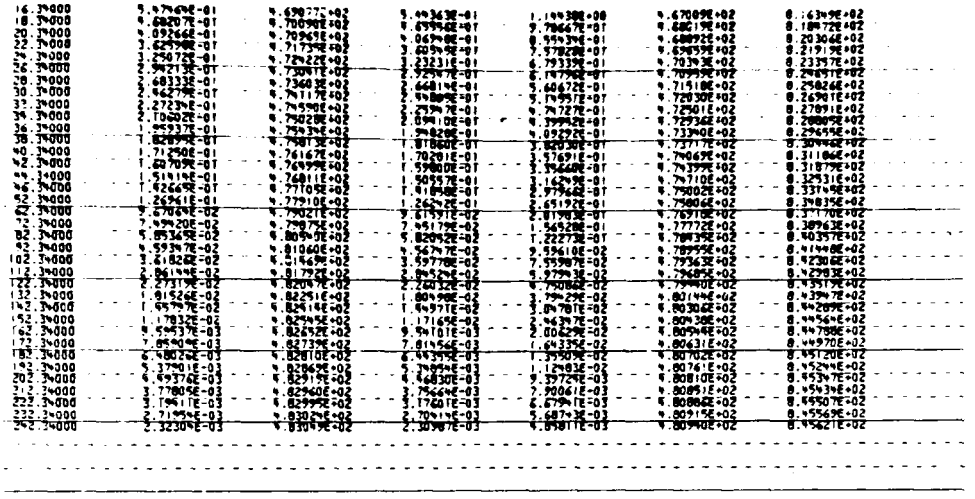
YY COARSE TWIGL 3.1 MS BURST

TIME SEC	TOTAL POWER MW	TOTAL ENERGY MW SEC	CORE POWER MW	TEST POWER KWTH PEAK	CORE ENERGY MW SEC	TEST ENERGY KWTH PEAK
0.00000	9.000008E-01	0.	3.981648E+01	6.779892E-01	0.	0.
.00005	9.128778E-01	4.032098E-05	4.109776E-01	6.873205E-01	1.027445E-05	1.718030E-05
.00010	9.331746E-01	8.228642E-05	4.295937E-01	7.184759E-01	2.259117E-05	3.779229E-05
.00015	9.613774E-01	1.278965E-04	4.593132E-01	7.683729E-01	3.732659E-05	6.240992E-05
.00020	9.861694E-01	1.751548E-04	4.840208E-01	7.997287E-01	4.944898E-05	8.268332E-05
.00025	9.411732E-01	2.248809E-04	5.034705E-01	8.350195E-01	5.991695E-05	1.002017E-04
.00030	9.780491E-01	2.773232E-04	5.397172E-01	8.709432E-01	7.194208E-05	1.203423E-04
.00035	9.855772E-01	3.326596E-04	5.467708E-01	9.233667E-01	8.391352E-05	1.403510E-04
.00040	9.933008E-01	3.906221E-04	5.542772E-01	9.193667E-01	9.588240E-05	1.603597E-04
.00045	6.322026E-01	4.213916E-04	5.986472E-01	9.697688E-01	9.990426E-05	1.670147E-04
.00050	6.620006E-01	4.513916E-04	6.179944E-01	1.017696E+00	1.059530E-04	1.772537E-04
.00055	6.850006E-01	4.804956E-04	6.397169E-01	1.067703E+00	1.132958E-04	1.893771E-04
.00060	7.003376E-01	5.086459E-04	6.597721E-01	1.104495E+00	1.203937E-04	2.013744E-04
.00065	7.626619E-01	5.358627E-04	7.662200E-01	1.259960E+00	1.302886E-04	2.200033E-04
.00070	8.193946E-01	5.643224E-04	8.397172E-01	1.382010E+00	1.408877E-04	2.464952E-04
.00075	8.888006E-01	5.940076E-04	8.194944E-01	1.348017E+00	1.504432E-04	2.632252E-04
.00080	9.996166E-01	6.250182E-04	9.194944E-01	1.508017E+00	1.604432E-04	2.807252E-04
.00085	1.042646E+00	6.573542E-04	9.994722E-01	1.691198E+00	1.725727E-04	3.020950E-04
.00090	1.088666E+00	6.910156E-04	1.079882E+00	1.783188E+00	1.846473E-04	3.232096E-04
.00095	1.137663E+00	7.260023E-04	1.170039E+00	1.933895E+00	1.689775E-04	2.782666E-04
.00100	1.272946E+00	7.623144E-04	1.266746E+00	2.094236E+00	1.933462E-04	3.189547E-04
.00105	1.334946E+00	8.000517E-04	1.369336E+00	2.263889E+00	2.197077E-04	3.621388E-04
.00110	1.399108E+00	8.392144E-04	1.476847E+00	2.441611E+00	2.488189E-04	4.099252E-04
.00115	1.465177E+00	8.798024E-04	1.589266E+00	2.627398E+00	2.780843E-04	4.580115E-04
.00120	1.533093E+00	9.218157E-04	1.706635E+00	2.821179E+00	3.120442E-04	5.141968E-04
.00125	1.603006E+00	9.652543E-04	1.829037E+00	3.023035E+00	3.477274E-04	5.730466E-04
.00130	1.674867E+00	1.010137E-03	1.956478E+00	3.232728E+00	3.861199E-04	6.376883E-04
.00135	2.114031E+00	1.056445E-03	2.138706E+00	3.534517E+00	4.274049E-04	7.061077E-04
.00140	2.387455E+00	1.104178E-03	2.297238E+00	3.808956E+00	4.717638E-04	7.796908E-04
.00145	2.477001E+00	1.153157E-03	2.469393E+00	4.089496E+00	5.193966E-04	8.586239E-04
.00150	2.567735E+00	1.203381E-03	2.644642E+00	4.380953E+00	5.703039E-04	9.429142E-04
.00155	2.659527E+00	1.254850E-03	2.823452E+00	4.706435E+00	6.245329E-04	1.032366E-03
.00160	3.053508E+00	1.307564E-03	3.039866E+00	5.044688E+00	6.820892E-04	1.126187E-03
.00165	3.467966E+00	1.361523E-03	3.451598E+00	5.725108E+00	7.976908E-04	1.320035E-03
.00170	4.167652E+00	1.416727E-03	4.149011E+00	6.881162E+00	9.877222E-04	1.635950E-03
.00175	4.893122E+00	1.473176E-03	4.980776E+00	8.262795E+00	1.215997E-03	2.021810E-03
.00180	5.645626E+00	1.530869E-03	5.926807E+00	9.901779E+00	1.485662E-03	2.468822E-03
.00185	7.168185E+00	1.589797E-03	7.136006E+00	1.184948E+01	1.781723E-03	3.011187E-03
.00190	8.562463E+00	2.219492E-03	8.522305E+00	1.414862E+01	2.208679E-03	3.667172E-03
.00195	.021166E+01	2.483877E-03	1.016224E+01	1.688005E+01	2.675829E-03	4.443743E-03
.00200	.276908E+01	3.253242E-03	1.211165E+01	2.011893E+01	3.232901E-03	5.368239E-03
.00205	1.496856E+01	3.907758E-03	1.489267E+01	2.473917E+01	3.895438E-03	6.469229E-03
.00210	1.720459E+01	4.699138E-03	1.711637E+01	2.842405E+01	4.686059E-03	7.779597E-03
.00215	2.060237E+01	5.641274E-03	2.049198E+01	3.403061E+01	5.625495E-03	9.336368E-03
.00220	2.436366E+01	6.760399E-03	2.422664E+01	4.024229E+01	6.742264E-03	1.119146E-02
.00225	2.855308E+01	8.071665E-03	2.839705E+01	4.715020E+01	8.063235E-03	1.339695E-02
.00230	3.438756E+01	9.672300E-03	3.423358E+01	5.687878E+01	9.664774E-03	1.605156E-02
.00235	4.062295E+01	1.159936E-02	4.045955E+01	6.753562E+01	1.157098E-02	1.919598E-02
.00240	4.844488E+01	1.377726E-02	4.826726E+01	8.016288E+01	1.376422E-02	2.281064E-02
.00245	5.751165E+01	1.622236E-02	5.725467E+01	9.511617E+01	1.637708E-02	2.720135E-02
.00250	6.823797E+01	1.896405E-02	6.793339E+01	1.128087E+02	1.960774E-02	3.240218E-02
.00255	8.093977E+01	2.202257E-02	8.058848E+01	1.338178E+02	2.322055E-02	3.857721E-02
.00260	9.600593E+01	2.542944E-02	9.557942E+01	1.586352E+02	2.742477E-02	4.589809E-02
.00265	1.202795E+02	3.172749E-02	1.198066E+02	1.990811E+02	3.436277E-02	5.703233E-02
.00270	1.539423E+02	3.989445E-02	1.534708E+02	2.547376E+02	4.397453E-02	7.302359E-02
.00275	2.108238E+02	5.058433E-02	2.098732E+02	3.488166E+02	6.050593E-02	1.005388E-01
.00280	2.786250E+02	6.307604E-02	2.774416E+02	4.610942E+02	8.000277E-02	1.329396E-01
.00285	3.681580E+02	1.058621E+00	3.666998E+02	6.091945E+02	1.057606E+00	1.757944E+00
.00290	4.859536E+02	1.398624E+00	4.837776E+02	8.041266E+02	1.397716E+00	2.322754E+00

.02020	6.962829E+02	1.896489E+00	6.379966E+02	1.060951E+03	1.896408E+00	3.068660E+00
.02080	8.949168E+02	2.938004E+00	8.982331E+02	1.396929E+03	2.937568E+00	4.851559E+00
.02140	1.108994E+03	4.121603E+00	1.109665E+03	1.831572E+03	4.119572E+00	6.834525E+00
.02200	1.356379E+03	5.237706E+00	1.349982E+03	2.241136E+03	5.237599E+00	8.704469E+00
.02260	1.905691E+03	6.577008E+00	1.897366E+03	3.156604E+03	6.576466E+00	9.271878E+00
.02320	2.489588E+03	7.326926E+00	2.479453E+03	4.118168E+03	7.325186E+00	1.218186E+01
.02500	3.227194E+03	9.602564E+00	3.212649E+03	5.349327E+03	9.600000E+00	1.596876E+01
.02580	4.166220E+03	1.259691E+01	4.147408E+03	6.905998E+03	1.259491E+01	2.097249E+01
.02660	5.380139E+03	1.633790E+01	5.356147E+03	8.863809E+03	1.633295E+01	2.718159E+01
.02740	6.789429E+03	2.117498E+01	6.757359E+03	1.121718E+04	2.115792E+01	3.523606E+01
.02820	8.507644E+03	2.727795E+01	8.469229E+03	1.415955E+04	2.726467E+01	4.540686E+01
.02900	1.051208E+04	3.487208E+01	1.046466E+04	1.751958E+04	3.486022E+01	5.807552E+01
.02980	1.279339E+04	4.418022E+01	1.273604E+04	2.133520E+04	4.410056E+01	7.346225E+01
.03060	1.538020E+04	5.541116E+01	1.532327E+04	2.558708E+04	5.528808E+01	9.235867E+01
.03140	1.790708E+04	6.869867E+01	1.782455E+04	3.002008E+04	6.851168E+01	1.144942E+02
.03220	2.040807E+04	8.405777E+01	2.030774E+04	3.394161E+04	8.377972E+01	1.396816E+02
.03300	2.290235E+04	1.014123E+02	2.279790E+04	3.856606E+04	1.010172E+02	1.696717E+02
.03380	2.597726E+04	1.206026E+02	2.585483E+04	4.219606E+04	1.201356E+02	2.011931E+02
.03460	2.656613E+04	1.412906E+02	2.643993E+04	4.500726E+04	1.406569E+02	2.389916E+02
.03540	2.757576E+04	1.629316E+02	2.744607E+04	4.684956E+04	1.622209E+02	2.755529E+02
.03620	2.791156E+04	1.851716E+02	2.778529E+04	4.758966E+04	1.843016E+02	3.131632E+02
.03700	2.786706E+04	2.074536E+02	2.773816E+04	4.758632E+04	2.065106E+02	3.509615E+02
.03780	2.722296E+04	2.295553E+02	2.709461E+04	4.646160E+04	2.284943E+02	3.870956E+02
.03860	2.608826E+04	2.509095E+02	2.596612E+04	4.477596E+04	2.496666E+02	4.236565E+02
.03940	2.452754E+04	2.711465E+02	2.441131E+04	4.220376E+04	2.698816E+02	4.584434E+02
.04020	2.270776E+04	2.900070E+02	2.260015E+04	3.915155E+04	2.886622E+02	4.909998E+02
.04100	2.073216E+04	3.074516E+02	2.063516E+04	3.581036E+04	3.059166E+02	5.209790E+02
.04180	1.869726E+04	3.233233E+02	1.862096E+04	3.229979E+04	3.216196E+02	5.483233E+02
.04260	1.673656E+04	3.377665E+02	1.666462E+04	2.889590E+04	3.356685E+02	5.727126E+02
.04340	1.495296E+04	3.508976E+02	1.488802E+04	2.592686E+04	3.481946E+02	5.944226E+02
.04420	1.279386E+04	3.608950E+02	1.273356E+04	2.222966E+04	3.580736E+02	6.113683E+02
.04500	1.109426E+04	3.703976E+02	1.104202E+04	1.929006E+04	3.676594E+02	6.300889E+02
.04580	9.569640E+03	3.786652E+02	9.525051E+03	1.664998E+04	3.760859E+02	6.444963E+02
.04660	8.208869E+03	3.857548E+02	8.170182E+03	1.427313E+04	3.830869E+02	6.568388E+02
.04740	7.017896E+03	3.918356E+02	6.984777E+03	1.222539E+04	3.890977E+02	6.671946E+02
.04820	5.980181E+03	3.970226E+02	5.953162E+03	1.040953E+04	3.942122E+02	6.760502E+02
.04900	5.087246E+03	4.014450E+02	5.063216E+03	8.869058E+03	3.986229E+02	6.836229E+02
.04980	4.319668E+03	4.052066E+02	4.299259E+03	7.532649E+03	4.023745E+02	6.900789E+02
.05060	3.666945E+03	4.083956E+02	3.697114E+03	6.391086E+03	4.055952E+02	6.956354E+02
.05140	3.107577E+03	4.110996E+02	3.092698E+03	5.420027E+03	4.083146E+02	7.010788E+02
.05220	2.635966E+03	4.133736E+02	2.662350E+03	4.597711E+03	4.114356E+02	7.050866E+02
.05300	2.233776E+03	4.153196E+02	2.227108E+03	3.902311E+03	4.133795E+02	7.084866E+02
.05380	1.902376E+03	4.169926E+02	1.893398E+03	3.317552E+03	4.150236E+02	7.113796E+02
.05460	1.620196E+03	4.183986E+02	1.612035E+03	2.825376E+03	4.164226E+02	7.138316E+02
.05540	1.363998E+03	4.195996E+02	1.377946E+03	2.413256E+03	4.176226E+02	7.159266E+02
.05620	1.106963E+03	4.206246E+02	1.180236E+03	2.066256E+03	4.186456E+02	7.177186E+02
.05700	1.020026E+03	4.215036E+02	1.015206E+03	1.776586E+03	4.195236E+02	7.192556E+02
.05780	8.810856E+02	4.222566E+02	8.772436E+02	1.536106E+03	4.202806E+02	7.205786E+02
.05860	7.543296E+02	4.229226E+02	7.420206E+02	1.332106E+03	4.209156E+02	7.217266E+02
.05940	6.489756E+02	4.234956E+02	6.458626E+02	1.153226E+03	4.215076E+02	7.227256E+02
.06020	5.625756E+02	4.239986E+02	5.868006E+02	1.026126E+03	4.220086E+02	7.235996E+02
.06100	4.948616E+02	4.244436E+02	5.216766E+02	9.056036E+02	4.224526E+02	7.243726E+02
.06180	4.391066E+02	4.248356E+02	4.669016E+02	8.136266E+02	4.228436E+02	7.250626E+02
.06260	4.230466E+02	4.251956E+02	4.210816E+02	7.331956E+02	4.232026E+02	7.256886E+02
.06340	3.899936E+02	4.255186E+02	3.826696E+02	6.657996E+02	4.235256E+02	7.262596E+02
.06420	3.615726E+02	4.258116E+02	3.505126E+02	6.093396E+02	4.238186E+02	7.267676E+02
.06500	3.351036E+02	4.260896E+02	3.239006E+02	5.620316E+02	4.240876E+02	7.272196E+02
.06580	3.096636E+02	4.263326E+02	2.994696E+02	5.174586E+02	4.243336E+02	7.276496E+02
.06660	2.869056E+02	4.265576E+02	2.763726E+02	4.827706E+02	4.245576E+02	7.280396E+02
.06740	2.658816E+02	4.267646E+02	2.562486E+02	4.476176E+02	4.247626E+02	7.283996E+02
.06820	2.493826E+02	4.269316E+02	2.403906E+02	4.200686E+02	4.249136E+02	7.286596E+02
.06900	1.777226E+02	4.270896E+02	1.766686E+02	3.114996E+02	4.250826E+02	7.289506E+02
.06980	1.574256E+02	4.272176E+02	1.576176E+02	2.756176E+02	4.252216E+02	7.291906E+02
.07060	1.395226E+02	4.273316E+02	1.397886E+02	2.442476E+02	4.253296E+02	7.293710E+02
.07140	1.179906E+02	4.274336E+02	1.179086E+02	2.111976E+02	4.254306E+02	7.295506E+02
.07220	1.044236E+02	4.275226E+02	1.039156E+02	1.873376E+02	4.255196E+02	7.297506E+02







TIME	CORE FRACTION	TEST FRACTION	TOTAL FRACTION
0.00000	0.	0.	0.
.00005	2.136211E-08	2.832908E-08	2.136211E-08
.00010	1.093952E-07	1.093952E-07	1.093952E-07
.00025	2.823648E-07	2.823711E-07	2.823648E-07
.00035	3.009422E-07	3.009422E-07	3.009422E-07
.00045	3.937206E-07	3.781211E-07	3.937206E-07
.00055	4.121388E-07	4.121388E-07	4.121388E-07
.00065	5.260028E-07	5.052711E-07	5.260028E-07
.00075	5.448028E-07	5.976428E-07	5.976428E-07
.00085	8.723126E-07	8.723126E-07	8.723126E-07
.00095	9.084208E-06	9.384833E-07	1.008242E-06
.00110	1.211116E-06	1.211116E-06	1.211116E-06
.00130	1.471946E-06	1.471946E-06	1.471946E-06
.00150	1.852336E-06	1.731858E-06	1.852336E-06
.00170	2.211717E-06	2.073476E-06	2.211717E-06
.00210	2.561920E-06	2.456136E-06	2.561920E-06
.00230	2.995592E-06	2.951128E-06	2.995592E-06
.00250	3.517936E-06	3.476167E-06	3.517936E-06
.00270	4.024736E-06	3.761012E-06	4.024736E-06
.00290	4.568228E-06	4.284251E-06	4.568228E-06
.00310	5.160928E-06	4.837466E-06	5.160928E-06
.00330	5.799336E-06	5.411158E-06	5.799336E-06
.00350	6.488022E-06	6.088822E-06	6.488022E-06
.00370	7.230106E-06	6.788626E-06	7.230106E-06
.00390	8.035634E-06	7.569098E-06	8.035634E-06
.00410	8.895694E-06	8.250146E-06	8.895694E-06
.00430	9.803138E-06	9.217834E-06	9.803138E-06
.00450	1.079566E-05	1.015334E-05	1.079566E-05
.00470	1.186226E-05	1.117652E-05	1.186226E-05
.00490	1.300225E-05	1.225205E-05	1.300225E-05
.00510	1.422411E-05	1.338617E-05	1.422411E-05
.00530	1.553042E-05	1.461378E-05	1.553042E-05
.00550	2.093736E-05	1.593642E-05	2.093736E-05
.00570	2.528311E-05	2.381908E-05	2.528311E-05
.00590	3.097308E-05	2.918036E-05	3.097308E-05
.00610	3.779836E-05	3.561726E-05	3.779836E-05
.00630	4.597648E-05	4.330211E-05	4.597648E-05
.00650	5.563008E-05	5.242704E-05	5.563008E-05
.00670	6.722046E-05	6.341162E-05	6.722046E-05
.00690	8.101552E-05	7.644334E-05	8.101552E-05
.00710	9.753668E-05	9.199376E-05	9.753668E-05
.00730	1.167668E-04	1.100908E-04	1.167668E-04
.00750	1.401896E-04	1.322368E-04	1.401896E-04
.00770	1.677838E-04	1.582211E-04	1.677838E-04
.00790	2.004618E-04	1.891394E-04	2.004618E-04
.00810	2.394078E-04	2.261764E-04	2.394078E-04
.00830	2.854224E-04	2.696844E-04	2.854224E-04
.00850	3.405366E-04	3.216764E-04	3.405366E-04
.00870	4.054128E-04	3.831742E-04	4.054128E-04
.00890	4.828166E-04	4.561306E-04	4.828166E-04
.00910	5.743968E-04	5.426034E-04	5.743968E-04
.00930	7.122338E-04	6.807178E-04	7.122338E-04
.00950	9.419778E-04	8.901782E-04	9.419778E-04
.00970	1.428156E-03	1.349226E-03	1.428156E-03
.00980	1.629676E-03	1.539676E-03	1.629676E-03
.00990	1.859676E-03	1.757026E-03	1.859676E-03
.01000	2.122036E-03	2.005426E-03	2.122036E-03
.01020	2.421716E-03	2.287666E-03	2.421716E-03
.01040	2.763216E-03	2.611216E-03	2.763216E-03
.01060	3.152716E-03	2.979216E-03	3.152716E-03
.01080	3.596116E-03	3.398116E-03	3.596116E-03
.01100	4.100116E-03	3.874116E-03	4.100116E-03
.01120	4.673116E-03	4.415116E-03	4.673116E-03
.01140	5.324116E-03	5.029116E-03	5.324116E-03
.01160	6.063116E-03	5.727116E-03	6.063116E-03
.01180	6.902116E-03	6.519116E-03	6.902116E-03
.01200	7.854116E-03	7.417116E-03	7.854116E-03
.01220	8.934116E-03	8.438116E-03	8.934116E-03
.01240	1.016116E-02	9.597116E-03	1.016116E-02
.01260	1.155116E-02	1.090916E-02	1.155116E-02
.01280	1.313116E-02	1.239916E-02	1.313116E-02
.01300	1.492116E-02	1.408116E-02	1.492116E-02
.01320	1.695116E-02	1.599116E-02	1.695116E-02
.01340	1.925116E-02	1.815116E-02	1.925116E-02
.01360	2.185116E-02	2.059116E-02	2.185116E-02
.01380	2.479116E-02	2.334116E-02	2.479116E-02
.01400	2.811116E-02	2.645116E-02	2.811116E-02
.01420	3.185116E-02	2.995116E-02	3.185116E-02
.01440	3.606116E-02	3.389116E-02	3.606116E-02
.01460	4.079116E-02	3.832116E-02	4.079116E-02
.01480	4.610116E-02	4.329116E-02	4.610116E-02
.01500	5.205116E-02	4.887116E-02	5.205116E-02
.01520	5.871116E-02	5.512116E-02	5.871116E-02
.01540	6.615116E-02	6.211116E-02	6.615116E-02
.01560	7.445116E-02	6.990116E-02	7.445116E-02
.01580	8.370116E-02	7.858116E-02	8.370116E-02
.01600	9.400116E-02	8.825116E-02	9.400116E-02
.01620	1.055116E-01	9.901116E-02	1.055116E-01
.01640	1.183116E-01	1.110116E-01	1.183116E-01
.01660	1.326116E-01	1.244116E-01	1.326116E-01
.01680	1.485116E-01	1.393116E-01	1.485116E-01
.01700	1.663116E-01	1.560116E-01	1.663116E-01
.01720	1.861116E-01	1.746116E-01	1.861116E-01
.01740	2.081116E-01	1.952116E-01	2.081116E-01
.01760	2.325116E-01	2.181116E-01	2.325116E-01
.01780	2.594116E-01	2.433116E-01	2.594116E-01
.01800	2.890116E-01	2.711116E-01	2.890116E-01
.01820	3.214116E-01	3.015116E-01	3.214116E-01
.01840	3.568116E-01	3.347116E-01	3.568116E-01
.01860	3.953116E-01	3.708116E-01	3.953116E-01
.01880	4.370116E-01	4.100116E-01	4.370116E-01
.01900	4.821116E-01	4.524116E-01	4.821116E-01
.01920	5.307116E-01	4.981116E-01	5.307116E-01
.01940	5.829116E-01	5.472116E-01	5.829116E-01
.01960	6.389116E-01	5.998116E-01	6.389116E-01
.01980	6.987116E-01	6.560116E-01	6.987116E-01
.02000	7.624116E-01	7.160116E-01	7.624116E-01
.02020	8.301116E-01	7.798116E-01	8.301116E-01
.02040	9.018116E-01	8.474116E-01	9.018116E-01
.02060	9.775116E-01	9.189116E-01	9.775116E-01
.02080	1.057116E+00	9.943116E-01	1.057116E+00
.02100	1.141116E+00	1.073116E+00	1.141116E+00
.02120	1.229116E+00	1.156116E+00	1.229116E+00
.02140	1.321116E+00	1.242116E+00	1.321116E+00
.02160	1.417116E+00	1.332116E+00	1.417116E+00
.02180	1.517116E+00	1.426116E+00	1.517116E+00
.02200	1.621116E+00	1.524116E+00	1.621116E+00
.02220	1.729116E+00	1.626116E+00	1.729116E+00
.02240	1.841116E+00	1.732116E+00	1.841116E+00
.02260	1.957116E+00	1.841116E+00	1.957116E+00

.02280	1.199793E-02	1.899648E-02	1.199793E-02
.02420	1.923108E-02	1.749857E-02	1.916708E-02
.02560	1.996629E-02	1.809908E-02	1.987792E-02
.02580	2.088236E-02	2.748038E-02	2.597889E-02
.02660	3.395336E-02	3.215436E-02	3.382668E-02
.02740	4.359176E-02	4.166808E-02	4.383706E-02
.02820	5.665386E-02	5.363646E-02	5.647356E-02
.02900	7.240068E-02	6.867726E-02	7.219296E-02
.02980	9.169446E-02	8.706126E-02	9.146516E-02
.03060	1.179598E-01	1.092676E-01	1.171116E-01
.03140	1.429566E-01	1.355716E-01	1.422196E-01
.03220	1.742562E-01	1.660516E-01	1.740016E-01
.03300	2.101544E-01	2.005836E-01	2.099966E-01
.03380	2.497991E-01	2.387946E-01	2.496476E-01
.03460	2.924566E-01	2.800176E-01	2.923926E-01
.03540	3.372756E-01	3.235076E-01	3.372756E-01
.03620	3.832116E-01	3.681826E-01	3.833386E-01
.03700	4.293876E-01	4.132006E-01	4.299396E-01
.03780	4.749936E-01	4.577606E-01	4.752176E-01
.03860	5.191216E-01	5.009936E-01	5.194196E-01
.03940	5.610186E-01	5.421386E-01	5.613616E-01
.04020	6.007206E-01	5.806626E-01	6.004976E-01
.04100	6.360806E-01	6.160806E-01	6.364776E-01
.04180	6.687206E-01	6.483206E-01	6.691316E-01
.04260	6.979786E-01	6.772686E-01	6.980076E-01
.04340	7.238076E-01	7.029616E-01	7.243136E-01
.04420	7.466076E-01	7.254826E-01	7.470266E-01
.04500	7.663816E-01	7.451176E-01	7.667976E-01
.04580	7.834036E-01	7.621176E-01	7.838776E-01
.04660	7.981976E-01	7.767526E-01	7.988016E-01
.04740	8.108016E-01	7.892266E-01	8.111726E-01
.04820	8.215626E-01	8.000116E-01	8.219226E-01
.04900	8.307256E-01	8.091376E-01	8.310766E-01
.04980	8.385176E-01	8.168966E-01	8.388576E-01
.05060	8.451256E-01	8.234826E-01	8.454516E-01
.05140	8.507266E-01	8.290696E-01	8.510506E-01
.05220	8.554816E-01	8.338086E-01	8.557906E-01
.05300	8.595156E-01	8.378296E-01	8.598206E-01
.05380	8.629426E-01	8.412546E-01	8.632496E-01
.05460	8.658086E-01	8.441506E-01	8.661676E-01
.05540	8.683456E-01	8.466276E-01	8.686446E-01
.05620	8.706726E-01	8.487626E-01	8.707626E-01
.05700	8.727296E-01	8.505646E-01	8.725926E-01
.05780	8.745876E-01	8.521306E-01	8.741646E-01
.05860	8.762366E-01	8.534866E-01	8.755266E-01
.05940	8.776426E-01	8.546426E-01	8.767126E-01
.06020	8.787656E-01	8.557016E-01	8.777256E-01
.06100	8.798376E-01	8.564166E-01	8.786756E-01
.06180	8.772096E-01	8.573116E-01	8.779756E-01
.06260	8.779686E-01	8.581226E-01	8.802336E-01
.06340	8.806166E-01	8.598246E-01	8.809016E-01
.06420	8.812266E-01	8.594276E-01	8.814106E-01
.06500	8.817876E-01	8.599816E-01	8.820706E-01
.06580	8.823016E-01	8.604916E-01	8.825806E-01
.06660	8.827646E-01	8.609536E-01	8.830506E-01
.06740	8.831786E-01	8.613646E-01	8.834636E-01
.06820	8.835416E-01	8.617316E-01	8.838256E-01
.06900	8.838576E-01	8.620466E-01	8.841476E-01
.06980	8.841256E-01	8.623226E-01	8.844166E-01
.07060	8.843716E-01	8.625736E-01	8.846596E-01
.07140	8.845806E-01	8.627866E-01	8.848646E-01
.07220	8.847646E-01	8.629756E-01	8.850476E-01
.07300	8.849256E-01	8.631436E-01	8.852116E-01
.07380	8.850716E-01	8.632946E-01	8.853586E-01
.07460	8.852056E-01	8.634326E-01	8.854926E-01
.07540	8.853326E-01	8.635606E-01	8.856156E-01