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AN EXAMINATION OF THE SCEPTRE AND CSMP PROGRAMS FOR SOLVING THE POINT-KINETICS EQUATIONS WITH FEEDBACK

by

P. D. Walkowski and B. R. Peterson

APPLIED TECHNOLOGY

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Prepared for the U. S. ENERGY RESEARCH
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Printed in the United States of America
Available from
U. S. Energy Research and Development Administration
Technical Information Center
P. O. Box 62
Oak Ridge, Tennessee 37830
Price: Printed Copy $4.50

Distribution Category:
LMFBR Instrumentation
and Controls (UC-79m)

ANL-76-62

ARGONNE NATIONAL LABORATORY
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AN EXAMINATION OF THE SCEPTRE AND CSMP PROGRAMS FOR SOLVING THE POINT-KINETICS EQUATIONS WITH FEEDBACK

by

P. D. Walkowski* and B. R. Peterson

EBR-II Project

September 1976

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AN EXAMINATION OF THE SCEPTRE AND CSMP PROGRAMS FOR SOLVING THE POINT-KINETICS EQUATIONS WITH FEEDBACK

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ABSTRACT

Two modeling programs, SCEPTRE and CSMP, are used to solve the point-kinetics equations--seven coupled nonlinear differential equations--with a linear-feedback function. The constants used are appropriate for EBR-II; therefore the computational accuracy may be tested against the experimental rod drops.

Run time, versatility, programming ease, and accuracy are criteria used to evaluate the two programs. SCEPTRE is found to be more efficient in run time and CSMP more versatile. The ease of programming is about the same for both programs. The accuracy is nearly equivalent if the optimum integration routines are used.

I. INTRODUCTION

Various feedback systems of the EBR-II reactor will be simulated to examine possible alternative methods of control. A modeling program will be used to solve the differential equations so that a model may be simulated efficiently without an advanced knowledge of FORTRAN. Both SCEPTRE[1] and the Continuous Systems Modeling Program (CSMP)[2] allow the equations and parameters to be written as a data set in an algebraic form. The programs then assemble and execute efficient FORTRAN programs using built-in integration routines.

This study was initiated to compare the capabilities of SCEPTRE and CSMP in solving the point-kinetics equations. The service each program was intended to perform made them considerably different.

II. THEORY

A. The Point-kinetics Equations

The reactivity of EBR-II follows the seven coupled point-kinetics equations derived by Henry:[3]

$$\frac{dn(t)}{dt} = \frac{\rho(t) - \beta_i}{\ell} n(t) + \sum_{i=1}^{6} \lambda_i C_i(t) \tag{1}$$

and

$$\left.\begin{aligned} \frac{dC_i(t)}{dt} &= \frac{\beta_i}{\ell} n(t) - \lambda_i C_i(t), \\ i &= 1, 2, \ldots, 6, \end{aligned}\right\} \tag{2}$$

where

$n(t)$ = neutron concentration at time t,

$C_i(t)$ = neutron-precursor concentration,

$\rho(t)$ = reactivity at time t,

λ_i = ith delayed-neutron decay constants,

β_i = ith delayed-neutron fraction,

and

ℓ = neutron-generation time.

The reactivity is described by the difference between the input and feedback reactivities:

$$\rho(t) = \rho_0(t) - \rho_{fb}(t). \tag{3}$$

The rod drops of EBR-II run 49F are represented by an input-reactivity function (Fig. 1). The rise time for the ramp to achieve unity is 5×10^{-6} sec. The magnitude and direction of the step change in reactivity were determined by the sign and value of k, the effective multiplication factor. The response to this input is shown in Fig. 2.

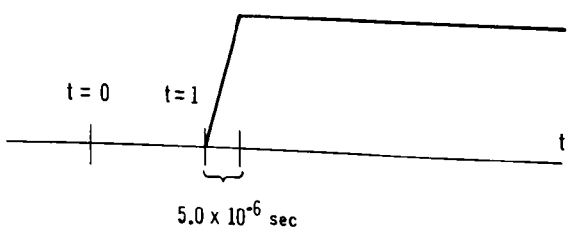


Fig. 1
Input Reactivity for Rod Drops in EBR-II Run 49F

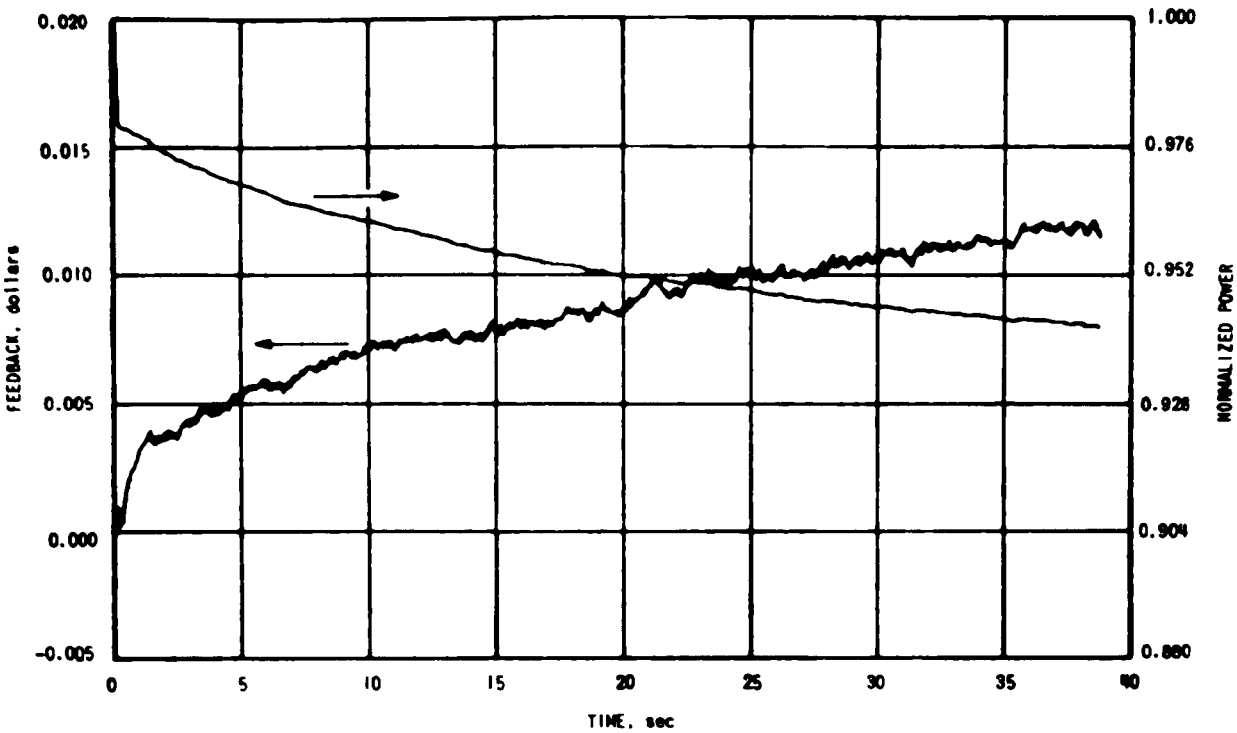


Fig. 2. Power and Feedback Reactivity at Start of EBR-II Run 49F

The control-system diagram for the nonlinear feedback system is shown in Fig. 3, in which G(s) is the driving function and H(s) is the feedback function.

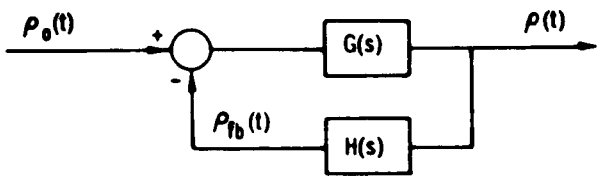


Fig. 3

Control-system Block Diagram for Nonlinear Feedback System

Hyndman and Nicholson[4] assumed the feedback function to be of the form

$$H(s) = \sum_{i=1}^{5} \frac{A_i \exp(-sT_i)}{1 + sT_i} = \sum_{i=1}^{5} \frac{(A_i/\tau_i)\exp(-sT_i)}{s + 1/\tau_i},$$

where τ_i is the feedback time constant, A_i is the feedback weighting function, and T_i is the delay of the ith term.

By an inverse Laplace transformation, this equation yields

$$h(\lambda) = \sum_{i=1}^{5} (A_i/\tau_i)\exp\left[\frac{-\lambda - T}{s + 1/\tau_i}\right].$$

The functional representation of a system is given by a Volterra expansion for all times. Gyftopoulos[5] was able to show that each kernel is related to the output through a convolution operation. Hence,

$$Y(t) = h_0 + \int_0^\infty h(t - \tau)x(\tau)d\tau$$

$$+ \int_0^\infty \int_0^\infty h(\tau_1, \tau_2)x(t - \tau_1)x(t - \tau_2)d\tau_1\, d\tau_2 + \ldots\, d\tau_i \ldots\, d\tau_k + \ldots, \tag{4}$$

where

x = input time-domain function

and

y = output time-domain function.

Because the effects of nonlinear terms are very small and the nature of $h(\tau_1, \tau_2)$ is unknown, the linear-feedback approximation is used:

$$Y(t) = H_0 + \int_0^\infty h(t - \tau)x(\tau)d\tau. \tag{5}$$

Because $h(t - \tau) = 0$ for $\tau > t$ for any causal system, one need only integrate from time zero to t.

Identifying like terms in the reactivity equation gives

$$\rho(t) = \rho_0(t) + \sum_i \frac{A_i}{\tau_i} \int_0^t \exp\left[\frac{-(t - T_i - \lambda)}{\tau_i}\right] P(\lambda)d\lambda.$$

In our normalized system,

$$P(\lambda) = \frac{\underline{n}(\lambda) - n_0}{n_0} = n(\lambda) - 1,$$

where

$\underline{n}(\lambda)$ = total neutron density,

n_0 = normalizing neutron density,

and

$n(\lambda)$ = normalized neutron density.

Therefore,

$$\rho_{fb}(t) = \sum_i \frac{A_i}{\tau_i} \int_0^t [n(\lambda) - 1] \exp\left[\frac{-(t - T_i - \lambda)}{\tau_i}\right] d\lambda. \tag{6}$$

The convolution integral in Eq. 6 can be broken up into (a) the integral for the current time step, where Eqs. 1 and 2 are evaluated, and (b) the remainder of the time integration to give

$$\rho_{new} = \int_0^{t_{save}} [n(\lambda) - 1] \exp\left[\frac{-(t - T_i - \lambda)}{\tau_i}\right] d\lambda$$

$$+ \int_{t_{save}}^{t} [n(\lambda) - 1] \exp\left[\frac{-(t - T_i - \lambda)}{\tau_i}\right] d\lambda. \tag{7}$$

With all the $T_i = 0$, the trapezoidal-rule approximation used in the computer program is

$$F_{new} \simeq F_{save} \exp\left[\frac{t_{save} - t}{\tau_i}\right]$$

$$+ \frac{t - t_{save}}{2} \left\{ [n(t_{save}) - 1] \exp\left[\frac{-(t - t_{save})}{\tau_i}\right] + [n(t) - 1] \right\}. \tag{8}$$

B. Physical Interpretation of the Feedback Polynomial

The feedback transfer function found experimentally by Hyndman and Nicholson[4] and fitted to EBR-II run 49F by Larson[6] originally had four terms. This number of terms was enough for modeling the first 15 sec of a rod drop. An additional term was necessary to reestablish 2 cents of reactivity at an infinite time. A fifth term, with a 36-sec time constant, was added to the expression to account for this reactivity observed in static measurements but not in the fit.

The time constant ξ was determined from

$$\rho(t) = \rho(t_\infty)(1 - e^{-t/\xi}),$$

where $\rho(t_\infty) = 0.02$ dollar of reactivity, and, at $t = 25$ sec, the value of ρ is 0.01 from Larson's curve-fit data.[6]

A_i was found to be 0.0984 dollar/($\Delta\rho/\rho$) from

$$H(0)_{measured} = H(0)_{rod\ drop} + A_5,$$

where

$$H(0)_{rod\ drop} = \frac{\sum_i A_i}{58\ MW} = 0.001\ 696\ \text{dollar/MW},$$

and

$$H(0)_{measured} = 0.005\ 144\ \text{dollar/MW}.$$

Fuel and coolant expansion are thought to account for the 0.2- and 0.4-sec negative coefficients. The long (2.0- and 10-sec) positive coefficients are postulated to be bowing effects of the subassemblies; the 5-sec negative coefficient is from rod-bank and bowing effects.

III. SCEPTRE

SCEPTRE (see Appendix A) is basically designed for electrical-engineering-oriented problems. Block circuit elements are modeled from simple components. The blocks are arranged between labeled modes, and the transient or steady-state output of parameters between various modes is requested. SCEPTRE then extracts the necessary differential equations and assembles and runs a double-precision FORTRAN program calling on built-in integration routines. Special considerations that allow for the direct entry of differential equations are used.

The CIRCUIT DESCRIPTION heading is the only structural element of SCEPTRE needed. The DEFINED PARAMETERS subheading contains a listing of constants, initial conditions, and all the differential and algebraic equations. The subheading OUTPUT partitions off the variables to be printed or printer-plotted, and FUNCTIONS is followed by the input-ramp function. The RUN CONTROLS subheading contains specifications for step size, error bounds, and integration type.

Algebraic expressions must be entered in a logical sequence because there is no internal sorting routine in SCEPTRE. All integrations, however, are executed at the end of the DEFINED PARAMETERS section.

The constants and initial conditions are entered in the DEFINED PARAMETERS section of SCEPTRE. A convention requires the use of P as the first letter of any parameter name.

The convention for performing algebraic operations dictates that the expressions be written in the form of PY = XS1(PA+PB**PC). Any algebraic FORTRAN statement may appear in the parentheses as long as the variable names begin with the letter P. The quantity inside the parentheses is identified as XS1 (a mnemonic for expression SL), and the result is called variable PY. Alternatively, TABLE consists of ordered pairs of points, and values at each integration step are determined by linear interpolation.

Only variable-step-size integration routines are available with SCEPTRE. The three methods are a crude but fast trapezoidal (TRAP) technique, a Runge-Kutta (RUK) routine, and a compromise, XPO. The entire program is run in a double-precision mode.

Many possible restrictions on the integration routines are included in SCEPTRE. Limits of minimum and maximum absolute error and of relative error may be preset. The starting step size is addressable, as are the maximum and minimum permissible values. The MAXIMUM INTEGRATION PASSES specification gives the user further control over the program when debugging and trying new input functions.

FORTRAN subroutines are easily included in the SCEPTRE simulation. They are called by an algebraic definition that passes parameters to the subroutine. Care must be taken to preserve the inherent accuracy of the system by using double-precision variables and operations.

Output is provided in tabular or printer-plot formats only. The broader label for the output is written directly below the CIRCUIT DESCRIPTION card; the parameters to be displayed occur after the OUTPUT card. The program chooses its own output intervals, which are not uniform, although the user may also specify the maximum number of points print-plotted. The output automatically indicates the number of integration steps taken and the number of steps that were accepted by satisfying the error criterion.

IV. CONTINUOUS SYSTEMS MODELING PROGRAM (CSMP)

The Continuous Systems Modeling Program (CSMP) (see Appendix B) allows the flexibility of either block-diagram or differential-equation representations of a system in a data set. From these, the program compiles and runs a FORTRAN program.

The INITIAL, DYNAMIC, and TERMINAL structural segments are the main subdivisions of the CSMP data set. CSMP builds the FORTRAN program from these segments. The INITIAL segment permits entry of constants and calculation of parameters that remain unchanged in the balance of the program. Error bounds, termination conditions, integration methods, and output are specified in the TERMINAL segment. The body of the program executed repeatedly for each time step is in the DYNAMIC section.

Sets of coupled equations that could be parallel-processed are grouped into SORT sections, where the program determines the order of computation. NOSORT sections are used where instruction order is critical.

The initial conditions of integration operations are specified by INCON statements in the INITIAL segment of the data set. PARAMETER and CONSTANT also initialize the data. Some procedures that require the results of several previous integration passes are used in the integration schemes and are stored internally.

Simple arithmetical expressions may be expressed in FORTRAN, but for longer computations, MACRO and PROCEDURE are more useful. The routines can specify the transfer functions of a block diagram. Input functions may be chosen from the CSMP library or fitted from ordered pairs of data points. CSMP uses AFGEN to linearly interpolate a steep ramp function for input reactivity simulating a rod drop.

There are built-in codes for fixed- and variable-step-size integration in CSMP that are called for by a METHOD statement. Three variable-step-size routines used were: RKS, a Runge-Kutta single-precision routing; RKSDP, a Runge-Kutta double-precision routine; and STIFF, a composite routine used for "stiff" equations. Stiff equations are those having a large spread in time constants. CSMP was designed for single-precision calculations, and only extensive modifications using subscript notation allow entirely double-precision calculations.

In integration routines in which the step size is varied, the maximum permissible relative and absolute errors may be specified. The absolute error (ABSERR) dominates for small integrator values, and the relative error (RELERR) dominates for larger values. The maximum possible error in CSMP is the sum of RELERR and ABSERR. This error is computed by testing the new functional value with two different formulas having complementary error terms. Step size is bounded by DELMIN and DELMAX statements.

Ordinary FORTRAN subroutines are easily called by an algebraic definition. For example, H1 = FSOL(N, TAU1, NZERO, 1.0, T) calls for subroutine FSOL passing the five parameters in parentheses to the subroutine and names the answer H1 in the main program.

Elaborate output documents are possible with CSMP built-in subroutines. Run and job headings are entered after TITLE and LABEL headings. Printed data are output in columns or blocks by PRINT statements at time increments specified by PRDEL. Printer-plotted data are called at OUTDEL intervals by an OUTPUT card. Shaded and contour printer plots are also possible, as are CALCOMP and microfilm graphs. A RANGE output is automatically called and lists the minimum and maximum values of all output variables. Table I shows the constants used in the simulation of 58-MWt run 49F.

TABLE I. Input Data: Constants Used in Simulation of 58-MWt Run 49F[a]

i	λ_i, sec^{-1}	β_i	$C_{i0} = \beta_i/\lambda_i\ell$	A_j	τ_i, sec	T_j, sec
1	0.0127	233	166 785.9699	0.060	0.2	0.0
2	0.0317	1410	404 359.0479	0.100	0.4	0.0
3	0.115	1300	102 766.7985	-0.020	2.0	0.0
4	0.311	2850	83 308.973 98	0.060	4.0	0.0
5	1.40	1050	6 818.181 818	0.0984	36.0	0.0
6	3.87	258	606.060 606 1			

[a]Values used to determine constants were: $\ell = 1.1 \times 10^{-7}$ sec, $\beta = 0.007\ 101$, $\eta_0 = 1.0$ neutrons/cm^3-sec, and $k = -1.4202 \times 10^{-4}$ dollar.

V. COMPARISON OF SCEPTRE AND CSMP

For convenience and lower cost, SCEPTRE was run on Aerojet Nuclear Corporation's IBM 360/70 computer, but the Version 3.6 CSMP could be assessed only on the Argonne IBM 370/195 computer at ANL-East. Nominal figures show the 370/195 to be eight times as fast as the 360/70.

A 20-sec simulation of a rod-drop worth of about 2 cents gave stable solutions both to SCEPTRE's XPO integration routine and CSMP's STIFF integration. Run times were fairly comparable (see Table II). Clearly, the Runge-Kutta single and double precision take far too long to converge for practical use in solving nonlinear equations of this type.

TABLE II. Comparison of Run Times

	Run Times, sec	
	Actual	Corrected for IBM 360/70[a]
SCEPTRE (Run on IBM 360/70)		
RUK	>269[b]	
XPO	121	
CSMP (Run on IBM 370/195)		
RKS	626	5 008
RKSDP	850	6 800
STIFF	20	160

[a]The IBM 370/195 is nominally eight times as fast as the IBM 360/70.
[b]The run used all the allocated time to simulate only 0.4 sec after the rod drop. The method was pursued no further.

The Runge-Kutta routine showed such instability in the accepted solution points that the variations were apparent in the crude printer plots. An example is in Appendix B. The XPO and STIFF routines show no such variance of output values.

These results of instability and long convergence times were confirmed in discussions with J. Kaganove, ANL-East. His experience with CSMP showed STIFF to be five times as fast as RKS integration (see p. 13). Additionally, he suggested the implementation of ordinary-differential-equation packages such as GEAR and EPISODE for these nonlinear systems to increase running speeds by a factor of 100 over the STIFF routine.

At the sample time intervals, the XPO and STIFF routines show good agreement with each other as well as with experimental data (see Table III). They are both low after the step function, high 10 sec later, and high at the end of the simulation. Because of this self-consistency, we speculate that the model is not an exact representation of the data.

TABLE III. Evaluation of N at Selected Time Intervals

Method	Value of N		
	Immediately after Rod Drop	At 11 sec	At 20 sec
Experimental Data	0.980 8	0.961 6	0.952
SCEPTRE			
RUK	0.980 392 (0.04)[a]	N.A.[b]	N.A.[b]
XPO	0.980 403 (0.04)	0.962 634 (0.11)	0.955 736 (0.37)
CSMP			
RKS	0.979 3 (0.15)	0.942 58 (1.98)	0.933 (2.00)
RKSDP	0.980 49 ± 0.004 48 (0.03)	0.978 29 ± 0.000 51 (1.74)	N.A.[b]
STIFF	0.980 29 (0.05)	0.961 84 (0.02)	0.954 25 (0.24)

[a]Parentheses indicate percentage deviation of computed data from experimental data.
[b]Data not available.

The most subjective consideration for evaluation is ease of programming. A clear advantage of SCEPTRE is that printer plots are always made, whether or not the run finishes. Thus, debugging is relatively easy.

CSMP, on the other hand, outputs at the end of a run, and a special DEBUG routine must be used to attain any results from a nonperfected program. The complexity of CSMP makes debugging a further hazard. SCEPTRE operates on a brief inflexible set of rules and is easy to learn. A knowledge of FORTRAN allows one to make up any minor deficiencies of SCEPTRE with subroutines.

The XPO and STIFF routines have similar accuracy when printing out single-precision results. The real difference between CSMP and SCEPTRE is in the use of double precision. SCEPTRE does all calculations in double precision, and care must be taken to account for this in writing FORTRAN subroutines. CSMP was designed to be single precision, and its extension to double-precision capabilities was ancillary. Consequently, the RKSDP calculates integrals in double precision and returns a single-precision answer to the main program. A true double-precision program in all stages of computations would require a new program in which all variables are subscripts. This is one serious drawback for CSMP.

VI. CONCLUSIONS

Both SCEPTRE and CSMP can readily solve nonlinear coupled equations with a linear feedback function if efficient integration routines are used. This examination has shown that XPO is the best routine provided by SCEPTRE for these equations and STIFF is the best routine provided by CSMP.

The routines are nearly comparable. The user should use the one with which he is most familiar. However, SCEPTRE is a little more efficient with respect to total run time and uses double precision as the standard approach. On the other hand, CSMP provides somewhat more versatility.

APPENDIX A

SCEPTRE Output

1. Input Program

```
SCEPTRE SYSTEM INPUT --  9/73 VERSION -- S/360 -- OS RELEASE 21.7

        CIRCUIT DESCRIPTION
        REACTOR RESPONSE
        DEFINED PARAMETERS
      PBETA = 0.007101
      PBETA1 = 0.000233
      PBETA2 = 0.00141
      PBETA3 = 0.00130
      PBETA4 = 0.00285
      PBETA5 = 0.00105
      PBETA6 = 0.000258
      PL =     1.1E-07
      PLAM1 = 0.0127
      PLAM2 = 0.0317
      PLAM3 = 0.115
      PLAM4 = 0.311
      PLAM5 = 1.40
      PLAM6 = 3.87
      PTAU1 = 0.2
      PTAU2 = 0.4
      PTAU3 = 2.0
      PTAU4 = 4.0
      PTAU5 = 36.0
      PA1 = 0.06
      PA2 = 0.1
      PA3 = -0.02
      PA4 = 0.06
      PA5 = 0.0984
      PK=-1.4202E-4
      PN = 1.0
      PNO=1.0
      PHOLD1 = X1(PLAM1*PC1+PLAM2*PC2+PLAM3*PC3+PLAM4*PC4+PLAM5*PC5
      +PLAM6*PC6)
      DPN=X2((PRO-PBETA)*PN/PL+PHOLD1)
      DPC1 = X3(PBETA1*PN/PL-PLAM1*PC1)
      DPC2 = X4(PBETA2*PN/PL-PLAM2*PC2)
      DPC3 = X5(PBETA3*PN/PL-PLAM3*PC3)
      DPC4 = X6(PBETA4*PN/PL-PLAM4*PC4)
      DPC5 = X7(PBETA5*PN/PL-PLAM5*PC5)
      DPC6 = X8(PBETA6*PN/PL-PLAM6*PC6)
      PH1 = FSOL(PN,PTAU1,PNO,1)
      PH2 = FSOL(PN,PTAU2,PNO,2)
      PH3 = FSOL(PN,PTAU3,PNO,3)
      PH4 = FSOL(PN,PTAU4,PNO,4)
      PH5 = FSOL(PN,PTAU5,PNO,5)
      PHH1=XX1(PA1*PH1/PTAU1)
      PHH2=XX2(PA2*PH2/PTAU2)
      PHH3=XX3(PA3*PH3/PTAU3)
      PHH4=XX4(PA4*PH4/PTAU4)
      PHH5=XX5(PA5*PH5/PTAU5)
      PROFB=X10((PHH1+PHH2+PHH3+PHH4+PHH5)*PBETA)
      PTBL1 = TABLE 1(TIME)
      PRO=X11(PK*PTBL1-PROFB)
      PC1=166785.9699
      PC2=404359.0479
      PC3=102766.7985
      PC4=83308.97398
      PC5=6818.181818
      PC6=606.0606061
         OUTPUTS
      PN,PC1,PC2,PC3,PC4,PC5,PC6,PRO,PLOT
```

```
PN,PLOT (PRC)
PROFB,PLOT
PHOLD1,PHH1,PHH2,PHH3,PHH4,PHH5,PTBL1,XSTPS2,DPN,PLOT
DPC1,DPC2,DPC3,DPC4,DPC5,DPC6,PLOT
   FUNCTIONS
   TABLE 1
 -1.0, 1.0,0.0, 1.000005,1.0, 30.0,1.0
   RUN CONTROLS
 STOP TIME =20.
MINIMUM STEP SIZE=.5E-08
STARTING STEP SIZE=2.E-06
   MAXIMUM PRINT POINTS = 400
MAXIMUM INTEGRATION PASSES = 40000
MINIMUM ABSOLUTE ERROR=0.0002
MAXIMUM ABSOLUTE ERROR=0.01
MINIMUM RELATIVE ERROR=0.0004
MAXIMUM RELATIVE ERROR=0.01
   END
```

```
LEVEL 21.7 ( JAN 73 )                          OS/360  FORTRAN H                                    DATE  75.234/17.37.15

        COMPILER OPTIONS - NAME=  MAIN,OPT=00,LINECNT=58,SIZE=0000K,
                           SOURCE,EBCDIC,NOLIST,NODECK,LOAD,NOMAP,NOEDIT,NOID,NOXREF
  ISN 0002            FUNCTION FSOL (PN,TAUI,PNO,AK)
  ISN 0003            IMPLICIT REAL*8(A-J,O-Z)
  ISN 0004            COMMON /CNTRLS/ TIME
  ISN 0005            COMMON /HLP/FSAVE(5),TSAVE,PNSAVE,KFIRST
  ISN 0006            K=AK
  ISN 0007            IF(KFIRST.EQ.1) GO TO 10
  ISN 0009            KFIRST=1
  ISN 0010            FSOL = 0.
  ISN 0011            TSAVE = TIME
  ISN 0012            DO 5 K=1,5
  ISN 0013          5 FSAVE(K)=0.
  ISN 0014            PNSAVE = PN
  ISN 0015            GO TO 100
  ISN 0016         10 FSOL = FSAVE(K)*DEXP((TSAVE-TIME)/TAUI)+
                     $(((PNSAVE-PNO)*DEXP(-(TIME-TSAVE)/TAUI)+PN-PNO)/2.)
                     $*(TIME-TSAVE)
  ISN 0017            FSAVE(K)=FSOL
  ISN 0018            IF(K.NE.5) GO TO 100
  ISN 0020            PNSAVE = PN
  ISN 0021            TSAVE = TIME
  ISN 0022        100 CONTINUE
  ISN 0023            RETURN
  ISN 0024            END

*OPTIONS IN EFFECT       NAME=  MAIN,OPT=00,LINECNT=58,SIZE=0000K,

 OPTIONS IN EFFECT*      SOURCE,EBCDIC,NOLIST,NODECK,LOAD,NOMAP,NOEDIT,NOID,NOXREF

*STATISTICS*     SOURCE STATEMENTS =      23 ,PROGRAM SIZE =      778

*STATISTICS*  NO  DIAGNOSTICS GENERATED

****** END OF COMPILATION ******                                          83K BYTES OF CORE NOT USED

*STATISTICS*   19 DIAGNOSTICS THIS STEP, HIGHEST SEVERITY CODE IS  4
```

TRANSIENT SOLUTION CONTROLS AFTER SIMULATION

INTEGRATION ROUTINE	XPO
CURRENT SIMULATION TIME	2.00012780 01
INTEGRATION STEP COUNTER	3.99600000D 03
INTEGRATION PASS COUNTER	8.51600000D 03
SOLUTION EXECUTION TIME(ELAPSED)	2.08000000D 00
SOLUTION EXECUTION TIME(CPU)	0.0
TERMINATION CONDITION	STOP TIME EXCEEDED (NORMAL STOP)

2. Printed Output

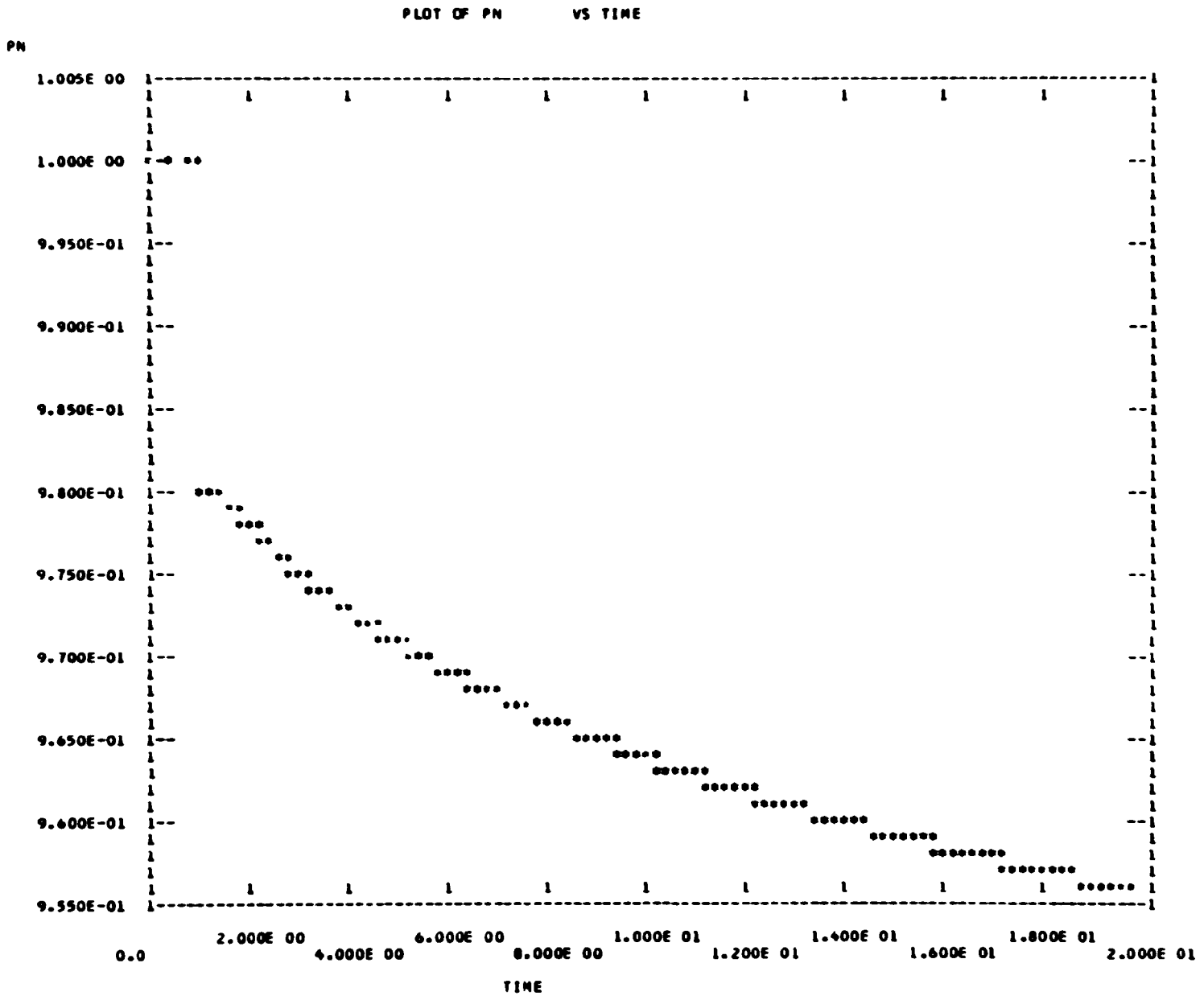
TRANSIENT ANALYSIS RESULTS

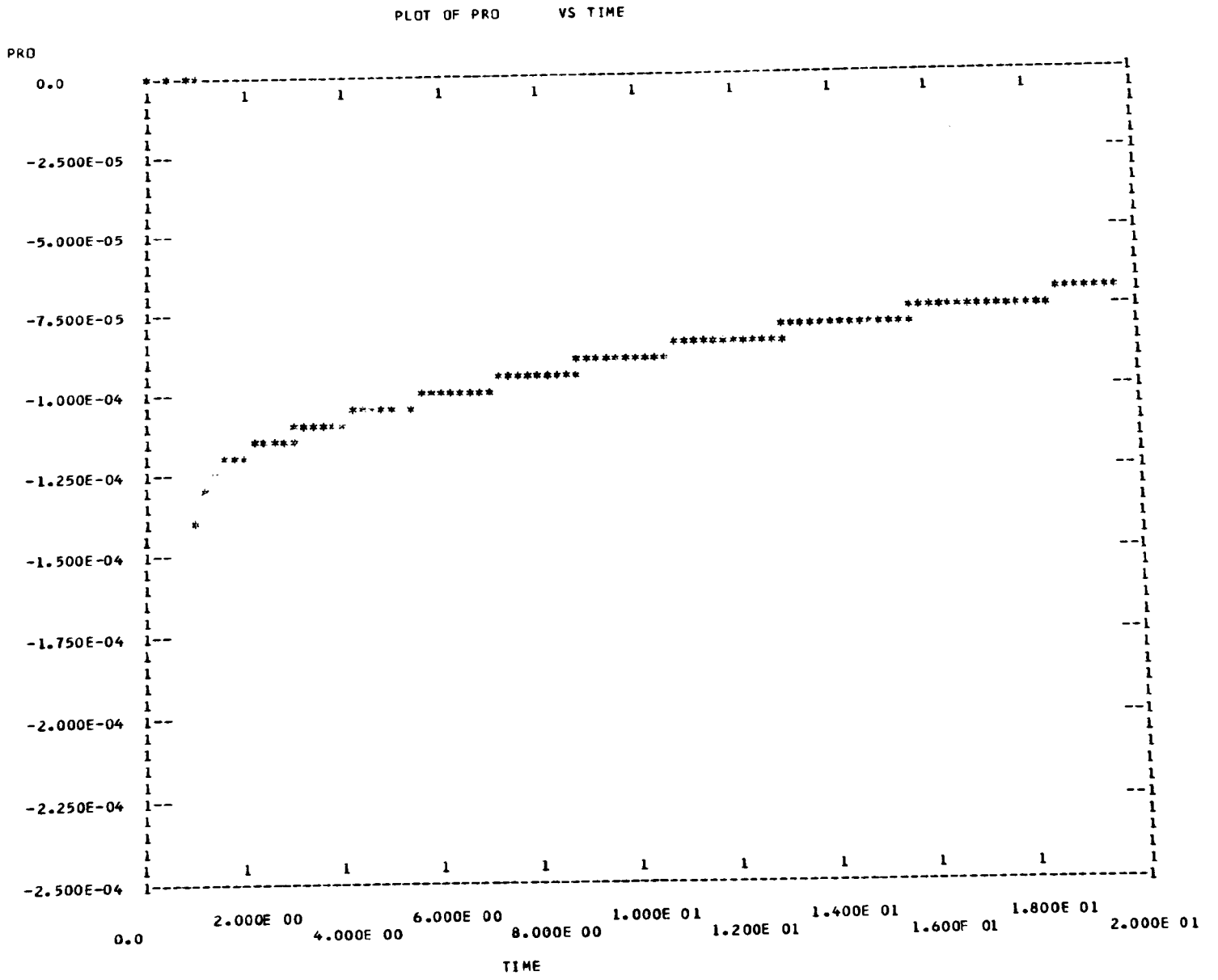
REACTOR RESPONSE

TIME	0.0	4.60000E-05	1.66000E-04	4.86000E-04	1.38200E-03	3.55800E-03	1.02140E-02
PN	1.00000E 00	1.00000E 00	1.00000E 00	1.00000E 00	1.00000E 00	1.00000E 00	1.00000E 00
PC1	1.66786E 05	1.66786E 05	1.66786E 05	1.66786E 05	1.66786E 05	1.66786E 05	1.66786E 05
PC2	4.04359E 05	4.04359E 05	4.04359E 05	4.04359E 05	4.04359E 05	4.04359E 05	4.04359E 05
PC3	1.02767E 05	1.02767E 05	1.02767E 05	1.02767E 05	1.02767E 05	1.02767E 05	1.02767E 05
PC4	8.33089E 04	8.33089E 04	8.33089E 04	8.33089E 04	8.33089E 04	8.33089E 04	8.33089E 04
PC5	6.81818E 03	6.81818E 03	6.81818E 03	6.81818E 03	6.81818E 03	6.81818E 03	6.81818E 03
PC6	6.06061E 02	6.06061E 02	6.06061E 02	6.06061E 02	6.06061E 02	6.06061E 02	6.06061E 02
PRO	0.0	-4.70411E-16	-2.25539E-15	-7.04264E-15	-2.04139E-14	-5.26853E-14	-1.49652E-13
PROFB	0.0	4.70411E-16	2.25539E-15	7.04264E-15	2.04139E-14	5.26853E-14	1.49652E-13
PHOLD1	6.45545E 04	6.45545E 04	6.45545E 04	6.45545E 04	6.45545E 04	6.45545E 04	6.45545E 04
PHH1	0.0	3.56322E-14	1.70827E-13	5.33321E-13	1.54507E-12	3.98243E-12	1.12674E-11
PHH2	0.0	2.96949E-14	1.42383E-13	4.44696E-13	1.28976E-12	3.33339E-12	9.50926E-12
PHH3	0.0	-1.18784E-15	-5.69618E-15	-1.77962E-14	-5.16608E-14	-1.33809E-13	-3.84261E-13
PHH4	0.0	1.78177E-15	8.54444E-15	2.66959E-14	7.75044E-14	2.00802E-13	5.77127E-13
PHH5	0.0	3.24679E-16	1.55701E-15	4.86484E-15	1.41252E-14	3.66050E-14	1.05285E-13
PTBL1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
XSTPSZ	2.00000E-06	8.00000E-06	1.60000E-05	6.40000E-05	1.28000E-04	5.12000E-04	1.02400E-03
DPN	2.44154E-04	1.24173E-05	4.23915E-09	-9.96806E-10	-9.76797E-10	-9.11314E-10	-4.18368E-11
DPC1	-8.18181E-07	6.78556E-06	7.19260E-06	7.19210E-06	7.19020E-06	7.18566E-06	7.17222E-06
DPC2	-6.68182E-05	-2.08041E-05	-1.83407E-05	-1.83434E-05	-1.83538E-05	-1.83789E-05	-1.84527E-05
DPC3	-1.81818E-04	-1.39393E-04	-1.37120E-04	-1.37118E-04	-1.37114E-04	-1.37104E-04	-1.37070E-04
DPC4	-4.90908E-06	8.80971E-05	9.30727E-05	9.30576E-05	9.30096E-05	9.28936E-05	9.25446E-05
DPC5	2.54545E-05	5.97171E-05	6.15412E-05	6.15115E-05	6.14262E-05	6.12198E-05	6.05944E-05
DPC6	-1.52455E-05	-6.82423E-06	-6.37051E-06	-6.36315E-06	-6.34313E-06	-6.29472E-06	-6.14869E-06

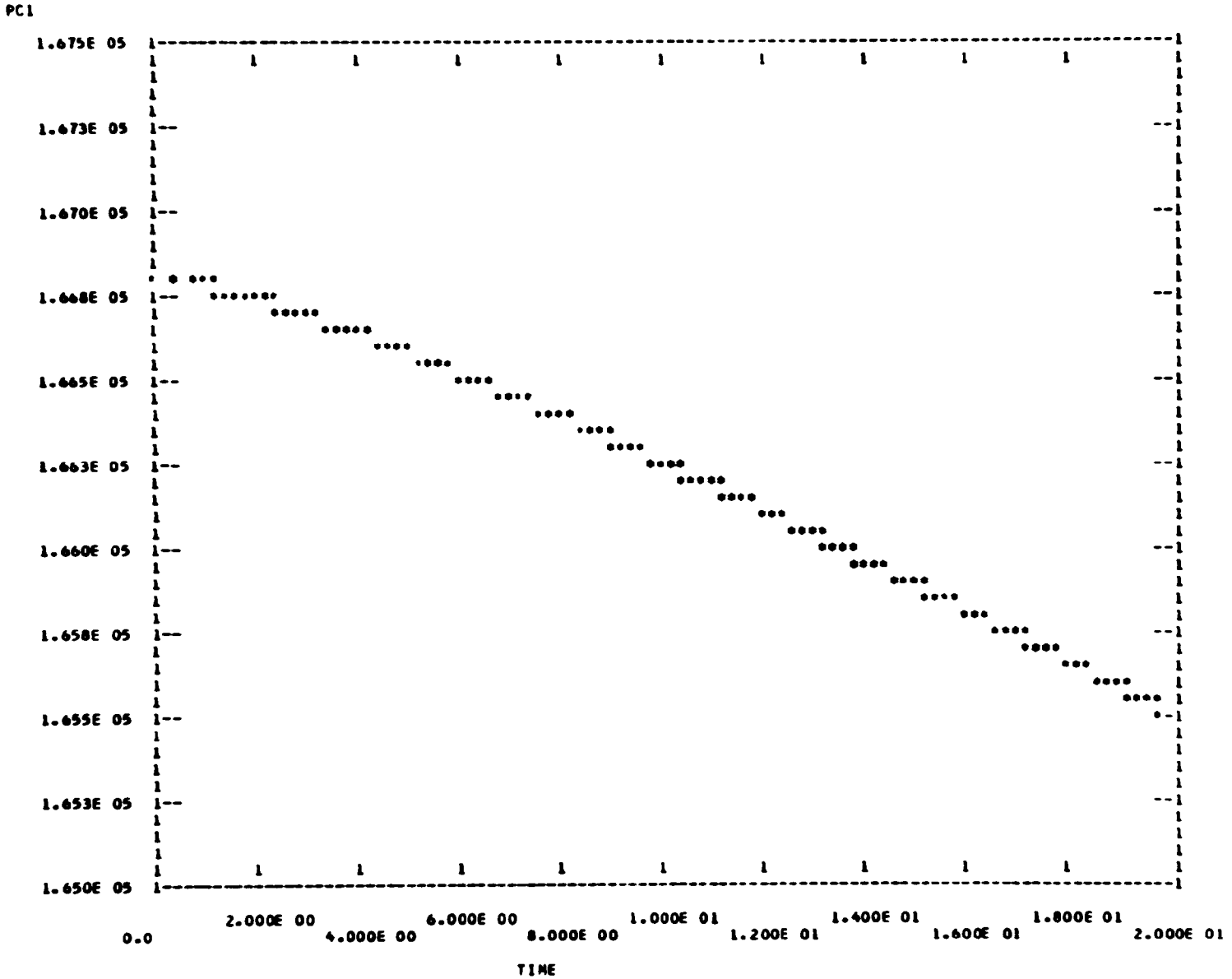
TIME	2.65980E-02	7.37020E-02	1.96582E-01	5.24262E-01	7.04486E-01	7.86406E-01	8.47846E-01
PN	1.00000E 00	1.00000E 00	1.00000E 00	1.00000E 00	9.99980E-01	1.00000E 00	1.00003E 00
PC1	1.66786E 05	1.66786E 05	1.66786E 05	1.66786E 05	1.66786E 05	1.66786E 05	1.66786E 05
PC2	4.04359E 05	4.04359E 05	4.04359E 05	4.04359E 05	4.04357E 05	4.04357E 05	4.04357E 05
PC3	1.02767E 05	1.02767E 05	1.02767E 05	1.02767E 05	1.02765E 05	1.02766E 05	1.02766E 05
PC4	8.33089E 04	8.33089E 04	8.33089E 04	8.33089E 04	8.33083E 04	8.33083E 04	8.33084E 04
PC5	6.81818E 03	6.81818E 03	6.81818E 03	6.81818E 03	6.81810E 03	6.81831E 03	6.81866E 03
PC6	6.06061E 02	6.06061E 02	6.06061E 02	6.06061E 02	6.06046E 02	6.06100E 02	6.06183E 02
PRO	-3.77581E-13	-9.57973E-13	-2.11689E-12	-1.81162E-09	2.04491E-08	1.10171E-08	-1.52165E-09
PROFB	3.77581E-13	9.57973E-13	2.11689E-12	1.81162E-09	-2.04491E-08	-1.10171E-08	1.52165E-09
PHOLD1	6.45545E 04	6.45545E 04	6.45545E 04	6.45545E 04	6.45540E 04	6.45545E 04	6.45553E 04
PHH1	2.81543E-11	6.95059E-11	1.43839E-10	1.29108E-07	-1.31974E-06	-5.89841E-07	3.55106E-07
PHH2	2.42420E-11	6.32470E-11	1.48396E-10	1.21720E-07	-1.49544E-06	-9.08978E-07	-1.09011E-07
PHH3	-9.95651E-13	-2.71986E-12	-7.14318E-12	-5.37580E-09	7.69700E-08	5.87140E-08	2.96866E-08
PHH4	1.49844E-12	4.11742E-12	1.09756E-11	8.16449E-09	-1.19186E-07	-9.34406E-08	-5.10580E-08
PHH5	2.73858E-13	7.56450E-13	2.04357E-12	1.50429E-09	-2.23419E-08	-1.79444E-08	-1.04370E-08
PTBL1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
XSTPSZ	2.04800E-03	8.19200E-03	1.63840E-02	6.55360E-02	8.19200E-03	4.09600E-03	8.19200E-03
DPN	-6.11180E-10	4.76930E-08	3.19969E-08	-1.36983E-02	9.01353E-01	-1.66053E-01	-1.17524E 00
DPC1	7.14205E-06	7.07377E-06	7.00244E-06	3.80355E-05	-3.84496E-02	1.13084E-02	6.74658E-02
DPC2	-1.86166E-05	-1.89760E-05	-1.92689E-05	1.97656E-04	-1.97810E-01	1.06241E-01	4.45528E-01
DPC3	-1.36972E-04	-1.36589E-04	-1.35016E-04	8.67631E-05	-6.98718E-02	1.82638E-01	4.94062E-01
DPC4	9.17242E-05	8.96092E-05	8.54275E-05	-5.40119E-04	-3.37883E-01	2.66753E-01	9.42649E-01
DPC5	5.90923E-05	5.50254E-05	4.58131E-05	-1.53702E-03	-7.90939E-02	-1.55524E-01	-3.84035E-01
DPC6	-5.80188E-06	-4.89982E-06	-3.23459E-06	-1.01626E-03	7.65235E-03	-1.45207E-01	-4.04262E-01

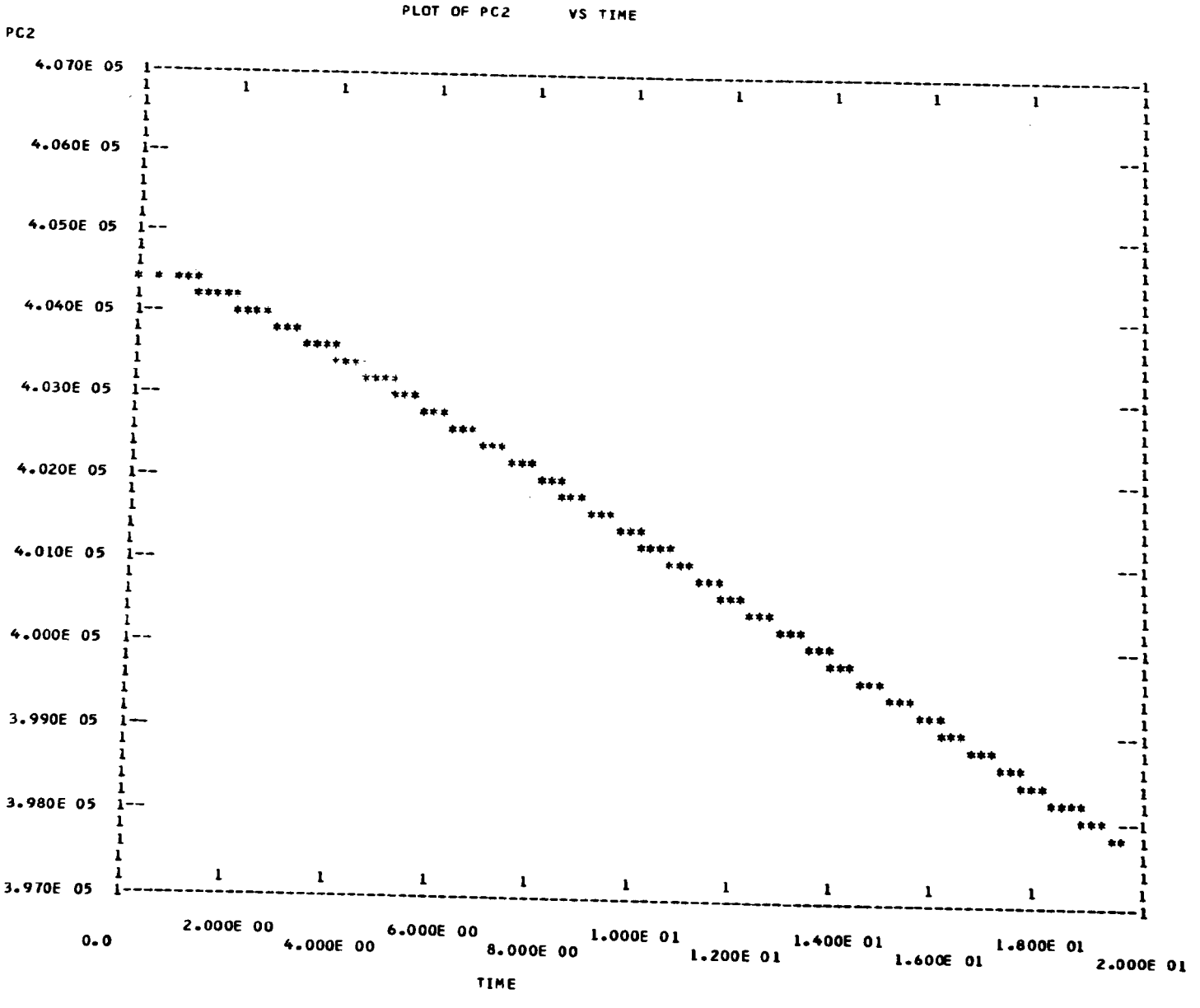
3. Printer-plotted Output

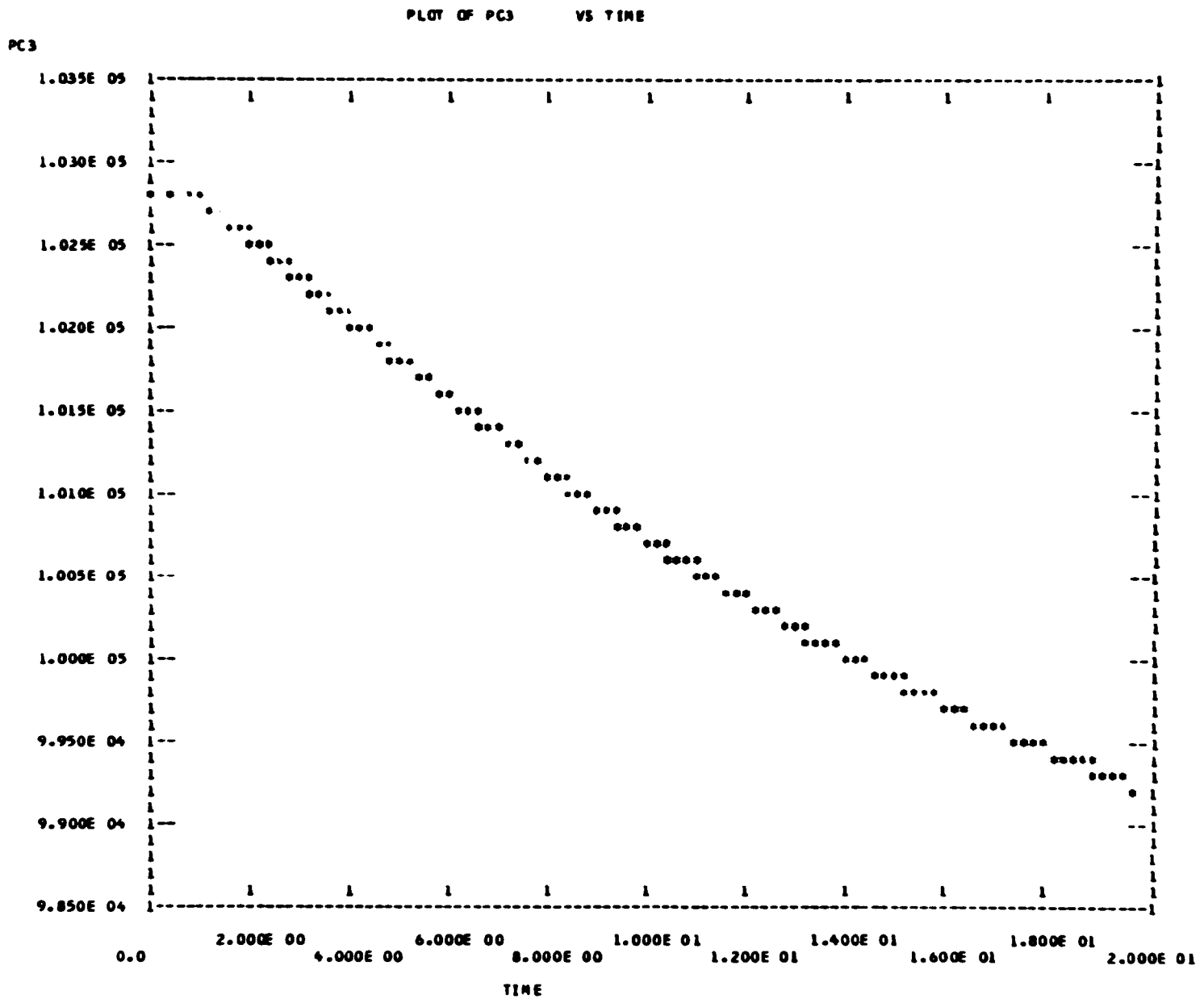



PLOT OF PRO VS TIME
PRO
0.0
-2.500E-05
-5.000E-05
-7.500E-05
-1.000E-04
-1.250E-04
-1.500E-04
-1.750E-04
-2.000E-04
-2.250E-04
-2.500E-04
0.0
2.000E 00
4.000E 00
6.000E 00
8.000E 00
1.000E 01
1.200E 01
1.400E 01
1.600F 01
1.800E 01
2.000E 01
TIME

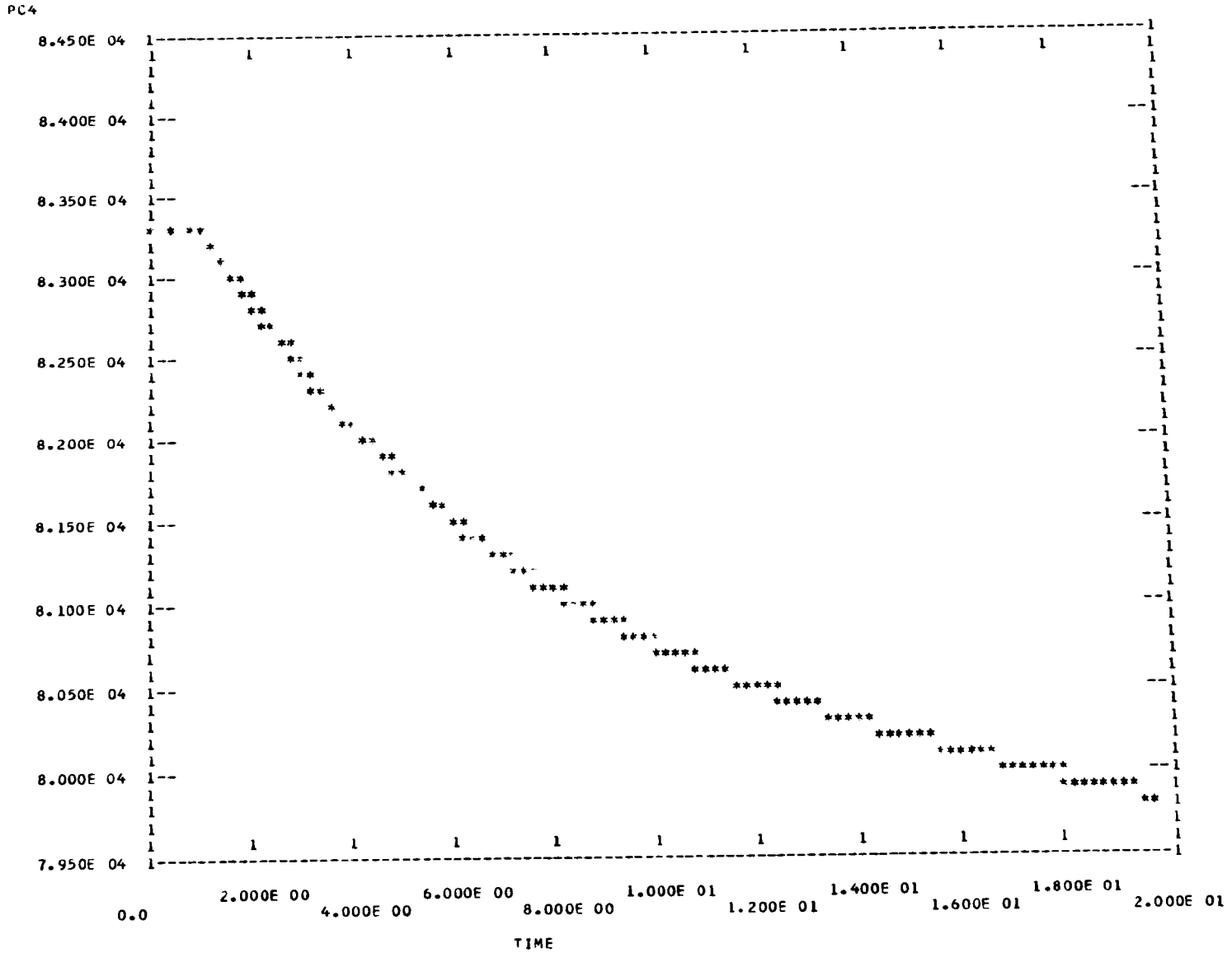
PLOT OF PC1 VS TIME

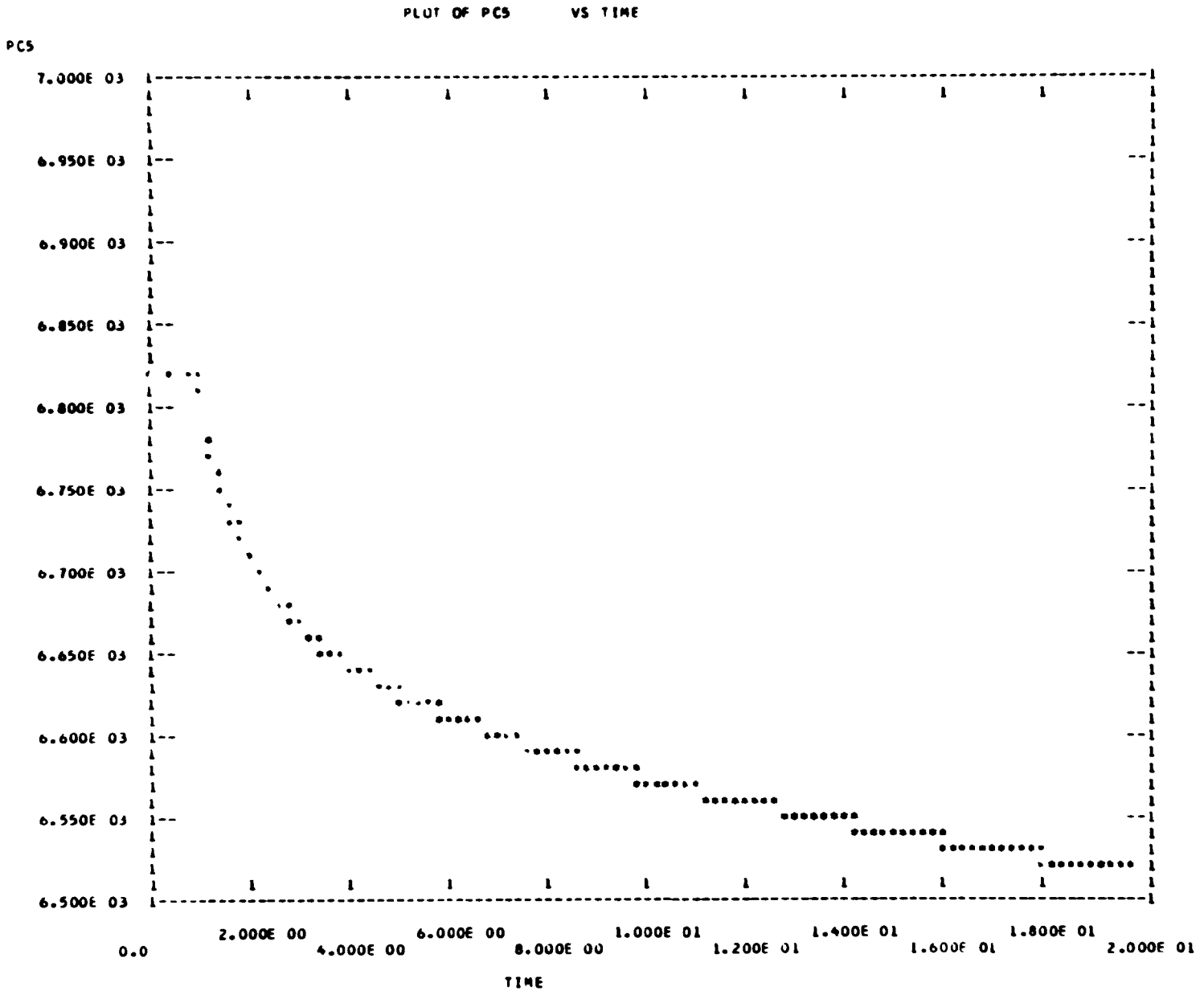


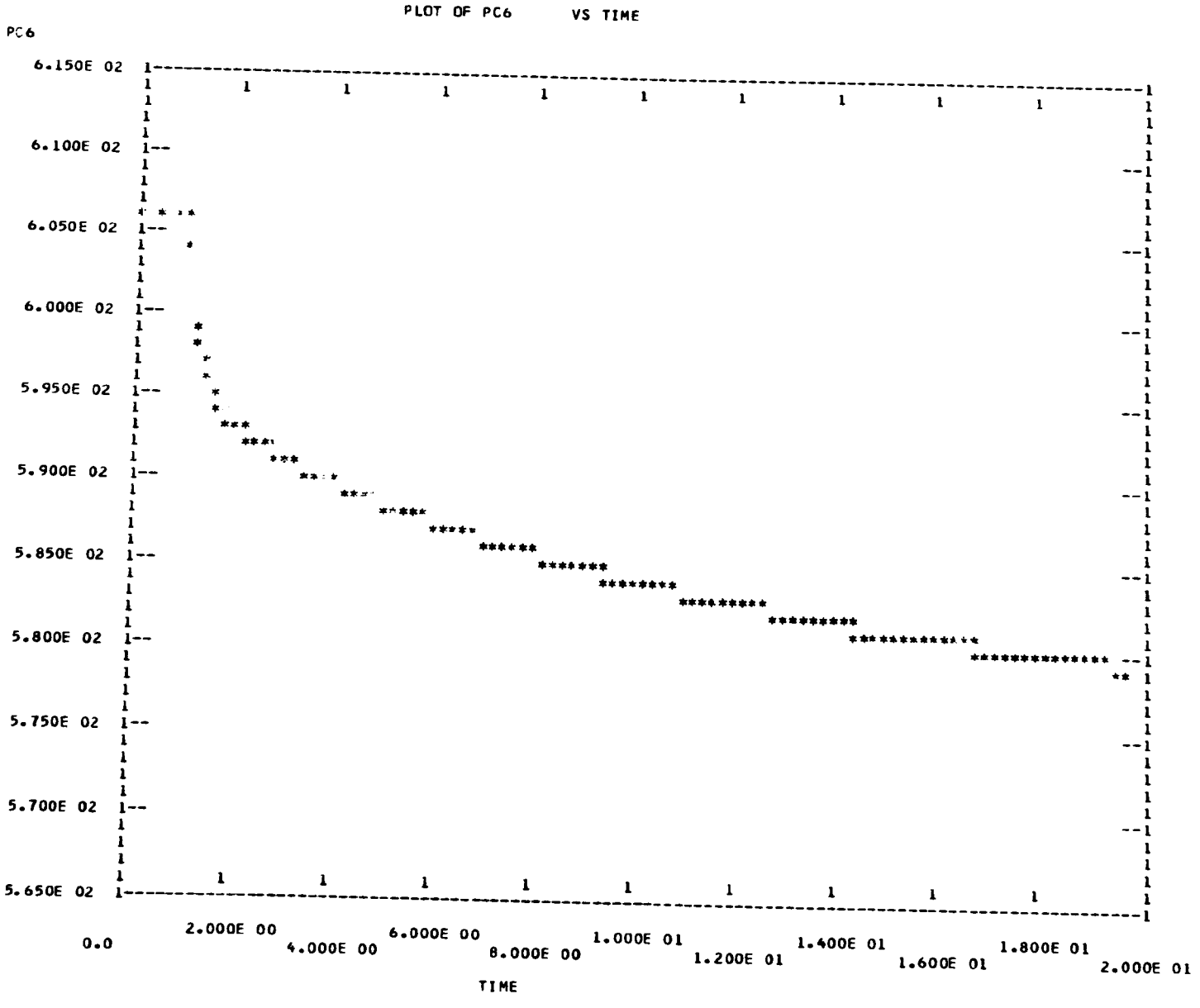

PLOT OF PC2 VS TIME
PC2
4.070E 05
4.060E 05
4.050E 05
4.040E 05
4.030E 05
4.020E 05
4.010E 05
4.000E 05
3.990E 05
3.980E 05
3.970E 05
0.0
2.000E 00
4.000E 00
6.000E 00
8.000E 00
1.000E 01
1.200E 01
1.400E 01
1.600E 01
1.800E 01
2.000E 01
TIME


PLOT OF PC3 VS TIME
PC3
1.035E 05
1.030E 05
1.025E 05
1.020E 05
1.015E 05
1.010E 05
1.005E 05
1.000E 05
9.950E 04
9.900E 04
9.850E 04
0.0
2.000E 00
4.000E 00
6.000E 00
8.000E 00
1.000E 01
1.200E 01
1.400E 01
1.600E 01
1.800E 01
2.000E 01
TIME

PLOT OF PC4 VS TIME




PLOT OF PC5 VS TIME
PC5
7.000E 03
6.950E 03
6.900E 03
6.850E 03
6.800E 03
6.750E 03
6.700E 03
6.650E 03
6.600E 03
6.550E 03
6.500E 03
0.0
2.000E 00
4.000E 00
6.000E 00
8.000E 00
1.000E 01
1.200E 01
1.400E 01
1.600E 01
1.800E 01
2.000E 01
TIME


PLOT OF PC6 VS TIME
PC6
6.150E 02
6.100E 02
6.050E 02
6.000E 02
5.950E 02
5.900E 02
5.850E 02
5.800E 02
5.750E 02
5.700E 02
5.650E 02
0.0
2.000E 00
4.000E 00
6.000E 00
8.000E 00
1.000E 01
1.200E 01
1.400E 01
1.600E 01
1.800E 01
2.000E 01
TIME

APPENDIX B

CSMP Output

1. Input Program

```
$$$CONTINUOUS SYSTEM MODELING PROGRAM  III   V1M1   TRANSLATOR OUTPUT$$$

      INITIAL
         DUM=0.0
         DC1=0.0
         DC2=0.0
         DC3=0.0
         DC4=0.0
         DC5=0.0
         DC6=0.0
         RO=0.0
         ROFB=0.0
         M1=0.0
         M2=0.0
         M3=0.0
         M4=0.0
         M5=0.0
         MM1=0.0
         MM2=0.0
         MM3=0.0
         MM4=0.0
         MM5=0.0
         C1=166785.9699
         C2=404359.0479
         C3=102766.7985
         C4=83308.97398
         C5=6818.181818
         C6=606.0606061
      FUNCTION TABLE1=(0.0,0.0),(1.0,0.0),(1.000005,1.),(30.,1.)
      PARAMETER BETA=.007101, BETA1=.000233, BETA2=.00141,...
                BETA3=.00130, BETA4=.00285, BETA5=.00105,...
                BETA6=.000258
      PARAMETER LAM1=0.0127, LAM2=0.0317, LAM3=0.115,...
                LAM4=0.311, LAM5=1.40, LAM6=3.87
      PARAMETER TAU1=0.2, TAU2=0.4, TAU3=2.0, TAU4=4.0,TAU5=36.0
      PARAMETER A1=0.06, A2=0.10, A3=-0.02, A4=0.06, A5=0.0984
      PARAMETER L=1.1E-07
      PARAMETER K=-.00014202
      PARAMETER NZERO=1.0
      PARAMETER NO=1.0
      INCON N=1.0
      INCON DC10=166785.9699
      INCON DC20=404359.0479
      INCON DC30=102766.7985
      INCON DC40=83308.97398
      INCON DC50=6818.181818
      INCON DC60=606.0606061
      DYNAMIC
          SORT
      DUM=AFGEN(TABLE1,TIME)
      RO=K*DUM-ROFB
      HOLD1=(LAM1*C1+LAM2*C2+LAM3*C3+LAM4*C4+...
             LAM5*C5+LAM6*C6)
      DN=((RO-BETA)*N/L+HOLD1)
      DC1=(BETA1*N/L-LAM1*C1)
      DC2=(BETA2*N/L-LAM2*C2)
      DC3=(BETA3*N/L-LAM3*C3)
      DC4=(BETA4*N/L-LAM4*C4)
      DC5=(BETA5*N/L-LAM5*C5)
      DC6=(BETA6*N/L-LAM6*C6)
```

```
N=INTGRL(NO,DN)
C1=INTGRL(DC10,DC1)
C2=INTGRL(DC20,DC2)
C3=INTGRL(DC30,DC3)
C4=INTGRL(DC40,DC4)
C5=INTGRL(DC50,DC5)
C6=INTGRL(DC60,DC6)
T=TIME
NOSORT
H1=FSOL(N,TAU1,NZERO,1.,T)
H2=FSOL(N,TAU2,NZERO,2.,T)
H3=FSOL(N,TAU3,NZERO,3.,T)
H4=FSOL(N,TAU4,NZERO,4.,T)
H5= FSOL(N,TAU5,NZERO,5.,T)
SORT
HH1=A1*H1/TAU1
HH2=A2*H2/TAU2
HH3=A3*H3/TAU3
HH4=A4*H4/TAU4
HH5=A5*H5/TAU5
ROFB=(HH1+HH2+HH3+HH4+HH5)*BETA
TERMINAL
TIMER FINTIM=20.0,PRDEL=.1,OUTDEL=.1,DELT=.00001
   METHOD RKS
LABEL CSMP/ DOUBLE PERCISION RKS INTEGRATION
PRINT N,RO,ROFB,C1,C2,C3,C4,C5,C6
 TITLE REACTOR RESPONCE

OUTPUT N,RO,ROFB
LABEL REACTOR RESPONCE TO ROD DROP N   RO   ROFB
OUTPUT C1,C2,C3
LABEL REACTOR RESPONCE TO ROD DROP  C1   C2   C3
OUTPUT C4,C5,C6
LABEL REACTOR RESPONCE TO ROD DROP   C4   C5   C6

ABSERR N=.0002
RELERR N=.0004

END
STOP
```

```
OUTPUT VARIABLE SEQUENCE
DUM    DC1    DC2    DC3    DC4    DC5    DC6    RO     ROFB   H1
H2     H3     H4     H5     HH1    HH2    HH3    HH4    HH5    C1
C2     C3     C4     C5     C6     DUM    RO     HOLD1  DN     N
DC1    C1     DC2    C2     DC3    C3     DC4    C4     DC5    C5
DC6    C6     T      H1     H2     H3     H4     H5     HH1    HH2
HH3    HH4    HH5    ROFB
```

```
$$$ TRANSLATION TABLE CONTENTS $$$        CURRENT          MAXIMUM

  MACRO AND STATEMENT OUTPUTS              60                1200
  STATEMENT INPUT WORK AREA               139                3800
  INTEGRATORS+MEMORY BLOCK OUTPUTS          7 +  0            300
  PARAMETERS+FUNCTION GENERATORS           38 +  1            400
  STORAGE VARIABLES+INTEGRATOR ARRAYS       0 +  0/2           50
  HISTORY AND MEMORY BLOCK NAMES           21                  50
  MACRO DEFINITIONS AND NESTED MACROS       6                 126
  MACRO STATEMENT STORAGE                  13                 200
  LITERAL CONSTANT STORAGE                  0                 100
  SORT SECTIONS                             3                  20
  MAXIMUM STATEMENTS IN SECTION            25                 987

      FUNCTION FSOL(PN,TAUI,PNO,AK,TIME)
      COMMON /HLP/FSAVE(5),TSAVE,PNSAVE,KFIRST
      K=AK
      IF(KFIRST.EQ.1) GO TO 10
      KFIRST= 1
      FSOL= 0.
      TSAVE=TIME
      DO 5 K=1,5
5     FSAVE(K)= 0.
      PNSAVE= PN
      GO TO 100
10    FSOL = FSAVE(K)* EXP((TSAVE-TIME)/TAUI)+
     $((PNSAVE-PNO)* EXP(-(TIME-TSAVE)/TAUI)+PN-PNO)/2.)
     $*(TIME-TSAVE)
      FSAVE(K)=FSOL
      IF(K.NE.5) GO TO 100
      PNSAVE=PN
      TSAVE=TIME
100   CONTINUE
      RETURN
      END


$$$END OF TRANSLATOR OUTPUT$$$
```

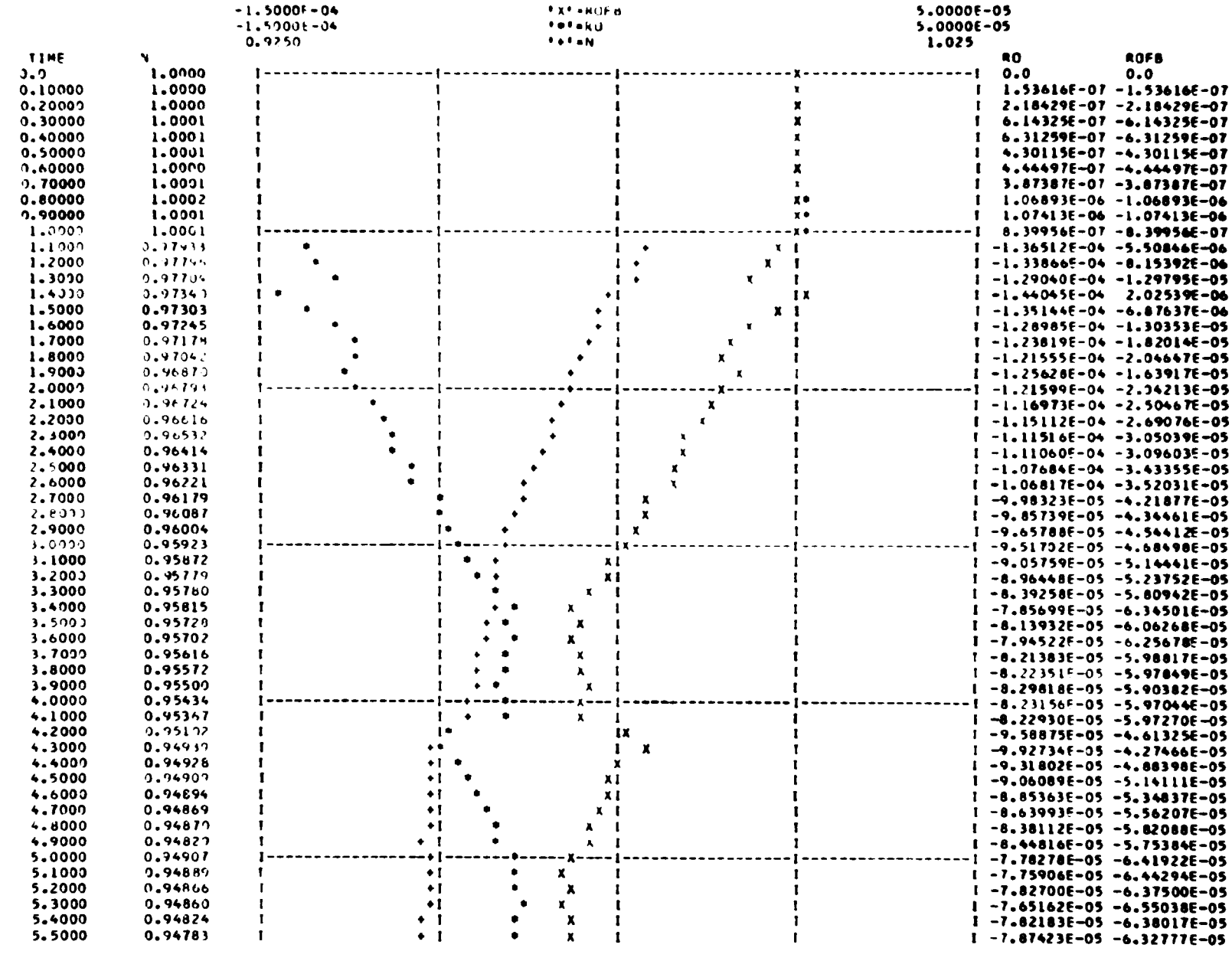
2. Printed Output

REACTOR RESPONCE

TIME	N	RO	ROFB	C1	C2	C3	C4	C5	C6
0.0	1.0000	0.0	0.0	1.66786E 05	4.04359E 05	1.02767E 05	83309.	6818.2	606.06
1.0000000-01	1.0000	1.53616E-07	-1.53616E-07	1.66786E 05	4.04359E 05	1.02767E 05	83309.	6818.2	606.06
0.200000	1.0000	2.18429E-07	-2.18429E-07	1.66786E 05	4.04359E 05	1.02767E 05	83309.	6818.2	606.06
0.300000	1.0001	6.14325E-07	-6.14325E-07	1.66786E 05	4.04359E 05	1.02767E 05	83309.	6818.2	606.06
0.400000	1.0001	6.31259E-07	-6.31259E-07	1.66786E 05	4.04359E 05	1.02767E 05	83309.	6818.2	606.06
0.500000	1.0001	4.30115E-07	-4.30115E-07	1.66786E 05	4.04359E 05	1.02767E 05	83309.	6818.2	606.06
0.600000	1.0000	4.44497E-07	-4.44497E-07	1.66786E 05	4.04359E 05	1.02767E 05	83309.	6818.2	606.06
0.700000	1.0001	3.87387E-07	-3.87387E-07	1.66786E 05	4.04359E 05	1.02767E 05	83309.	6818.2	606.06
0.800000	1.0002	1.06893E-06	-1.06893E-06	1.66786E 05	4.04359E 05	1.02767E 05	83309.	6818.2	606.06
0.900000	1.0001	1.07413E-06	-1.07413E-06	1.66786E 05	4.04359E 05	1.02767E 05	83309.	6818.2	606.06
1.00000	1.0001	8.39956E-07	-8.39956E-07	1.66786E 05	4.04359E 05	1.02767E 05	83309.	6818.2	606.06
1.10000	0.97933	-1.36512E-04	-5.50846E-06	1.66786E 05	4.04212E 05	1.02620E 05	83153.	6794.9	601.94
1.20000	0.97796	-1.33866E-04	-8.15392E-06	1.66786E 05	4.04068E 05	1.02476E 05	82995.	6771.9	598.90
1.30000	0.97704	-1.29040E-04	-1.29795E-05	1.66783E 05	4.03916E 05	1.02324E 05	82841.	6754.6	596.61
1.40000	0.97340	-1.44045E-04	2.02539E-06	1.66783E 05	4.03766E 05	1.02177E 05	82670.	6739.1	594.79
1.50000	0.97303	-1.35144E-04	-6.87637E-06	1.66783E 05	4.03608E 05	1.02028E 05	82511.	6720.4	593.02
1.60000	0.97245	-1.28985E-04	-1.30353E-05	1.66783E 05	4.03451E 05	1.01894E 05	82354.	6707.0	591.63
1.70000	0.97178	-1.23819E-04	-1.82014E-05	1.66783E 05	4.03298E 05	1.01753E 05	82202.	6693.7	590.75
1.80000	0.97042	-1.21555E-04	-2.04647E-05	1.66782E 05	4.03128E 05	1.01606E 05	82032.	6678.2	589.78
1.90000	0.96870	-1.25628E-04	-1.63917E-05	1.66763E 05	4.02984E 05	1.01462E 05	81887.	6667.4	588.89
2.00000	0.96793	-1.21599E-04	-2.04213E-05	1.66723E 05	4.02829E 05	1.01342E 05	81733.	6655.2	588.12
2.10000	0.96724	-1.16973E-04	-2.50467E-05	1.66721E 05	4.02677E 05	1.01190E 05	81582.	6645.5	587.51
2.20000	0.96616	-1.15112E-04	-2.69076E-05	1.66679E 05	4.02523E 05	1.01069E 05	81429.	6633.2	586.74
2.30000	0.96532	-1.11516E-04	-3.05039E-05	1.66646E 05	4.02374E 05	1.00944E 05	81280.	6622.0	586.03
2.40000	0.96414	-1.11060E-04	-3.09603E-05	1.66606E 05	4.02220E 05	1.00822E 05	81126.	6612.3	585.28
2.50000	0.96331	-1.07684E-04	-3.43355E-05	1.66605E 05	4.02070E 05	1.00672E 05	80976.	6602.8	584.69
2.60000	0.96221	-1.06817E-04	-3.52031E-05	1.66540E 05	4.01908E 05	1.00539E 05	80842.	6592.7	584.06
2.70000	0.96179	-9.98323E-05	-4.21877E-05	1.66460E 05	4.01751E 05	1.00388E 05	80691.	6582.9	583.48
2.80000	0.96087	-9.85739E-05	-4.34461E-05	1.66434E 05	4.01604E 05	1.00261E 05	80564.	6573.4	582.88
2.90000	0.96004	-9.65788E-05	-4.54412E-05	1.66381E 05	4.01445E 05	1.00146E 05	80450.	6563.4	582.26
3.00000	0.95923	-9.51702E-05	-4.68498E-05	1.66303E 05	4.01288E 05	99995.	80368.	6553.6	581.65
3.10000	0.95872	-9.05759E-05	-5.14441E-05	1.66301E 05	4.01136E 05	99867.	80241.	6544.4	581.15
3.20000	0.95779	-8.96448E-05	-5.23752E-05	1.66299E 05	4.00985E 05	99747.	80120.	6536.8	580.62
3.30000	0.95780	-8.39258E-05	-5.80942E-05	1.66198E 05	4.00831E 05	99645.	80044.	6532.1	580.38
3.40000	0.95815	-7.85699E-05	-6.34501E-05	1.66193E 05	4.00681E 05	99518.	80039.	6532.1	580.38
3.50000	0.95728	-8.13932E-05	-6.06268E-05	1.66144E 05	4.00526E 05	99398.	79990.	6530.7	580.29
3.60000	0.95702	-7.94522E-05	-6.25678E-05	1.66078E 05	4.00360E 05	99332.	79946.	6528.1	580.08
3.70000	0.95616	-8.21383E-05	-5.98817E-05	1.65989E 05	4.00204E 05	99243.	79903.	6523.2	579.62
3.80000	0.95572	-8.22351E-05	-5.97849E-05	1.65985E 05	4.00054E 05	99117.	79898.	6519.7	579.27
3.90000	0.95500	-8.29818E-05	-5.90382E-05	1.65930E 05	3.99899E 05	99062.	79842.	6516.2	578.92
4.00000	0.95434	-8.23156E-05	-5.97044E-05	1.65826E 05	3.99744E 05	98958.	79772.	6510.6	578.54
4.10000	0.95367	-8.22930E-05	-5.97270E-05	1.65729E 05	3.99591E 05	98861.	79708.	6506.8	578.18
4.20000	0.95102	-9.58875E-05	-4.61325E-05	1.65648E 05	3.99433E 05	98779.	79626.	6498.4	577.48
4.30000	0.94939	-9.92734E-05	-4.27466E-05	1.65622E 05	3.99280E 05	98654.	79501.	6489.1	576.85
4.40000	0.94928	-9.31802E-05	-4.88398E-05	1.65589E 05	3.99130E 05	98527.	79410.	6480.1	576.15
4.50000	0.94909	-9.06089E-05	-5.14111E-05	1.65544E 05	3.98975E 05	98482.	79365.	6475.6	575.55
4.60000	0.94894	-8.85363E-05	-5.34837E-05	1.65500E 05	3.98820E 05	98438.	79321.	6473.1	575.22
4.70000	0.94869	-8.63993E-05	-5.56207E-05	1.65445E 05	3.98664E 05	98382.	79266.	6471.4	575.06
4.80000	0.94870	-8.38112E-05	-5.82088E-05	1.65387E 05	3.98511E 05	98324.	79231.	6470.7	574.99
4.90000	0.94829	-8.44816E-05	-5.75384E-05	1.65297E 05	3.98356E 05	98234.	79229.	6468.9	574.78
5.00000	0.94907	-7.78278E-05	-6.41922E-05	1.65226E 05	3.98206E 05	98218.	79227.	6468.8	574.78
5.10000	0.94889	-7.75906E-05	-6.44294E-05	1.65169E 05	3.98052E 05	98162.	79227.	6468.8	574.78
5.20000	0.94866	-7.82700E-05	-6.37500E-05	1.65119E 05	3.97895E 05	98111.	79217.	6468.8	574.78
5.30000	0.94860	-7.65162E-05	-6.55038E-05	1.65098E 05	3.97741E 05	98091.	79197.	6468.8	574.78
5.40000	0.94824	-7.82183E-05	-6.38017E-05	1.65089E 05	3.97592E 05	98082.	79188.	6468.4	574.77
5.50000	0.94783	-7.87423E-05	-6.32777E-05	1.65002E 05	3.97438E 05	98075.	79186.	6466.6	574.59
5.60000	0.94775	-7.97747E-05	-6.22453E-05	1.64984E 05	3.97286E 05	98057.	79168.	6465.2	574.42

3. Printer-plotted Output: RKS

CSMP/ DOUBLE PERCISION RKS INTEGRATION
REACTOR RESPONCE TO ROD DROP N RO ROFB



TIME	N	RO	ROFB
0.0	1.0000	0.0	0.0
0.10000	1.0000	1.53616E-07	-1.53616E-07
0.20000	1.0000	2.18429E-07	-2.18429E-07
0.30000	1.0001	6.14325E-07	-6.14325E-07
0.40000	1.0001	6.31259E-07	-6.31259E-07
0.50000	1.0001	4.30115E-07	-4.30115E-07
0.60000	1.0000	4.44497E-07	-4.44497E-07
0.70000	1.0001	3.87387E-07	-3.87387E-07
0.80000	1.0002	1.06893E-06	-1.06893E-06
0.90000	1.0001	1.07413E-06	-1.07413E-06
1.0000	1.0001	8.39956E-07	-8.39956E-07
1.1000	0.97933	-1.36512E-04	-5.50846E-06
1.2000	0.97795	-1.33866E-04	-8.15392E-06
1.3000	0.97704	-1.29040E-04	-1.29795E-05
1.4000	0.97343	-1.44045E-04	2.02539E-06
1.5000	0.97303	-1.35144E-04	-6.87637E-06
1.6000	0.97245	-1.28985E-04	-1.30353E-05
1.7000	0.97178	-1.23819E-04	-1.82014E-05
1.8000	0.97042	-1.21555E-04	-2.04647E-05
1.9000	0.96870	-1.25628E-04	-1.63917E-05
2.0000	0.96793	-1.21599E-04	-2.04213E-05
2.1000	0.96724	-1.16973E-04	-2.50467E-05
2.2000	0.96616	-1.15112E-04	-2.69076E-05
2.3000	0.96532	-1.11516E-04	-3.05039E-05
2.4000	0.96414	-1.11060E-04	-3.09603E-05
2.5000	0.96331	-1.07684E-04	-3.43355E-05
2.6000	0.96221	-1.06817E-04	-3.52031E-05
2.7000	0.96179	-9.98323E-05	-4.21877E-05
2.8000	0.96087	-9.85739E-05	-4.34461E-05
2.9000	0.96004	-9.65788E-05	-4.54412E-05
3.0000	0.95923	-9.51702E-05	-4.68498E-05
3.1000	0.95872	-9.05759E-05	-5.14441E-05
3.2000	0.95779	-8.96448E-05	-5.23752E-05
3.3000	0.95760	-8.39258E-05	-5.80942E-05
3.4000	0.95815	-7.85699E-05	-6.34501E-05
3.5000	0.95728	-8.13932E-05	-6.06268E-05
3.6000	0.95702	-7.94522E-05	-6.25678E-05
3.7000	0.95616	-8.21383E-05	-5.98817E-05
3.8000	0.95572	-8.22351E-05	-5.97849E-05
3.9000	0.95500	-8.29818E-05	-5.90382E-05
4.0000	0.95434	-8.23156E-05	-5.97044E-05
4.1000	0.95367	-8.22930E-05	-5.97270E-05
4.2000	0.95192	-9.58875E-05	-4.61325E-05
4.3000	0.94939	-9.92734E-05	-4.27466E-05
4.4000	0.94928	-9.31802E-05	-4.88398E-05
4.5000	0.94909	-9.06089E-05	-5.14111E-05
4.6000	0.94894	-8.85363E-05	-5.34837E-05
4.7000	0.94869	-8.63993E-05	-5.56207E-05
4.8000	0.94870	-8.38112E-05	-5.82088E-05
4.9000	0.94829	-8.44816E-05	-5.75384E-05
5.0000	0.94907	-7.78278E-05	-6.41922E-05
5.1000	0.94889	-7.75906E-05	-6.44294E-05
5.2000	0.94866	-7.82700E-05	-6.37500E-05
5.3000	0.94860	-7.65162E-05	-6.55038E-05
5.4000	0.94824	-7.82183E-05	-6.38017E-05
5.5000	0.94783	-7.87423E-05	-6.32777E-05

5.7000	0.94733	-7.87523E-05	-6.32677E-05
5.8000	0.94668	-8.19346E-05	-6.00854E-05
5.9000	0.94675	-7.88358E-05	-6.31842E-05
6.0000	0.94640	-7.77176E-05	-6.43024E-05
6.1000	0.94613	-7.68738E-05	-6.51462E-05
6.2000	0.94575	-7.84458E-05	-6.35742E-05
6.3000	0.94561	-7.62587E-05	-6.57613E-05
6.4000	0.94540	-7.50091E-05	-6.70109E-05
6.5000	0.94541	-7.39004E-05	-6.81196E-05
6.6000	0.94472	-7.75798E-05	-6.44402E-05
6.7000	0.94458	-7.78819E-05	-6.41381E-05
6.8000	0.94472	-7.61018E-05	-6.59182E-05
6.9000	0.94454	-7.58184E-05	-6.62016E-05
7.0000	0.94430	-7.59340E-05	-6.60860E-05
7.1000	0.94416	-7.37201E-05	-6.82999E-05
7.2000	0.94425	-7.19178E-05	-7.01022E-05
7.3000	0.94358	-7.53615E-05	-6.66585E-05
7.4000	0.94312	-7.44276E-05	-6.75924E-05
7.5000	0.94318	-7.29522E-05	-6.90678E-05
7.6000	0.94325	-7.14979E-05	-7.05221E-05
7.7000	0.94330	-6.93606E-05	-7.26594E-05
7.8000	0.94325	-6.84063E-05	-7.36137E-05
7.9000	0.94327	-6.73767E-05	-7.46433E-05
8.0000	0.94273	-7.02349E-05	-7.17851E-05
8.1000	0.94188	-7.49077E-05	-6.71123E-05
8.2000	0.94220	-7.15084E-05	-7.05116E-05
8.3000	0.94196	-7.02315E-05	-7.17885E-05
8.4000	0.94213	-6.79810E-05	-7.40390E-05
8.5000	0.94216	-6.71067E-05	-7.49133E-05
8.6000	0.94191	-6.84028E-05	-7.36172E-05
8.7000	0.94168	-6.69998E-05	-7.50202E-05
8.8000	0.94174	-6.55465E-05	-7.64735E-05
8.9000	0.94297	-5.53866E-05	-8.66334E-05
9.0000	0.94281	-5.58950E-05	-8.61250E-05
9.1000	0.94307	-5.33954E-05	-8.86246E-05
9.2000	0.94295	-5.35730E-05	-8.84470E-05
9.3000	0.94281	-5.41193E-05	-8.79007E-05
9.4000	0.94326	-4.99203E-05	-9.20997E-05
9.5000	0.94367	-4.63176E-05	-9.57024E-05
9.6000	0.94359	-4.63667E-05	-9.56533E-05
9.7000	0.94317	-4.89071E-05	-9.31129E-05
9.8000	0.94301	-5.04089E-05	-9.16111E-05
9.9000	0.94278	-5.07474E-05	-9.12726E-05
10.000	0.94348	-4.48514E-05	-9.71686E-05
10.100	0.94288	-4.88332E-05	-9.31868E-05
10.200	0.94275	-4.93012E-05	-9.27188E-05
10.300	0.94289	-4.76229E-05	-9.43971E-05
10.400	0.94443	-3.55672E-05	-1.06453E-04
10.500	0.94395	-3.86387E-05	-1.03381E-04
10.600	0.94308	-4.46468E-05	-9.73732E-05
10.700	0.94331	-4.23472E-05	-9.96728E-05
10.800	0.94277	-4.57361E-05	-9.62839E-05
10.900	0.94291	-4.40902E-05	-9.79298E-05
11.000	0.94258	-4.59736E-05	-9.60464E-05
11.100	0.94278	-4.41797E-05	-9.78403E-05
11.200	0.94237	-4.63359E-05	-9.56841E-05
11.300	0.94222	-4.69069E-05	-9.51131E-05
11.400	0.94314	-4.00930E-05	-1.01927E-04
11.500	0.94259	-4.28713E-05	-9.91487E-05
11.600	0.94239	-4.31215E-05	-9.88985E-05
11.700	0.94244	-4.28293E-05	-9.91907E-05
11.800	0.94138	-4.99723E-05	-9.20477E-05
11.900	0.94112	-5.02367E-05	-9.17833E-05

12.000	0.94051	-5.07473E-05	-9.12727E-05
12.100	0.93998	-5.43696E-05	-8.76504E-05
12.200	0.93962	-5.31700E-05	-8.88500E-05
12.300	0.93779	-6.41323E-05	-7.78877E-05
12.400	0.93745	-6.08745E-05	-8.11455E-05
12.500	0.93720	-5.70748E-05	-8.49452E-05
12.600	0.93699	-5.66183E-05	-8.54017E-05
12.700	0.93673	-5.45416E-05	-8.74784E-05
12.800	0.93655	-5.30943E-05	-8.89257E-05
12.900	0.93929	-3.17066E-05	-1.10313E-04
13.000	0.93958	-2.89983E-05	-1.13022E-04
13.100	0.93898	-3.34487E-05	-1.08571E-04
13.200	0.93842	-3.68126E-05	-1.05207E-04
13.300	0.93814	-3.84348E-05	-1.03585E-04
13.400	0.93836	-3.61634E-05	-1.05857E-04
13.500	0.94040	-2.03300E-05	-1.21690E-04
13.600	0.93967	-2.55078E-05	-1.16512E-04
13.700	0.93875	-3.17311E-05	-1.10289E-04
13.800	0.93879	-3.10621E-05	-1.10958E-04
13.900	0.93835	-3.36851E-05	-1.08335E-04
14.000	0.93800	-3.57280E-05	-1.06292E-04
14.100	0.93770	-3.74363E-05	-1.04584E-04
14.200	0.93745	-3.88148E-05	-1.03205E-04
14.300	0.93726	-3.93399E-05	-1.02680E-04
14.400	0.93491	-5.34915E-05	-8.85285E-05
14.500	0.93477	-5.19280E-05	-9.00920E-05
14.600	0.93306	-6.08215E-05	-8.11985E-05
14.700	0.93300	-5.41079E-05	-8.79121E-05
14.800	0.93308	-5.02937E-05	-9.17263E-05
14.900	0.93239	-5.31034E-05	-8.89166E-05
15.000	0.93222	-5.04623E-05	-9.15577E-05
15.100	0.93257	-4.67643E-05	-9.52557E-05
15.200	0.93246	-4.66531E-05	-9.53669E-05
15.300	0.93241	-4.51320E-05	-9.68880E-05
15.400	0.93370	-3.47740E-05	-1.07246E-04
15.500	0.93572	-1.89357E-05	-1.23084E-04
15.600	0.93479	-2.57437E-05	-1.16276E-04
15.700	0.93432	-2.87132E-05	-1.13307E-04
15.800	0.93390	-3.25531E-05	-1.09467E-04
15.900	0.93360	-3.33571E-05	-1.08663E-04
16.000	0.93442	-2.66202E-05	-1.15400E-04
16.100	0.93395	-2.98591E-05	-1.12161E-04
16.200	0.93429	-2.69324E-05	-1.15088E-04
16.300	0.93367	-2.96615E-05	-1.12358E-04
16.400	0.93445	-2.48541E-05	-1.17166E-04
16.500	0.93475	-2.22214E-05	-1.19799E-04
16.600	0.93420	-2.63087E-05	-1.15711E-04
16.700	0.93390	-2.80105E-05	-1.14009E-04
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18.400	0.93480	I + X I	I	I * I	I	-1.65599E-05	-1.25460E-04
18.500	0.93469	I + X I	I	I * I	I	-1.73594E-05	-1.24661E-04
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19.000	0.93387	I-----+----X-------I	I	I---------*--------I	I	-2.28228E-05	-1.19197E-04
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19.600	0.93377	I + X I	I	I * I	I	-2.27918E-05	-1.19228E-04
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19.800	0.93424	I + X I	I	I * I	I	-1.88548E-05	-1.23165E-04
19.900	0.93363	I + X I	I	I * I	I	-2.19944E-05	-1.20026E-04
20.000	0.93367	I-----+-----X------I	I	I---------*--------I	I	-2.38053E-05	-1.18215E-04

CSMP/ DOUBLE PERCISION RKS INTEGRATION
REACTOR RESPONCE TO ROD DROP C1 C2 C3

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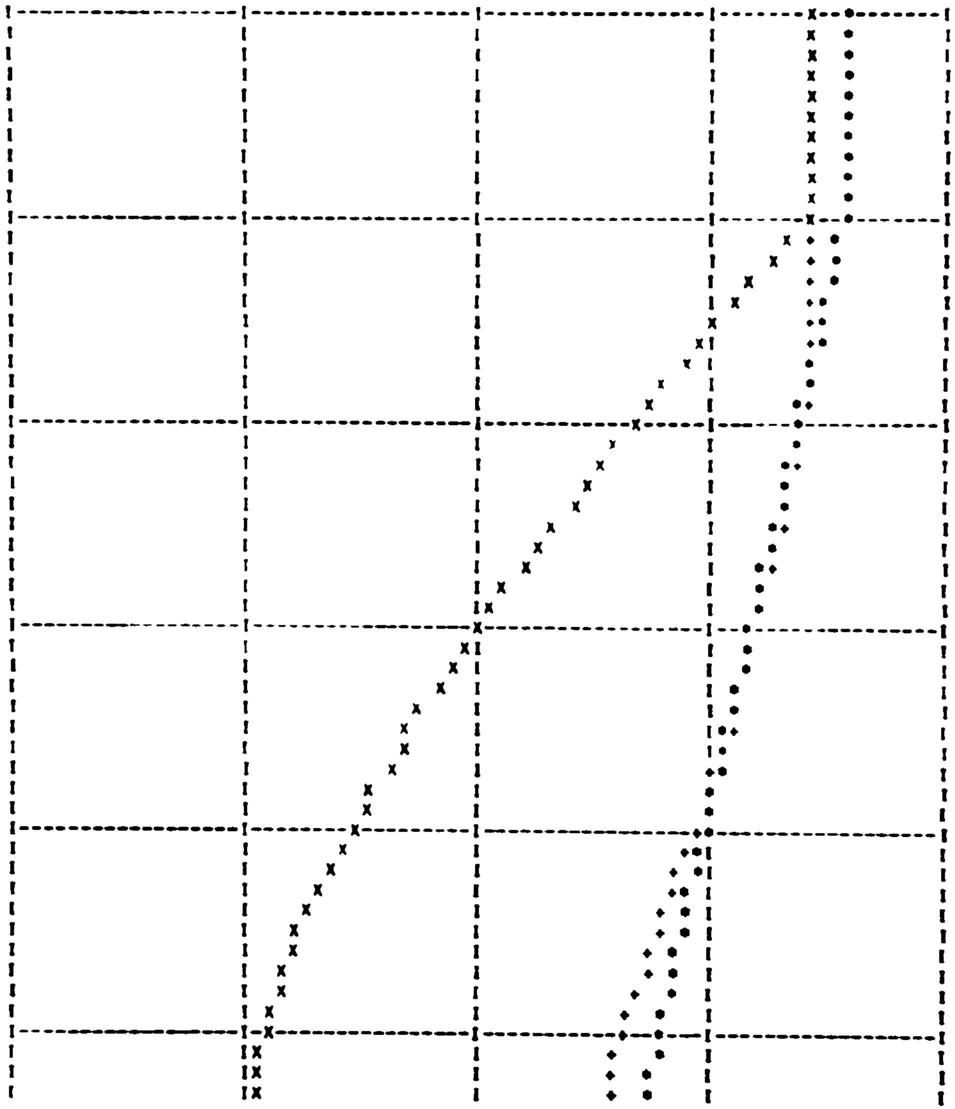
3.7600E 05 '*'=C2 4.0800E 05
1.6000E 05 '+'=C1 1.6800E 05



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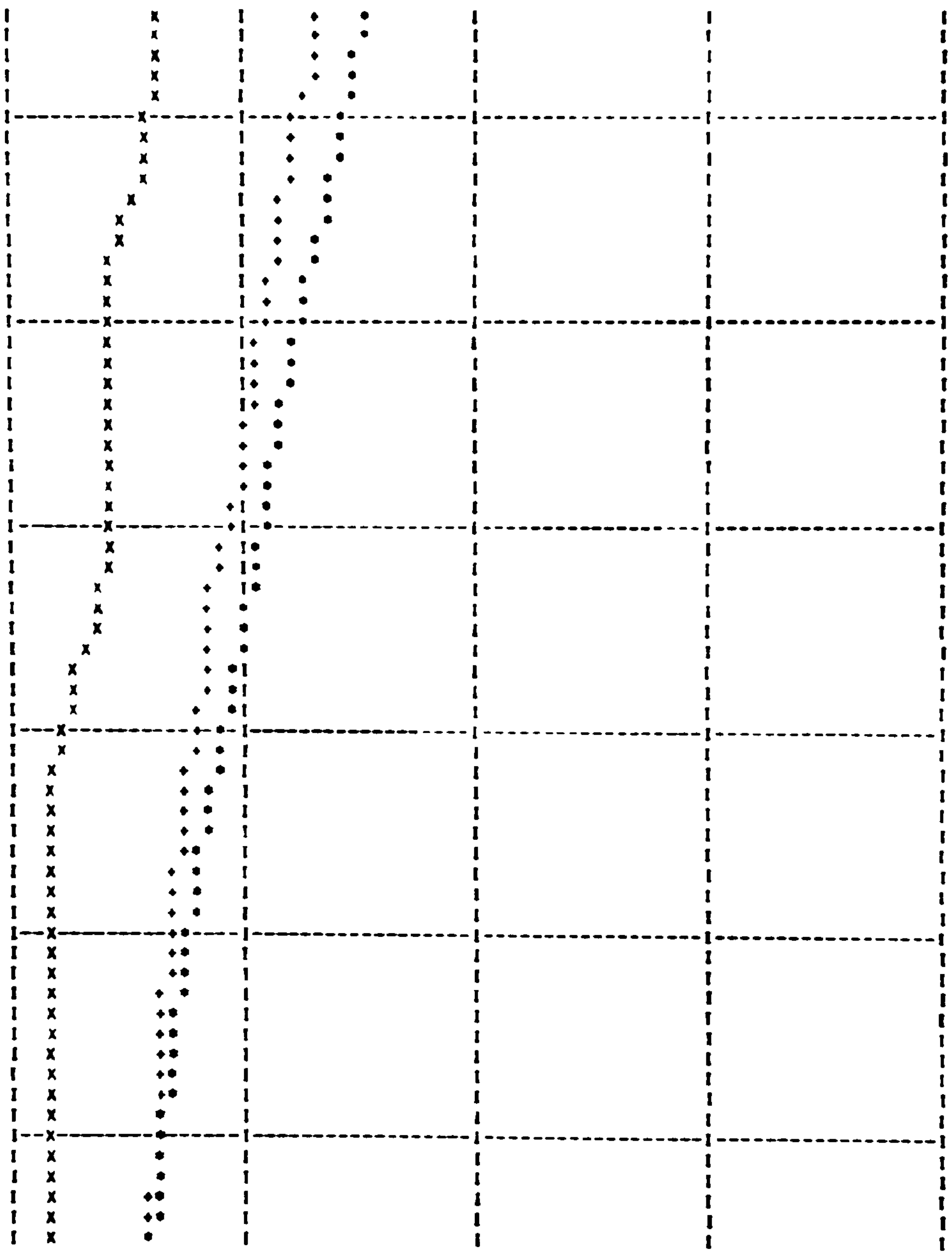

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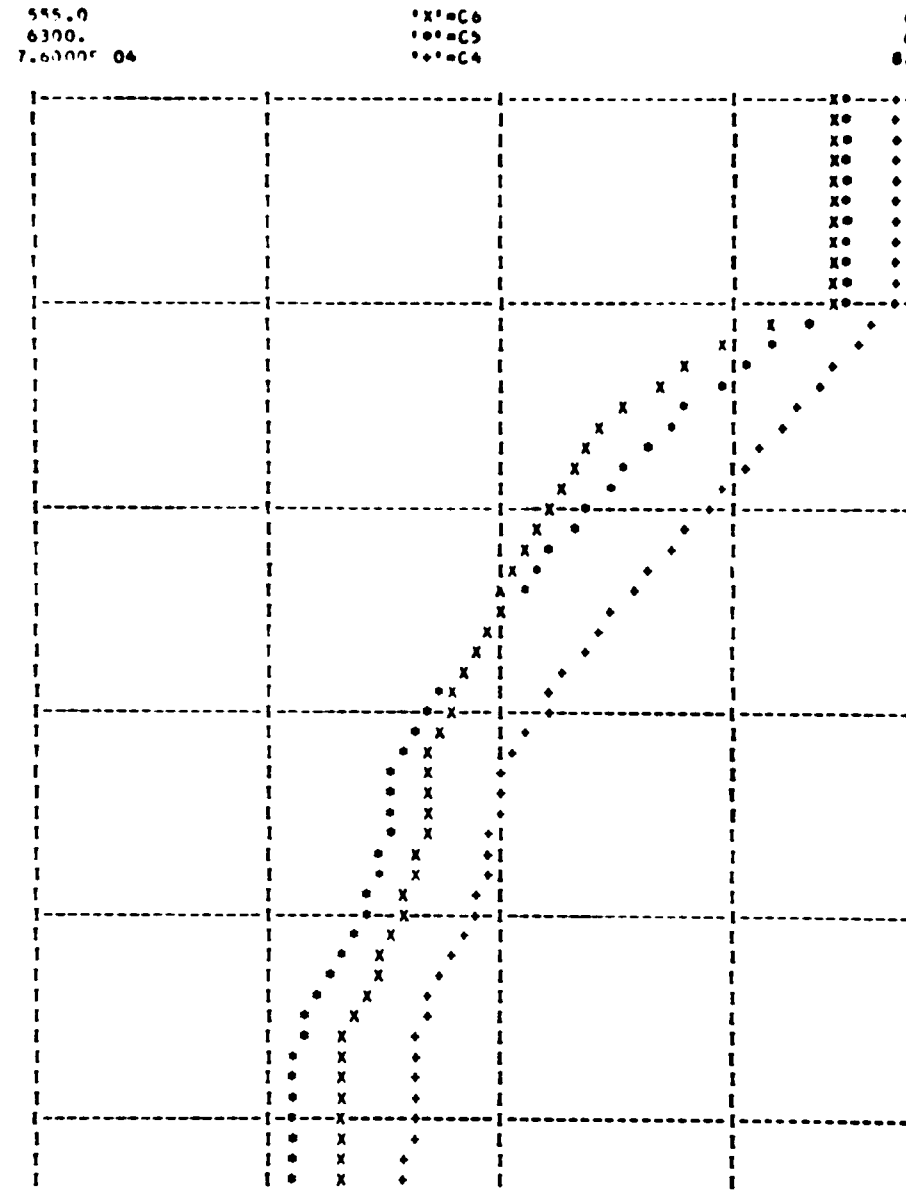
CSMP/ DOUBLE PERCISION RKS INTEGRATION
REACTOR RESPONCE TO ROD DROP C4 C5 C6



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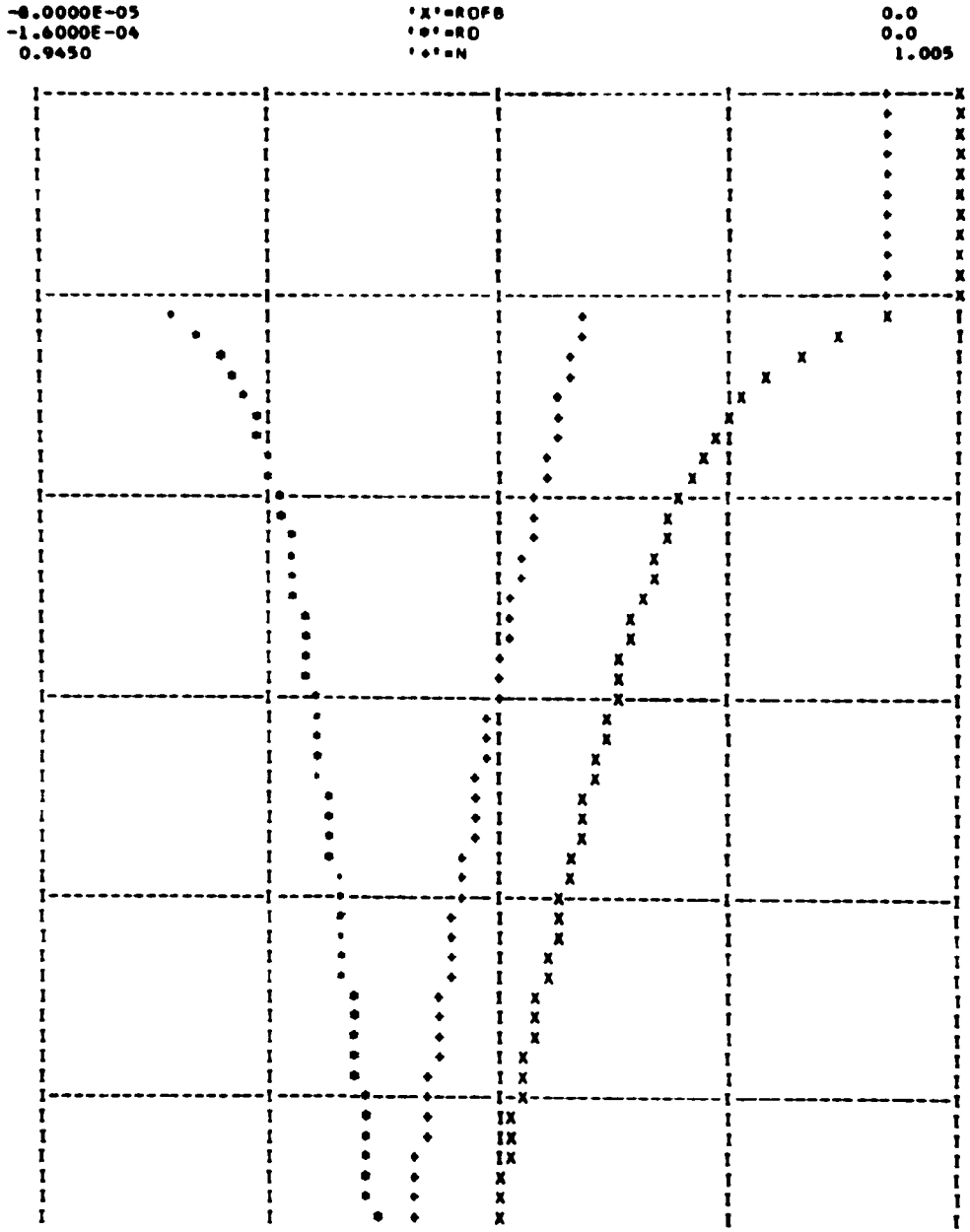
5.8000	79128.	I	I* X +	I	I	I 6458.8	573.88
5.9000	79101.	I	I* X +	I	I	I 6457.3	573.77
6.0000	79057.	I	*---X-----+	I	I	I 6455.9	573.67
6.1000	79011.	I	* X +	I	I	I 6453.9	573.52
6.2000	79006.	I	* X +	I	I	I 6452.1	573.32
6.3000	78977.	I	* X +	I	I	I 6450.5	573.20
6.4000	78938.	I	*I X +	I	I	I 6448.1	573.01
6.5000	78938.	I	*I X +	I	I	I 6448.1	573.01
6.6000	78935.	I	*I X +	I	I	I 6444.6	572.63
6.7000	78931.	I	*I X +	I	I	I 6444.1	572.59
6.8000	78919.	I	*I X +	I	I	I 6442.8	572.48
6.9000	78918.	I	*I X +	I	I	I 6442.7	572.45
7.0000	78900.	I	*I--X----+	I	I	I 6440.9	572.29
7.1000	78853.	I	* I X +	I	I	I 6440.2	572.29
7.2000	78853.	I	* I X +	I	I	I 6440.2	572.29
7.3000	78844.	I	* I X +	I	I	I 6436.4	571.92
7.4000	78788.	I	* I X +	I	I	I 6433.6	571.70
7.5000	78782.	I	* I X +	I	I	I 6433.2	571.65
7.6000	78778.	I	* I X +	I	I	I 6433.0	571.65
7.7000	78748.	I	* I X +	I	I	I 6432.9	571.65
7.8000	78748.	I	* I X +	I	I	I 6432.9	571.65
7.9000	78748.	I	* I X +	I	I	I 6432.9	571.65
8.0000	78747.	I	*--I-X----+	I	I	I 6430.6	571.40
8.1000	78737.	I	* IX +	I	I	I 6427.4	571.07
8.2000	78733.	I	* IX +	I	I	I 6425.9	570.96
8.3000	78683.	I	* IX +	I	I	I 6425.4	570.95
8.4000	78679.	I	* IX +	I	I	I 6425.3	570.95
8.5000	78679.	I	* IX +	I	I	I 6425.3	570.95
8.6000	78675.	I	* IX +	I	I	I 6425.0	570.88
8.7000	78632.	I	* IX +	I	I	I 6422.8	570.77
8.8000	78632.	I	* IX +	I	I	I 6422.7	570.76
8.9000	78628.	I	* IX +	I	I	I 6422.6	570.74
9.0000	78628.	I	*---IX----+	I	I	I 6422.6	570.74
9.1000	78628.	I	* IX +	I	I	I 6422.6	570.74
9.2000	78628.	I	* IX +	I	I	I 6422.6	570.74
9.3000	78628.	I	* IX +	I	I	I 6422.6	570.74
9.4000	78628.	I	* IX +	I	I	I 6422.6	570.79
9.5000	78628.	I	* IX +	I	I	I 6422.6	570.89
9.6000	78628.	I	* IX +	I	I	I 6422.6	570.90
9.7000	78628.	I	* IX +	I	I	I 6422.6	570.90
9.8000	78628.	I	* IX +	I	I	I 6422.6	570.90
9.9000	78628.	I	* IX +	I	I	I 6422.6	570.90
10.000	78628.	I	*---IX----+	I	I	I 6422.6	570.92
10.100	78628.	I	* IX +	I	I	I 6422.6	570.92
10.200	78628.	I	* IX +	I	I	I 6422.6	570.92
10.300	78628.	I	* IX +	I	I	I 6422.6	570.92
10.400	78628.	I	* IX +	I	I	I 6422.6	571.14
10.500	78628.	I	* IX +	I	I	I 6422.6	571.15
10.600	78628.	I	* IX +	I	I	I 6422.6	571.16
10.700	78628.	I	* IX +	I	I	I 6422.6	571.16
10.800	78628.	I	* IX +	I	I	I 6422.6	571.16
10.900	78628.	I	* IX +	I	I	I 6422.6	571.16
11.000	78628.	I	*---IX----+	I	I	I 6422.6	571.16
11.100	78628.	I	* IX +	I	I	I 6422.6	571.16
11.200	78628.	I	* IX +	I	I	I 6422.6	571.16
11.300	78628.	I	* IX +	I	I	I 6422.6	571.04
11.400	78628.	I	* IX +	I	I	I 6422.6	571.04
11.500	78628.	I	* IX +	I	I	I 6422.6	571.04

11.700	78627.	6422.6	571.04
11.800	78624.	6422.2	570.80
11.900	78609.	6419.4	570.44
12.000	78553.	6416.0	570.13
12.100	78549.	6412.4	569.75
12.200	78514.	6410.2	569.56
12.300	78480.	6405.9	569.25
12.400	78409.	6397.6	568.59
12.500	78326.	6393.2	568.07
12.600	78302.	6391.4	567.91
12.700	78248.	6389.5	567.78
12.800	78213.	6388.2	567.66
12.900	78212.	6388.1	567.79
13.000	78212.	6388.1	568.06
13.100	78212.	6388.1	568.19
13.200	78212.	6388.1	568.19
13.300	78212.	6388.1	568.19
13.400	78212.	6388.1	568.19
13.500	78212.	6388.1	568.30
13.600	78212.	6388.1	568.46
13.700	78212.	6388.1	568.49
13.800	78212.	6388.1	568.49
13.900	78212.	6388.1	568.49
14.000	78212.	6388.1	568.49
14.100	78212.	6388.1	568.36
14.200	78212.	6388.1	568.20
14.300	78212.	6388.1	568.09
14.400	78175.	6381.6	567.52
14.500	78150.	6376.7	566.91
14.600	78092.	6373.1	566.41
14.700	77998.	6365.1	565.81
14.800	77944.	6364.3	565.56
14.900	77923.	6361.9	565.32
15.000	77874.	6358.7	565.03
15.100	77871.	6358.7	565.03
15.200	77871.	6358.7	565.03
15.300	77845.	6358.7	565.03
15.400	77844.	6358.6	565.03
15.500	77844.	6358.6	565.30
15.600	77844.	6358.6	565.49
15.700	77844.	6358.6	565.54
15.800	77844.	6358.6	565.54
15.900	77844.	6358.6	565.54
16.000	77844.	6358.6	565.54
16.100	77844.	6358.6	565.55
16.200	77844.	6358.6	565.55
16.300	77844.	6358.6	565.55
16.400	77844.	6358.6	565.56
16.500	77844.	6358.6	565.56
16.600	77844.	6358.6	565.57
16.700	77844.	6358.6	565.57
16.800	77844.	6358.6	565.57
16.900	77844.	6358.6	565.57
17.000	77844.	6358.6	565.57
17.100	77844.	6358.6	565.60
17.200	77844.	6358.6	565.77
17.300	77844.	6358.6	565.79
17.400	77844.	6358.6	565.79
17.500	77844.	6358.6	565.79
17.600	77844.	6358.6	565.80
17.700	77844.	6358.6	565.80
17.800	77844.	6358.6	565.81
17.900	77844.	6358.6	565.81
18.000	77844.	6358.6	565.82
18.100	77844.	6358.6	565.82

```
18.300     77844.   I      *     X    + I                 I                 I                 I   6358.6     565.82
18.400     77844.   I      *     X    + I                 I                 I                 I   6358.6     565.82
18.500     77844.   I      *     X    + I                 I                 I                 I   6358.6     565.84
18.600     77844.   I      *     X    + I                 I                 I                 I   6358.6     565.84
18.700     77844.   I      *     X    + I                 I                 I                 I   6358.6     565.84
18.800     77844.   I      *     X    + I                 I                 I                 I   6358.6     565.84
18.900     77844.   I      *     X    + I                 I                 I                 I   6358.6     565.84
19.000     77844.   I------*-----X---+-I-----------------I-----------------I-----------------I   6358.6     565.84
19.100     77844.   I      *     X    + I                 I                 I                 I   6358.6     565.84
19.200     77844.   I      *     X    + I                 I                 I                 I   6358.6     565.84
19.300     77844.   I      *     X    + I                 I                 I                 I   6358.6     565.84
19.400     77844.   I      *     X    + I                 I                 I                 I   6358.6     565.84
19.500     77844.   I      *     X    + I                 I                 I                 I   6358.6     565.84
19.600     77844.   I      *     X    + I                 I                 I                 I   6358.6     565.84
19.700     77844.   I      *     X    + I                 I                 I                 I   6358.6     565.84
19.800     77844.   I      *     X    + I                 I                 I                 I   6358.6     565.84
19.900     77844.   I      *     X    + I                 I                 I                 I   6358.6     565.84
20.000     77844.   I------*-----X---+-I-----------------I-----------------I-----------------I   6358.6     565.84
```

4. Printer-plotted Output: STIFF

REACTOR RESPONCE TO ROD DROP N RO ROFB



TIME	N	RO	ROFB
0.0	1.0000	0.0	0.0
0.10000	1.0000	6.46155E-11	-6.46155E-11
0.20000	1.0000	1.06468E-10	-1.06468E-10
0.30000	1.0000	1.52726E-10	-1.52726E-10
0.40000	1.0000	3.83141E-10	-3.83141E-10
0.50000	1.0000	5.62461E-10	-5.62461E-10
0.60000	1.0000	6.98912E-10	-6.98912E-10
0.70000	1.0000	8.54364E-10	-8.54364E-10
0.80000	1.0000	9.27167E-10	-9.27167E-10
0.90000	1.0000	9.30105E-10	-9.30105E-10
1.0000	1.0000	1.04369E-09	-1.04369E-09
1.1000	0.98029	-1.35530E-04	-6.49003E-06
1.2000	0.98012	-1.30972E-04	-1.10482E-05
1.3000	0.97988	-1.27677E-04	-1.43426E-05
1.4000	0.97960	-1.25216E-04	-1.68038E-05
1.5000	0.97929	-1.23311E-04	-1.87091E-05
1.6000	0.97896	-1.21787E-04	-2.02329E-05
1.7000	0.97863	-1.20532E-04	-2.14881E-05
1.8000	0.97830	-1.19468E-04	-2.25516E-05
1.9000	0.97798	-1.18545E-04	-2.34753E-05
2.0000	0.97766	-1.17724E-04	-2.42962E-05
2.1000	0.97735	-1.16980E-04	-2.50402E-05
2.2000	0.97703	-1.16294E-04	-2.57264E-05
2.3000	0.97673	-1.15652E-04	-2.63678E-05
2.4000	0.97644	-1.15050E-04	-2.69702E-05
2.5000	0.97614	-1.14477E-04	-2.75426E-05
2.6000	0.97587	-1.13932E-04	-2.80878E-05
2.7000	0.97560	-1.13408E-04	-2.86116E-05
2.8000	0.97533	-1.12902E-04	-2.91180E-05
2.9000	0.97508	-1.12411E-04	-2.96088E-05
3.0000	0.97482	-1.11932E-04	-3.00875E-05
3.1000	0.97457	-1.11464E-04	-3.05561E-05
3.2000	0.97433	-1.11007E-04	-3.10129E-05
3.3000	0.97408	-1.10557E-04	-3.14627E-05
3.4000	0.97383	-1.10115E-04	-3.19051E-05
3.5000	0.97360	-1.09677E-04	-3.23427E-05
3.6000	0.97336	-1.09244E-04	-3.27764E-05
3.7000	0.97312	-1.08813E-04	-3.32075E-05
3.8000	0.97290	-1.08389E-04	-3.36312E-05
3.9000	0.97269	-1.07975E-04	-3.40450E-05
4.0000	0.97249	-1.07568E-04	-3.44516E-05
4.1000	0.97228	-1.07169E-04	-3.48515E-05
4.2000	0.97207	-1.06774E-04	-3.52461E-05
4.3000	0.97187	-1.06381E-04	-3.56390E-05
4.4000	0.97167	-1.05992E-04	-3.60279E-05
4.5000	0.97147	-1.05606E-04	-3.64140E-05
4.6000	0.97126	-1.05222E-04	-3.67977E-05
4.7000	0.97107	-1.04842E-04	-3.71784E-05
4.8000	0.97087	-1.04466E-04	-3.75544E-05
4.9000	0.97068	-1.04094E-04	-3.79259E-05
5.0000	0.97050	-1.03724E-04	-3.82958E-05
5.1000	0.97031	-1.03359E-04	-3.86612E-05
5.2000	0.97013	-1.02995E-04	-3.90246E-05
5.3000	0.96995	-1.02636E-04	-3.93844E-05
5.4000	0.96977	-1.02279E-04	-3.97407E-05
5.5000	0.96957	-1.01926E-04	-4.00944E-05
5.6000	0.96938	-1.01570E-04	-4.04496E-05

5.8000	0.96904	-1.00862E-04	-4.11581E-05	
5.9000	0.96887	-1.00517E-04	-4.15035E-05	
6.0000	0.96871	-1.00177E-04	-4.18431E-05	
6.1000	0.96855	-9.98407E-05	-4.21793E-05	
6.2000	0.96838	-9.95085E-05	-4.25115E-05	
6.3000	0.96821	-9.91754E-05	-4.28446E-05	
6.4000	0.96806	-9.88442E-05	-4.31758E-05	
6.5000	0.96789	-9.85155E-05	-4.35045E-05	
6.6000	0.96773	-9.81888E-05	-4.38312E-05	
6.7000	0.96757	-9.78637E-05	-4.41563E-05	
6.8000	0.96741	-9.75401E-05	-4.44799E-05	
6.9000	0.96725	-9.72185E-05	-4.48015E-05	
7.0000	0.96710	-9.69005E-05	-4.51195E-05	
7.1000	0.96694	-9.65846E-05	-4.54354E-05	
7.2000	0.96680	-9.62727E-05	-4.57473E-05	
7.3000	0.96666	-9.59653E-05	-4.60547E-05	
7.4000	0.96651	-9.56611E-05	-4.63589E-05	
7.5000	0.96636	-9.53579E-05	-4.66621E-05	
7.6000	0.96621	-9.50531E-05	-4.69669E-05	
7.7000	0.96606	-9.47483E-05	-4.72717E-05	
7.8000	0.96590	-9.44460E-05	-4.75740E-05	
7.9000	0.96575	-9.41415E-05	-4.78785E-05	
8.0000	0.96560	-9.38363E-05	-4.81837E-05	
8.1000	0.96546	-9.35335E-05	-4.84865E-05	
8.2000	0.96532	-9.32329E-05	-4.87871E-05	
8.3000	0.96516	-9.29339E-05	-4.90861E-05	
8.4000	0.96503	-9.26375E-05	-4.93825E-05	
8.5000	0.96489	-9.23434E-05	-4.96766E-05	
8.6000	0.96476	-9.20542E-05	-4.99658E-05	
8.7000	0.96463	-9.17694E-05	-5.02506E-05	
8.8000	0.96451	-9.14892E-05	-5.05308E-05	
8.9000	0.96438	-9.12127E-05	-5.08073E-05	
9.0000	0.96425	-9.09417E-05	-5.10783E-05	
9.1000	0.96413	-9.06671E-05	-5.13529E-05	
9.2000	0.96401	-9.03959E-05	-5.16241E-05	
9.3000	0.96389	-9.01254E-05	-5.18946E-05	
9.4000	0.96376	-8.98578E-05	-5.21622E-05	
9.5000	0.96364	-8.95925E-05	-5.24275E-05	
9.6000	0.96353	-8.93296E-05	-5.26904E-05	
9.7000	0.96341	-8.90680E-05	-5.29520E-05	
9.8000	0.96329	-8.88084E-05	-5.32116E-05	
9.9000	0.96317	-8.85503E-05	-5.34697E-05	
10.000	0.96305	-8.82928E-05	-5.37272E-05	
10.100	0.96293	-8.80356E-05	-5.39844E-05	
10.200	0.96281	-8.77780E-05	-5.42420E-05	
10.300	0.96269	-8.75212E-05	-5.44988E-05	
10.400	0.96256	-8.72642E-05	-5.47558E-05	
10.500	0.96245	-8.70079E-05	-5.50121E-05	
10.600	0.96233	-8.67539E-05	-5.52661E-05	
10.700	0.96219	-8.65006E-05	-5.55194E-05	
10.800	0.96207	-8.62438E-05	-5.57762E-05	
10.900	0.96194	-8.59873E-05	-5.60327E-05	
11.000	0.96184	-8.57318E-05	-5.62882E-05	
11.100	0.96174	-8.54838E-05	-5.65362E-05	
11.200	0.96164	-8.52426E-05	-5.67774E-05	
11.300	0.96152	-8.50046E-05	-5.70154E-05	
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11.500	0.96130	-8.45224E-05	-5.74976E-05	
11.600	0.96120	-8.42824E-05	-5.77376E-05	
11.700	0.96110	-8.40462E-05	-5.79738E-05	
11.800	0.96099	-8.38133E-05	-5.82067E-05	
11.900	0.96085	-8.35725E-05	-5.84475E-05	
12.000	0.96075	-8.33320E-05	-5.86880E-05	
12.100	0.96064	-8.30946E-05	-5.89254E-05	
12.200	0.96054	-8.28582E-05	-5.91618E-05	

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12.600	0.96011					-8.19380E-05 -6.00820E-05
12.700	0.96001					-8.17079E-05 -6.03121E-05
12.800	0.95990					-8.14791E-05 -6.05409E-05
12.900	0.95979					-8.12483E-05 -6.07717E-05
13.000	0.95968					-8.10161E-05 -6.10039E-05
13.100	0.95959					-8.07858E-05 -6.12342E-05
13.200	0.95949					-8.05607E-05 -6.14593E-05
13.300	0.95938					-8.03388E-05 -6.16812E-05
13.400	0.95927					-8.01131E-05 -6.19069E-05
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13.600	0.95910					-7.96727E-05 -6.23473E-05
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13.800	0.95892					-7.92456E-05 -6.27744E-05
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14.700	0.95822					-7.74635E-05 -6.45565E-05
14.800	0.95813					-7.72732E-05 -6.47468E-05
14.900	0.95805					-7.70832E-05 -6.49368E-05
15.000	0.95797					-7.68923E-05 -6.51277E-05
15.100	0.95790					-7.67018E-05 -6.53182E-05
15.200	0.95783					-7.65133E-05 -6.55067E-05
15.300	0.95774					-7.63269E-05 -6.56931E-05
15.400	0.95767					-7.61402E-05 -6.58798E-05
15.500	0.95760					-7.59546E-05 -6.60654E-05
15.600	0.95752					-7.57697E-05 -6.62503E-05
15.700	0.95745					-7.55862E-05 -6.64338E-05
15.800	0.95737					-7.54030E-05 -6.66170E-05
15.900	0.95729					-7.52208E-05 -6.67992E-05
16.000	0.95721					-7.50360E-05 -6.69840E-05
16.100	0.95713					-7.48512E-05 -6.71688E-05
16.200	0.95705					-7.46666E-05 -6.73534E-05
16.300	0.95697					-7.44825E-05 -6.75375E-05
16.400	0.95689					-7.42972E-05 -6.77228E-05
16.500	0.95680					-7.41124E-05 -6.79076E-05
16.600	0.95673					-7.39255E-05 -6.80945E-05
16.700	0.95665					-7.37397E-05 -6.82803E-05
16.800	0.95658					-7.35564E-05 -6.84636E-05
16.900	0.95650					-7.33748E-05 -6.86452E-05
17.000	0.95642					-7.31938E-05 -6.88261E-05
17.100	0.95634					-7.30134E-05 -6.90066E-05
17.200	0.95626					-7.28315E-05 -6.91884E-05
17.300	0.95618					-7.26494E-05 -6.93706E-05
17.400	0.95612					-7.24696E-05 -6.95504E-05
17.500	0.95604					-7.22916E-05 -6.97284E-05
17.600	0.95598					-7.21153E-05 -6.99047E-05
17.700	0.95590					-7.19401E-05 -7.00799E-05
17.800	0.95581					-7.17660E-05 -7.02540E-05
17.900	0.95575					-7.15903E-05 -7.04297E-05
18.000	0.95568					-7.14167E-05 -7.06033E-05
18.100	0.95560					-7.12413E-05 -7.07787E-05
18.200	0.95553					-7.10678E-05 -7.09522E-05
18.300	0.95546					-7.08948E-05 -7.11252E-05
18.400	0.95539					-7.07234E-05 -7.12966E-05
18.500	0.95533					-7.05531E-05 -7.14669E-05
18.600	0.95526					-7.03838E-05 -7.16362E-05
18.700	0.95519					-7.02156E-05 -7.18044E-05
18.800	0.95512					-7.00478E-05 -7.19722E-05

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19.000    0.95496    I------x----+------I-----------------I----*------------I-----------------I  -6.97076E-05 -7.23124E-05
19.100    0.95490    I      X    +      I                 I    *            I                 I  -6.95375E-05 -7.24825E-05
19.200    0.95483    I      X    +      I                 I    *            I                 I  -6.93696E-05 -7.26504E-05
19.300    0.95475    I     X     +      I                 I    *            I                 I  -6.92042E-05 -7.28158E-05
19.400    0.95468    I     X     +      I                 I    *            I                 I  -6.90330E-05 -7.29870E-05
19.500    0.95461    I     X     +      I                 I    *            I                 I  -6.88644E-05 -7.31556E-05
19.600    0.95454    I     X     +      I                 I    *            I                 I  -6.86942E-05 -7.33258E-05
19.700    0.95446    I     X     +      I                 I     *           I                 I  -6.85246E-05 -7.34954E-05
19.800    0.95439    I     X     +      I                 I     *           I                 I  -6.83562E-05 -7.36638E-05
19.900    0.95433    I    X      +      I                 I     *           I                 I  -6.81916E-05 -7.38284E-05
20.000    0.95425    I----x-----+------I-----------------I-----*-----------I-----------------I  -6.80251E-05 -7.39949E-05
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ACKNOWLEDGMENTS

No project at Argonne National Laboratory can be entirely the work of one or two individuals. We wish to express our gratitude to the many whose efforts made this work possible. Our special thanks goes to Howard A. Larson, Judith A. Koerner, and Eric M. Dean, whose technical finesse supplemented the authors' areas of experience.

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