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A DIGITAL - COMPUTER PROGRAM
FOR REACTOR-ROCKET-TRANSIENT SIMULATION

MASTER

AEROJET GENERAL CORPORATION

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OSCAG

A DIGITAL COMPUTER PROGRAM FOR
ROCKET REACTOR TRANSIENT SIMULATION

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I. SUMMARY

The OSCAG, digital-computer, reactor-kinetics program was developed for use in nuclear-rocket-transient simulation. Its two variations covered in this report are designated as OSCAG 1 and 2. The program is designed for the solution of a wide variety of problems involving the interrelationships of many neutronic and thermal parameters. It may be used independently in analyzing a reactor that is uncooled or has constant power removal to coolant. In conjunction with an engine-analysis program, it can provide transient simulation for the cooled nuclear-rocket engine. One combination of this type has been developed that employs OSCAG 2 and the FLOW program of subroutines; this combination is designated as AGTRAN.

The OSCAG program permits the determination of (a) the total reactor power and the power contributions that make up that total, (b) the net reactivity and its component contributions, and (c) the core temperatures. The program sequence is basically constructed for the simulation of a test run, but an accident can also be simulated.

A reactor test run is represented in three consecutive phases: the startup, programmed-total-power operation, and shutdown. Kinetic equations establish the power transient during the startup and shutdown phases; a schedule of reactor power vs time is used during the programmed-total-power phase. Transition from the startup phase to the programmed-total-power phase is initiated when the power exceeds a designated value. The shutdown phase begins at a specified time after the initiation of the programmed-total power phase.

During the startup and shutdown phases, imposed reactivity and source power may be programmed by tabulating conditions at various time points. Power resulting from fission-product decay heat may be programmed during all but the startup phase. Throughout all phases, the power from decay heat may also be simulated by the use of decay-heat precursors with decay constants, in a manner analogous to the use of delayed-neutron precursors. Power from fission capture of delayed neutrons is also determined throughout, to yield continuity of conditions for the calculation of reactor-neutron kinetics through transitions between the startup, programmed-total-power, and shutdown phases.

I, Summary (cont.)

Reactor-core temperatures may be calculated in as many as six regions, with conditions of no cooling or of constant power removal by coolant. A phase change is included for use in analyzing extreme temperature conditions prior to core-geometry change during a power excursion.

Reactivity-feedback terms are provided to allow for the effects of material temperatures, fuel burnup, core deterioration, coolant mass, and coolant temperature. Calculations made in the area of neutron kinetics include checks against numerical-stability limits, and automatic correction of digital time increments to assure numerical stability and to permit adjustments for significant changes in the derivative of fission power.

The OSCAG program included options associated with the selection of input data, initial conditions relative to criticality, time increments, printout intervals, power- and temperature-calculation methods, and calculation methods for reactivity feedback and imposed reactivity. Computations may be run for individual cases or for a succession of cases, each of which is defined by a set of input data cards. The cards that cover the input for a specific case are selected on the basis of designated requirements established by options, input indices, and other input data.

Approximately half of the program is devoted to preliminary operations performed only at the initiation of work on each case. These operations establish the initial conditions and set up indices and constants for functional requirements that reduce computer time during the iterative calculations. The remainder of the program provides the repetitive calculations made during time iterations throughout a transient, and during transitions between phases.

The source deck is written in FORTRAN for the IBM-7090 computer with 32K storage; it consists of approximately 1400 FORTRAN cards. This program requires the use of Input Tape 5 and Output Tape 6.

II. OBJECTIVES AND APPLICATIONS

The OSCAG program is designed to provide data characteristic of nuclear-rocket transients with minimal computer time. It may be used independently as a tool for accurate calculations of reactor kinetics, or it may be integrated with a nuclear-rocket-engine analysis program. Used independently, it permits the solution of a wide variety of problems, such as those related to startup transients, accidents resulting from rapid reactivity addition or the loss of cooling, extended shutdown conditions, or any other transient in which there is no appreciable cooling or in which the rate of heat removal by coolant does not change appreciably. Used with an engine-analysis program, it provides the simulation of a basic test-run sequence (startup, programmed-total-power, and shutdown phases).

The accuracy of kinetic calculations is emphasized, and computation time is reduced whenever reasonable accuracy can be maintained. The kinetic equations are derived accurately for use with values of effective-neutron multiplication that are radically different from unity, as well as at or near the critical condition. Two such formulations are used: The first kinetic formulation is designed for use when conditions are changing rapidly and the digital time increments required are shorter than the time associated with the prompt jump of power from a step reactivity change; (b) the second kinetic formulation is designed to save computational time during more slowly changing conditions by using relatively long digital time increments. The equations are based on one neutron energy group, with several delayed-neutron groups. Delayed-neutron contributions to fission power are accurately calculated throughout all phases of each analysis, and the effects of neutron multiplication on delayed-neutron power above or below criticality are included.

Programmed-source-power variation is provided to permit examination of the effects of any neutron source other than prompt and delayed neutrons from fission. Photoneutrons may act as varying sources, for example, and their relative changes in concentration may be programmed into the shutdown phase following a power run. The programmed-source-power values may also be used to investigate the effects of inserting or withdrawing a startup neutron source.

II, Objectives and Applications (cont.)

Decay-heat precursors and programmed decay heat are used in combination to permit analyses of such different situations as a predetermined test run or an unknown accident condition. During the programmed-total-power and shutdown phases of a typical test run, the power from decay heat may be predetermined at successive intervals from graphs or formulas relating decay heat to operational power level, duration of operational power, and time after shutdown. The resulting values are tabulated as programmed-decay-heat power. The digital program subtracts the decay-heat power from the total power to establish the fission power during the programmed-total-power phase. It adds the decay-heat power to the fission power to establish the total power during the shutdown phase when decay heat may be most significant. For the startup phase, there is no programmed decay heat other than a constant continuing from the initial condition, because there is normally relatively little decay heat in this phase and its transient value cannot be obtained easily except by the use of precursors.

The decay-heat precursors are intended for use when decay heat is a significant parameter and its magnitude cannot be predicted in advance by normal calculation methods - e.g., when fission power rises rapidly but does not remain at a constant high level for an extended period. This procedure requires the establishment of decay constants and proportional contributions to power for identified or fictitious fission products that build up and decay to produce gamma and beta heating. The combined use of decay-heat precursors for short-lived fission products and programmed decay heat for representation of the long-lived fission products may offer a reasonable approach for the analysis of transients in general.

The programmed-total-power phase simulates the holding of reactor power at predetermined levels up to a time when another transient (such as a scram) may be initiated. Straight-line interpolation between tabulated points is used, but these points may be at varying time intervals. A transcendental function (e.g., an exponential curve) may be programmed with a sequence of values at successively shorter time intervals as the rate of power rise increases, while a linear relationship may be programmed by merely tabulating the end points regardless of the time between these points.

II, Objectives and Applications (cont.)

Imposed reactivity may be programmed to simulate the action of control devices, environmental changes, accidental excursion, or any other factor that alters reactivity. Straight-line interpolation is not used, because reactivity is a fundamental consideration in reactor kinetics. Imposed reactivity is programmed by means of a specific equation that reflects reactor design. During the startup and shutdown phases, it may be programmed to simulate step changes and/or parabolic relationships between reactivity and time, originating from a succession of time points.

An option is available to change the base reactivity condition to the imposed reactivity value at the end of the startup phase. This permits another change in power level using reactor kinetics at a different rate of imposed reactivity, after the attainment of a designated power level and completion of a programmed-total-power phase (which may be extremely short, if desired). Another option permits the simulation of a scram after the programmed-total-power phase by a reactivity ramp from the imposed reactivity existing at that time to a value designated from the original base reactivity during startup. Following any scram simulation it is then possible to have other imposed reactivity programmed, such as for a restart.

Material-temperature values provide reactivity feedback for the lumped reactor core, or for up to six separate regions. The regions may all represent core fuel, or (if temperatures are calculated by means of an engine-analysis program) they may represent various materials such as fuel, reflector, shield, and structure. Fuel-burnup effects are simulated by a reactivity feedback proportional to the integrated total power. For simulation of core deterioration at high temperatures, another reactivity feedback is provided that is proportional to time after the average fuel temperature reaches a designated high value.

II, Objectives and Applications (cont.)

Coolant-mass and coolant-temperature reactivity-feedback equations are included in the program for use in conjunction with an engine-analysis program that supplies the basic coolant data. A control-reactivity term is also provided to permit the incorporation of an automatic-control or scram-simulation subroutine.

Reactor-core-temperature calculations are included for use with or without an engine-analysis program. With an engine program, core temperatures are calculated by the OSCAG program during every time increment, with the heat-removal rate determined from less frequent calculations of coolant conditions by the engine program. The core temperatures are corrected with each heat-transfer calculation that is fed in by the engine program. The engine program may also be used to calculate other temperatures than that of the core fuel, and the OSCAG program can provide reactivity feedback to the kinetic equations from the other temperatures as well as that of the fuel.

Independent use of the OSCAG program permits temperature calculations to be performed for one material, which is assumed to be core fuel. For accident studies the temperatures may extend into or through a phase change, which may represent either melting or vaporization for a localized region during the early stage of a destructive accident prior to significant geometric movement of materials. Constant heat removal may be assumed, for example, in analysis of a power change that occurs so rapidly as to permit most of the excess heat to be absorbed in the fuel without significant additional heat flow to the coolant. It is also possible to assume no heat removal, such as for analysis of loss of coolant.

A succession of cases may be set up in which each case uses data from the end of the preceding one but with new inputs such as the various programmed data, limits, and option selections. This capability may be used, for example, (a) to extend the number of programmed source, decay-heat, or total-power points or imposed-reactivity points beyond the limit of 30 tabulated points for each; (b) to calculate a series of power changes by reactor kinetics to new programmed-power levels; (c) to change the maximum time increment for use in calculations

II, Objectives and Applications (cont.)

of reactor kinetics (e.g., to extend the increment when calculating slowly changing conditions of very long duration after a scram); or (d) to determine a series of cooled and uncooled reactor conditions.

For use in later designated cases, data at any of four significant times during a transient may be stored: (a) the start of the case, (b) the end of the startup phase, (c) the end of the programmed-total-power phase, or (d) the end of the case. This option is included to reduce input and computer time for such cases as those requiring repeated scram calculations (at different rates of change of imposed reactivity) following a startup and programmed-power run; then the startup and programmed-power calculations are not repeated after the first case. A number of cases can thus be solved in one computer run, with minimum computer time and without complete duplication of input cards for each case.

The initial conditions for any case may be indicated as steady state for a subcritical or critical reactor, with the program calculating the balanced conditions, or data may be provided as input for an unsteady-state condition. The base reactivity conditions may be designated as the initial conditions, corresponding to steady state, or the base conditions may be given by input. These options provide flexibility, and the input time and the probability of human input error are reduced by the use of steady-state conditions. For a steady-state condition, the program will assure, for example, that the reactivity, source power, and fission power are in balance for proper source multiplication.

Three data groups are provided for printout at different intervals. The printout intervals may be based on either the time or the number of time increments since the last printout. The first group includes the basic data for most transient analyses and provides columnar output, interspersed with two other data groups as frequently as designated by option selections.

II, Objectives and Applications (cont.)

Unnecessary calculations are bypassed according to input options and internal indices throughout the program, thereby reducing computer time while retaining a capability for many optional calculations and techniques.

The overall objectives of the program include accurate calculations of reactor-neutron kinetics (within the limitations of one-neutron-energy-group theory), limited thermal analysis independently but with a capability for integration with an engine-analysis program, and flexibility for satisfying many potential requirements for transient analyses without excessive computer time.

III. KINETIC EQUATIONS AND NUMERICAL TECHNIQUES

The OSCAG program is designed for the solution of a wide variety of nuclear-rocket-transient problems involving the interrelationships of many neutronic and thermal parameters. Some simplified numerical procedures have been introduced to save computer time while still providing sufficiently accurate solutions. The commonest simplification is the use of straight-line interpolation between data points to determine intermediate values. Kinetic equations are applied in such a way as to increase the utility of the program for nuclear-rocket-transient analyses. The principal complexity results from the interrelationships of the data that describe reactor transient phenomena, and the associated data-input requirements, rather than from the equations and numerical techniques. The symbols used in equations in this section are defined in Table 1. The sequence of the principal digital operations in OSCAG 1 is summarized in Table 2. For OSCAG 1, the input and output FORTRAN symbols used are defined in Table 3, the input-card sequence and requirements are set forth in Table 4, and program options and indices are given in Table 5; their counterparts for OSCAG 2 are Tables 6 through 8, respectively. The discussion that follows applies generally to OSCAG 1 and 2, but occasional exemplary references are made to OSCAG 1 tables for convenience.

A. NEUTRON KINETICS

The two kinetic equations employed in the OSCAG program are derived from a basic one-energy group equation for use with several delayed-neutron groups; they are formulated simply but accurately. The first formulation is used for relatively rapid power changes, for conditions in which the second formulation would be numerically unstable, and for determining the required imposed reactivity during the programmed-total-power phase of the simulated test run. This formulation is differentiated to obtain the second formulation, used for relatively slowly changing power conditions when digital time increments are long as compared with typical response times in neutron kinetics; its use is limited to below-prompt-critical conditions.

III, A, Neutron Kinetics (cont.)

Numerical-stability analyses establish that the time increments for the first formulation must be less than a limiting function of prompt neutron lifetime, delayed-neutron fraction, and effective-neutron multiplication. The time increments for the second formulation must be greater than twice that limiting function because of the way this formulation is expressed for digital use.

The digital time increments used in reactor-transient analyses are generally long as compared with the associated prompt-neutron lifetimes. This is true even for nuclear-rocket startup and shutdown transients, where the typical digital time increment is too long to permit the resolution of time-dependent changes in conditions between different neutron energy groups. For transient analyses, however, the overall effects of the energy-group changes may be described through variations in prompt-neutron lifetimes, power distributions, and reactivity feedbacks. Only the reactivity feedbacks are provided in this program. The reactivity changes associated with changes in material temperatures and coolant mass include neutron-energy-spectrum effects related to variations in the relative importance of different energy groups.

The basic kinetic equation* for neutron flux (ϕ) and its rate of change is as follows:

$$\ell \frac{d\phi}{dt} = \left[(1 - \beta) k_e - 1 \right] \phi + \frac{pk_e}{k\Sigma_a} \sum_i \lambda_i C_i \quad (1)$$

The contributions to power from fission capture of delayed neutrons (Q_d) and from all fission capture (Q_f) are represented as follows:

$$Q_d = \frac{pk_e}{k} \sum_i \lambda_i C_i \quad (2)$$

$$Q_f = \Sigma_a \phi \quad (3)$$

*S. Glasstone, Principles of Nuclear Reactor Engineering, New York, Van Nostrand, 1955, p. 227, Equation 4.14.1.

III, A, Neutron Kinetics (cont.)

The first kinetic formulation is obtained by multiplying Equation (1) through by Σ_a (which is assumed constant), substituting from Equations (2) and (3), and adding a term for source power (Q_s) from fission capture of source neutrons. It is as follows:

$$\mathcal{L} \frac{dQ_f}{dt} = \left[(1 - \beta) k_e - 1 \right] Q_f + Q_d + Q_s \quad (4)$$

The second kinetic formulation is obtained by differentiating Equation (4) and rearranging it, with the assumption that $\mathcal{L}$ and β are constant:

$$\frac{dQ_f}{dt} = \frac{(1 - \beta) Q_f \frac{dk_e}{dt} + \frac{dQ_d}{dt} + \frac{dQ_s}{dt} - \mathcal{L} \frac{d^2 Q_f}{dt^2}}{1 - (1 - \beta) k_e} \quad (5)$$

B. DELAYED-NEUTRON PRECURSORS

For both kinetic formulations it is necessary to keep track of the changing delayed-neutron precursors as associated with the delayed-neutron power (Q_d) and its derivative. The basic equation for the rate of change of delayed-neutron-precursor groups* is as follows:

$$\frac{\partial C_i}{\partial t} = \beta_i \frac{k}{p} \Sigma_a \phi - \lambda_i C_i \quad (6)$$

Multiplying Equation (6) throughout by pk_e/k , substituting from Equation (3), and using the total derivative as applicable to the specific case, the rate of change of delayed-neutron-precursor concentration is established in the following form, suitable for conversion to power terms:

*Ibid., p. 226, Equation 4.10.1.

III, B, Delayed-Neutron Precursors (cont.)

$$\frac{pk_e}{k} \frac{dC_i}{dt} = \beta_i k_e Q_f - \frac{pk_e}{k} \lambda_i C_i \quad (7)$$

Delayed-neutron power as used in Equations (2) and (4) may be summed from the delayed-neutron-group powers (D_i) caused by fission capture of neutrons originating from the various precursor groups:

$$Q_d = \sum_i D_i \quad (8)$$

Equation (2) shows a single delayed-neutron-group power to be

$$D_i = \frac{pk_e}{k} \lambda_i C_i \quad (9)$$

The rate of change of delayed-neutron-group power is obtained as follows by differentiating Equation (9), with constant values for p , k , and λ_i , which are basic to the properties of the materials and their geometric arrangement:

$$\frac{dD_i}{dt} = \frac{pk_e}{k} \lambda_i \frac{dC_i}{dt} + \frac{D_i}{k_e} \frac{dk_e}{dt} \quad (10)$$

Combining Equations (7), (9), and (10), the derivative of D_i is established, in terms of fission power and effective-neutron multiplication, as follows:

$$\frac{dD_i}{dt} = (\beta_i k_e Q_f - D_i) \lambda_i + \frac{D_i}{k_e} \frac{dk_e}{dt} \quad (11)$$

III, Kinetic Equations and Numerical Techniques (cont.)

C. DECAY-HEAT PRECURSORS

Fission products that result in decay heat are treated in a manner analogous to delayed-neutron precursors. The resulting power (Q_{gd}) is made up of the group powers (D_j) caused by the absorption of gamma or beta energy originating from emissions by the various precursor groups in their radioactive decay:

$$Q_{gd} = \sum_j D_j \quad (12)$$

No neutron multiplication is associated with decay heat; therefore, the effective multiplication (k_e) does not appear in the decay-heat equations. Otherwise the rate of change of decay-heat-precursor-group power is analogous to Equation (11) for delayed neutrons:

$$\frac{dD_j}{dt} = (b_j Q_f - D_j) \lambda_j \quad (13)$$

D. DIGITAL KINETICS AND PRECURSOR FORMULATIONS

For digital use, the first and second kinetic formulations from Equations (4) and (5) and the delayed-neutron and decay-heat-precursor formulations from Equations (11) and (13) become, respectively,

$$\Delta Q_f = (Q_d + Q_s - B_2 Q_f) A \quad (14)$$

$$\Delta Q_f = \left[B_1 Q_f \Delta K_e + \Delta Q_d + \Delta Q_s - (\Delta^2 Q_f / A) \right] / B_2 \quad (15)$$

III, D, Digital Kinetics and Precursor Formulations (cont.)

$$\Delta Q_d = \sum_i \left[(\beta_i k_e Q_f - D_i) X_i + (D_i \Delta k_e / k_e) \right] \quad (16)$$

$$\Delta Q_{gd} = \sum_j (b_j Q_f - D_j) X_j \quad (17)$$

The following terms apply for Equations (14) through (17):

$$A = \Delta t / \ell \quad (18)$$

$$B_1 = 1 - \beta \quad (19)$$

$$B_2 = 1 - B_1 k_e \quad (20)$$

$$X_i = \lambda_i \Delta t \quad (21)$$

$$X_j = \lambda_j \Delta t \quad (22)$$

E. NUMERICAL STABILITY AND TIME-INCREMENT SELECTION

To assure the numerical stability of Equation (14), the first kinetic formulation, the following test must be satisfied:

$$|AB_2| < 1 \quad (23)$$

This limit prevents overshooting of the prompt jump of neutron kinetics in a single time increment. If the test is not satisfied, the time increment (Δt) is decreased sufficiently to cause the absolute value of AB_2 to equal exactly 0.5 in OSCAG 1, or a number less than 1.0 in OSCAG 2 as determined by dividing Δt by an integer.

III, E, Numerical Stability and Time-Increment Selection (cont.)

When Equation (15), the second kinetic formulation, is used, two tests are made automatically by the program to assure numerical stability:

$$AB_2 > 2.5 \quad (24)$$

$$|B_1 \Delta k_e| < B_2 \quad (25)$$

If these tests are not satisfied, the first formulation is used. The test given in Equation (24) assures that the divergent limit $AB_2 = 2$ is not approached closely.

The initial stability check made at the beginning of the startup phase is aimed at determining whether the second kinetic formulation can be used. This check is not made if the input time increment for the programmed-total-power phase is as short as the first-formulation time increment. The initial stability check following the end of the programmed-total-power phase has the same objective and is made only if the time increment for that completed phase is not less than the second-formulation time increment.

When the second formulation is used, there is also the requirement that in any single time increment the proportional change of fission power may not exceed a designated value, which is provided by the input FORTRAN symbol QTL. When the first formulation is used, the second cannot then be employed unless extrapolation of the last calculated rate of change of fission power would not produce a proportional change in fission power greater than one-half of QTL in the longer time increment used for the second formulation. To change from the first to the second formulation, Equation (25) must also be satisfied and Equation (24) is replaced by the following test:

$$AB_2 \geq 4 \quad (26)$$

Equation (26) is used only when the first kinetic formulation has been employed during the preceding time increment.

III, E, Numerical Stability and Time-Increment Selection (cont.)

The general procedure is set up to give preference to the use of the second kinetic formulation, but not for a change into it from the first formulation near the limits that would force return to the first formulation. When any test for possible use of the second formulation is not satisfied during any given time-increment iteration, the first formulation is used and the second is not considered again until the next time-increment iteration. If the numerical-stability test for the first formulation is not satisfied after the second formulation is ruled out, the time increment is reduced so that the stability condition for the first formulation will be satisfied.

The time increment for the first formulation is never lengthened during any given case; it may only be reduced. Any desired increase or decrease in the time increment for the first kinetic formulation may be achieved, however, by dividing a problem into more than one part, with each successive part treated as a new case with option N1 = -1 (see Table 5). This use of option N1 results in retaining values of most basic parameters from the end of the preceding case, but allows some data revisions that include new time increments.

Whenever the time increment is changed, the excess-neutron-multiplication value is corrected, because the imposed-reactivity contribution (such as from movement of control devices) may vary with time. Appropriate numerical-stability tests are then made again, and the time increment is reduced if necessary.

The numerical stability of Equations (16) and (17) requires the following tests:

$$X_i \leq 1 \quad (27)$$

$$X_j \leq 1 \quad (28)$$

III, E, Numerical Stability and Time-Increment Selection (cont.)

If any value of X_i or X_j calculated from Equation (21) or (22) does not satisfy Equation (27) or (28), the value is set equal to unity. This is an approximation technique that represents radioactive decay as instantaneous when the decay constant is such that nearly all decay would be complete during a digital time increment. This condition normally occurs only when time increments exceeding about 0.3 sec are used; precursors with the shortest half-lives are then treated as being in equilibrium, while the several longer-lived precursors are not affected in computation unless significantly longer time increments are used.

F. CONTRIBUTIONS TO NEUTRON MULTIPLICATION

The effective-neutron multiplication (k_e) is determined by the summing of several component contributions. These contributions are expressed in terms of excess-neutron multiplication ($k_e - 1$), identified by the FORTRAN symbol R. Because excess-neutron multiplication is generally very nearly the same as reactivity, which is $(k_e - 1)/k_e$, the term "reactivity" is used in this discussion to mean "excess-neutron multiplication," "reactivity feedback" is used to mean "contribution to change in excess-neutron multiplication," and "coefficient of reactivity" is used to mean "coefficient of excess-neutron multiplication." This translation of terms is reasonably consistent with typical usage. For example, the temperature coefficient of reactivity may frequently be calculated by dividing a change in excess-neutron multiplication between two temperatures by the temperature change, in which case it is actually a coefficient of excess-neutron multiplication although it is still called a coefficient of reactivity.

The net reactivity is determined from the sum of the feedback and imposed terms plus a base value. The reactivity-feedback terms include feedbacks from component temperatures, coolant mass, time, and integrated power.

The component temperatures for various material regions are multiplied by individual temperature coefficients of reactivity for each region, and the reactivity effects are summed to give the total temperature-reactivity feedback.

III, F, Contributions to Neutron Multiplication (cont.)

One specific core region, with a temperature designated by FORTRAN symbol TFC, may utilize an additional coefficient (FORTRAN symbol RF2) multiplied by the square of the temperature deviation from the base value at which there is no reactivity feedback from the regional temperature. Formulas for material-temperature reactivity feedbacks are given in Tables 3 and 6, under FORTRAN-symbol definitions for RA(NR1), RF1 and RF2, and RTS.

Coolant-mass reactivity feedback is also calculated by regions when coolant mass is provided; this is done by linking this program to another program which establishes the quantity of coolant in the core. The coolant-mass reactivity-feedback term for each coolant region includes a multiplier for coolant-temperature effect, which alters the reactivity effect of regional coolant mass linearly with the regional coolant temperature. The formula for the coolant-temperature multiplier RMM(NR2) in OSCAG 1 is given in Table 3, under the FORTRAN-symbol definition for RCT(NR2), while alternate formulas for RMM(NR2) in OSCAG 2 are given in Table 8, under option N10. The formulas for coolant-region and total-mass reactivity feedback are shown in Tables 5 and 8, under option N10.

A time coefficient of reactivity is multiplied by the length of time past that at which a designated average fuel temperature is reached, to give the reactivity feedback due to the deterioration of materials. To establish the feedback from fuel-burnup effects, an integrated power coefficient of reactivity is multiplied by the value of integrated power. Formulas for these reactivity-feedback terms are provided in Table 3, under FORTRAN-symbol definitions for RZR and RHQR.

The imposed reactivity is based on a tabulated schedule. This programmed-imposed-reactivity schedule consists of coefficients to give step, ramp, and parabolic functions of imposed reactivity vs time after any of the 30 possible designated time points. The formula for initial imposed reactivity prior to the first scheduled time point is given in Table 3, under the definition

III, F, Contributions to Neutron Multiplication (cont.)

of coefficients R00, R01, and R02; the formula for imposed reactivity from the first tabulated time point and thereafter is given under the definition of coefficients R0(IR), R1(IR), and R2(IR). The accumulated value of imposed reactivity RR is used as the constant coefficient R0(IR) at each tabulated time point unless a step change is desired. An imposed-reactivity step would be given by the amount that R0(IR) departs from the value of RR calculated at the new time but using the coefficients and time-point base for the preceding value of IR.

A contribution to imposed reactivity can also be supplied by an additional FORTRAN symbol RRC intended for use with a controls subroutine that would alter imposed reactivity according to automatic control or safety responses. Without such a subroutine, RRC remains constant at the input value.

A starting base reactivity value (FORTRAN symbol RS) is carried throughout the calculations. All feedback and imposed-reactivity contributions are added to this base value to determine the net reactivity (excess-neutron multiplication, given by FORTRAN symbol R).

G. PROGRAMMED POWER: DECAY HEAT, NEUTRON SOURCE, AND TOTAL POWER

Operation in the programmed-total-power phase is simulated by using as input a set of values for total power vs time. This phase may be initiated when the total power exceeds a designated value during the startup phase, or the startup phase may be omitted and the programmed-total-power phase may be used at the start of a case. The shutdown phase follows the programmed-total-power phase.

During the startup and shutdown phases, the neutron-source-power level may be programmed in accordance with tabulations of source power vs time. The source power contributes to establishing the fission-power level through the kinetic equations used by the program during those phases.

III, G, Programmed Power: Decay Heat, Neutron Source, and Total Power (cont.)

Decay heat may be programmed by the use of a similar tabulation during the programmed-total-power and shutdown phases. Straight-line interpolation is used to establish values between tabulated time points for decay heat, source power, and total power.

The total reactor power is the sum of the decay heat and fission power:

$$Q_r = Q_g + Q_f \quad (29)$$

The power due to decay heat is determined by the summing of a constant or programmed value (Q_{gc}) and the value (Q_{gd}) determined by means of Equations (12) and (13) for designated decay-heat-precursor groups:

$$Q_g = Q_{gc} + Q_{gd} \quad (30)$$

There is no programmed decay heat during the startup phase, and Q_{gc} is a constant value determined by the solution of Equations (29) and (30) with given initial values of Q_r , Q_f , and Q_{gd} .

The fission power includes contributions from the fission of source neutrons, delayed neutrons, and the prompt neutrons generated in the fission process:

$$Q_f = Q_s + Q_d + Q_p \quad (31)$$

Equation (31) is not actually used in the digital program, because the fission power is determined by solution of Equations (4) and (5) during the startup and shutdown phases, without requiring the Q_p term. During the programmed-total-power phase, the fission power is determined by subtracting the decay-heat power from the total power in Equation (29).

III, G, Programmed Power: Decay Heat, Neutron Source, and Total Power (cont.)

The net reactivity (excess-neutron multiplication) is determined during the programmed-total-power phase by rearrangement of the first kinetic formulation, Equation (4). As a close approximation it is assumed that the rate of change of fission power equals the rate of change of total power, so that the slope of the straight-line interpolation between tabulated total-power values may be used directly. The solution is as follows:

$$R = k_e - 1 = \frac{\beta Q_f - Q_d - Q_s + \lambda \frac{dQ_r}{dt}}{(1 - \beta) Q_f} \quad (32)$$

The imposed reactivity (FORTRAN symbol RR) is then determined on the basis of the difference between the calculated R and all reactivity contributions from other than imposed reactivity. This imposed reactivity would be required to maintain the programmed-total-power derivative.

There is no numerical-stability limitation for the use of Equation (32) during the programmed-total-power phase, other than a limitation that would be associated with delayed-neutron equations. This potential stability limitation is handled during the preliminary operations by making the test given in Equation (27) for each delayed-neutron group, and using a value of unity for any X_i that would otherwise be greater than unity.

A constant time increment is used throughout the programmed-total-power phase. In OSCAG 1 that time increment is equal to the input value of ZI, and in OSCAG 2 it is equal to DELTA divided by JZ3. In order to make a calculation exactly at a tabulated time point, it is not required that the time increments and tabulated total-power values be coordinated. All tabulations serve as base points for interpolations; in general, the time iterations are carried out independently of the tabulated values of time.

III, Kinetic Equations and Numerical Techniques (cont.)

H. TEMPERATURE KINETICS

Temperature calculations are made for the lumped reactor core or for separate regions. A phase change such as melting or vaporization may be simulated when all temperatures are calculated for the same material. Constant heat removal may be simulated throughout all phases or only through the shutdown phase, as desired.

Incremental temperature changes are calculated by dividing the heat retention by the heat capacity:

$$\Delta T = \frac{F Q_{rt} \Delta t}{H_c} \quad (33)$$

If the designated temperature for phase change has been reached, a fictitious temperature is calculated and stored as though the material remained in the solid phase. This fictitious temperature is then converted to the actual temperature by relating the ratio of heat capacities in the melting or molten state to the heat capacity in the solid state. Melting is treated as though it occurs over a specified temperature range; if this range is designated as l° , the relative heat capacity during melting is the ratio of the heat of fusion to the solid specific heat. Another relative heat capacity is designated for use above the temperature at which melting is completed.

The phase change may also be treated as vaporization (sublimation) instead of melting; in this case, it is meaningless to consider the condition after completion of vaporization. Consideration of temperatures at or above the melting (or vaporization) point is included only for the purpose of approximating localized conditions or examining the preliminary phase of a severe accident before geometry change destroys reactor function. No hydrodynamic effects are included in the program calculations.

III, H, Temperature Kinetics (cont.)

Temperatures and reactivity feedbacks may be calculated separately for each designated region or for the lumped reactor (i.e., not divided into regions). Separate fractions of the total reactor power may be designated as generated in each region. A separate volume fraction of fuel is designated for each region for the determination of average fuel temperature. All calculations are stopped when the average fuel temperature (FORTRAN symbol TFA) exceeds a designated limiting value (FORTRAN symbol TFL). Regional-temperature calculations are bypassed when the temperature of a region exceeds the same limiting value.

Regions may be inside or outside the reactor core and may represent any materials. For materials outside the core, or non-fuel materials in the core, the volume fraction of fuel would be designated as zero; consequently, these materials would have no influence on the average fuel temperatures. Materials other than fuel, however, could still give rise to reactivity feedbacks through their separate temperature coefficients of reactivity.

Regional breakdowns were originally established so that there would be a lumped calculation of fuel temperature in the core (FORTRAN symbol TFC), with other regional temperatures [FORTRAN symbol TA(NR1)] representing components such as the reflector, shield, and structure. With the additional consideration that all these regions may be used as fuel, volume fractions of fuel and thermal properties for a single material are designated. When temperatures are to be calculated in more than one material, or these are regional variations in heat-removal rate, this program must be integrated with an engine-analysis program in order to obtain thermal analyses.

The heat-removal rate may optionally be designated to equal zero, the initial power, or the power at the start of the shutdown phase, with temperature calculations bypassed prior to the shutdown phase. The remaining power [Q_{rt} in Equation (33)], applied to changing material temperatures, is distributed to the various regions according to their designated power fractions [F in Equation (33)].

III, H, Temperature Kinetics (cont.)

Values for coolant masses and temperatures can be printed out and reactivity-feedback calculations can be made in this program when values are supplied from an associated program.

IV. OSCAG 1

A. DESCRIPTION OF PROGRAM SEQUENCE AND FUNCTION

This program is subdivided into two main portions, one for preliminary operations and calculations made only once for each case and the other for repetitive calculations made for every time increment. The two portions are arranged so as to speed computation for the options provided, and to facilitate the use of this program in conjunction with others that provide heat-transfer and fluid-flow calculations.

In the preliminary operations all the data are read into the core, internal indices are set, some checks are made to ensure proper starting conditions, and constants are combined wherever possible for simplification of calculations during time iterations. The repetitive-calculation portion of the program provides changes in all significant variables during each time iteration, with different calculation procedures during the startup, programmed-total-power, and shutdown phases.

The sequence of principal digital operations is presented in Table 2. Operational steps are given in the sequence in which they are normally performed in each portion of the program. Source-deck statement numbers are listed for each step. The preliminary operations include Steps 1 through 15; the repetitive calculations include the remaining steps.

1. Preliminary Operations

Tables 3, 4, and 5 contain complete explanations of the FORTRAN symbols, input-card sequence, and program options and input indices. These are discussed briefly below to provide background for the ensuing discussion of operational sequence.

IV, A, Description of Program Sequence and Function (cont.)

The program input is coordinated with the sequence of operations in the preliminary-operation portion in accordance with the selection of options, which are included to provide program flexibility. The principal data output is in columnar printout, and groups of data can be inserted at specified intervals, if desired.

a. FORTRAN Symbols

The input and output FORTRAN symbols listed in Table 3 are organized into general coded groups designated by the first letter of the symbol. The initial letters have the following meanings or implications:

	Definition
A	Ratio between time increment and prompt-neutron lifetime
B	Delay fraction of neutrons, or of radiation that produces decay heat (synonymous with β , as used in Section III)
C	Coolant mass
E	Neutron lifetime (EL)
F	Fraction of fissions
H	Heat, such as heat capacity or heat in terms of integrated power
I	Index, number of increments, or number of isotopes
J	Time increment
L	Fuel-phase index
N	Option number (when N is followed directly by a number), number of groups or regions, or number index of groups or regions
P	Inverse period (PIN)
Q	Power
R	Reactivity, excess-neutron multiplication, effective-neutron multiplication, or coefficient of reactivity
T	Temperature; however, the printout heading "TIME" means simply time, and TP(L) means problem title
V	Volume fraction
X	Product of decay constant and time increment
Y	Decay constant
Z	Time

IV, A, Description of Program Sequence and Function (cont.)

b. Input-Card Sequence

Table 4 lists the program input-card requirements and sequence for a single case. Input cards are used only as required for the particular conditions of the case. When two or more option values are listed under a given option number for an input card in Table 4, any one of the listed values will satisfy the requirement for that option number. The cards with requirements that are not met in a given case are to be omitted. Cards 10000 through 12000 are used for every case. Cards 12100 through 22000 are used only as needed, with the need established by the value selected for applicable options or other indices. For example, card 12100 is used only if option N1 = 0 or N1 = 1.

Several cases may be submitted together in series, with the input cards required for each case determined by the requirements associated with option selections and other indices of that case. When any case has option N1 $\neq$ 1, there must be input cards for a preceding case from which data will be used; if N1 = 0, there must be a preceding-case input having N2 $\neq$ -1.

c. Program Options and Input Indices

The input options are given in Table 5. The principal options are indicated by symbols N1 through N12. Also available are other input indices that provide optional choices, such as the programming of particular items and the regional breakdowns provided for thermal and reactivity data. These input indices include IQG, IQR, IRN, ISQS, NRM, and NRT, which are also listed and explained in Table 5.

All input data and the results of preliminary operations are printed for each case prior to the time iterations of transient simulation. During the time iterations, data are printed as explained under option N7 in Table 5. At the end of each case, all data groups are printed out to show the final conditions; if NRT $\neq$ -1 the fuel-phase indices LFC and LF(NR1) are also printed.

IV, A, Description of Program Sequence and Function (cont.)

d. Operational Sequence

Many alternate paths are available, according to the input options and selections. The data required and the sequence in which the input is read depend on these options and selections, and particularly on the fixed-point data from the four input cards that follow the initial title card. Because a series of cases may be submitted in one computer run, internally generated data and indices are corrected at the start of each case unless options indicate the use of stored data.

During the preliminary operations, several internal indices are established to reflect the initial conditions. These include (1) an index that is changed to signal the final data printout and the end of a case when specified limits are exceeded, (2) indices used to obtain routine and special data printouts, (3) indices for indicating material phases in each material region, (4) indices related to the selection of the kinetics formulation and to testing for changing the choice of kinetics formulation, (5) the index that indicates the phase of operation (startup, programmed total power, or shutdown, and (6) indices that designate the current time periods and specific significant ranges of time for use with tabulated values of decay heat, source and total power, and imposed reactivity.

The initial checks will yield the corrections needed to suit the program requirements. The time (Z, on input card 12000) must be a positive number or zero. The material-volume fractions VFC and VF(NR1) (on card 13300) are normalized so the total equals unity. If the initial condition is designated as subcritical steady state ($N5 = -1$), the fission power from source multiplication is calculated and the total power QR (card 12000) is then corrected by any difference between the calculated fission power QF and the input value from card 17000. The decay-heat power QG is thereby maintained as the difference between input QR and QF. If the critical or subcritical

IV, A, Description of Program Sequence and Function (cont.)

steady-state selection is designated (i.e., $N5 = 1$), the excess-neutron multiplication R is calculated to be subcritical if there is a nonzero input source power QS (card 17000), in order to maintain a zero fission-power derivative. If the input value of the time ZRZ (card 12110) is negative, and the average fuel temperature (input on card 13000, or calculated from card 13100 data) is greater than or equal to the temperature $TFRZ$ (card 12110), ZRZ is changed to equal the initial time Z (card 12000), and the time reactivity feedback RZ (card 12100) is reset to zero. However, if the input value of ZRZ is not negative, the input value of RZ is replaced by a new value for RZ calculated by multiplying the time reactivity coefficient RZR (card 12100) by the difference between initial time Z and ZRZ , even if this is a negative difference.

Initial checks such as those described above are accomplished as needed for reading in and operating on the related data. Preliminary operations are discussed below, in the sequence in which they are performed, beginning with Step 5 of Table 2.

If option $N9 = -1$ is designated, the base temperatures and coolant masses for reactivity calculations are set equal to the initial material temperatures and coolant masses. Coolant masses are used only if index NRM (card 11010) has a positive nonzero value. The coolant-mass values must be supplied through a tie-in with another program (such as an engine-simulation program) in which heat transfer and coolant flow are calculated. This program has no input card on which coolant masses may be designated.

In Step 6 of Table 2, the input constant for reactivity-feedback calculations are combined as appropriate to reduce computation during the time iterations if coolant masses are used. Constants are similarly combined for temperature-feedback calculations if index NRT (card 11010) is not negative. Initial reactivity feedbacks are also calculated.

IV, A, Description of Program Sequence and Function (cont.)

With $N_3 = -1$, the initial volume-weighted average fuel temperature is calculated for all temperature regions. If $N_3 = 0$, the initial average fuel temperature TFA and the core temperature TFC are equated throughout, and any subscripted temperatures TA(NR1) are considered to be for regions external to the reactor core and therefore to contain no fuel. Any fuel temperatures (from cards 13000 or 13100) at or above the melting point TFM (card 12200) are converted to the fictitious temperatures they would have with solid-phase properties if there were no phase change. This is done to facilitate accurate thermal calculations, particularly in the transitions from below the melting point to the partially molten condition, or from the partially molten condition to a higher all-liquid temperature, during any finite digital time increment. Conversion back from fictitious to actual temperatures results in a printout of the proper values after time iterations. Phase-change calculations are not provided in this program for materials other than fuel.

With options $N_1 = 1$ and $N_4 \neq -1$, Step 8 of Table 2 establishes this sum FRT of fractions of fissions FR(IFM) (card 17100) in fuel isotopes. Each fraction of fissions is divided by FRT when the effective delayed-neutron fraction B(ND) is calculated for each delay group, from input BD(ND,IFM) on card 17200 and BR on card 17000. The values of B(ND) are summed to give the total effective delayed-neutron fraction BE. Power caused by the fission of neutrons originating from delayed-neutron precursors is calculated from equilibrium conditions unless $N_5 = 0$, in which case this delayed-neutron-group power QD(ND) is input (card 18000). The total delayed-neutron power QDT is obtained from the summing of QD(ND) values.

If $N_1 = 1$ and $N_4 = 1$, the total decay-heat-precursor fraction BGP is obtained from the summing of the group fractions BG(NG) on card 18200. Equilibrium conditions are calculated unless $N_5 = 0$, in which case the decay-heat-precursor-group power QGD(NG) is input (card 18100). The total decay-heat power QGDT is obtained by the summing of all QGD(NG) values. The initial constant-decay heat other than from designated precursors is obtained by subtracting QGDT from the difference between the initial values of total power QR and fission power QF.

IV, A, Description of Program Sequence and Function (cont.)

The initial inverse reactor period PIN is calculated for conditions prior to imposed-reactivity addition if the case is initially in the startup or shutdown phase, or from the initial slope on the power vs time graph if the case is initially in the programmed-total-power phase.

The values of IQG , IQR , and IQS (from card 11000) are compared in Step 13, and IQL is set equal to the highest. If IQL has a positive value above zero, tabulations of programmed decay heat, source power, and total power vs time are read in as appropriate, and the slopes between all programmed-power points are calculated for straight-line interpolation. The final slopes are set equal to zero for time points following the last programmed-power point in each table except for the programmed total power, which maintains the slope between the two final tabulated-total-power values.

If the case is started in the programmed-total-power phase, the net reactivity R is calculated as the value that would be required to give the power slope at the current fission power. The imposed reactivity RR is determined by subtracting from the net reactivity R the sum of the initial base reactivity RS , additional control reactivity RRC , and the following reactivity-feedback terms: RHQ , RMS , RTS , and RZ . If the case is initially in the startup or shutdown phase, R is obtained by adding RS and RR to the feedback terms RRC , RHQ , RMS , RTS , and RZ . However, if equilibrium condition $N5 = 1$ is designated, R is calculated from the source power QS and fission power QF to give a zero fission-power derivative, and the base reactivity RS is obtained as the difference between R and the feedback terms without imposed reactivity RR . A value for control reactivity RRC is not calculated in the basic program; if one is not supplied from a subroutine, the value of RRC remains as provided on input card 12100.

Time increments are converted to multiples of prompt-neutron lifetime, and to fractions of reciprocal decay constants for delayed-neutron and decay-heat precursors, in order to reduce the number of multiplications

IV, A, Description of Program Sequence and Function (cont.)

during time iterations. Any product of a time increment (input ZI, Z1, or Z2, cards 12000 and 19200) and a decay constant [YD(ND) from card 17300, or YG(NG) from card 18300] that is greater than unity is replaced by unity.

The input value of time increment ZI (card 12000) is stored for use during the simulated programmed-total-power phase. If the case is not initially in the programmed-total-power phase and if $N_6 = 0$, the tentative initial time increment will be Z1 (from card 19200) if input ZI is not greater than Z1, or will be Z2 (from card 19200) if input ZI is greater than Z1. During the first time-increment calculation, if $N_6 = 0$, numerical-stability and proportional-power-change checks may alter the initial time-increment magnitude before it is used for calculations of reactor kinetics. When $N_6 = -1$, the time increment remains constant as the input ZI value.

The input data and the values determined or corrected by preliminary calculations are printed out after the problem title (card 10000). The data for printout are generated as the preliminary operations proceed, so that the first printout of any variable or constant is generally the input value, and any subsequent printout prior to an indicated change in the initial time allows for the recording of possible changes of input numbers.

The end of preliminary operations is indicated by the printed statement (on a new page): "BEGIN TRANSIENT CALCULATIONS." This statement is followed by the initial data corresponding to the first and third data groups normally printed out during time iterations.

If $N_2 = 0$, a substantial amount of the initial data is stored for future use in subsequent problems, and a statement to this effect is printed in the initial time printout. If $N_1 = 0$, some input is eliminated by the use of data stored during the last problem having a non-negative value for N_2 .

IV, A, Description of Program Sequence and Function (cont.)

2. Repetitive Calculations

The time iterations, changes between program phases, and operations concerned with printout intervals and checking limits are performed after the preliminary operations. The principal program flow paths are determined by the index IK, which designates the startup phase ($IK = -1$), the programmed-total-power phase ($IK = 0$), or the shutdown phase ($IK = 1$). The repetitive calculations performed for each time increment are shown in Steps 16 through 35 of Table 2.

The calculations performed during the startup and shutdown phases are identical with regard to reactor kinetics; they differ only in relation to certain programmed data (particularly decay heat) and the initial and final conditions. What is called a shutdown phase could therefore be used for any power variation involving reactor kinetics, including a startup analysis. When the programming of total power has not been designated in the preliminary operations ($IQR = 0$), the program sets $IK = 1$ and computations are made in what is here described as the shutdown phase. However, the phase descriptions that follow in paragraphs IV, A, 2a through c, below, are provided to explain the manner of computing a complete test run through all phases.

In order to have a startup or a shutdown phase it is necessary that QR be less than QRK , and $N4 \neq -1$. If $N1 = -1$, it is required that the $N4$ value for the preceding case in the computer run be equal to or greater than the $N4$ for the current problem, so that the delayed-neutron data (and decay-heat-precursor data, if $N4 = 1$) are in storage. If $N1 = 0$, the last prior case in which $N2 \neq -1$ must have had an $N4$ value equal to or greater than the $N4$ for the current case.

a. Startup Phase

The principal operations after advancement of time increment and time (Step 16, Table 2) are as described below during every time increment in the startup phase.

IV, A, Description of Program Sequence and Function (cont.)

The latest calculated value of total power QR is checked against the limiting value QRK (card 17000) at which calculations of reactor kinetics end and the programmed-total-power phase begins. If QR is less than QRK, the startup phase continues for another iteration, bypassing Steps 18 through 20.

The imposed reactivity RR is calculated for the new time Z, using the schedule of coefficients and times from input cards 20000 through 20200. A tentative, new, net reactivity R is established on the basis of the base reactivity RS (card 19000 or 19100), plus the feedback terms determined in the preceding time increment.

As shown in Step 22 of Table 2, numerical stability for reactor kinetics is checked if $N_6 = 0$. If it is permissible to use the second kinetic formulation for a long time increment (Z2), the preceding proportional rate of change of fission power is checked against its permissible value QTL (card 12000); if QTL is exceeded, the first kinetic formulation for a short time increment (Z1) is used. If numerical-stability requirements are not satisfied for the current value of Z1 when the first formulation is used, this value is reduced and the following statement is printed out: "REDUCE Z1 to MEET NUMERICAL STABILITY REQUIREMENTS."

Whenever Z1 has been used in the preceding increment but the numerical stability and rate of change of power permit the use of a longer time increment Z2, "CHANGE FROM Z1 to Z2" is printed out. When Z2 has been used in the preceding increment but is not permitted in the current increment, "CHANGE FROM Z2 to Z1" is printed out, with one of three explanations: (1) "TO PREVENT EXCESSIVE POWER INCREMENT" if QTL was exceeded, (2) "TO PREVENT EXCESSIVE REACTIVITY INCREMENT" if the reactivity would exceed prompt critical or would drop more than a permissible amount for numerical stability, or (3) "TO MEET NUMERICAL STABILITY REQUIREMENTS." Whenever there is a change in time increment, the computer prints the increment number J, time Z, new time increment ZI, and ratio A of ZI to the prompt-neutron lifetime. When the value of ZI is changed,

IV, A, Description of Program Sequence and Function (cont.)

the products of time increment and decay constants for delayed-neutron and decay-heat precursors are corrected. With any change in time increment, the imposed and net reactivities (RR and R) are corrected by a return to Step 21 of Table 2.

Following numerical-stability checks and the establishment of a proper current time increment, the programmed source power is determined from the tabulated values of QSSP(ISQ) as a function of ZSQ(ISQ) given on cards 21500 and 21600, and from the slopes between the points established in the preliminary operations. If ISQ = 0, the interpolation is from the input QS (card 17000) to QSSP(1). When Z equals or exceeds ZSQ(1), ISQ is advanced to unity and continues to be advanced as time reaches higher values of ZSQ(ISQ). When Z equals or exceeds ZSQ(ISQS), the value of QS remains constant as QSSP(ISQS) until the shutdown phase begins.

The power changes due to the buildup and decay of delayed-neutron and decay-heat precursors are calculated to yield the delayed-neutron power QDT and decay-heat power QG. The latter is obtained from the summing of decay-heat-precursor power QGDT and constant additional decay-heat power QGC, which is the difference between the initial values of QG and QGDT.

The kinetic equations give the fission-power increment QFI and fission power QF. The total power QR is the sum of QF and QG. The integrated power HQ is augmented by the average of the preceding and new values of QR multiplied by the time increment ZI. The inverse reactor period PIN is calculated by dividing QFI by the product of the new QF and ZI.

Testing of the new value of integrated power HQ against HQT (card 12100) determines whether temperature calculations will be made, as shown in Step 25 of Table 2. If HQ is less than HQT, all temperature, temperature-reactivity-feedback, and coolant-reactivity-feedback values remain unchanged. For higher values of HQ, and if NRT is not negative, the temperatures of each region

IV, A, Description of Program Sequence and Function (cont.)

and the appropriate average fuel temperature (TFA) are calculated according to Option N3. The temperature-reactivity feedback RTS is calculated by summing the effect of TFC and each TA(NR1).

Any fuel temperatures above the melting point TFM are calculated as applicable to a fictitious material with the specific heat of solid fuel and with no phase change. Fictitious temperatures are then converted back to appropriate fuel temperatures with phase changes. Indices LFC and LF(NR1) are corrected to indicate phase changes. If N3 = -1, all regional temperatures are calculated, including TFC and each TA(NR1), and the volume-weighted average is used to establish TFA. If N3 = 0, only TFC is calculated and used as TFA, while the values of TA(NR1) are assumed to represent temperatures outside the reactor core supplied by an engine-analysis program used concurrently. If N3 = 1, all temperatures must be supplied by an engine-analysis program.

If HQ is not less than HQT and N10 is not negative, coolant-temperature and coolant-mass reactivity calculations are made in Step 29 of Table 2 to determine the coolant reactivity feedback RMS. Coolant-temperature multipliers RMM(NR2), which are included in the coolant-mass reactivity-feedback terms RM(NR2) for each region, are calculated to equal unity when the coolant temperatures TC(NR2) equal the base temperatures TCR(NR2) for no reactivity feedback. If N10 = 1, each RM(NR2) is calculated from the product of RMM(NR2), the coolant-mass RB(NR2) in the region, and the difference between the coolant-region mass CB(NR2) and the base-region mass CBR(NR2) at which no reactivity feedback exists. If N10 = 0, the same method of calculation is used to establish RM(NR2) for each NR2 greater than unity, but RM(1) is calculated from a different formula intended for optional use with N3 = 0 when the reactor core includes only one temperature region and one coolant region (see Table 5). For N10 = 0 or N10 = 1, the coolant-reactivity feedback RMS is obtained by summing the values of RM(NR2).

The value of ZRZ is checked in each time increment to determine whether the elapsed-time reactivity feedback RZ has to be calculated.

IV, A, Description of Program Sequence and Function (cont.)

The input value of ZRZ (card 12110) is normally negative, unless the RZ calculation is to begin at the start of the problem. During each time increment in which ZRZ is found to remain negative, the average fuel temperature TFA is checked against the temperature TFRZ at which the RZ feedback calculation is initiated. If TFA is less than TFRZ, the values of ZRZ and RZ are left unchanged. If TFA has reached TFRZ, the value of ZRZ is set equal to the current time Z and RZ is set equal to zero. Thereafter, and also for the initial condition in which ZRZ does not have a negative value, RZ is calculated by multiplying the time-reactivity coefficient RZR by the difference between the current time Z and ZRZ. This is intended to represent deterioration or chemical-combination effects at a high temperature.

The integrated-power reactivity feedback RHQ is calculated in every time increment; it is the product of the integrated-power reactivity coefficient RHQR and the integrated power HQ as determined for the end of the current time increment. This is intended for simplified representation of fuel-burnup and fission-product-buildup effects on reactivity.

In Step 32 of Table 2 the net reactivity R is determined from the base value RS plus the imposed reactivity RR, the additional control reactivity RRC, and the following reactivity-feedback terms: RHQ, RMS, RTS, and RZ. This value of R, which is printed out at the end of the time increment, is generally slightly different from that used for the calculation of reactor kinetics, because reactivity-feedback terms are calculated after the power calculation in the cycle. These reactivity-feedback terms from Steps 28 through 30 of Table 2, with a revised value of imposed reactivity RR from Step 21, determine the value of R used for calculations in Step 24 during the next time increment.

b. Programmed-Total-Power Phase

The startup phase ends and the programmed-total-power phase begins when the total power QR equals or exceeds the limiting power QRK (card 17000), in Step 17 of Table 2. If N2 = 1, the current data are stored and

IV, A, Description of Program Sequence and Function (cont.)

"DATA STORED FOR FUTURE PROBLEM HAVING $N1 = 0$ " is printed. This printout is followed by "INITIAL REACTOR KINETICS POWER TRANSIENT ENDS. PROGRAMMED POWER BEGINS. $IK = 0$, $IQ = 0$." All grouped data are printed out from the end of the preceding time increment.

The time ZK at which startup ends is set equal to the current time Z before Z is advanced by the new increment. The increment is set equal to the input ZI from card 12000. All input values of $ZQ(IQ)$ from card 21000 are increased by ZK , and the new values of $ZQ(IQ)$ are printed out. Indices are set to again print all groups of data at the end of the initial programmed-total-power time increment.

A zero value is used for ZK if there is no startup phase, and the case begins with the programmed-total-power phase, as indicated by an initial QR greater than QRK while IQR is greater than zero. If $N4 = -1$, setting QRK equal to zero in the preliminary operations assures that there is no startup phase.

During each time increment, Z is checked against the tabulated $ZQ(IQ)$ times, and the IQ index is advanced by unity when the next higher $ZQ(IQ)$ is reached. Straight-line interpolation is used between tabulated values of total power $QRP(IQ)$ to give QR . The integrated power HQ is augmented by the average of the initial and final QR values multiplied by the time increment.

If $N4 = -1$, the fission power QF is set equal to the total power QR , and no decay heat is calculated. If $N4 = 0$, the decay-heat power QG is determined by straight-line interpolation from tabulated values of $QGP(IQ)$ as a function of $ZQ(IQ)$ if IQG is greater than IQR ; with other IQG values, the initial QG value is held constant. If $N4 = 1$, the decay-heat power QG is calculated by summing the interpolated values of $QGP(IQ)$ and the calculated power from decay-heat precursors, or by summing the initial QG and the decay-heat-precursor power if IQG is not greater than IQR .

IV, A, Description of Program Sequence and Function (cont.)

The fission power Q_F is obtained from the difference between Q_R and Q_G . Changes in delayed-neutron and decay-heat precursors are calculated on the basis of the average fission power over the time increment.

Steps 20 through 24 in Table 2 are bypassed during the programmed-total-power phase. If the integrated power H_Q equals or exceeds H_{QT} , the temperature and coolant-mass reactivity feedbacks (RTS and RMS) are calculated in Steps 25 through 29 as described for the startup phase (Step 30 of Table 2).

If N_4 is not negative, the net reactivity R is calculated from the first kinetic formulation as the value required to give the slope of programmed total power applicable to the current value of index I_Q . For this purpose, it is assumed that the rate of change of fission power equals the rate of change of total power. If $N_4 = -1$, a fictitious zero value is maintained for R .

The imposed reactivity RR is calculated as the remaining reactivity required to give the newly calculated net reactivity R . This RR value is obtained from the difference between R and the sum of the following terms: RS , RRC , RHQ , RMS , RTS , and RZ .

The inverse reactor period PIN is determined by dividing the rate of change of total power for the current value of index I_Z , by the new fission power Q_F .

If $N_6 = 0$, the time at which programmed total power ends and the shutdown phase begins is exactly the stored value of time point $ZQ(IQR)$ as determined by the summing of input $ZQ(IQR)$ and ZK . This is accomplished by adjusting the final time increment during the programmed-total-power phase so that it falls exactly on $Z = ZQ(IQR)$. If $N_6 = -1$, however, the time increment is constant and the programmed-total-power phase ends at the end of the increment for which $Z \geq ZQ(IQR)$. In either case the total power Q_R is set equal to the

IV, A, Description of Program Sequence and Function (cont.)

programmed value of $QRP(IQR)$ from card 21100, and the reactivity calculation for R is based upon the slope of the programmed-total-power-curve from the scheduled total-power change between $ZQ(IQR - 1)$ and $ZQ(IQR)$, and upon the final fission power ($QF = QRP(IQR) - QG$). The final inverse reactor period PIN during the programmed-total-power phase is also calculated from the slope of the programmed-total-power tabulation, which is correct when $N6 = 0$ because the final time is exactly $ZQ(IQR)$, but may be incorrect when $N6 = 1$ because time may have stepped somewhat beyond $ZQ(IQR)$ while total power is set at $QRP(IQR)$.

All groups of data are printed out at the end of the programmed-total-power phase, together with "COMPLETION OF PROGRAMMED POWER. CONTINUE WITH REACTOR KINETICS. IK = 1." (All groups of data are printed again at the first time increment during the shutdown phase.) If ZK plus the input $ZQ(IQR)$ gives a revised $ZQ(IQR) \geq ZL$, or if $N4 = -1$, the printout will be "COMPLETION OF PROGRAMMED POWER. NO REACTOR KINETICS." If $N2 = 2$, data are stored for possible use in future cases, and the foregoing statements are preceded by "DATA STORED FOR FUTURE PROBLEM HAVING $N1 = 0$."

The programmed-total-power phase is continued until time $ZQ(IQR)$ unless other limits are exceeded.

c. Shutdown Phase

The shutdown phase follows the programmed-total-power phase in the reactor-transient simulation and utilizes reactor kinetics in essentially the same manner as during startup. The shutdown phase, however, permits the use of programmed decay heat and some initial adjustments in imposed reactivity (determined by the N12 option) that are not available during the startup phase if the startup is to be followed by programmed total power. When there is no programmed-total-power phase, the startup phase is calculated as in the shutdown phase, and so may also utilize programmed decay heat; however, in this case there

IV, A, Description of Program Sequence and Function (cont.)

is no imposed reactivity adjustment to be made by use of the N12 option designation as during the shutdown phase.

To have a shutdown phase, it is necessary that the limiting time ZL be no greater than the sum of the final tabulated time point ZQ(IQR) from card 21000 and the value of ZK at which the startup phase ends. This sum is the recalculated ZQ(IQR) used as the time base for the shutdown phase. Other requirements for a shutdown phase relative to options N1, N2, and N4 are as given in paragraph IV,A,2,a, above, for the startup phase.

At the transition from programmed total power to the shutdown phase, the programmed imposed excess-neutron-multiplication schedule is revised if $IRN > 0$ and $N12 \neq -1$. The base reactivity is effectively altered by changing the constant multiplication coefficients $RO(IR)$. The remaining schedule for imposed reactivity, beyond that used during startup, is initiated from the end of programmed total power when $N12 \neq -1$. For $N12 = -1$, the imposed excess-multiplication schedule utilizes the unchanged data from input cards 20000 through 20200, and the base reactivity remains unchanged. For $N12 = 0$ or $N12 = 1$, the imposed schedule is continued from the next higher value of the index IR than that used at the last time increment during startup, unless there was no startup phase; if there was no startup phase, the imposed schedule is based on the IR index at the start of the problem.

Option $N12 = 0$ is used when it is desired to base the imposed excess multiplication after programmed total power on the imposed value RR at the end of the startup phase. With this selection, the RR value at the end of the startup phase is stored until the end of the programmed-total-power phase and is then added to each $RO(IR)$ used during the shutdown phase. This produces the same effect as a new base reactivity RS equal to the input RS plus the imposed reactivity RR at the end of startup. The current ZR(IR) for the new IR index at the beginning of the shutdown phase is set equal to the time Z at

IV, A, Description of Program Sequence and Function (cont.)

which that phase begins. All tabulated time points $ZR(IR)$ for IR indices higher than the current value are corrected by the difference in time between the newly established current $ZR(IR)$ and the input value of the current $ZR(IR)$ from card 20200.

Option $N12 = 1$ permits the simulation of a scram or other reactivity change that may be limited by the available reactivity according to the existing control-mechanism position. This selection effectively results in beginning the shutdown phase with the base reactivity established by the sum of the initial RS and the RR value most recently calculated at the end of programmed total power, and then changing to the same base reactivity that was used during startup. If the current value of index IR is not less than the input final index IRN given on card 11010, however, the base does not change from that established by the imposed reactivity RR at the end of programmed total power, because IR is not further augmented beyond IRN . At the initiation of the shutdown phase, the current value of the imposed reactivity coefficient $RO(IR)$ scheduled for that phase is normally increased by the RR calculated at the end of the programmed-total-power phase, and the current tabulated $ZR(IR)$ is set equal to the time Z at the beginning of the shutdown phase. The next scheduled time $[ZR(IR + 1)]$ at which the imposed reactivity coefficients $[RO(IR + 1), R1(IR + 1), \text{ and } R2(IR + 1)]$ begin to be used is established by

$$ZR(IR + 1) = \frac{ZR(IR) + [RO(IR+1) - RO(IR)]}{R1(IR)}$$

If the resulting $ZR(IR + 1)$ is less than $ZR(IR)$, the sign of $R1(IR)$ is changed and $ZR(IR + 1)$ is corrected accordingly; this corresponds to reversing the direction of control-mechanism action from that which had been anticipated by use of the input rate of change of imposed reactivity $R1(IR)$. To provide continuity in imposed-reactivity values when $N12 = 1$, the value of $R2(IR)$ should be zero for the IR at the initiation of the shutdown phase. The newly calculated $ZR(IR + 1)$ is used as the base time for further $ZR(IR)$ values, by adding to

IV, A, Description of Program Sequence and Function (cont.)

them the difference between the calculated $ZR(IR + 1)$ and the input value for $ZR(IR + 1)$ from card 20200.

If IQS is greater than IQR on card 11000, the source power during shutdown is scheduled as $QSP(IQ)$ on card 21400, using the time schedule $ZQ(IQ)$ from card 21000 plus the automatic addition of ZK at the end of startup. If IQG is greater than IQR on card 11000, the same time schedule $ZQ(IQ)$ is used for scheduling decay-heat power $QGP(IQ)$ on card 21200. The decay-heat-power schedule includes the $ZQ(IQ)$ times during the programmed-total-power phase as well as the shutdown phase. The source-power schedule begins at the end of the programmed-total-power phase with time $ZQ(IQR)$. Straight-line interpolation is used for determining intermediate values of both source-power and decay-heat power between $ZQ(IQ)$ values. After $ZQ(IQS)$ is reached, the source power remains constant at $QSP(IQS)$. After $ZQ(IQG)$ is reached, the programmed component of decay-heat power remains constant at $QGP(IQG)$.

If $N^4 = 1$, the programmed-decay-heat-power values $QGP(IQ)$ are added to any decay-heat power resulting from the buildup of decay-heat precursors according to calculations made in essentially the same manner as those made for delayed-neutron-precursor buildup and decay. Calculations are made for delayed-neutron and decay-heat precursors throughout all phases of the case, and are therefore continuous through the transition from programmed total power to shutdown. If $N^4 = 0$, delayed-neutron precursors are calculated but decay-heat precursors are not, and the decay-heat power is only that determined by programmed or constant values. If IQG is not greater than IQR , there is no programmed-decay-heat power, regardless of the N^4 selection; instead, a constant value of decay-heat power (to be added to decay-heat-precursor power if $N^4 = 1$) is carried throughout all phases of the case. This constant decay-heat-power component is equal to the difference between the input total power QR and fission power QF on cards 12000 and 17000, minus any initial power from decay-heat precursors. If IQS is not greater than IQR , the source power during shutdown remains constant at the value

IV, A, Description of Program Sequence and Function (cont.)

last calculated during startup. That value would be the input source power Q_S from card 17000 if $ISQS = 0$; otherwise, for $ISQS$ greater than zero, it would be the calculated value of Q_S at time ZK based upon interpolation in the schedule of source power $QSSP(ISQ)$ and time $ZSQ(ISQ)$ on cards 21500 and 21600.

When $N6 = 0$, the initial time increment during the shutdown phase is determined by comparison of the time increment used during programmed total power (which is the input ZI on card 12000) with the time increment $Z2$ (on card 19200). If $Z2$ is larger, the initial shutdown time increment is $Z1$; otherwise, the initial increment is $Z2$. However, the regular checks on numerical stability and the checks for the proportional rate of change of power in comparison with Q_{T1} (on card 12000) may change the time increment even before it is used in the kinetics formulations.

Reactivity and temperature calculations as related to the power calculations are the same throughout the shutdown phase as during the startup phase.

d. Iterative Operations Common to All Phases

Certain routine operations are performed each time increment in the startup, programmed-total-power, and shutdown phases. At the beginning of the increment in Step 16 of Table 2, the time increment J is advanced by unity, and the Z is increased by ZI ; however, the time may later be corrected if a change is made in the value of ZI . A test is made on IK to establish the phase of the preceding time increment, and checks are then made to determine whether that phase should be ended.

At the end of each time increment, if limits for stopping the problem are not exceeded in Step 33 of Table 2, a check is made in Step 34 for the number of time increments since the last data printout if $N7 \neq 1$, or for

IV, A, Description of Program Sequence and Function (cont.)

the time elapsed since the last data printout if $N_7 = 1$. The first data group is printed if these increments are equal to or greater than indices IP_1 and ZIP_1 , respectively. If the first data group is printed and if N_7 is not negative, checks are made of indices IP_2 and IP_3 (if $N_7 = 0$) or ZIP_2 and ZIP_3 (if $N_7 = 1$) and the second and third data groups are printed out when their appropriate increments have been reached.

Work on the case is stopped after any time iteration in which any of the following conditions is found to exist: time increment J is not less than J_L , time Z is not less than Z_L , average fuel temperature TFA is greater than TFL , or fission power QF has a negative value. For the last two listed causes (involving TFA or QF) the reason for stopping the problem is printed out, but there is no printout when the limits on J_L or Z_L are exceeded. All data groups are printed out at the end of the case, together with the values for fuel-phase indices LFC and $LF(NR_1)$ if index NRT is not negative. If $N_2 = 2$, data are stored for use in a later case having $N_1 = 0$, and a statement to this effect is printed. The statement "END PROBLEM" is then printed.

B. PROGRAM APPLICATION

Application of the OSCAG 1 program to the solution of a specific case involves establishing the basic representation, including the choices of optional computation techniques. It is also necessary (1) to determine limiting values; (2) to obtain input data on materials; (3) to establish the initial thermal, reactivity, and kinetic conditions; (4) to designate appropriate time increments; (5) to tabulate programmed values of reactivity and of component and total contributions to power; and (6) to determine the frequency of printout for various data groups.

IV, B, Program Application (cont.)

1. Basic Case Representation

A case to be analyzed is described by the complete input data, and certain data are especially significant in describing the case and methods of calculation. The first input card provides an alphanumeric title for the case. Four fixed-point input cards follow the title card, and another fixed-point input card occurs later in the sequence. The indices and option selections that make up the fixed-point data include much of the basic representation of the case.

The input values chosen for IQG, IQR, IQS, and ISQS determine whether programmed decay heat, source power, and total power will be used. A value of zero for IQR or ISQS establishes that the total power and startup source power are not programmed from predetermined values, and values of 2 or more indicate the use of programmed values. A value greater than IQR is required for IQG or IQS in order for programmed values of decay heat or source power to be used after the startup phase.

Changes in the coefficients used for calculating imposed reactivity are indicated to occur at specified times when IRN is greater than zero. Additional variations in the imposed-reactivity coefficients used during the shutdown phase are indicated by value selected for option N12.

The number of temperature regions in the reactor-core model is indicated by the value of NRT: A zero input value indicates a lumped core model, and higher positive values give the number of subscripted temperature regions in addition to an unsubscripted central-core-temperature region. In order to have no regional-temperature calculations, the input value of NRT must be -1.

The methods of calculating fuel temperatures and associated heat transfer to the coolant are determined by the values selected for options N3 and N8.

IV, B, Program Application (cont.)

The number of coolant regions for coolant-reactivity-feedback calculations is given directly by the input value of NRM, with zero indicating no coolant regions. The method of calculating coolant-reactivity feedback is determined by the value selected for option N10. The value chosen for option N9 designates whether the reactivity-feedback base conditions for all material temperatures and for coolant masses in the various regions are based on initial-case values or on other input values.

Initial conditions of critical or subcritical steady state, or unsteady state, are established by option N5. For steady-state conditions, the program sets values consistent with this condition; for unsteady-state conditions, there must instead be additional input.

Option N4 indicates the use of kinetic calculations (including delayed-neutron precursors) and of decay-heat precursors. When neutron kinetics are to be calculated as occurs when $N4 \neq -1$, the number of fissionable materials contributing delayed neutrons is given by IFN, the number of delayed-neutron-precursor groups by NDN, and the number of decay-heat-precursor groups by NGN.

Other options include N1 for establishing whether the input data are all new or some are taken from a preceding case, N2 for determining whether data are to be retained for use in a subsequent case, N6 for selecting constant or varying time increments, and N7 for designating intervals of printout. Table 5 explains the various option selections and certain input indices for OSCAG 1.

2. Limiting Values

The overall case is bounded by initial and limiting values. The limiting values at which the case is stopped include the maximum number of time increments JL, the maximum time ZL, and the maximum average fuel temperature TFL.

IV, B, Program Application (cont.)

Typically, ZL is established as the time value intended for ending the case. A probable number of digital increments may be estimated from input time increments Z1 and Z2 for the first and second kinetic formulations used for calculations of neutron kinetics, and from the input time increment ZI used during the programmed-total-power phase. The limiting number of time increments JL is typically set at a few times the estimated number of increments, thereby providing a backup limit to prevent excessive computer time in the event of input errors or unanticipated conditions. The short time increment Z1 can be automatically reduced by the program to prevent numerical instability; in so doing, however, a condition may ensue that involves more printout and computer time than anticipated. It is also possible that the total power QR may never reach QRK, due to unanticipated reactivity conditions or an input error; as a result, the long time increments of the programmed-total-power phase may be replaced by the short increments of reactor kinetics. Use of a JL limit can prevent continued calculation and unnecessary data printouts in such cases.

As a fixed-point number, JL is limited to a value of approximately 131,000. The use of more time increments requires that a succession of cases be set up with NL = -1 and J = 0 for each continuation case after the first. The data in use at the end of each case then become initial data for the next case.

The average fuel-temperature limit TFL is generally used to represent some physical condition, such as the temperature at which the core would be vaporized and beyond which it would be meaningless to continue the case.

The startup phase is limited by the total power QRK, which is the maximum value permitted during calculation of reactor kinetics prior to the initiation of programmed total power. The case begins in the startup phase only if there is a programmed-total-power phase, as indicated by a positive nonzero value of IQR, and if the initial value of total power QR is less than QRK. For any other conditions, the program treats the case as if there is no startup phase.

IV, B, Program Application (cont.)

A startup analysis can in fact be run, however, in what is called the shutdown phase because the methods of calculating reactor neutron kinetics are identical in the startup and shutdown phases.

The programmed-total-power phase begins when QR first exceeds QRK ; it lasts an amount of additional time given by the input value of $ZQ(IQ)$ in which IQ is equal to the input value of IQR . This may not be the final value of $ZQ(IQ)$, which is designated $ZQ(IQL)$, because there may be time points after the programmed-total-power phase that give tabulated values of decay heat or source power.

The shutdown phase begins at the end of the programmed-total-power phase, or at the initial time if $IQR = 0$, and ends when a limiting value for the case is reached. Any of the phases are stopped by the limits JL , ZL , and TFL .

A limiting proportional fission-power rise QTL is applicable to the use of the second kinetic formulation. When the absolute value of the fission-power increment is greater than QTL times the fission power, the first kinetic formulation and its associated shorter time increment are used. This prevents serious extrapolation errors. Typical values for QTL may be 0.01 to 0.05.

Temperature calculations are bypassed until the integrated power reaches the value HQT . This is useful for reducing computer time during a startup from very low power, which involves a great many time increments before there is sufficient sensible heat generation to warrant thermal calculations.

A reactivity feedback for core deterioration with time at a high temperature is initiated when the average fuel temperature TFA reaches the input value of $TFRZ$, if the input value of time ZRZ is negative and not zero. In order for this feedback to begin immediately and to be proportional to time from the start of the case, the input value of ZRZ is set equal to the initial time Z ; then, the value of $TFRZ$ is never used. A step reactivity change may be initiated

IV, B, Program Application (cont.)

when the temperature TFRZ is reached, by setting the input RZ equal to the negative of the desired step change, and the input ZRZ to any negative value. The input RZ is then included in the initial net reactivity R, and that value of RZ holds constant until the average fuel temperature reaches TFRZ, at which time RZ suddenly changes to zero. To determine RZ, the coefficient RZR is thereafter multiplied by the difference between current time Z and the time ZRZ at which TFA reached TFRZ.

3. Thermal and Associated Reactivity Data

Thermal calculations and the associated reactivity feedbacks require input data for heat capacities, temperatures, regional power fractions and volume fractions, base reactivity conditions, and reactivity coefficients.

The fuel heat capacity HCF is the heat capacity of the entire core, which is represented by the average fuel temperature TFA in the solid state. Its units are those of power QR multiplied by time Z. Between phase-change temperatures TFM and TFMC, the heat capacity HCFM is actually a dimensionless ratio (to the solid fuel heat capacity HCF), as is the heat capacity HCFL for fuel temperatures above TFMC. If the temperature change required to complete the phase change on going from TFM to TFMC is arbitrarily set at 1° (so that $TFMC = TFM + 1$), the value of HCFM equals the ratio of the fuel heat of fusion (or of vaporization if sublimation is taking place) to the solid fuel heat capacity.

For a lumped-core temperature analysis, NRT = 0 and input values are required for TFA and the core power fraction QRFC. The value of QRFC may be less than unity because some heat is generated outside the core, due to gammas and neutrons escaping the core. No volume fraction is required for the lumped core, because the program uses a volume fraction of unity for the entire core.

For regional analysis, it is necessary to designate the initial temperatures and power fractions for all regions. If option N3 = 0 is selected,

IV, B, Program Application (cont.)

no volume fraction is designated because all fuel is represented by the core temperature TFC (which is equated to TFA) and by the core power fraction QRFC. Temperatures TA(NR1) and the corresponding power fractions QRF(NR1) represent regions outside the core, and the thermal calculations for these regions must be made in an engine-analysis program because OSCAG 1 bypasses TA(NR1) calculations when N3 = 0, except for reactivity feedback. When N3 = -1 is selected, however, all regions are considered fuel and their temperatures are calculated. The temperature TFC and power fraction QRFC then may represent center-region core conditions.

The sum of input power fractions QRFC and all QRF(NR1) values should not be greater than unity; however, this requirement does not apply to the volume fractions VFC and VF(NR1), which are input when NRT > 0, N3 = -1, and N1 = 1. The program normalizes the volume fractions so that their sum is unity. Any numbers giving proportional volumes may therefore be used as input for VFC and VF(NR1); these may, for example, represent the number of coolant channels per region if each channel cools the same volume of fuel.

For an initial steady state, the base reactivity condition normally corresponds to the initial condition, and departure from initial temperature and coolant-mass values results in reactivity feedbacks. This condition is designated by use of option N9 = -1. However, N9 = 1 is selected for any other base condition, and input values must be provided for base temperatures and coolant masses. There is then an initial reactivity feedback; e.g., the initial regional-temperature feedback RT(2) equals the coefficient RA(2) multiplied by the difference between input temperature TA(2) and input base temperature TAR(2).

The integrated power reactivity feedback RHQ is determined simply by the product of input coefficient RHQR and integrated power HQ. By using an initial HQ of zero, RHQ can represent a reactivity loss proportional to the fuel burnup.

IV, B, Program Application (cont.)

4. Delayed Neutrons, Decay-Heat Precursors, and Other Initial Kinetics Data

Delayed-neutron and decay-heat-precursor data are established in similar fashion, except that the delayed-neutron data may involve a mixture of several materials and an effective delay fraction greater (by the multiple BR) than the basic delay fraction for an infinite material.

For delayed-neutron input data, the fraction of fissions $FR(IRM)$ occurring in each fuel isotope may be designated by proportional values that do not have to total unity. The program sums the input $FR(IRM)$ and divides each by the sum when calculating the effective delayed-neutron fraction for each delay group. When data are used for six delayed-neutron groups and a mixture of fuel isotopes, representative decay constants for all the materials should be used for at least five of the groups, while one delay group may be represented by two decay constants for unmatched values. This provision is made for a total of seven delayed-neutron groups because all but the third group can generally have decay constants matched within the accuracy of experimental data, and the third delay group may be divided into two decay constants that can approximately be fitted to the various isotopes.

Decay-heat-precursor data are not required unless $N4 = 1$. The use of such data requires the establishment of relative yields $BG(NG)$ and decay constants $YG(NG)$ for the appropriate real or fictitious fission-product precursors.

If steady-stage conditions are designated, by $N5 = -1$ or $N5 = 1$, the delayed-neutron and decay-heat-precursor powers are calculated for equilibrium and do not have to be provided as input. An unsteady-state condition, designated by $N5 = 0$, makes inputs for these power values necessary, and they may be taken from some previous transient-case data or from estimated conditions.

The starting reactivity condition RS designates the initial reactivity applicable to the condition of no reactivity feedback and no external

IV, B, Program Application (cont.)

imposed reactivity. An input value of RS is required except for $N5 = 1$, which represents a critical or subcritical steady-state condition in which the net reactivity R is calculated from the source power QS and fission power QF to correspond to the proper source multiplication. If QS is zero, $N5 = 1$ may be selected because it gives a net reactivity equal to zero, and $N5 = 0$ may also be used; however, $N5 = -1$ may not be used if either QS or R is zero, because the ratio of those values is used to establish QF, which cannot start from zero.

For unsteady-state condition $N5 = 0$, data from a previously calculated transient must be provided, or the values must be estimated, for the net reactivity RP in the preceding time increment and for the two preceding power increments QFI and QFIP. These input-power increments are those that would apply to the use of the time increment Z2 for the second kinetic formulation. If no values are known for QFI and QFIP, it is best to use equal values corresponding to the approximate change of power in a time increment Z2 as input.

The initial value of time increment Z1 should be substantially less than $EL/(BE - R)$. The value of time increment Z2 should be substantially greater than twice $EL/(BE - R)$, unless it is desired not to utilize the second kinetic formulation for the longer time increments. The second formulation will never be used if Z2 is less than the initial value of $2.5 \times EL/(BE - R)$, and if thereafter the lowest value of R gives Z2 less than $4 \times EL/(BE - R)$. These are approximate formulas that are very close to the exact values used in program calculations. The value $EL/(BE - R)$ is the time constant for the prompt jump in neutron kinetics.

5. Programmed Reactivity and Power Data

Imposed-reactivity values are programmed in a cumulative manner, by coefficients that define parabolic equations of imposed reactivity RR vs time Z between designated time points ZR(IR). The initial coefficient R00 indicates

IV, B, Program Application (cont.)

an initial step change in imposed reactivity; R01 indicates a linear ramp, and R02 a coefficient multiplied by the square of time after the starting time ZS.

The use of coefficients R00, R01, and R02 ends at time ZR(1). If R0(1) does not equal $R00 + [R01 + R02 \times (ZR(1) - ZS)] \times (ZR(1) - ZS)$, the amount by which R0(1) differs from that value is applied as an imposed step change in reactivity at time ZR(1). The coefficients R1(1) and R2(1) are multiplied by the first and second power, respectively, of the time after ZR(1). Similarly, the use of coefficients R0(1), R1(1), and R2(1) ends at time ZR(2), and a step reactivity change is imposed if R0(2) does not equal $R0(1) + [R1(1) + R2(1) \times [ZR(2) - ZR(1)]] \times [ZR(2) - ZR(1)]$.

When N12 = 0 or N12 = 1 is selected to effect changes in imposed reactivity after the end of the programmed-total-power phase, the tabulated time ranges for imposed reactivity during the shutdown phase may actually be input at times greater than the time limit ZL for stopping the problem. If coefficients for the startup phase have values through index IR = 2, a time range IR = 3 may be established with R0(3) giving the maximum possible imposed reactivity, and R1(3) and R2(3) equal to zero. The time ZR(4), to be made applicable to the beginning of the shutdown phase, may then be given an input value equal to ZL or higher, in order to assure that it will not be used during the startup phase. The program will then automatically translate the time ZR(4) and higher tabulated times, with their corresponding coefficients for imposed reactivity, to make them applicable to the shutdown phase as described for N12 = 0 and N12 = 1 in Table 5.

There are no input coefficients to define equations for the programming of decay heat, source power and total power; instead, there are input power values at designated times. The program uses straight-line interpolation between the input power values. A common set of input time points ZQ(IQ) is used for all power points after the start of the programmed-total-power phase. Only source power is programmed during the startup phase, using input time points ZSQ(ISQ).

IV, B, Program Application (cont.)

6. Printout

The basic printout of data groups is summarized in the explanation of option N7 in Table 5. When no thermal data exist, such as in a low-power startup analysis, N7 = -1 eliminates unnecessary thermal-data printout; N7 = 0 and N7 = 1 give complete printouts of time, power, reactivity, temperature, and coolant-mass data.

When a data printout is desired after specified numbers of time increments, regardless of the length of the time increments, N7 = 0 is designated. When printout is desired after specified lengths of time, N7 = 1 is designated; this selection generally assures more economical use of output sheets. In any situation, however, the output may be designated for as frequent or as long intervals as desired, for each of three data groups. The extent of the printed output depends upon input values of IP1 when N7 = -1; of IP1, IP2, and IP3 when N7 = 0; and of ZIP1, ZIP2, and ZIP3 when N7 = 1.

To obtain columnar output of the most important first data group, the input values for ZIP2 and ZIP3 (or IP2 and IP3) should be much larger than ZIP1 (or IP1). The use of an input time ZIP1 between printouts however, may result in a longer time between printouts, because the printout occurs at the time increment when the elapsed time is equal to or greater than ZIP1. For this reason, it is generally best for the input value of ZIP1 to be slightly less than the desired time for the printout interval, considering also the non-integer nature of floating-point numbers as used by the computer.

V. OSCAG 2 AND AGTRAN

The OSCAG 2 digital nuclear-reactor-transient simulation program is an advanced version of OSCAG 1. Essentially all the capabilities of the OSCAG 1 program are incorporated in OSCAG 2. The basic changes are those made in the input and output symbols (see Table 6), the input-card sequence and requirements (see Table 7), and the options available (see Table 8).

The OSCAG 2 program has been improved to provide easy integration with an engine-analysis program. This is accomplished by providing dummy subroutines in the main computer program that can be replaced by real subroutines intended for heat-transfer and fluid-flow calculations when integration is required. With dummy subroutines FLOW (1) and FLOW (2), and with option N3 $\neq$ 1, OSCAG 2 can be used for analyses of reactor kinetics independently of an engine-analysis program.

This program was prepared specifically for integration with the core and nozzle heat-transfer and fluid-flow program written by Aerojet-General Corporation and covered in the Appendix. The integrated program is called AGTRAN. All information presented here on OSCAG 2 is also applicable to AGTRAN. The use of N3 = 1 designates the inclusion of fluid-flow calculations in AGTRAN; these calculations are not accomplished within OSCAG 2, but are provided by meaningful subroutines FLOW (1) and FLOW (2), such as those included in AGTRAN and described in the Appendix.

During the preliminary operations, subroutine FLOW (1) is inserted for input of thermal and fluid data, and associated initial calculations. Subroutine FLOW (2) is inserted during the repetitive portion of the program for iterative calculations of heat transfer and fluid flow data. It is intended that FLOW (1) will also transfer to FLOW (2) to obtain initial equilibrium thermal and coolant-flow conditions. The initial data may be used to establish base reactivity conditions in OSCAG 2, by the selection of N9 = -1.

V, OSCAG 2 and AGTRAN (cont.)

Indices are set up for transfer to and initiation of the proper use of FLOW (2) after each time increment DELTA, and also whenever the average fuel temperature TFA departs by more than the limit TFl from the corresponding average fuel temperature calculated in FLOW (2). Regional and average fuel temperatures are calculated for every time increment in OSCAG 2 if $NRT \geq 0$, with the assumption that the power transferred to the coolant equals the total power QR existing when temperatures were last calculated under FLOW (2). However, when the FLOW (2) subroutine is called, the temperature values in OSCAG 2 are corrected to those calculated in FLOW (2).

For $NRT > 0$, the total number of fuel-temperature regions is exactly the same as the value of NRT, rather than $NRT + 1$ as in OSCAG 1. Up to six temperature and coolant-mass regions are possible. If $NRT = 0$, the lumped-core temperature is calculated. When $NRT = -1$, no temperature calculations are performed, but any average core temperature calculated in the FLOW (1) or FLOW (2) subroutines may be printed out as TFA if $N3 = 1$.

The manner of determining time increments is different in OSCAG 2. The time increment DELTA is used in subroutine FLOW (2) as the basic time interval between fluid-flow calculations. That subroutine may also be called at odd intervals to adjust the fuel-temperature calculations because the limiting deviation TFl in the average fuel temperature has been exceeded. The use of time increments Z1, Z2, and Z3 must result in summing to the increment DELTA, so these increments are set up in integer multiples.

The input integer JZ3 multiplied by the input time increment Z3 (used during the programmed-total-power phase) equals DELTA. The input integer JZ3 multiplied by the input time increment Z2 (used for the second kinetics formulation in the startup and shutdown phases) equals Z3. The input integer JZ1 multiplied by the input time increment Z1 (used for the first kinetics formulation in the startup and shutdown phases) equals Z2.

V, OSCAG 2 and AGTRAN (cont.)

When the first kinetics formulation is being used, there cannot be a change to the second kinetics formulation until an integer multiple of JZ1 number of time increments Z1 has been accumulated. When the increment Z1 is reduced to maintain numerical stability, the Z1 reduction is made by dividing it by an integer; and simultaneously an increased value for JZ1 is obtained by multiplying JZ1 by the same integer, with a corresponding correction in the accumulated number of Z1 increments.

The time increment Z1 for the first kinetics formulation is assumed for initial trial use at the beginning of the startup and programmed-total-power phases. However, the initial time increment for these phases may be Z2 for the second kinetics formulation, if tests for its use are satisfied Equations [(25 and (26) in Section III].

The input requirements for OSCAG 2 are similar to those for OSCAG 1. Card 20000 is the first input card. After five input cards identical to those for OSCAG 1, there are three new and revised cards (21200, 22000 and 22100) in OSCAG 2. A 30000 series of card numbers is set aside for thermal and fluid-flow data, to be included when subroutine FLOW (1) is used (i.e., when N3 = 1), in the AGTRAN program. Additional input cards 40000 through 46000 have requirements that are somewhat different from their counterparts in OSCAG 1, but cards 46100 to 52000 are identical to cards 17100 to 22000 in OSCAG 1. (Time increment card 19200 is omitted because the data are otherwise provided.

Some input data are rearranged for increased utility and convenience. As one example, the limiting power QRK that ends the startup phase is transferred to a card (22000) which lists several limits that are input with every case; in OSCAG 1, QRK is input only when N1 = 1. This transfer permits a series of cases with transitions to new power levels before programmed-total-power-phase initiation, while continuing from data in use at other than the start of preceding cases.

V, OSCAG 2 and AGTRAN (cont.)

Table 7 lists the input cards in sequence, the data included on each card, and the requirements for the use of each card.

Many of the OSCAG 2 options are the same as those for OSCAG 1. Options N3, N5, and N10 have been changed; option N6 has been eliminated; and option N11 has been added. Table 8 summarizes the options available in OSCAG 2 and defines two modified input indices (NRM and NRT, which are related to regional coolant-mass and fuel-temperature calculations).

TABLE 1

SYMBOLS USED IN SECTION III

Used in Equations	Symbols	
		FORTRAN
		Definition
A	A, A1, A2	Ratio of prompt-neutron lifetime to time increment, $\ell/\Delta t$
b_j	BG(NG)	Fraction of fission power which augments decay-heat-precursor group j, and which in equilibrium would create decay-heat power $D_j = b_j Q_f$
B_1	B1	Prompt-neutron fraction, $1 - \beta$
B_2	B2	Effective margin of k_e from prompt critical condition; $B_2 = 1 - B_1$, k_e , with positive value below and negative above prompt critical.
C_i	-	Delayed-neutron-precursor concentration in group i
D_i	QD(ND)	Power from fission capture of delayed neutrons in group i
D_j	QGD(NG)	Power from decay-heat-precursor group j
F	QRFC, QRF(NR1)	Fraction of total reactor power generated in a material region
H_c	HCF	Heat capacity of solid material in the region for which temperature change is being calculated
k	-	Neutron-multiplication factor in an infinite medium
k_e	RK	Effective-neutron multiplication factor for a finite reactor
ℓ	EL	Prompt-neutron lifetime in a finite medium
p	-	Resonance-escape probability
Q_d	QDT	Power from fission capture of delayed neutrons in all groups

TABLE 1 (cont.)

Used in Equations	Symbols		Definition
		FORTTRAN	
Q_f		QF	Power from all fission captures, but not including decay heat
Q_g		QG	Total decay-heat power
Q_{gc}		QGC	Constant or programmed value of decay heat, not including effect of designated decay-heat precursors
Q_{gd}		QGDT	Power from all decay-heat-precursor groups
Q_p		-	Power from fission capture of prompt neutrons
Q_r		QR	Total reactor power
Q_{rt}		QRFT	Difference between total reactor power and power transferred to coolant
Q_s		QS	Power from fission capture of neutrons originating from a source other than delayed-neutron precursors and fission
R		R	Excess-neutron multiplication, $k_e - 1$
t		Z	Time (Δt = time increment)
T		TA(NR1), TFC	Temperature of a material region (the region may or may not be fuel, and TFC may represent the temperature of either the lumped reactor core or a core region)
X_i		X(ND), X1(ND), X2(ND)	Product of decay constant for delayed-neutron-precursor group i and the time increment, $\lambda_i \Delta t$
X_j		XG(NG), XG1(NG), XG2(NG)	Product of decay constant for decay-heat-precursor group j and the time increment, $\lambda_j \Delta t$
β		BE	Effective-delayed-neutron fraction

TABLE 1 (cont.)

Symbols		
Used in Equations	FORTTRAN	Definition
β_i	B(ND)	Effective-delayed-neutron fraction for delay group i, which in equilibrium would create delayed-neutron group power $D_i = \beta_i Q_f$
λ_i	YD(ND)	Decay constant for delayed-neutron-precursor group i
λ_j	YG(NG)	Decay constant for decay-heat-precursor group j
Σ_a	-	Macroscopic absorption cross section
$\sum$	-	Sum
ϕ	-	Neutron flux

TABLE 2

SEQUENCE OF PRINCIPAL DIGITAL OPERATIONS, OSCAG 1

Step No.	Statements	Computer Operations		
1	1000-1340	Read in and print out fixed point data		
2	1400-1564	Read in and print out basic thermal and time data		
		If N1=0		
3	5600-5960	If N1=-1	If N1=-1	Obtain data stored from previous problem for all case requirements
4	1565-1570		If N1-1 and NRT>0	Normalize materials volume fractions after printout of input volume fractions
5	1571-1606	Read in and establish additional thermal and base reactivity data (successive operations from here through Step 15 automatically include printout)		
6	1608-2000	Read in reactivity coefficients and calculate reactivity feedback terms; and if NRT≠-1 calculate average fuel temperature and set fuel phase indices		
		If N4=-1		
7	2010-2018	If N4≠-1	Set QF=QR, set other power terms to zero, and bypass delayed neutron and reactivity calculations	
8	2020-2300		If N1-1 If N1=0	Read in delayed neutron data and calculate effective delayed neutron fractions and total delayed neutron power
		N1≠-1 N4=-1	N1=-1	N1-1 N4≠-1
9	2310-2540		If N4=1	Read in decay heat precursor data and calculate total fraction of decay heat precursors

TABLE 2 (cont.)

Step No.	Statements	<u>Computer Operations</u>				
		$N1 \neq -1$ $N4 = -1$	$N1 = -1$	$N1 = 0$ $N4 \neq -1$	$N1 = 1$ $N4 = 0$	$N1 = 1$ $N4 = 1$
10	2600-3200					Establish initial reactivity and power condition according to N5 option and data read in
11	3210-3710					Read in time increments if $N6 = 0$; set indices for time increment selection, calculate constants associated with decay constants and neutron lifetime, and calculate initial inverse period
12	3720-3800					Read in imposed reactivity schedule
13	3900-5140					Read in schedules for total power, decay heat and source power, establish related indices, calculate slopes between all scheduled time points, and establish values for use before initial scheduled time points and after final scheduled time points
14	5500-5526					Set intervals for printout equal to zero, and if $N7 = 1$ read in time intervals for printouts
15	5528-5598					Set $QRTC = QR$, calculate initial imposed and net reactivities, establish time increment, and print, "BEGIN TRANSIENT CALCULATIONS," followed by basic initial data
<u>End of Preliminary Operations</u>						
<u>Start of Repetitive Calculations</u>						
16	6100-6150					Advance time increment number by one, advance time by time increment, and test IK index for phase
		From Step 35				
				If $IK = 1$	If $IK = 0$	If $IK = -1$

TABLE 2 (cont.)

Step No.	Statements	Computer Operations	
		From Step 35	If IK=0 If IK=-1
17	6152	If IK-1	Test QR against QRK
			If QR<QRK If QR≥QRK
18	6154-6198	IK≠0	Correct time increment, time, and schedule of times for programmed power points; set indices for programmed total power phase and for data printout; and print, "INITIAL REACTOR KINETICS POWER TRANSIENT ENDS. PROGRAMMED POWER BEGINS. IK=0, IQ=0"
19	6200-6551		If IQ IQR Determine values and correct indices for programmed total power, decay heat power and source power; if IQ is advanced to IQ=IQR set QR=QRP(IQR) and then if N8=1 set QRTC=QR; calculate power from delayed neutrons and decay heat precursors; and determine net decay heat and fission power
		From Step 19	
		IK≠0	IK=0, and from preceding time increment IQ=IQR
20	6600-7097	From Step 15	Revise imposed reactivity schedule if IRN>0 and N12≠-1; correct time increment and time; set indices for shutdown phase and for data printout; and print, "COMPLETION OF PROGRAMMED POWER. CONTINUE WITH REACTOR KINETICS. IK=1"
21	7100-7420		Calculate imposed and net reactivities and effective neutron multiplication
		If N6=-1 or Z1 reduced	From Step 22 If N6=0 and Z1 not already reduced during this time increment

TABLE 2 (cont.)

Step No.	Statements	Computer Operations			
		From Step 35	From Step 19		
22	7430-7997		If N6=-1 or Z1 reduced	If N6=0 and Z1 not already reduced during this time increment check numerical stability and proportional fission power increment, correct time increment and time as appropriate, and write out information on any time increment change	
		From Step 15		If time increment changed	If time increment unchanged
23	8000-8490		Determine values and correct indices for programmed decay heat and source power, and calculate decay heat precursors and net decay heat power		
			IK≠0		
24	8500-8740		Calculate delayed neutron power, fission power, total power, integrated power, and inverse period		
25	8750-8754		Test HQ against HQT, and if HQ≥HQT test N3, NRT and N8		
		If HQ<HQT; or if N3≠1, NRT≠-1, N8=1, and IK≠1	If HQ≥HQT and N3=1	If HQ≥HQT, N3≠1, and NRT≠-1; and either N8≠1, or N8=1 and IK=1	
			If HQ≥HQT and NRT=-1		
26	8755-8757		If N8=-1 set QRFT=QR, and otherwise set QRFT=QR-QRTC		
27	8758-8885		Calculate fuel temperatures and if phases change set fuel phase indices		

TABLE 2 (cont.)

Step No.	Statements	From Step 15	From Step 25	Computer Operations	From Step 27
28	8886-8907			Calculate temperature reactivity feedbacks; and if $N3=-1$ calculate TFA, or if $N3 \neq -1$ set $TFA=TFC$	
29	8910-8929		If $N10 \neq -1$	Calculate coolant reactivity feedbacks	
30	8933-8980		If $N10=-1$	If ZRZ positive calculate RZ; if ZRZ negative and $TFA \geq TFRZ$ set $ZRZ=Z$ and $RZ=0$; and calculate RHQ	
				If $IK=0$	
31	6552-6570		If $IK \neq 0$	If $N4 \neq -1$ calculate net reactivity; and calculate imposed reactivity, inverse period, and effective neutron multiplication	
32	8985-8990			Calculate net reactivity	
33	9000-9140			Test for exceeding limits JL, ZL and TFL, and for negative QF; and if limits exceeded or QF negative set index for final readout of data and stopping case; and print cause of stoppage unless due to exceeding JL or ZL	
34	9150-9810			Print data groups as indicated by option selection N7; or at end of case print all data and statement, "END PROBLEM"	
35	9820-9930			If $N2 \neq -1$ and if indices indicate appropriate time for data storage according to option N2, store data and print, "DATA STORED FOR FUTURE PROBLEM HAVING $N1=0$ "	
	If case not ended go to Step 16			If indices show case is ended	
36				End of case; go back to Step 1 if there are additional input cards for another case	

TABLE 3

INPUT AND OUTPUT SYMBOLS FOR OSCAG 1

<u>FORTRAN Symbol</u>	<u>Definition</u>
A, A1, and A2	Ratio of digital time increment to prompt-neutron life-time, giving time increments Z1, Z1, and Z2, respectively, as multiples of prompt-neutron lifetime
B(ND)	Effective delayed-neutron fraction of delay group ND: $B(ND) = BR \times \sum_{IFM} [BD(ND, IFM) \times FR(IFM) / FRT]$
BD(ND, IFM)	Delayed-neutron fraction of delay group ND for fuel isotope IFM in infinite medium
BE	Effective delayed-neutron fraction: $BE = \sum B(ND)$
BG(NG)	Delay fraction for decay-heat-precursor group NG, applied as a multiple of fission power Q^F to augment the precursor group
BGP	Total delay fraction for decay-heat-precursor groups: $BGP = \sum BG(NG)$
BR	Ratio of effective delayed-neutron fraction to theoretical delayed-neutron fraction in an infinite medium
CB(NR2)	Coolant mass in region NR2
CBR(NR2)	Base coolant mass which gives no neutron-multiplication feedback from region NR2, at which value of CB(NR2) the coolant-mass reactivity RM(NR2) is zero
EL	Prompt-neutron lifetime in a finite medium
FR(IFM)	Fraction of fissions occurring in fuel isotope IFM
FRT	Total fraction of fissions in fuel isotopes: $FRT = \sum FR(IFM)$
HCF	Heat capacity of solid fuel (below phase-change temperature TFM)
HCFL	Ratio between fuel-heat capacity after phase change (above TFM) and solid heat capacity (below TFM)

TABLE 3 (cont.)

<u>FORTRAN Symbol</u>	<u>Definition</u>
HCFM	Ratio between solid heat capacity (below TFM) and fuel heat capacity during temperature range for phase change (TFM to TFMC)
HQ	Integrated power, equal to the time integral of total power QR
HQT	Value of integrated power HQ below which fuel-temperature and coolant-mass calculations are not made except for initial conditions
IFM	Index of fuel isotope
IFN	Number of fuel isotopes used in calculating effective delayed-neutron fraction
IK	Index of phase relative to determination of power by reactor kinetics or programmed values: IK = -1, initial kinetics or startup phase, to be followed by programmed total power when $QR \geq QRK$ IK = 0, programmed-total-power phase IK = 1, final kinetics or shutdown phase
IP1, IP2, and IP3	Number of digital time increments between printouts of information as described for option N7 in Table 5
IQ	Index of time points for tabulating programmed values of decay heat, source power, and total power after start of programmed total power, when IK = 0 and IK = 1
IQG	IQ value at final programmed-decay-heat-power time point (IQG > IQR if decay heat is programmed)
IQL	Maximum of the following three input values: IQG, IQR, and IQS
IQR	IQ value at final programmed-total-power time point (IQR > 0 if total power is programmed)
IQS	IQ value at final programmed-source-power time point in phase IK = 1 (IQS > IQR if source is programmed in this phase)
IR	Index of time points for tabulating programmed values of imposed excess-neutron-multiplication (reactivity) contributions of RR

TABLE 3 (cont.)

<u>FORTTRAN Symbol</u>	<u>Definition</u>
IRN	IR value at final programmed-imposed-reactivity time point [IRN > 0 if RR is programmed for a series of time points ZR(IR)]
ISQ	Index of time points for tabulating programmed values of source power in phase IK = -1, prior to programmed total power
ISQS	ISQ value at final programmed-source-power time point in phase IK = -1 (ISQS > 0 if source is programmed in this phase)
J	Digital time-increment number
JL	Limiting time increment J at which work on case is stopped
LFC	Fuel-phase index for reactor core (or for region identified with fuel temperature TFC if more than one reactor region is used): LFC = -1 indicates solid fuel (below TFM) LFC = 0 indicates fuel in process of phase change (between TFM and TFMC) LFC = 1 indicates fuel has completed phase change (TFMC or higher)
LF(NR1)	Fuel-phase index for reactor region NR1, with meaning of values as shown for LFC
N1-N12	Input options (see Table 5)
ND	Number index of delayed-neutron group
NDN	Total number of delayed-neutron groups
NG	Number index of decay-heat-precursor group
NGN	Total number of decay-heat-precursor groups
NR1	Number index of temperature region
NR2	Number index of coolant-mass region
NRM	Total number of coolant-mass regions (see Table 5)

TABLE 3 (cont.)

<u>FORTTRAN Symbol</u>	<u>Definition</u>
NRT	Total number of subscripted temperature regions having temperatures TA(NR1); but including the one unsubscripted temperature region having temperature TFC, there is a total of one more region than the value of NRT (see Table 5)
PIN	Inverse reactor period (proportional rate of change of fission power QF)
QD(ND)	Power from fission capture of delayed neutrons in group ND
QDT	Power from fission capture of all delayed neutrons: $QDT = \sum QD(ND)$
QF	Reactor power from fission, including QDT and QS but not QG
QFI	Change in QF during current or most recently calculated time increment
QFIP	Change in QF during time increment preceding that which gave QFI, for use only in the second kinetics formulation with time increment Z2
QG	Total decay-heat power, including designated precursor and programmed or constant contributions
QGC	Decay-heat power, not including designated precursor contributions
QGD(NG)	Power from decay-heat-precursor group NG
QGDT	Power from all designated decay-heat-precursor groups: $QGDT = \sum QGD(NG)$
QGP(IQ)	Programmed value of decay-heat power QGC at time ZQ(IQ)
QGPs(IQ)	Slope of programmed-decay-heat power from ZQ(IQ) to ZQ(IQ + 1)
QR	Total reactor power: $QR = QF + QG$
QRF(NR1)	Fraction of QR generated in material of region NR1
QLFC	Fraction of QR generated as thermal power in reactor core (or in region identified with fuel temperature TFC if more than one reactor region is used)

TABLE 3 (cont.)

<u>FORTTRAN Symbol</u>	<u>Definition</u>
QRFT	Difference between total reactor power and power transferred to coolant.
QRK	Upper limit of QR during initial reactor-kinetics phase; this limit, when reached, results in changing IK to 0 and initiating programmed-total-power phase
QRP(IQ)	Programmed value of total power QR at time ZQ(IQ)
QRPS(IQ)	Slope of programmed total power from ZQ(IQ) to ZQ(IQ + 1)
QS	Source power, from fission capture of neutrons originating from a source other than delayed-neutron precursors and fission
QSI	Change in QS during current or most recently calculated time increment
QSP(IQ)	Programmed value of source power QS at time ZQ(IQ), used when IK = 1
QSPS(IQ)	Slope of programmed source power from ZQ(IQ) to ZQ(IQ + 1)
QSSP(ISQ)	Programmed value of source power QS at time ZSQ(ISQ), used when IK = -1
QSSPS(ISQ)	Slope of programmed source power from ZSQ(ISQ) to ZSQ(ISQ + 1)
QTL	Limiting value of proportional change in QF per time increment when the second kinetics formulation is used; above this limit, the time increment is reduced from Z2 to Z1 and the first kinetics formulation is used
R	Net excess-neutron multiplication (reactivity): $R = RS + RR + RRC + RHQ + RMS + RTS + RZ$
ROO, R01, and R02	Coefficients used for determining imposed reactivity RR when IRN = 0, and with $Z < ZR(1)$ when IRN > 0, in $RR = ROO + [R01 + R02 \times (Z - ZS)] \times (Z - ZS)$; however, ROO is not included in the initial RR at the starting time point
RO(IR), R1(IR), and R2(IR)	Coefficients used for determining imposed reactivity RR when IRN > 0 and $Z \geq ZR(1)$, between $Z = ZR(IR)$ and $ZR(IR + 1)$ in $RR = RO(IR) + \{R1(IR) + R2(IR) \times [Z - ZR(IR)]\} \times [Z - ZR(IR)]$

TABLE 3 (cont.)

<u>FORTTRAN Symbol</u>	<u>Definition</u>
RA(NR1)	Temperature coefficient of reactivity for region NR1 in $RT(NR1) = RA(NR1) \times [TA(NR1) - TAR(NR1)]$
RB(NR2)	Coolant-mass coefficient of reactivity for region NR2, used to obtain RM(NR2) as shown for option N10 in Table 5
RC1 and RC2	Coolant-mass coefficients used in formula for obtaining RM(NR2) when N10 = 0, as shown for option N10 in Table 5
RCT(NR2)	Coolant-temperature coefficient for modifying coolant reactivity feedback RM(NR2) for region NR2, used in $RMM(NR2) = 1 + RCT(NR2) \times [TC(NR2) - TCR(NR2)]$
RF1 and RF2	Fuel-temperature coefficients of reactivity used in formula for obtaining RTC when $NRT > 0$ and $N3 \neq 0$ in $RTC = [RF1 + RF2 \times (TFC - TFCR)] \times (TFC - TFCR)$ and for obtaining RTS directly when $NRT = 0$ or $N3 = 0$ in $RTS = [RF1 + RF2 \times (TFA - TFAR)] \times (TFA - TFAR)$
RHQ	Integrated power contribution to reactivity
RHQR	Integrated power coefficient of reactivity, in $RHQ = RHQR \times HQ$
RK	Effective neutron multiplication: $RK = R + 1$
RM(NR2)	Reactivity contribution from coolant mass in region NR2, including coolant-temperature effect RMM(NR2), as shown for option N10 in Table 5
RMM(NR2)	Coolant-temperature multiplier, which modifies neutron-reactivity feedback due to coolant mass in region NR2, calculated and used as shown for option N10 in Table 5
RMS	Total coolant-mass and temperature contribution to reactivity: $RMS = \sum RM(NR2)$
RP	Value of imposed reactivity R in the preceding time increment, retained for determining the change in R
RR	Total imposed contribution to reactivity determined by programmed values from coefficients ROO, RO1, RO2, RO(IR), R1(IR), and R2(IR)

TABLE 3 (cont.)

<u>FORTTRAN Symbol</u>	<u>Definition</u>
RRC	Control contribution to reactivity, not including programmed imposed reactivity RR, and determined external to this program
RS	Base reactivity to which other reactivity contributions are added to obtain R
RT(NR1)	Reactivity contribution from temperature in region NR1, calculated by formula listed under RA(NR1)
RTC	Reactivity contribution from reactor-core regional temperature T _{CC} , calculated by formula listed under RF1 and RF2
RTS	Total temperature contribution to reactivity other than from coolant: $RTS = RTC + \sum RT(NR1)$
RZ	Reactivity contribution from time elapsed after time ZRZ, which time is established by an input non-negative ZRZ, or at the first calculated time point for which $TFA \geq TFRZ$ if input ZRZ is negative
RZR	Time coefficient of reactivity in $RZ = RZR \times (Z - ZRZ)$
TA(NR1)	Average temperature of material in region NR1
TAR(NR1)	Base temperature which gives no reactivity feedback from region NR1, so that $RT(NR1) = 0$
TC(NR2)	Average temperature of coolant in region NR2
TCR(NR2)	Base coolant temperature which does not cause modification of reactivity feedback from coolant mass in region NR2, so that $RMM(NR2) = 1$ when $TC(NR2) = TCR(NR2)$
TFA	Average reactor-fuel temperature
TFAR	Base temperature which gives no reactivity feedback from TFA, so that $RTS = 0$ when $TFA = TFAR$; this symbol is used when $NRT = 0$
TFC	Average temperature of reactor core or region for which RF1 and RF2 serve as coefficients of reactivity

TABLE 3 (cont.)

<u>FORTRAN Symbol</u>	<u>Definition</u>
TFCR	Base temperature which gives no reactivity feedback from TFC, so that $RTC = 0$ when $TFC = TFCR$; this symbol is used when $NRT > 0$
TFL	Limiting temperature above which TFC and $TA(NR1)$ are not calculated, and at which problem is stopped when reached by TFA
TFM	Temperature at which phase change (such as fuel melting or vaporization) is initiated
TFMC	Temperature at which phase change (such as fuel melting or vaporization) is completed
FRZ	Temperature at which calculation of time-reactivity feedback RZ is initiated if input ZRZ is negative
TIME	Time (same as Z)
TP(L)	Problem title
VF(NR1)	Volume fraction of material in region NR1, with input normalized by program to give $VFC + \sum VF(NR1) = 1$
VFC	Volume fraction of material in reactor core or region to which temperature TFC applies, normalized as given for VF(NR1) above
X(ND), X1(ND), and X2(ND)	Fraction of delayed-neutron precursors of group ND which decay in each time increment, calculated by product of YD(ND) times input ZI, Z1, and Z2, respectively, except that any value greater than unity is set equal to unity
XG(NG), XG1(NG), and XG2(NG)	Fraction of decay-heat precursors of group NG that decay in each time increment, calculated by product of YG(NG) times input ZI, Z1, and Z2, respectively, except that any value greater than unity is set equal to unity
YD(ND)	Decay constant for delayed-neutron-precursor group ND
YG(NG)	Decay constant for decay-heat-precursor group NG
Z	Time
Z1	Digital time increment when the first kinetics formulation is used

TABLE 3 (cont.)

<u>FORTRAN Symbol</u>	<u>Definition</u>
Z2	Digital time increment when the second kinetics formulation is used
ZI	Digital time increment currently in use; however, the input value is stored for use as a constant time increment during programmed power; if $N6 = 0$, the initial trial increment selection ZI for reactor kinetics is Z2 if input $ZI > Z1$, or Z1 if input $ZI \leq Z1$
ZIP1, ZIP2, and ZIP3	Time between printouts of information as described for option N7 in Table 5
ZK	Time Z at which programmed total power and programmed decay heat begin, and also time base for programmed source power after completion of programmed total power
ZL	Limiting time at which computer run ends
ZQ(IQ)	Time after ZK at which programmed values of QRP(IQ), QGP(IQ), and QSP(IQ) apply as values of QR, QGC, and QS, respectively
ZR(IR)	Time at which programmed coefficients RO(IR), RI(IR), and R2(IR) apply to calculations of RR
ZRZ	Time at which RZ calculation is initiated, as described in definitions of RZ and RZR
ZS	Time at start of problem
ZSQ(ISQ)	Time at which programmed values of QSSP(ISQ) apply as values of QS

TABLE 4

INPUT-CARD SEQUENCE AND REQUIREMENTS FOR OSAG 1*

<u>Card No.</u>	<u>Symbol</u>	<u>Limitations</u>	<u>Type of Units**</u>	<u>Format</u>
10000	TP(L)	72 characters and spaces	***	12A6
11000	IP1 IP2 IP3 IQG IQR IQS	<131,000 <131,000 <131,000 ≤ 30 but $\neq 1$ ≤ 30 but $\neq 1$ ≤ 30 but $\neq 1$	-	6I12
11010	IRN ISQS J JL NRM NRT	≤ 30 ≤ 30 but $\neq 1$ <131,000 <131,000 $0 \leq \text{NRM} \leq 5$ $-1 \leq \text{NRT} \leq 5$	-	6I12
11020	N1 N2 N3 N4 N5 N6	-1, 0, 1 -1, 0, 1, 2, 3 -1, 0, 1 -1, 0, 1 -1, 0, 1 -1, 0	-	6I12
11030	N7 N8 N9 N10 N11 N12	-1, 0, 1 -1, 0, 1 -1, 1 -1, 0, 1 -*** -1, 0, 1	-	6I12

*Cards 10000 through 12000 are used for every case. Cards 12100 through 22000 are used only as required, with the need established by the value selected for applicable options or other indices, as shown on succeeding sheets of this table. For example, card 12200 is used only if option N1 = 0 or 1, option N3 = -1 or 0, and NRT ≥ 0 .

**Throughout Table 4, the units are arbitrary, but typically with time in seconds, temperature in °R, power normalized to the starting value or to full power, and coolant mass in any desired units or normalization to represent quantities of coolant in designated regions. Effective neutron multiplication and reactivity are designated in terms of k and Δk , which are dimensionless.

***These and other hyphens throughout Table 4 indicate "not applicable."

TABLE 4 (cont.)

Card No.	Symbol	Limitations	Type of Units	Format	Option and Index Designation Requirements		
					N1	N3	Other Indices
12000	QT1 ZI ZL Z EL QR	-	Dimensionless Time Time Time Time Power	6E12.8	-	-	-
					} 1 { The last three symbols are omitted from this card if N1 $\neq$ 1		
12100	HQ HQT RHQR RRC RZ RZR	-	Power x time Power x time $\Delta k / (\text{power} \times \text{time})$ Δk Δk $\Delta k / \text{time}$	6E12.8	0,1	-	-
12110	TFRZ ZRZ	-	Temp Time	6E12.8	0,1	-	-
12200	HCF HCFL HCFM TFL TFM TFMC	- - - $< 10^5$ - -	Power x time/temp Dimensionless Dimensionless Temp Temp Temp	6E12.8	0,1	-1,0	NRT $\geq$ 0
13000	TFA	-	Temp	6E12.8	1	-1,0	NRT = 0

TABLE 4 (cont.)

Card No.	Symbol	Limitations	Type of Units	Format	Option and Index Designation Requirements			
					N1	N3	N9	Other Indices
13100	TFC TA(1) TA(NRT)	-	Temp Temp	6E12.8	1	-1,0	-	NRT > 0
13200	QRFC QRF(1) QRF(NRT)	-	Dimensionless Dimensionless	6E12.8	1	-1,0	-	NRT > 0
13300	VFC VF(1) VF(NRT)	-	Dimensionless Dimensionless	6E12.8	1	-1	-	NRT > 0
14000	TFAR	-	Temp	6E12.8	0,1	-	1	NRT = 0
14100	TFCR TAR(1) TAR(NRT)	-	Temp Temp	6E12.8	0,1	-	1	NRT > 0
14200	CBR(1) CBR(NRM)	-	Mass	6E12.8	0,1	-	1	NRM > 0

TABLE 4 (cont.)

Card No.	Symbol	Limitations	Type of Units	Format	Option and Index Designation Requirements			
					N1	N9	N10	Other Indices
14300	TCR(1)	-	Temp	6E12.8	0,1	1	-	NRM > 0
	TCR(NRM)							
15000	RF1	-	$\Delta k/\text{temp}$	6E12.8	0,1	-	-	NRT ≥ 0
	RF2		$\Delta k/\text{temp}^2$	6E12.8	0,1	-	-	NRT ≥ 0
	RA(1)		$\Delta k/\text{temp}$	6E12.8	0,1	-	-	NRT > 0
	RA(NRT)							
15100	RC1	-	Mass^{-1}	6E12.8	0,1	-	0	NRM > 0
	RC2		Dimensionless					
	RB(1)		$\Delta k/\text{mass}$					
	RB(NRM)							
15200	RB(1)	-	$\Delta k/\text{mass}$	6E12.8	0,1	-	1	NRM > 0
	RB(NRM)							
15300	RCT(1)	-	Temp^{-1}	6E12.8	0,1	-	0,1	NRM > 0
	RCT(NRM)							

TABLE 4 (cont.)

Card No.	Symbol	Limitations	Type of Units	Format	Option and Index Designation Requirements		
					N1	N4	N5
16000	IFN NDN NGN	≤ 6 ≤ 7 ≤ 7	-	6I12	1	0,1	-
17000	BR QF QRK QS	-	Dimensionless Power Power Power	6E12.8	1	0,1	-
17100	FR(1) FR(IFN)	-	Dimensionless	6E12.8	1	0,1	-
17200	BD(1,1) BD(1,IFN) BD(2,1) BD(NDN,IFN)	-	Dimensionless	6E12.8	1	0,1	-
17300	YD(1) YD(NDN)	-	Time ⁻¹	6E12.8	1	0,1	-
18000	QD(1) QD(NDN)	-	Power	6E12.8	1	0,1	0

TABLE 4 (cont.)

Card No.	Symbol	Type of Units	Format	Option and Index Designation Requirements			
				<u>N1</u>	<u>N4</u>	<u>N5</u>	<u>N6</u>
18100	QGD(1) QGD(NGN)	Power	6E12.8	1	1	0	-
18200	BG(1) BG(NGN)	Dimensionless	6E12.8	1	1	-	-
18300	YG(1) YG(NGN)	Time ⁻¹	6E12.8	1	1	-	-
19000	RS	k	6E12.8	1	0,1	-1	-
19100	RS RP QFI QFIP	k k Power Power	6E12.8	1	0,1	0	-
19200	Z1 Z2	Time Time	6E12.8	-	0,1	-	0
20000	R00 R01 R02	Δk $\Delta k/\text{time}$ $\Delta k/\text{time}^2$	6E12.8	-	0,1	-	-

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TABLE 4 (cont.)

<u>Card No.</u>	<u>Symbol</u>	<u>Type of Units</u>	<u>Format</u>	<u>Option and Index Designation Requirements</u>	
				<u>N⁴</u>	<u>Other Indices</u>
20100	R0(1)	Δk	6E12.8	0,1	IRN > 0
	R1(1)	$\Delta k/\text{time}$			
	R2(1)	$\Delta k/\text{time}^2$			
	R0(IRN)				
	R1(IRN)				
	R2(IRN)				
20200	ZR(1)	Time	6E12.8	0,1	IRN > 0
	ZR(IRN)				
21000	ZQ(1)	Time	6E12.8	-	IQL > 0
	ZQ(IQL)				
21100	QRP(1)	Power	6E12.8	-	IQR > 0
	QRP(IQR)				
21200	QGP(1)	Power	6E12.8	-	IQG > IQR
	QGP(IQG)				
21300	QSP(1)	Power	6E12.8	-	IQR = 0 & IQS > 0
	QSP(IQS)				

TABLE 4 (cont.)

<u>Card No.</u>	<u>Symbol</u>	<u>Type of Units</u>	<u>Format</u>	<u>Option and Index Designation Requirements</u>	
				<u>N7</u>	<u>Other Indices</u>
21400	QSP(IQR)	Power	6E12.8	-	IQR > 0 &
	QSP(IQS)				IQS > IQR
21500	QSSP(1)	Power	6E12.8	-	IQR > 0,
	QSSP(ISQS)				ISQS > 0, & QRK > QR
21600	ZSQ(1)	Time	6E12.8	-	IQR > 0,
	ZSQ(ISQS)				ISQS > 0, & QRK > QR
22000	ZIP1	Time	6E12.8	1	-
	ZIP2	Time			
	ZIP3	Time			

TABLE 5

OPTIONS AVAILABLE IN OSCAG 1

<u>Designation</u>	<u>Value</u>	<u>Definition</u>
Principal Input Options		
N1	-	Input data selection
	-1	Data in use at end of preceding case replace input cards 12100 through 19100, and last half of card 12000.
	0	Data are retained in accordance with most recent case having option N2 $\neq$ -1 replace input cards 13000 through 13300, 16000 through 19100, and last half of 12000.
	1	All new data input is required.
N2	-	Retention of data for subsequent case input
	-1	No retention of data.
	0	Data are retained from input and initial calculations.
	1	Data are retained at completion of startup phase, immediately preceding programmed-total-power phase.
	2	Data are retained at completion of programmed-total-power phase.
N3	3	Data are retained at completion of case.
	-	Regional-temperature calculations (Disregarded if NRT = -1)
	-1	Regional temperatures are calculated in this program, and all regions are considered fuel, with TFA calculated from $TFA = TFC \times VFC + \sum [TA(NR1) \times VF(NR1)]$.
	0	Only core temperature TFC is calculated in this program (i.e., $TFA = TFC$), while regional temperatures $TA(NR1)$ may be calculated external to this program.
	1	Temperatures TFC, $TA(NR1)$, and TFA may only be calculated external to this program.

TABLE 5 (cont.)

<u>Designation</u>	<u>Value</u>	<u>Definition</u>
N ⁴	-	Neutron-kinetics and decay-heat-precursor calculations
	-1	Neutron-kinetics and decay-heat-precursor calculations are not included in the current case, or, if N ² $\neq$ -1, they are not included in subsequent cases using data from the current case.
	0	Neutron kinetics calculations are included, but decay-heat precursors are not, with decay-heat power only constant or programmed values.
	1	Neutron-kinetics and decay-heat-precursor calculations are included, with decay-heat power determined from the sum of precursors and constant or programmed values.
N ⁵	-	Initial conditions relative to precursors and source multiplication (Disregarded if N ¹ = -1)
	-1	Equilibrium subcritical initial condition, with fission power determined by source multiplication ($Q_F = -Q_S/R$), and delayed-neutron and decay-heat precursors in equilibrium. Do not use this selection if initial $Q_S = 0$ or $R = 0$.
	0	Input or stored data establish initial conditions. Always use this selection when N ¹ $\neq$ 1.
	1	Equilibrium critical or subcritical initial condition, with excess multiplication calculated to give zero inverse period including any source effect ($R = -Q_S/Q_F$), and delayed-neutron and decay-heat precursors in equilibrium.
N ⁶	-	Time increments
	-1	Constant time increment is used throughout.
	0	During reactor-kinetics calculations (startup and shutdown phases) two time increments are designated, one for use with each of two kinetics formulations, and a different time increment may be used during programmed power. The time increment for the first kinetics formulation is automatically reduced when necessary for maintaining numerical stability.

TABLE 5 (cont.)

<u>Designation</u>	<u>Value</u>	<u>Definition</u>
N7	-	Printout intervals
	-1	After each digital-time-increment interval designated by IP1, print out as follows: J, TIME, QR, QF, QDT, QG, QS, PIN, R, RR.
	0	After digital time-increment intervals designated by IP1, IP2, and IP3, print out data groups as listed for N7 = 1.
	1	After time intervals designated by ZIP1, ZIP2, and ZIP3, print out as follows: At the ZIP1 (or IP1) interval, print J, TIME, QR, QF, PIN, R, RR, RRC, RMS, RTS, TFA. At the ZIP2 (or IP2) interval, If $N4 \neq -1$, print QDT and QD(ND). If $N4 = 1$, also print QGDT and QGD(NG). At the ZIP3 (or IP3) interval, print ZI, QFI, QSI, QG, QS, HQ, RHQ, RZ. If $NRT > 0$, print TFC, TA(NR1), RTC, and RT(NR1). If $NRM > 0$, print CB(NR2). If $NRM > 0$ and $N10 \neq -1$, print RM(NR2), RMM(NR2), and TC(NR2).
N8	-	Power transferred to coolant (Disregarded if $N3 = 1$ or $NRT = -1$)
	-1	No power is transferred to coolant.
	0	Constant power is transferred from fuel to coolant, equal to initial QR.
	1	The power transferred from the fuel to the coolant equals the power at the beginning of the shutdown phase, and temperatures are not calculated prior to the shutdown phase.
N9	-	Reactivity-feedback base conditions (Disregarded if $N1 = -1$)
	-1	Base condition of zero reactivity feedback is established by initial values of TFA, TFC, TA(NR1), TC(NR2), and CB(NR2).
	1	Base condition of zero reactivity feedback is established by input values of TFAR, TFCR, TAR(NR1), TCR(NR2), and CBR(NR2).

TABLE 5 (cont.)

<u>Designation</u>	<u>Value</u>	<u>Definition</u>
N10	-	Coolant-mass reactivity-feedback formulations
	-1	Throughout the problem, $RMS = 0$.
	0	Mass-reactivity feedback for coolant region $NR2 = 1$ is given by $RM(1) = RMM(1) \times RB(1) \times [CB(1) - CBR(1)] / \{ RC1 \times [CB(1) - CBR(1)] + RC2 \}$ and other coolant regions ($NR2 > 1$) provide feedback as given for $N10 = 1$.
	1	Mass-reactivity feedback for each coolant region is given by $RM(NR2) = RMM(NR2) \times RB(NR2) \times [CB(NR2) - CBR(NR2)]$.
	0,1	$RMS = \sum RM(NR2)$.
N11	-	(This option is not included; disregard input value.)
N12	-	Base condition for imposed reactivity after programmed-total-power phase
	-1	No change in base condition. Calculations of imposed reactivity RR both before and after programmed-total-power phase are based on the original input, without adjustment of reactivity base or of tabulated times $ZR(IR)$ at which coefficients $RO(IR)$, $R1(IR)$, and $R2(IR)$ are imposed.
	0	Revision of base condition in order to base imposed reactivity during the shutdown phase on the value of imposed reactivity RR at the end of the startup phase. At the end of the programmed-total-power phase, the index IR is advanced by unity, the corresponding input $ZR(IR)$ is changed to equal the current Z , input $ZR(IR)$ values for all higher IR indices are altered by the same time change applied to the current $ZR(IR)$, and all input $RO(IR)$ values are augmented by the value of RR at time ZK .

TABLE 5 (cont.)

<u>Designation</u>	<u>Value</u>	<u>Definition</u>
N12 (cont.)	1	Scram or setback simulation by linear reactivity ramp. The imposed reactivity during the shutdown phase is initially based on the calculated imposed reactivity RR at the end of the programmed-total-power phase, and is then changed by a linear reactivity ramp to the reactivity base used at the start of the case. At the end of the programmed-total-power phase, the index IR is advanced by unity, the corresponding input ZR(IR) is changed to equal the current Z, and the current value of RR calculated at the end of the programmed-total-power phase is added to the input current RO(IR), but values of RO(IR) for higher IR are not changed. The time from ZR(IR) to ZR(IR + 1) is then set equal to $[RO(IR + 1) - RO(IR)]/R1(IR)$, except that if the resulting time difference is negative the input value of R1(IR) is changed in sign to make ZR(IR + 1) - ZR(IR) positive, while this R2(IR) input should equal zero; and all values of ZR(IR) beyond the ZR(IR + 1) just calculated are altered by the difference between the input and revised values of this ZR(IR + 1).
Other Input Indices		
IQG	-	Number of programmed-decay-heat time points
	0	Decay heat is constant, equal to difference between QR and QF on input cards 12000 and 17000.
	2 to 30	Decay heat is programmed by straight-line interpolation from QGP(IQ) vs ZQ(IQ) if IQG > IQR. Initial value of QG (equal to difference between input QR and QF) is held constant until start of programmed power, and QG is varied by programmed QGP(IQ) values throughout and after the programmed-total-power phase.
IQR	-	Number of programmed-total-power time points
	0	Total power is not programmed but is only calculated by fission power from reactor kinetics, plus decay-heat power.
	2 to 30	Total power is programmed by straight-line interpolation from QRP(IQ) vs ZQ(IQ). Input QR serves as the initial programmed value if input QR is greater than QRK; otherwise, QRK serves as the initial programmed value after QR reaches QRK to initiate the programmed-total-power phase.

TABLE 5 (cont.)

<u>Designation</u>	<u>Value</u>	<u>Definition</u>
IQS	-	Number of programmed-source-power time points after the programmed-total-power phase (or from start of the case if IQR = 0)
	0	Source power is not programmed after programmed power, but remains constant at QSSP(ISQS) if ISQS > 0, or at the value of input QD if ISQS = 0.
	2 to 30	Source power is programmed by straight-line interpolation from QSP(IQ) vs ZQ(IQ) if IQS > IQR. The first programmed value is at time ZQ(IQR) if IQR > 0. The input QS serves as the initial programmed value if IQR = 0, with the first programmed input value QSP(1) at time ZQ(1).
IRN	-	Number of programmed-imposed-reactivity time points
	0	Imposed reactivity is not programmed other than by use of initial coefficients R00, R01, and R02 for all time Z after start of the case.
	1 to 30	Imposed reactivity is programmed by table of times ZR(IR) and coefficients R0(IR), R1(IR), and R2(IR), with time from start of the case to ZR(1) based upon coefficients R00, R01, and R02.
ISQS	-	Number of programmed-source-power time points prior to programmed-total-power phase (input value disregarded if IQR = 0 or QRK ≤ QR at start)
	0	Source power is not programmed prior to programmed-total-power phase, but remains constant at input value QS.
	2 to 30	Source power is programmed prior to start of programmed-total-power phase by straight-line interpolation from QSSP(ISQ) vs ZSQ(ISQ). Input QS from card 17000 serves as the initial programmed value at the start of the case.
NRM	-	Number of coolant-mass regions calculated in an engine-analysis program external to this program, and printed out by this program (if N10 ≠ -1, these regions provide reactivity feedback and the masses and reactivity contributions are printed out in this program).
	0	Calculations and printouts do not include any coolant-mass regions.

TABLE 5 (cont.)

<u>Designation</u>	<u>Value</u>	<u>Definition</u>
NRM (cont.)	1 to 5	The actual number of coolant-mass regions used equals the input value of NRM. Title heading formats are written for a limit of five regions.
NRT	-	Number of subscripted temperature regions calculated either within this program or external to this program, and used for reactivity-feedback calculations and printed out in this program.
	-1	No temperature regions are included..
	0	A single unsubscripted region with temperature TFC is calculated and used as the average fuel temperature TFA. This region has temperature coefficients of reactivity RF1 and RF2.
	1 to 5	The input value of NRT equals the total number of regions with subscripted temperatures TA(NR1) which have temperature coefficients of reactivity RA(NR1). There is, in addition, the temperature region TFC, which (as for NRT = 0) has temperature coefficients of reactivity RF1 and RF2. The average fuel temperature TFA is calculated according to the value selected for option N3.

TABLE 6

INPUT AND OUTPUT SYMBOLS FOR OSCAG 2

<u>Symbol</u>	<u>New or Revised*</u>	
DELTA	New	Basic time increment for fluid-flow calculations and for determination of time increments Z3, Z2, and Z1 from successive division by integers JZ3, JZ2, and JZ1.
JZ1	New	Number of time increments Z1 in increment Z2.
JZ2	New	Number of time increments Z2 in increment Z3.
JZ3	New	Number of time increments Z3 in increment DELTA.
NRT	Revised	Total number of temperature regions having temperatures TA(NR1). When NRT = 0, however, a lumped-core-temperature calculation is used; when NRT = -1, no temperature calculations are made (see Table 8).
RCT (NR2)	Revised	Coolant-temperature coefficient for modification of coolant-reactivity feedback RM(NR2) as shown by formula for RMM(NR2) given under Option N10 in Table 8.
RTS	Revised	Total temperature contribution to reactivity other than from coolant, in general representing total core fuel-temperature-reactivity feedback: When NRT = 0, RTS = RTC. When NRT > 0, RTS = $\sum$ RT (NR1).
TF1	New	Limiting change in average fuel temperature TFA permitted for temperature calculations within OSCAG 2 when N3 = 1; when exceeded, this limit results in transfer to subroutine FLOW (2) for obtaining heat-transfer and fluid-flow adjustments and corrected temperatures.
VF(NR1)	Revised	Volume fraction of material in region NR1, with input normalized by program to give $\sum$ VF(NR1) = 1.
VFC	Eliminated	---

*As compared with OSCAG 1 symbols described in Table 3, which Table 6 augments.

TABLE 6 (cont.)

<u>Symbol</u>	<u>New or Revised*</u>	
Z3	New	Digital time increment in programmed-total-power phase.
ZI	Revised	Digital time increment currently in use; initial trial increment selection ZI is Z1 for entering startup and shutdown phases; ZI = Z3 throughout programmed-total-power phase.

*As compared with OSCAG 1 symbols described in Table 3, which Table 6 augments.

TABLE 7

INPUT-CARD SEQUENCE AND REQUIREMENTS FOR OSCAG 2

Card No.	Symbols	Requirements
20000	TP(L)	Cards 20000 through 21100 identical to cards 10000 through 11030 in OSCAG 1*
20100	IP1, IP2, IP3, IQG, IQR, IQS	
20200	IRN, ISQS, J, JL, NRM, NRT	
21000	N1 through N6	
21100	N7 through N12	
21200	JZ1, JZ2, JZ3	--
22000	DELTA, HQT, QRK, QT1, TFL, ZL	--
22100	EL, HQ, QR, A	N1 = 1
30000 series	--	Here, insert thermal and fluid-flow input from subroutine FLOW (1), as 30000 series cards when N3 = 1.
40000	RHQR, RRC, RZ, RZR, TFRZ, ZRZ	N1 $\neq$ -1
40100	HCF, HCFL, HCFM, TFL, TFM, TFMC	N1 $\neq$ -1, N3 $\neq$ -1
41000	TFA, QRFC	N1 = 1, N3 = 0, NRT = 0
41100	TA(NR1), NR1 = 1, NRT	N1 = 1, N3 = 0, NRT > 0
41200	QRF(NR1), NR1 = 1, NRT	N1 = 1, N3 $\neq$ -1, NRT > 0
41300	VF(NR1), NR1 = 1, NRT	N1 = 1, N3 $\neq$ -1, NRT > 0
42000	TFAR	N1 $\neq$ 1, N3 $\neq$ -1, N9 = 1, NRT = 0
42100	TAR(NR1), NR1 = 1, NRT	N1 $\neq$ -1, N3 $\neq$ -1, N9 = 1, NRT > 0
42200	CBR(NR2), NR2 = 1, NRM	N1 $\neq$ -1, N9 = 1, NRM > 0
42300	TCR(NR2), NR2 = 1, NRM	N1 $\neq$ -1, N9 = 1, NRM > 0
43000	RF1, RF2	N1 $\neq$ -1, NRT = 0

*See Table 4.

TABLE 7 (cont.)

<u>Card No.</u>	<u>Symbols</u>	<u>Requirements</u>
43100	RA(NR1), NR1 = 1, NRT	$N1 \neq -1$, $NRT > 0$
44000	RC1, RC2, [RB(NR2), NR2 = 1, NRM]	$N1 \neq -1$, $N10 = 0$, $NRM > 0$
44100	RB(NR2), NR2 = 1, NRM	$N1 \neq -1$, $N10 > 0$, $NRM > 0$
44200	RCT(NR2), NR2 = 1, NRM	$N1 \neq -1$, $N10 \neq -1$, $NRM > 0$
45000	IFN, NDN, NGN	$N1 \neq 1$, $N4 \neq -1$
46000	BR, QF, QS	$N1 = 1$, $N4 \neq -1$
46100 through 48100	Identical to cards 17100 through 19100 in OSCAG 1. (Omit equivalent of card 19200 in OSCAG 1.)	
49000 through 50200	Identical to cards 2000 through 21200 in OSCAG 1.	
51000 through 52000	Identical to cards 21300 through 22000 in OSCAG 1.	

TABLE 8

OPTIONS AVAILABLE IN OSCAG 2

<u>Designation</u>	<u>Value</u>	<u>Definition</u>
Principal Input Options		
N1	-	Input data selection
	-1	Data in use at end of preceding case replaces input cards 22100 through 48100.
	0	Data retained in accordance with most recent case having N2 $\neq$ -1 replaces input cards 22100, 41000 through 41300, and 45000 through 48100.
	1	All new data input is required.
N2	-	Retention of data for subsequent problem input
	-1	No retention of data.
	0	Data retained from input and initial calculations.
	1	Data retained at completion of startup phase, immediately preceding programmed-total-power phase.
	2	Data retained at completion of programmed-total-power phase.
N3	-	Fuel-temperature and fluid-flow calculations
	-1	Fuel temperatures and fluid flow are not calculated.
	0	Average fuel temperature TFA is calculated without fluid-flow analysis. If $NRT > 0$, regional temperatures are calculated and TFA is determined from $TFA = \sum [TA(NR1) \times VF(NR1)]$.
	1	Average fuel temperature TFA is calculated as for N3 = 0, and is periodically adjusted by averaging fuel-segment temperatures calculated together with fluid-flow analysis in subroutine FLOW.
N4	-	Neutron-kinetics and decay-heat-precursor calculations
	-1	Neutron-kinetics and decay-heat-precursor calculations are not included in the current case; if N2 $\neq$ -1, they are not included in subsequent cases using data from the current case.

TABLE 8 (cont.)

<u>Designation</u>	<u>Value</u>	<u>Definition</u>
N4 (cont.)	0	Neutron-kinetics calculations are included, but decay-heat-precursor calculations are not, with decay-heat power only constant or programmed values.
	1	Neutron kinetics and decay-heat-precursor calculations are included, with decay-heat power determined from the sum of precursor and constant or programmed values.
N5	-	Initial conditions relative to precursors and source multiplication (disregarded if N1 = -1)
	-1	Equilibrium subcritical initial condition for delayed-neutron and decay-heat precursors, with calculation of source multiplication ($Q^F = -Q^S/R$) and printout of this value as "QF REQUIRED FOR STEADY STATE," and printout of difference between input QF and calculated source multiplication as "ERROR IN INPUT QF." The input QF value is not changed, and is used as the initial fission power.
	0	Input or stored data establish initial conditions. Always use this selection when N1 $\neq$ 1.
	1	Equilibrium critical or subcritical initial condition for power level and for delayed-neutron and decay-heat precursors, with excess multiplication calculated ($R = -Q^S/Q^F$) to give zero inverse period including source effect.
N6	-	(This option is not included; disregard input value.)
N7	-	Printout intervals
	-1	After each digital time-increment interval designated by IP1, print J, TIME, QR, QF, QDT, QG, QS, PIN, R, RR.
	0	After digital time-increment intervals designated by IP1, IP2, and IP3, print data groups as listed for N7 = 1.

TABLE 8 (cont.)

<u>Designation</u>	<u>Value</u>	<u>Definition</u>
N7 (cont.)	1	<p>After time intervals designated by ZIP1, ZIP2, and ZIP3, print out as follows:</p> <p>At ZIP1 (or IP1) interval print J, TIME, QR, QF, PIN, R, RR, RRC, RMS, RTS, TFA.</p> <p>At the ZIP2 (or IP2) interval, If $N4 \neq -1$, print QDT and QD(ND). If $N4 = 1$, also print QGDT and QGD(NG).</p> <p>At the ZIP3 (or IP3) interval print ZI, QFI, QSI, QG, QS, HQ, RHQ, RZ. If $NRT > 0$, print TFC, TA(NR1), RTC, and RT(NR1). If $NRM > 0$, print CB(NR2). If $NRM > 0$ and $N10 \neq -1$, print RM(NR2), RMM(NR2), and TC(NR2).</p>
N8	-	Power transferred to coolant (disregard if $N3 \neq 0$)
	-1	No power is transferred from fuel to coolant.
	0	Constant power is transferred from fuel to coolant, equal to initial QR.
	1	The power transferred to the coolant equals the power at the beginning of the shutdown phase, and temperatures are not calculated prior to the shutdown phase.
N9	-	Reactivity-feedback base conditions (disregard if $N1 = -1$)
	-1	Base condition of zero reactivity feedback is established by initial values of TFA, TA(NR1), TC(NR2), and CB(NR2).
	1	Base condition of zero reactivity feedback is established by input values of TFAR, TAR(NR1), TCR(NR2), and CBR(NR2).

TABLE 8 (cont.)

<u>Designation</u>	<u>Value</u>	<u>Definition</u>
N10	-	Coolant-mass reactivity-feedback formulations
	-1	RMS = 0 throughout the case.
	0	Mass-reactivity feedback for coolant region NR2 = 1 is given by $RM(1) = RMM(1) \times RB(1) \times [CB(1) - CBR(1)] / \{RC1 \times [CB(1) - CBR(1)] + RC2\}$ and other coolant regions (NR2 > 1) provide feedback as given by formula under N10 - 1; also, RMM(NR2) is calculated as shown for N10 = 1.
	1	Mass-reactivity feedback for each coolant region is given by $RM(NR2) = RMM(NR2) \times RB(NR2) \times [CB(NR2) - CBR(NR2)]$ $RMM(NR2) = 1 + RCT(NR2) \times [TC(NR2) - TCR(NR2)].$
	2	Mass-reactivity feedback for each coolant region is given by $RM(NR2) = RB(NR2) \times [CB(NR2) - CBR(NR2)] + RMM(NR2) \times CB(NR2)$ $RMM(NR2) = RCT(NR2) \times [TC(NR2) - TCR(NR2)].$
	0,1,2	RMS = $\sum RM(NR2)$
N11	-	Use of fluid-flow calculations relative to phases (disregarded if N3 $\neq$ 1)
	0	Fluid-flow calculations are used during all phases.
	1	No fluid-flow calculations are performed during the startup phase, and the power transferred from the fuel to the coolant equals the initial QR during the startup phase, but fluid-flow calculations are used during the programmed-total-power and shutdown phases.
N12	-	Base condition for imposed reactivity after programmed-total-power phase
	-1	No change in base condition. Calculations of the imposed reactivity RR both before and after the programmed-total-power phase are based on the original input, without adjustment of the reactivity base or of tabulated times ZR(IR) at which coefficients R0(IR), R1(IR), and R2(IR) are imposed.

TABLE 8 (cont.)

<u>Designation</u>	<u>Value</u>	<u>Definition</u>
N12 (cont.)	0	Revision of base condition in order to base imposed reactivity during the shutdown phase on the value of imposed reactivity RR at the end of the startup phase. At the end of the programmed-total-power phase, the index IR is advanced by unity, the corresponding input ZR(IR) is changed to equal the current Z, the input ZR(IR) values for all higher IR indices are altered by the same time change applied to the current ZR(IR), and all input RO(IR) values are augmented by the value of RR at time ZK.
	1	Scram or setback simulation by linear reactivity ramp. The imposed reactivity during the shutdown phase is initially based on the calculated imposed reactivity RR at the end of the programmed-total-power phase, and is then changed by a linear reactivity ramp to the reactivity base used at the start of the case. At end of the programmed-total-power phase the index IR is advanced by unity, the corresponding input ZR(IR) is changed to equal the current Z, and the current value of RR calculated at the end of the programmed-total-power phase is added to the input current RO(IR), but values of RO(IR) for higher IR are not changed. The time from ZR(IR) to ZR(IR + 1) is then set equal to $[RO(IR + 1) - RO(IR)]/R1(IR)$, except that if the resulting time difference is negative, the input value of R1(IR) is changed in sign to make ZR(IR + 1) - ZR(IR) positive, while this R2(IR) input should equal zero; and all values of ZR(IR) beyond the ZR(IR + 1) just calculated are altered by the difference between the input and revised values of this ZR(IR + 1).
Other Input Indices*		
NRM	-	Number of coolant-mass regions calculated in subroutines FLOW (1) and FLOW (2), and printed out in OSCAG 2 (If N10 $\neq$ -1 these regions provide reactivity feedback, and the masses and reactivity contributions are printed out in this program.)
	0	Calculations and printouts do not include any coolant-mass regions.
	1	Actual number of coolant-mass regions used equals the input
	to	value of NRM. Title heading formats are written for a limit
	6	of six regions.

*Other input indices, which by their use offer optional selections, remain unchanged from the listing in Table 5 except for NRM and NRT, as shown here.

TABLE 8 (cont.)

<u>Designation</u>	<u>Value</u>	<u>Definition</u>
NRT	-	Number of subscripted temperature regions calculated, used for reactivity-feedback calculations, and having temperatures and reactivity contributions printed out in OSCAG 2
	-1	No temperatures are calculated in OSCAG 2, but TFA may be calculated by FLOW (2) subroutine if N3 = 1.
	0	Only an average fuel temperature TFA is calculated. This region has temperature coefficients of reactivity RF1 and RF2.
	1	The input value of NRT equals the total number of regions with subscripted temperatures TA(NR1) that have temperature coefficients of reactivity RA(NR1). The average fuel temperature TFA is calculated according to the value selected for option N3. The corresponding TFA last calculated by the FLOW (1) or FLOW (2) subroutines may be printed out as TFC if N3 = 1.
	to 6	

RN-TM-0220

APPENDIX A

INPUT SHEETS

FOR

OSCAG I AND II

FORTRAN FIXED 10 DIGIT DECIMAL DATA

Sheet 1

DECK NO. _____ PROGRAMMER _____ DATE _____ PAGE _____ of _____ JOB NO. _____

NUMBER	IDENTIFICATION	DESCRIPTION	DO NOT KEY PUNCH
1		TP (L)	Include with every problem up to 72 letters
13			or numbers
25			
37			
49			
61			
1			
13			
25			
37			
49			
61			
1			
13			
25			
37			
49			
61			

FORTRAN FIXED 10 DIGIT DECIMAL DATA

Sheet 2

DATE _____ PROGRAMMER _____ PAGE _____ of _____ JOB NO. _____

NUMBER

IDENTIFICATION

NOT KEY PUNCH

Include with error problem

1			
17			IP2 $\leq 10^6$
25			P $\leq 10^6$
37			IQ4 $0 < IQ4 \leq 30$ but $\neq 1$
49			IQR $0 < IQR \leq 30$ but $\neq 1$
61		11000	IQS $0 < IQS \leq 30$ but $\neq 1$
1			IRN $0 < IRN \leq 30$
13			ISQS $0 < ISQS \leq 30$ but $\neq 1$
25			J
37			JL
49			NRM $0 \leq NRM \leq 5$
61		11010	NRT $-1 \leq NRT \leq 5$
1			N1
13			N2
25			N3
37			N4
49			N5
61		11020	N6
1			N7
13			N8
25			N9
37			N10
49			N11
61		11030	N12

FORTTRAN FLOATING

DECIMAL DATA

SHEET 3

JOB NO. _____		ANALYST _____		DATE _____		PAGE _____ of _____		WORK ORDER _____	
NUMBER		D	IDENTIFICATION	DESCRIPTION DO NOT KEY PUNCH					
1		-		<div>QT1</div> <div>Z1</div> <div>ZL</div> <div>Z</div> <div>EL</div> <div>QR</div>					
13		-							
25		-							
37		-		<div>EL</div> <div>QR</div>					
49		-							
61		-	1 2 0 0 0						
1		-		<div>HQ</div> <div>HQT</div> <div>RHQR</div> <div>RRC</div> <div>RZ</div> <div>RZR</div>					
13		-							
25		-							
37		-		<div>RHQR</div> <div>RRC</div> <div>RZ</div> <div>RZR</div>					
49		-							
61		-	1 2 1 0 0						
1		-		<div>TFRZ</div> <div>ZRZ</div>					
13		-							
25		-							
37		-		<div>ZRZ</div>					
49		-							
61		-	1 2 1 1 0						
1		-		<div>HCF</div> <div>HCFL</div> <div>HCFM</div> <div>TFL</div> <div>TFM</div> <div>TFMC</div>					
13		-							
25		-							
37		-		<div>HCFM</div> <div>TFL</div> <div>TFM</div> <div>TFMC</div>					
49		-							
61		-	1 2 2 0 0						

FORTRAN FLOATING

DECIMAL DATA

Sheet 4

JOB NO.		ANALYST		DATE	PAGE of	WORK ORDER
NUMBER	D	IDENTIFICATION	DESCRIPTION	DO NOT KEY PUNCH	Include if N1 $\neq$ -1 and N3 $\neq$ 1	
1	-				Include if NRT = 0	
13	-		ORFC			
25	-					
37	-					
49	-					
61	-	73 00	1 3 0 0 0			
1	-		TFC			
13	-		TA (1)			
25	-		↓			
37	-		TA (NRT)		Include if NRT > 0	
49	-	73 00				
61	-		1 3 1 0 0			
1	-		QRFC			
13	-		QRF (1)			
25	-		↓			
37	-		QRF (NRT)			
49	-	73 00				
61	-		1 3 2 0 0			
1	-		VFC			
13	-		VF (1)		Include if NRT > 0 and N3 = -1	
25	-		↓		Program normalizes the sum of these values	
37	-		VF (NRT)		to 1.	
49	-	73 00				
61	-		1 3 3 0 0			

FORTRAN FLOATING

DECIMAL DATA

Sheet 5

JOB NO. _____		ANALYST _____		DATE _____	PAGE _____ of _____	WORK ORDER _____
NUMBER	D	IDENTIFICATION	DESCRIPTION	DO NOT KEY PUNCH	Include if N1 $\neq$ -1 and N9 = 1	
1	-		TFAR	Include if NRT = 0		
13	-					
25	-					
37	-					
49	-					
61	-	73 80	1 4 0 0 0			
1	-		TFCR	} Include if NRT > 0		
13	-		TAR (1)			
25	-		↓			
37	-		TAR (NRT)			
49	-		73 80			
61	-	1 4 1 0 0				
1	-		CBR (1)	} Include if NRM > 0		
13	-		↓			
25	-		CBR (NRM)			
37	-					
49	-		73 80			
61	-	1 4 2 0 0				
1	-		TCR (1)	} Include if NRM > 0		
13	-		↓			
25	-		TCR (NRM)			
37	-					
49	-		73 80			
61	-	1 4 3 0 0				

FORTRAN FLOATING

DECIMAL DATA

Sheet 6

JOB NO.		ANALYST		DATE	PAGE of	WORK ORDER
NUMBER	D	IDENTIFICATION	DESCRIPTION	DO NOT KEY PUNCH Include if N1 $\neq$ -1		
	-		RF1	} Include if NRT $\geq$ 0		
	-		RF2			
	-		RA (1)			
	-		↓	} Include if NRT $\geq$ 1		
	-		RA (NRT)			
	-	73 1 5 0 0 0 80				
	-		RC1			
	-		RC2			
	-		RB (1)	} Include if N10 = 0		
	-		↓			
	-		RB (NRM)			
	-	73 1 5 1 0 0 80				
	-		RB (1)			
	-		↓	} Include if N10 = 1		
	-		RB (NRM)			
	-					
	-					
	-	73 1 5 2 0 0 80				
	-		RCT (1)			
	-		↓	} Include if N10 $\neq$ -1		
	-		RCT (NRM)			
	-					
	-					
	-	73 1 5 3 0 0 80				

FORTRAN FIXED 10 DIGIT DECIMAL DATA

Sheet 7

DECK NO. _____ PROGRAMMER _____ DATE _____ PAGE _____ of _____ JOB NO. _____

	NUMBER	IDENTIFICATION	DESCRIPTION DO NOT KEY PUNCH <small>Include if N1=-1 and N4 ≠ -1</small>
1			IFN ≤ 6
13			NDN ≤ 7
25			NGN ≤ 7
37			
49			
61		73 80 1 6 0 0 0	
1			
13			
25			
37			
49			
61		73 80	
1			
13			
25			
37			
49			
61		73 80	
1			
13			
25			
37			
49			
61		73 80	

FORTRAN FLOATING

DECIMAL DATA

SHEET 8

JOB NO. _____		ANALYST _____		DATE _____		PAGE _____ of _____		WORK ORDER _____	
NUMBER		D	IDENTIFICATION	DESCRIPTION	DO NOT KEY PUNCH	Include if N1 = 1 and N4 ≠ -1			
1		-	73 80	BR					
13		-		QF					
25		-		QPK					
37		-		QS					
49		-							
61		-		1 7 0 0 0					
1		-	73 80	FR (1)					
13		-		↓					
25		-		FR (IFN); IFN ≥ 6					
37		-							
49		-							
61		-		1 7 1 0 0					
1		-	73 80	BD (1,1)					
13		-		↓					
25		-		BD (1, IFN) IFN ≥ 6					
37		-		BD (2,1)					
49		-		↓					
61		-		BD (NDN, IFN) Use as many cards as needed					
1		-	73 80	YD (1) (Start on new card)					
13		-		↓					
25		-		YD (NDN)					
37		-							
49		-							
61		-		1 7 3 0 0					

FORTRAN FLOATING

DECIMAL DATA

Sheet 9

JOB NO.		ANALYST		DATE		PAGE of		WORK ORDER	
NUMBER		D	IDENTIFICATION	DESCRIPTION	DO NOT KEY PUNCH Include if N1 = 1				
1		-		QD (1)	Include if N4 $\neq$ -1 and N5 = 0				
13		-		↓					
25		-		QD (NDN)					
37		-							
49		-							
61		-	73 80 1 8 0 0 0						
1		-		QGD (1)	Include if N4 = 1 and N5 = 0				
13		-		↓					
25		-		QGD (NGN)					
37		-							
49		-							
61		-	73 80 1 8 1 0 0						
1		-		BG (1)	Include if N4 = 1				
13		-		↓					
25		-		BG (NGN)					
37		-							
49		-							
61		-	73 80 1 8 2 0 0	(Use as many cards as needed)					
1		-		YG (1)					
13		-		↓					
25		-		YG (NGN)					
37		-							
49		-							
61		-	73 80 1 8 3 0 0	(Use as many cards as needed)					

FORTRAN FLOATING

DECIMAL DATA

Sheet 10

JOB NO		ANALYST		DATE		PAGE of		WORK ORDER	
NUMBER		D	IDENTIFICATION	DESCRIPTION	DO NOT KEY PUNCH Include if N4 $\neq$ -1				
1		-		RS	Include if N5 = -1 and N1 = 1				
13		-							
25		-							
37		-							
49		-							
61		-							
			19000						
1		-		RS	} Include if N5 = 0 and N1 = 1				
13		-		RP					
25		-		QFI					
37		-		QFIP					
49		-							
61		-							
			19100						
1		-		Z1	} Include if N6 = 0				
13		-		Z2					
25		-							
37		-							
49		-							
61		-							
			19200						
1		-							
13		-							
25		-							
37		-							
49		-							
61		-							

FORTTRAN FLOATING

DECIMAL DATA

S. 11

JOB NO.		ANALYST LYON		DATE	PAGE 7 of 9	WORK ORDER	
NUMBER	D	IDENTIFICATION	DESCRIPTION	DO NOT KEY PUNCH	Include if N4	-1	
1	-		R00	Coef used in determining RR for IRN = 0 or for			
13	-		R01	Z < ZR(1) when IRN > 0 in RR = R00 + [R01 + R02 x			
25	-		R02		(Z-ZS) x (Z-ZS)		
37	-						
49	-						
61	-	2 0 0 0 0		Use as new cards as needed			
1	-		R0 (1)	Coefficients used in determining			
13	-		R1 (1)		RR		
25	-		R2 (1)				
37	-		R0 (2)	Include if IRN > 0			
49	-		R1 (2)				
61	-	2 0 1 0 0	R2 (2)	Use as new cards as needed			
1	-						
13	-						
25	-						
37	-						
49	-						
61	-	2 0 1 1 0	R2 (IRN)	Use as new cards as needed			
1	-		ZR (1) (New Card)	Time at which programmed coefficients			
13	-				RO(IR), R1(IR), and R2(IR) apply to		
25	-		ZR (IRN)		calculations of RR		
37	-						
49	-						
61	-	2 0 2 0 0					

JOB NO. _____		ANALYST _____		DATE _____		PAGE _____ of _____		WORK ORDER _____	
NUMBER		D	IDENTIFICATION	DESCRIPTION	DO NOT KEY PUNCH				
1		-		ZQ (1)	} Include if IQL > 0				
13		-		↓					
25		-		ZQ (IQL)					
37		-							
49		-	73	80					
61		-	2 1 0 0 0						
1		-		QRP (1)	} Include if IQR > 0				
13		-		↓					
25		-		QRP (IQR)					
37		-							
49		-	73	80					
61		-	2 1 1 0 0						
1		-		QGP (1)	} Include if IQG > IQR				
13		-		↓					
25		-		QGP (IQG)					
37		-							
49		-	73	80					
61		-	2 1 2 0 0						
1		-							
13		-							
25		-							
37		-							
49		-	73	80					
61		-							

FORTRAN FLOATING

DECIMAL DATA

SHEET 13

JOB NO. _____		ANALYST _____		DATE _____		PAGE _____ of _____		WORK ORDER _____		
NUMBER		D	IDENTIFICATION	DESCRIPTION DO NOT KEY PUNCH						
1		-		QSP (1)						
13		-		↓						
25		-		QSP (IQS)						
37		-		} Include if IQR = 0 and IQS > 0						
49		-								
61		-	73	80						
				2 1 3 0 0						
1		-		QSP (IQR)						
13		-		↓						
25		-		QSP (IQS)						
37		-		} Include if IQR > 0 and IQS > IQR						
49		-								
61		-	73	80						
				2 1 4 0 0						
1		-		QSSP (1)						
13		-		↓						
25		-		QSSP (ISQS)						
37		-		} Include if QRK > QR and ISQS > 0						
49		-								
61		-	73	80						
				2 1 5 0 0						
1		-		ZSQ (1)						
13		-		↓						
25		-		ZSQ (ISQS)						
37		-								
49		-								
61		-	73	80						
				2 1 6 0 0						

FORTRAN FIXED 10 DIGIT DECIMAL DATA

Sheet 14

DECK NO. _____ PROGRAMMER _____ DATE _____ PAGE _____ of _____ JOB NO. _____

NUMBER	IDENTIFICATION	DESCRIPTION	DO NOT KEY PUNCH	Include if N7 = 1
1		ZIP1		
13		ZIP2		
25		ZIP3		
37				
49				
61				
1				
13				
25				
37				
49				
61				
1				
13				
25				
37				
49				
61				
1				
13				
25				
37				
49				
61				
1				
13				
25				
37				
49				
61				

FORTRAN FIXED 10 DIGIT DECIMAL DATA

DECK NO. _____ PROGRAMMER _____ DATE _____ PAGE _____ of _____ JOB NO. _____

NUMBER	IDENTIFICATION	DESCRIPTION	DO NOT KEY PUNCH
1		TP (L)	
13	1		
25	2		
37	3		
49	73	80	
61	2 0 0 0 0		
1		IP1	$\leq 10^6$
13		IP2	$\leq 10^6$
25		IP3	$\leq 10^6$
37		IQG	≤ 30 but $\neq 1$
49	73	80	IQR ≤ 30 but $\neq 1$
61	2 0 1 0 0	IQS	≤ 30 but $\neq 1$
1		IRN	≤ 30
13		ISQS	≤ 30 but $\neq 1$
25		J	$\leq 10^6$
37		JL	$\leq 10^6$
49	73	80	NRM $0 \leq \text{NRM} \leq 5$
61	2 0 2 0 0	NRT	$-1 \leq \text{NRT} \leq 5$
1			
13			
25			
37			
49	73	80	
61			

FORTTRAN FIXED 10 DIGIT DECIMAL DATA

DECK NO. _____ PROGRAMMER _____ DATE _____ PAGE _____ of _____ JOB NO. _____

NUMBER		IDENTIFICATION	DESCRIPTION DO NOT KEY PUNCH
1			N1
13			N2
25			N3
37			N4
49			N5
61		2 1 0 0 0	N6
1			N7
13			N8
25			N9
37			N10
49			N11
61		2 1 1 0 0	N12
1			JZ1
13			JZ2
25			JZ3
37			
49			
61		2 1 2 0 0	
1			
13			
25			
37			
49			
61			

FORTTRAN FLOATING

DECIMAL DATA

JOB NO. _____		ANALYST _____		DATE _____	PAGE _____ of _____	WORK ORDER _____
NUMBER	D	IDENTIFICATION	DESCRIPTION DO NOT KEY PUNCH			
1	-					
13	-					
25	-					
37	-					
49	-					
61	-					
1	-					
13	-					
25	-					
37	-					
49	-					
61	-					
1	-					DELTA
13	-					HQT
25	-					QRK Input value is disregarded if IQR = 0
37	-					QTI Input value is disregarded if N4 = 1
49	-					TFI Input value is disregarded if N3 ≠ 1
61	-					
1	-					
13	-					
25	-					
37	-					
49	-					
61	-					
1	-					
13	-					
25	-					
37	-					
49	-					
61	-					
1	-					
13	-					
25	-					
37	-					
49	-					
61	-					
1	-					
13	-					
25	-					
37	-					
49	-					
61	-					

JOB NO. _____		ANALYST _____		DATE _____	PAGE _____ of _____	WORK ORDER _____
NUMBER	D	IDENTIFICATION	DESCRIPTION	DO NOT KEY PUNCH Include If N1 = 1		
1			TFA	Include If N3 = 0 and NRT = 0		
13	QRFC					
25	-					
37	-					
49	-					
61	-	73 80	4 1 0 0 0			
1	-		TA (1)	Include If N3 = 0 and NRT > 0		
13	↓					
25	-		TA (NRT)			
37	-					
49	-					
61	-	73 80	4 1 1 0 0			
1	-		QRF (1)	Include If N3 ≠ -1 and NRT > 0		
13	↓					
25	-		QRF (NRT)			
37	-					
49	-					
61	-	73 80	4 1 2 0 0			
1	-		VF (1)			
13	↓					
25	-		VF (NRT)			
37	-					
49	-					
61	-	73 80	4 1 3 0 0			

JOB NO.		ANALYST		DATE	PAGE of	WORK ORDER
NUMBER	D	IDENTIFICATION	DESCRIPTION	DO NOT KEY PUNCH	Include if N1 $\neq$ -1 and N9 = 1	
1	-	73 80	TFAR	Include if N3 $\neq$ -1 and NRT = 0		
13	-					
25	-					
37	-					
49	-					
61	-	4 2 0 0 0				
1	-	73 80	TAR (1)	} Include if N3 $\neq$ -1 and NRT $>$ 0		
13	-		↓			
25	-		TAR (NRT)			
37	-					
49	-					
61	-	4 2 1 0 0				
1	-	73 80	CBR (1)	} Include if NRM $>$ 0		
13	-		↓			
25	-		CBR (NRM)			
37	-					
49	-					
61	-	4 2 2 0 0				
1	-	73 80	TCR (1)	} Include if NRM $>$ 0		
13	-		↓			
25	-		TCR (NRM)			
37	-					
49	-					
61	-	4 2 3 0 0				

JOB NO. _____		ANALYST _____		DATE _____	PAGE _____ of _____	WORK ORDER _____
NUMBER	D	IDENTIFICATION	DESCRIPTION	DO NOT KEY PUNCH Include If N1 $\neq$ -1		
1			RF1	}	Include If NRT = 0	
13			RF2			
25	-					
37	-					
49	-					
61	-	73 80 4 3 0 0 0				
1	-		RA (1)	}	Include If NRT $>$ 0	
13	-		↓			
25	-		RA (NRT)			
37	-					
49	-					
61	-	73 80 4 3 1 0 0				
1	-
13	-					
25	-					
37	-					
49	-					
61	-	73 80				
1	-
13	-					
25	-					
37	-					
49	-					
61	-	73 80				

FORTRAN FLOATING

DECIMAL DATA

JOB NO.		ANALYST		DATE	PAGE of	WORK ORDER
NUMBER	D	IDENTIFICATION	DESCRIPTION	DO NOT KEY PUNCH	Include if N1 $\neq$ -1 and NRM $>$ 0	
1	-		RC1	}	Include if N10 = 0	
13	-		RC2			
25	-		RB (1)			
37	-		↓			
49	-		RB (NRM)			
61	-	4 4 0 0 0	Use an additional card if NRM $>$ 4			
1	-		RB (1)	}	Include if N10 = 1	
13	-		↓			
25	-		RB (NRM)			
37	-					
49	-					
61	-	4 4 1 0 0				
1	-		RCT (1)	}	Include if N10 $\neq$ -1	
13	-		↓			
25	-		RCT (NRM)			
37	-					
49	-					
61	-	4 4 2 0 0				
1	-
13	-					
25	-					
37	-					
49	-					
61	-					

FORTRAN FIXED 10 DIGIT DECIMAL DATA

DECK NO. _____ PROGRAMMER _____ DATE _____ PAGE _____ of _____ JOB NO. _____

NUMBER	IDENTIFICATION	DESCRIPTION	DO NOT KEY PUNCH	Include If N1 = 1 and N4 ≠ -1
1		IFN ≤ 6		
13		NDN ≤ 7		
25		NGN ≤ 7		
37				
49	73 80			
61	4 5 0 0 0			
1				
13				
25				
37				
49	73 80			
61				
1				
13				
25				
37				
49	73 80			
61				
1				
13				
25				
37				
49	73 80			
61				

FORTTRAN FLOATING

DECIMAL DATA

JOB NO.		ANALYST		DATE	PAGE of	WORK ORDER
NUMBER	D	IDENTIFICATION	DESCRIPTION	DO NOT KEY PUNCH	Include if N1 = 1 and N4 ≠ -1	
1	-		BR			
13	-		QF			
25	-		QS			
37	-					
49	-	73	80			
61	-	4 6 0 0 0				
1	-		FR (1)			
13	-		↓			
25	-		FR (IFN)			
37	-					
49	-	73	80			
61	-	4 6 1 0 0				
1	-		BD (1,1)			
13	-		↓			
25	-		BD (1, IFN)			
37	-		BD (2,1)			
49	-	73	80			
61	-	4 6 2 0 0	BD (NDN, IFN)	Use as many cards as needed		
1	-		YD (1)	(Start on new card)		
13	-		↓			
25	-		YD (NDN)			
37	-					
49	-	73	80			
61	-	4 6 3 0 0		Use as many cards as needed		

JOB NO.		ANALYST		DATE		PAGE of		WORK ORDER	
NUMBER		D	IDENTIFICATION		DESCRIPTION		DO NOT KEY PUNCH		
1		-			QD (1)	}	Include if $N_4 \neq -1$ and $N_r = 0$		
13	-				↓				
25	-				QD (NDN)				
37	-								
49	-		73	80					
61	-		4 7 0 0 0		Use as many cards as needed				
1		-			QGD (1)	}	Include if $N_4 = 1$ and $N_5 = 0$		
13	-				↓				
25	-				QGD (NGN)				
37	-								
49	-		73	80					
61	-		4 7 1 0 0		Use as many cards as needed				
1		-			BG (1)	}	Include if $N_4 = 1$		
13	-				↓				
25	-				BG (NGN)				
37	-								
49	-		73	80					
61	-		4 7 2 0 0		Use as many cards as needed				
1		-			YG (1)	}			
13	-				↓				
25	-				YG (NGN)				
37	-								
49	-		73	80					
61	-		4 7 3 0 0		Use as many cards as needed				

JOB NO. _____		ANALYST _____		DATE _____	PAGE _____ of _____	WORK ORDER _____
NUMBER		D	IDENTIFICATION	DESCRIPTION DO NOT KEY PUNCH		
1		-		RS Include if N5 = -1 and N1 = 1		
13		-				
25		-				
37		-				
49		-				
61		-	73 80	4 8 0 0 0		
1		-		RS		
13		-		RP		
25		-		QFI		
37		-		QFIP		
49		-	73 80	Include if N5 = 0 and N1 = 1		
61		-		4 8 1 0 0		
1		-				
13		-				
25		-				
37		-				
49		-	73 80			
61		-				
1		-				
13		-				
25		-				
37		-				
49		-	73 80			
61		-				

FORTTRAN FLOATING

DECIMAL DATA

SHEET 13

JOB NO.		ANALYST		DATE		PAGE of		WORK ORDER	
NUMBER		D	IDENTIFICATION		DESCRIPTION DO NOT KEY PUNCH				
1		-							
13		-							
25		-							
37		-							
49		-							
61		-			73		80		
					4 9 0 0 0				Use as many cards as needed
1		-							
13		-							
25		-							
37		-							
49		-							
61		-			73		80		
					4 9 1 0 0				
1		-							
13		-							
25		-							
37		-							
49		-							
61		-			73		80		
					4 9 1 1 0				
1		-							
13		-							
25		-							
37		-							
49		-							
61		-			73		80		
					4 9 2 0 0				
									Use as many cards as needed

JOB NO.		ANALYST		DATE	PAGE of	WORK ORDER
NUMBER	D	IDENTIFICATION	DESCRIPTION	DO NOT KEY PUNCH		
1	-		ZQ (1)	}	Include If IQL > 0	
13	-		↓			
25	-		ZQ (IQL)			
37	-					
49	-	73	80			
61	-	5 0 0 0 0		Use as many cards as needed		
1	-		QRP (1)	}	Include If IQR > 0	
13	-		↓			
25	-		QRP (IQR)			
37	-					
49	-	73	80			
61	-	5 0 1 0 0		Use as many cards as needed		
1	-		QGP (1)	}	Include If IQG > IQR	
13	-		↓			
25	-		QGP (IQG)			
37	-					
49	-	73	80			
61	-	5 0 2 0 0		Use as many cards as needed		
1	-					
13	-					
25	-					
37	-					
49	-	73	80			
61	-					

JOB NO. _____		ANALYST _____		DATE _____	PAGE _____ of _____	WORK ORDER _____
NUMBER	D	IDENTIFICATION	DESCRIPTION	DO NOT KEY PUNCH		
1	-		QSP (1)	}	Include If IQR = 0 and IQS > 0	
13	-		↓			
25	-		QSP (IQS)			
37	-					
49	-					
61	-	73 . 80				
	-	5 1 0 0 0			Use as many cards as needed	
1	-		QSP (IQR)	}	Include If IQR > 0 and IQS > IQR	
13	-		↓			
25	-		QSP (IQS)			
37	-					
49	-					
61	-	73 . 80				
	-	5 1 1 0 0			Use as many cards as needed	
1	-		QSSP (1)	}	Include If IQR > 0, QRK > QR and ISQS > 0	
13	-		↓			
25	-		QSSP (ISQS)			
37	-					
49	-					
61	-	73 . 80				
	-	5 1 2 0 0			Use as many cards as needed	
1	-		ZSQ (1)	}		
13	-		↓			
25	-		ZSQ (ISQS)			
37	-					
49	-					
61	-	73 . 80				
	-	5 1 3 0 0			Use as many cards as needed	

JOB NO.		ANALYST		DATE	PAGE of	WORK ORDER
NUMBER	D	IDENTIFICATION	DESCRIPTION DO NOT KEY PUNCH Include if N7 = 1			
1	-		ZIP 1			
13	-		ZIP 2			
25	-		ZIP 3			
37	-					
49	-	73 80				
61	-	5.2.0.0.0				
1	-					
13	-					
25	-					
37	-					
49	-	73 80				
61	-					
1	-					
13	-					
25	-					
37	-					
49	-	73 80				
61	-					
1	-					
13	-					
25	-					
37	-					
49	-	73 80				
61	-					

APPENDIX B

SAMPLE CASE USING OSCAG I

The OSCAG I program provides data for the analysis of a variety of problems in reactor kinetics. Its versatility is illustrated here in a sample case involving a programmed-power run that demonstrates the use of many of the available options and include changes in engine operating parameters during the computer run.

The programmed-power run has three distinct phases: startup, full power, and shutdown (or scram). The startup phase is divided into sub-power startup (power is less than or equal to 0.1%) and ramped power startup. The reactivity is entered at a constant rate to bring the power up to 0.1% of full power. The power level is held at 0.1% for 15 seconds. The next programmed value of power occurs 35 seconds later and is 100%, or full power. This requires the computer to adjust the reactivity to values that increase the power level on a ramp to reach 100% in the required 35 seconds. The case is now in the full-power phase and is scheduled to remain at full power for 1200 seconds before shutdown occurs. At the end of the full-power run, shutdown is initiated by allowing 25 seconds to reduce the power level from 100% to 1%. The 1% power level is held for 20 seconds. An additional 2500 seconds is allowed for the power level to drop from 1% to 0.03% decay-fission power. The computer run was limited to a total of 3000 seconds by ZL, and this last operation was therefore not completed.

FORTRAN FIXED 10 DIGIT DECIMAL DATA

Sheet 1

DECK NO. _____ PROGRAMMER LYON DATE _____ PAGE 1 of 9 JOB NO. _____

NUMBER		IDENTIFICATION	DESCRIPTION	DO NOT KEY PUNCH
1	N 0 0 1 1 T E S T		TP (L)	Include with every problem up to 72 letters
13	P R 0 B T 0 C H E C			or numbers
25	K P R 0 G R A M M E D			Title card
37	P 0 W E R , S T A R T			
49	- U P , A N D S H U T			
61	D 0 W N P H A S E S	73 80 1 0 0 0 0		
1				
13				
25				
37				
49				
61		73 80		
1				
13				
25				
37				
49				
61		73 80		
1				
13				
25				
37				
49				
61		73 80		

FORTRAN FIXED 10 DIGIT DECIMAL DATA

Sheet 2

DECK NO. _____ PROGRAMMER LYON DATE _____ PAGE 2 of 9 JOB NO. _____

NUMBER		IDENTIFICATION	DESCRIPTION	DO NOT KEY PUNCH	Include with every problem
1			IP1 $\leq 10^6$		No. of digital time increments
13	4 0		IP2 $\leq 10^6$		between printouts of information
25	4 0		IP3 $\leq 10^6$		as described by Option 7
37	6		IQG $0 < IQG \leq 30$ but $\neq 1$		IG values at final for decay heat
49	5 73		IQR $0 < IQR \leq 30$ but $\neq 1$		programmed time for total power
61	0	1 1 0 0 0	IQS $0 < IQS \leq 30$ but $\neq 1$		point for source power
1	4		IRN $0 < IRN \leq 30$		IR value at final programmed RR time point
13	0		ISQS $0 < ISQS \leq 30$ but $\neq 1$		Index of time points, final programmed source power in Stage IK = -1
25	0		J		Starting - digital increment no.
37	1 3 0 0 0 0		JL $\leq 131,000$		limiting value of J
49	0 73		NRM $0 \leq NRM \leq 5$		Total no. of coolant-mass regions
61	1	1 1 0 1 0	NRT $-1 \leq NRT \leq 5$		Total no. of temp regions
1	1		N1		Options: Input data selection
13	1		N2		Subsequent-problem data retention selection
25	1		N3		Region temp calc.
37	0		N4		Neutron kinetics and decay heat precursor calc.
49	1 73		N5		Initial conditions for precursors & source multiplication
61	0	1 1 0 2 0	N6		Time increments
1	1		N7		Printout intervals
13	1		N8		Power transfer to coolant
25	1		N9		Reactivity feedback base conditions
37	1		N10		Coolant-mass reactivity feedback formulations
49	1 73		N11		Option not used, input disregarded
61	1	1 1 0 3 0	N12		Base condition for imposed reactivity after programmed total power phase.

FORTTRAN FLOATING

DECIMAL DATA

Sheet 3

JOB NO.		ANALYST LYON		DATE	PAGE 3 of 9	WORK ORDER
NUMBER		D	IDENTIFICATION	DESCRIPTION DO NOT KEY PUNCH		
1	1	- 0 1		QT1	} Limiting value of proportional change in $QF/\Delta t$ Include with every problem. Current digital time increment Limit time Time (initial) Include only if $N1 = 1$. Prompt-neutron lifetime	
13	1	+ 0 2		ZI		
25	3	+ 0 4		ZL		
37	0	- 0 0		Z		
49	2 4	- 0 4		EL		
61	1	- 1 1	1 2 0 0 0	QR	} Total reactor power	
1	0	- 0 0		HQ	} Time integral of total power HQ value below which fuel temp & coolant mass are not calcd. Include if $N1 \neq -1$. Integrated power coef of neutron multiplication Control contribution to neutron multiplication Neutron-mult. contribution from time elapsed after ZRZ	
13	0	- 0 0		HQT		
25	0	- 0 0		RHQR		
37	0	- 0 0		RRC		
49	0	- 0 0		RZ		
61	0	- 0 0	1 2 1 0 0	RZR	} Time coef. of neutron mult in $RZ = RZR \times (Z - ZRZ)$	
1	1	+ 0 1		TFRZ	} Temp at which calc of time feedback RZ is initiated Input Neg. No. Unless RZ Calc. is to start immediately Time at which RZ calc is initiated as described by definitions of RZ & RZR	
13	1	- 0 0		ZRZ		
25		-				
37		-				
49		-				
61		-	1 2 1 1 0			
1		-		HCF	} Include if $N1 \neq -1$, $N3 \neq 1$, and $NRT \geq 0$	
13		-		HCFL		
25		-		HCFM		
37		-		TFL		
49		-		TFM		
61		-	1 2 2 0 0	TFMC		

FORTRAN FIXED 10 DIGIT DECIMAL DATA

Sheet 7

DECK NO. _____ PROGRAMMER LYON DATE _____ PAGE 4 of 9 JOB NO. _____

NUMBER		IDENTIFICATION	DESCRIPTION	DO NOT KEY PUNCH	Include if N1 = 1 and N4 ≠ -1
1			IFN	≤ 6	Fuel isotopes used in calculating K _{eff}
13			NDN	≤ 7	No. of delayed-neutron groups
25			NGN	≤ 7	No. of decay-heat precursor groups
37					
49					
61					
1					
13					
25					
37					
49					
61					
1					
13					
25					
37					
49					
61					
1					
13					
25					
37					
49					
61					

1 6 0 0 0

FORTTRAN FLOATING

DECIMAL DATA

Sheet 8

JOB NO.		ANALYST LYON		DATE	PAGE 5 of 9	WORK ORDER
NUMBER	D	IDENTIFICATION	DESCRIPTION	DO NOT KEY PUNCH	Include if N1 = 1 and N4 ≠ -1	
1	1 1 3	+ 0.1	73 80	BR	Ratio of beta effective to beta theoretical	
13	1	- 1.1		QF	Reactor power from fission } Input may be changed if N5 = -1	
25	1	- 0.2		QRK	Upper limit of QR for initial reactor kinetics stage	
37	2 7 6	- 1.3		QS	Power from fission capture of sources-originated neutrons	
49		-				
61		-	1 7 0 0 0			
1	1	+ 0.1	73 80	FR (1)	Fraction of fissions occurring in fuel	
13		-		↓	isotope IFN	
25		-		FR (IFN)	IFN ≤ 6	
37		-				
49		-				
61		-	1 7 1 0 0			
1	2 6 2 2	- 0.3	73 80	BD (1,1)	Delay-neutron fraction of delay group ND for	
13	1 4 6 9 7	- 0.2		↓	fuel isotope IFN	
25	1 2 9 7 2	- 0.2		BD (1, IFN)	IFN ≤ 6	
37	2 8 0 8 3	- 0.2		BD (2,1)		
49	8 8 3 2	- 0.3				
61	1 7 9 4	- 0.3	1 7 2 0 0	BD (NDN, IFN)	Use as many cards as needed	
1	1 2 7	- 0.1	73 80	YD (1)	(Start on new card)	
13	3 1 7	- 0.1		↓	Delay constant for delay-neutron precursor	
25	1 1 5	- 0.0		YD (NDN)	group ND	
37	3 1 1	- 0.0				
49	1 4 0	+ 0.1				
61	3 8 7	+ 0.1	1 7 3 0 0		Use as many cards as needed	

FORTTRAN FLOATING

DECIMAL DATA

Sheet 10

JOB NO.		ANALYST LYON		DATE	PAGE 6 of 9	WORK ORDER	
NUMBER	D	IDENTIFICATION	DESCRIPTION	DO NOT KEY PUNCH	Include if N4 $\neq$ -1		
1	-		RS	Include if N5 = -1 and N1 = 1			
13	-						
25	-						
37	-						
49	-						
61	-	73 80	1 9 0 0 0				
1	-		RS	} Include if N5 = 0 and N1 = 1			
13	-		RP				
25	-		QFI				
37	-		QFIP				
49	-		73 80	1 9 1 0 0			
1	1	0.2		Z1	Digital time increments: For 1st kinetics formulation		
13	5	0.1		Z2	} Include if N6 = 0. For 2nd kinetics formulation		
25	-						
37	-						
49	-						
61	-	73 80	1 9 2 0 0				
1	-
13	-						
25	-						
37	-						
49	-						
61	-	73 80					

FORTTRAN FLOATING

DECIMAL DATA

Sheet 11

JOB NO.		ANALYST LYON		DATE	PAGE 7 of 9	WORK ORDER
NUMBER		D	IDENTIFICATION	DESCRIPTION DO NOT KEY PUNCH Include if N4 ≠ -1		
1	0	- 0 0		R00	Coef used in determining RR for IRN = 0 or for	
13	9 0 6 0 5 8 8 8	- 0 3		R01	Z ← ZR(1) when IRN > 0 in RR = R00 + [R01 + R02 x	
25	0	- 0 0		R02	(Z-ZS) x (Z-ZS)	
37		-				
49		-	73 80			
61		-	2 0 0 0 0	Use as many cards as needed		
1	3 2 6	- 0 1		R0 (1)	Coefficients used in determining	
13	0	- 0 0		R1 (1)	RR	
25	0	- 0 0		R2 (1)		
37	0	- 0 0		R0 (2)	Include if IRN > 0	
49	6	- 0 1	73 80	R1 (2)		
61	0	- 0 0	2 0 1 0 0	R2 (2)	Use as many cards as needed	
1	7 6	- 0 2				
13	2	- 0 1				
25	0	- 0 0				
37	3 2 4	- 0 1		R0 (IRN)		
49	0	- 0 0	73 80	R1 (IRN)		
61	0	- 0 0	2 0 1 1 0	R2 (IRN)	Use as many cards as needed	
1	3 5 9 8	+ 0 2		ZR (1) (New Card)	Time at which programmed coefficients	
13	1 0 0 0 0 0	+ 0 5			RO(IR), R1(IR), and R2(IR) apply to	
25	1 0 0 0 0 5	+ 0 5		ZR (IRN)	calculations of RR	
37	1 0 5 0 0 0	+ 0 5				
49		+	73 80			
61		-	2 0 2 0 0	Use as many cards as needed		

FORTTRAN FLOATING

DECIMAL DATA

Sheet 12

JOB NO.		ANALYST LYON		DATE	PAGE 8 of 9	WORK ORDER
NUMBER	D	IDENTIFICATION	DESCRIPTION	DO NOT KEY PUNCH		
1	1 5	- 0 2	ZQ (1)	Time (after programmed power begins)		
13	5 0	- 0 2	↓	Include if IQL > 0 at which programmed		
25	1 2 6 5	- 0 4	ZQ (IQL)	values QRP(IQ), QRG(IQ), and QSP(IQ)		
37	1 2 9 0	- 0 4		apply as values of QR, QGC, and QS, respectively		
49	1 3 1 0	- 0 4				
61	3 8 1 0	- 0 4	2 1 0 0 0	Use as many cards as needed		
1	1	- 0 2	QRP (1)	Programmed value of total power QR at		
13	1	- 0 1	↓	Include if IQR > 0 time ZQ(IQ)		
25	1	- 0 1	QRP (IQR)			
37	1	- 0 0				
49	1	- 0 0				
61		-	2 1 1 0 0	Use as many cards as needed		
1	1	- 0 3	QGP (1)	Programmed value of decoy heat from		
13	1	- 0 0	↓	Include if IQG > IQR ZQ(IQ) to ZQ(IQ + 1)		
25	1	- 0 0	QGP (IQG)			
37	1	- 0 1				
49	1	- 0 1				
61	3	- 0 3	2 1 2 0 0	Use as many cards as needed		
1		-				
13		-				
25		-				
37		-				
49		-				
61		-				

FORTRAN FLOATING

DECIMAL DATA

JOB NO.		ANALYST LYON		DATE	PAGE 9 of 9	
NUMBER	D	IDENTIFICATION	DESCRIPTION	DO NOT KEY PUNCH	Include if N7 = 1	
1	4.9	+ 0.1		ZIP 1	Time between printouts	
13	1.9.9.9.9	+ 0.2		ZIP 2	of information as described	
25	1.9.9.9.9	+ 0.2		ZIP 3	in Option 7	
37		-				
49		-				
61		-	73. 80			
		-	2.2.0.0.0			
1		-				
13		-				
25		-				
37		-				
49		-				
61		-	73. 80			
		-				
1		-				
13		-				
25		-				
37		-				
49		-				
61		-	73. 80			
		-				
1		-				
13		-				
25		-				
37		-				
49		-				
61		-	73. 80			
		-				

OSGAG 1, NUCLEAR REACTOR TRANSIENT SIMULATION WITH KINETICS AND PROGRAMMED POWER

BY OSCAR D. SEAWELL, CONSULTANT TO REON, AEROJET GENERAL CORPORATION

NO. 011 TEST PROB TO CHECK PROGRAMMED POWER, START-UP, AND SHUTDOWN PHASES

IP1 4	IP2 40	IP3 40	IQG 6	IQR 5	IQS 0	IRN 4	ISQS 0	J 0	JL 130000	NRM 0	NRT -1
N1 1	N2 -1	N3 1	N4 0	N5 1	N6 0	N7 1	N8 -1	N9 -1	N10 -1	N11 -1	N12 1
QT1 9.9999999E-03	ZI 1.0000000E 01	ZL 3.0000000E 03	Z 0.	EL 2.3999999E-05	QR 1.0000000E-12						
HQ 0.	HQT 0.	RHQR 0.	RRC 0.	RZ 0.	RZR 0.	TFRZ 1.00000E 09	ZRZ -1.00000E-01				
IFN 1	NDN 6	NGN 0	BE 7.7969998E-03	BR 1.1300000E 00	QF 1.0000000E-12	QRK 9.9999999E-04	QS 2.7600000E-14				
FRT 1.0000000E 00	FR(1) 1.0000000E 00	FR(2) 0.	FR(3) 0.	FR(4) 0.	FR(5) 0.	FR(6) 0.					
ND 1	B(ND) 2.9628599E-04	YC(ND) 1.2700000E-02									
2	1.6607610E-03	3.1700000E-02									
3	1.4658360E-03	1.1500000E-01									
4	3.1733789E-03	3.1100000E-01									
5	9.9801598E-04	1.4000000E 00									
6	2.0272200E-04	3.8700000E 00									
Z1 9.9999999E-04	Z2 4.9999999E-02	A1 4.1666666E 01	A2 2.0833333E 03								
ND 1	X1(ND) 1.2700000E-05	X2(ND) 6.3499998E-04									
2	3.1699999E-05	1.5850000E-03									
3	1.1500000E-04	5.7499999E-03									
4	3.1099999E-04	1.5550000E-02									
5	1.4000000E-03	6.9999998E-02									

6 3.8699999E-03 1.9350000E-01

QDT QG
7.5818024E-15 0.

ND QD(ND)
1 2.8810849E-16
2 1.6149239E-15
3 1.4253789E-15
4 3.0857936E-15
5 9.7047073E-16
6 1.9712687E-16

RK RS RP QF QFI QFIP QS PIN
9.72400E-01 -2.76000E-02 -2.76000E-02 1.00000E-12 0. 0. 2.76000E-14 0.

R00 R01 R02
0. 9.0605888E-04 0.

IR R0(IR) R1(IR) R2(IR) ZR(IR)
1 3.2599999E-02 0. 0. 3.5979999E 01
2 0. 5.9999999E-02 0. 1.0000000E 04
3 7.5999999E-03 -2.0000000E-02 0. 1.0000500E 04
4 -3.2400000E-02 0. 0. 1.0002500E 04

IK IQ QRP(IQ) QRPS(IQ) ZQ(IQ) - ZK
-1 0 10.000000E-04 0. 0.
1 10.000000E-04 2.854286E-02 1.500000E 01
2 1.000000E 00 0. 5.000000E 01
3 1.000000E 00 -3.600000E-02 1.265000E 03
4 1.000000E-01 0. 1.290000E 03
5 1.000000E-01 0. 1.310000E 03

ND X(ND)
1 1.270000E-01
2 3.170000E-01
3 1.000000E 00
4 1.000000E 00
5 1.000000E 00
6 1.000000E 00

IQ QGP(IQ) QGPS(IQ) ZQ(IQ) - ZK
0 0. 6.666667E-06 0.

1	10.000000E-05	2.854286E-03	1.500000E 01
2	1.000000E-01	0.	5.000000E 01
3	1.000000E-01	-3.600000E-03	1.265000E 03
4	10.000000E-03	0.	1.290000E 03
5	10.000000E-03	-3.880000E-06	1.310000E 03
6	3.000000E-04	0.	3.810000E 03

ZIP1	ZIP2	ZIP3
4.9000000E 00	1.9999000E 01	1.9999000E 01

BEGIN TRANSIENT CALCULATIONS

J	TIME	QR	QF	PIN	R	RR	RRC	RMS	RTS	TFA
0	0.	1.000E-12	1.000E-12	0.	-2.760E-02	0.	0.	0.	0.	0.
ZI	QFI	QSI	QG	QS	HQ	RHQ	RZ			
5.00000E-02	0.	0.	0.	2.76000E-14	0.	0.	0.			

J	TIME	QR	QF	PIN	R	RR	RRC	RMS	RTS	TFA
99	4.9500E 00	1.161E-12	1.161E-12	3.376E-02	-2.312E-02	4.48E-03	0.	0.	0.	0.
198	9.9000E 00	1.399E-12	1.399E-12	4.164E-02	-1.863E-02	8.97E-03	0.	0.	0.	0.
297	1.4850E 01	1.763E-12	1.763E-12	5.252E-02	-1.415E-02	1.35E-02	0.	0.	0.	0.
396	1.9800E 01	2.380E-12	2.380E-12	6.978E-02	-9.660E-03	1.79E-02	0.	0.	0.	0.
495	2.4750E 01	3.610E-12	3.610E-12	1.016E-01	-5.175E-03	2.24E-02	0.	0.	0.	0.

QDT	QD(1)	QD(2)	QD(3)	QD(4)	QD(5)	QD(6)	QD(7)
1.90954E-14	3.60799E-16	2.47970E-15	3.24324E-15	8.94938E-15	3.35254E-15	7.09728E-16	

ZI	QFI	QSI	QG	QS	HQ	RHQ	RZ
5.00000E-02	1.83335E-14	0.	0.	2.76000E-14	4.39061E-11	0.	0.

J	TIME	QR	QF	PIN	R	RR	RRC	RMS	RTS	TFA
594	2.9700E 01	6.995E-12	6.995E-12	1.765E-01	-6.901E-04	2.69E-02	0.	0.	0.	0.

CHANGE FROM Z2 TO Z1 TO PREVENT EXCESSIVE POWER INCREMENT

J	Z	ZI	A
612	3.055097E 01	10.000000E-04	4.166667E 01

J	TIME	QR	QF	PIN	R	RR	RRC	RMS	RTS	TFA
4662	3.4601E 01	2.881E-11	2.881E-11	4.884E-01	3.750E-03	3.14E-02	0.	0.	0.	0.
9563	3.9501E 01	3.080E-10	3.080E-10	4.043E-01	5.000E-03	3.26E-02	0.	0.	0.	0.
14464	4.4402E 01	2.162E-09	2.162E-09	3.943E-01	5.000E-03	3.26E-02	0.	0.	0.	0.
19365	4.9303E 01	1.488E-08	1.488E-08	3.931E-01	5.000E-03	3.26E-02	0.	0.	0.	0.

QDT	QD(1)	QD(2)	QD(3)	QD(4)	QD(5)	QD(6)	QD(7)
4.22945E-11	1.38499E-13	1.84945E-12	4.95411E-12	2.09492E-11	1.16513E-11	2.75187E-12	

ZI	QFI	QSI	QG	QS	HQ	RHQ	RZ
10.00000E-04	5.84851E-12	0.	0.	2.76000E-14	3.77733E-08	0.	0.

J	TIME	QR	QF	PIN	R	RR	RRC	RMS	RTS	TFA
24266	5.4203E 01	1.021E-07	1.021E-07	3.929E-01	5.000E-03	3.26E-02	0.	0.	0.	0.

29167	5.9104E 01	7.007E-07	7.007E-07	3.929E-01	5.000E-03	3.26E-02	0.	0.	0.	0.
34068	6.4005E 01	4.807E-06	4.807E-06	3.929E-01	5.000E-03	3.26E-02	0.	0.	0.	0.
38969	6.8903E 01	3.298E-05	3.298E-05	3.929E-01	5.000E-03	3.26E-02	0.	0.	0.	0.
43870	7.3801E 01	2.263E-04	2.263E-04	3.929E-01	5.000E-03	3.26E-02	0.	0.	0.	0.

QDT	QD(1)	QD(2)	QD(3)	QD(4)	QD(5)	QD(6)	QD(7)
6.43585E-07	2.10901E-09	2.81874E-08	7.54560E-08	3.18779E-07	1.77204E-07	4.18494E-08	

ZI	QFI	QSI	QG	QS	HQ	RHQ	RZ
10.00000E-04	8.88945E-08	0.	0.	2.76000E-14	5.75831E-04	0.	0.

J	TIME	QR	QF	PIN	R	RR	RRC	RMS	RTS	TFA
47652	7.7581E 01	1.000E-03	1.000E-03	3.929E-01	5.000E-03	3.26E-02	0.	0.	0.	0.

ZI	GFI	QSI	QG	QS	HQ	RHQ	RZ
10.00000E-04	3.92905E-07	0.	0.	2.76000E-14	2.54508E-03	0.	0.

IQ	ZQ(IQ)	
1	9.258108E	01
2	1.275811E	02
3	1.342581E	03
4	1.367581E	03
5	1.387581E	03
6	3.887581E	03

J	TIME	QR	QF	PIN	R	RR	RRC	RMS	RTS	TFA
47653	8.7581E 01	10.000E-04	9.333E-04	0.	1.072E-03	2.87E-02	0.	0.	0.	0.

QDT	QD(1)	QD(2)	QD(3)	QD(4)	QD(5)	QD(6)	QD(7)
6.28407E-06	4.45133E-08	5.94025E-07	1.41704E-06	3.06773E-06	9.64790E-07	1.95973E-07	

ZI	QFI	QSI	QG	QS	HQ	RHQ	RZ
1.00000E 01	3.92905E-07	0.	6.66667E-05	2.76000E-14	1.25455E-02	0.	0.

J	TIME	QR	QF	PIN	R	RR	RRC	RMS	RTS	TFA
47654	9.7581E 01	1.437E-01	1.293E-01	2.207E-01	4.610E-03	3.22E-02	0.	0.	0.	0.
47655	1.0758E 02	4.291E-01	3.362E-01	7.390E-02	3.481E-03	3.11E-02	0.	0.	0.	0.

QDT	QD(1)	QD(2)	QD(3)	QD(4)	QD(5)	QD(6)	QD(7)
1.67821E-03	1.18823E-05	1.59534E-04	3.78208E-04	8.18780E-04	2.57503E-04	5.23053E-05	

ZI	QFI	CSI	QG	QS	HQ	RHQ	RZ
1.00000E 01	3.92905E-07	0.	4.29143E-02	2.76000E-14	3.60040E 00	0.	0.

J	TIME	QR	QF	PIN	R	RR	RRC	RMS	RTS	TFA
47656	1:1758E 02	7.146E-01	6.431E-01	4.438E-02	2.510E-03	3.01E-02	0.	0.	0.	0.
47657	1:2758E 02	1.000E 00	9.000E-01	0.	2.009E-03	2.96E-02	0.	0.	0.	0.

QDT	QD(1)	QD(2)	QD(3)	QD(4)	QD(5)	QD(6)	QD(7)
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5.22309E-03 5.49545E-05 6.65187E-04 1.13025E-03 2.44686E-03 7.69529E-04 1.56311E-04

ZI QFI QSI QG QS HQ RHQ RZ
1.00000E 01 3.92905E-07 0. 1.00000E-01 2.76000E-14 1.78918E 01 0. 0.

J	TIME	QR	QF	PIN	R	RR	RRC	RMS	RTS	TFA
47658	1.3758E 02	1.000E 00	9.000E-01	0.	8.443E-04	2.84E-02	0.	0.	0.	0.
47659	1.4758E 02	1.000E 00	9.000E-01	0.	6.225E-04	2.82E-02	0.	0.	0.	0.

QDT QD(1) QD(2) QD(3) QD(4) QD(5) QD(6) QD(7)
6.46146E-03 1.05193E-04 1.10643E-03 1.31772E-03 2.85272E-03 8.97169E-04 1.82238E-04

ZI QFI QSI QG QS HQ RHQ RZ
1.00000E 01 3.92905E-07 0. 1.00000E-01 2.76000E-14 3.78918E 01 0. 0.

J	TIME	QR	QF	PIN	R	RR	RRC	RMS	RTS	TFA
47660	1.5758E 02	1.000E 00	9.000E-01	0.	4.564E-04	2.81E-02	0.	0.	0.	0.
47661	1.6758E 02	1.000E 00	9.000E-01	0.	3.421E-04	2.79E-02	0.	0.	0.	0.

QDT QD(1) QD(2) QD(3) QD(4) QD(5) QD(6) QD(7)
6.71184E-03 1.43560E-04 1.31319E-03 1.31903E-03 2.85557E-03 8.98065E-04 1.82420E-04

ZI QFI QSI QG QS HQ RHQ RZ
1.00000E 01 3.92905E-07 0. 1.00000E-01 2.76000E-14 5.78918E 01 0. 0.

J	TIME	QR	QF	PIN	R	RR	RRC	RMS	RTS	TFA
47662	1.7758E 02	1.000E 00	9.000E-01	0.	2.600E-04	2.79E-02	0.	0.	0.	0.
47663	1.8758E 02	1.000E 00	9.000E-01	0.	2.006E-04	2.78E-02	0.	0.	0.	0.

QDT QD(1) QD(2) QD(3) QD(4) QD(5) QD(6) QD(7)
6.83815E-03 1.72814E-04 1.40981E-03 1.31914E-03 2.85581E-03 8.98141E-04 1.82435E-04

ZI QFI QSI QG QS HQ RHQ RZ
1.00000E 01 3.92905E-07 0. 1.00000E-01 2.76000E-14 7.78918E 01 0. 0.

J	TIME	QR	QF	PIN	R	RR	RRC	RMS	RTS	TFA
47664	1.9758E 02	1.000E 00	9.000E-01	0.	1.571E-04	2.78E-02	0.	0.	0.	0.
47665	2.0758E 02	1.000E 00	9.000E-01	0.	1.248E-04	2.77E-02	0.	0.	0.	0.

QDT QD(1) QD(2) QD(3) QD(4) QD(5) QD(6) QD(7)
6.90582E-03 1.95119E-04 1.45497E-03 1.31919E-03 2.85592E-03 8.98175E-04 1.82442E-04

ZI QFI QSI QG QS HQ RHQ RZ

J	TIME	QR	QF	PIN	R	RR	RRC	RMS	RTS	TFA
47666	2.1758E 02	1.000E 00	9.000E-01	0.	1.006E-04	2.77E-02	0.	0.	0.	0.
47667	2.2758E 02	1.000E 00	9.000E-01	0.	8.203E-05	2.77E-02	0.	0.	0.	0.
QDT	QD(1)	QD(2)	QD(3)	QD(4)	QD(5)	QD(6)	QD(7)			
6.94405E-03	2.12126E-04	1.47609E-03	1.31922E-03	2.85597E-03	8.98193E-04	1.82445E-04				
ZI	QFI	QSI	QG	QS	HQ	RHQ	RZ			
1.00000E 01	3.92905E-07	0.	1.00000E-01	2.76000E-14	1.17892E 02	0.	0.			
47668	2.3758E 02	1.000E 00	9.000E-01	0.	6.768E-05	2.77E-02	0.	0.	0.	0.
47669	2.4758E 02	1.000E 00	9.000E-01	0.	5.639E-05	2.77E-02	0.	0.	0.	0.
QDT	QD(1)	QD(2)	QD(3)	QD(4)	QD(5)	QD(6)	QD(7)			
6.96694E-03	2.25091E-04	1.48597E-03	1.31923E-03	2.85600E-03	8.98201E-04	1.82447E-04				
ZI	QFI	QSI	QG	QS	HQ	RHQ	RZ			
1.00000E 01	3.92905E-07	0.	1.00000E-01	2.76000E-14	1.37892E 02	0.	0.			
47670	2.5758E 02	1.000E 00	9.000E-01	0.	4.739E-05	2.76E-02	0.	0.	0.	0.
47671	2.6758E 02	1.000E 00	9.000E-01	0.	4.011E-05	2.76E-02	0.	0.	0.	0.
QDT	QD(1)	QD(2)	QD(3)	QD(4)	QD(5)	QD(6)	QD(7)			
6.98148E-03	2.34974E-04	1.49060E-03	1.31924E-03	2.85602E-03	8.98206E-04	1.82448E-04				
ZI	QFI	QSI	QG	QS	HQ	RHQ	RZ			
1.00000E 01	3.92905E-07	0.	1.00000E-01	2.76000E-14	1.57892E 02	0.	0.			
47672	2.7758E 02	1.000E 00	9.000E-01	0.	3.416E-05	2.76E-02	0.	0.	0.	0.
47673	2.8758E 02	1.000E 00	9.000E-01	0.	2.923E-05	2.76E-02	0.	0.	0.	0.
QDT	QD(1)	QD(2)	QD(3)	QD(4)	QD(5)	QD(6)	QD(7)			
6.99119E-03	2.42508E-04	1.49276E-03	1.31924E-03	2.85602E-03	8.98209E-04	1.82449E-04				
ZI	QFI	QSI	QG	QS	HQ	RHQ	RZ			
1.00000E 01	3.92905E-07	0.	1.00000E-01	2.76000E-14	1.77892E 02	0.	0.			
J	TIME	QR	QF	PIN	R	RR	RRC	RMS	RTS	TFA

47674	2.9758E 02	1.000E 00	9.000E-01	0.	2.512E-05	2.76E-02	0.	0.	0.	0.
47675	3.0758E 02	1.000F 00	9.000E-01	0.	2.166E-05	2.76E-02	0.	0.	0.	0.

QDT	QD(1)	QD(2)	QD(3)	QD(4)	QD(5)	QD(6)	QD(7)
6.99796E-03	2.48250E-04	1.49378E-03	1.31925E-03	2.85603E-03	8.98211E-04	1.82449E-04	

ZI	CFI	QSI	QG	QS	HQ	RHQ	RZ
1.00000E 01	3.92905E-07	0.	1.00000E-01	2.76000E-14	1.97892E 02	0.	0.

J	TIME	QR	QF	PIN	R	RR	RRC	RMS	RTS	TFA
47676	3.1758E 02	1.000E 00	9.000E-01	0.	1.872E-05	2.76E-02	0.	0.	0.	0.
47677	3.2758E 02	1.000F 00	9.000E-01	0.	1.621E-05	2.76E-02	0.	0.	0.	0.

QDT	QD(1)	QD(2)	QD(3)	QD(4)	QD(5)	QD(6)	QD(7)
7.00282E-03	2.52627E-04	1.49425E-03	1.31925E-03	2.85603E-03	8.98212E-04	1.82449E-04	

ZI	QFI	QSI	QG	QS	HQ	RHQ	RZ
1.00000E 01	3.92905E-07	0.	1.00000E-01	2.76000E-14	2.17892E 02	0.	0.

J	TIME	QR	QF	PIN	R	RR	RRC	RMS	RTS	TFA
47678	3.3758E 02	1.000E 00	9.000E-01	0.	1.407E-05	2.76E-02	0.	0.	0.	0.
47679	3.4758E 02	1.000E 00	9.000E-01	0.	1.222E-05	2.76E-02	0.	0.	0.	0.

QDT	QD(1)	QD(2)	QD(3)	QD(4)	QD(5)	QD(6)	QD(7)
7.00639E-03	2.55963E-04	1.49448E-03	1.31925E-03	2.85603E-03	8.98212E-04	1.82449E-04	

ZI	QFI	QSI	QG	QS	HQ	RHQ	RZ
1.00000E 01	3.92905E-07	0.	1.00000E-01	2.76000E-14	2.37892E 02	0.	0.

J	TIME	QR	QF	PIN	R	RR	RRC	RMS	RTS	TFA
47680	3.5758E 02	1.000E 00	9.000E-01	0.	1.063E-05	2.76E-02	0.	0.	0.	0.
47681	3.6758E 02	1.000E 00	9.000E-01	0.	9.250E-06	2.76E-02	0.	0.	0.	0.

QDT	QD(1)	QD(2)	QD(3)	QD(4)	QD(5)	QD(6)	QD(7)
7.00904E-03	2.58506E-04	1.49458E-03	1.31925E-03	2.85604E-03	8.98213E-04	1.82450E-04	

ZI	QFI	QSI	QG	QS	HQ	RHQ	RZ
1.00000E 01	3.92905E-07	0.	1.00000E-01	2.76000E-14	2.57892E 02	0.	0.

J	TIME	QR	QF	PIN	R	RR	RRC	RMS	RTS	TFA
47682	3.7758E 02	1.000E 00	9.000E-01	0.	8.057E-06	2.76E-02	0.	0.	0.	0.
47683	3.8758E 02	1.000E 00	9.000E-01	0.	7.021E-06	2.76E-02	0.	0.	0.	0.

QDT	QD(1)	QD(2)	QD(3)	QD(4)	QD(5)	QD(6)	QD(7)
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7.01103E-03 2.60445E-04 1.49463E-03 1.31925E-03 2.85604E-03 8.98213E-04 1.82450E-04

ZI QFI QSI QG QS HQ RHQ RZ
1.00000E 01 3.92905E-07 0. 1.00000E-01 2.76000E-14 2.77892E 02 0. 0.

J	TIME	QR	QF	PIN	R	RR	RRC	RMS	RTS	TFA
47684	3.9758E 02	1.000E 00	9.000E-01	0.	6.120E-06	2.76E-02	0.	0.	0.	0.
47685	4.0758E 02	1.000E 00	9.000E-01	0.	5.337E-06	2.76E-02	0.	0.	0.	0.

QDT QD(1) QD(2) QD(3) QD(4) QD(5) QD(6) QD(7)
7.01253E-03 2.61922E-04 1.49466E-03 1.31925E-03 2.85604E-03 8.98214E-04 1.82450E-04

ZI QFI QSI QG QS HQ RHQ RZ
1.00000E 01 3.92905E-07 0. 1.00000E-01 2.76000E-14 2.97892E 02 0. 0.

J	TIME	QR	QF	PIN	R	RR	RRC	RMS	RTS	TFA
47686	4.1758E 02	1.000E 00	9.000E-01	0.	4.655E-06	2.76E-02	0.	0.	0.	0.
47687	4.2758E 02	1.000E 00	9.000E-01	0.	4.062E-06	2.76E-02	0.	0.	0.	0.

QDT QD(1) QD(2) QD(3) QD(4) QD(5) QD(6) QD(7)
7.01367E-03 2.63048E-04 1.49467E-03 1.31925E-03 2.85604E-03 8.98214E-04 1.82450E-04

ZI QFI QSI QG QS HQ RHQ RZ
1.00000E 01 3.92905E-07 0. 1.00000E-01 2.76000E-14 3.17892E 02 0. 0.

J	TIME	QR	QF	PIN	R	RR	RRC	RMS	RTS	TFA
47688	4.3758E 02	1.000E 00	9.000E-01	0.	3.544E-06	2.76E-02	0.	0.	0.	0.
47689	4.4758E 02	1.000E 00	9.000E-01	0.	3.093E-06	2.76E-02	0.	0.	0.	0.

QDT QD(1) QD(2) QD(3) QD(4) QD(5) QD(6) QD(7)
7.01454E-03 2.63906E-04 1.49468E-03 1.31925E-03 2.85604E-03 8.98214E-04 1.82450E-04

ZI QFI QSI QG QS HQ RHQ RZ
1.00000E 01 3.92905E-07 0. 1.00000E-01 2.76000E-14 3.37892E 02 0. 0.

J	TIME	QR	QF	PIN	R	RR	RRC	RMS	RTS	TFA
47690	4.5758E 02	1.000E 00	9.000E-01	0.	2.699E-06	2.76E-02	0.	0.	0.	0.
47691	4.6758E 02	1.000E 00	9.000E-01	0.	2.356E-06	2.76E-02	0.	0.	0.	0.

QDT QD(1) QD(2) QD(3) QD(4) QD(5) QD(6) QD(7)
7.01520E-03 2.64561E-04 1.49468E-03 1.31925E-03 2.85604E-03 8.98214E-04 1.82450E-04

ZI QFI QSI QG QS HQ RHQ RZ

1.00000E 01 3.92905E-07 0. 1.00000E-01 2.76000E-14 3.57892E 02 0. 0.

J	TIME	QR	QF	PIN	R	RR	RRC	RMS	RTS	TFA
47692	4.7758E 02	1.000E 00	9.000E-01	0.	2.056E-06	2.76E-02	0.	0.	0.	0.
47693	4.8758E 02	1.000E 00	9.000E-01	0.	1.795E-06	2.76E-02	0.	0.	0.	0.

QDT	QD(1)	QD(2)	QD(3)	QD(4)	QD(5)	QD(6)	QD(7)
7.01570E-03	2.65059E-04	1.49468E-03	1.31925E-03	2.85604E-03	8.98214E-04	1.82450E-04	

ZI	QFI	QSI	QG	QS	HQ	RHQ	RZ
1.00000E 01	3.92905E-07	0.	1.00000E-01	2.76000E-14	3.77892E 02	0.	0.

J	TIME	QR	QF	PIN	R	RR	RRC	RMS	RTS	TFA
47694	4.9758E 02	1.000E 00	9.000E-01	0.	1.567E-06	2.76E-02	0.	0.	0.	0.
47695	5.0758E 02	1.000E 00	9.000E-01	0.	1.368E-06	2.76E-02	0.	0.	0.	0.

QDT	QD(1)	QD(2)	QD(3)	QD(4)	QD(5)	QD(6)	QD(7)
7.01608E-03	2.65439E-04	1.49468E-03	1.31925E-03	2.85604E-03	8.98214E-04	1.82450E-04	

ZI	QFI	QSI	QG	QS	HQ	RHQ	RZ
1.00000E 01	3.92905E-07	0.	1.00000E-01	2.76000E-14	3.97892E 02	0.	0.

J	TIME	QR	QF	PIN	R	RR	RRC	RMS	RTS	TFA
47696	5.1758E 02	1.000E 00	9.000E-01	0.	1.194E-06	2.76E-02	0.	0.	0.	0.
47697	5.2758E 02	1.000E 00	9.000E-01	0.	1.042E-06	2.76E-02	0.	0.	0.	0.

QDT	QD(1)	QD(2)	QD(3)	QD(4)	QD(5)	QD(6)	QD(7)
7.01637E-03	2.65729E-04	1.49468E-03	1.31925E-03	2.85604E-03	8.98214E-04	1.82450E-04	

ZI	QFI	QSI	QG	QS	HQ	RHQ	RZ
1.00000E 01	3.92905E-07	0.	1.00000E-01	2.76000E-14	4.17892E 02	0.	0.

J	TIME	QR	QF	PIN	R	RR	RRC	RMS	RTS	TFA
47698	5.3758E 02	1.000E 00	9.000E-01	0.	9.100E-07	2.76E-02	0.	0.	0.	0.
47699	5.4758E 02	1.000E 00	9.000E-01	0.	7.945E-07	2.76E-02	0.	0.	0.	0.

QDT	QD(1)	QD(2)	QD(3)	QD(4)	QD(5)	QD(6)	QD(7)
7.01659E-03	2.65950E-04	1.49468E-03	1.31925E-03	2.85604E-03	8.98214E-04	1.82450E-04	

ZI	QFI	QSI	QG	QS	HQ	RHQ	RZ
1.00000E 01	3.92905E-07	0.	1.00000E-01	2.76000E-14	4.37892E 02	0.	0.

J	TIME	QR	QF	PIN	R	RR	RRC	RMS	RTS	TFA
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47706	5.5758E 02	1.000E 00	9.000E-01	0.	6.937E-07	2.76E-02	0.	0.	0.	0.
47701	5.6758E 02	1.000E 00	9.000E-01	0.	6.056E-07	2.76E-02	0.	0.	0.	0.

QDT	QD(1)	QD(2)	QD(3)	QD(4)	QD(5)	QD(6)	QD(7)
7.01676E-03	2.66118E-04	1.49468E-03	1.31925E-03	2.85604E-03	8.98214E-04	1.82450E-04	

ZI	QFI	QSI	QG	QS	HQ	RHQ	RZ
1.00000E 01	3.92905E-07	0.	1.00000E-01	2.76000E-14	4.57892E 02	0.	0.

J	TIME	QR	QF	PIN	R	RR	RRC	RMS	RTS	TFA
47702	5.7758E 02	1.000E 00	9.000E-01	0.	5.287E-07	2.76E-02	0.	0.	0.	0.
47703	5.8758E 02	1.000E 00	9.000E-01	0.	4.613E-07	2.76E-02	0.	0.	0.	0.

QDT	QD(1)	QD(2)	QD(3)	QD(4)	QD(5)	QD(6)	QD(7)
7.01689E-03	2.66246E-04	1.49468E-03	1.31925E-03	2.85604E-03	8.98214E-04	1.82450E-04	

ZI	QFI	QSI	QG	QS	HQ	RHQ	RZ
1.00000E 01	3.92905E-07	0.	1.00000E-01	2.76000E-14	4.77892E 02	0.	0.

J	TIME	QR	QF	PIN	R	RR	RRC	RMS	RTS	TFA
47704	5.9758E 02	1.000E 00	9.000E-01	0.	4.030E-07	2.76E-02	0.	0.	0.	0.
47705	6.0758E 02	1.000E 00	9.000E-01	0.	3.519E-07	2.76E-02	0.	0.	0.	0.

QDT	QD(1)	QD(2)	QD(3)	QD(4)	QD(5)	QD(6)	QD(7)
7.01699E-03	2.66344E-04	1.49468E-03	1.31925E-03	2.85604E-03	8.98214E-04	1.82450E-04	

ZI	QFI	QSI	QG	QS	HQ	RHQ	RZ
1.00000E 01	3.92905E-07	0.	1.00000E-01	2.76000E-14	4.97892E 02	0.	0.

J	TIME	QR	QF	PIN	R	RR	RRC	RMS	RTS	TFA
47706	6.1758E 02	1.000E 00	9.000E-01	0.	3.072E-07	2.76E-02	0.	0.	0.	0.
47707	6.2758E 02	1.000E 00	9.000E-01	0.	2.682E-07	2.76E-02	0.	0.	0.	0.

QDT	QD(1)	QD(2)	QD(3)	QD(4)	QD(5)	QD(6)	QD(7)
7.01706E-03	2.66419E-04	1.49468E-03	1.31925E-03	2.85604E-03	8.98214E-04	1.82450E-04	

ZI	QFI	QSI	QG	QS	HQ	RHQ	RZ
1.00000E 01	3.92905E-07	0.	1.00000E-01	2.76000E-14	5.17892E 02	0.	0.

J	TIME	QR	QF	PIN	R	RR	RRC	RMS	RTS	TFA
47708	6.3758E 02	1.000E 00	9.000E-01	0.	2.342E-07	2.76E-02	0.	0.	0.	0.
47709	6.4758E 02	1.000E 00	9.000E-01	0.	2.045E-07	2.76E-02	0.	0.	0.	0.

QDT	QD(1)	QD(2)	QD(3)	QD(4)	QD(5)	QD(6)	QD(7)
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7.01712E-03 2.66475E-04 1.49468E-03 1.31925E-03 2.85604E-03 8.98214E-04 1.82450E-04

ZI QFI QSI QG QS HQ RHQ RZ
1.00000E 01 3.92905E-07 0. 1.00000E-01 2.76000E-14 5.37892E 02 0. 0.

J	TIME	QR	QF	PIN	R	RR	RRC	RMS	RTS	TFA
47710	6.5758E 02	1.000E 00	9.000E-01	0.	1.785E-07	2.76E-02	0.	0.	0.	0.
47711	6.6758E 02	1.000E 00	9.000E-01	0.	1.559E-07	2.76E-02	0.	0.	0.	0.

QDT QD(1) QD(2) QD(3) QD(4) QD(5) QD(6) QD(7)
7.01716E-03 2.66519E-04 1.49468E-03 1.31925E-03 2.85604E-03 8.98214E-04 1.82450E-04

ZI QFI QSI QG QS HQ RHQ RZ
1.00000E 01 3.92905E-07 0. 1.00000E-01 2.76000E-14 5.57892E 02 0. 0.

J	TIME	QR	QF	PIN	R	RR	RRC	RMS	RTS	TFA
47712	6.7758E 02	1.000E 00	9.000E-01	0.	1.361E-07	2.76E-02	0.	0.	0.	0.
47713	6.8758E 02	1.000E 00	9.000E-01	0.	1.188E-07	2.76E-02	0.	0.	0.	0.

QDT QD(1) QD(2) QD(3) QD(4) QD(5) QD(6) QD(7)
7.01719E-03 2.66552E-04 1.49468E-03 1.31925E-03 2.85604E-03 8.98214E-04 1.82450E-04

ZI QFI QSI QG QS HQ RHQ RZ
1.00000E 01 3.92905E-07 0. 1.00000E-01 2.76000E-14 5.77892E 02 0. 0.

J	TIME	QR	QF	PIN	R	RR	RRC	RMS	RTS	TFA
47714	6.9758E 02	1.000E 00	9.000E-01	0.	1.038E-07	2.76E-02	0.	0.	0.	0.
47715	7.0758E 02	1.000E 00	9.000E-01	0.	9.060E-08	2.76E-02	0.	0.	0.	0.

QDT QD(1) QD(2) QD(3) QD(4) QD(5) QD(6) QD(7)
7.01722E-03 2.66577E-04 1.49468E-03 1.31925E-03 2.85604E-03 8.98214E-04 1.82450E-04

ZI QFI QSI QG QS HQ RHQ RZ
1.00000E 01 3.92905E-07 0. 1.00000E-01 2.76000E-14 5.97892E 02 0. 0.

J	TIME	QR	QF	PIN	R	RR	RRC	RMS	RTS	TFA
47716	7.1758E 02	1.000E 00	9.000E-01	0.	7.913E-08	2.76E-02	0.	0.	0.	0.
47717	7.2758E 02	1.000E 00	9.000E-01	0.	6.909E-08	2.76E-02	0.	0.	0.	0.

QDT QD(1) QD(2) QD(3) QD(4) QD(5) QD(6) QD(7)
7.01724E-03 2.66596E-04 1.49468E-03 1.31925E-03 2.85604E-03 8.98214E-04 1.82450E-04

ZI QFI QSI QG QS HQ RHQ RZ

J	TIME	QR	QF	PIN	R	RR	RRC	RMS	RTS	TFA
47718	7.3758E 02	1.000E 00	9.000E-01	0.	6.029E-08	2.76E-02	0.	0.	0.	0.
47719	7.4758E 02	1.000E 00	9.000E-01	0.	5.267E-08	2.76E-02	0.	0.	0.	0.
QDT	QD(1)	QD(2)	QD(3)	QD(4)	QD(5)	QD(6)	QD(7)			
7.01725E-03	2.66611E-04	1.49468E-03	1.31925E-03	2.85604E-03	8.98214E-04	1.82450E-04				
ZI	QFI	QSI	QG	QS	HQ	RHQ	RZ			
1.00000E 01	3.92905E-07	0.	1.00000E-01	2.76000E-14	6.37892E 02	0.	0.			
47720	7.5758E 02	1.000E 00	9.000E-01	0.	4.602E-08	2.76E-02	0.	0.	0.	0.
47721	7.6758E 02	1.000E 00	9.000E-01	0.	4.022E-08	2.76E-02	0.	0.	0.	0.
QDT	QD(1)	QD(2)	QD(3)	QD(4)	QD(5)	QD(6)	QD(7)			
7.01726E-03	2.66622E-04	1.49468E-03	1.31925E-03	2.85604E-03	8.98214E-04	1.82450E-04				
ZI	QFI	QSI	QG	QS	HQ	RHQ	RZ			
1.00000E 01	3.92905E-07	0.	1.00000E-01	2.76000E-14	6.57892E 02	0.	0.			
47722	7.7758E 02	1.000E 00	9.000E-01	0.	3.513E-08	2.76E-02	0.	0.	0.	0.
47723	7.8758E 02	1.000E 00	9.000E-01	0.	3.070E-08	2.76E-02	0.	0.	0.	0.
QDT	QD(1)	QD(2)	QD(3)	QD(4)	QD(5)	QD(6)	QD(7)			
7.01727E-03	2.66630E-04	1.49468E-03	1.31925E-03	2.85604E-03	8.98214E-04	1.82450E-04				
ZI	QFI	QSI	QG	QS	HQ	RHQ	RZ			
1.00000E 01	3.92905E-07	0.	1.00000E-01	2.76000E-14	6.77892E 02	0.	0.			
47724	7.9758E 02	1.000E 00	9.000E-01	0.	2.679E-08	2.76E-02	0.	0.	0.	0.
47725	8.0758E 02	1.000E 00	9.000E-01	0.	2.340E-08	2.76E-02	0.	0.	0.	0.
QDT	QD(1)	QD(2)	QD(3)	QD(4)	QD(5)	QD(6)	QD(7)			
7.01728E-03	2.66637E-04	1.49468E-03	1.31925E-03	2.85604E-03	8.98214E-04	1.82450E-04				
ZI	QFI	QSI	QG	QS	HQ	RHQ	RZ			
1.00000E 01	3.92905E-07	0.	1.00000E-01	2.76000E-14	6.97892E 02	0.	0.			

7.01729E-03 2.66652E-04 1.49468E-03 1.31925E-03 2.85604E-03 8.98214E-04 1.82450E-04

ZI QFI QSI QG QS HQ RHQ RZ
1.00000E 01 3.92905E-07 0. 1.00000E-01 2.76000E-14 7.97892E 02 0. 0.

J TIME LR QF PIN P RR RRC RMS RTS TFA
47736 9.1758E 02 1.000E 00 9.000E-01 0. 5.410E-09 2.76E-02 0. 0. 0. 0.
47737 9.2758E 02 1.000E 00 9.000E-01 0. 4.758E-09 2.76E-02 0. 0. 0. 0.

QDT QD(1) QD(2) QD(3) QD(4) QD(5) QD(6) QD(7)
7.01730E-03 2.66653E-04 1.49468E-03 1.31925E-03 2.85604E-03 8.98214E-04 1.82450E-04

ZI QFI QSI QG QS HQ RHQ RZ
1.00000E 01 3.92905E-07 0. 1.00000E-01 2.76000E-14 8.17892E 02 0. 0.

J TIME LR QF PIN R RR RRC RMS RTS TFA
47738 9.3758E 02 1.000E 00 9.000E-01 0. 4.172E-09 2.76E-02 0. 0. 0. 0.
47739 9.4758E 02 1.000E 00 9.000E-01 0. 3.650E-09 2.76E-02 0. 0. 0. 0.

QDT QD(1) QD(2) QD(3) QD(4) QD(5) QD(6) QD(7)
7.01730E-03 2.66654E-04 1.49468E-03 1.31925E-03 2.85604E-03 8.98214E-04 1.82450E-04

ZI QFI QSI QG QS HQ RHQ RZ
1.00000E 01 3.92905E-07 0. 1.00000E-01 2.76000E-14 8.37892E 02 0. 0.

J TIME LR QF PIN R RR RRC RMS RTS TFA
47740 9.5758E 02 1.000E 00 9.000E-01 0. 3.194E-09 2.76E-02 0. 0. 0. 0.
47741 9.6758E 02 1.000E 00 9.000E-01 0. 2.803E-09 2.76E-02 0. 0. 0. 0.

QDT QD(1) QD(2) QD(3) QD(4) QD(5) QD(6) QD(7)
7.01730E-03 2.66655E-04 1.49468E-03 1.31925E-03 2.85604E-03 8.98214E-04 1.82450E-04

ZI QFI QSI QG QS HQ RHQ RZ
1.00000E 01 3.92905E-07 0. 1.00000E-01 2.76000E-14 8.57892E 02 0. 0.

J TIME LR QF PIN R RR RRC RMS RTS TFA
47742 9.7758E 02 1.000E 00 9.000E-01 0. 2.477E-09 2.76E-02 0. 0. 0. 0.
47743 9.8758E 02 1.000E 00 9.000E-01 0. 2.216E-09 2.76E-02 0. 0. 0. 0.

QDT QD(1) QD(2) QD(3) QD(4) QD(5) QD(6) QD(7)
7.01730E-03 2.66656E-04 1.49468E-03 1.31925E-03 2.85604E-03 8.98214E-04 1.82450E-04

ZI QFI QSI QG QS HQ RHQ RZ

47726	8.1758E 02	1.000E 00	9.000E-01	0.	2.047E-08	2.76E-02	0.	0.	0.	0.
47727	8.2758E 02	1.000E 00	9.000E-01	0.	1.793E-08	2.76E-02	0.	0.	0.	0.

QDT	QD(1)	QD(2)	QD(3)	QD(4)	QD(5)	QD(6)	QD(7)
7.01728E-03	2.66642E-04	1.49468E-03	1.31925E-03	2.85604E-03	8.98214E-04	1.82450E-04	

ZI	CFI	QSI	QG	QS	HQ	RHQ	RZ
1.00000E 01	3.92905E-07	0.	1.00000E-01	2.76000E-14	7.17892E 02	0.	0.

J	TIME	QR	QF	PIN	R	RR	RRC	RMS	RTS	TFA
47728	8.3758E 02	1.000E 00	9.000E-01	0.	1.564E-08	2.76E-02	0.	0.	0.	0.
47729	8.4758E 02	1.000F 00	9.000E-01	0.	1.369E-08	2.76E-02	0.	0.	0.	0.

QDT	QD(1)	QD(2)	QD(3)	QD(4)	QD(5)	QD(6)	QD(7)
7.01729E-03	2.66645E-04	1.49468E-03	1.31925E-03	2.85604E-03	8.98214E-04	1.82450E-04	

ZI	CFI	QSI	QG	QS	HQ	RHQ	RZ
1.00000E 01	3.92905E-07	0.	1.00000E-01	2.76000E-14	7.37892E 02	0.	0.

J	TIME	QR	QF	PIN	R	RR	RRC	RMS	RTS	TFA
47730	8.5758E 02	1.000E 00	9.000E-01	0.	1.199E-08	2.76E-02	0.	0.	0.	0.
47731	8.6758E 02	1.000E 00	9.000E-01	0.	1.049E-08	2.76E-02	0.	0.	0.	0.

QDT	QD(1)	QD(2)	QD(3)	QD(4)	QD(5)	QD(6)	QD(7)
7.01729E-03	2.66648E-04	1.49468E-03	1.31925E-03	2.85604E-03	8.98214E-04	1.82450E-04	

ZI	CFI	QSI	QG	QS	HQ	RHQ	RZ
1.00000E 01	3.92905E-07	0.	1.00000E-01	2.76000E-14	7.57892E 02	0.	0.

J	TIME	QR	QF	PIN	R	RR	RRC	RMS	RTS	TFA
47732	8.7758E 02	1.000E 00	9.000E-01	0.	9.191E-09	2.76E-02	0.	0.	0.	0.
47733	8.8758E 02	1.000E 00	9.000E-01	0.	8.018E-09	2.76E-02	0.	0.	0.	0.

QDT	QD(1)	QD(2)	QD(3)	QD(4)	QD(5)	QD(6)	QD(7)
7.01729E-03	2.66650E-04	1.49468E-03	1.31925E-03	2.85604E-03	8.98214E-04	1.82450E-04	

ZI	CFI	QSI	QG	QS	HQ	RHQ	RZ
1.00000E 01	3.92905E-07	0.	1.00000E-01	2.76000E-14	7.77892E 02	0.	0.

J	TIME	QR	QF	PIN	R	RR	RRC	RMS	RTS	TFA
47734	8.9758E 02	1.000E 00	9.000E-01	0.	7.040E-09	2.76E-02	0.	0.	0.	0.
47735	9.0758E 02	1.000E 00	9.000E-01	0.	6.192E-09	2.76E-02	0.	0.	0.	0.

QDT	QD(1)	QD(2)	QD(3)	QD(4)	QD(5)	QD(6)	QD(7)
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47752	1.0776E 03	1.000E 00	9.000E-01	0.	7.822E-10	2.76E-02	0.	0.	0.	0.
47753	1.0876E 03	1.000E 00	9.000E-01	0.	7.170E-10	2.76E-02	0.	0.	0.	0.

QDT	QD(1)	QD(2)	QD(3)	QD(4)	QD(5)	QD(6)	QD(7)
7.01730E-03	2.66657E-04	1.49468E-03	1.31925E-03	2.85604E-03	8.98214E-04	1.82450E-04	

ZI	QFI	QSI	QG	QS	HQ	RHQ	RZ
1.00000E 01	3.92905E-07	0.	1.00000E-01	2.76000E-14	9.77892E 02	0.	0.

J	TIME	QR	QF	PIN	R	RR	RRC	RMS	RTS	TFA
47754	1.0976E 03	1.000E 00	9.000E-01	0.	6.518E-10	2.76E-02	0.	0.	0.	0.
47755	1.1076E 03	1.000E 00	9.000E-01	0.	5.866E-10	2.76E-02	0.	0.	0.	0.

QDT	QD(1)	QD(2)	QD(3)	QD(4)	QD(5)	QD(6)	QD(7)
7.01730E-03	2.66657E-04	1.49468E-03	1.31925E-03	2.85604E-03	8.98214E-04	1.82450E-04	

ZI	QFI	QSI	QG	QS	HQ	RHQ	RZ
1.00000E 01	3.92905E-07	0.	1.00000E-01	2.76000E-14	9.97892E 02	0.	0.

J	TIME	QR	QF	PIN	R	RR	RRC	RMS	RTS	TFA
47756	1.1176E 03	1.000E 00	9.000E-01	0.	5.214E-10	2.76E-02	0.	0.	0.	0.
47757	1.1276E 03	1.000E 00	9.000E-01	0.	4.563E-10	2.76E-02	0.	0.	0.	0.

QDT	QD(1)	QD(2)	QD(3)	QD(4)	QD(5)	QD(6)	QD(7)
7.01730E-03	2.66657E-04	1.49468E-03	1.31925E-03	2.85604E-03	8.98214E-04	1.82450E-04	

ZI	QFI	QSI	QG	QS	HQ	RHQ	RZ
1.00000E 01	3.92905E-07	0.	1.00000E-01	2.76000E-14	1.01789E 03	0.	0.

J	TIME	QR	QF	PIN	R	RR	RRC	RMS	RTS	TFA
47758	1.1376E 03	1.000E 00	9.000E-01	0.	4.563E-10	2.76E-02	0.	0.	0.	0.
47759	1.1476E 03	1.000E 00	9.000E-01	0.	3.911E-10	2.76E-02	0.	0.	0.	0.

QDT	QD(1)	QD(2)	QD(3)	QD(4)	QD(5)	QD(6)	QD(7)
7.01730E-03	2.66657E-04	1.49468E-03	1.31925E-03	2.85604E-03	8.98214E-04	1.82450E-04	

ZI	QFI	QSI	QG	QS	HQ	RHQ	RZ
1.00000E 01	3.92905E-07	0.	1.00000E-01	2.76000E-14	1.03789E 03	0.	0.

J	TIME	QR	QF	PIN	R	RR	RRC	RMS	RTS	TFA
47760	1.1576E 03	1.000E 00	9.000E-01	0.	3.911E-10	2.76E-02	0.	0.	0.	0.
47761	1.1676E 03	1.000E 00	9.000E-01	0.	3.259E-10	2.76E-02	0.	0.	0.	0.

QDT	QD(1)	QD(2)	QD(3)	QD(4)	QD(5)	QD(6)	QD(7)
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1.00000E 01 3.92905E-07 0. 1.00000E-01 2.76000E-14 8.77892E 02 0. 0.

J	TIME	QR	QF	PIN	R	RR	RRC	RMS	RTS	TFA
47744	9.9758E 02	1.000E 00	9.000E-01	0.	1.955E-09	2.76E-02	0.	0.	0.	0.
47745	1.0076E 03	1.000E 00	9.000E-01	0.	1.695E-09	2.76E-02	0.	0.	0.	0.

QDT	QD(1)	QD(2)	QD(3)	QD(4)	QD(5)	QD(6)	QD(7)
7.01730E-03	2.66656E-04	1.49468E-03	1.31925E-03	2.85604E-03	8.98214E-04	1.82450E-04	

ZI	QFI	QSI	QG	QS	HQ	RHQ	RZ
1.00000E 01	3.92905E-07	0.	1.00000E-01	2.76000E-14	8.97892E 02	0.	0.

J	TIME	QR	QF	PIN	R	RR	RRC	RMS	RTS	TFA
47746	1.0176E 03	1.000E 00	9.000E-01	0.	1.499E-09	2.76E-02	0.	0.	0.	0.
47747	1.0276E 03	1.000E 00	9.000E-01	0.	1.369E-09	2.76E-02	0.	0.	0.	0.

QDT	QD(1)	QD(2)	QD(3)	QD(4)	QD(5)	QD(6)	QD(7)
7.01730E-03	2.66656E-04	1.49468E-03	1.31925E-03	2.85604E-03	8.98214E-04	1.82450E-04	

ZI	QFI	QSI	QG	QS	HQ	RHQ	RZ
1.00000E 01	3.92905E-07	0.	1.00000E-01	2.76000E-14	9.17892E 02	0.	0.

J	TIME	QR	QF	PIN	R	RR	RRC	RMS	RTS	TFA
47748	1.0376E 03	1.000E 00	9.000E-01	0.	1.238E-09	2.76E-02	0.	0.	0.	0.
47749	1.0476E 03	1.000E 00	9.000E-01	0.	1.108E-09	2.76E-02	0.	0.	0.	0.

QDT	QD(1)	QD(2)	QD(3)	QD(4)	QD(5)	QD(6)	QD(7)
7.01730E-03	2.66657E-04	1.49468E-03	1.31925E-03	2.85604E-03	8.98214E-04	1.82450E-04	

ZI	QFI	QSI	QG	QS	HQ	RHQ	RZ
1.00000E 01	3.92905E-07	0.	1.00000E-01	2.76000E-14	9.37892E 02	0.	0.

J	TIME	QR	QF	PIN	R	RR	RRC	RMS	RTS	TFA
47750	1.0576E 03	1.000E 00	9.000E-01	0.	9.777E-10	2.76E-02	0.	0.	0.	0.
47751	1.0676E 03	1.000E 00	9.000E-01	0.	8.474E-10	2.76E-02	0.	0.	0.	0.

QDT	QD(1)	QD(2)	QD(3)	QD(4)	QD(5)	QD(6)	QD(7)
7.01730E-03	2.66657E-04	1.49468E-03	1.31925E-03	2.85604E-03	8.98214E-04	1.82450E-04	

ZI	QFI	QSI	QG	QS	HQ	RHQ	RZ
1.00000E 01	3.92905E-07	0.	1.00000E-01	2.76000E-14	9.57892E 02	0.	0.

J	TIME	QR	QF	PIN	R	RR	RRC	RMS	RTS	TFA
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1.00000E 01 3.92905E-07 0. 1.00000E-01 2.76000E-14 1.13789E 03 0. 0.

J	TIME	QR	QF	PIN	R	RR	RRC	RMS	RTS	TFA
47770	1.2576E 03	1.000E 00	9.000E-01	0.	2.607E-10	2.76E-02	0.	0.	0.	0.
47771	1.2676E 03	1.000E 00	9.000E-01	0.	1.955E-10	2.76E-02	0.	0.	0.	0.

QDT	QD(1)	QD(2)	QD(3)	QD(4)	QD(5)	QD(6)	QD(7)
7.01730E-03	2.66657E-04	1.49468E-03	1.31925E-03	2.85604E-03	8.98214E-04	1.82450E-04	

ZI	QFI	QSI	QG	QS	HQ	RHQ	RZ
1.00000E 01	3.92905E-07	0.	1.00000E-01	2.76000E-14	1.15789E 03	0.	0.

J	TIME	QR	QF	PIN	R	RR	RRC	RMS	RTS	TFA
47772	1.2776E 03	1.000E 00	9.000E-01	0.	1.955E-10	2.76E-02	0.	0.	0.	0.
47773	1.2876E 03	1.000E 00	9.000E-01	0.	1.955E-10	2.76E-02	0.	0.	0.	0.

QDT	QD(1)	QD(2)	QD(3)	QD(4)	QD(5)	QD(6)	QD(7)
7.01730E-03	2.66657E-04	1.49468E-03	1.31925E-03	2.85604E-03	8.98214E-04	1.82450E-04	

ZI	QFI	QSI	QG	QS	HQ	RHQ	RZ
1.00000E 01	3.92905E-07	0.	1.00000E-01	2.76000E-14	1.17789E 03	0.	0.

J	TIME	QR	QF	PIN	R	RR	RRC	RMS	RTS	TFA
47774	1.2976E 03	1.000E 00	9.000E-01	0.	1.955E-10	2.76E-02	0.	0.	0.	0.
47775	1.3076E 03	1.000E 00	9.000E-01	0.	1.955E-10	2.76E-02	0.	0.	0.	0.

QDT	QD(1)	QD(2)	QD(3)	QD(4)	QD(5)	QD(6)	QD(7)
7.01730E-03	2.66657E-04	1.49468E-03	1.31925E-03	2.85604E-03	8.98214E-04	1.82450E-04	

ZI	QFI	QSI	QG	QS	HQ	RHQ	RZ
1.00000E 01	3.92905E-07	0.	1.00000E-01	2.76000E-14	1.19789E 03	0.	0.

J	TIME	QR	QF	PIN	R	RR	RRC	RMS	RTS	TFA
47776	1.3176E 03	1.000E 00	9.000E-01	0.	1.303E-10	2.76E-02	0.	0.	0.	0.
47777	1.3276E 03	1.000E 00	9.000E-01	0.	1.955E-10	2.76E-02	0.	0.	0.	0.

QDT	QD(1)	QD(2)	QD(3)	QD(4)	QD(5)	QD(6)	QD(7)
7.01730E-03	2.66657E-04	1.49468E-03	1.31925E-03	2.85604E-03	8.98214E-04	1.82450E-04	

ZI	QFI	QSI	QG	QS	HQ	RHQ	RZ
1.00000E 01	3.92905E-07	0.	1.00000E-01	2.76000E-14	1.21789E 03	0.	0.

J	TIME	QR	QF	PIN	R	RR	RRC	RMS	RTS	TFA
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7.01730E-03 2.66657E-04 1.49468E-03 1.31925E-03 2.85604E-03 8.98214E-04 1.82450E-04

ZI CFI QSI QG QS HQ RHQ RZ
1.00000E 01 3.92905E-07 0. 1.00000E-01 2.76000E-14 1.05789E 03 0. 0.

J	TIME	QR	QF	PIN	R	RR	RRC	RMS	RTS	TFA
47762	1.1776E 03	1.000E 00	9.000E-01	0.	3.259E-10	2.76E-02	0.	0.	0.	0.
47763	1.1876E 03	1.000E 00	9.000E-01	0.	2.607E-10	2.76E-02	0.	0.	0.	0.

QDT QD(1) QD(2) QD(3) QD(4) QD(5) QD(6) QD(7)
7.01730E-03 2.66657E-04 1.49468E-03 1.31925E-03 2.85604E-03 8.98214E-04 1.82450E-04

ZI QFI QSI QG QS HQ RHQ RZ
1.00000E 01 3.92905E-07 0. 1.00000E-01 2.76000E-14 1.07789E 03 0. 0.

J	TIME	QR	QF	PIN	R	RR	RRC	RMS	RTS	TFA
47764	1.1976E 03	1.000E 00	9.000E-01	0.	3.259E-10	2.76E-02	0.	0.	0.	0.
47765	1.2076E 03	1.000E 00	9.000E-01	0.	2.607E-10	2.76E-02	0.	0.	0.	0.

QDT QD(1) QD(2) QD(3) QD(4) QD(5) QD(6) QD(7)
7.01730E-03 2.66657E-04 1.49468E-03 1.31925E-03 2.85604E-03 8.98214E-04 1.82450E-04

ZI QFI QSI QG QS HQ RHQ RZ
1.00000E 01 3.92905E-07 0. 1.00000E-01 2.76000E-14 1.09789E 03 0. 0.

J	TIME	QR	QF	PIN	R	RR	RRC	RMS	RTS	TFA
47766	1.2176E 03	1.000E 00	9.000E-01	0.	2.607E-10	2.76E-02	0.	0.	0.	0.
47767	1.2276E 03	1.000E 00	9.000E-01	0.	1.955E-10	2.76E-02	0.	0.	0.	0.

QDT QD(1) QD(2) QD(3) QD(4) QD(5) QD(6) QD(7)
7.01730E-03 2.66657E-04 1.49468E-03 1.31925E-03 2.85604E-03 8.98214E-04 1.82450E-04

ZI QFI QSI QG QS HQ RHQ RZ
1.00000E 01 3.92905E-07 0. 1.00000E-01 2.76000E-14 1.11789E 03 0. 0.

J	TIME	QR	QF	PIN	R	RR	RRC	RMS	RTS	TFA
47768	1.2376E 03	1.000E 00	9.000E-01	0.	2.607E-10	2.76E-02	0.	0.	0.	0.
47769	1.2476E 03	1.000E 00	9.000E-01	0.	1.955E-10	2.76E-02	0.	0.	0.	0.

QDT QD(1) QD(2) QD(3) QD(4) QD(5) QD(6) QD(7)
7.01730E-03 2.66657E-04 1.49468E-03 1.31925E-03 2.85604E-03 8.98214E-04 1.82450E-04

ZI QFI QSI QG QS HQ RHQ RZ

COMPLETION OF PROGRAMMED POWER. CONTINUE WITH REACTOR KINETICS. IK=1

IR	RO(IR)	RI(IR)	R2(IR)	ZR(IR)
2	2.1329204E-02	-5.9999999E-02	0.	1.3375811E 03
3	7.5999999E-03	-2.0000000E-02	0.	1.3878099E 03
4	-3.2400000E-02	0.	0.	1.3898099E 03

J	TIME	QR	QF	PIN	R	RR	RRC	RMS	RTS	TFA
47784	1.3876E 03	8.395E-02	7.395E-02	-4.341E 00	-9.270E-03	1.93E-02	0.	0.	0.	0.

QDT	QD(1)	QD(2)	QD(3)	QD(4)	QD(5)	QD(6)	QD(7)
1.25897E-03	1.79153E-04	5.48048E-04	1.33549E-04	2.89049E-04	9.07836E-05	1.83846E-05	

ZI	QFI	QSI	QG	QS	HQ	RHQ	RZ
5.00000E-02	-1.60498E-02	0.	10.00000E-03	2.76000E-14	1.24820E 03	0.	0.

CHANGE FROM Z2 TO Z1 TO PREVENT EXCESSIVE POWER INCREMENT

J	Z	ZI	A
47785	1.387632E 03	10.000000E-04	4.166667E 01

REDUCE Z1 TO MEET NUMERICAL STABILITY REQUIREMENTS

J	Z	ZI	A
47903	1.387749E 03	4.295779E-04	2.081575E 01

REDUCE Z1 TO MEET NUMERICAL STABILITY REQUIREMENTS

J	Z	ZI	A
50135	1.388838E 03	2.497407E-04	1.040586E 01

CHANGE FROM Z1 TO Z2

J	Z	ZI	A
54120	1.389861E 03	5.000000E-02	2.083333E 03

J	TIME	QR	QF	PIN	R	RR	RRC	RMS	RTS	TFA
54173	1.3925E 03	2.192E-02	1.192E-02	-5.442E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
54272	1.3975E 03	1.959E-02	9.588E-03	-3.689E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
54371	1.4024E 03	1.814E-02	8.137E-03	-3.052E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
54470	1.4074E 03	1.705E-02	7.051E-03	-2.775E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
54569	1.4123E 03	1.617E-02	6.172E-03	-2.623E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.

QDT	QD(1)	QD(2)	QD(3)	QD(4)	QD(5)	QD(6)	QD(7)
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47778	1.3376E 03	1.000E 00	9.000E-01	0.	1.303E-10	2.76E-02	0.	0.	0.	0.
47779	1.3476E 03	8.200E-01	7.380E-01	-4.878E-02	-1.018E-03	2.66E-02	0.	0.	0.	0.

QDT	QD(1)	QD(2)	QD(3)	QD(4)	QD(5)	QD(6)	QD(7)
6.49857E-03	2.63609E-04	1.45204E-03	1.20052E-03	2.59900E-03	8.17375E-04	1.66029E-04	

ZI	QFI	QSI	QG	QS	HQ	RHQ	RZ
1.00000E 01	3.92905E-07	0.	8.20000E-02	2.76000E-14	1.23699E 03	0.	0.

J	TIME	QR	QF	PIN	R	RR	RRC	RMS	RTS	TFA
47780	1.3576E 03	4.600E-01	4.140E-01	-8.696E-02	-4.082E-03	2.35E-02	0.	0.	0.	0.
47781	1.3676E 03	1.000E-01	9.000E-02	0.	-2.240E-02	5.20E-03	0.	0.	0.	0.

QDT	QD(1)	QD(2)	QD(3)	QD(4)	QD(5)	QD(6)	QD(7)
2.70178E-03	2.28300E-04	1.01215E-03	3.66796E-04	7.94075E-04	2.49734E-04	5.07272E-05	

ZI	CFI	QSI	QG	QS	HQ	RHQ	RZ
1.00000E 01	3.92905E-07	0.	10.00000E-03	2.76000E-14	1.24619E 03	0.	0.

J	TIME	QR	QF	PIN	R	RR	RRC	RMS	RTS	TFA
47782	1.3776E 03	1.000E-01	9.000E-02	0.	-8.003E-03	1.96E-02	0.	0.	0.	0.
47783	1.3876E 03	1.000E-01	9.000E-02	0.	-6.271E-03	2.13E-02	0.	0.	0.	0.

QDT	QD(1)	QD(2)	QD(3)	QD(4)	QD(5)	QD(6)	QD(7)
1.26170E-03	1.79482E-04	5.49394E-04	1.33740E-04	2.89533E-04	9.10569E-05	1.84959E-05	

ZI	CFI	QSI	QG	QS	HQ	RHQ	RZ
1.00000E 01	3.92905E-07	0.	10.00000E-03	2.76000E-14	1.24819E 03	0.	0.

J	TIME	QR	QF	PIN	R	RR	RRC	RMS	RTS	TFA
56153	1.4915E 03	1.112E-02	1.122E-03	-1.818E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
56252	1.4964E 03	1.103E-02	1.027E-03	-1.784E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
56351	1.5014E 03	1.094E-02	9.406E-04	-1.751E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
56450	1.5063E 03	1.086E-02	8.632E-04	-1.719E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
56549	1.5113E 03	1.079E-02	7.934E-04	-1.689E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.

QDT	QD(1)	QD(2)	QD(3)	QD(4)	QD(5)	QD(6)	QD(7)
5.34419E-05	3.59103E-05	1.28318E-05	1.29018E-06	2.50434E-06	7.53447E-07	1.51857E-07	

ZI	QFI	QSI	QG	QS	HQ	RHQ	RZ
5.00000E-02	-6.70159E-07	0.	10.00000E-03	2.76000E-14	1.24988E 03	0.	0.

J	TIME	QR	QF	PIN	R	RR	RRC	RMS	RTS	TFA
56648	1.5162E 03	1.073E-02	7.303E-04	-1.661E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
56747	1.5212E 03	1.067E-02	6.732E-04	-1.633E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
56846	1.5261E 03	1.062E-02	6.213E-04	-1.608E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
56945	1.5311E 03	1.057E-02	5.742E-04	-1.583E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
57044	1.5360E 03	1.053E-02	5.312E-04	-1.560E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.

QDT	QD(1)	QD(2)	QD(3)	QD(4)	QD(5)	QD(6)	QD(7)
3.57874E-05	2.62704E-05	6.39115E-06	8.51143E-07	1.66911E-06	5.03974E-07	1.01637E-07	

ZI	QFI	QSI	QG	QS	HQ	RHQ	RZ
5.00000E-02	-4.14406E-07	0.	10.00000E-03	2.76000E-14	1.25014E 03	0.	0.

J	TIME	QR	QF	PIN	R	RR	RRC	RMS	RTS	TFA
57143	1.5410E 03	1.049E-02	4.920E-04	-1.539E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
57242	1.5459E 03	1.046E-02	4.562E-04	-1.518E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
57341	1.5509E 03	1.042E-02	4.234E-04	-1.499E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
57440	1.5558E 03	1.039E-02	3.933E-04	-1.482E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
57539	1.5608E 03	1.037E-02	3.656E-04	-1.465E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.

QDT	QD(1)	QD(2)	QD(3)	QD(4)	QD(5)	QD(6)	QD(7)
2.46381E-05	1.92158E-05	3.28135E-06	5.79422E-07	1.14494E-06	3.46630E-07	6.99364E-08	

ZI	QFI	QSI	QG	QS	HQ	RHQ	RZ
5.00000E-02	-2.67845E-07	0.	10.00000E-03	2.76000E-14	1.25039E 03	0.	0.

J	TIME	QR	QF	PIN	R	RR	RRC	RMS	RTS	TFA
57638	1.5657E 03	1.034E-02	3.402E-04	-1.450E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
57737	1.5707E 03	1.032E-02	3.167E-04	-1.435E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
57836	1.5756E 03	1.030E-02	2.951E-04	-1.422E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.

4.15551E-04 1.24919E-04 2.45517E-04 1.77179E-05 2.03126E-05 5.90102E-06 1.18410E-06

ZI QFI CSI QG QS HQ RHQ RZ
5.00000E-02 -8.09427E-06 0. 10.00000E-03 2.76000E-14 1.24866E 03 0. 0.

J	TIME	QR	QF	PIN	R	RR	RRC	RMS	RTS	TFA
54668	1.4173E 03	1.544E-02	5.435E-03	-2.521E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
54767	1.4222E 03	1.481E-02	4.808E-03	-2.442E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
54866	1.4272E 03	1.427E-02	4.268E-03	-2.378E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
54965	1.4321E 03	1.380E-02	3.800E-03	-2.321E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
55064	1.4370E 03	1.339E-02	3.392E-03	-2.270E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.

QDT QD(1) QD(2) QD(3) QD(4) QD(5) QD(6) QD(7)
2.28385E-04 9.15580E-05 1.15731E-04 6.28435E-06 1.09271E-05 3.23449E-06 6.50146E-07

ZI QFI QSI QG QS HQ RHQ RZ
5.00000E-02 -3.84974E-06 0. 10.00000E-03 2.76000E-14 1.24902E 03 0. 0.

J	TIME	QR	QF	PIN	R	RR	RRC	RMS	RTS	TFA
55163	1.4420E 03	1.304E-02	3.035E-03	-2.222E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
55262	1.4469E 03	1.272E-02	2.722E-03	-2.177E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
55361	1.4519E 03	1.245E-02	2.447E-03	-2.133E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
55460	1.4568E 03	1.220E-02	2.204E-03	-2.090E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
55559	1.4618E 03	1.199E-02	1.990E-03	-2.048E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.

QDT QD(1) QD(2) QD(3) QD(4) QD(5) QD(6) QD(7)
1.34002E-04 6.70503E-05 5.49244E-05 3.39171E-06 6.36027E-06 1.89461E-06 3.81220E-07

ZI QFI QSI QG QS HQ RHQ RZ
5.00000E-02 -2.03765E-06 0. 10.00000E-03 2.76000E-14 1.24933E 03 0. 0.

J	TIME	QR	QF	PIN	R	RR	RRC	RMS	RTS	TFA
55658	1.4667E 03	1.180E-02	1.800E-03	-2.007E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
55757	1.4717E 03	1.163E-02	1.632E-03	-1.967E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
55856	1.4766E 03	1.148E-02	1.482E-03	-1.928E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
55955	1.4816E 03	1.135E-02	1.348E-03	-1.890E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
56054	1.4865E 03	1.123E-02	1.229E-03	-1.854E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.

QDT QD(1) QD(2) QD(3) QD(4) QD(5) QD(6) QD(7)
8.27609E-05 4.90773E-05 2.63419E-05 2.03676E-06 3.90119E-06 1.16836E-06 2.35302E-07

ZI QFI QSI QG QS HQ RHQ RZ
5.00000E-02 -1.13894E-06 0. 10.00000E-03 2.76000E-14 1.24961E 03 0. 0.

6.40373E-06 5.49749E-06 3.55753E-07 1.47430E-07 2.95168E-07 8.97655E-08 1.81248E-08

ZI QFI QSI QG QS HQ RHQ RZ
5.00000E-02 -6.12786E-08 0. 10.00000E-03 2.76000E-14 1.25139E 03 0. 0.

J	TIME	QR	QF	PIN	R	RR	RRC	RMS	RTS	TFA
59618	1.6647E 03	1.009E-02	8.687E-05	-1.303E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
59717	1.6696E 03	1.008E-02	8.333E-05	-1.300E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
59816	1.6746E 03	1.008E-02	7.814E-05	-1.298E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
59915	1.6795E 03	1.007E-02	7.328E-05	-1.296E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
60014	1.6845E 03	1.007E-02	6.873E-05	-1.294E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.

QDT QD(1) QD(2) QD(3) QD(4) QD(5) QD(6) QD(7)
4.64889E-06 4.02034E-06 2.29655E-07 1.06748E-07 2.13925E-07 6.50789E-08 1.31409E-08

ZI QFI QSI QG QS HQ RHQ RZ
5.00000E-02 -4.44838E-08 0. 10.00000E-03 2.76000E-14 1.25164E 03 0. 0.

J	TIME	QR	QF	PIN	R	RR	RRC	RMS	RTS	TFA
60113	1.6894E 03	1.006E-02	6.447E-05	-1.293E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
60212	1.6944E 03	1.006E-02	6.047E-05	-1.292E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
60311	1.6993E 03	1.006E-02	5.673E-05	-1.290E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
60410	1.7043E 03	1.005E-02	5.322E-05	-1.289E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
60509	1.7092E 03	1.005E-02	4.993E-05	-1.289E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.

QDT QD(1) QD(2) QD(3) QD(4) QD(5) QD(6) QD(7)
3.38345E-06 2.94007E-06 1.53672E-07 7.74967E-08 1.55391E-07 4.72803E-08 9.54723E-09

ZI QFI QSI QG QS HQ RHQ RZ
5.00000E-02 -3.21736E-08 0. 10.00000E-03 2.76000E-14 1.25188E 03 0. 0.

J	TIME	QR	QF	PIN	R	RR	RRC	RMS	RTS	TFA
60608	1.7142E 03	1.005E-02	4.685E-05	-1.288E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
60707	1.7191E 03	1.004E-02	4.396E-05	-1.287E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
60806	1.7241E 03	1.004E-02	4.125E-05	-1.287E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
60905	1.7290E 03	1.004E-02	3.870E-05	-1.287E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
61004	1.7340E 03	1.004E-02	3.631E-05	-1.287E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.

QDT QD(1) QD(2) QD(3) QD(4) QD(5) QD(6) QD(7)
2.46636E-06 2.15004E-06 1.05658E-07 5.63383E-08 1.12994E-07 3.43827E-08 6.94291E-09

ZI QFI QSI QG QS HQ RHQ RZ
5.00000E-02 -2.33621E-08 0. 10.00000E-03 2.76000E-14 1.25212E 03 0. 0.

57935	1.5806E 03	1.028E-02	2.752E-04	-1.410E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
58034	1.5855E 03	1.026E-02	2.567E-04	-1.399E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.

QDT	QL(1)	QD(2)	QD(3)	QD(4)	QD(5)	QD(6)	QD(7)
1.73040E-05	1.40544E-05	1.75169E-06	4.03645E-07	8.01933E-07	2.43240E-07	4.90917E-08	

ZI	QFI	QSI	QG	QS	HQ	RHQ	RZ
5.00000E-02	-1.79493E-07	0.	10.00000E-03	2.76000E-14	1.25064E 03	0.	0.

J	TIME	QR	QF	PIN	R	RR	RRC	RMS	RTS	TFA
58133	1.5905E 03	1.024E-02	2.396E-04	-1.388E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
58232	1.5954E 03	1.022E-02	2.237E-04	-1.378E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
58331	1.6004E 03	1.021E-02	2.090E-04	-1.369E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
58430	1.6053E 03	1.020E-02	1.954E-04	-1.361E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
58529	1.6103E 03	1.018E-02	1.827E-04	-1.354E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.

QDT	QD(1)	QD(2)	QD(3)	QD(4)	QD(5)	QD(6)	QD(7)
1.23219E-05	1.02788E-05	9.79457E-07	2.85769E-07	5.69845E-07	1.73063E-07	3.49357E-08	

ZI	QFI	QSI	QG	QS	HQ	RHQ	RZ
5.00000E-02	-1.23640E-07	0.	10.00000E-03	2.76000E-14	1.25089E 03	0.	0.

J	TIME	QR	QF	PIN	R	RR	RRC	RMS	RTS	TFA
58628	1.6152E 03	1.017E-02	1.709E-04	-1.347E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
58727	1.6202E 03	1.016E-02	1.599E-04	-1.340E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
58826	1.6251E 03	1.015E-02	1.497E-04	-1.334E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
58925	1.6301E 03	1.014E-02	1.401E-04	-1.329E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
59024	1.6350E 03	1.013E-02	1.312E-04	-1.324E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.

QDT	QD(1)	QD(2)	QD(3)	QD(4)	QD(5)	QD(6)	QD(7)
8.85587E-06	7.51724E-06	5.75892E-07	2.04530E-07	4.08846E-07	1.24271E-07	2.50897E-08	

ZI	QFI	QSI	QG	QS	HQ	RHQ	RZ
5.00000E-02	-8.68713E-08	0.	10.00000E-03	2.76000E-14	1.25114E 03	0.	0.

J	TIME	QR	QF	PIN	R	RR	RRC	RMS	RTS	TFA
59123	1.6399E 03	1.012E-02	1.229E-04	-1.320E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
59222	1.6449E 03	1.012E-02	1.151E-04	-1.316E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
59321	1.6498E 03	1.011E-02	1.079E-04	-1.312E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
59420	1.6548E 03	1.010E-02	1.011E-04	-1.309E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
59519	1.6597E 03	1.009E-02	9.479E-05	-1.306E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.

QDT	QD(1)	QD(2)	QD(3)	QD(4)	QD(5)	QD(6)	QD(7)
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62885	1.8280E 03	1.001E-02	1.076E-05	-1.308E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
62984	1.8330E 03	1.001E-02	1.009E-05	-1.311E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.

QDT	QD(1)	QD(2)	QD(3)	QD(4)	QD(5)	QD(6)	QD(7)
7.00486E-07	6.14850E-07	2.70720E-03	1.56769E-08	3.14073E-08	9.55124E-09	1.92847E-09	

ZI	QFI	QSI	QG	QS	HQ	RHQ	RZ
5.00000E-02	-6.61206E-09	0.	10.00000E-03	2.76000E-14	1.25309E 03	0.	0.

J	TIME	QR	QF	PIN	R	RR	RRC	RMS	RTS	TFA
63083	1.8379E 03	1.001E-02	9.452E-06	-1.314E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
63182	1.8429E 03	1.001E-02	8.856E-06	-1.317E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
63281	1.8478E 03	1.001E-02	8.296E-06	-1.320E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
63380	1.8527E 03	1.001E-02	7.771E-06	-1.324E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
63479	1.8577E 03	1.001E-02	7.277E-06	-1.328E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.

QDT	QD(1)	QD(2)	QD(3)	QD(4)	QD(5)	QD(6)	QD(7)
5.11399E-07	4.49609E-07	1.95046E-08	1.13278E-08	2.26740E-08	6.89252E-09	1.39155E-09	

ZI	QFI	QSI	QG	QS	HQ	RHQ	RZ
5.00000E-02	-4.83173E-09	0.	10.00000E-03	2.76000E-14	1.25333E 03	0.	0.

J	TIME	QR	QF	PIN	R	RR	RRC	RMS	RTS	TFA
63578	1.8626E 03	1.001E-02	6.814E-06	-1.332E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
63677	1.8676E 03	1.001E-02	6.379E-06	-1.336E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
63776	1.8725E 03	1.001E-02	5.970E-06	-1.341E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
63875	1.8775E 03	1.001E-02	5.586E-06	-1.346E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
63974	1.8824E 03	1.001E-02	5.225E-06	-1.352E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.

QDT	QD(1)	QD(2)	QD(3)	QD(4)	QD(5)	QD(6)	QD(7)
3.73206E-07	3.28769E-07	1.40472E-08	8.14974E-09	1.62916E-08	4.94942E-09	9.99142E-10	

ZI	QFI	QSI	QG	QS	HQ	RHQ	RZ
5.00000E-02	-3.53173E-09	0.	10.00000E-03	2.76000E-14	1.25357E 03	0.	0.

J	TIME	QR	QF	PIN	R	RR	RRC	RMS	RTS	TFA
64073	1.8874E 03	1.000E-02	4.886E-06	-1.358E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
64172	1.8923E 03	1.000E-02	4.568E-06	-1.364E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
64271	1.8973E 03	1.000E-02	4.269E-06	-1.371E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
64370	1.9022E 03	1.000E-02	3.988E-06	-1.378E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
64469	1.9072E 03	1.000E-02	3.725E-06	-1.386E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.

QDT	QD(1)	QD(2)	QD(3)	QD(4)	QD(5)	QD(6)	QD(7)
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J	TIME	QR	QF	PIN	R	RR	RRC	RMS	RTS	TFA
61103	1.7389E 03	1.003E-02	3.407E-05	-1.287E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
61202	1.7439E 03	1.003E-02	3.197E-05	-1.287E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
61301	1.7488E 03	1.003E-02	3.000E-05	-1.287E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
61400	1.7538E 03	1.003E-02	2.815E-05	-1.287E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
61499	1.7587E 03	1.003E-02	2.641E-05	-1.288E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.

QDT	QD(1)	QD(2)	QD(3)	QD(4)	QD(5)	QD(6)	QD(7)
1.79956E-06	1.57230E-06	7.40601E-08	4.09735E-08	8.21803E-08	2.50059E-08	5.04942E-09	

ZI	CFI	QSI	QG	QS	HQ	RHQ	RZ
5.00000E-02	-1.70072E-08	0.	10.00000E-03	2.76000E-14	1.25236E 03	0.	0.

J	TIME	QR	QF	PIN	R	RR	RRC	RMS	RTS	TFA
61598	1.7637E 03	1.002E-02	2.478E-05	-1.289E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
61697	1.7686E 03	1.002E-02	2.325E-05	-1.289E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
61796	1.7736E 03	1.002E-02	2.181E-05	-1.290E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
61895	1.7785E 03	1.002E-02	2.046E-05	-1.291E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
61994	1.7835E 03	1.002E-02	1.919E-05	-1.292E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.

QDT	QD(1)	QD(2)	QD(3)	QD(4)	QD(5)	QD(6)	QD(7)
1.31374E-06	1.14979E-06	5.25874E-08	2.97876E-08	5.97347E-08	1.81743E-08	3.66986E-09	

ZI	CFI	QSI	QG	QS	HQ	RHQ	RZ
5.00000E-02	-1.24013E-08	0.	10.00000E-03	2.76000E-14	1.25261E 03	0.	0.

J	TIME	QR	QF	PIN	R	RR	RRC	RMS	RTS	TFA
62093	1.7884E 03	1.002E-02	1.800E-05	-1.293E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
62192	1.7934E 03	1.002E-02	1.689E-05	-1.295E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
62291	1.7983E 03	1.002E-02	1.584E-05	-1.296E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
62390	1.8033E 03	1.001E-02	1.485E-05	-1.298E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
62489	1.8082E 03	1.001E-02	1.393E-05	-1.300E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.

QDT	QD(1)	QD(2)	QD(3)	QD(4)	QD(5)	QD(6)	QD(7)
9.59297E-07	8.40806E-07	3.76453E-08	2.16309E-08	4.33616E-08	1.31904E-08	2.66339E-09	

ZI	CFI	QSI	QG	QS	HQ	RHQ	RZ
5.00000E-02	-9.05225E-09	0.	10.00000E-03	2.76000E-14	1.25285E 03	0.	0.

J	TIME	QR	QF	PIN	R	RR	RRC	RMS	RTS	TFA
62588	1.8132E 03	1.001E-02	1.306E-05	-1.302E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
62687	1.8181E 03	1.001E-02	1.225E-05	-1.304E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
62786	1.8231E 03	1.001E-02	1.148E-05	-1.306E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.

J	TIME	QR	QF	PIN	R	RR	RRC	RMS	RTS	TFA
66053	1.9864E 03	1.000E-02	1.142E-06	-1.660E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
66152	1.9913E 03	1.000E-02	1.051E-06	-1.694E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
66251	1.9963E 03	1.000E-02	9.658E-07	-1.732E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
66350	2.0012E 03	1.000E-02	8.855E-07	-1.775E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
66449	2.0062E 03	1.000E-02	8.101E-07	-1.822E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.

QDT	QD(1)	QD(2)	QD(3)	QD(4)	QD(5)	QD(6)	QD(7)
7.59628E-08	6.86834E-08	2.47541E-09	1.31486E-09	2.56409E-09	7.69986E-10	1.55106E-10	

ZI	QFI	QSI	QG	QS	HQ	RHQ	RZ
5.00000E-02	-7.38107E-10	0.	10.00000E-03	2.76000E-14	1.25478E 03	0.	0.

J	TIME	QR	QF	PIN	R	RR	RRC	RMS	RTS	TFA
66548	2.0111E 03	1.000E-02	7.393E-07	-1.876E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
66647	2.0161E 03	1.000E-02	6.728E-07	-1.936E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
66746	2.0210E 03	1.000E-02	6.103E-07	-2.005E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
66845	2.0260E 03	1.000E-02	5.516E-07	-2.083E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
66944	2.0309E 03	1.000E-02	4.965E-07	-2.174E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.

QDT	QD(1)	QD(2)	QD(3)	QD(4)	QD(5)	QD(6)	QD(7)
5.48473E-08	5.02010E-08	1.65983E-09	8.29363E-10	1.58895E-09	4.73091E-10	9.51478E-11	

ZI	QFI	QSI	QG	QS	HQ	RHQ	RZ
5.00000E-02	-5.39755E-10	0.	10.00000E-03	2.76000E-14	1.25502E 03	0.	0.

J	TIME	QR	QF	PIN	R	RR	RRC	RMS	RTS	TFA
67043	2.0359E 03	1.000E-02	4.447E-07	-2.280E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
67142	2.0408E 03	1.000E-02	3.961E-07	-2.405E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
67241	2.0458E 03	1.000E-02	3.504E-07	-2.553E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
67340	2.0507E 03	1.000E-02	3.075E-07	-2.733E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
67439	2.0556E 03	1.000E-02	2.672E-07	-2.955E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.

QDT	QD(1)	QD(2)	QD(3)	QD(4)	QD(5)	QD(6)	QD(7)
3.94061E-08	3.66849E-08	1.06377E-09	4.74334E-10	8.75848E-10	2.55980E-10	5.13020E-11	

ZI	QFI	QSI	QG	QS	HQ	RHQ	RZ
5.00000E-02	-3.94711E-10	0.	10.00000E-03	2.76000E-14	1.25527E 03	0.	0.

J	TIME	QR	QF	PIN	R	RR	RRC	RMS	RTS	TFA
67538	2.0606E 03	1.000E-02	2.293E-07	-3.234E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
67637	2.0655E 03	1.000E-02	1.937E-07	-3.595E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
67736	2.0705E 03	1.000E-02	1.603E-07	-4.081E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.

2.72186E-07 2.40400E-07 1.00918E-08 5.92673E-09 1.16261E-08 3.52900E-09 7.12290E-10

ZI QFI QSI QG QS HQ RHQ RZ
5.00000E-02 -2.58194E-09 0. 10.00000E-03 2.76000E-14 1.25381E 03 0. 0.

J	TIME	QR	QF	PIN	R	RR	RRC	RMS	RTS	TFA
64568	1.9121E 03	1.000E-02	3.477E-06	-1.395E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
64667	1.9171E 03	1.000E-02	3.244E-06	-1.404E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
64766	1.9220E 03	1.000E-02	3.026E-06	-1.414E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
64865	1.9270E 03	1.000E-02	2.820E-06	-1.425E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
64964	1.9319E 03	1.000E-02	2.628E-06	-1.437E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.

QDT QD(1) QD(2) QD(3) QD(4) QD(5) QD(6) QD(7)
1.98329E-07 1.75776E-07 7.21592E-09 4.12844E-09 8.21521E-09 2.49052E-09 5.02569E-10

ZI QFI QSI QG QS HQ RHQ RZ
5.00000E-02 -1.88779E-09 0. 10.00000E-03 2.76000E-14 1.25406E 03 0. 0.

J	TIME	QR	QF	PIN	R	RR	RRC	RMS	RTS	TFA
65063	1.9369E 03	1.000E-02	2.446E-06	-1.450E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
65162	1.9418E 03	1.000E-02	2.276E-06	-1.463E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
65261	1.9468E 03	1.000E-02	2.117E-06	-1.478E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
65360	1.9517E 03	1.000E-02	1.966E-06	-1.495E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
65459	1.9567E 03	1.000E-02	1.825E-06	-1.512E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.

QDT QD(1) QD(2) QD(3) QD(4) QD(5) QD(6) QD(7)
1.44326E-07 1.28517E-07 5.12050E-09 2.88672E-09 5.72124E-09 1.73121E-09 3.49226E-10

ZI QFI QSI QG QS HQ RHQ RZ
5.00000E-02 -1.38036E-09 0. 10.00000E-03 2.76000E-14 1.25430E 03 0. 0.

J	TIME	QR	QF	PIN	R	RR	RRC	RMS	RTS	TFA
65558	1.9616E 03	1.000E-02	1.693E-06	-1.532E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
65657	1.9666E 03	1.000E-02	1.569E-06	-1.553E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
65756	1.9715E 03	1.000E-02	1.452E-06	-1.576E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
65855	1.9765E 03	1.000E-02	1.342E-06	-1.601E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
65954	1.9814E 03	1.000E-02	1.239E-06	-1.629E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.

QDT QD(1) QD(2) QD(3) QD(4) QD(5) QD(6) QD(7)
1.04838E-07 9.39570E-08 3.59172E-09 1.97878E-09 3.89761E-09 1.17599E-09 2.37099E-10

ZI QFI QSI QG QS HQ RHQ RZ
5.00000E-02 -1.00937E-09 0. 10.00000E-03 2.76000E-14 1.25454E 03 0. 0.

67835	2.0754E 03	1.000E-02	1.289E-07	-4.766E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
67934	2.0804E 03	1.000E-02	9.946E-08	-5.804E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.

QDT	QD(1)	QD(2)	QD(3)	QD(4)	QD(5)	QD(6)	QD(7)
2.81143E-08	2.68007E-08	6.28044E-10	2.14709E-10	3.54375E-10	9.72103E-11	1.92384E-11	

ZI	QFI	QSI	QG	QS	HQ	RHQ	RZ
5.00000E-02	-2.88646E-10	0.	10.00000E-03	2.76000E-14	1.25551E 03	0.	0.

J	TIME	GR	QF	PIN	R	RR	RRC	RMS	RTS	TFA
68033	2.0853E 03	1.000E-02	7.177E-08	-7.555E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
68132	2.0903E 03	1.000E-02	4.576E-08	-1.113E-01	-6.000E-02	-3.24E-02	0.	0.	0.	0.

CHANGE FROM Z2 TO Z1 TO PREVENT EXCESSIVE POWER INCREMENT

J	Z	ZI	A
68221	2.094689E 03	2.497407E-04	1.040586E 01

CHANGE FROM Z1 TO Z2

J	Z	ZI	A
68231	2.094741E 03	5.000000E-02	2.083333E 03

J	TIME	GR	QF	PIN	R	RR	RRC	RMS	RTS	TFA
68240	2.0952E 03	1.000E-02	3.454E-07	1.124E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
68339	2.1001E 03	1.000E-02	3.391E-07	-8.491E-03	-6.000E-02	-3.24E-02	0.	0.	0.	0.
68438	2.1051E 03	1.000E-02	3.228E-07	-1.093E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.

QDT	QD(1)	QD(2)	QD(3)	QD(4)	QD(5)	QD(6)	QD(7)
2.17300E-08	1.95959E-08	4.58564E-10	3.52522E-10	9.56209E-10	3.05120E-10	6.16762E-11	

ZI	QFI	QSI	QG	QS	HQ	RHQ	RZ
5.00000E-02	-1.76331E-10	0.	10.00000E-03	2.76000E-14	1.25575E 03	0.	0.

J	TIME	GR	QF	PIN	R	RR	RRC	RMS	RTS	TFA
68537	2.1100E 03	1.000E-02	3.051E-07	-1.171E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
68636	2.1150E 03	1.000E-02	2.876E-07	-1.203E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
68735	2.1199E 03	1.000E-02	2.709E-07	-1.219E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
68834	2.1249E 03	1.000E-02	2.550E-07	-1.229E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
68933	2.1298E 03	1.000E-02	2.399E-07	-1.235E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.

QDT	QD(1)	QD(2)	QD(3)	QD(4)	QD(5)	QD(6)	QD(7)
1.61516E-03	1.43299E-08	4.42342E-10	3.61344E-10	7.45043E-10	2.27057E-10	4.58609E-11	

72398	2.3030E 03	1.000E-02	2.719E-08	-1.263E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
QDT	QD(1)	QD(2)	QD(3)	QD(4)	QD(5)	QD(6)	QD(7)			
1.83003E-09	1.60275E-09	6.97275E-11	4.20813E-11	8.45323E-11	2.57379E-11	5.19783E-12				
ZI	QFI	QSI	QG	QS	HQ	RHQ	RZ			
5.00000E-02	-1.71750E-11	0.	10.00000E-03	2.76000E-14	1.25768E 03	0.	0.			
J	TIME	QR	QF	PIN	R	RR	RRC	RMS	RTS	TFA
72497	2.3080E 03	1.000E-02	2.554E-08	-1.263E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
72596	2.3129E 03	1.000E-02	2.399E-08	-1.264E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
72695	2.3179E 03	1.000E-02	2.254E-08	-1.264E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
72794	2.3228E 03	1.000E-02	2.117E-08	-1.264E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
72893	2.3278E 03	1.000E-02	1.989E-08	-1.264E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
QDT	QD(1)	QD(2)	QD(3)	QD(4)	QD(5)	QD(6)	QD(7)			
1.33857E-09	1.17208E-09	5.12320E-11	3.07841E-11	6.18373E-11	1.88278E-11	3.80230E-12				
ZI	QFI	QSI	QG	QS	HQ	RHQ	RZ			
5.00000E-02	-1.25660E-11	0.	10.00000E-03	2.76000E-14	1.25792E 03	0.	0.			
J	TIME	QR	QF	PIN	R	RR	RRC	RMS	RTS	TFA
72992	2.3327E 03	1.000E-02	1.868E-08	-1.264E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
73091	2.3377E 03	1.000E-02	1.755E-08	-1.264E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
73190	2.3426E 03	1.000E-02	1.649E-08	-1.264E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
73289	2.3476E 03	1.000E-02	1.549E-08	-1.264E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
73388	2.3525E 03	1.000E-02	1.455E-08	-1.264E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
QDT	QD(1)	QD(2)	QD(3)	QD(4)	QD(5)	QD(6)	QD(7)			
9.79022E-10	8.57136E-10	3.75795E-11	2.25187E-11	4.52337E-11	1.37724E-11	2.78136E-12				
ZI	QFI	QSI	QG	QS	HQ	RHQ	RZ			
5.00000E-02	-9.19219E-12	0.	10.00000E-03	2.76000E-14	1.25817E 03	0.	0.			
J	TIME	QR	QF	PIN	R	RR	RRC	RMS	RTS	TFA
73487	2.3575E 03	1.000E-02	1.367E-08	-1.264E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
73586	2.3624E 03	1.000E-02	1.284E-08	-1.264E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
73685	2.3674E 03	1.000E-02	1.206E-08	-1.264E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
73784	2.3723E 03	1.000E-02	1.133E-08	-1.264E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
73883	2.3773E 03	1.000E-02	1.064E-08	-1.264E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
QDT	QD(1)	QD(2)	QD(3)	QD(4)	QD(5)	QD(6)	QD(7)			
7.16025E-10	6.26818E-10	2.75364E-11	1.64723E-11	3.30885E-11	1.00745E-11	2.03457E-12				

70517	2.2090E 03	1.000E-02	8.906E-08	-1.259E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
70616	2.2140E 03	1.000E-02	8.368E-08	-1.260E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
70715	2.2189E 03	1.000E-02	7.862E-08	-1.260E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
70814	2.2239E 03	1.000E-02	7.387E-08	-1.260E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
70913	2.2288E 03	1.000E-02	6.940E-08	-1.261E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.

QDT	QD(1)	QD(2)	QD(3)	QD(4)	QD(5)	QD(6)	QD(7)
4.67201E-09	4.09822E-09	1.71695E-10	1.07381E-10	2.15753E-10	6.56961E-11	1.32676E-11	

ZI	QFI	QSI	QG	QS	HQ	RHQ	RZ
5.00000E-02	-4.37497E-11	0.	10.00000E-03	2.76000E-14	1.25696E 03	0.	0.

J	TIME	QR	QF	PIN	R	RR	RRC	RMS	RTS	TFA
71012	2.2338E 03	1.000E-02	6.520E-08	-1.261E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
71111	2.2387E 03	1.000E-02	6.125E-08	-1.261E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
71210	2.2437E 03	1.000E-02	5.755E-08	-1.262E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
71309	2.2486E 03	1.000E-02	5.406E-08	-1.262E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
71408	2.2536E 03	1.000E-02	5.079E-08	-1.262E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.

QDT	QD(1)	QD(2)	QD(3)	QD(4)	QD(5)	QD(6)	QD(7)
3.41922E-09	2.99699E-09	1.27919E-10	7.86023E-11	1.57913E-10	4.80821E-11	9.71033E-12	

ZI	QFI	QSI	QG	QS	HQ	RHQ	RZ
5.00000E-02	-3.20534E-11	0.	10.00000E-03	2.76000E-14	1.25720E 03	0.	0.

J	TIME	QR	QF	PIN	R	RR	RRC	RMS	RTS	TFA
71507	2.2585E 03	1.000E-02	4.772E-08	-1.262E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
71606	2.2634E 03	1.000E-02	4.483E-08	-1.263E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
71705	2.2684E 03	1.000E-02	4.211E-08	-1.263E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
71804	2.2733E 03	1.000E-02	3.956E-08	-1.263E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
71903	2.2783E 03	1.000E-02	3.716E-08	-1.263E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.

QDT	QD(1)	QD(2)	QD(3)	QD(4)	QD(5)	QD(6)	QD(7)
2.50167E-09	2.19167E-09	9.46461E-11	5.75181E-11	1.15546E-10	3.51814E-11	7.10496E-12	

ZI	QFI	QSI	QG	QS	HQ	RHQ	RZ
5.00000E-02	-2.34682E-11	0.	10.00000E-03	2.76000E-14	1.25744E 03	0.	0.

J	TIME	QR	QF	PIN	R	RR	RRC	RMS	RTS	TFA
72002	2.2832E 03	1.000E-02	3.491E-08	-1.263E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
72101	2.2882E 03	1.000E-02	3.280E-08	-1.263E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
72200	2.2931E 03	1.000E-02	3.081E-08	-1.263E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
72299	2.2981E 03	1.000E-02	2.894E-08	-1.263E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.

75467	2.4565E 03	1.000E-02	3.915E-09	-1.262E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
75566	2.4614E 03	1.000E-02	3.678E-09	-1.262E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
75665	2.4664E 03	1.000E-02	3.455E-09	-1.262E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
75764	2.4713E 03	1.000E-02	3.246E-09	-1.262E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
75863	2.4762E 03	1.000E-02	3.050E-09	-1.261E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.

QDT	QD(1)	QD(2)	QD(3)	QD(4)	QD(5)	QD(6)	QD(7)
2.04849E-10	1.79271E-10	7.90602E-12	4.71981E-12	9.48191E-12	2.88714E-12	5.83069E-13	

ZI	QFI	QSI	QG	QS	HQ	RHQ	RZ
5.00000E-02	-1.92346E-12	0.	10.00000E-03	2.76000E-14	1.25937E 03	0.	0.

J	TIME	QR	QF	PIN	R	RR	RRC	RMS	RTS	TFA
75962	2.4812E 03	1.000E-02	2.865E-09	-1.261E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
76061	2.4861E 03	1.000E-02	2.692E-09	-1.261E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
76160	2.4911E 03	1.000E-02	2.529E-09	-1.261E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
76259	2.4960E 03	1.000E-02	2.376E-09	-1.260E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
76358	2.5010E 03	1.000E-02	2.233E-09	-1.260E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.

QDT	QD(1)	QD(2)	QD(3)	QD(4)	QD(5)	QD(6)	QD(7)
1.49822E-10	1.31100E-10	5.78618E-12	3.45463E-12	6.94068E-12	2.11343E-12	4.26817E-13	

ZI	QFI	QSI	QG	QS	HQ	RHQ	RZ
5.00000E-02	-1.40664E-12	0.	10.00000E-03	2.76000E-14	1.25962E 03	0.	0.

J	TIME	QR	QF	PIN	R	RR	RRC	RMS	RTS	TFA
76457	2.5059E 03	1.000E-02	2.098E-09	-1.260E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
76556	2.5109E 03	1.000E-02	1.971E-09	-1.260E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
76655	2.5158E 03	1.000E-02	1.852E-09	-1.259E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
76754	2.5208E 03	1.000E-02	1.740E-09	-1.259E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
76853	2.5257E 03	1.000E-02	1.635E-09	-1.258E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.

QDT	QD(1)	QD(2)	QD(3)	QD(4)	QD(5)	QD(6)	QD(7)
1.09581E-10	9.58734E-11	4.23535E-12	2.52940E-12	5.08227E-12	1.54761E-12	3.12550E-13	

ZI	QFI	QSI	QG	QS	HQ	RHQ	RZ
5.00000E-02	-1.02868E-12	0.	10.00000E-03	2.76000E-14	1.25986E 03	0.	0.

J	TIME	QR	QF	PIN	R	RR	RRC	RMS	RTS	TFA
76952	2.5307E 03	1.000E-02	1.536E-09	-1.258E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
77051	2.5356E 03	1.000E-02	1.443E-09	-1.258E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
77150	2.5406E 03	1.000E-02	1.356E-09	-1.257E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
77249	2.5455E 03	1.000E-02	1.275E-09	-1.257E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.

77348 2.5505E 03 1.000E-02 1.198E-09 -1.256E-02 -6.000E-02 -3.24E-02 0. 0. 0. 0.

QDT	QD(1)	QD(2)	QD(3)	QD(4)	QD(5)	QD(6)	QD(7)
8.01519E-11	7.01122E-11	3.10096E-12	1.85277E-12	3.72321E-12	1.13383E-12	2.28986E-13	

ZI	QFI	QSI	QG	QS	HQ	RHQ	RZ
5.00000E-02	-7.52271E-13	0.	10.00000E-03	2.76000E-14	1.26010E 03	0.	0.

J	TIME	QR	QF	PIN	R	RR	RRC	RMS	RTS	TFA
77447	2.5554E 03	1.000E-02	1.126E-09	-1.256E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
77546	2.5604E 03	1.000E-02	1.058E-09	-1.255E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
77645	2.5653E 03	1.000E-02	9.941E-10	-1.254E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
77744	2.5703E 03	1.000E-02	9.343E-10	-1.254E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
77843	2.5752E 03	1.000E-02	8.781E-10	-1.253E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.

QDT	QD(1)	QD(2)	QD(3)	QD(4)	QD(5)	QD(6)	QD(7)
5.86308E-11	5.12732E-11	2.27126E-12	1.35796E-12	2.72933E-12	8.31226E-13	1.67876E-13	

ZI	QFI	QSI	QG	QS	HQ	RHQ	RZ
5.00000E-02	-5.50133E-13	0.	10.00000E-03	2.76000E-14	1.26034E 03	0.	0.

J	TIME	QR	QF	PIN	R	RR	RRC	RMS	RTS	TFA
77942	2.5802E 03	1.000E-02	8.253E-10	-1.252E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
78041	2.5851E 03	1.000E-02	7.758E-10	-1.251E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
78140	2.5901E 03	1.000E-02	7.292E-10	-1.251E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
78239	2.5950E 03	1.000E-02	6.855E-10	-1.250E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
78338	2.6000E 03	1.000E-02	6.444E-10	-1.249E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.

QDT	QD(1)	QD(2)	QD(3)	QD(4)	QD(5)	QD(6)	QD(7)
4.28925E-11	3.74963E-11	1.66445E-12	9.96101E-13	2.00251E-12	6.09937E-13	1.23186E-13	

ZI	QFI	QSI	QG	QS	HQ	RHQ	RZ
5.00000E-02	-4.02310E-13	0.	10.00000E-03	2.76000E-14	1.26058E 03	0.	0.

J	TIME	QR	QF	PIN	R	RR	RRC	RMS	RTS	TFA
78437	2.6049E 03	1.000E-02	6.058E-10	-1.248E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
78536	2.6099E 03	1.000E-02	5.695E-10	-1.247E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
78635	2.6148E 03	1.000E-02	5.355E-10	-1.245E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
78734	2.6198E 03	1.000E-02	5.035E-10	-1.244E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
78833	2.6247E 03	1.000E-02	4.734E-10	-1.243E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.

QDT	QD(1)	QD(2)	QD(3)	QD(4)	QD(5)	QD(6)	QD(7)
3.13831E-11	2.74214E-11	1.22066E-12	7.31477E-13	1.47099E-12	4.48109E-13	9.05049E-14	

ZI	CFI	QSI	QG	QS	HQ	RHQ	RZ
5.00000E-02	-2.94207E-13	0.	10.00000E-03	2.76000E-14	1.26082E 03	0.	0.

J	TIME	QR	QF	PIN	R	RR	RRC	RMS	RTS	TFA
78932	2.6297E 03	1.000E-02	4.452E-10	-1.242E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
79031	2.6346E 03	1.000E-02	4.187E-10	-1.240E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
79130	2.6396E 03	1.000E-02	3.938E-10	-1.238E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
79229	2.6445E 03	1.000E-02	3.704E-10	-1.237E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
79328	2.6495E 03	1.000E-02	3.484E-10	-1.235E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.

QDT	QD(1)	QD(2)	QD(3)	QD(4)	QD(5)	QD(6)	QD(7)
2.29664E-11	2.00537E-11	8.96111E-13	5.37959E-13	1.08230E-12	3.29765E-13	6.66053E-14	

ZI	CFI	QSI	QG	QS	HQ	RHQ	RZ
5.00000E-02	-2.15152E-13	0.	10.00000E-03	2.76000E-14	1.26107E 03	0.	0.

J	TIME	QR	QF	PIN	R	RR	RRC	RMS	RTS	TFA
79427	2.6544E 03	1.000E-02	3.278E-10	-1.233E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
79526	2.6594E 03	1.000E-02	3.084E-10	-1.231E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
79625	2.6643E 03	1.000E-02	2.902E-10	-1.229E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
79724	2.6693E 03	1.000E-02	2.731E-10	-1.227E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
79823	2.6742E 03	1.000E-02	2.570E-10	-1.224E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.

QDT	QD(1)	QD(2)	QD(3)	QD(4)	QD(5)	QD(6)	QD(7)
1.68113E-11	1.46657E-11	6.58763E-13	3.96440E-13	7.98046E-13	2.43221E-13	4.91277E-14	

ZI	CFI	QSI	QG	QS	HQ	RHQ	RZ
5.00000E-02	-1.57339E-13	0.	10.00000E-03	2.76000E-14	1.26131E 03	0.	0.

J	TIME	QR	QF	PIN	R	RR	RRC	RMS	RTS	TFA
79922	2.6791E 03	1.000E-02	2.419E-10	-1.222E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
80021	2.6841E 03	1.000E-02	2.277E-10	-1.219E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
80120	2.6890E 03	1.000E-02	2.144E-10	-1.216E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
80219	2.6940E 03	1.000E-02	2.019E-10	-1.213E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
80318	2.6989E 03	1.000E-02	1.901E-10	-1.210E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.

QDT	QD(1)	QD(2)	QD(3)	QD(4)	QD(5)	QD(6)	QD(7)
1.23102E-11	1.07256E-11	4.85189E-13	2.92948E-13	5.90175E-13	1.79932E-13	3.63464E-14	

ZI	CFI	QSI	QG	QS	HQ	RHQ	RZ
5.00000E-02	-1.15061E-13	0.	10.00000E-03	2.76000E-14	1.26155E 03	0.	0.

J	TIME	QR	QF	PIN	R	RR	RRC	RMS	RTS	TFA
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80417	2.7039E 03	1.000E-02	1.791E-10	-1.207E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
80516	2.7088E 03	1.000E-02	1.687E-10	-1.203E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
80615	2.7138E 03	1.000E-02	1.590E-10	-1.200E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
80714	2.7187E 03	1.000E-02	1.498E-10	-1.196E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
80813	2.7237E 03	1.000E-02	1.413E-10	-1.191E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.

QDT	QD(1)	QD(2)	QD(3)	QD(4)	QD(5)	QD(6)	QD(7)
9.01847E-12	7.84414E-12	3.58254E-13	2.17266E-13	4.38160E-13	1.33649E-13	2.69995E-14	

ZI	QFI	QSI	QG	QS	HQ	RHQ	RZ
5.00000E-02	-8.41434E-14	0.	10.00000E-03	2.76000E-14	1.26179E 03	0.	0.

J	TIME	QR	QF	PIN	R	RR	RRC	RMS	RTS	TFA
80912	2.7286E 03	1.000E-02	1.332E-10	-1.187E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
81011	2.7336E 03	1.000E-02	1.256E-10	-1.182E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
81110	2.7385E 03	1.000E-02	1.185E-10	-1.177E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
81209	2.7435E 03	10.000E-03	1.118E-10	-1.172E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
81308	2.7484E 03	10.000E-03	1.055E-10	-1.167E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.

QDT	QD(1)	QD(2)	QD(3)	QD(4)	QD(5)	QD(6)	QD(7)
6.61128E-12	5.73698E-12	2.65427E-13	1.61919E-13	3.26993E-13	9.98024E-14	2.01642E-14	

ZI	QFI	QSI	QG	QS	HQ	RHQ	RZ
5.00000E-02	-6.15335E-14	0.	10.00000E-03	2.76000E-14	1.26203E 03	0.	0.

J	TIME	QR	QF	PIN	R	RR	RRC	RMS	RTS	TFA
81407	2.7534E 03	10.000E-03	9.959E-11	-1.161E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
81506	2.7583E 03	10.000E-03	9.405E-11	-1.155E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
81605	2.7633E 03	10.000E-03	8.884E-11	-1.148E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
81704	2.7682E 03	10.000E-03	8.395E-11	-1.141E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
81803	2.7732E 03	10.000E-03	7.935E-11	-1.134E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.

QDT	QD(1)	QD(2)	QD(3)	QD(4)	QD(5)	QD(6)	QD(7)
4.85092E-12	4.19602E-12	1.97543E-13	1.21445E-13	2.45697E-13	7.50508E-14	1.51656E-14	

ZI	QFI	QSI	QG	QS	HQ	RHQ	RZ
5.00000E-02	-4.49990E-14	0.	10.00000E-03	2.76000E-14	1.26227E 03	0.	0.

J	TIME	QR	QF	PIN	R	RR	RRC	RMS	RTS	TFA
81902	2.7781E 03	10.000E-03	7.503E-11	-1.127E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
82001	2.7831E 03	10.000E-03	7.098E-11	-1.119E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
82100	2.7880E 03	10.000E-03	6.717E-11	-1.110E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
82199	2.7930E 03	10.000E-03	6.359E-11	-1.102E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.

82298 2.7979E 03 10.000E-03 6.023E-11 -1.093E-02 -6.000E-02 -3.24E-02 0. 0. 0. 0.

QDT QD(1) QD(2) QD(3) QD(4) QD(5) QD(6) QD(7)
3.56359E-12 3.06914E-12 1.47900E-13 9.18461E-14 1.86245E-13 5.69501E-14 1.15101E-14

ZI QFI QSI QG QS HQ RHQ RZ
5.00000E-02 -3.29075E-14 0. 10.00000E-03 2.76000E-14 1.26252E 03 0. 0.

J	TIME	QR	QF	PIN	R	RR	RRC	RMS	RTS	TFA
82397	2.8029E 03	10.000E-03	5.707E-11	-1.083E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
82496	2.8078E 03	10.000E-03	5.411E-11	-1.073E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
82595	2.8128E 03	10.000E-03	5.132E-11	-1.063E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
82694	2.8177E 03	10.000E-03	4.871E-11	-1.052E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
82793	2.8227E 03	10.000E-03	4.625E-11	-1.041E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.

QDT QD(1) QD(2) QD(3) QD(4) QD(5) QD(6) QD(7)
2.62217E-12 2.24505E-12 1.11596E-13 7.02008E-14 1.42769E-13 4.37132E-14 8.83694E-15

ZI QFI QSI QG QS HQ RHQ RZ
5.00000E-02 -2.40650E-14 0. 10.00000E-03 2.76000E-14 1.26276E 03 0. 0.

J	TIME	QR	QF	PIN	R	RR	RRC	RMS	RTS	TFA
82892	2.8276E 03	10.000E-03	4.394E-11	-1.029E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
82991	2.8326E 03	10.000E-03	4.177E-11	-1.017E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
83090	2.8375E 03	10.000E-03	3.973E-11	-1.004E-02	-6.000E-02	-3.24E-02	0.	0.	0.	0.
83189	2.8425E 03	10.000E-03	3.782E-11	-9.907E-03	-6.000E-02	-3.24E-02	0.	0.	0.	0.
83288	2.8474E 03	10.000E-03	3.602E-11	-9.770E-03	-6.000E-02	-3.24E-02	0.	0.	0.	0.

QDT QD(1) QD(2) QD(3) QD(4) QD(5) QD(6) QD(7)
1.93371E-12 1.64240E-12 8.50475E-14 5.43717E-14 1.10975E-13 3.40331E-14 6.88204E-15

ZI QFI QSI QG QS HQ RHQ RZ
5.00000E-02 -1.75986E-14 0. 10.00000E-03 2.76000E-14 1.26300E 03 0. 0.

J	TIME	QR	QF	PIN	R	RR	RRC	RMS	RTS	TFA
83387	2.8524E 03	10.000E-03	3.434E-11	-9.629E-03	-6.000E-02	-3.24E-02	0.	0.	0.	0.
83486	2.8573E 03	10.000E-03	3.275E-11	-9.433E-03	-6.000E-02	-3.24E-02	0.	0.	0.	0.
83585	2.8623E 03	10.000E-03	3.126E-11	-9.332E-03	-6.000E-02	-3.24E-02	0.	0.	0.	0.
83684	2.8672E 03	10.000E-03	2.986E-11	-9.177E-03	-6.000E-02	-3.24E-02	0.	0.	0.	0.
83783	2.8722E 03	10.000E-03	2.855E-11	-9.017E-03	-6.000E-02	-3.24E-02	0.	0.	0.	0.

QDT QD(1) QD(2) QD(3) QD(4) QD(5) QD(6) QD(7)
1.43025E-12 1.20169E-12 6.56325E-14 4.27960E-14 8.77244E-14 2.69541E-14 5.45243E-15

ZI	QFI	QSI	QG	QS	HQ	RHQ	RZ
5.00000E-02	-1.28697E-14	0.	10.00000E-03	2.76000E-14	1.26324E 03	0.	0.

J	TIME	QR	QF	PIN	R	RR	RRC	RMS	RTS	TFA
83882	2.8771E	03 10.000E-03	2.731E-11	-8.853E-03	-6.000E-02	-3.24E-02	0.	0.	0.	0.
83981	2.8820E	03 10.000E-03	2.615E-11	-8.684E-03	-6.000E-02	-3.24E-02	0.	0.	0.	0.
84080	2.8870E	03 10.000E-03	2.506E-11	-8.512E-03	-6.000E-02	-3.24E-02	0.	0.	0.	0.
84179	2.8919E	03 10.000E-03	2.404E-11	-8.336E-03	-6.000E-02	-3.24E-02	0.	0.	0.	0.
84278	2.8969E	03 10.000E-03	2.308E-11	-8.156E-03	-6.000E-02	-3.24E-02	0.	0.	0.	0.

QDT	QD(1)	QD(2)	QD(3)	QD(4)	QD(5)	QD(6)	QD(7)
1.06207E-12	8.79401E-13	5.14345E-14	3.43308E-14	7.07214E-14	2.17773E-14	4.40697E-15	

ZI	QFI	QSI	QG	QS	HQ	RHQ	RZ
5.00000E-02	-9.41151E-15	0.	10.00000E-03	2.76000E-14	1.26348E 03	0.	0.

J	TIME	QR	QF	PIN	R	RR	RRC	RMS	RTS	TFA
84377	2.9018E	03 10.000E-03	2.217E-11	-7.973E-03	-6.000E-02	-3.24E-02	0.	0.	0.	0.
84476	2.9068E	03 10.000E-03	2.133E-11	-7.788E-03	-6.000E-02	-3.24E-02	0.	0.	0.	0.
84575	2.9117E	03 10.000E-03	2.053E-11	-7.599E-03	-6.000E-02	-3.24E-02	0.	0.	0.	0.
84674	2.9167E	03 10.000E-03	1.978E-11	-7.408E-03	-6.000E-02	-3.24E-02	0.	0.	0.	0.
84773	2.9216E	03 10.000E-03	1.908E-11	-7.215E-03	-6.000E-02	-3.24E-02	0.	0.	0.	0.

QDT	QD(1)	QD(2)	QD(3)	QD(4)	QD(5)	QD(6)	QD(7)
7.92826E-13	6.43713E-13	4.10515E-14	2.81403E-14	5.82871E-14	1.79916E-14	3.64244E-15	

ZI	QFI	QSI	QG	QS	HQ	RHQ	RZ
5.00000E-02	-6.88258E-15	0.	10.00000E-03	2.76000E-14	1.26372E 03	0.	0.

J	TIME	QR	QF	PIN	R	RR	RRC	RMS	RTS	TFA
84872	2.9266E	03 10.000E-03	1.842E-11	-7.020E-03	-6.000E-02	-3.24E-02	0.	0.	0.	0.
84971	2.9315E	03 10.000E-03	1.780E-11	-6.824E-03	-6.000E-02	-3.24E-02	0.	0.	0.	0.
85070	2.9365E	03 10.000E-03	1.722E-11	-6.627E-03	-6.000E-02	-3.24E-02	0.	0.	0.	0.
85169	2.9414E	03 10.000E-03	1.667E-11	-6.429E-03	-6.000E-02	-3.24E-02	0.	0.	0.	0.
85268	2.9464E	03 10.000E-03	1.615E-11	-6.231E-03	-6.000E-02	-3.24E-02	0.	0.	0.	0.

QDT	QD(1)	QD(2)	QD(3)	QD(4)	QD(5)	QD(6)	QD(7)
5.95928E-13	4.71356E-13	3.34586E-14	2.36131E-14	4.91940E-14	1.52230E-14	3.08333E-15	

ZI	QFI	QSI	QG	QS	HQ	RHQ	RZ
5.00000E-02	-5.03318E-15	0.	10.00000E-03	2.76000E-14	1.26397E 03	0.	0.

J	TIME	QR	QF	PIN	R	RR	RRC	RMS	RTS	TFA
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85367	2.9513E	03	10.000E-03	1.567E-11	-6.034E-03	-6.000E-02	-3.24E-02	0.	0.	0.	0.
85466	2.9563E	03	10.000E-03	1.522E-11	-5.837E-03	-6.000E-02	-3.24E-02	0.	0.	0.	0.
85565	2.9612E	03	10.000E-03	1.479E-11	-5.640E-03	-6.000E-02	-3.24E-02	0.	0.	0.	0.
85664	2.9662E	03	10.000E-03	1.439E-11	-5.445E-03	-6.000E-02	-3.24E-02	0.	0.	0.	0.
85763	2.9711E	03	10.000E-03	1.402E-11	-5.252E-03	-6.000E-02	-3.24E-02	0.	0.	0.	0.

QDT	QD(1)	QD(2)	QD(3)	QD(4)	QD(5)	QD(6)	QD(7)
4.51938E-13	3.45313E-13	2.79059E-14	2.03025E-14	4.25442E-14	1.31984E-14	2.67446E-15	

ZI	QFI	QSI	QG	QS	HQ	RHQ	RZ
5.00000E-02	-3.68073E-15	0.	10.00000E-03	2.76000E-14	1.26421E 03	0.	0.

J	TIME	QR	QF	PIN	R	RR	RRC	RMS	RTS	TFA
85862	2.9761E	03	10.000E-03	1.366E-11	-5.061E-03	-6.000E-02	-3.24E-02	0.	0.	0.
85961	2.9810E	03	10.000E-03	1.333E-11	-4.872E-03	-6.000E-02	-3.24E-02	0.	0.	0.
86060	2.9860E	03	10.000E-03	1.302E-11	-4.686E-03	-6.000E-02	-3.24E-02	0.	0.	0.
86159	2.9909E	03	10.000E-03	1.273E-11	-4.503E-03	-6.000E-02	-3.24E-02	0.	0.	0.
86258	2.9959E	03	10.000E-03	1.245E-11	-4.323E-03	-6.000E-02	-3.24E-02	0.	0.	0.

QDT	QD(1)	QD(2)	QD(3)	QD(4)	QD(5)	QD(6)	QD(7)
3.46639E-13	2.53138E-13	2.38452E-14	1.78814E-14	3.76813E-14	1.17179E-14	2.37546E-15	

ZI	QFI	QSI	QG	QS	HQ	RHQ	RZ
5.00000E-02	-2.69169E-15	0.	10.00000E-03	2.76000E-14	1.26445E 03	0.	0.

J	TIME	QR	QF	PIN	R	RR	RRC	RMS	RTS	TFA
86341	3.0000E	03	10.000E-03	1.223E-11	-4.175E-03	-6.000E-02	-3.24E-02	0.	0.	0.

QDT	QD(1)	QD(2)	QD(3)	QD(4)	QD(5)	QD(6)	QD(7)
3.31990E-13	2.40314E-13	2.32803E-14	1.75446E-14	3.70048E-14	1.15119E-14	2.33386E-15	

ZI	QFI	QSI	QG	QS	HQ	RHQ	RZ
5.00000E-02	-2.55409E-15	0.	10.00000E-03	2.76000E-14	1.26449E 03	0.	0.

END PROBLEM

RN-TM-0220

APPENDIX C

JOB NO. 544

SUBROUTINE FLOW

(FOR USE WITH OSCAG-II IN AGTRAN)

SUBROUTINE FLOW

- I. INTRODUCTION
- II. GENERAL DESCRIPTION
- III. SIMPLIFIED FLOW DIAGRAM
- IV. INPUT
- V. OUTPUT
- VI. DETAILED FLOW DIAGRAM
- VII. NOMENCLATURE AND PROGRAM LISTING

SUBROUTINE FLOW

I. INTRODUCTION

Subroutine Flow is the result of minor revisions to Job 357CN - Core and nozzle heat transfer and fluid flow program generated by Aerojet.

Subroutine Flow reads in thermal and fluid input data and computes heat flows, temperatures, mass flows, and pressures. If desired, intermediate results are printed. The Agtran main program supplies Subroutine flow with the current power level and time and Subroutine Flow returns average coolant and fuel temperatures and coolant mass to Agtran.

II. GENERAL DESCRIPTION OF PROGRAM

Subroutine Flow is divided into two sections, Flow(1) and Flow (2). Flow(1) reads and prints the thermal and fluid input data and goes to Flow(2) to obtain initial equilibrium thermal and coolant flow conditions.

In computing heat transfer and fluid flow, Flow(2) calculates:

1. Boundary layer heat transfer coefficients.
2. Thermal conductances.
3. Heat flow rate relaxation coefficients.
4. Heat flow rates.
5. Error heat flow rates at each node (residuals).
6. Temperatures.
7. Average coolant mass and temperatures.
8. Average fuel temperatures.
9. Mass flow rate conductances.
10. Pressures.

III. SIMPLIFIED FLOW DIAGRAM

IV. INPUT DISCUSSION

Input sequence and requirements are listed below. See Section VII (Nomenclature) for definition of symbols.

<u>CARD NO.</u>	<u>SYMBOL</u>	<u>LIMITATIONS</u>	<u>UNITS</u>	<u>FORMAT</u>
30000	N M LIMIT MAJOR NOTE			(6I12)
30100	AREA(I), I=1,N A(I), I=1,N XK(I), I=1,N RH(I), I=1,N			(4E12.8)
30200	Al(I), I=1,N ALPHA(I), I=1,N E(I), I=1,N SF(I), I=1,N			(4E12.8)
30300	D(I,L) ,L=1,M-1; I=1,N FSTAR(I,L) " C(I,L) " TCZERO(I,L) " FLUX(I,L) " Z3(I,L) "			(6E12.8)
31000	ORDP(K), K=1,LIMIT ORD3(K) " ORDT(K) "			(3E12.8)
31100	GAMMA CP XMW XC XMU WSTAR			(6E12.8)
31200	ALLOW TOLER COEFF TAU DN PLF			(6E12.8)
31300	T1F TWALL P3F T2F			(6E12.8)
32000	I1, I2, I3, I4, I5			(6I12)

VI. DETAILED FLOW DIAGRAM

VII. NOMENCLATURE (CTD)

WSTAR = TOTAL CORE MASS FLOW RATE AT DESIGN POINT, LBM/SEC
WYE(N) = MASS FLOW RATE CONDUCTANCE OF CHANNEL (N),
LB./SEC.)/(LBF./SQ.IN.)
XC = THERMAL CONDUCTIVITY OF COOLANT FLUID, BTU/IN-SEC-DEG R
XK(N) = LOSS COEFFICIENT ASSOCIATED WITH THE EXIT OF CHANNEL (N)
XMU = ABSOLUTE VISCOSITY OF COOLANT FLUID, LBM/IN-SEC
XMW = MOLECULAR WEIGHT OF FLUID, LB./LB.-MOLE
Y(N,L) = MASS FLOW RATE CONDUCTANCE OF SEGMENT (L),
CHANNEL (N), (LB./SEC.)/(LBF./SQ.IN.)
YIN(N) = MASS FLOW RATE CONDUCTANCE OF THE INLET ORIFICE
IN CHANNEL (N), (LB./SEC.)/(LBF./SQ.IN.)
YOUT(N) = MASS FLOW RATE CONDUCTANCE ASSOCIATED WITH THE
EXIT LOSS OF CHANNEL (N), (LB./SEC.)/(LBF./SQ.IN.)
Z1(N,L) = HEAT CONDUCTANCE OF COOLANT FLOW, BTU/SEC-DEG R
Z2(N,L) = HEAT CONDUCTANCE FROM CORE WALL TO COOLANT FLOW,
BTU/SEC-DEG R
Z3(N,L) = HEAT CONDUCTANCE AXIALLY BETWEEN NODES IN SOLID-
MATERIAL, BTU/SEC-DEG R

OPTIONAL PRINT OUT INDICATORS

IF I1 IS POSITIVE INTERMEDIATE OUTPUT FROM SUBROUTINES
Y1, Y2, Y3, IS LISTED
IF I2 IS POSITIVE HEAT FLOW RATES ARE LISTED AT THE END OF
EACH MAJOR TIME STEP.
IF I3 IS POSITIVE, THE PROGRAM WILL LIST INTERMEDIATE
RESULTS OF MAIN PROGRAM HEAT FLOW CALCULATIONS.
IF I4 IS POSITIVE, THE PROGRAM WILL LIST INTERMEDIATE
RESULTS OF MAIN PROGRAM
IF I5 IS POSITIVE TEMPERATURES, PRESSURES, AND MASS FLOW RATES
ARE PRINTED AT THE END OF EACH MAJOR TIME STEP.