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MIXING AND GASIFICATION OF COAL IN ENTRAINED FLOW SYSTEMS.

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Volume 2.

USER'S MANUAL FOR A COMPUTER PROGRAM FOR 1-DIMENSIONAL COAL COMBUSTION OR GASIFICATION (1-DICOG).

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FOREWORD

This document is the second volume of the final report, prepared for the Department of Energy (DOE). It is the User's Manual for a computer model for One-Dimensional Coal Combustion or Gasification. Work on this code was initiated under contract to EPRI and the U.S. Department of Energy in December of 1974.

Work during the past year has been supported by the Electric Power Research Institute, Palo Alto, California, under Contract No. RP-364-1-3 with Mr. John Dimmer as Contract Officer and by the U.S. Department of Energy, Washington, D.C. under Contract No. EF 77-S-01-2666 with Dr. Robert C. Wellek as Contract Officer. Financial cost sharing from the Research Division of Brigham Young University for development of this code is gratefully acknowledged. The assistance of Mr. Scott M. Woodfield with computer program development is also acknowledged.

CODE AVAILABILITY

This code can be obtained at a minimal cost from:

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Included in the materials to be provided are the User's Manual and the card deck. The cost of obtaining these materials provides for some assistance by telephone in implementing the code and interpreting the output.

ABSTRACT

A one-dimensional, steady-state model describing pulverized coal combustion and gasification is presented. While emphasis has been placed on the description of the coal reaction processes and gas-particle interactions, one-dimensional fluid mechanics and particle-particle, particle-wall radiation have been included. Moisture vaporization from the coal particles, multi-step coal pyrolysis, and heterogeneous char oxidation by multiple oxidizers are modeled for polydispersed coal particle sizes or types. Although the formulation is one-dimensional, mixing rates of primary and secondary streams and recirculation within the reactor have been accounted for as specified input. The resulting model predicts thermal, chemical and physical histories for both the gaseous and particle phases. Gas-particle interactions account for appropriate diffusion and kinetic rates. Gas phase reactions are assumed to be in local chemical equilibrium. The solution technique uses predictor-corrector methods for integration of the ordinary non-linear differential equations which are coupled with a number of auxiliary algebraic equations. An iterative approach is required for the radiant heat transfer calculations by the zone method. Stiffness in differential energy equations is overcome by a pseudo steady-state method when needed. The generalized nature of the model allows for calculation of both coal combustion and coal gasification characteristics. User information is presented, along with a sample computation and a listing of the program.

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NOMENCLATURE

Symbol	Units	Definitions
A_j	cm^2	Particle area
A	s^{-1}	Pre-exponential factor
A	cm^2	Corss sectional area
a	$cal\ g^{-1}\ K^{-(k)}$	Heat capacity coefficient (Eq. 33)
a	cm^{-1}	Radiative absorption coefficient
b	$cal\ g^{-1}\ K^{-(k)}$	Heat capacity coefficient (Eq. 59)
B	---	Blowing parameter
C	$mol\ cm^{-3}$	Molar concentration
C_p	$cal\ g^{-1}\ K^{-1}$	Heat capacity
D	$cm^2\ s^{-1}$	Mass diffusivity
D_s	cm	Diameter of reactor chamber
d	cm	Particle diameter
E	$cal\ mol^{-1}$	Activation energy
E_λ	---	Absorption efficiency
h	$cal\ s^{-1}\ cm^{-2}\ K^{-1}$	Heat transfer coefficient
h	$cal\ g^{-1}$	Enthalpy
h	---	Step size
Δh	$cal\ g^{-1}$	Heat of reaction
I	$cal\ cm^{-2}\ s^{-1}$	Radiative intensity
J	---	Total number of particles
K	---	Total number of elements
k	s^{-1}, $cm\ s^{-1}$	Reaction rate coefficient
k	$cal\ s^{-1}\ cm^{-1}\ K^{-1}$	Thermal conductivity

k_c	$cm\ s^{-1}$	Mass transfer coefficient
k_g	$cal\ s^{-1}\ cm^{-1}\ K^{-1}$	Gas conductivity
k_x	$moles\ cm^{-2}\ s^{-1}$	Mass transfer coefficient
M	$g\ mol^{-1}$	Molecular weight
m	$g\ cm^{-1}\ s^{-1}$	Mass addition rate
Nu	---	Nusselt number
n	cm^{-3}	Particle number density
Pr	---	Prandtl number
p	atm	Pressure
Q	$cal\ cm^{-3}\ s^{-1}$	Particle-gas heat transfer rate
R	$cal\ mol^{-1}\ K^{-1}$	Gas constant
r	$g\ cm^{-3}\ s^{-1}$	Particle reaction rate
Re	---	Reynolds number
Sc	---	Schmidt number
T	K	Temperature
v	$cm\ s^{-1}$	Velocity
w	$g\ s^{-1}$	Mass flow rate
X	---	Mole fraction
x	cm	Axial space cooredinate
y	---	Arbitrary independent variable
Y	---	Devolatilization coefficient
α	g	Coal component mass
δ	---	Stockmayer parameter
ε	---	Emmissivity
γ	---	Particle swelling parameter
ϕ	---	Interaction parameter
ϕ	---	Stoichiometric coefficient
σ	---	Particle internal area factor

μ	$g\ cm^{-1}\ s^{-1}$	Viscosity
π	---	Pi, 3.14159
ρ	$g\ cm^{-3}$	Density
σ	Å	Collision diameter
σ	$cal\ s^{-1}\ cm^{-2}\ K^{-4}$	Stefan-Boltzmann constant
ω	---	Mass fraction
Ω	---	Collision integral

Subscripts

a	ash
b	boundary
c	coal
c	convection
d	diffusion
e	equilibrium
f	flame
g	gas
h	char
i	gas species, summation index
j	particle type, surface of particle
k	kinetic, element, summation index
ℓ	char oxidation reaction
m	mean, mixture, devolatilization reaction, mass transfer
n	reaction order, total species, position
o	initial value, without blowing, oxidizer
p	radiation region, summation index
q	radiation region, summation index
r	radiation

s	secondary
v	volatiles
w	moisture
y	hydrocarbon
μ	viscosity
α	coal component
ρ	recirculation

I. USER'S MANUAL FOR ONE-DIMENSIONAL COAL COMBUSTION OR GASIFICATION MODEL

A. INTRODUCTION

1. Background

This manual presents the details of the one-dimensional computer code, referred to as 1-DICOG (1 - DImensional Combustion Or Gasification), for describing pulverized coal combustion or gasification processes. A description of coal reaction processes, including devolatilization, char oxidation, gas-phase oxidation, and gas-particle interchange is emphasized. Coal and gas physical properties are also included. The resulting model, which describes the response of a coal particle to its thermal, chemical and physical environment, has been coupled with one-dimensional fluid mechanics and radiative heat transfer to form a working model to describe the performance of pulverized coal combustors and gasifiers. The formulation of the coal reaction processes can also be readily applied to other fluid mechanics models in order to extend investigations to multi-dimensional examples (1).

Development of an analytical treatment of pulverized coal-char behavior in reacting systems is based largely on experimental observations and kinetic parameters deduced from these observations. Since there are still unresolved questions regarding the kinetics of coal reaction, an attempt has been made to formulate a general reaction scheme that can accommodate results of future measurements and improved kinetic parameters.

The description that follows applies to pulverized coal reaction processes, where particles are small (<100 μm) and heating rates are high (10^3-10^5 K s^{-1}). This treatment would not necessarily apply to fixed or fluidized bed processes without modification, but is intended for application to pulverized coal furnaces and entrained coal gasifiers.

The fluid mechanics model is time-steady in one space dimension and requires input specification of the rates of jet mixing and recirculation. The potential uses and advantages of this model include: 1) low computer costs for investigating effects of operating and configurational variables on coal reaction processes; 2) a method for evaluating various descriptions of coal kinetics together with model parameters; 3) a basis for development of multi-dimensional codes of coal reaction processes; 4) interpretation of experimental data; 5) a single model for describing both combustion and gasification processes for pulverized coal systems; and 6) potential use as a component in systems analysis codes that describe processes with a combustion or gasification step. This one-dimensional model is not well-suited for comparison with local measurements in two or more dimensions inside combustors or gasifiers. Further, it would not be applicable to the detailed design or optimization of such systems.

In this volume of the final report, review of other pulverized coal combustion and gasification models is presented. The basis for the model is then explained including a description of all model equations and required assumptions. The numerical solution technique is discussed and methods used for improved computational efficiency are disclosed. User information regarding the 1-DICOG code is then presented. The appendices contain a sample calculation, the program listing and helpful equilibrium parameters.

2. Literature Review

Several models have been developed for combustion of pulverized coal systems, but relatively few have been applied to gasification. The complex fluid mechanics involved in both must be coupled with the local heterogeneous and homogenous gas and particle-phase reactions. Overcoming these types of complexities has forced most modeling efforts to look at a more macroscopic level of approximation, where larger areas of the reactor are characterized by simplifying assumptions, rather than defining the detailed mechanisms throughout the reactor. A notable exception to this is the multi-dimensional work originating at Imperial College (2), where modeling in gaseous-fired furnaces is being extended to coal-fired systems. It is to this type of modeling effort that the present formulation of coal reaction processes may make the largest contribution.

Models for pulverized coal combustion include those of Vulis (3), Hedley and Jackson (4), Horn et al. (5) and Field et al. (6). These models may be considered to be plug-flow in nature, where some have been modified to include the effects of recirculation. Beer and Lee (7) have developed a model which incorporates a combination of perfectly-stirred reactors and plug-flow reactors. Lewellen et al. (8) have recently developed a model for a swirling-coal combustor, wherein they identified the dominant physical processes in four regions of interest. Some initial efforts have been expended to incorporate coal combustion with complex two-dimensional turbulent fluid mechanics by Richter and Quack (9); and Gibson and Morgan (10). In all such cases very simple coal reaction models were used in order to accommodate the more detailed mixing.

Entrained flow gasification models are only recently being developed. Batchelder et al. (11) presented some of the earliest work in this area. Mehta (12) has developed a model combining perfectly-stirred reactors and plug-flow reactors to describe a three-stage, entrained gasifier. Two models of gasification are being developed by George et al. (13), one being a combination of perfectly-stirred reactors and plug-flow reactors, the other based on a characteristic-time approach. Lewis et al. (14) are preparing a gasification model consisting of two parts, one part containing the single particle chemistry, etc., the other part containing the fluid mechanics and homogeneous chemistry. Blake (15) has initiated development of a generalized, multidimensional, gasification model and some work has been done to include coal combustion in two dimensional models similar to that described in Section 4 of Volume 1 of this report, and by Gibson and by Morgan (10); and Richter and Quack (11).

The formulation incorporated in 1-DICOG contains physical and chemical descriptions which extend beyond any that have been included in previous mathematical models for pulverized coal entrained flow reactors, whether for combustion or gasification. Currently, researchers engaged in developing coal conversion models on this level include Sprouse (16), Blake (15) and Stickler (18). Sprouse is formulating a one-dimensional model much like 1-DICOG. Blake, as already mentioned, is developing a multi-dimensional approach. Also, a two-dimensional, axi-symmetric, combustion and gasification model incorporating the concepts of 1-DICOG is being developed by the BYU Combustion Laboratory as reported by Smoot and Hedman (1); and Smoot and Pratt (17). Stickler et al. (18) have developed a one-dimensional coal combustion model designed to simulate MHD power generators. Although radiation has been ignored in their model, the approach is very similar to 1-DICOG.

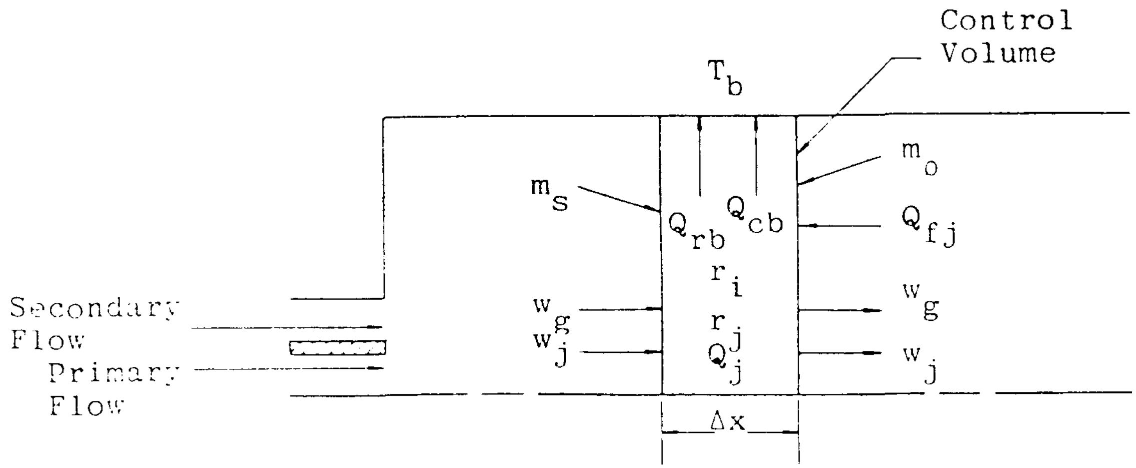
II. THEORETICAL MODEL DEVELOPMENT

A. MODEL BASIS

1-DICOG, by its one-dimensional formulation, assumes no gradients normal to the direction of flow. The differential formulation is based on a volume element inside a gasifier or furnace as depicted in the schematic shown in Figure 1. As depicted by this schematic, the following aspects of pulverized coal combustion and gasification have been included in the model: 1) mixing of primary and secondary streams (specified as input); 2) recirculation of reacted products (specified as input); 3) devolatilization and swelling of the coal; 4) reaction of the char by oxygen, steam carbon dioxide, hydrogen or any arbitrary oxidizer; 5) conductive heat transfer between the coal or char particles and the gases; 6) convective losses to the reactor wall; 7) variations in composition of inlet gases and solids; 8) variation in coal or char particle sizes; 9) oxidation of the coal devolatilization products; 10) radiative interchange among particles and with the reactor walls; and 11) inclusion of multiple sizes or types of coal particles, each with their own individual properties, composition, reaction rates, etc.

The following are considered to be the major limitations of the one-dimensional model (1-DICOG). 1) The model does not predict local mean or fluctuating properties within the pulverized coal reactor as a function of both radial and axial position. 2) The model does not predict rates of jet mixing or recirculation; rather, these values are required input. 3) The detailed behavior of coal reactions is not yet well understood, which leads to uncertainty in the kinetic description and parameters for the pulverized coal systems. 4) Some details of the pulverized coal gasification and combustion processes have been neglected to reduce model complexity and computation time. These include particle velocity lag effects, micromixing processes, gas-phase rate-limiting reactions and gas-phase radiation. A complete summary of key model assumptions and conditions is given in Table 1.

1-DICOG has been developed for an arbitrary number of chemical elements (K in total number). All equations are derived for elemental balances as opposed to species balances. This simplification is rendered tractable by the local gas phase chemical equilibrium approximation. Local equilibrium signifies that the gas phase species are in chemical equilibrium at each point within the reactor, which is equivalent to assuming infinite gas-phase reaction rates. It does not imply that neighboring elements are in equilibrium with each other. The elemental balances simplify the approach in two ways. First, the number of differential equations involved in elemental balances is usually much smaller than those required for species balances. Secondly, this greatly simplifies the required link with the coal reaction model. Volatiles, for example, need not be specified by species composition, which are difficult to identify, but only by elemental composition which is easier to define from an ultimate analysis of the char. From the element balances and the calculated energy level, the Gibb's free energy is minimized and



m_s = rate of flow of secondary stream into control volume

w_g = rate of gas flow into control volume

w_j = rate of particle flow into control volume

m_ρ = rate of recirculated product flow into control volume

Q_j = heat transferred by conduction between gas and particles.

r_j = rate of pyrolysis and oxidation of coal/char

r_i = rate of reaction of gas species

Q_{cb} = rate of heat loss by convection

Q_{rb} = rate of heat loss by radiation

Q_{fj} = rate of radiative heat transfer in reactor

T_b = wall temperature

Figure 1. Schematic diagram of volume element for 1-DICOG (1).

TABLE 1

SUMMARY OF KEY ASSUMPTIONS AND CONDITIONS OF COAL REACTION MODEL (1-DICOG) (Modified from Smoot and Pratt (1))

1. Steady-state, compressible gas, with specified uniform pressure or specified pressure variation, and specified reactor area variation.
2. Particles and gases in dynamic equilibrium.
3. Specified secondary gas and recirculated product input along reactor with instantaneous mixing at each interval of reactor area.
4. Multiple particle sizes or types.
5. Each particle size and type and gas are distinct phases.
6. Negligible gas conduction, molecular diffusion, thermal diffusion, gravity effects, particle interactions, wall friction, viscous dissipation, work on surroundings, gas phase radiation, particle-phase convective losses, kinetic energy, particle volume.
7. Coal reactions take place by competing processes of devolatilization and char oxidation.
8. Rate-limiting steps include upstream radiative transport, rate of gross oxidizer/fuel mixing, rate of product recirculation, rate of coal particle devolatilization, rate of char reaction (with O_2, CO_2, H_2 and H_2O), rate of molecular diffusion to/from particle surface, and rate of heat transfer by conduction to/from particle surface.
9. Gas phase in local equilibrium.
10. Particles are composed of raw coal, char, ash and moisture.
11. Ash is inert and remains with the particle. Any volatile mineral matter is considered part of volatiles or char content.
12. Coal devolatilization is by an arbitrary sequence of irreversible, parallel, activated processes with specified activation energies.
13. Coal particle swelling is proportional to extent of devolatilization.
14. Spherical particles of uniform local particle temperature with arbitrary change in char particle diameter during reaction and with internal and external surface reactions according to specified burn area per particle.
15. Char contains specified proportions of other elements which enter the gas phase at a rate proportional to the carbon reaction.
16. Coal moisture loss controlled by vapor diffusion and heat transfer.
17. Devolatilization produces a fuel-rich product whose gases block diffusion and conduction by surface transpiration.

complete species composition, gas temperature, and other properties are computed from the assumption of local equilibrium.

1-DICOG is also derived for an arbitrary number of particle types (J in total number). This is an important feature of the model since George et al. (13) have indicated that approximating a pulverized coal system with a mono-dispersed particle size might lead to significant error. The code allows for the formal examination of different sizes or types in the same reactor. This will be evidenced in the equation set by noting that all particle equations will be written with a subscript j denoting the equation for the jth particle classification. The most common application of this option would be to examine the effect of a particle size distribution, but this is not the only possibility. The description is such that each particle type may have its own properties such as composition, rate of devolatilization, rate of oxidation, and rate of swelling. This option could be used to study the effects of feeding a mixture of different coal types, or perhaps recycling some char along with makeup coal.

The process by which each particle reacts is schematically presented in Figure 2. The reacting particle is composed of specified amounts of raw coal, char, ash, and moisture. The raw coal, or the dry ash free portion of the coal, undergoes devolatilization to volatiles and char by one or more reactions (M in total number) of the form:

$$(\text{raw coal})_j \xrightarrow{k_{jm}} Y_{jm}(\text{volatiles})_{jm} + (1 - Y_{jm})(\text{char}) \tag{1}$$

The volatiles react further in the gas phase. The char reacts heterogeneously after diffusion of the oxidizer (i.e., O_2, CO_2, H_2O, H_2) to the particle surface by one or more reactions (L in total number) of the form:

$$\phi_\ell(\text{char}) + (\text{oxidizer})_\ell \xrightarrow{k_\ell} (\text{gaseous products})_\ell \tag{2}$$

The ash is defined as that portion of the particle which remains inert throughout the entire combustion or gasification process. Moisture loss is controlled by heat transfer to the particle surface and water vapor diffusion away. During devolatilization, the particle swells at a rate proportional to the extent of devolatilization. After completion of devolatilization, the particle may continue heterogeneous char oxidation as either a constant diameter, changing-density particle, or a constant density, shrinking-diameter particle. The details of this coal submodel are presented in the following sections and also in Smoot and Pratt (17).

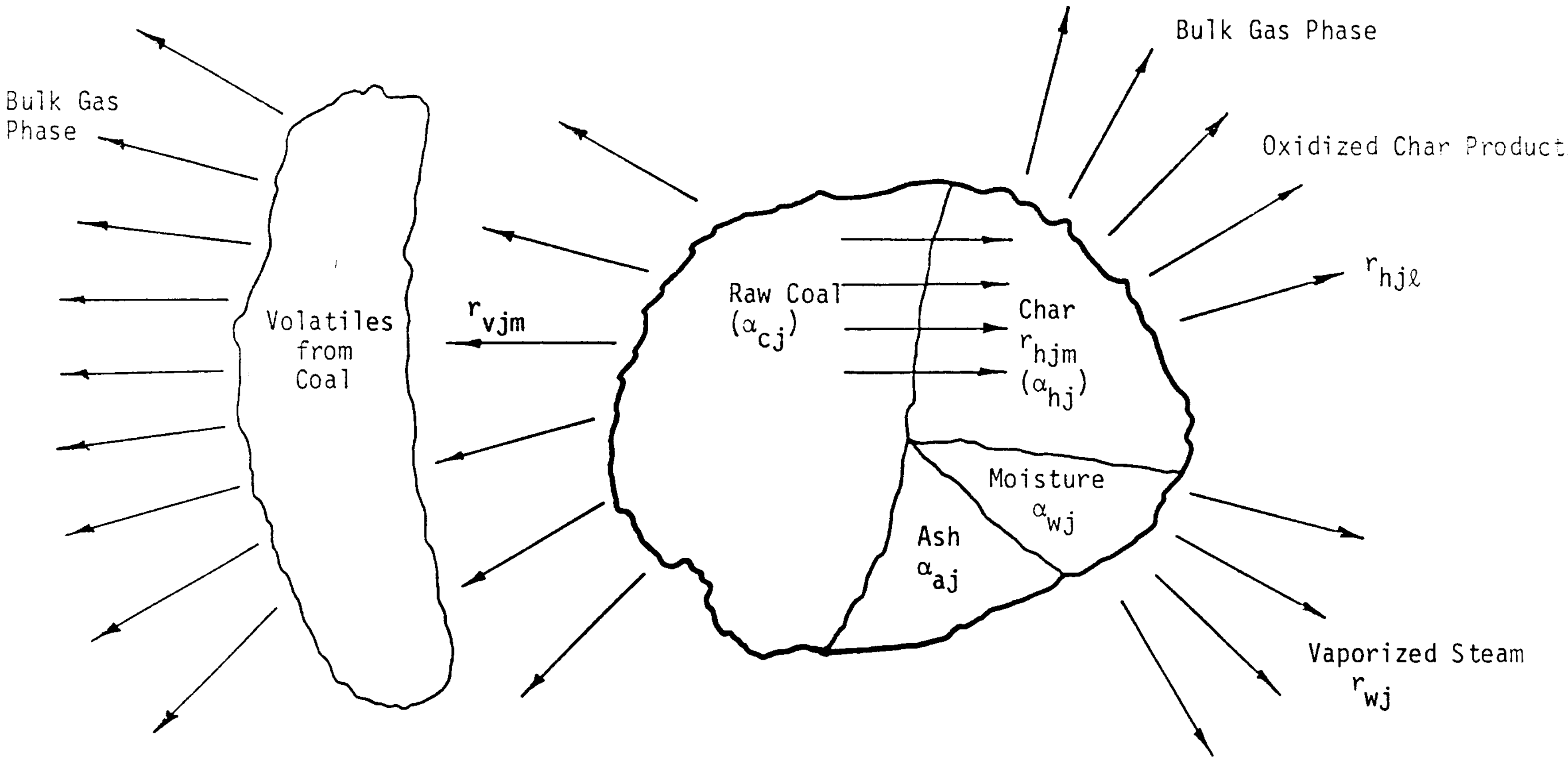


Figure 2. Schematic of jth particle, illustrating constituents and reaction processes (1).

The required set of differential equations will be discussed next. In addition, a number of auxiliary or constitutive algebraic equations are required as component model parts. These equations decribe the following aspects of the coal reaction process: (1) enthalpy-temperature relationships; (2) physical properties including heat capacity, thermal conductivity, diffusivity, and viscosity; (3) radiative interchange inside the gasifier; (4) equations of state and mass flow continuity; (5) convective and conductive heat interchange among the gases, particles and walls; and (6) rates of devolatilization and oxidation of coal and char. Each of these aspects of the model will then be discusses in turn. Finally, the local gas phase equilibrium calculations will be described.

B. DIFFERENTIAL EQUATIONS

The differential equation set which is solved by 1-DICOG is summarized in Table 2. This set of non-linear, highly coupled, ordinary differential equations is derived for a volume element as depicted in Figure 1 (see for example, Bird et al. 19). A general derivation of equations governing pulverized coal systems is given by Smoot and Pratt (17). The set is reduced to ordinary differential equations where derivatives are taken with respect to the one space dimension by considering the system to be at steady-state and only one-dimensional.

Equation 3 (Table 2) depicts the mass rate of change of each element. There is one of these equations solved for each of the K total elements considered. The sources or sinks of elemental mass addition or depletion for the gas phase are only three in number. Mass addition or depletion may take place through reaction with any of the J particle classifications. This is shown in the first term on the right hand side of Eq. 3. The summation is required since each of the particle phases represents a potential contributor. The final two terms represent sources or sinks due to secondary mixing and recirculation. As mentioned previously, these last two terms must be specified by the user, since they represent two-dimensional effects that might be important in the early regions of the reactor. Modeling of these terms is discussed in the sub-section entitled "Specified Mixing Processes".

Equation 4 represents the mass rate of change of each particle phase. There is one of these equations for each particle phase classification. As with the gas phase elemental balances of Eq. 3 the only sources and sinks are the overall particle reaction, secondary mixing and recirculation. No summation is required since the equation is written for each individual particle classification. Note particularly the sign on the reaction rate term in Eqs. 3 and 4. Reaction rates are written as the rate of mass addition to the gas phase per unit gas volume per unit time; thus, a positive reaction rate signifies a source of mass for the gas phase and a sink for the particle phase.

Equation 5 is the gas phase energy balance. Again, the first two terms on the right hand side depict the energy exchange due to secondary mixing and recirculation respectively. The final terms enclosed between parentheses represent all other gas phase heat transfer mechanisms. Q_j accounts for the conductive heat transfer from the jth particle type

TABLE 2

SUMMARY OF MODEL DIFFERENTIAL EQUATIONS

NO.	TYPE	EQUATION	NO. OF EQNS.
3	Gas Element Continuity (k^{th})	$d(w_g \omega_k)/dx = A \sum_j r_{jk} + m_{sgk} + m_{\rho gk}$	K
4	j^{th} Particle Phase Continuity	$dw_j/dx = -Ar_j + m_{sj} + m_{\rho j}$	J
5	Gas Energy	$d(w_g h_g)/dx = h_{sg} m_{sg} + h_{\rho g} m_{\rho g} + A(\sum_j Q_j - Q_{cb} + \sum_j r_j h_{jg})$	1
6	Particle Energy	$d(w_j h_j)/dx = m_{sj} h_{sj} + m_{\rho j} h_{\rho j} + A(Q_{fj} - Q_{rbj} - Q_j - r_j h_j)$	J
7	Particle Number	$d(vn_j A)/dx = (m_{\rho j}/\alpha_j) + (m_{sj}/\alpha_j)$	J
8	Total Gas Continuity	$d(w_g)/dx = A\sum_j r_j + m_{sg} + m_{\rho g}$	1
9	Coal Mass	$d(\alpha_{cj})/dx = (r_{cj}/n_j v)$	J
10	Char Mass	$d(\alpha_{hj})/dx = (r_{hj}/n_j v)$	J
11	Moisture Mass	$d(\alpha_{wj})/dx = -(r_{wj}/n_j v)$	J

to the gas. Q_{cb} is the convective heat transfer from the gas to the boundary or reactor walls. The last term is the energy carried to the gas by the mass addition from the particle phase, The summation over each of the partcle terms accounts for all particle classifications.

Equation 6 is the analogous particle phase energy equation. Energy exchange due to secondary mixing or recirculation of jth particle phase is accounted for in the first two terms. The particle energy is similar to the gas phase energy equation with the exception of two radiation terms and no convective wall term. The radiation terms include particle phase radiation but with the assumption of no gas phase radiation. Q_{fj} accounts for particle-particle radiation within the reactor. Q_{rbj} is the radiative heat transfer rate from the particle cloud to the reactor boundaries. There is a separate particle energy equation for each particle phase. The Q_j term arising in both the particle and gas energy equations results in the tightest coupling of any of the differential equations. Numerical techniques which are used to avoid problems with this tight coupling are discussed in the Solution Technique section.

Equation 7 represents the linear rate of change of the particle number for each of the j particle types. The only source or sink terms in this case are recirculation or secondary mixing of the jth particle class. In other words, if there is no recirculation or secondary addition of the coal particles in the jth classification, then the number of particles passing any point in the reactor per unit time (vn_jA) is constant. This observation emphasizes another approximation in the coal reaction model. The particles are not allowed to break or fragment during the history of the reaction process. Some studies, such as Padia et al. (20), have counted many more particles (up to 3-5 per coal particle) evolving from the combustion process than were input; however, the fragmentation is thought to occur during the final burnout phases of char combustion when the fine ash structure is not mechanically strong enough to remain integral. This being the case, the assumption of no fragmentation may not introduce significant error in the estimate of particle burnout times. It should be realized that this approximation is at least a conservative one, since smaller fragments should react even faster than the larger particles.

Equation 8 represents the rate of change of the gas phase mass flow rate and is exactly analogous to Eq. 4. It is also the sum of the gas element balances (Eq. 3) over all of the elements. Equation 3 and 8 are independent equations. It is possible to write continuity equations for each element mass fraction (ω_k), the sum of the mass fractions ($\Sigma\omega_k = 1$), and an overall gas phase mass continuity (w_g). Thus, there are $(K + 2)$ equations, of which any $(K + 1)$ are independent. 1-DICOG makes use of the equations in ω_k and w_g. The sum of the mass fractions is not used. The solution of Eq. 8 gives the history of the gas phase mass flow rate. With this information and the solution to Eq. 1 for each element, the history of the gas phase elemental composition is known.

Equations 9 through 11 show the rate of change of each of the constituents of each of the particle classifications considered. Initially, the reacting particles are represented as being composed of specified amounts of raw coal (α_{cjo}), char (α_{hjo}), moisture (α_{wjo}), and ash (α_{ajo}). The only sink terms for any of these constituents is their respective reaction rate terms. Ash is defined in this code as that portion of the initial particle which is inert to any reaction. The ash content is thus constant, and no differential equation is required. The sign on the reaction rate term for the moisture mass is different from the others simply due to the definition of the reaction rates of the raw coal and char which, by convention, are taken to be the rate of disappearance of each of these constituents per unit volume of reacting, particle-gas mixture. All other reaction rates use the opposite convention.

The solution strategy for this set of 6J + K + 2 differential equations is given in the section entitled "Solution Technique". The solution of these equations determines the history of ω_k, w_j, h_g, h_j, n_j, w_g, α_{cj}, α_{hj} and α_{wj}.

C. ENTHALPY-TEMPERATURE RELATIONSHIPS

The temperature of the gas and particle phases are determined by tracking the enthalpy of each phase by means of the differential energy equations represented in Eqs. 5 and 6 of Table 2. Auxiliary enthalpy-temperature relationships are required to solve these energy equations and to obtain the temperature history for each particle classification and for the gas phase. These relationships are indicated in Table 3 and are now discussed in more detail.

The particle enthalpy is obtained directly from the particle differential energy equation. No additional enthalpy terms appear on the right hand side of Eq. 6 in Table 2 other than the dependent variable (h_j) itself. The temperature of the individual particle phase is determined directly from Eq. 12 of Table 3 once the enthalpy (h_j) has been found from the differential equation set. The finite difference approximation used is completely acceptable, since each element used for the differential equation solution technique must be small enough for only mild temperature changes to occur across it (see Solution Technique section). The heat capacity (C_{pj}) is treated as a quadratic equation in temperature. Since the particle temperature must be known to calculate the heat capacity and vice versa, the solution of Eq. 12 must be accomplished by iteration, but convergence is rapid and straightforward.

The gas temperature is calculated in the gas phase chemical equilibrium sub-routine but requires the pressure, the local enthalpy level and elemental composition of the gas phase as input. The gas enthalpy comes from the differetial energy equation which requires the term h_{jg} which appears on the right hand side of Eq. 6 in Table 2. The remainder of this section will deal with this term.

Equation 13 shows the constitutive equation used to calculate h_{jg}. This term represents the net enthalpy given to the gas phase due to products evolving from the jth particle phase. There are three sources of gaseous products in this coal particle model: devolatilization, heterogeneous char oxidation, and moisture vaporization. The corresponding terms appear on the right hand side of Eq. 13. The reaction rate fraction (i.e., r_{wj}/r_j) tells what fraction of each unit mass added to the gas

TABLE 3

1-DICOG CONSTITUTIVE EQUATIONS: ENTHALPY-TEMPERATURE RELATIONSHIPS

NO.	TYPE	EQUATION
12	Particle temperature	$\Delta T_j = \Delta h_j / C_{pj}$
13	Net particle product (gas) enthalpy	$h_{jg} = (\sum_m r_{vjm} h_{vjm} + h_{hj} \sum_\ell r_{hj\ell} + r_{wj} h_{wj}) / r_j$
14	Volatiles enthalpy	$h_{vjm} = \int C_{pvjm} dT_j + h^\circ_{vjm}$
15	Char enthalpy	$h_{hj} = \int C_{phj} dT_j + h^\circ_{hj}$
16	Mositure enthalpy	$h_{wj} = \int C_{pwj} dT_j + h^\circ_{wj}$

phase corresponds to the respective source. The denominator, r_j, being the total particle reaction rate (see Eq. 65, Table 8) and the terms in the numerator are the net rates for reaction of each source. The three enthalpy terms (h_{vjm}, h_{hj}, h_{wj}) represent the net energy level of each source. These enthalpies are calculated in the last three equations of Table 3.

At this point another modeling assumption is required. Since the three reactions which are responsible for exchanging matter and energy between the particle and gas phases are two-phase reactions, it is not immediately obvious to which phase to credit the heat of reaction. This credit (or debit for endothermic reaction) could be given to either the particle or the gas phase or both. Experimental evidence indicating which should be the proper choice is hard to obtain. Ayling, et al. (21) have reported measurements of both particle and gas temperatures in a reacting system. Their particle measurements seem to be 200-300 K higher than the gas temperatures indicating that the particle receives some of the heat of reaction. Since physical arguments could be made for all three cases and since this author feels that the experimental evidence is inconclusive, the choice is made, somewhat arbitrarily, to give all heats of reaction to the gas phase. This is the way the model was developed and coded. The methodology for the other two assumptions is given at the end of this section. It should be realized that whichever assumption is chosen it is not crucial to the overall prediction. 1-DICOG allows for energy exchange beteen the particle and gas phases by conduction, which gives rise to a certain amount of self-adjusting between the two phases.

Equations 14, 15 and 16 are all analogous. The enthalpy level of each constituent is composed of the integrated heat capacity and the standard heat of formation; however, this formulation requires some subtle observations. Since the heat of reaction of each is given to the gas phase, the heat of reaction does not even appear in the equations. All three terms (h_{vjm}, h_{hj}, h_{wj}) are based on the particle-phase constituents, not on the respective gas-phase constituents. The adiabatic reaction process may be considered to take place completely in the gas phase; therefore, the energy added is only that energy carried by the corresponding particle (solid) phase material being added to the gas. Figure 3 may help in visualizing this process. With the added assumption that the evolving gases from the particle are leaving at or near the particle temperature, the formulation is complete. With a quadratic equation in temperature for each of the heat capacities, the integration can be formally performed from 298 K to the particle temperature. The respective heats of formation (h°_{vjm}, h°_{hj}, h°_{wj}) are for each constituent in the particle phase. For example, the moisture may be considered to be bound in a liquid state thus:

$$h^\circ_{wj} = -3792 \text{ cal g}^{-1} \tag{17}$$

If the char is considered to be mostly solid carbon:

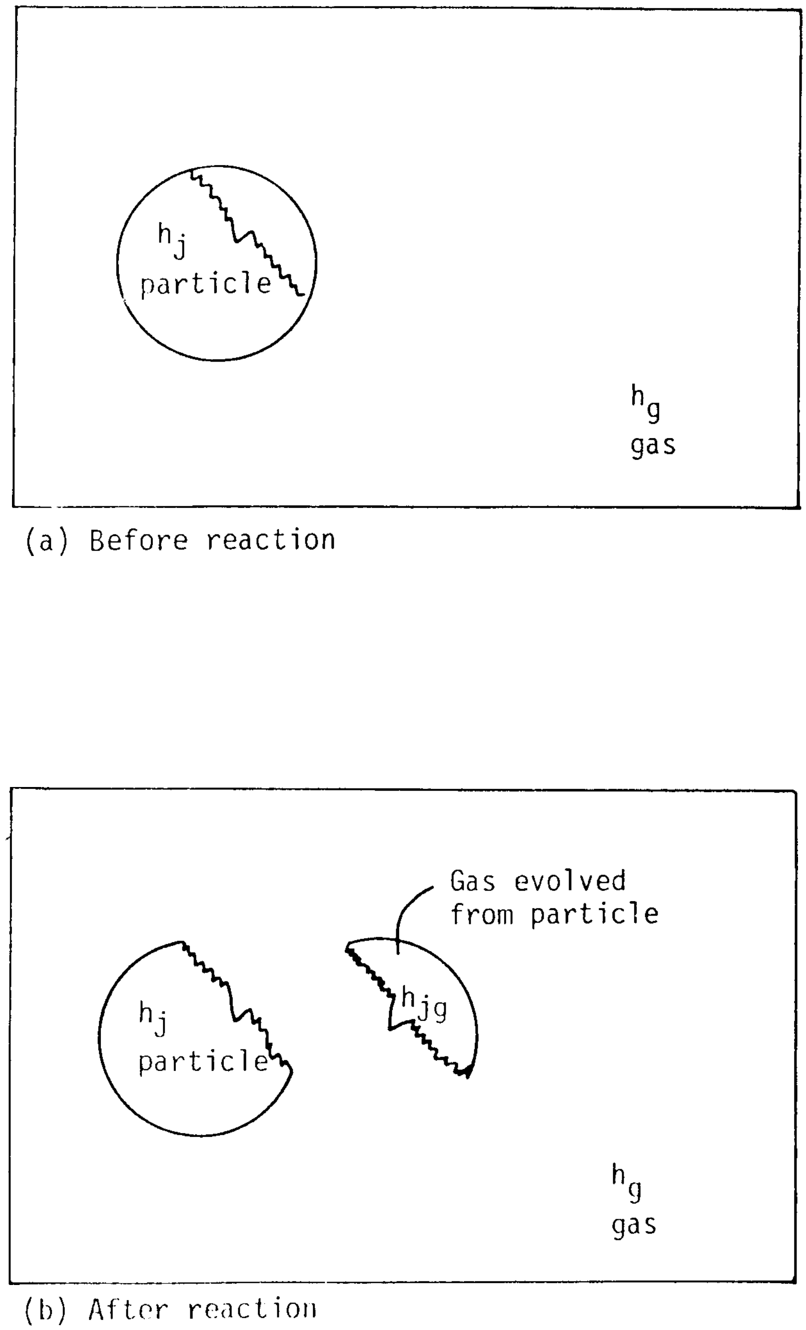


Figure 3. Schematic of energy partitioning during coal particle reaction.

$$h^{\circ}_{hj} = 0.0 \text{ cal g}^{-1} \tag{18}$$

An approximate heat of formation for the solid volatiles matter may be obtained from an ultimate analysis and heating value data of the coal. From Eq. 1 it can be seen that:

$$h^{\circ}_{(\text{raw coal})} = Y\, h^{\circ}_{(\text{vol.})} + (1 - Y)\, h^{\circ}_{(\text{char})}$$

$$h^{\circ}_{(\text{vol.})} = h^{\circ}_{(\text{raw coal})}/Y \tag{19}$$

The raw coal is the dry, ash-free portion of the coal analysis; thus:

$$h^{\circ}_{vj} = h^{\circ}_{(\text{vol})} = h^{\circ}{}_{(\text{DAF coal})}/Y$$

$$= [h^{\circ}_{(\text{total combustion products})} + (\text{heating value of DAF coal})]/Y \tag{20}$$

Finally, how does the formulation change if it is assumed that the heat liberated during particle reaction is assigned to the particle phase instead of the gas phase or if the heats of reaction were partitioned between the two phases? The approach is straightforward. When all heats of reaction are given to the solid phase, Eqs. 14, 15 and 16 of Table 3 must be charged for these heats of reaction; therefore,

$$h_{vjm} = \int C_{pvjm}\, dT_j + h^{\circ}_{vjm} - \Delta h_{vjm} \tag{21}$$

$$h_{hj} = \int C_{phj} dT_j + h^{\circ}_{hj} - \Delta h_{hj} \tag{22}$$

$$h_{wj} = \int C_{pwj} dT_j + h^{\circ}_{wj} - \Delta h_{wj} \tag{23}$$

where the h terms represent the respective heats of reaction in question. In addition, these heats of reaction must be given to the solid phase and Eq. 6 of Table 2 must have the following term added to the right hand side:

TABLE 4

1-DICOG CONSTITUTIVE EQUATIONS: PHYSICAL PROPERTIES

NO.	TYPE	EQUATION
25	Particle heat capacity	$C_{pj} = \omega_{hj}C_{phj} + \omega_{cj}C_{pcj} + \omega_{wj}C_{pwj} + \omega_{aj}C_{paj}$
26	Gas species conductivity	$k_i = [C_{pi} + (5R/4M_i)]\mu_i$
27	Gas mixture conductivity	$k_g = \sum_i [X_i\ k_i/\sum_k X_k\phi_{ik}]$
28	Gas species viscosity	$\mu_i = 2.67 \times 10^{-5}(M_i T_g)^{1/2}/\sigma_i^2\Omega_\mu$
29	Interaction parameter	$\phi_{ik} = (1/8)^{1/2}[1 + M_i/M_k)]^{-1/2}[1 + (\mu_i/\mu_k)^{1/2}(M_k/M_i)^{1/4}]^2$
30	Gas mixture viscosity	$\mu_g = \sum_i [X_i\mu_i/\sum_k X_k\phi_{ik}]$
31	Species diffusivity	$D_{ik} = 1.84 \times 10^{-3}\ T_g^{3/2}\ [(1/M_k) + (1/M_i)]^{1/2}/p\sigma_{ik}^2\Omega_d$
32	Mixture diffusivity	$D_{im} = (1 - X_i)/\sum_{i\neq k}(X_k/D_{ik})$
33	Particle diameter	$d_j = d_{jo}[1 + \gamma(\alpha_{cjo} - \alpha_{cj})/\alpha_{cjo}]$
34	Particle surface area	$A_j = \pi d_j^2$

$$+ A(\sum_m r_{vjm}\, \Delta h_{vjm} + \Delta h_{hj} \sum_\ell r_{hj\ell} + r_{wj}\, \Delta h_{wj}) \tag{24}$$

If partitioning of the heats of reaction between the particle and gas phase is desired, all the respective heats of reaction need only be weighted by that proportion which is to be given to the particle phase.

D. PHYSICAL PROPERTIES

A number of physical properties of the gas and particle phases are required. Table 4 shows how each of these are calculated. Equation 25 simply shows how to calculate the weighted heat capacity for the jth particle type. This comes from the coal model depicted in Figure 2 which shows the four constituents of the modeled particle. As in the previous section, all heat capacities are given as quadratic equations in temperature. The constituent particle mass fractions are calculated directly from the local constituent mass as obtained from the differential equation set (Eqs. 9, 10, 11 of Table 2). For example:

$$\omega_{hj} = \alpha_{hj}/\alpha_j \tag{35}$$

where

$$\alpha_j = \alpha_{cj} + \alpha_{hj} + \alpha_{wj} + \alpha_{aj} \tag{36}$$

The overall particle heat capacity (C_{pj}) is needed to determine particle temperature in Eq. 12 of Table 3.

Equations 26 and 27 comprise the computations for the gaseous thermal conductivity which will be needed in the convective and conductive heat transfer calculations. These equations are based on a semi-empirical method of handling energy exchange in polyatomic gases Bird et al. (19). Equation 26 shows Euken's formula for a single gaseous species i and Eq. 27 shows the equation used to estimate the conductivity of a gaseous mixture (22). This procedure requires the individual species viscosity (μ_i) and the coefficient ϕ_{ik} defined in Eq. 29.

The gaseous viscosity is calculated by means of Eqs. 28, 29 and 30. Equation 28 for a single gaseous species is based on a derivation for pure monatomic gases. The Stockmayer collision diameter σ and collision integral Ω_μ, which is a slowly varying function of the dimensionless temperature (kT/ε) and the polar parameter (δ = (dipole moment)$^2/2\varepsilon\sigma^3$), may be obtained from tabulated values (23). As with the thermal conductivity, the semi-empirical formula of Wilke (19) is used for the viscosity of the multicomponent gas mixture at low densities through Eq. 30.

The mass diffusivity for a single gaseous species i through the gas mixture m is determined with Eqs. 31, 32. This diffusivity is needed in both the devolatilization and oxidation equations and in the heat transfer equations. For ordinary binary diffusion, the ChapmanEnskog formula for gaseous diffusivity at low density and for an ideal gas is given in Eq. 31 (19). The collision integral for diffusion Ω_d is a dimensionless function of the temperature and of the intermolecular potential field for one molecule of i and one of k. This function can be conveniently approximated by a Lennard-Jones function, (19, 23). This requires a suitable estimate of the Lennard-Jones parameters σ_{ik} and ε_{ik} from the individual species parameters σ_i and ε_i by

$$\sigma_{ik} = 1/2(\sigma_i + \sigma_k) \tag{37}$$

$$\varepsilon_{ik} = \sqrt{\varepsilon_i \varepsilon_k} \tag{38}$$

The effective binary diffusivity of species i in the multicomponent mixture (D_{im}) is calculated as shown in Eq. 32. This formulation assumes that each species in the mixture moves with the same velocity (19).

Finally, the physical characteristics of the jth particle type are calculated with Eqs. 33 and 34. The particle is allowed to swell linearly with the extent of devolatilization as shown in Eq. 33. The swelling coeffecent y must be specified a priori. This swelling during devolatilization is an experimentally observed phenomenon (24). This average particle diameter increase is often in the order of 10% (25). Experimental quantification of particle diameter change after devolatilization and during heterogeneous char oxidation do not seem to be available. Two possible options regarding the diameter of the char residue have been proposed and incorporated in the model. After devolatilization, the particle could be envisioned as a porous sphere where reaction takes place mainly within the pores themselves. As char combustion proceeds, the particle diameter can be taken to remain relatively constant, but with variable density until breakup or complete burnout of the fuel. This situation seems to be substantiated by visual observation of scanning electron micrographs of coal particle samples taken from combustors (24, 1, 26). Alternatively, the particle may be perceived to react mostly on the surface and thus burn out at a near constant density but as a shrinking particle. In this case

$$d_j = [6\alpha_j/(\pi\rho_{\sigma j})]^{1/3} \tag{39}$$

where ρ_{sj} is the solid density of the jth particle type after complete devolatilization (ie. when α_{cj}=0). Both options have been coded in 1-DICOG. External particle surface area is shown in Eq. 34.

The calculations of gaseous properties such as thermal conductivity, coefficient of viscosity, and mass diffusivity require a large number of algebraic computations for each individual species as well as summations over all species. To minimize computational time, these iterative calculations for physical properties have been modularized in the computer code. This permits these calculations to be performed only when required due to significant property variations, rather than at every element. This strategy for computational efficiency is discussed further in the Solution Technique section.

E. RADIATIVE HEAT TRANSFER

The processes involved in coal conversion systems are known to be strongly influenced by radiative heat transfer within the reactor (27). Table 5 summarizes the equations required to solve the radiative interchange within a one-dimensional, particle-laden reacting system. The additional assumptions are made of a radiatively transparent gas phase and radiatively gray, non-scattering particles. The only radiative energy transfer is thus between the particles within the reactor and between the particle cloud and the reactor walls.

Radiative transfer involves an integral analysis arising from integration over all of the individual surface areas which are emitting and absorbing energy throughout the entire system. The zone method (27) is a rigorous technique for determining radiative transport, given the temperature and number density distributions. Its weakness lies in obtaining these distributions and in uncertainty of radiative properties of the solids. The resulting problem is solved by assuming an initial distribution for all T_j and n_j, calculating the resulting radiative fluxes by the zone method and then solving all the differential and constitutive equations with the given radiative transfer as input. The assumed profiles are then updated and the procedure is repeated. This iterative technique for the zone method is discussed further in the Solution Technique section.

The one-dimensional nature of this model simplifies the radiation solution technique. The entire length of the reactor is divided into a number of zones (usually about 250), each assumed uniform in ε_j and T_j and thin enough so that it may be assumed that no particle is hidden from view by any other particle within the zone. It is emphasized that in the formulation of 1-DICOG, these radiation regions or zones do not usually correspond with the elements used for numerically solving the differential equation set.

Equation 40 shows the net rate of radiative heat transfer per unit reactor volume to the jth particle classification from all other particles within the reactor. The first term on the right hand side depicts the absorbed portion of the total radiative energy arriving at that particle type surface per unit volume from all other particle surfaces within the reactor. The absorptivity is assumed equal to the

TABLE 5

1-DICOG CONSTITUTIVE EQUATIONS: RADIATIVE HEAT TRANSFER

NO.	TYPE	EQUATION
40	Radiative heat transfer in reactor	$Q_{fj} = (\pi/4) I_{qt} n_j d_j^2 \varepsilon_j - I_{qoj}/\Delta x_p$
41	Local radiative intensity	$I_{qt} = \sum_p I_{pq}$
42	Radiative emission	$I_{poj} = (a_j\ T_j^4)_p\ \sigma \Delta x_p$
43	Radiative intensity	$I_{pq} = (\sum_j I_{poj})\ \exp[-\sum_{p \neq q} (\sum_j a_j)_p \Delta x_p]$
44	Radiative adsorption coefficient	$a_j = (\pi/4)\ \varepsilon_j n_j d_j^2$
45	Radiative heat exchange	$Q_{rbj} = (4\sigma\varepsilon_b/D_s)(T_j^4 - T_b^4)\{1 - \exp[-E_\lambda(\pi/4)(D_s/2)d_j^2 n_j]\}$

emissivity ε_j. I_{qt} is the total intensity of the radiative energy reaching the zone q where the local n_j and d_j are assumed known. The second term depicts the energy emitted from the jth particle type originating in the qth zone.

Equation 41 shows how the total radiative intensity arriving at each zone q must be summed over all zones in the reactor. Eq. 42 represents the energy intensity emitted from the jth particle type at each of the p zones. Equation 43 is simply the Bouger-Lambert Law (27) for the attenuation of the one-dimensional beam due to its passage through the absorbing, non-scattering, particle cloud. The exponent term is the transmittance of the beam and ($\Sigma_j I_{pqj}$) is the intensity entering the p zone of thickness Δx_p. The radiative absorption coefficient for each particle type in each zone is given the local properties by means of Eq. 44. If both absorption and scattering were to be considered, this coefficient should be the total extinction coefficient, which would be the sum of the given absorption coefficients and scattering coefficients.

The above scheme is formal and correct with the given assumptions; however, it gives rise to some significant numerical problems in some applications. As mentioned previously, the zones must be selected so that each particle is optically visible; in other words, no significant attenuation must take place across the chosen radiative zone. Some gasification systems at high pressure and heavy particle loading do not readily satisfy the criterion. The BI-GAS gasification system is a case in point (28). In this case the optical depth is so small that the zone technique requires unrealistically small zones. In such cases improved computational efficiency and accuracy is achieved by treating the radiative transfer as a diffusion process for such systems.

For optically dense systems, Eq. 15 may be replaced by the diffusion equation as shown by Hottel and Sarofim (27).

$$Q_{fj} = \frac{-16\sigma T_j^3}{3\Delta x_p(\Sigma_j a_j)} \quad \frac{dT_j}{dx} \qquad (46)$$

The derivative of the jth particle temperature may be expressed in terms of the differential equation variables of Table 2 as follows:

$$\frac{dT_j}{dx} = \left[\frac{d(w_j h_j)}{dx} - h_j \frac{dw_j}{dx}\right] (1/w_j C_{pj}) \qquad (47)$$

When Eq. 47 is substituted into Eq. 46 and subsequently into Eq. 6 of Table 2 and rearranged, the particle energy equation becomes:

$$\frac{d(w_j h_j)}{dx} = \left(\frac{1}{1 - AC_{rj}}\right) \left[m_{sj}h_{sj} + m_{\rho j}h_{\rho j} - A\left(C_{rj}h_j\frac{dw_j}{dx} + Q_{rbj} + Q_j + r_j h_j\right)\right] \tag{48}$$

where:

$$C_{rj} = (-16\sigma T_j^3)/(3\Delta x_p(\sum_j a_j)w_j C_{pj}) \tag{49}$$

This approach greatly simplifies the solution strategy for optically thick systems, since the radiation treatment no longer needs an iterative technique but can be solved directly with the differential equations. In this case, Δx_p becomes the volume element width. The reason for this simplification is that the diffusion approximation transforms the integral equations for radiation into differential equations of a form similar to the other differential equations of the model. 1-DICOG is coded to permit calculation by either the zone method or the diffusional approximation method described above.

Equation 45 presents the radiative heat transfer rate per unit reactor volume for energy exchange between the reactor walls and the cloud of the jth particles. This approximation assumes a gray, bounding surface with equal emissivity and absorptivity ε_b. The particle cloud is also assumed to have equal emissivity and absorptivity, approximated by the terms enclosed within the braces. This expression allows for reduction of either of the primary beams, (i.e. cloud to surface or surface to cloud). Secondary reflections are ignored. If the wall is considered black, there are no secondary reflections. The exponent within the brackets assumes spherical particles and a characteristic dimension taken to be the radius of the vessel ($D_s/2$). The other terms in the exponent between the brackets represent the projected area of randomly oriented particles with no negative curvature. E_λ is an absorption efficiency and usually taken as unity. In order for Q_{rbj} to have the proper units, the area to volume ratio of the reactor must be identified. The term ($4/D_s$), contained within the first set of parenthesis on the right hand side of Eq. 45 represents the cylindrical geometry chosen for 1-DICOG.

F. STATE AND MASS FLOW CONTINUITY

This set of constitutive equations shown in Table 6 is straightforward and requires little explanation. Eq. 50 shows the ideal gas equation of state chosen for this formulation for its simplicity and accuracy for high-temperature systems. Equations 52 through 57 show how the total particle mass is composed of each of its constitutive

TABLE 6

1-DICOG CONSTITUTIVE EQUATIONS: STATE AND MASS FLOW CONTINUITY

NO.	TYPE	EQUATION
50	Molar gas concentration	$C_g = p/RT_g$
51	Gas velocity	$v = w_g/\rho_g A$
52	Particle density	$\rho_j = \rho_{cj} + \rho_{hj} + \rho_{aj} + \rho_{wj}$
53	Coal density	$\rho_{cj} = \alpha_{cj} n_j$
54	Moisture density	$\rho_{wj} = \alpha_{wj} n_j$
55	Char density	$\rho_{hj} = \alpha_{hj} n_j$
56	Ash density	$\rho_{aj} = \alpha_{aj} n_j$
57	Particle mass	$\alpha_j = \alpha_{hj} + \alpha_{cj} + \alpha_{aj} + \alpha_{wj}$

parts, raw coal, char, ash and moisture. The density of each constituent (constitutive particle mass per unit reactor volume) is obtained from the constituent mass and the particle number density, each of which is obtained from the differential equation set.

Equation 51 deserves some discussion. In the formulation of 1-DICOG, the assumption is made of no velocity lag between the particle and gas phases; thus, the velocity of the gas is also the velocity of each particle. In addition, the particles may be assumed to occupy a negligible volume as compared to the gas phase volume. Under these conditions, the velocity is calculated directly from the equation of continuity for the gas phase as shown in Eq. 51. This approach alleviates the need to solve a momentum differential equation. Since the completion of 1-DICOG, there has been some motivation to incorporate the effects of particle drag. It is thought that the most significant effect would be to alter the particle-gas heat transfer rates due to increased convection. Stickler et al. (18) have incorporated particle lag by tracking the velocity difference between each particle classification and the gas phase. By assuming that the time scale for particle acceleration is small compared to that for mass loss, explicit integration of a conveniently chosen drag law reduces the formulation to a simple algebraic equation. This approach is feasible with 1-DICOG but is not included in the present version.

G. CONVECTIVE AND CONDUCTIVE HEAT TRANSFER

All heat transfer within the reactor comes from either radiation or conduction. Conduction may also be modified or augmented by convective flow. The previous Radiative Heat Transfer section, discussed the assumptions and equations for radiative heat transfer in 1-DICOG. This section concludes the discussion and heat transfer phenomena. An important aspect of the conductive/convective heat transfer is the effect of simultaneous mass transfer. The mass transfer aspects of the problem are discussed in more detail under the Particle Reactions section; thus, the next two sections are closely related.

Equation 58 of Table 7 represents the heat transfer rate per unit reactor volume between the jth particle classification and the gas phase. This equation reflects the assumptions of spherical particles and no slip between the gas and particle phases. The leading number 2 represents the mean conductive Nusselt Number for heat transfer from spheres without the presence of particle blowing. The term enclosed between brackets is the correction on the heat transfer rate for the presence of mass transfer or particle blowing. Smith (29) discusses the derivation of this term based on classical film theory as well as introducing other approximate corrections from other considerations. The blowing parameter or transpiration parameter for heat transfer is given in Eq. 60. The relationship of this parameter to that for mass transfer is also discussed in Smith (29). A transformed form of this parameter is sometimes called the Spalding Number (see Smith 29). The resulting Q_j is required for both the particle and gas differential energy equations.

TABLE 7

1-DICOG CONSTITUTIVE EQUATIONS: CONVECTIVE AND CONDUCTIVE HEAT TRANSFER

NO.	TYPE	EQUATION
58	Particle-gas heat transfer	$Q_j = 2\pi[B_j/(\exp B_j - 1)]k_g(T_j - T_g)d_j n_j$
59	Convective heat exchange with surroundings	$Q_{cb} = 4h_m(T_g - T_b)/D_s$
60	Transpiration parameter	$B_j = r_j C_{pg}/2\pi d_j k_g n_j$
61	Heat transfer coefficient-wall losses	$(h_m D_s/k_g) = 0.023\ (Re_g)^{0.8}(Pr_g)^{1/3}$
62	Reynolds No.	$Re_g = D_s w_g/(\mu_g A_s)$
63	Prandtl No.	$Pr_g = (C_{pg}\mu_g/k_g)$

The sub-section entitled State and Mass Flow Continuity introduced a method of incorporating particle drag. Correspondingly, Eq. 58 would require modification. The mean Nusselt Number without mass transfer would change from 2.0 to

$$Nu_{jg} = 2.0 + 0.65\ (Re_{jg})^{1/2}(Pr_g)^{1/3} \tag{64}$$

or some similar expression to account for the enhanced convective flow (see for example Kreith, (30)). Here Re_{jg} is the local relative Reynolds Number between the jth particle group and the gas.

The energy balance also accounts for convective heat exchange of the gas phase with the reactor walls. Equation 59 shows the expression for calculating Q_{cb} as a function of a mean heat transfer coefficient (h_m). This heat transfer coefficient can be obtained through empirical correlations for the Nusselt Number such as shown in Eqs. 61 to 63 (30).

H. PARTICLE REACTIONS

This section discusses each of the reactions involved in the reaction model of the jth particle classification. The rate expression for each is presented and the effect of oxidizer diffusion and high rates of mass transfer or particle blowing are incorporated. As presented schematically in Figure 2, the three overall mass loss processes for each particle are moisture vaporization, devolatilization and heterogeneous char oxidation. The corresponding equations are shown in Table 8. The model allows one moisture vaporization rate expression per particle, M devolatilization reactions per particle type of the form shown in Eq. 1, and L char oxidation reactions per particle type of the form shown in Eq. 2. Each of these reaction sets will be discussed in turn. The total reaction rate of the jth particle classification per unit reactor volume is then the sum of each of these reactions, (L+M+1) in total number, as shown in Eq. 65.

The moisture vaporization rate is computed from the rate of diffusion of the moisture from the particle surface to the bulk gas phase. At the particle surface, the moisture mole fraction is assumed to be in equilibrium with the particle and is therefore be calculated from the equilibrium vapor pressure by use of Raoult's Law, as shown in Eq. 77. The vapor pressure is calculated from the particle temperature by either an Antoine Eq. 7 or an empirically fitted, five-term, power series in particle temperature. 1-DICOG was coded for either option. The resulting moisture vaporization rate, corrected for the presence of high mass transfer rates, is shown in Eq. 76. The derivation of this type of expression is discussed in Smith (29).

The devolatilization reaction Eq. 1 for the jth particle has been proposed by Ubayakar et al. (31). The kinetic rate of production of volatiles from the mth reaction is given in Eq. 72, where the reaction rate constant is given in Eq. 75 and the mass density of the raw coal

TABLE 8

1-DICOG CONSTITUTIVE EQUATIONS: PARTICLE REACTIONS

NO.	TYPE	EQUATION
65	Particle reaction rate to gas phase	$r_j = \sum_\ell r_{hj\ell} + \sum_m r_{vjm} + r_{wj}$
66	Net char reaction rate	$r_{hj} = \sum_m r_{hjm} - \sum_\ell r_{hj\ell}$
67	Oxidizer-char reaction rate	$r_{hj\ell} = (A_j n_n)^2 M_{hj} M_g \phi_\ell k_{cj\ell} k_{j\ell} \zeta_j C_{o\ell g} C_g / [M_g A_j n_j C_g (\zeta_j k_{j\ell} + k_{cj\ell}) + r_j]$
68	Kinetic char rate	$k_{j\ell} = A_{j\ell} T_j^m \exp(-E_{j\ell}/RT_j)$
69	Transpiration parameter for mass transfer	$B_{mj} = r_j/(2\pi D_{om} \rho_g d_j n_j)$
70	Char mass transfer coefficient	$k_{cj\ell} = 2D_{om} B_{mj}/[d_j(\exp B_{mj} - 1)]$
71	Total coal reaction rate	$r_{cj} = \sum_m r_{cjm} = -[\sum_m (r_{hjm} + r_{vjm})]$
72	Volatiles reaction rate	$r_{vjm} = k_{mj} Y_{mj} \rho_{cj}$

TABLE 8 (Cont.)

NO.	TYPE	EQUATION
73	Char production rate	$r_{hjm} = r_{vjm}(1 - Y_{mj})/Y_{mj}$
74	Gas element production	$r_{jk} = \phi_{wjk} r_{wj} + \sum_{\ell} \phi_{hk\ell} r_{hj\ell} + \sum_{m} \phi_{vjkm} r_{vjm}$
75	Coal kinetic rate	$k_{mj} = A_{mj} \exp(-E_{mj}/RT_j)$
76	Moisture vaporization rate	$r_{jw} = [2\pi B_{mj}/(\exp B_{mj} - 1)] C_g M_w (X_{wj} - X_{wg})\ d_j n_j D_{wg} + x_{wj} r_j$
77	Moisture equilibrium mole fraction	$X_{wj} = p_{ej}/p$

per unit reactor volume (ρ_{Ci}) was previously explained in Eq. 53 of Table 6. It is possible that volatile products could accumulate at the particle surface and in the particle pores. In this case, the rate of volatiles depletion would be affected by diffusion or convection from particle blow holes and from the immediate surface into the bulk gas phase while competing with condensation or repolymerization processes. If this were true, diffusion would affect the reaction rate and an expression similar to the moisture vaporization rate could be included (also see Smith (29)). It is important to realize that diffusional effects only become important when the volatiles can repolymerize or condense prior to diffusion into the gas phase. Because of uncertainties in the repolymerization rate coefficients, the nature of the volatiles diffusion process, and because the techniques and models used to correlate existing pyrolysis data most often have utilized forms like Eq. 72, 1-DICOG has been formulated with the pyrolisis model based on Eq. 72.

The recommended rate constants for devolatilization are shown in Table 9. The chosen two-step mechanism of Ubhayakar et al. (31) seemed to be a reasonable compromise between the simple one-step mechanism of Badzioch et al. (12), which would not account for the effect of particle history on volatiles yield, and a more complex, multistep mechanism of (i.e., Reidelbach and Summerfield (33)) which could increase computational time.

In accordance with Eq. 1 the devolatilization of the raw coal also produces char. A simple mass balance results in the rate of formation of char from the jth particle type per unit reactor volume from the mth reaction as shown in Eq. 73. Finally, the net rate of disappearance of the raw coal in the jth particle class may be obtained by summing over all of the m reactions. The rate of raw coal disappearance is the negative of the sum of the rate of char and volatiles formation according to Eq. 1 and as shown in Eq. 71.

Char is assumed to react heterogeneously by a gaseous oxidizer that diffuses to the particle surface, adsorbs, reacts with char, desorbs and diffuses back into the bulk gas phase. Two rate-limiting steps are considered for this process: (1) gas phase diffusion and (2) heterogeneous reaction. The combined reaction rate is given in Eq. 67. The derivation of this equation is shown in Smith (29). In this form of the equation, the surface reaction has been assumed to be first order in the surface concentration of the oxidizer. The Arrhenius expression for the rate constant is given in Eq. 68. Following the recommendations of Smoot and Pratt (17), values of the experimental constants are shown in Table 9. The mass transfer coefficient, which is also required must be corrected for particle blowing or high rates of mass transfer according to one of the theories discussed in Smith (29). The mass transfer coefficient without blowing may be calculated from an empirical correlation for the Sherwood Number such as (19):

TABLE 9

SELECTED KINETIC PARAMETERS FOR 1-DICOG

PROCESS	REFERENCE	REACTION	RATE CONSTANT	PARAMETERS
Devolatilization	Ubayakar et al. (17)	raw coal $\xrightarrow{k_1}$ $Y_1(\text{volatiles})_1 + (1-Y_1)(\text{char})$	$k_1 = A_1 \exp(-E_1/RT_j)$	$Y_1 = 0.39$
		simultaneously with reaction 2		$A_1 = 3.7 \times 10^5\ s^{-1}$
				$E_1 = 17.6$ kcal mol^{-1}
		raw coal $\xrightarrow{k_2}$ $Y_2(\text{volatiles})_2 + (1-Y_2)(\text{char})$	$k_2 = A_2 \exp(-E_2/RT_j)$	$Y_2 = 0.8$
		simultaneously with reaction 1		$A_2 = 1.46 \times 10^{13}\ s^{-1}$
				$E_2 = 60.0$ kcal mol^{-1}
Char Oxidation with O_2	Field (20)	$2C + O_2 \xrightarrow{k} CO$	$k = T_j(A + BT_j)$	$A = -1.68 \times 10^{-2}\ ms^{-1}K^{-1}$
				$B = 1.32 \times 10^{-5}\ ms^{-1}K^{-2}$
Char Oxidation with CO_2	Mayers (21)	$C + CO_2 \xrightarrow{k} 2CO$	$k = AT_j^n \exp(-E/RT_j)$	$n = 1.0$
				$A = 4.40\ ms^{-1}K^{-1}$
				$E = 38.7$ kcal mol^{-1}
Char Oxidation with H_2O	Mayers (22)	$C + H_2O \xrightarrow{k} CO + H_2$	$k = AT_j^n \exp(-E/RT_j)$	$n = 1.0$
				$A = 1.33\ ms^{-1}K^{-1}$
				$E = 35.1$ kcal mol^{-1}

$$Sh = (k_{co} d_j)/(D_{im}) = 2.0 + 0.65\ (Re_{jg})^{1/2} (Sc)^{1/3} \tag{78}$$

where the Schmidt Number is $(\mu_g/\rho_g D_{im})$ and the Reynolds Number is based on the difference in velocity between the particle and the gas phases. When there is no particle lag, as is assumed in this version of 1-DICOG, this expression reduces to the theoretical value of 2.0 for molecular diffusion and the resulting expression for k_{co}, corrected for particle blowing, is given in Eq. 70. In this case, the blowing parameter is that for mass transfer as described in Smith (29) and shown in Eq. 69.

Since char is being formed by each of the m devolatilization reactions and also being depleted by each of the ℓ oxidation reactions, the net rate of char reaction is given in Eq. 66. Since the heterogeneous reaction is zero order with respect to the char concentration, heterogeneous ignition is permitted. Thus ignition phenomenon of the coal is not limited to devolatilization. Heterogeneous surface ignition is possible even if devolatilization has not been initiated.

Finally, each of the particle reactions act as a source for gas-phase material. In keeping with the local gas phase equilibrium assumption discussed in the next section, only element balances need be tracked. The total rate of production per unit reactor volume of the kth element from the jth particle is shown in Eq. 74. It is simply the sum of the stoichiometric coefficient times the reaction rate for each of the particle reactions. All of the r_{jk} values are needed for Eq. 1 of the differential equation set as shown in Table 2.

I. LOCAL GAS PHASE EQUILIBRIUM

By use of the gas phase continuity equation (Eq. 3, Table 2), the mass fraction of the elements in the gas phase may be followed. The energy balance for the gas phase (Eq. 5, Table 2) gives the history of the energy level throughout the reactor. This information, together with the specified reactor pressure, is sufficient to permit gaseous equilibrium calculations which produce the gaseous species composition and the local gas temperature. This local gas phase equilibrium assumption is justified if it can be assumed that the heterogeneous and particle reactions are much slower than gas phase kinetics. In addition, the one-dimensional assumption requires instantaneous radial mixing and ignores turbulent fluctuations. The equilibrium assumption is at least consistent with other levels of approximation in 1-DICOG.

Calculating the complex equilibrium states and temperature at prescribed pressure and enthalpy is not a simple task. Three schemes could be considered, namely: equating of forward and reverse rates, equilibrium constant formulation, and Gibbs function minimization. The first, dynamic equilibrium scheme, encounters all the difficulties of a full kinetic scheme. Even if all the reactions could be identified, there still remains the task of finding accurate experimental rate constants, to say nothing of the numerical scheme to solve the set of equations. The second scheme, the equilibrium constant approach, is perhaps the most familiar and conceptually the easiest to formulate; however, it is known to be equivalent to the Gibbs function minimization principle for a mixture at specified energy level and pressure, but is highly in efficient for complex chemical systems. The third scheme which determines the mixture composition corresponding to the minimum total Gibbs free energy of the reacting mixture was first described by White et al. (37). This approach has been proven to be vastly superior in its computational efficiency to the other schemes. Algorithms for calculating chemical equilibrium based on this principle have been developed. Among the more well known of these are the NASA-Lewis program (38) and the Edwards Air Force Base program (39). Both were developed for the aerospace industry.

1-DICOG was coded with a thermochemical equilibrium subroutine based on the Edwards program (39). The existing code was stripped of all statements not pertaining directly to the equilibrium calculations and then implemented straightforwardly. The efficiency of this subroutine is crucial since its complex equilibrium calculation may be performed as many as 30,000 times during the course of a computer computation for a typical coal reactor.

J. SPECIFIED MIXING PROCESSES

Since entrainment of the secondary air into the primary jet is a multidimensional process, it cannot be predicted by a one-dimensional calculation. Likewise, the recirculation process within the reactor is not predictable without multidimensional computations. These two processes are accounted for in 1-DICOG by the a priori specification of these respective rates of entrainment and recirculation (m_s, m_ρ). This section discusses ways of modeling these terms. It should be noted that 1-DICOG does not require either of these processes to be included. For example, if a plug flow approximation is valid throughout the computational domain, then m_s and m_ρ are set to zero.

1. Secondary Mixing

When incorporating the effects of secondary mixing, the one-dimensional scheme of 1-DICOG may be thought of as following the progress of the primary jet. As shown in Figure 4, the jet is assumed to expand into the reaction chamber at a growth angle θ. This jet expansion is observed to be nearly linear and appropriate values for the growth angle θ may be obtained from Abramovich (40). The flow within the jet is assumed to have a uniform velocity profile at all axial positions in accordance with the one-dimensional nature of the computation. The secondary stream is allowed to entrain into the primary jet at a mass addition rate m_s (mass of secondary per unit time per unit axial length). Several of these parameters must be identified to completely specify the problem, each of which is needed for the differential equation set of Table 2. These are:

m_{sg}: total mass addition rate of the gas from the secondary stream (g cm^{-1} s^{-1})

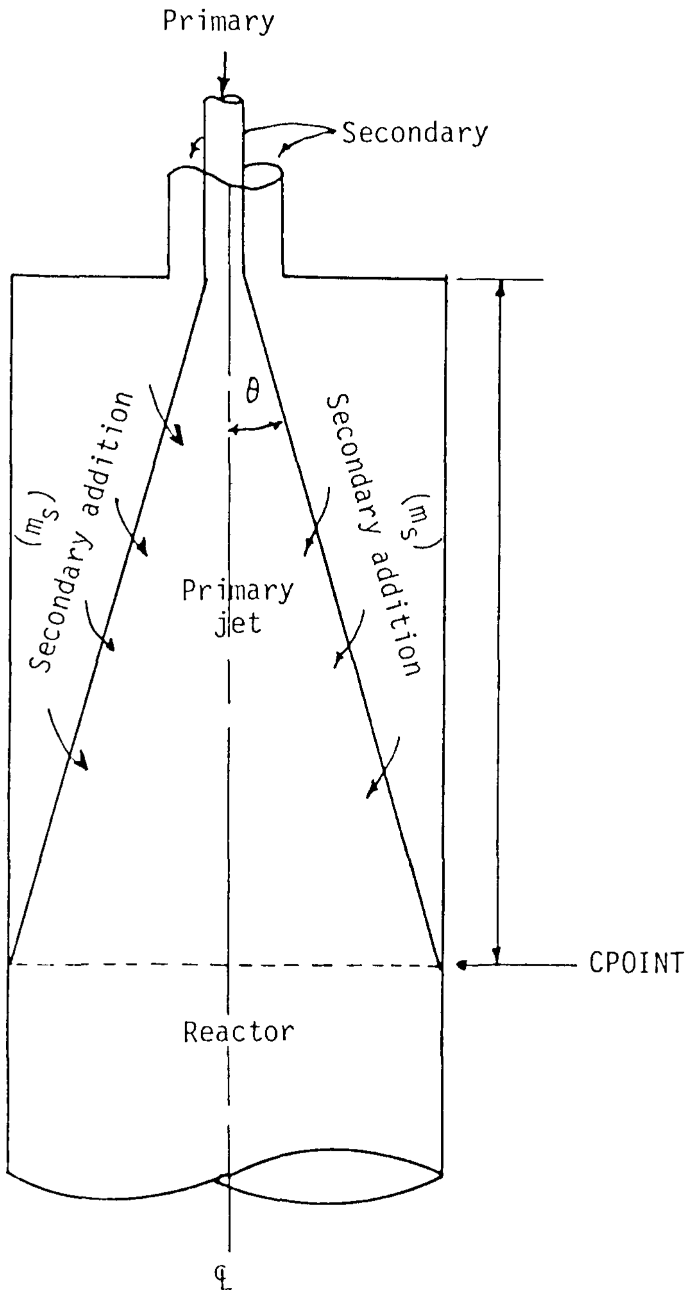


Figure 4. Schematic representation of the secondary mixing process.

m_{sj}: total mass addition rate of the jth particle classification from the secondary stream (g cm^{-1} s^{-1})

m_{sgk}: total mass addition rate of the kth gas phase element from the secondary stream (g cm^{-1} s^{-1})

h_{sg}: enthalpy of the gas phase portion of the secondary stream (g cm^{-1} s^{-1})

h_{sj}: enthalpy of the jth particle classification in the secondary stream (cal g^{-1})

Often, there are no particles in the secondary stream in which case $m_{sj} = 0$. The elemental mass addition rate (m_{sgk}) is readily obtained from the elemental composition of the secondary stream together with the secondary gaseous addition rate m_{sg}. The enthalpy levels of the secondary components (h_{sg}, h_{sj}) required by 1-DICOG from the reference state of 298 K, are evaluated at the secondary temperature. For example:

$$h_{sg} = h^{\circ}_{sg} + \int_{298}^{T_s} C_{psg}\, dT \tag{79}$$

This value is taken as constant throughout the mixing process.

The final value to be specified (m_{sg}), must be defined as an appropriate function of the axial coordinate x. In reference to Figure 4 the value of m_{sg} must be finite and positive for $0 < x <$ CPOINT and must have a zero value for all x = CPOINT. Within the code the FORTRAN variable CPOINT identifies the end of the mixing region. This value is obtained directly from the given growth angle r and the reactor dimensions. Any reasonable function for m_{sg} is permissible. An additional requirement is the conservation of mass such that:

$$w_{gs} = \int_{0}^{CPOINT} m_{gs}\, dx \tag{80}$$

Stickler et al. (18) have used an exponential form for m_{sg}. The present version of 1-DICOG is coded to handle any power series in x up to a quadratic. This could be easily altered to take any arbitrary function of x by changing only a few FORTRAN statements.

2. Recirculation

The recirculation process downstream of a sudden dump region fed by two coaxial jets with particles is extremely complex. If this process is to be specified in a one-dimensional framework, the description can only be expected to be qualitative at best.

The same parameters for recirculation must be prescibed for use in the differential equation set of Table 2 as were needed for secondary mixing; namely $m_{\rho g}$, $m_{\rho i}$, $m_{\rho gk}$, $h_{\rho g}$ and $h_{\rho i}$. Figure 5 schematically represents the recirculation process. In this case, there is a region of detrainment as well as one of entrainment with respect to the primary jet.

Determining the amount and distribution of recirculation of gases and particles is a difficult task. Thring and Newby (41) have proposed a simple theoretical treatment for recirculation based on empirical laws of entrainment for a free jet. More refined theories for confined jets have been put forward by Craya and Curtet (42), Barchilon and Curtet (42) and Hill (44). These empirical theories have been reviewed by Field et al. (6) and Beer and Chigier (45). None of these approaches were meant for two coaxial jets with a sudden-dump configuration, so they could not be expected to apply directly; however, they are able to give guidance for order-of-magnitude estimates of the amount of recirculating material.

To construct general functions in x for each of the gaseous recirculation parameters is difficult. An overall mass balance requires that:

$$\int_0^{CPOINT} (m_{\rho g} + \sum_j m_{\rho j})\, dx = 0 \tag{81}$$

In addition an overall energy balance requires that:

$$\int_0^{CPOINT} (h_{\rho g} m_{\rho g} + \sum_j h_{\rho j} m_{\rho j})\, dx = 0 \tag{82}$$

These two statements require that no net change in mass or energy is permitted through the recirculation process.

1-DICOG has been formulated and coded to allow the user to incorporate any function he deems realistic with a minimum of statement changes. The difficulty in formulating an approach lies in the fact that in the recirculation zone itself, the particles can continue to react. The extent of reaction is very much dependent on the point of exit from the primary jet, the length of time in the recirculation zone, and the

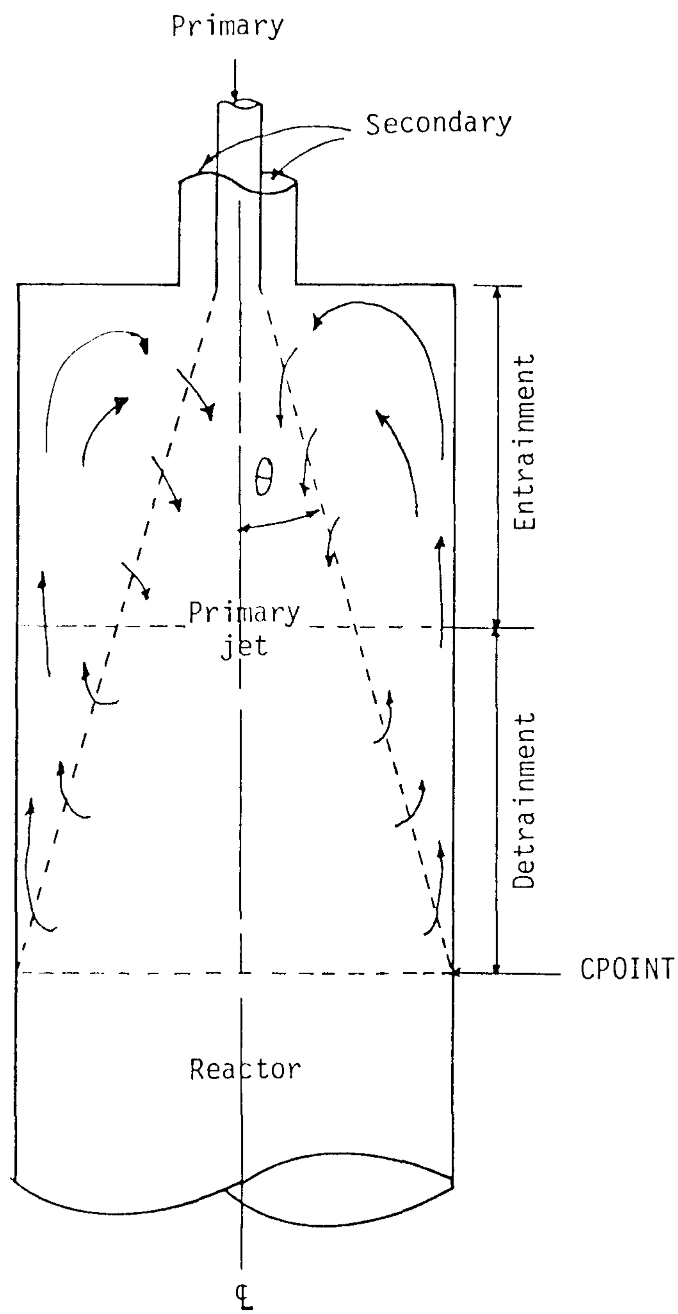


Figure 5. Schematic representation of the recirculation process.

point of reentry. The composition of the gas is also changing due to particle reaction in the recirculation zone. In addition, there will be a different history involved with the particles that are recirculated and those that are not. Without a full, multi-dimensional calculation, the exact influence of these parameters can not be stated. The approach which is outlined next is only meant to be an example of how this might be handled.

First, it has been observed experimentally (26) that, in some reactors, the particle dispersion is very much slower than gas mixing. In this limiting case, there are comparatively few particles that are recirculated. By making the assumption of no particle recirculation, the problem is already greatly simplified, since none of the particle recirculation parameters are required. The constraints are now reduced to:

$$\int_0^{CPOINT} m_{\rho g}\, dx = 0 \tag{83}$$

$$\int_0^{CPOINT} m_{\rho gk}\, dx = \int_0^{CPOINT} \omega_{\rho gk}\, m_{\rho g}\, dx = 0 \tag{84}$$

$$\int_0^{CPOINT} h_{\rho g} m_{\rho g}\, dx = 0 \tag{85}$$

Next, the midpoint of the recirculation zone is defined as the dividing point between detrainment and entrainment (see Figure 5). Since there are no particles in the recirculation zone, no reaction is allowed to take place in this region. The properties ($\omega_{\rho gk}$, $h_{\rho g}$) of this recirculating gas are chosen to be constant and equal to the properties of the gas stream at some average location in the detrainment stage of the process (for example where x = 3CPOINT/4). This means that $\omega_{\rho gk}$ and $h_{\rho g}$ can be factored from Eqs. 84 and 85 and all three constraints reduce to Eq. 83. The solution technique is iterative due to the radiation treatment. It is consequently, a straightforward matter to initially guess values for $\omega_{\rho gk}$ and $h_{\rho g}$ and find the correct values iteratively. Finally, $m_{\rho g}$ is defined as a function of x to meet the constraint of Eq. 83. A reasonable approach would be to choose any function symmetric about CPOINT/2 and the x axis. A simple but reasonable function is a straight line with x-intercept at CPOINT/2. The total mass flow rate of recirculated gas is determined by one of the integrals below

$$\int_0^{CPOINT/2} m_{\rho g}\, dx = \int_{CPOINT/2}^{CPOINT} -m_{\rho g}\, dx = w_{\rho g} \tag{86}$$

By choosing an appropriate $\omega_{\rho g}$ the problem is completely defined.

III. SOLUTION TECHNIQUE

The set of 6J + K + 2 first order, non-linear, ordinary differential equations of Table 2, and the associated constitutive algebraic equations must be solved simultaneously in a numerical scheme. The zone method for radiation and the recirculation treatment both require an iterative solution technique. The tight coupling between differential equations through particle-gas interaction terms causes numerical stiffness. The overall procedure for overcoming these obstacles and obtaining an economic and efficient solution procedure is discussed in this section.

A. DIFFERENTIAL EQUATION SOLVER

There are many numerical techniques available for solving ordinary differential equations. The solution strategy chosen for 1-DICOG was an Adams-Moulton PredictorCorrector method. Several recent, efficient implicit algorithms were also examined (46, 47). These methods require Jacobian information which cannot be obtained explicitly with the differential equations of Table 2. The Jacobian could be determined through a numerical differentiation scheme but this was not thought to be an efficient approach. This particular equation set requires a large amount of computation for an evaluation of a derivative. As can be studying Table 2, each time a derivative is to be determined all of the constituitive equations must be solved, including the complex thermochemical equilibrium algorithm. The attractive advantage of the predictor-corrector methods is that they require a minimal number of derivative evaluations to be computed at each step (as compared with four evaluations for the Runge-Kutta method, for example).

The method incorporated in 1-DICOG calls for an Adams-Bashforth Predictor, namely:

$$y_{n+1} = y_n + \frac{h}{24}(55y'_n - 59y'_{n-1} + 37y'_{n-2} - 9y'_{n-3}) \tag{87}$$

In this equation, y represents the independent variable and y' is the derivative with respect to the dependent variable, n is the particular step in question and h is the step size. The predicted function value is thus based on the last function value and the derivatives at four back points. The error term associated with this predictor (48) is:

$$\left(\frac{251}{6}\right) \frac{h^5 y^{(5)}}{5!} \tag{88}$$

After predicting the value of each function at (n+1) from Eq. 87 the predicted values of y_{n+1} are used in the differential equation set and in the constitutive equations to determine a predicted value for each derivative at (n+1). After this evaluation, the predicted value of the function is then corrected with an Adams-Moulton corrector

$$y_{n+1}^{(c)} = y_n + \frac{h}{24}(9y_{n+1}^{\prime(P)} + 19y_n' - 5y_{n-1}' + y_{n-2}') \tag{89}$$

In this equation, y_{n+1} is the corrected functional value at (n+1) and y_{n+1} is the predicted derivative at the (n+1) step. The accuracy is thus greatly enhanced. With the new corrected value of each function at (n+1), the derivatives may be updated from the differential equation set and the auxiliary equations.

It can be obviously proposed to first predict and then correct, and if the two are not close enough, the correction could be repeated several times, using the latest estimate of the derivative, until no appreciable change occurs. Hamming (48) points out that, as a matter of principle, it is generally better to shorten the interval than to do repeated evaluations of the corrector formula (Eq. 89). During application in 1-DICOG, where the system is very dynamic and changing radically from one region to the other, it can be more economic to repeat the corrector for a few steps than to change the step size for an entire region. The trade-off is optimized by finding which requires the minimum number of derivative evaluations. 1-DICOG has been coded to allow the user to apply as many or as few correctors as desired. The sum of the derivatives of all particle energy equations (Eq. 6, Table 2) is monitored continuously and if this sum changes drastically from predictor to corrector then another corrector and another evaluation are applied. The test is performed again to determine if any more correctors should be applied. The user specifies the convergence criterion as well as the maximum number of correctors permissible. The particle energy equations are used since they have been found to be a sensitive measure of the stability of the whole system. It appears that the coupling through Q_{ig} is so tight that it reflects the first signs of instability. The number of correctors applied at each computational step is printed on the output to allow the user to evaluate his choice of step sizes.

This Adams-Moulton predictor-corrector method requires the derivatives at four back points before it can be initiated. This function and derivative information for the first four increments are obtained by a regular Runge-Kutta, fourth-order method (48) namely

$$k_1 = hy'(x_n, y_n)$$

$$k_2 = hy'(x_{n+h/2}, y_{n+k_1/2})$$

$$k_3 = hy'(x_{n+h/2}, y_{n+k_2/2})$$

$$k_4 = hy'(x_{n+h}, y_{n+k_3})$$

$$y_{n+1} = y_n + (k_1 + 2k_2 + 2k_3 + k_4)/6 \tag{90}$$

As soon as the first four increments have been completed the Adams-Moulton Predictor Corrector technique is initiated.

With appropriate step-size control discussed below this differential equation solution procedure is found to give accurate results with good stabililty.

B. TREATMENT FOR RADIATION

The approach for the calculation of radiant energy transfer within the reactor was introduced in the section entitled Radiative Heat Transfer. The radiative heat transfer and the recirculating fluid mechanics are the only mechanisms which require an iterative solution procedure. In some isolated cases where the radiation may be closely approximated by a diffusion process (see the Radiative Heat Transfer section) and where recirculation is not considered, then the differential equations may be recast (particularly Eqs. 5 and 6 of Table 2) and solved directly with the methods described in the previous section with no iteration.

The iterative technique is initiated by guessing initial profiles for each particle classification for temperature (T_j), number particle density (n_j), diameter (d_j) and the required recirculation parameters (h_{pg}, ω_{pgk}). The subroutine INPUT in the present version of 1-DICOG generates initial guesses for these profiles if a restart data set is not specified. The restart data set is an ap ropriately formated output set these required variables from previous iterations or calculations of 1-DICOG. The user is thus allowed to stop 1-DICOG after any given iteration and continue without any penalty. This restart option also allows the user to find a previous computation to specify an initial guess for the new computation.

From these initial guessed profiles, the first estimate of radiative heat transfer is computed. The set of differential equations, with constitutive relations, is integrated along the reactor as described in the previous section. The resulting temperature profile and local properties are used to compute radiative tranfer for the next iteration. This process is repeated until the user-specified convergence level is achieved. The convergence criterion is defined as a variation in the root mean square of the temperatures of each particle classification as follows:

$$\text{SUMSQ} = \left[\frac{1}{PJ} \sum_p \sum_j (T_{jold} - T_{jnew})_p^2\right]^{1/2} \qquad (91)$$

where P is the total number of increments, J is the total number of particle types, T_{jold} is the jth particle temperature of the last iteration, and T_{jnew} is the jth particle temperature of the present iteration. When SUMSQ has reached a user specified minimum the solution is considered converged. For this work a value of 5 Kelvin degrees was required for convergence. Figure 6 depicts the solution strategy outlined in these two sections.

C. STEP SIZE CONTROL

The zones required by the radiation treatment and the increments of the differential equation are not theoretically related. This section discusses how these step sizes are handled in 1-DICOG and how computational efficiency has been enhanced by using different step sizes at appropriate regions of the reactor.

1-DICOG is coded so that the reactor is initially divided into a userspecified number of equal-sized radiation zones or regions. These zones are used for computation of the radiation properties. Then, these radiation regions are further subdivided into equal sized steps for the ordinary differential equation (O.D.E.) solver. The user specifies the number of O.D.E. steps per radiation region. Although the functional values of each variable are computed at each O.D.E. step, they are only saved at each radiation region. The stored value of each variable is a spaceweighted average of all the O.D.E. steps within the radiation region. The final output contains the saved variables at each of the equally spaced radiation regions. This approach allows maximum versatility with a minimum amount of storage.

As mentioned in the Physical Properties Section, the calculation of the physical properties requires a great deal of summation arithmetic which could conceivably absorb an unacceptable share of the computational time. This is minimized by a user-specified variable, which controls the frequency of calculation of this tedious property updating. The user identifies the number of O.D.E. steps per property update; thus, variables, such as viscosity, thermal conductivity, and mass diffusivity are only calculated as frequently as deemed necessary.

Finally, physical characteristics of coal conversion processes help to identify regions in the reactor where numerical problems may arise. Often, there is a region of physical coal particle heat-up where very little is happening, followed by a region of dynamic exponential temperature and reaction rate growth due to rapid devolatilization. Usually this is followed by slower char oxidation and even complete particle burnout. It is apparent that a variable step size would be a great advantage for such a system. The predictor-corrector technique does not lend itself to a true variable step size approach since it is based on four equally spaced back points. 1-DICOG circumvents these difficulties by identifying four physical regions in the reactor and using different step sizes in the four regions but equal size steps for any given region. The four regions are: (1) initial particle heat-up,

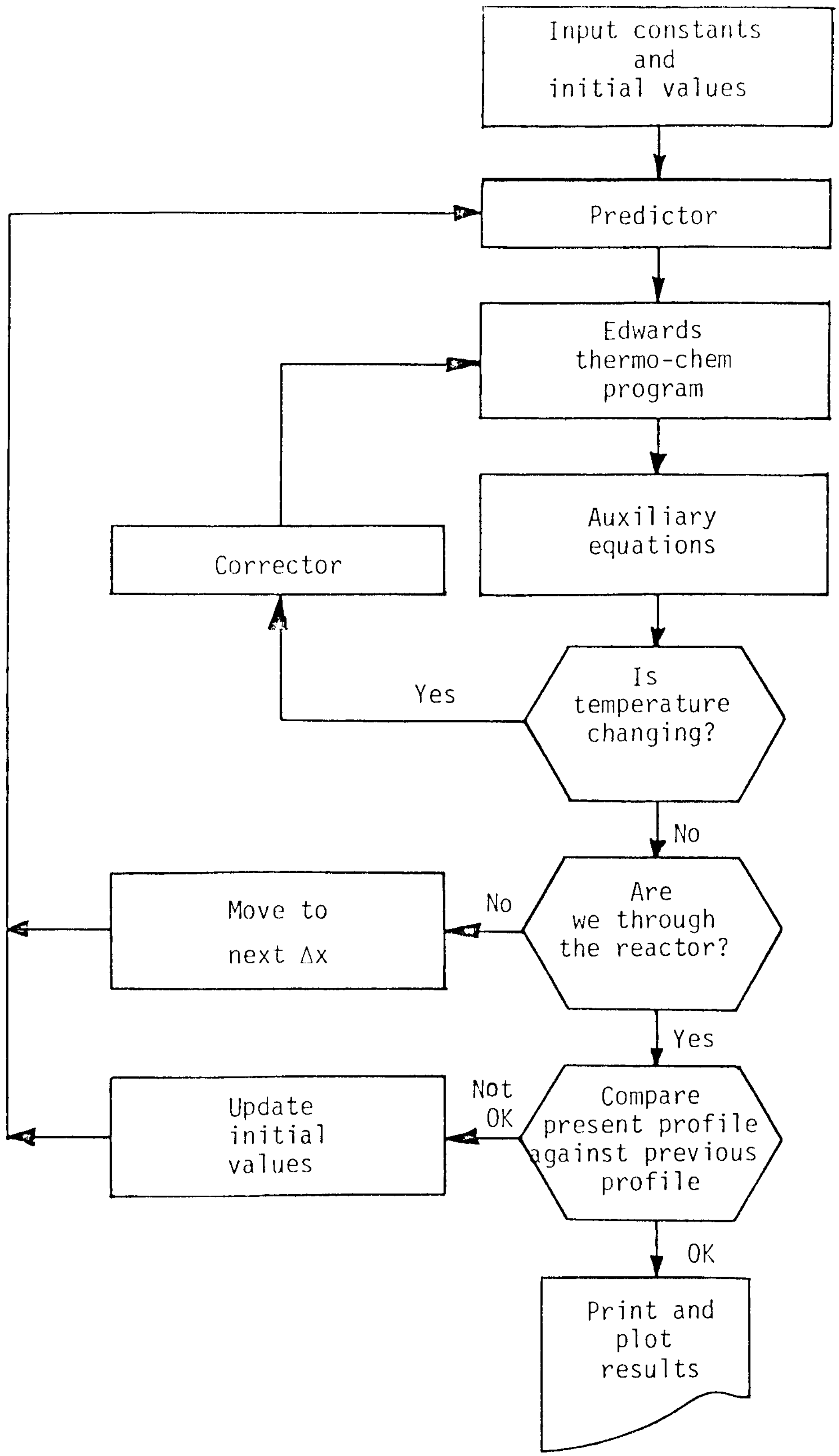


Figure 6. Information flow for 1-DICOG.

(2) devolatilization, (3) after devolatilization but during char burnout, (4) after char burnout. In this approach, the integration procedure procedes until a flag is raised indicating a physical region border has been crossed (i.e. for the change between regions (1)-(2), a specified particle temperature is reached, for (2)-(3), volatiles are depleted from all the particle types, and for (3)-(4) all the char has been consumed). The existing step size is continued until a radiation region is reached. At that point the O.D.E. solution technique is terminated and reinitiated with the new step size. This means that the Runge-Kutta method is used for the next four O.D.E. steps then the Adams-Moulton predictor corrector method is reinitiated, all at the new step size. The user specifies the O.D.E. step size used in each region by specifying the initial number of O.D.E. steps per radiation region for region (1) above; then, by specifying what multiple of this will be used for each subsequent region. For region (4), where very little is happening, the specified factor is a division factor which allows the user to specify large steps to minimize computational time. A wise use of these step size control options permits extremely efficient use of the computational time spent on any given problem.

D. NUMERICAL STIFFNESS

In systems of differential equations, the term "stiff" has been classically used when such systems correspond to tight coupling between the driver and the driven in servo-mechanisms. This type of phenomenon is typical in such situations as control and kinetic systems. Indeed, all of the equations of Table 2 show signs of this kind of coupling. Luckily, the coupling is not too tight and a wise use of repeated correctors and of step size control is usually sufficient. Extensive experience with this set of equations uncovers one particularly difficult problem with stiffness. The problem occurs after or near complete burnout of the particle, the reaction rate is negligible and the energy of the system only changes due to heat transfer effects such as radiation and convection to the reactor walls, conduction between particles and gas, and particle-particle radiation within the reactor. A tight coupling is observed in the particle and gas energy differential equations (Eqs. 5 and 6 of Table 2) through the gas-particle conduction term. This problem does not occur to such an extent in regions where secondary mixing or recirculation are significant or in regions where the particle is reacting strongly. In such regions, these respective terms overshadow the gas-particle conduction term. 1-DICOG allows for the introduction of the pseudo steady-state approximation (pssa) for stiff differential systems (49). This approach need only be invoked after secondary mixing, recirculation and reaction rates become negligible and stiffness becomes severe.

The stiffness criterion is established by monitoring the value of the sum ($Q_{fj} Q_{rbj} - Q_j$) for each particle type after secondary mixing and recirculation are complete. When this value drops to a user specified minimum (on the order of 10^{-2} - 10^{-3}), then the pssa is invoked for that particle classification. At this point, the particle and gas energy equations form the stiff differential set and the particle temperature is the particular stiff variable which is sought. The technique requires decomposition of each of the particle energy equations as they go stiff.

The pssa method calls for setting $d(w_j h_j)/dx=0$ resulting in Eq. 4 of Table 2 becoming an algebraic expression.

$$0 = m_{sj} h_{sj} + m_{vj} h_{vj} + A(Q_{fj} - Q_{rbj} - Q_j - r_j h_j) \tag{92}$$

From this, the temperature of the jth particle type must be determined. At this point in the reactor, the first two terms are identically zero. The last reactionrate term will be very small but conceivably finite. This term is assumed to change insignificantly with temperature and is taken as the value at the immediately past O.D.E. step. The remaining terms are functions of T_j or T_j^4. With a little algebraic manipulation, an extremely fast iterative procedure is obtained for T_j. This value may then be used in the gas differential evergy equation and the solution procedes as normal. This technique is easily derived for radiation heat transfer (Q_{fj}) calculated from either the zone method or the diffusion method.

The success of the pssa method in this particular application can be explained on physical grounds. Stiffness is not a problem with the reaction rate terms. The Adams-Moulton predictor-corrector is sufficient to handle the heterogeneous reactions. Stiffness is a result of the particle-gas heat transfer but only towards the end of the reaction process. On physical grounds, this is when the derivative of the particle energy approaches zero, or in other words when the total particle energy stops changing. Thus, the "steady state solution" has been reached and pssa solves the equations efficiently.

This approach is an extremely powerful tool in increasing computational efficiency. By skillful use of the techniques outlined in the section on Solution Technique, computational time for 1-DICOG is on the order of 2 CPU minutes per particle type per length iteration on a relatively small DEC-SYSTEM 10 computer. Convergence requires usually about six iterations.

This code has been applied to the prediction of a large number of pulverized coal combustion and gasification systems. Predictions have included parametric studies of model parameters and combustor variables. Predicted results have been compared with measurements. These predictions and the comparisons with measurements are presented in Volume 1 of this final report.

IV. 1-DICOG CODE

A. GENERAL DESCRIPTION

1. Language and Availability

Every effort has been made to write 1-DICOG in ANS (American National Standard) FORTRAN-IV. Syntax should thus be compatible with most compilers. Plotting routines, which are used for convenience in interpreting the output, have been included. These routines were designed for use with a CALCOMP plotter. Plotting is not an essential feature of the output since all numbers plotted also appear in the written output. Plotting may be omitted by simply deleting lines 136 through 254 in subroutine OUTPUT and by omitting completely subroutines GRPH, ASCALE and LGND.

The total number of card images, including comment card as listed in Appendix B is 3340. Card decks punched in EBCID card format are available upon request from the authors for a specified cost.

2. Units

All input data to 1-DICOG must be in cgs units. All working variables within the program are either dimensionless or in cgs units. Units associated with all variables are given in the Nomenclature.

3. Debugging

Inevitably, problems will arise concerning the application of 1-DICOG to the individual needs of the user. A debugging feature in the code allows varying degrees of debugging output. The level desired is simply specified by setting the variable "BUG" in the input data to its corresponding value. BUG=0 is the normal operating condition. No extra debugging output is printed. All output will look like the output shown in the example calculation given in Appendix A. BUG=1 causes outprint of all previous output plus values of variables appearing in the differential equations as they are calculated. The variables output from each subroutine are as follows:

SOLVE: x, T_g, T_j

DIFF: v, n_j, A

RODEVL: w_g, w_j, h_g, h_j, α_k, α_h, α_w, α_c, A

AUX1: ω_c, ω_h, ω_w, ω_a

AUX3: Q_{cb}, Q_{rbj}, Q_j, Q_f, r_{jk}, r_{cj}, r_{wj}, r_{jg}, r_j

BUG=2 causes outprint of all previous output plus values of variables which have a significant impact upon the differential equations. The variables output from each subroutine are those of BUG=1 plus the following:

RINTS: I_{op}, I_{qt}

AUX1: C_{pcj}, C_{phj}, C_{paj}, C_{pj}, T_j, h_j, h_{old}, ρ_{cj}, ρ_{hj}, ρ_{wj}, ρ_{wj}, ρ_j, h_h, h_w

AUX2PR: k_g, ω_g

AUX3: r_{hjm}, r_{cjm}, $r_{hj\ell}$, B_j, B_{mj}, $r_{h\ell}$, $\Sigma\, r_{vjm}$, $\Sigma\, r_{hvjm}$

EQUIL: T_g, M_g, C_{pg}, X_i, C_{pi}, h_g, ρ_g, $C_{o\ell}$

BUG=3 causes outprint of all previous output from each subroutine as listed under BUG=1 and BUG=2 plus the following:

SOLVE: $d(W_g\omega_p)/dx$, $d(W_j)/dx$, $d(W_g h_g)/dx$, $d(W_j h_j)/dx$, $d(vn_j A)/dx$, $d(W_g)/dx$, $d(\alpha_{cj})/dx$, $d(\alpha_{nj})/dx$, $d(\alpha_{wj})/dx$, $(W_g\omega_k)$, W_j, $(W_g h_g)$, $(W_j h_j)$, α_g, α_{cj}, α_{hj}, α_{wj}

AUX2PR: k_j, μ_j

AUX3: k_{mj}, r_{vjm}, $k_{\ell j}$, C_g, A_j, P_{ej}, X_{wj}

BUG=4 causes outprint of all previous variables plus additional information on the physical properties. The variables which are output are all of those listed under BUG=1 through BUG=3 plus the following:

AUX2PR: Ω_μ, Ω_D, σ_{ijk}, Re, Pr, h, D_{ij}, D_{om}

BUG=5 causes output of all previous variables plus additional information on radiation. The variables which are output are all of those listed under BUG=1 through BUG=4 plus the following:

RINTS: a_j, $(a_j T^4)$, $\Sigma\, I_{pg}$

BUG=6 is a special level designed for debugging the radiation subroutine RINTS only. All of the variables in RINTS are output then the program execution will terminate.

In the incremental technique employed in 1-DICOG, there could conceivably be several thousand increments in each iteration. Printing each variable for each iteration would generate several hundred pages of output. To help with paper conservation when debugging 1-DICOG, the user may specify the frequency of the debugging printout by setting the value of the variable "NPRINT" (see section entitled Input). For example, with NPRINT=1, each variable specified by the debug option BUG would be printed for every increment; whereas, if NPRINT=10 each variable would be printed only after every ten increments. The only exception to this rule is the printing of variables in subroutine SOLVE. This subroutine is not subject to restrictions by NPRINT and the output selected by the BUG option will be printed for every iteration. A little experience in debugging 1-DICOG will quickly show the wisdom behind this logic.

B. DESCRIPTION OF SUBROUTINES

Each of the subroutines in 1-DICOG is briefly described in this section. The listing of the program is given in Appendix B. Detailed descriptions of model equations and assumptions were given previously. The purpose of this section is to briefly acquaint potential users with the operations performed in each subroutine and thus present a rough overview of the program structure. Detailed understanding of subroutine operations can only come through careful study of the FORTRAN code.

MAIN. The main routine is only a short scheme which controls overall operation of the program. Control of the number of system iterations required for convergence of the temperature profiles for radiation is handled in MAIN. Step size control for different regions in the calculation is also managed in this routine.

ASCALE. This is a self-scaling subroutine used by GRPH to establish ordinate and abscissa values.

AUX1. This is the first of three subroutines which computes the values of each of the constitutive equations required in 1-DICOG. The order of solving these auxiliary-equations is chosen for convenience. Those equations solved in AUX1 are for the most part needed in AUX2PR and/or AUX3.

AUX2PR. All the gas phase physical property equations are modularized into this subroutine. This routine is only called after every NPROP ODE steps to save on computational time when desired.

AUX3. This is the final subroutine for evaluating the auxiliary equations. This routine concentrates mostly on the particle reaction equations. It includes an iterative scheme for calculating the total particle reaction rate r_j.

DIFF. This subroutine calculates the value of each of the differential equations in the system at each of the evaluation stages of the predictor corrector solution technique. This is actually done at the end of the subroutine. Performing this task requires updated values for each variable. The first part of the routine obtains these values by controlling call statements to the appropriate subroutines.

EDWRDS. This is the main controlling routine for the thermochemical equilibrium calculations. This routine initializes required variables and calls the other thermochemical subroutines.

FIND. This is short extrapolation subroutine used by SIGMAM.

GRPH. The initial plotting routine for plotting the output on an available CALCOMP plotter with the BYU DEC-10 computer.

INPUT. This routine is rather long but only performs three functions. First, all of the input data are read into 1-DICOG through the subroutine INPUT. Secondly, default values of certain variables are established. Finally, all input variables are printed for review.

LGND. This is a small subroutine for printing a title or legend on the plot created by GRPH.

OPEN. This is a short subroutine used on the BYU DEC-10 to open the input data file on disc.

OUTPUT. This subroutine controls printing and plotting of all output information.

PROFIL. This subroutine saves all the profiles in their appropriate arrays in preparation for printout and plotting. In addition some of the profiles prepared here are used for the next pass through the reactor in calculating initial profiles for RINTS. It should be noted that values are only stored for the radiation regions. This means that the values calculated at each ODE step are averaged (linearly) to obtain values for the radiation region in question.

RESTRT. This subroutine does all the work necessary for reading and writing information necessary for a restart.

RINTS. This subroutine is a compact calculation of all parameters needed for the radiation calculations within the reactor. It is for this subroutine that an initial or past temperature profile, particle number density profile, and diameter profile of the particles are needed. These initial profiles come from INPUT, or from RESTRT, or of course, from the immediately past calculation in the iterative loop. The values calculated in RINTS are used in AUX1 and AUX3.

RODEVL. This subroutine returns the value of each of the seperate variables from the functions given by the predictor corrector calculations. For example SOLVE can calculate the value of $(w_j h_j)$ from Eq. 6 of Table 2, the particle energy equation. SOLVE also calculates w_j from the particle continuity equation. RODEVL takes this information and returns h_j.

SETUP1, EQUIL, TOY, SLE. These are other manipulative subroutines for the EDWARDS thermochemical equilibrium computations.

SIGMAD. This subroutine is used by AUX2PR for determining the value of the potential function needed for mass diffusivity as a function of the Lennard-Jones parameters and temperature.

SIGMAM. This is the routine used by AUX2R for determining the value of the potential function needed for viscosity and thermal conductivity as a function of the Stockmayer parameters and temperature.

SOLVE. This subroutine manages the Adams-Moulton predictor corrector solution technique. After some preliminary initialization the routine peforms the Runge-Kutta fourth order computations for the first four ODE steps. It then switches to the Adams-Moulton predictor corrector computations. At each step the routine checks to see if a restart should be initiated due to completion of mixing or due to a step size change. The pssa method for stiff differential systems is monitored and controlled in this routine.

TIMET. This is a convenience subroutine used for running night batch on the BYU DEC-10 computer. This subroutine accepts a time of day and monitors the current run time. If run time is beyond the accepted time then this routine calls TRBLE.

TRBLE. This is a subroutine used by TIMET to get output and kill the program if it gets in trouble.

VALUE. This subroutine sets up all the initial values needed for the predictorcorrector differential equation solution performed in SOLVE. These values are stored in the dimensioned FORTRAN variable VALINT.

C. INPUT

The required set of data cards for input for 1-DICOG is shown in Table 10. Each punched card is identified within each group. The required format is also indicated. Table 11 gives a definition of the FORTRAN variables used in Table 10. A Group 1 of Table 10 contains comment cards that will be printed at the top of the output to identify the run, etc. Group 2 contains all of the variables pertaining to the numerical control of the computation. Group 3 contains the initial gas stream information. Group 4 contains all the data pertaining to each particle classification. This group must be repeated for as many times as there are paticle classifications (presently a maximum of 5). Group 5 contains required data on each element to be used in the computation and is repeated for each element. Group 6 contains the information required for each species to be considered and is also repeated for each species. Finally, Group 7 contains reactor geometry and other miscellaneous parameters. At least one set of each group is required. Table 11 contains a detailed list of definitions of these program data variables together with further information on the requirements for each variable. Much of the thermochemical data required for Group 6 has been compiled for a number of species for the original EDWARDS thermochemical program (39) and is included in Appendix C.

TABLE 10

INPUT DATA FOR 1-DICOG

GROUP	CARD	DATA ITEMS	FORMAT
	1	NCARD	I5
	2	COMENT (1,1), ... , COMENT (1,20)	20A4
1		COMENT (2,1), ...	.
		. . . .	.
	NCARD+1	. . . . COMENT (NCARD,20)	.
	1	ODESTP, OSPRR, DYNAMO(1), DYNAMO(2), DYNAMO(3), NPRINT	6I5
2	2	ELEMNT, SPECIE, PRTCLS, CRXN, HRXN, ICNVLM, ITRAMX	
		NPROP, BUG, ISASUM, EUCKEN, KEQ, SHRINK, IRAD	14I5
	3	DYNTEM, SQDIF, DELTPJ, DELRRJ, TTEST, STIFVAL, FUR	
	1	GMW, HGAS, RHOG, WG, P	5E10.3
3	2	SGH, SGMC(1), SGMC(2), SGMC(3)	4E10.3
	3	PGX, PGH, PGMC(1), PGMC(2), PGMC(3), PGMC(4)	6E10.3
	1	DI(1), E(1), H(1), XI(1), W(1)	5E10.3
	2	ALPHAA(1), ALPHAC(1), PLPHAH(1), ALPHAW(1), HHO(1), HWO(1)	6E10.3
	3	TMIN(1), XBEGIN(1), TMAX(1), XCHNG(1)	4E10.3
	4	SJH(1), SJMC(1,1), SJMC(1,2), SJMC(1,3)	4E10.3
	5	PJX(1), PJH(1), PJMC(1,1), PJMC(1,2), PJMC(1,3), PJMC(1,4)	6E10.3
4	6	AMJ(1,1), EMJ(1,1), YY(1,1)	3E10.3
	7	CPVC(1,1,1), CPVC(2,1,1), CPVC(3,1,1), HFV(1,1)	4E10.3
		Repeat Cards 6 & 7 for other m raw coal reactions, if any, up to CRXN	
	8	AL(1,1), EL(1,1), EMM(1,1)	3E10.3
		Repeat card 8 for other l char reactions, if any, up to HRXN	
	9	PHIJWK(1,1), ... , PHIJWK(1,ELEMNT)	9E10.3
	10	PHIVK (1,1,1), ... , PHIVK(1,1,CRXN)	5E10.3
		Repeat card 10 for each element to be considered up to ELEMNT	
	11	CCP(1,1,1), CCP(1,1,2), CCP(1,1,3)	3E10.4
	12	CCP(1,2,1), ...	
	13	. . . .	
	14	. . . . .CCP(1,4,3)	
		Repeat Group 4 for other particle classifications, if any, up to PRTCLS	
	1	EDNAME(1), ATWT(1), OMEGAK(1), OSGKM(1), OPGKM(1)	2A4,2X, 3E10.3
	2	PHIKL(1,1),-PHIKL(1,2). . . . . . . , PHIKL(1,HRXN)	5E10.3
		Repeat Group 5 for each element in the computation up to ELEMNT	

TABLE 10 (Cont.)

GROUP	CARD	DATA ITEMS	FORMAT
	1	NAME1(1), NAME2(1), S(1), EK(1), DELTA(1), YINT(1)	2A4,2X, 4E10.3
	2	A(1,1), A(1,2), ... , A(1,ELEMNT)	9E10.3
6	3	HR(1), SR(1)	2E10.3
	4	Z(1,1), Z(1,2), ... , Z(1,5)	5E10.3
	5	Z(1,6), Z(1,7), ... , Z(1,10)	5E10.3
		Repeat Group 6 for each species to be considered in gaseous equilibrium computation up to SPECIE	
	1	DDUCT, DS, ALEN, AGANGL, EB, TB	6E10.3
	2	ELAM, GAMMA, MG	3E10.3
7	3	OXYD(1), OXYD(2), ... , OXYD(HRXN)	5J5
	4	PHIL(1), PHIL(2), ... , PHIL(HRXN)	5E10.3
	5	IVPFLG, VPRCOF(1), VPRCOF(2), ... , VPRCOF(5)	I5,5X, 5E10.3
	6	RSTRT	I5

Table 11

FORTRAN VARIABLE NOMENCLATURE

FORTRAN Variable	Type	Units	Description and Usual Symbol
A(K,JX)	real	-	Number of elements JX per species I
AGANGL	real	deg.	Area growth angle, θ
AL(J,L)	real	s^{-1}	Pre-exponential factor for the Lth char reaction for the Jth particle, $A_{j\ell}$
ALEN	real	cm	Reactor length
ALPHAA(J)	real	g	Mass of ash in Jth particle, α_{aj}
ALPHAC(J)	real	g	Mass of raw coal in Jth particle, α_{cj}
ALPHAH(J)	real	g	Mass of char in Jth particle, α_{nj}
ALPHAW(J)	real	g	Mass of moisture in Jth particle, α_{wj}
AMJ(J,M)	real	s^{-1}	Pre-exponential factor for the Mth devolatilization reaction for the Jth particle, A_{jm}
ATWT(K)	real	$gmol^{-1}$	Atomic, weight of the Kth element
BUG	integer	-	Debug level (see Debugging)
CCP(J,N,I)	real	cal $g^{-1}K^{-(I)}$	Quadratic heat capacity coefficients (I=1,3) for the Jth particle for: N=1, coal component; N=2, char component; N=3, moisture component; N=4 ash component
COMENT(I,N)	ASCII	-	Comment words for top of output
CPVC(I,J,M)	real	cal $g^{-1}K^{-(I)}$	Quadratic heat capacity coefficients (I-1,3) for the volatiles from the Mth devolatilization reaction for the jth particle
CRXN	integer	-	Number of raw coal devolatilization reactions, M
DI(J)	real	cm	Diameter of the Jth particle, d_j
DDUCT	real	cm	Diameter of the initial injection duct
DELRRJ	real	-	The fractional change tolerance for convergence of the total particle reaction rate (see AUX3, Section 4, Code Operation)

Table 11 (cont.)

FORTRAN Variable	Type	Units	Description and Usual Symbol
DELTA(I)	real	-	Stockmayer polar parameter of species I, δ
DELTPJ	real	-	Temperature change tolerance for convergence of particle temperature calculations (see AUX1, Section 4, Code Operation)
DS	real	cm	Diameter of reaction vessel, D_s
DYNAMO(I)	real	-	Multiplication factor (I=1,2) or division factor (I=3) for the number of O.D.E. steps per radiation region in the three regions following the first (see Section 4, Code Operation)
DYNTEM	real	K	Temperature at which the second step size region will be initiated (see above)
ELAM	real	-	Absorption efficiency, E_λ
ELEMNT	integer	-	Number of elements in prediction
EMJ(J,M)	real	cal mol^{-1}	Activation energy for the Mth devolatilization reaction for the Jth particle
E(J)	real	-	Emissivity of the Jth particle type, ε_j
EB	real	-	Emissivity of the reactor boundary or wall, ε_b
EDNAME(K)	ASCII	-	Name of the Kth element
EK(I)	real	-	Stockmayer Parameter for the Ith species, ε/k
EL(J,L)	real	cal mol^{-1}	Activiation energy for the Mth devolatilization reaction for the Jth particle
EMM(J,L)	real	-	Exponent on temperature in Equation 2-68 of Table 2-8, m
EUKEN	integer	-	If EUKEN=1 viscosity calculated from Euken equation
		-	If EUKEN=0 viscosity calculated from Sage-Galloway equation

Table 11 (cont.)

FORTRAN Variable	Type	Units	Description and Usual Symbol
FUR	real	-	If $0.0 \leq FUR \leq 1.0$, underrelaxation factor for Adams-Moulton corrector equation If $0.0 > FUR$, or $FUR > 1.0$ then $FUR = 1.0$ (i.e. no underrelaxation)
GAMMA	real	-	Particle swelling parameter, γ
GMW	real	$gmol^{-1}$	Molecular weight of input gas phase, M_g
H(J)	real	$cal\ g^{-1}$	Initial enthalpy level of Jth particle
HRV(J,M)	real	$cal\ g^{-1}$	Heat of formation of the volatiles from the Mth devolatilization reaction in the Jth particle h_{vjm}
HGAS	real	$cal\ g^{-1}$	Initial enthalpy of the gaseous stream $h_g = \int_{298}^{T_g} C_{pg}\, dT + h_g^{\circ}$
HHO(J)	real	$cal\ g^{-1}$	Heat of formation of the char in the Jth particle, h_{hj}
HR(I)	real	$kcal\ mol^{-1}$	Enthalpy of species I at 1200 K $= \int_{298}^{1200} C_{pi}\, dT + h_{i,\ 298}^{\circ}$
HRXN	integer	-	Number of char oxidation reactions, L
HWO(J)	real	$cal\ g^{-1}$	Heat of formation of the moisture in the Jth particle, h_{wj}°
ICNVLM	integer	-	Maximum number of Adams-Moulten correctors
IRAD	integer	-	If IRAD=1 radiation is calculated as a diffusion process, if IRDA≠1 radiation is calculated by the zone method
ISASUM	integer	-	If ISASUM≤0 then the pssa method is not invoked; If ISASUM=1 the pssa method is introduced only when required after char burnout; If ISASUM=2 the pssa method is introduced when needed even if the char has not yet been completely reacted

Table 11 (cont.)

FORTRAN Variable	Type	Units	Description and Usual Symbol
ITRMAX	integer	-	Maximum number of system iterations
IVPFLG	integer	-	If IVPFLG=0 vapor pressure for moisture is calculated from Antoine Equation If IVPFLG≠0 vapor pressure coefficients are used in a power series equation
KEQ	integer	-	If KEQ=1 the linear form of the Field (1969) char oxidation rate expression is used; If KEQ≠1 normal Arhenius form used
MH	real	$gmol^{-1}$	Char molecular weight, M_h
NAME1(I)	ASCII	-	First four characters of the name of the Ith species
NAME2(I)	ASCII	-	Second four characters of the name of the Ith species
NCARD	integer	-	Number of comment cards to follow
NPROP	integer	-	Number of O.D.E. steps per property recalculation
ODESTP	integer	-	Initial number of O.D.E. steps
OPGKM(K)	real	-	Initial mass fraction of element K in the recirculation, $\omega_{gk\rho}$
OSGKM(K)	real	-	Mass fraction of element K in the secondary gas, ω_{gks}
OSPRR	integer	-	Number of initial O.D.E. steps per radiation region
OMEGAK(K)	real	-	Initial mass fraction of element K in primary, ω_{gk}
OXYD(L)	integer	-	Identification number for the oxidizer for the Lth char oxidation reaction
P	real	atm	Pressure, P
PGH	real	cal g^{-1}	Enthalpy of recirculation gas (initial guess), $h_{\rho g}$

Table 11 (Cont.)

FORTRAN Variable	Type	Units	Description and Usual Symbol
PGMC(N)	real	$g\ s^{-1}\ cm^{-(N-1)}$	Nth coefficient for recirculation function, see Chapter 2 Recirculation
PGX	real	cm	Axial location for recirculation properties
PHIJWK(J,K)	real	-	Stoichiometric coefficient for Kth element in Jth particle with respect to moisture vaporization, ϕ_{jwk}
PHIKL(K,L)	real	-	Stoichiometric coefficient for Kth element with respect to the Lth char oxidation reaction, $\phi_{k\ell}$
PHIL(L)	real	-	Stoichiometric coefficient for the oxidizer in the Lth char oxidation reaction, ϕ_{ℓ}
PHIVK(J,K,M)	real	-	Stoichiometric coefficient for the Kth element in the Jth particle with respect to the Mth devolatilization reaction, ϕ_{vjkm}
PJH(J)	real	$cal\ g^{-1}$	Enthalpy of the Jth particle in the recirculation (initial guess), $h_{\rho j}$
PJMC(J,N)	real	$g\ s^{-1} cm^{-(N-1)}$	Nth coefficient for recirculation of the Jth particle type (see Chapter 2, Recirculation)
PJX(J)	real	cm	Location for properties of the Jth particle type in recirculation
PRTCLS	integer	-	Number of particle types in computation, J
RHOG	real	$g\ cm^{-3}$	Initial gas density, ρ_g
RSTRT	integer	-	If RESTRT=1 external restart information is used for initial guesses
S(I)	real	Å	Stockmayer collision diameter, σ_i
SGH	real	$cal\ g^{-1}$	Enthalpy of secondary gas, h_{gs}
SGMC(N)	real	$g\ s^{-1}\ cm^{-(N-1)}$	Coefficients for secondary mass addition

Table 11 (Cont.)

FORTRAN Variable	Type	Units	Description and Usual Symbol
SHRINK	integer	-	If SHRINK=1 the shrinking particle model is used for char oxidation; If SHRINK≠ 1 the constant diameter model is used
SJH(J)	real	cal g^{-1}	Enthalpy of particle J in secondary stream, h_{js}
SJMC(J,N)	real	g s^{-1} $cm^{-(N-1)}$	Nth coefficient for mass addition of Jth particle type by secondary stream
SPECIE	integer	-	Number of species to be included
SQDIF	real	K	The maximum acceptable root mean square temperature profile difference for convergence
SR(I)	real	cal mol^{-1} K^{-1}	Entropy of species I at 1200 K
STIFVL	real	cal cm^{-3} s^{-1}	Value of stiffness criterion for initiation of pssa method (see Section 4, Code Operation)
TB	real	K	Reactor wall temperature, T_b
TMAX(J)	real	K	Initial guess at maximum Jth particle temperature
TMIN	real	K	Initial temperature of Jth particle group
TTEST	real	-	Fractional change in the sum of the slopes of all particle energy equations that is acceptable without applying another corrector
VPRCOF(N)	real	atm $K^{-(N-1)}$	Nth coefficient of moisture partial pressure power series if JVPFLG≠0
W(J)	real	g s^{-1}	Initial mass flow rate of Jth particle group, w_j
WG	real	g s^{-1}	Initial mass flow rate of gas stream, w_g
XBEGIN(J)	real	cm	Axial location for Jth particle phase for initial guess of temperature profile as shown in Figure 4-1

Table 11 (Cont.)

FORTRAN Variable	Type	Units	Description and Used Symbol
XCHNG(J)	real	cm	Axial location for Jth particle phase for initial guess of temperature profile in Figure 4-1
XI(J)	real	-	Surface area factor for Jth particle type, ζ_j
YINT(I)	real	-	Rough order of magnitude initial guess for gas phase mole fractions
YY(J,M)	real	-	Stoichiometric coefficient for Jth particle with regards to Mth devolatilization reaction, Y_{jm}
Z(I,N)	real	-	Nth coefficient for Ith species heat capacity equation. For N=1-5 the temperature range of the heat capacity is 1200 K-6000 K and $C_p = \sum_{i=0}^{4} Z_{i+1} \left(\frac{1000}{T}\right)^i$ where T is in Kelvin and C_p is cal g $mol^{-1} K^{-1}$. For N=6-10 the temperature range of the heat capacity is 298 K - 1200 K and $C_p = \sum_{i=0}^{4} Z_{i+6} \left(\frac{T}{1000}\right)^i$

A sample input file for a prediction of the BYU combustor (26) is shown in Appendix A. The card images, as indicated in Table 10, are shown as well as the echo output printed by 1-DICOG. This sample should also prove useful to the user in estimating what values to input for his particular application.

D. OUTPUT

The user has the ability to govern the extent of output obtained from 1-DICOG through the debugging options already discussed in the debugging section. Under normal operating procedure the debug switch would be turned off and the standard output would be received. Appendix A shows a sample input and output package.

The first section of the output is simply an echo of all the input parameters formated as shown in Appendix A.

The next section of output is invaluable data regarding the numerical operation of the solution history. The ordered pair of the axial location and the number of correctors applied is given for each ordinary differential equation set. Section 3 discussed how the solution procedure uses multiple correctors when appropriate. The next section on Code Operation discusses how to use this information to optimize computational efficiency.

The last sections give the computational output. First, parameters for each individual particle phase are given for each radiation region through the reactor. Appendix A shows the sample output and the headings indicate the appropriate particle properties and their units for each particle phase as identified by its number j. The masses shown are for an individual particle of the given classification. Following each particle phase is a history of normalized compositions for the sum total of all particle phases. These are the numbers for the plots which follow. The final group is a printout of gas phase properties through the reactor. The mole fraction of each species is given for each radiation region through the reactor.

Appendix A also shows the plots which are obtained from the CALCOMP plotter when the plotting routines are included as discussed under Language and Availability. Particle and gas temperature histories are plotted. The mass history of each particle classification and of the total of all particles are also plotted. These plots show the normalized mass of each component of the particles (moisture, ash, char, raw coal, and the total of all components) at axial locations through the reactor. The final plot shows the gas phase mole fraction history of each gas phase species.

E. CODE OPERATION

The section on Input gave the user a description of all the variables needed for operating the computer code. This section is meant to give helpful insight into selection of the parameters that might be the most ambiguous, or that are the most important, in obtaining a successful converged computation.

As was discussed in Section 3 the solution procedure calls for iteration due to the zone method for solving the radiative heat transfer. Experience with the code has indicated that a large majority of combustion or gasification chambers are radiation stabilized. This physical insight indicates the important contribution of the radiative processes to the overall operation of these sysems. Numerically, this importance is manifest in the need for a good guess on the temperature profile to initiate the radiation iteration. This guess is input for each jth particle classification on card 3 of group 4 in Table 10. The initial profile is schematically represented in Figure 7. If the parameters in this figures are not chosen carefully the first iteration will tend to cool the system temperatures such that ignition will not occur. Sometimes extreme cooling will be predicted even to the point of causing numerical instabilities. When this behavior is observed the user should try another guess for the particle temperature profile. The locations of XBEGIN and XCHNG are most crucial. It is obvious that when a restart is available from some previous computation it could prove extremely useful as a fist guess for a similar prediction. The sample computation shown in Appendix A may prove helpful in giving the user some experience at guessing initial profiles.

Another important consideration in obtaining accurate predictions for coal combustion or gasification is a reasonable particle size distribution. If the descrete size distribution chosen by the user is not representative of the true continuous distribution, the prediction will not be realistic. Figure 8 shows the measured cumulative particle size distrbution for the input coal of the sample pediction shown in Appendix A. The three particles size descretization chosen for this sample computation is also shown. If the user will perform a similar excercise for his paticular case any difficulties from poor choice of particle size distribution should be alleviated. After the size classes have been picked, the user should assure himself that the descrete distribution has near the same mass mean particle diameter as the measured distribution.

Some of the more difficult input data to obtain, might be the species equilibrium input parameters of group 6 in Table 10. To help the user with these input variables, Appendix C contains a compilation of variables for selected species which might be important to combustion or gasification processes.

Group 2 of the Input Data shown in Table 10 contains the input variables which govern the numerics of the solution strategy. These were discussed in general terms in Section 3, but the successfully obtaining a solution in reasonable computational times is contingent on appropriate selection of these variables. Due to the sensitivity of these parameters to efficient operation a further discussion is presented here.

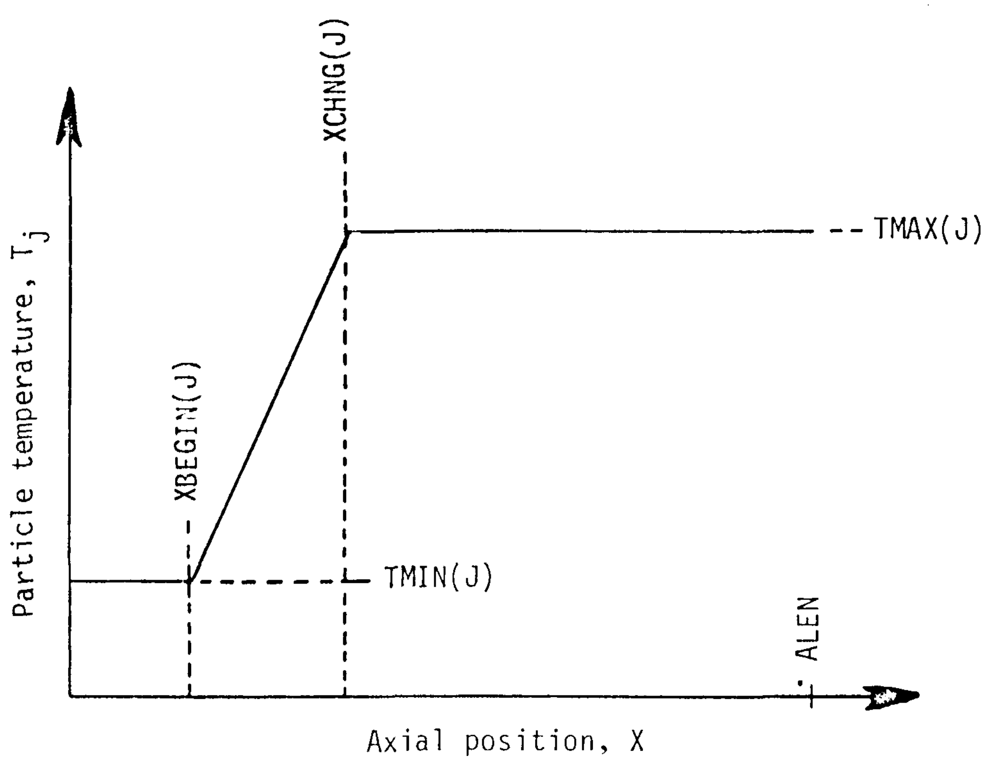


Figure 7. Initial guess at the jth particle type temperature profile.

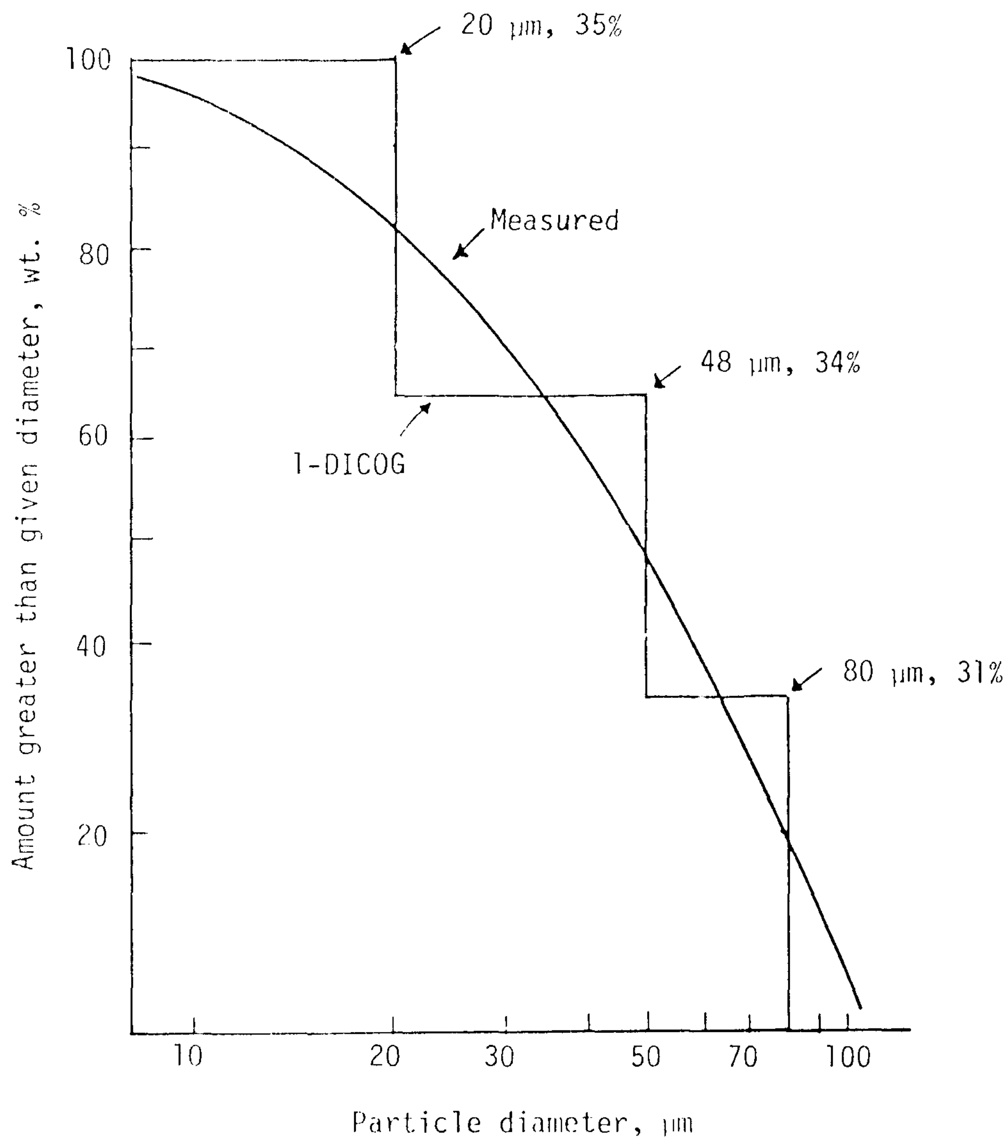


Figure 8. Particle size distribution used for the three increment poly-dispersed combustion calculation of Appendix A.

The variables on card 1 govern the step size in the reactor. These variables should be adjusted carefully for each particular application to insure the most efficient code operation. Trial and error is the best way of optimizing these parameters; however, some guidance is available. The output is structured to guide the user in this optimization (see Appendix A for sample). Immediately following the echo input a consolidated printout follows the progression of the ordinary differential equation steps. This output contains the ordered pair of the location in the reactor and the number of correctors applied at that location (see section 3). The difference between locations will tell the step size at that step. In general the step size should be adjusted (through the variables in card 1 of group 2, Table 10) to keep the number of correctors at 1 with an occasional 2 (see Appendix A for example). If the number of correctors is consistently greater than 1, more efficient operation can generally be achieved by decreasing the step size in that particular region. Just before the step size is about to change due to initiation of the dynamic region or completion of devolatilization, the number of correctors applied may increase for a few steps without any adverse effects on computational efficiency. The sample computation of Appendix A is operating quite efficiently and should be used as a pattern for efficient operation.

In selecting the numbers for these variables it is generally good practice to have about 250 radiation regions. Thus, after selecting the initial number of ordinary differential equation steps (ODESTP) the number of initial ordinary differential equation steps per radiation region (OSPRR) should be selected according to this criterion. The location of the first step size change is governed by the dynamic region initiation temperature (DYNTEM) which is usually selected around 800 K - 900 K. The size of the steps in each subsequent region should then be chosen by setting the three DYNAMO variables according to the criteria given in the preceding paragraph.

The convergence criteria of card 3 in group 3 are adjustable by the user. Suggested ranges are given below:

SQDIF = 5K - 20K

DELTPJ = 0.001K - 0.05K

DELRRJ = $1.0 \times 10^{-7} - 1.0 \times 10^{-6}$

TTEST = 0.001 - 0.05

STIFVAL = 0.0001 - 0.010

FUR = 0.0

In preparing the input all other variables should be straightforward; however, some confusion has sometimes arisen regarding the stochiometric coefficients, PHIJWK, PHIKL, PHIL, PHIK, and YY. To clarify the values to be used for these variables the following derivation is presented for the sample case shown in Appendix A. Table 12 shows the analysis of the coal used for these computations.

PHIJWK(J,K) is the mass of element K per mass of water vapor. thus in virtually all cases PHIJWK for hydrogen is 0.1111... and for oxygen it is 0.8888...

Next, the char composition must be defined by the user. In this example char was chosen to be pure carbon. Now PHIL(L) may be defined for each oxidizer with the help of Eq. 2. PHIL is the moles of char per mole of oxidizer. For the sample calculation only O_2 was considered as an oxidizer and the char was taken to be pure carbon. The gaseous products of Eq. 2-2 were taken to be only CO: thus, PHIL(1) is 2.

Now, since the char reaction is defined, the elemental stoichometric coefficients PHIKL(K,L) can be computed. PHIKL(K,L) is the mass of element K given to the gas due to the char heterogeneous reaction per mass of gaseous product from the heterogeneous reaction. Thus for this sample, all PHIKL(K,L) will be zero, except for the element carbon, for which the value will be 1.0.

The PHIVK(J,K,M) are dependent on the coal analysis and the overall devolatilization stochiometry (YY(J,M)). For the two step devolatilization mechanism suggested in Table 9 the YY (mass of volatile matter per mass of dry, ash free coal) are:

$$YY(J,1) = 0.39$$

$$YY(J,2) = 0.80$$

for all J. PHIVK(J,K,M) is the elemental stochiometric coefficients for each devolatilization reaction and is defined as the mass of element K per total mass of volatiles from the mth reaction for the jth particle. In the sample calcultaion all of the J particles undergo the same two M reactions and have the same composition; thus for M = 1:

$$1.0(\text{raw coal}) \rightarrow 0.39(\text{volatiles}) + 0.61(\text{char})$$

Basis: 100 gms of DAF coal

raw coal	gms	volatiles	gms	char	gms
H	6.0	H	6.0	C	61.0
C	79.9	C	18.9		
N	1.6	N	1.6		
S	0.6	S	0.6		
O	11.9	O	11.9		
total	100.0	total	39.0		

TABLE 12

COAL ANALYSIS FOR SAMPLE CALCULATION OF APPENDIX A

	AS RECEIVED wt%	DAF wt%
Proximate Analysis		
moisture	3.1	N/A
volatile matter	42.2	48.3
fixed carbon	45.2	51.7
ash	9.5	N/A
total	100.0	100.0
Ultimate Analysis		
hydrogen	5.6	6.0
carbon	69.8	79.9
nitrogen	1.4	1.6
sulfur	0.5	0.6
oxygen	13.2	11.9
ash	9.5	N/A
total	100.0	100.0

Which gives the following values for PHIVK(J,K,M):

	PHIVK(J,K,M)
H	0.15
C	0.48
N	0.04
S	0.02
O	0.31

The values of PHIVK for M = 2 are calculated in a similar manner and the results are shown in Appendix A.

Any further questions on code operation may be addressed to the authors directly.

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Appendix A

1-DICOG SAMPLE CALCULATION

OUTPUT FOR SAMPLE COMPUTATION

```
************************************************************************
**********************  BRIGHAM YOUNG UNIVERSITY  **********************
************* 1 DIMENSIONAL COMBUSTION OR GASIFICATION ***************
*********************** USER'S MANUAL EXAMPLE ************************
*************************** 3 PARTICLE SIZES *************************
************************************************************************

RUN PARAMETERS*****************

          INITIAL NUMBER OF O.D.E. STEPS                         750
          NUMBER OF INITIAL STEPS PER RADIATION REGION             3
          DYNAMIC REGION MULTIPLICATION FACTOR                     2
          MULTIPLICATION FACTOR AFTER DEVOLATILIZATION             3
          DIVISION FACTOR AFTER CHAR BURNOUT                       3
          NUMBER OF STEPS PER PRINT                               10
          NUMBER OF ELEMENTS                                       6
          NUMBER OF SPECIES                                       10
          NUMBER OF PARTICLE TYPES/SIZES                           3
          NUMBER OF COAL REACTIONS                                 2
          NUMBER OF CHAR REACTIONS                                 1
          MAXIMUM NUMBER OF CORRECTORS                            10
          MAXIMUM NUMBER OF SYSTEM ITERATIONS                     10
          NUMBER OF STEPS PER PHY. PROP. CALCULATION               5
          DEBUG LEVEL                                              0
          STIFF PARTICLE ENERGY EQUATION ASSUMPTION USED           2
          THERMAL CONDUCTIVITY CALCULATIONS USE EUCKEN CORRECTION
          THE K EQUATION OF FIELD ET. AL. IS USED FOR CHAR OXIDATION WITH O2
          DYNAMIC REGION INITIATION TEMP.(DEGREES K)               800.00
          MAXIMUM ACCEPTABLE ROOT MEAN SQUARE(DEGREES K)            10.00
          TEMP. CHANGE TOLERANCE(DEGREES K)                    0.01000000
          TOTAL PARTICLE REACTION RATE CHANGE TOLERANCE        0.00000010
          CORRECTOR CONVERGENCE SLOPE TOLERANCE                0.01000000
          TOLERANCE FOR STIFF ASSUMPTION APPLICATION           0.00100000

GAS PARAMETERS*****************

     GAS MOLECULAR  ENTHALPY OF THE GAS  DENSITY OF THE GAS    MASS FLOW RATE         PRESSURE
        WEIGHT
      (G/GMOLE)          (CAL/G)            (G/CM**3)            (G/SEC)             (ATM)
       29.5000           13.5900          0.98930E-03            5.6000             0.9252

                       ENTHALPY OF                              MASS ADDITON RATE
                      THE SECONDARY                              FROM SECONDARY
                         (CAL/G)                                  (G/CM-SEC)
                         71.5400                     0.0000X**2 +   -0.0593X   +    2.0691

      DISTANCE FOR      ENTHALPY OF                              MASS ADDITION RATE
     RECIRCULATION     RECIRCULATION                            FROM RECIRCULATION
    PROPERTIES (CM)       (CAL/G)                                   (G/CM-SEC)
        26.0000           71.5400          0.0000X**3 +   0.0000X**2 +   -0.0657X +    1.1463
```

PARAMETERS FOR THE NUMBER 1 PARTICLE PHASE******

DIAMETER (CM)	EMISSIVITY	ENTHALPY (CAL/G)	SURFACE AREA FACTOR	MASS FLOW RATE (G/SEC)
0.0020	0.7000	-713.0000	0.10000E+01	1.3300

ASH MASS (G)	COAL MASS (G)	CHAR MASS (G)	WATER MASS (G)	CHAR REF. ENTHALPY (CAL/G)	WATER REF. ENTHALPY (CAL/G)
0.51700E-09	0.47600E-08	0.00000E+00	0.16900E-09	0.0000	-3185.4500

STARTING TEMPERATURE (K)	DISTANCE TEMP RISE BEGINS (CM)	INITIAL MAXIMUM TEMP IS REACHED (K)	DISTANCE INITIAL MAX (CM)
355.6000	80.0000	2100.0000	130.0000

ENTHALPY OF THE SECONDARY (CAL/G)	MASS ADDITON RATE FROM SECONDARY (G/CM-SEC)
0.0000	0.0000X**2 + 0.0000X + 0.0000

DISTANCE FOR RECIRCULATION PROPERTIES (CM)	ENTHALPY OF RECIRCULATION (CAL/G)	MASS ADDITION RATE FROM RECIRCULATION (G/CM-SEC)
17.0000	-600.0000	0.0000X**3 + 0.0000X**2 + 0.0000X + 0.0000

PARAMETERS FOR EACH COAL REACTION AND PARTICLE

REACTION	PYROLYSIS PRE-EXPONENTIAL FACTOR (1/SEC)	ACTIVATION ENERGY IN REACTION (CAL/GMOLE-K)	MASS FRACTION
1	0.37000E+06	17600.0000	0.3900
2	0.14600E+14	60000.0000	0.8000

CP COEFFICIENTS (CAL/G)			H FVJ
0.174E+00	0.810E-03	0.000E+00	-807.000

CP COEFFICIENTS (CAL/G)			H FVJ
0.543E+00	0.610E-03	0.000E+00	-394.000

PARAMETERS FOR EACH CHAR REACTION AND PARTICLE

REACTION	SURFACE REACTION PRE-EXPONENTIAL FACTOR (CM/SEC-K**M)	ACTIVATION ENERGY (CAL/GMOLE)	M
1	0.10051E+03	20400.0000	1.00

THE K EQUATION OF FIELD ET. AL. IS USED FOR CHAR OXIDATION WITH O2

STOICHIOMETRIC COEFFICIENT FOR JTH PARTICLE TO KTH ELEMENT IN MOISTURE EVAPORATION

ELEMENT	COEFFICIENT
C	0.0000
H	0.1111
N	0.0000
S	0.0000
O	0.8889
Ar	0.0000

STOICHIOMETRIC COEFFICIENT FOR JTH PARTICLE TO KTH ELEMENT IN MTH REACTION (DEVOLATILIZATION)

ELEMENT	REACTION	COEFFICIENT
C	1	0.4846
H	1	0.1538
N	1	0.0410
S	1	0.0154
O	1	0.3052
Ar	1	0.0000
C	2	0.7488
H	2	0.0750
N	2	0.0200
S	2	0.0075
O	2	0.1488
Ar	2	0.0000

COEFFICIENTS FOR QUADRATIC EQUATION OF HEAT CAPACITY

COAL PART	1	2	3
COAL	0.300E+00	0.000E+00	0.000E+00
CHAR	0.300E+00	0.000E+00	0.000E+00
WATER	0.100E+01	0.000E+00	0.000E+00
ASH	0.300E+00	0.000E+00	0.000E+00

PARAMETERS FOR THE NUMBER 2 PARTICLE PHASE******

DIAMETER (CM)	EMISSIVITY	ENTHALPY (CAL/G)	SURFACE AREA FACTOR	MASS FLOW RATE (G/SEC)
0.0048	0.7000	-713.0000	0.10000E+01	1.2900

ASH MASS (G)	COAL MASS (G)	CHAR MASS (G)	WATER MASS (G)	CHAR REF. ENTHALPY (CAL/G)	WATER REF. ENTHALPY (CAL/G)
0.71510E-08	0.65790E-07	0.00000E+00	0.23340E-08	0.0000	-3185.0000

STARTING TEMPERATURE (K)	DISTANCE TEMP RISE BEGINS (CM)	INITIAL MAXIMUM TEMP IS REACHED (K)	DISTANCE INITIAL MAX (CM)
355.6000	80.0000	2100.0000	130.0000

ENTHALPY OF THE SECONDARY (CAL/G)	MASS ADDITON RATE FROM SECONDARY (G/CM-SEC)
0.0000	0.0000X**2 + 0.0000X + 0.0000

DISTANCE FOR RECIRCULATION PROPERTIES (CM)	ENTHALPY OF RECIRCULATION (CAL/G)	MASS ADDITION RATE FROM RECIRCULATION (G/CM-SEC)
0.0000	0.0000	0.0000X**3 + 0.0000X**2 + 0.0000X + 0.0000

PARAMETERS FOP EACH COAL REACTION AND PARTICLE

REACTION	PYROLYSIS PRE-EXPONENTIAL FACTOR (1/SEC)	ACTIVATION ENERGY IN REACTION (CAL/GMOLE-K)	MASS FRACTION
1	0.37000E+06	17600.0000	0.3900
2	0.14600E+14	60000.0000	0.8000

	CP COEFFICIENTS (CAL/G)		H FVJ
0.174E+00	0.810E-03	0.000E+00	-807.000

	CP COEFFICIENTS (CAL/G)		H FVJ
0.543E+00	0.610E-03	0.000E+00	-394.000

PARAMETERS FOR EACH CHAR REACTION AND PARTICLE

REACTION	SURFACE REACTION PRE-EXPONENTIAL FACTOR (CM/SEC-K**M)	ACTIVATION ENERGY (CAL/GMOLE)	M
1	0.10051E+03	20400.0000	1.00

THE K EQUATION OF FIELD ET. AL. IS USED FOR CHAR OXIDATION WITH O2

STOICHIOMETRIC COEFFICIENT FOR JTH PARTICLE TO KTH ELEMENT IN MOISTURE EVAPORATION

ELEMENT	COEFFICIENT
C	0.0000
H	0.1111
N	0.0000
S	0.0000
O	0.8889
Ar	0.0000

STOICHIOMETRIC COEFFICIENT FOR JTH PARTICLE TO KTH ELEMENT IN MTH REACTION (DEVOLATILIZATION)

ELEMENT	REACTION	COEFFICIENT
C	1	0.4846
H	1	0.1538
N	1	0.0410
S	1	0.0154
O	1	0.3052
Ar	1	0.0000
C	2	0.7488
H	2	0.0750
N	2	0.0200
S	2	0.0075
O	2	0.1488
Ar	2	0.0000

COEFFICIENTS FOR QUADRATIC EQUATION OF HEAT CAPACITY

COAL PART	1	2	3
COAL	0.300E+00	0.000E+00	0.000E+00
CHAR	0.300E+00	0.000E+00	0.000E+00
WATER	0.100E+01	0.000E+00	0.000E+00
ASH	0.300E+00	0.000E+00	0.000E+00

PARAMETERS FOR THE NUMBER 3 PARTICLE PHASE******

DIAMETER (CM)	EMISSIVITY	ENTHALPY (CAL/G)	SURFACE AREA FACTOR	MASS FLOW RATE (G/SEC)
0.0080	0.7000	-713.0000	0.10000E+01	1.1800

ASH MASS (G)	COAL MASS (G)	CHAR MASS (G)	WATER MASS (G)	CHAR REF. ENTHALPY (CAL/G)	WATER REF. ENTHALPY (CAL/G)
0.33100E-07	0.30500E-06	0.00000E+00	0.10800E-07	0.0000	-3798.0000

STARTING TEMPERATURE (K)	DISTANCE TEMP RISE BEGINS (CM)	INITIAL MAXIMUM TEMP IS REACHED (K)	DISTANCE INITIAL MAX (CM)
355.6000	80.0000	2100.0000	130.0000

ENTHALPY OF THE SECONDARY (CAL/G)
0.0000

MASS ADDITON RATE FROM SECONDARY (G/CM-SEC)
0.0000X**2 + 0.0000X + 0.0000

DISTANCE FOR RECIRCULATION PROPERTIES (CM)
17.0000

ENTHALPY OF RECIRCULATION (CAL/G)
300.0000

MASS ADDITION RATE FROM RECIRCULATION (G/CM-SEC)
0.0000X**3 + 0.0000X**2 + 0.0000X + 0.0000

PARAMETERS FOR EACH COAL REACTION AND PARTICLE

REACTION	PYROLYSIS PRE-EXPONENTIAL FACTOR (1/SEC)	ACTIVATION ENERGY IN REACTION (CAL/GMOLE-K)	MASS FRACTION
1	0.37000E+06	17600.0000	0.3900
2	0.14600E+14	60000.0000	0.8000

CP COEFFICIENTS (CAL/G)			H FVJ
0.174E+00	0.810E-03	0.000E+00	-807.000

CP COEFFICIENTS (CAL/G)			H FVJ
0.543E+00	0.610E-03	0.000E+00	-394.000

PARAMETERS FOR EACH CHAR REACTION AND PARTICLE

REACTION	SURFACE REACTION PRE-EXPONENTIAL FACTOR (CM/SEC-K**M)	ACTIVATION ENERGY (CAL/GMOLE)	M
1	0.10051E+03	20400.0000	1.00

THE K EQUATION OF FIELD ET. AL. IS USED FOR CHAR OXIDATION WITH O2

STOICHIOMETRIC COEFFICIENT FOR JTH PARTICLE TO KTH ELEMENT IN MOISTURE EVAPORATION

ELEMENT	COEFFICIENT
C	0.0000
H	0.1111
N	0.0000
S	0.0000
O	0.8889
Ar	0.0000

STOICHIOMETRIC COEFFICIENT FOR JTH PARTICLE TO KTH ELEMENT IN MTH REACTION (DEVOLATILIZATION)

ELEMENT	REACTION	COEFFICIENT
C	1	0.4846
H	1	0.1538
N	1	0.0410
S	1	0.0154
O	1	0.3052
Ar	1	0.0000
C	2	0.7488
H	2	0.0750
N	2	0.0200
S	2	0.0075
O	2	0.1488
Ar	2	0.0000

COEFFICIENTS FOR QUADRATIC EQUATION OF HEAT CAPACITY

COAL PART	1	2	3
COAL	0.300E+00	0.000E+00	0.000E+00
CHAR	0.300E+00	0.000E+00	0.000E+00
WATER	0.100E+01	0.000E+00	0.000E+00
ASH	0.300E+00	0.000E+00	0.000E+00

ELEMENT PARAMETERS****************

ELEMENT	ATOMIC WT.	INITIAL MASS FRACTION	MASS FRACTION IN SEC. (G/CM-SEC)	MASS FRACTION IN RECIRC. (G/CM-SEC)	STOICHIOMETRIC COEFFECIENTS FROM LTH REACTION 1
C	12.00000	0.00000	0.00000	0.00000	1.00000
H	1.00000	0.00000	0.00000	0.00000	0.00000
N	14.00000	0.70120	0.75890	0.76000	0.00000
S	32.00000	0.00000	0.00000	0.00700	0.00000
O	16.00000	0.22180	0.23080	0.23080	0.00000
Ar	40.00000	0.07700	0.01030	0.01030	0.00000

SPECIES PARAMETERS***************

SPECIES	COLLISION DIAMETER	EPSILON/K	DELTA	MOL FRAC IN	NUMBER OF ELEMENTS IN A SPECIES C	H	N	S	O	Ar
AR	3.41800	124.00000	0.00000	0.10000	0.	0.	0.	0.	0.	1.
CO	3.59000	110.00000	0.00000	0.10000	1.	0.	0.	0.	1.	0.
O2	3.43300	113.00000	0.00000	0.20000	0.	0.	0.	0.	2.	0.
N2	3.68100	91.50000	0.00000	1.00000	0.	0.	2.	0.	0.	0.
CO2	3.99600	190.00000	0.00000	0.10000	1.	0.	0.	0.	2.	0.
H2O	2.64100	809.10000	1.00000	0.20000	0.	2.	0.	0.	1.	0.
H2	2.91500	38.00000	0.00000	0.10000	0.	2.	0.	0.	0.	0.
CH4	3.82200	137.00000	0.00000	0.60000	1.	4.	0.	0.	0.	0.
SO2	4.29000	252.00000	0.42000	0.01000	0.	0.	0.	1.	2.	0.
NO	3.49200	116.70000	0.00000	0.00100	0.	0.	1.	0.	1.	0.

SPECIES	ENTHALPY	ENTROPY	HEAT CAPACITY COEFF. FOR EDWARDS				
AR	4.48700	43.90100					
			4.9870	0.0000	0.0000	0.0000	0.0000
			4.9870	0.0000	0.0000	0.0000	0.0000
CO	-19.62150	57.49990					
			9.6744	-4.2373	9.0746	-12.0826	5.6376
			7.5994	-4.8661	11.5395	-8.5080	2.1666
O2	7.11490	59.73200					
			10.9940	-1.0300	-16.8890	32.3940	-17.5193
			7.1663	-3.3897	12.9769	-12.1542	3.7360
N2	6.71870	55.95780					
			9.7325	-4.9604	11.2348	-15.2917	7.2889
			7.5309	-4.0828	8.9494	-5.9095	1.3277
CO2	-83.42260	66.75520					
			16.9476	-12.9426	31.5939	-40.9050	18.7665
			4.4269	19.8206	-19.3181	10.4840	-2.4332
H2O	-49.55700	57.44630					
			15.5208	-6.7693	0.7168	-2.1223	2.6974
			8.0455	-1.8538	7.2725	-4.7628	1.1489
H2	6.40480	41.03490					
			12.8548	-23.8674	52.9484	-61.0990	27.0132
			6.1563	4.6572	-9.6723	8.7834	-2.7044
CH4	-5.16060	62.43440					

			25.7473	1.2222	-22.0015	15.0340	-2.7867
			7.4307	-6.3982	44.3471	-39.8204	11.5976
SO2	-60.07880	75.46430					
			16.0201	-11.0806	25.7165	-30.4358	13.0862
			5.9938	14.2911	-8.3110	0.0191	1.0272
NO	28.54110	60.88110					
			9.6120	-3.4797	7.1128	-9.1987	4.1679
			8.1959	-7.8995	18.6061	-14.9907	4.2114

PHYSICAL PARAMETERS*************

DIAMETER OF DUCT (CM)	DIAMETER OF CHAMBER (CM)	REACTOR LENGTH (CM)	GROWTH AREA ANGLE (DEGREES)	EMISSIVITY OF THE WALL	TEMPERATURE OF THE WALL (K)
1.5875	20.3200	152.4000	15.0000	1.0000	1200.0000

ABSORBTION EFFICIENCY	PARTICLE SWELLING	MOLECULAR WEIGHT OF CHAR (G/GMOLE)
1.0000	0.1000	12.0000

CHAR REACTION DATA*************

REACTION	OXYDIZER	STOICHIOMETRIC COEFFICIENT
1	02	2.0000

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THE ORDERED PAIR OF (X,# OF CORRECTORS APPLIED) FOLLOWS FOR EACH O.D.E. STEP
*****************************************************************************
(  1.22, 1)(  2.03, 1)(  2.24, 1)(  2.44, 1)(  2.64, 1)(  2.84, 1)(  3.66, 1)(  3.86, 1)(  4.06, 1)(  4.27, 1)(  4.47, 1)(  4.67, 1)
(  4.88, 1)(  5.08, 1)(  5.28, 1)(  5.49, 1)(  5.69, 1)(  5.89, 1)(  6.10, 1)(  6.30, 1)(  6.50, 1)(  6.71, 1)(  6.91, 1)(  7.11, 1)
(  7.32, 1)(  7.52, 1)(  7.72, 1)(  7.92, 1)(  8.13, 1)(  8.33, 1)(  8.53, 1)(  8.74, 1)(  8.94, 1)(  9.14, 1)(  9.35, 1)(  9.55, 1)
(  9.75, 1)(  9.96, 1)( 10.16, 1)( 10.36, 1)( 10.57, 1)( 10.77, 1)( 10.97, 1)( 11.18, 1)( 11.38, 1)( 11.58, 1)( 11.79, 1)( 11.99, 1)
( 12.19, 1)( 12.40, 1)( 12.60, 1)( 12.80, 1)( 13.00, 1)( 13.21, 1)( 13.41, 1)( 13.61, 1)( 13.82, 1)( 14.02, 1)( 14.22, 1)( 14.43, 1)
( 14.63, 1)( 14.83, 1)( 15.04, 1)( 15.24, 1)( 15.44, 1)( 15.65, 1)( 15.85, 1)( 16.05, 1)( 16.26, 1)( 16.46, 1)( 16.66, 1)( 16.87, 1)
( 17.07, 1)( 17.27, 1)( 17.48, 1)( 17.68, 1)( 17.88, 1)( 18.08, 1)( 18.29, 1)( 18.49, 1)( 18.69, 1)( 18.90, 1)( 19.10, 1)( 19.30, 1)
( 19.51, 1)( 19.71, 1)( 19.91, 1)( 20.12, 1)( 20.32, 1)( 20.52, 1)( 20.73, 1)( 20.93, 1)( 21.13, 1)( 21.34, 1)( 21.54, 1)( 21.74, 1)
( 21.95, 1)( 22.15, 1)( 22.35, 1)( 22.56, 1)( 22.76, 1)( 22.96, 1)( 23.16, 1)( 23.37  1)( 23.57, 1)( 23.77, 1)( 23.98, 1)( 24.18, 1)
( 24.38, 1)( 24.59, 1)( 24.79, 1)( 24.99, 1)( 25.20, 1)( 25.40, 1)( 25.60, 1)( 25.81, 1)( 26.01, 1)( 26.21, 1)( 26.42, 1)( 26.62, 1)
( 26.82, 1)( 27.03, 1)( 27.23, 1)( 27.43, 1)( 27.64, 1)( 27.84, 1)( 28.04, 1)( 28.24, 1)( 28.45, 1)( 28.65, 1)( 28.85, 1)( 29.06, 1)
( 29.26, 1)( 29.46, 1)( 29.67, 2)( 29.87, 2)( 30.07, 1)( 30.28, 1)( 30.48, 1)( 30.68, 2)( 30.89, 2)( 31.09, 1)( 31.29, 1)( 31.50, 1)
( 31.70, 2)( 31.90, 2)( 32.11, 2)( 32.31, 1)( 32.51, 1)( 32.72, 2)( 32.92, 2)( 33.12, 2)( 33.32, 1)( 33.53, 1)( 33.73, 2)( 33.93, 2)
( 34.14, 2)( 34.34, 1)( 34.54, 1)( 34.75, 2)( 34.95, 2)( 35.76, 4)( 35.97, 2)( 36.17, 2)( 36.37, 1)( 36.58, 1)( 36.78, 2)( 36.98, 2)
( 37.19, 2)( 37.39, 1)( 37.59, 1)( 37.80, 2)( 38.00, 2)( 38.20, 2)( 38.40, 1)( 38.61, 1)( 38.81, 2)( 39.01, 2)( 39.22, 2)( 39.42, 1)
( 39.62, 1)( 39.83, 2)( 40.03, 2)( 40.23, 2)( 40.44, 2)( 40.64, 1)( 40.84, 2)( 41.05, 2)( 41.25, 2)( 41.45, 1)( 41.66, 1)( 41.86, 2)
( 42.06, 2)( 42.27, 2)( 42.47, 1)( 42.67, 1)( 42.88, 2)( 43.08, 2)( 43.28, 2)( 43.48, 2)( 43.69, 1)( 43.89, 2)( 44.09, 2)( 44.30, 2)
( 44.50, 2)( 44.70, 1)( 44.91, 2)( 45.11, 2)( 45.31, 2)( 45.52, 1)( 45.72, 1)( 45.92, 1)( 46.13, 2)( 46.33, 2)( 46.53, 2)( 46.74, 2)
( 46.94, 1)( 47.14, 2)( 47.35, 2)( 47.55, 2)( 47.75, 1)( 47.96, 1)( 48.16, 2)( 48.36, 2)( 48.56, 2)( 48.77, 1)( 48.97, 1)( 49.17, 2)
( 49.38, 2)( 49.58, 2)( 49.78, 1)( 49.99, 1)( 50.19, 2)( 50.39, 2)( 50.60, 2)( 50.80, 1)( 51.00, 1)( 51.21, 2)( 51.41, 2)( 51.61, 2)
( 51.82, 1)( 52.02, 1)( 52.22, 2)( 52.43, 2)( 52.63, 2)( 52.83, 1)( 53.04, 1)( 53.24, 2)( 53.44, 2)( 53.64, 2)( 53.85, 1)( 54.05, 1)
( 54.25, 2)( 54.46, 2)( 54.66, 2)( 54.86, 1)( 55.07, 1)( 55.27, 2)( 55.47, 2)( 55.68, 2)( 55.88, 1)( 56.08, 1)( 56.29, 2)( 56.49, 2)
( 56.69, 2)( 56.90, 1)( 57.10, 1)( 57.30, 2)( 57.51, 2)( 57.71, 2)( 57.91, 1)( 58.12, 1)( 58.32, 2)( 58.52, 2)( 58.72, 2)( 58.93, 1)
( 59.13, 1)( 59.33, 2)( 59.54, 2)( 59.74, 2)( 59.94, 1)( 60.15, 1)( 60.35, 2)( 60.55, 2)( 60.76, 2)( 60.96, 1)( 61.16, 1)( 61.37, 2)
( 61.57, 2)( 61.77, 2)( 61.98, 1)( 62.18, 1)( 62.38, 2)( 62.59, 2)( 62.79, 2)( 62.99, 1)( 63.20, 1)( 63.40, 2)( 63.60, 2)( 63.80, 1)
( 64.01, 1)( 64.21, 1)( 64.41, 1)( 64.62, 1)( 64.82, 1)( 65.02, 1)( 65.23, 1)( 65.43, 2)( 65.63, 2)( 65.84, 2)( 66.04, 2)( 66.24, 1)
( 66.45, 2)( 66.65, 2)( 66.85, 1)( 67.06, 1)( 67.26, 1)( 67.46, 1)( 67.67, 1)( 67.87, 1)( 68.07, 1)( 68.28, 1)( 68.48, 2)( 68.68, 2)
( 68.88, 2)( 69.09, 2)( 69.29, 1)( 69.49, 2)( 69.70, 2)( 69.90, 1)( 70.10, 1)( 70.31, 1)( 70.51, 1)( 70.71, 1)( 70.92, 1)( 71.12, 2)
( 71.32, 2)( 71.53, 1)( 71.73, 2)( 71.93, 2)( 72.14, 2)( 72.34, 2)( 72.54, 2)( 72.75, 1)( 72.95, 2)( 73.15, 1)( 73.36, 1)( 73.56, 1)
( 73.76, 1)( 73.96, 2)( 74.17, 2)( 74.37, 1)( 74.57, 2)( 74.78, 2)( 74.98, 2)( 75.18, 2)( 75.39, 2)( 75.59, 2)( 75.79, 1)( 76.00, 2)
( 76.20, 1)( 76.40, 1)( 76.61, 2)( 76.81, 1)( 77.01, 2)( 77.22, 2)( 77.42, 1)( 77.62, 2)( 77.83, 3)( 78.03, 2)( 78.23, 2)( 78.44, 3)
( 78.64, 2)( 78.84, 2)( 79.04, 2)( 79.25, 2)( 79.45, 1)( 79.65, 2)( 79.86, 1)( 80.06, 2)( 80.26, 2)( 80.47, 1)( 80.67, 2)( 80.87, 2)
( 81.08, 2)( 81.28, 1)( 81.48, 2)( 81.69, 2)( 81.89, 1)( 82.09, 2)( 82.30, 1)( 82.50, 1)( 82.70, 1)( 82.91, 1)( 83.11, 2)( 83.31, 2)
( 83.52, 1)( 83.72, 2)( 83.92, 2)( 84.12, 1)( 84.33, 1)( 84.53, 2)( 84.73, 2)( 84.94, 1)( 85.14, 1)( 85.34, 1)( 85.55, 1)( 85.75, 1)
( 85.95, 1)( 86.16, 1)( 86.36, 1)( 86.56, 1)( 86.77, 2)( 86.97, 1)( 87.17, 1)( 87.38, 1)( 87.58, 1)( 87.78, 1)( 87.99, 1)( 88.19, 1)
( 88.39, 1)( 88.60, 1)( 88.80, 1)( 89.00, 1)( 89.41, 1)( 89.51, 1)( 89.61, 1)( 89.71, 1)( 89.81, 1)( 89.92, 1)( 90.02, 1)( 90.12, 1)
( 90.22, 1)( 90.32, 1)( 90.42, 1)( 90.53, 1)( 90.63, 1)( 90.73, 1)( 90.83, 1)( 90.93, 1)( 91.03, 1)( 91.14, 1)( 91.24, 1)( 91.34, 1)
( 91.44, 1)( 91.54, 1)( 91.64, 1)( 91.74, 1)( 91.85, 1)( 91.95, 1)( 92.05, 1)( 92.15, 1)( 92.25, 1)( 92.35, 1)( 92.46, 1)( 92.56, 1)
( 92.66, 1)( 92.76, 1)( 92.86, 1)( 92.96, 1)( 93.07, 1)( 93.17, 1)( 93.27, 1)( 93.37, 1)( 93.47, 1)( 93.57, 1)( 93.68, 1)( 93.78, 1)
( 93.88, 1)( 93.98, 1)( 94.08, 1)( 94.18, 1)( 94.28, 1)( 94.39, 1)( 94.49, 1)( 94.59, 1)( 94.69, 1)( 94.79, 1)( 94.89, 1)( 95.00, 1)
( 95.10, 1)( 95.20, 1)( 95.30, 1)( 95.40, 1)( 95.50, 1)( 95.61, 1)( 95.71, 1)( 95.81, 1)( 95.91, 1)( 96.01, 1)( 96.11, 1)( 96.22, 1)
( 96.32, 1)( 96.42, 1)( 96.52, 1)( 96.62, 1)( 96.72, 1)( 96.82, 1)( 96.93, 1)( 97.03, 1)( 97.13, 1)( 97.23, 1)( 97.33, 1)( 97.43, 1)
( 97.54, 1)( 97.64, 1)( 97.74, 1)( 97.84, 1)( 97.94, 1)( 98.04, 1)( 98.15, 1)( 98.25, 1)( 98.35, 1)( 98.45, 1)( 98.55, 1)( 98.65, 1)
( 98.76, 1)( 98.86, 1)( 98.96, 1)( 99.06, 1)( 99.16, 1)( 99.26, 1)( 99.36, 1)( 99.47, 1)( 99.57, 1)( 99.67, 1)( 99.77, 1)( 99.87, 1)
( 99.97, 1)(100.08, 1)(100.18, 1)(100.28, 1)(100.38, 1)(100.48, 1)(100.58, 1)(100.69, 1)(100.79, 1)(100.89, 1)(100.99, 1)(101.09, 1)
(101.19, 1)(101.30, 1)(101.40, 1)(101.50, 1)(101.60, 1)(101.70, 1)(101.80, 1)(101.90, 1)(102.01, 1)(102.41, 1)(102.51, 1)(102.62, 1)
(102.72, 1)(102.82, 1)(102.92, 1)(103.02, 1)(103.12, 1)(103.23, 1)(103.33, 2)(103.43, 2)(103.84, 1)(103.94, 1)(104.04, 1)(104.14, 1)
(104.24, 1)(104.34, 1)(104.44, 2)(104.55, 2)(104.65, 2)(104.75, 1)(104.85, 1)(104.95, 1)(105.05, 2)(105.16, 2)(105.26, 2)(105.36, 2)
(105.46, 2)(105.56, 2)(105.66, 3)(105.77, 3)(105.87, 2)(105.97, 1)(106.07, 1)(106.17, 2)(106.27, 3)(106.38, 3)(106.48, 3)(106.58, 2)
(106.95, 1)(107.02, 1)(107.09, 1)(107.15, 1)(107.22, 1)(107.29, 1)(107.36, 1)(107.43, 2)(107.49, 3)(107.56, 2)(107.63, 2)(107.70, 1)
(107.76, 1)(107.83, 1)(107.90, 1)(107.97, 1)(108.03, 2)(108.10, 3)(108.17, 2)(108.24, 1)(108.31, 1)(108.37, 1)(108.44, 1)(108.51, 1)
(108.58, 1)(108.64, 3)(108.71, 3)(108.78, 3)(108.85, 2)(108.92, 2)(108.98, 2)(109.05, 2)(109.12, 3)(109.19, 3)(109.25, 4)(109.32, 3)
(109.39, 2)(109.46, 1)(109.52, 1)(109.59, 1)(109.66, 1)(109.73, 2)(109.80, 4)(109.86, 4)(109.93, 4)(110.00, 4)(110.07, 3)(110.13, 3)
(110.20, 2)(110.27, 2)(110.34, 1)(110.41, 5)(110.47, 6)(110.54, 6)(110.61, 5)(110.68, 4)(110.74, 4)(110.81, 3)(110.88, 1)(110.95, 5)
(111.01, 7)(111.08, 8)(111.15, 8)(111.22, 8)(111.29, 8)(111.35, 9)(111.42, 9)(111.49, 8)(111.56, 6)(111.62,11)(111.69,11)(111.76,11)
THE STIFF PARTICLE ENERGY EQUATION ASSUMPTION IS INITIATED FOR PARTICLE NO. 1 AT 112.03 CM. DOWN THE REACTOR
(112.03, 1)(112.10, 1)(112.17, 1)(112.23, 1)(112.30, 1)(112.37, 1)(112.44, 1)(112.51, 1)(112.57, 1)(112.64, 1)(112.71, 1)(112.78, 1)
(112.84, 1)(112.91, 2)(112.98, 1)(113.05, 1)(113.11, 1)(113.18, 1)(113.25, 1)(113.32, 1)(113.39, 1)(113.45, 2)(113.52, 2)(113.59, 1)
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THE STIFF PARTICLE ENERGY EQUATION ASSUMPTION IS INITIATED FOR PARTICLE NO. 2 AT 113.59 CM. DOWN THE REACTOR
(113.66, 2)(113.72, 1)(113.79, 1)(113.86, 1)(113.93, 1)(114.00, 1)(114.06, 1)(114.13, 1)(114.20, 1)(114.27, 1)(114.33, 1)(114.40, 1)
(114.47, 1)(114.54, 1)(114.60, 1)(114.67, 1)(114.74, 2)(114.81, 1)(114.88, 1)(114.94, 1)(115.01, 1)(115.08, 1)(115.15, 1)(115.21, 2)
THE STIFF PARTICLE ENERGY EQUATION ASSUMPTION IS INITIATED FOR PARTICLE NO. 3 AT 115.21 CM. DOWN THE REACTOR
(117.65, 1)(118.26, 1)(118.87, 1)(119.48, 1)(120.09, 1)(120.70, 1)(121.31, 1)(121.92, 1)(122.53, 1)(123.14, 1)(123.75, 1)(124.36, 1)
(124.97, 1)(125.58, 1)(126.19, 1)(126.80, 1)(127.41, 1)(128.02, 1)(128.63, 1)(129.24, 1)(129.84, 1)(130.45, 1)(131.06, 1)(131.67, 1)
(132.28, 1)(132.89, 1)(133.50, 1)(134.11, 1)(134.72, 1)(135.33, 1)(135.94, 1)(136.55, 1)(137.16, 1)(137.77, 1)(138.38, 1)(138.99, 1)
(139.60, 1)(140.21, 1)(140.82, 1)(141.43, 1)(142.04, 1)(142.65, 1)(143.26, 1)(143.87, 1)(144.48, 1)(145.08, 1)(145.69, 1)(146.30, 1)
(146.91, 1)(147.52, 1)(148.13, 1)(148.74, 1)(149.35, 1)(149.96, 1)(150.57, 1)(151.18, 1)(151.79, 1)(152.40, 1)(

AFTER  1 ITERATION(S) THROUGH THE REACTOR THE ROOT MEAN SQUARE OF ALL PARTICLE TEMPERATURES IS  535.742 DEGREES KELVIN
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THE ORDERED PAIR OF (X,# OF CORRECTORS APPLIED) FOLLOWS FOR EACH O.D.E. STEP
*****************************************************************************
(  1.22, 1)(  2.03, 1)(  2.24, 1)(  2.44, 1)(  2.64, 1)(  2.84, 1)(  3.66, 1)(  3.86, 1)(  4.06, 1)(  4.27, 1)(  4.47, 1)(  4.67, 1)
(  4.88, 1)(  5.08, 1)(  5.28, 1)(  5.49, 1)(  5.69, 1)(  5.89, 1)(  6.10, 1)(  6.30, 1)(  6.50, 1)(  6.71, 1)(  6.91, 1)(  7.11, 1)
(  7.32, 1)(  7.52, 1)(  7.72, 1)(  7.92, 1)(  8.13, 1)(  8.33, 1)(  8.53, 1)(  8.74, 1)(  8.94, 1)(  9.14, 1)(  9.35, 1)(  9.55, 1)
(  9.75, 1)(  9.96, 1)( 10.16, 1)( 10.36, 1)( 10.57, 1)( 10.77, 1)( 10.97, 1)( 11.18, 1)( 11.38, 1)( 11.58, 1)( 11.79, 1)( 11.99, 1)
( 12.19, 1)( 12.40, 1)( 12.60, 1)( 12.80, 1)( 13.00, 1)( 13.21, 1)( 13.41, 1)( 13.61, 1)( 13.82, 1)( 14.02, 1)( 14.22, 1)( 14.43, 1)
( 14.63, 1)( 14.83, 1)( 15.04, 1)( 15.24, 1)( 15.44, 1)( 15.65, 1)( 15.85, 1)( 16.05, 1)( 16.26, 1)( 16.46, 1)( 16.66, 1)( 16.87, 1)
( 17.07, 1)( 17.27, 1)( 17.48, 1)( 17.68, 1)( 17.88, 1)( 18.08, 1)( 18.29, 1)( 18.49, 1)( 18.69, 1)( 18.90, 1)( 19.10, 1)( 19.30, 1)
( 19.51, 1)( 19.71, 1)( 19.91, 1)( 20.12, 1)( 20.32, 1)( 20.52, 1)( 20.73, 1)( 20.93, 1)( 21.13, 1)( 21.34, 1)( 21.54, 1)( 21.74, 1)
( 21.95, 1)( 22.15, 1)( 22.35, 1)( 22.56, 1)( 22.76, 1)( 22.96, 1)( 23.16, 1)( 23.37, 1)( 23.57, 1)( 23.77, 1)( 23.98, 1)( 24.18, 1)
( 24.38, 1)( 24.59, 1)( 24.79, 1)( 24.99, 1)( 25.20, 1)( 25.40, 1)( 25.60, 1)( 25.81, 1)( 26.01, 1)( 26.21, 1)( 26.42, 1)( 26.62, 1)
( 26.82, 1)( 27.03, 1)( 27.23, 1)( 27.43, 1)( 27.64, 1)( 27.84, 1)( 28.04, 1)( 28.24, 1)( 28.45, 1)( 28.65, 2)( 28.85, 2)( 29.06, 1)
( 29.26, 1)( 29.46, 1)( 29.67, 2)( 29.87, 2)( 30.07, 1)( 30.28, 1)( 30.48, 1)( 30.68, 2)( 30.89, 2)( 31.09, 1)( 31.29, 1)( 31.50, 1)
( 31.70, 2)( 31.90, 2)( 32.11, 2)( 32.31, 1)( 32.51, 1)( 32.72, 2)( 32.92, 2)( 33.12, 2)( 33.32, 1)( 33.53, 1)( 33.73, 2)( 33.93, 2)
( 34.14, 2)( 34.34, 1)( 34.54, 1)( 34.75, 2)( 34.95, 2)( 35.76, 3)( 35.97, 3)( 36.17, 2)( 36.37, 1)( 36.58, 1)( 36.78, 2)( 36.98, 2)
( 37.19, 2)( 37.39, 2)( 37.59, 1)( 37.80, 2)( 38.00, 2)( 38.20, 2)( 38.40, 2)( 38.61, 1)( 38.81, 2)( 39.01, 2)( 39.22, 2)( 39.42, 1)
( 39.62, 1)( 39.83, 2)( 40.03, 2)( 40.23, 2)( 40.44, 2)( 40.64, 1)( 40.84, 2)( 41.05, 3)( 41.25, 2)( 41.45, 1)( 41.66, 1)( 41.86, 2)
( 42.06, 2)( 42.27, 2)( 42.47, 1)( 42.67, 1)( 42.88, 2)( 43.08, 2)( 43.28, 2)( 43.48, 2)( 43.69, 1)( 43.89, 2)( 44.09, 3)( 44.30, 2)
( 44.50, 1)( 44.70, 1)( 44.91, 2)( 45.11, 2)( 45.31, 2)( 45.52, 1)( 45.72, 1)( 45.92, 1)( 46.13, 2)( 46.33, 2)( 46.53, 2)( 46.74, 2)
( 46.94, 1)( 47.14, 2)( 47.35, 2)( 47.55, 2)( 47.75, 2)( 47.96, 1)( 48.16, 2)( 48.36, 2)( 48.56, 2)( 48.77, 1)( 48.97, 1)( 49.17, 2)
( 49.38, 2)( 49.58, 2)( 49.78, 2)( 49.99, 1)( 50.19, 2)( 50.39, 2)( 50.60, 2)( 50.80, 2)( 51.00, 1)( 51.21, 2)( 51.41, 2)( 51.61, 2)
( 51.82, 1)( 52.02, 1)( 52.22, 2)( 52.43, 2)( 52.63, 2)( 52.83, 2)( 53.04, 1)( 53.24, 2)( 53.44, 2)( 53.64, 2)( 53.85, 2)( 54.05, 1)
( 54.25, 2)( 54.46, 2)( 54.66, 2)( 54.86, 1)( 55.07, 1)( 55.27, 2)( 55.47, 2)( 55.68, 2)( 55.88, 2)( 56.08, 1)( 56.29, 2)( 56.49, 2)
( 56.69, 2)( 56.90, 2)( 57.10, 1)( 57.30, 2)( 57.51, 2)( 57.71, 2)( 57.91, 1)( 58.12, 1)( 58.32, 2)( 58.52, 2)( 58.72, 2)( 58.93, 1)
( 59.13, 1)( 59.33, 2)( 59.54, 2)( 59.74, 2)( 59.94, 1)( 60.15, 1)( 60.35, 2)( 60.55, 2)( 60.76, 2)( 60.96, 1)( 61.16, 1)( 61.37, 2)
( 61.57, 2)( 61.77, 2)( 61.98, 1)( 62.18, 1)( 62.38, 2)( 62.59, 2)( 62.79, 2)( 62.99, 1)( 63.20, 1)( 63.40, 2)( 63.60, 2)( 63.80, 2)
( 64.01, 1)( 64.21, 1)( 64.41, 2)( 64.62, 2)( 64.82, 2)( 65.02, 1)( 65.23, 1)( 65.43, 2)( 65.63, 2)( 65.84, 2)( 66.04, 1)( 66.24, 1)
( 66.45, 2)( 66.65, 2)( 66.85, 2)( 67.06, 1)( 67.26, 1)( 67.46, 2)( 67.67, 2)( 67.87, 2)( 68.07, 1)( 68.28, 1)( 68.48, 2)( 68.68, 2)
( 68.88, 2)( 69.09, 1)( 69.29, 1)( 69.49, 2)( 69.70, 2)( 69.90, 1)( 70.10, 1)( 70.31, 1)( 70.51, 1)( 70.71, 1)( 70.92, 1)( 71.12, 1)
( 71.32, 1)( 71.53, 1)( 71.73, 2)( 71.93, 1)( 72.14, 1)( 72.34, 1)( 72.54, 1)( 72.75, 1)( 72.95, 1)( 73.15, 1)( 73.36, 1)( 73.56, 1)
( 73.76, 1)( 73.96, 1)( 74.17, 1)( 74.37, 1)( 74.57, 1)( 74.78, 1)( 74.98, 1)( 75.18, 1)( 75.39, 1)( 75.59, 1)( 75.79, 1)( 76.00, 1)
( 76.20, 1)( 76.40, 1)( 76.61, 1)( 76.81, 1)( 77.01, 1)( 77.22, 1)( 77.42, 1)( 77.62, 1)( 77.83, 1)( 78.03, 1)( 78.23, 1)( 78.44, 1)
( 78.64, 1)( 78.84, 1)( 79.04, 1)( 79.25, 1)( 79.45, 1)( 79.65, 1)( 79.86, 1)( 80.06, 1)( 80.26, 1)( 80.47, 1)( 80.67, 1)( 80.87, 1)
( 81.08, 1)( 81.28, 1)( 81.48, 1)( 81.69, 1)( 81.89, 1)( 82.09, 1)( 82.30, 1)( 82.70, 1)( 82.80, 1)( 82.91, 1)( 83.01, 1)( 83.11, 1)
( 83.21, 1)( 83.31, 1)( 83.41, 1)( 83.52, 1)( 83.62, 1)( 83.72, 1)( 83.82, 1)( 83.92, 1)( 84.02, 1)( 84.12, 1)( 84.23, 1)( 84.33, 1)
( 84.43, 1)( 84.53, 1)( 84.63, 1)( 84.73, 1)( 84.84, 1)( 84.94, 1)( 85.04, 1)( 85.14, 1)( 85.24, 1)( 85.34, 1)( 85.45, 1)( 85.55, 1)
( 85.65, 1)( 85.75, 1)( 85.85, 1)( 85.95, 1)( 86.06, 1)( 86.16, 1)( 86.26, 1)( 86.36, 1)( 86.46, 1)( 86.56, 1)( 86.66, 1)( 86.77, 1)
( 86.87, 1)( 86.97, 1)( 87.07, 1)( 87.17, 1)( 87.27, 1)( 87.38, 1)( 87.48, 1)( 87.58, 1)( 87.68, 1)( 87.78, 1)( 87.88, 1)( 87.99, 1)
( 88.09, 1)( 88.19, 1)( 88.29, 1)( 88.39, 1)( 88.49, 1)( 88.60, 1)( 88.70, 1)( 88.80, 1)( 88.90, 1)( 89.00, 1)( 89.10, 1)( 89.20, 1)
( 89.31, 1)( 89.41, 1)( 89.51, 1)( 89.61, 1)( 89.71, 1)( 89.81, 1)( 89.92, 1)( 90.02, 1)( 90.12, 1)( 90.22, 1)( 90.32, 1)( 90.42, 1)
( 90.53, 1)( 90.63, 1)( 90.73, 1)( 90.83, 1)( 90.93, 1)( 91.03, 1)( 91.14, 1)( 91.24, 1)( 91.34, 1)( 91.44, 1)( 91.54, 1)( 91.64, 1)
( 91.74, 1)( 91.85, 1)( 91.95, 1)( 92.05, 1)( 92.15, 1)( 92.25, 1)( 92.35, 1)( 92.46, 1)( 92.56, 1)( 92.66, 1)( 92.76, 1)( 92.86, 1)
( 92.96, 1)( 93.07, 1)( 93.17, 1)( 93.27, 1)( 93.37, 1)( 93.47, 1)( 93.57, 1)( 93.68, 1)( 93.78, 1)( 93.88, 1)( 93.98, 1)( 94.08, 1)
( 94.18, 1)( 94.28, 1)( 94.69, 1)( 94.79, 1)( 94.89, 1)( 95.00, 1)( 95.10, 1)( 95.20, 1)( 95.30, 1)( 95.40, 1)( 95.81, 1)( 95.91, 1)
( 96.01, 1)( 96.11, 1)( 96.22, 1)( 96.32, 1)( 96.42, 1)( 96.52, 1)( 96.62, 1)( 96.72, 1)( 96.82, 1)( 96.93, 1)( 97.03, 1)( 97.13, 1)
( 97.23, 1)( 97.33, 1)( 97.43, 1)( 97.54, 1)( 97.64, 1)( 97.74, 1)( 97.84, 1)( 97.94, 1)( 98.04, 1)( 98.42, 1)( 98.48, 1)( 98.55, 1)
( 98.62, 1)( 98.69, 1)( 98.76, 1)( 98.82, 1)( 98.89, 1)( 98.96, 1)( 99.03, 1)( 99.09, 1)( 99.16, 1)( 99.23, 1)( 99.30, 1)( 99.36, 1)
( 99.43, 1)( 99.50, 1)( 99.57, 1)( 99.64, 1)( 99.70, 1)( 99.77, 1)( 99.84, 1)( 99.91, 1)( 99.97, 1)(100.04, 1)(100.11, 2)(100.18, 2)
(100.25, 2)(100.31, 1)(100.38, 1)(100.45, 1)(100.52, 1)(100.58, 1)(100.65, 1)(100.72, 2)(100.79, 2)(100.85, 2)(100.92, 2)(100.99, 2)
(101.06, 2)(101.13, 2)(101.19, 2)(101.26, 2)(101.33, 2)(101.40, 3)(101.46, 3)(101.53, 1)(101.60, 1)(101.67, 1)(101.74, 2)(101.80, 3)
(101.87, 3)(101.94, 4)(102.01, 3)(102.07, 1)(102.14, 1)(102.21, 1)(102.28, 2)(102.35, 3)(102.41, 2)(102.48, 3)(102.55, 5)(102.62, 4)
(102.68, 3)(102.75, 3)(102.82, 1)(102.89, 3)(102.95, 1)(103.02, 1)(103.09, 6)(103.16, 9)(103.23,10)(103.29,10)(103.36,11)(103.43,11)
THE STIFF PARTICLE ENERGY EQUATION ASSUMPTION IS INITIATED FOR PARTICLE NO. 1 AT 103.84 CM. DOWN THE REACTOR
(103.50, 1)(103.56,10)(103.84,11)(103.90, 1)(103.97, 1)(104.04, 1)(104.11, 1)(104.17, 1)(104.24, 1)(104.31, 1)(104.38, 1)(104.44, 1)
(104.51, 1)(104.58, 1)(104.65, 1)(104.72, 1)(104.78, 1)(104.85, 1)(104.92, 1)(104.99, 1)(105.05, 1)(105.12, 1)(105.19, 1)(105.26, 1)
(105.33, 1)(105.39, 1)(105.46, 1)(105.53, 1)(105.60, 1)(105.66, 1)(105.73, 1)(105.80, 1)(105.87, 1)(105.93, 1)(106.00, 1)(106.07, 1)
(106.14, 1)(106.21, 1)(106.27, 1)(106.34, 1)(106.41, 1)(106.48, 1)(106.54, 1)(106.61, 1)(106.68, 1)(106.75, 1)(106.82, 1)(106.88, 1)
(106.95, 1)(107.02, 1)(107.09, 1)(107.15, 1)(107.22, 1)(107.29, 1)(107.36, 1)(107.43, 1)(107.49, 1)(107.56, 1)(107.63, 1)(107.70, 1)
(107.76, 1)(107.83, 1)(107.90, 1)(107.97, 1)(108.03, 1)(108.10, 1)(108.17, 1)(108.24, 1)(108.31, 1)(108.37, 1)(108.44, 1)(108.51, 1)
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(108.58, 1)(108.64, 1)(108.71, 1)(108.78, 1)(108.85, 1)(108.92, 1)(108.98, 1)(109.05, 1)(109.12, 1)(109.19, 1)(109.25, 1)(109.32, 1)
(109.39, 1)(109.46, 1)(109.52, 1)(109.59, 1)(109.66, 1)(109.73, 1)(109.80, 1)(109.86, 1)(109.93, 1)(110.00, 1)(110.07, 1)(110.13, 1)
(110.20, 1)(110.27, 1)(110.34, 1)(110.41, 1)(110.47, 1)(110.54, 1)(110.61, 1)(110.68, 1)(110.74, 1)(110.81, 1)(110.88, 1)(110.95, 1)
(111.01, 1)(111.08, 1)(111.15, 1)(111.22, 1)(111.29, 1)(111.35, 1)(111.42, 1)(111.49, 1)(111.56, 1)(111.62, 1)(111.69, 1)(111.76, 1)
(111.83, 1)(111.90, 1)(111.96, 1)(112.03, 1)(112.10, 1)(112.17, 1)(112.23, 1)(112.30, 1)(112.37, 1)(112.44, 1)(112.51, 1)(112.57, 1)
(112.64, 1)(112.71, 1)(112.78, 1)(112.84, 1)(112.91, 1)(112.98, 1)(113.05, 1)(113.11, 1)(113.18, 1)(113.25, 1)(113.32, 1)(113.39, 1)
THE STIFF PARTICLE ENERGY EQUATION ASSUMPTION IS INITIATED FOR PARTICLE NO. 2 AT 113.39 CM. DOWN THE REACTOR
(113.45, 2)(113.52, 1)(113.59, 1)(113.66, 1)(113.72, 1)(113.79, 1)(113.86, 1)(113.93, 1)(114.00, 1)(114.06, 1)(114.13, 1)(114.20, 1)
(114.27, 1)(114.33, 1)(114.40, 1)(114.47, 1)(114.54, 1)(114.60, 1)(114.67, 1)(114.74, 1)(114.81, 1)(114.88, 1)(114.94, 1)(115.01, 1)
(115.08, 1)(115.15, 1)(115.21, 1)(115.28, 1)(115.35, 1)(115.42, 1)(115.49, 1)(115.55, 1)(115.62, 1)(115.69, 1)(115.76, 1)(115.82, 1)
(115.89, 1)(115.96, 1)(116.03, 1)(116.10, 1)(116.16, 1)(116.23, 1)(116.30, 1)(116.37, 1)(116.43, 1)(116.50, 1)(116.57, 1)(116.64, 1)
(116.70, 1)(116.77, 1)(116.84, 1)(116.91, 1)(116.98, 1)(117.04, 1)(117.11, 1)(117.18, 1)(117.25, 1)(117.31, 1)(117.38, 1)(117.45, 1)
(117.52, 1)(117.59, 1)(117.65, 1)(117.72, 1)(117.79, 1)(117.86, 1)(117.92, 1)(117.99, 1)(118.06, 1)(118.13, 1)(118.19, 1)(118.26, 1)
(118.33, 1)(118.40, 1)(118.47, 1)(118.53, 1)(118.60, 1)(118.67, 1)(118.74, 1)(118.80, 1)(118.87, 1)(118.94, 1)(119.01, 1)(119.08, 1)
(119.14, 1)(119.21, 1)(119.28, 1)(119.35, 1)(119.41, 1)(119.48, 1)(119.55, 1)(119.62, 1)(119.68, 1)(119.75, 1)(119.82, 1)(119.89, 1)
(119.96, 1)(120.02, 1)(120.09, 1)(120.16, 1)(120.23, 1)(120.29, 1)(120.36, 1)(120.43, 1)(120.50, 1)(120.57, 1)(120.63, 1)(120.70, 1)
(120.77, 1)(120.84, 1)(120.90, 1)(120.97, 1)(121.04, 1)(121.11, 1)(121.18, 1)(121.24, 1)(121.31, 1)(121.38, 1)(121.45, 1)(121.51, 1)
(121.58, 1)(121.65, 1)(121.72, 1)(121.78, 1)(121.85, 1)(121.92, 1)(121.99, 1)(122.06, 1)(122.12, 1)(122.19, 1)(122.26, 1)(122.33, 1)
(122.39, 1)(122.46, 1)(122.53, 1)(122.60, 1)(122.67, 1)(122.73, 1)(122.80, 1)(122.87, 1)(122.94, 1)(123.00, 1)(123.07, 1)(123.14, 1)
(123.21, 1)(123.27, 1)(123.34, 1)(123.41, 1)(123.48, 1)(123.55, 1)(123.61, 1)(123.68, 1)(123.75, 1)(123.82, 1)(123.88, 1)(123.95, 1)
(124.02, 1)(124.09, 1)(124.16, 1)(124.22, 1)(124.29, 1)(124.36, 1)(124.43, 1)(124.49, 1)(124.56, 1)(124.63, 1)(124.70, 1)(124.76, 1)
(124.83, 1)(124.90, 1)(124.97, 1)(125.04, 1)(125.10, 1)(125.17, 1)(125.24, 1)(125.31, 1)(125.37, 1)(125.44, 1)(125.51, 1)(125.58, 1)
(125.65, 1)(125.71, 1)(125.78, 1)(125.85, 1)(125.92, 1)(125.98, 1)(126.05, 1)(126.12, 1)(126.19, 1)(126.26, 1)(126.32, 1)(126.39, 1)
(126.46, 1)(126.53, 1)(126.59, 1)(126.66, 1)(126.73, 1)(126.80, 1)(126.86, 1)(126.93, 1)(127.00, 1)(127.07, 1)(127.14, 1)(127.20, 1)
(127.27, 1)(127.34, 1)(127.41, 1)(127.47, 1)(127.54, 1)(127.61, 1)(127.68, 1)(127.75, 1)(127.81, 1)(127.88, 1)(127.95, 1)(128.02, 1)
(128.08, 1)(128.15, 1)(128.22, 1)(128.29, 1)(128.35, 1)(128.42, 1)(128.49, 1)(128.56, 1)(128.63, 1)(128.69, 1)(128.76, 1)(128.83, 1)
(128.90, 1)(128.96, 1)(129.03, 1)(129.10, 1)(129.17, 1)(129.24, 1)(129.30, 1)(129.37, 1)(129.44, 1)(129.51, 1)(129.57, 1)(129.64, 1)
THE STIFF PARTICLE ENERGY EQUATION ASSUMPTION IS INITIATED FOR PARTICLE NO. 3 AT 130.18 CM. DOWN THE REACTOR
(129.71, 1)(129.78, 1)(129.84, 1)(129.91, 1)(129.98, 1)(130.05, 1)(130.12, 1)(130.18, 1)(130.25, 1)(130.32, 1)(130.39, 1)(130.45, 1)
(132.89, 1)(133.50, 1)(134.11, 1)(134.72, 1)(135.33, 1)(135.94, 1)(136.55, 1)(137.16, 1)(139.60, 1)(140.21, 1)(140.82, 1)(141.43, 1)
(142.04, 1)(142.65, 1)(143.26, 1)(143.87, 1)(144.48, 1)(145.08, 1)(145.69, 1)(146.30, 1)(146.91, 1)(147.52, 1)(148.13, 1)(148.74, 1)
(149.35, 1)(149.96, 1)(150.57, 1)(151.18, 1)(151.79, 1)(152.40, 1)(

AFTER  2 ITERATION(S) THROUGH THE REACTOR THE ROOT MEAN SQUARE OF ALL PARTICLE TEMPERATURES IS  460.601 DEGREES KELVIN
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THE ORDERED PAIR OF (X,# OF CORRECTORS APPLIED) FOLLOWS FOR EACH O.D.E. STEP
******************************************************************************
(  1.22,11)(  2.03, 1)(  2.24, 1)(  2.44, 1)(  2.64, 1)(  3.45, 1)(  3.66, 1)(  3.86, 1)(  4.06, 1)(  4.27, 1)(  4.47, 1)(  4.67, 1)
(  4.88, 1)(  5.08, 1)(  5.28, 1)(  5.49, 1)(  5.69, 1)(  5.89, 1)(  6.10, 1)(  6.30, 1)(  6.50, 1)(  6.71, 1)(  6.91, 1)(  7.11, 1)
(  7.32, 1)(  7.52, 1)(  7.72, 1)(  7.92, 1)(  8.13, 1)(  8.33, 1)(  8.53, 1)(  8.74, 1)(  8.94, 1)(  9.14, 1)(  9.35, 1)(  9.55, 1)
(  9.75, 1)(  9.96, 1)( 10.16, 1)( 10.36, 1)( 10.57, 1)( 10.77, 1)( 10.97, 1)( 11.18, 1)( 11.38, 1)( 11.58, 1)( 11.79, 1)( 11.99, 1)
( 12.19, 1)( 12.40, 1)( 12.60, 1)( 12.80, 1)( 13.00, 1)( 13.21, 1)( 13.41, 1)( 13.61, 1)( 13.82, 1)( 14.02, 1)( 14.22, 1)( 14.43, 1)
( 14.63, 1)( 14.83, 1)( 15.04, 1)( 15.24, 1)( 15.44, 1)( 15.65, 1)( 15.85, 1)( 16.05, 1)( 16.26, 1)( 16.46, 1)( 16.66, 1)( 16.87, 1)
( 17.07, 1)( 17.27, 1)( 17.48, 1)( 17.68, 1)( 17.88, 1)( 18.08, 1)( 18.29, 1)( 18.49, 1)( 18.69, 1)( 18.90, 1)( 19.10, 1)( 19.30, 1)
( 19.51, 1)( 19.71, 1)( 19.91, 1)( 20.12, 1)( 20.32, 1)( 20.52, 1)( 20.73, 1)( 20.93, 1)( 21.13, 1)( 21.34, 1)( 21.54, 1)( 21.74, 1)
( 21.95, 1)( 22.15, 1)( 22.35, 1)( 22.56, 1)( 22.76, 1)( 22.96, 1)( 23.16, 1)( 23.37, 1)( 23.57, 1)( 23.77, 1)( 23.98, 1)( 24.18, 1)
( 24.38, 1)( 24.59, 1)( 24.79, 1)( 24.99, 1)( 25.20, 1)( 25.40, 1)( 25.60, 1)( 25.81, 2)( 26.01, 1)( 26.21, 1)( 26.42, 1)( 26.62, 2)
( 26.82, 2)( 27.03, 1)( 27.23, 1)( 27.43, 1)( 27.64, 1)( 27.84, 1)( 28.04, 1)( 28.24, 1)( 28.45, 1)( 28.65, 2)( 28.85, 2)( 29.06, 2)
( 29.26, 1)( 29.46, 1)( 29.67, 2)( 29.87, 2)( 30.07, 1)( 30.28, 1)( 30.48, 1)( 30.68, 2)( 30.89, 2)( 31.09, 1)( 31.29, 1)( 31.50, 1)
( 31.70, 2)( 31.90, 2)( 32.11, 2)( 32.31, 1)( 32.51, 1)( 32.72, 2)( 32.92, 2)( 33.12, 2)( 33.32, 1)( 33.53, 1)( 33.73, 2)( 33.93, 2)
( 34.14, 2)( 34.34, 2)( 34.54, 1)( 34.75, 2)( 34.95, 3)( 35.76, 3)( 35.97, 3)( 36.17, 2)( 36.37, 1)( 36.58, 1)( 36.78, 2)( 36.98, 2)
( 37.19, 2)( 37.39, 2)( 37.59, 1)( 37.80, 2)( 38.00, 3)( 38.20, 2)( 38.40, 2)( 38.61, 1)( 38.81, 2)( 39.01, 2)( 39.22, 2)( 39.42, 1)
( 39.62, 1)( 39.83, 2)( 40.03, 2)( 40.23, 2)( 40.44, 2)( 40.64, 1)( 40.84, 2)( 41.05, 3)( 41.25, 2)( 41.45, 2)( 41.66, 1)( 41.86, 2)
( 42.06, 3)( 42.27, 2)( 42.47, 1)( 42.67, 1)( 42.88, 2)( 43.08, 2)( 43.28, 2)( 43.48, 2)( 43.69, 1)( 43.89, 2)( 44.09, 3)( 44.30, 2)
( 44.50, 2)( 44.70, 1)( 44.91, 2)( 45.11, 2)( 45.31, 2)( 45.52, 1)( 45.72, 1)( 45.92, 1)( 46.13, 2)( 46.33, 2)( 46.53, 2)( 46.74, 2)
( 46.94, 2)( 47.14, 2)( 47.35, 2)( 47.55, 2)( 47.75, 2)( 47.96, 1)( 48.16, 2)( 48.36, 2)( 48.56, 2)( 48.77, 1)( 48.97, 1)( 49.17, 2)
( 49.38, 2)( 49.58, 2)( 49.78, 2)( 49.99, 1)( 50.19, 2)( 50.39, 3)( 50.60, 2)( 50.80, 1)( 51.00, 2)( 51.21, 2)( 51.41, 3)( 51.61, 2)
( 51.82, 1)( 52.02, 1)( 52.22, 2)( 52.43, 2)( 52.63, 2)( 52.83, 2)( 53.04, 1)( 53.24, 2)( 53.44, 2)( 53.64, 2)( 53.85, 2)( 54.05, 1)
( 54.25, 2)( 54.46, 2)( 54.66, 2)( 54.86, 1)( 55.07, 1)( 55.27, 2)( 55.47, 2)( 55.68, 2)( 55.88, 2)( 56.08, 1)( 56.29, 2)( 56.49, 2)
( 56.69, 2)( 56.90, 2)( 57.10, 1)( 57.30, 2)( 57.51, 2)( 57.71, 2)( 57.91, 1)( 58.12, 1)( 58.32, 2)( 58.52, 2)( 58.72, 2)( 58.93, 1)
( 59.13, 1)( 59.33, 2)( 59.54, 2)( 59.74, 2)( 59.94, 2)( 60.15, 1)( 60.35, 2)( 60.55, 2)( 60.76, 2)( 60.96, 1)( 61.16, 1)( 61.37, 2)
( 61.57, 2)( 61.77, 2)( 61.98, 1)( 62.18, 1)( 62.38, 2)( 62.59, 2)( 62.79, 2)( 62.99, 1)( 63.20, 1)( 63.40, 2)( 63.60, 2)( 63.80, 2)
( 64.01, 1)( 64.21, 1)( 64.41, 2)( 64.62, 2)( 64.82, 2)( 65.02, 1)( 65.23, 1)( 65.43, 2)( 65.63, 2)( 65.84, 2)( 66.04, 1)( 66.24, 1)
( 66.45, 2)( 66.65, 2)( 66.85, 1)( 67.06, 1)( 67.26, 1)( 67.46, 1)( 67.67, 1)( 67.87, 1)( 68.07, 1)( 68.28, 1)( 68.48, 2)( 68.68, 2)
( 68.88, 2)( 69.09, 1)( 69.29, 1)( 69.49, 2)( 69.70, 2)( 69.90, 1)( 70.10, 1)( 70.31, 1)( 70.51, 1)( 70.71, 1)( 70.92, 1)( 71.12, 1)
( 71.32, 1)( 71.53, 1)( 71.73, 2)( 71.93, 1)( 72.14, 1)( 72.34, 1)( 72.54, 1)( 72.75, 1)( 72.95, 1)( 73.15, 1)( 73.36, 1)( 73.56, 1)
( 73.76, 1)( 73.96, 1)( 74.17, 1)( 74.37, 1)( 74.57, 1)( 74.78, 1)( 74.98, 1)( 75.18, 1)( 75.39, 1)( 75.59, 1)( 75.79, 1)( 76.00, 1)
( 76.20, 1)( 76.61, 1)( 76.71, 1)( 76.81, 1)( 76.91, 1)( 77.01, 1)( 77.11, 1)( 77.22, 1)( 77.32, 1)( 77.42, 1)( 77.52, 1)( 77.62, 1)
( 77.72, 1)( 77.83, 1)( 77.93, 1)( 78.03, 1)( 78.13, 1)( 78.23, 1)( 78.33, 1)( 78.44, 1)( 78.54, 1)( 78.64, 1)( 78.74, 1)( 78.84, 1)
( 78.94, 1)( 79.04, 1)( 79.15, 1)( 79.25, 1)( 79.35, 1)( 79.45, 1)( 79.55, 1)( 79.65, 1)( 79.76, 1)( 79.86, 1)( 79.96, 1)( 80.06, 1)
( 80.16, 1)( 80.26, 1)( 80.37, 1)( 80.47, 1)( 80.57, 1)( 80.67, 1)( 80.77, 1)( 80.87, 1)( 80.98, 1)( 81.08, 1)( 81.18, 1)( 81.28, 1)
( 81.38, 1)( 81.48, 1)( 81.58, 1)( 81.69, 1)( 81.79, 1)( 81.89, 1)( 81.99, 1)( 82.09, 1)( 82.19, 1)( 82.30, 1)( 82.40, 1)( 82.50, 1)
( 82.60, 1)( 82.70, 1)( 82.80, 1)( 82.91, 1)( 83.01, 1)( 83.11, 1)( 83.21, 1)( 83.31, 1)( 83.41, 1)( 83.52, 1)( 83.62, 1)( 83.72, 1)
( 83.82, 1)( 83.92, 1)( 84.02, 1)( 84.12, 1)( 84.23, 1)( 84.33, 1)( 84.43, 1)( 84.53, 1)( 84.63, 1)( 84.73, 1)( 84.84, 1)( 84.94, 1)
( 85.04, 1)( 85.14, 1)( 85.24, 1)( 85.34, 1)( 85.45, 1)( 85.55, 1)( 85.65, 1)( 85.75, 1)( 85.85, 1)( 85.95, 1)( 86.06, 1)( 86.16, 1)
( 86.26, 1)( 86.36, 1)( 86.46, 1)( 86.56, 1)( 86.66, 1)( 86.77, 1)( 86.87, 1)( 86.97, 1)( 87.07, 1)( 87.17, 1)( 87.27, 1)( 87.38, 1)
( 87.48, 1)( 87.58, 1)( 87.68, 2)( 87.78, 2)( 87.88, 1)( 88.29, 1)( 88.39, 1)( 88.49, 1)( 88.60, 1)( 88.70, 1)( 88.80, 1)( 88.90, 1)
( 89.31, 1)( 89.41, 1)( 89.51, 1)( 89.61, 1)( 89.71, 1)( 89.81, 1)( 89.92, 1)( 90.02, 1)( 90.12, 1)( 90.22, 1)( 90.32, 1)( 90.42, 1)
( 90.53, 1)( 90.63, 1)( 90.73, 1)( 90.83, 1)( 90.93, 1)( 91.03, 1)( 91.14, 1)( 91.24, 1)( 91.34, 1)( 91.44, 1)( 91.54, 1)( 91.95, 1)
( 92.05, 1)( 92.32, 1)( 92.39, 1)( 92.46, 1)( 92.52, 1)( 92.59, 1)( 92.66, 1)( 92.73, 1)( 92.79, 1)( 92.86, 1)( 92.93, 1)( 93.00, 1)
( 93.07, 1)( 93.13, 1)( 93.20, 1)( 93.27, 1)( 93.34, 1)( 93.40, 2)( 93.47, 2)( 93.54, 2)( 93.61, 2)( 93.68, 2)( 93.74, 2)( 93.81, 1)
( 93.88, 1)( 93.95, 2)( 94.01, 3)( 94.08, 3)( 94.15, 2)( 94.22, 1)( 94.28, 1)( 94.35, 1)( 94.42, 1)( 94.49, 1)( 94.56, 1)( 94.62, 3)
( 94.69, 3)( 94.76, 2)( 94.83, 1)( 94.89, 1)( 94.96, 1)( 95.03, 1)( 95.10, 1)( 95.17, 2)( 95.23, 4)( 95.30, 4)( 95.37, 4)( 95.44, 4)
( 95.50, 4)( 95.57, 4)( 95.64, 3)( 95.71, 1)( 95.77, 3)( 95.84, 4)( 95.91, 5)( 95.98, 5)( 96.05, 1)( 96.11, 3)( 96.18, 1)( 96.25, 4)
THE STIFF PARTICLE ENERGY EQUATION ASSUMPTION IS INITIATED FOR PARTICLE NO. 1 AT  97.20 CM. DOWN THE REACTOR
( 96.32, 6)( 96.38, 7)( 96.45, 1)( 96.52, 9)( 96.59,10)( 96.66,10)( 96.72,11)( 96.79,11)( 96.86, 8)( 96.93,11)( 97.20, 1)( 97.27, 2)
( 97.33, 1)( 97.40, 1)( 97.47, 1)( 97.54, 1)( 97.60, 1)( 97.67, 1)( 97.74, 1)( 97.81, 1)( 97.87, 1)( 97.94, 1)( 98.01, 1)( 98.08, 1)
( 98.15, 1)( 98.21, 1)( 98.28, 1)( 98.35, 1)( 98.42, 1)( 98.48, 1)( 98.55, 1)( 98.62, 1)( 98.69, 1)( 98.76, 1)( 98.82, 1)( 98.89, 1)
( 98.96, 1)( 99.03, 1)( 99.09, 1)( 99.16, 1)( 99.23, 1)( 99.30, 1)( 99.36, 1)( 99.43, 1)( 99.50, 1)( 99.57, 1)( 99.64, 1)( 99.70, 1)
( 99.77, 1)( 99.84, 1)( 99.91, 1)( 99.97, 1)(100.04, 1)(100.11, 1)(100.18, 1)(100.25, 1)(100.31, 1)(100.38, 1)(100.45, 1)(100.52, 1)
(100.58, 1)(100.65, 1)(100.72, 1)(100.79, 1)(100.85, 1)(100.92, 1)(100.99, 1)(101.06, 1)(101.13, 1)(101.19, 1)(101.26, 1)(101.33, 1)
(101.40, 1)(101.46, 1)(101.53, 1)(101.60, 1)(101.67, 1)(101.74, 1)(101.80, 1)(101.87, 1)(101.94, 1)(102.01, 1)(102.07, 1)(102.14, 1)
(102.21, 1)(102.28, 1)(102.35, 1)(102.41, 1)(102.48, 1)(102.55, 1)(102.62, 1)(102.68, 1)(102.75, 1)(102.82, 1)(102.89, 1)(102.95, 1)
THE STIFF PARTICLE ENERGY EQUATION ASSUMPTION IS INITIATED FOR PARTICLE NO. 2 AT 103.02 CM. DOWN THE REACTOR
(103.02, 1)(103.09, 2)(103.16, 1)(103.23, 1)(103.29, 1)(103.36, 1)(103.43, 1)(103.50, 1)(103.56, 1)(103.63, 1)(103.70, 1)(103.77, 1)
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(103.84, 1)(103.90, 1)(103.97, 1)(104.04, 1)(104.11, 1)(104.17, 1)(104.24, 1)(104.31, 2)(104.38, 1)(104.44, 1)(104.51, 1)(104.58, 1)
(104.65, 1)(104.72, 1)(104.78, 1)(104.85, 1)(104.92, 1)(104.99, 1)(105.05, 1)(105.12, 1)(105.19, 1)(105.26, 1)(105.33, 1)(105.39, 1)
(105.46, 1)(105.53, 1)(105.60, 1)(105.66, 1)(105.73, 1)(105.80, 1)(105.87, 1)(105.93, 1)(106.00, 1)(106.07, 1)(106.14, 1)(106.21, 1)
(106.27, 1)(106.34, 1)(106.41, 1)(106.48, 1)(106.54, 1)(106.61, 1)(106.68, 1)(106.75, 1)(106.82, 1)(106.88, 1)(106.95, 1)(107.02, 1)
(107.09, 1)(107.15, 1)(107.22, 1)(107.29, 1)(107.36, 1)(107.43, 1)(107.49, 1)(107.56, 1)(107.63, 1)(107.70, 1)(107.76, 1)(107.83, 1)
(107.90, 1)(107.97, 1)(108.03, 1)(108.10, 1)(108.17, 1)(108.24, 1)(108.31, 1)(108.37, 1)(108.44, 1)(108.51, 1)(108.58, 1)(108.64, 1)
(108.71, 1)(108.78, 1)(108.85, 1)(108.92, 1)(108.98, 1)(109.05, 1)(109.12, 1)(109.19, 1)(109.25, 1)(109.32, 1)(109.39, 1)(109.46, 1)
(109.52, 1)(109.59, 1)(109.66, 1)(109.73, 1)(109.80, 1)(109.86, 1)(109.93, 1)(110.00, 1)(110.07, 1)(110.13, 1)(110.20, 1)(110.27, 1)
(110.34, 1)(110.41, 1)(110.47, 1)(110.54, 1)(110.61, 1)(110.68, 1)(110.74, 1)(110.81, 1)(110.88, 1)(110.95, 1)(111.02, 1)(111.08, 1)
(111.15, 1)(111.22, 1)(111.29, 1)(111.35, 1)(111.42, 1)(111.49, 1)(111.56, 1)(111.62, 1)(111.69, 1)(111.76, 1)(111.83, 1)(111.90, 1)
(111.96, 1)(112.03, 1)(112.10, 1)(112.17, 1)(112.23, 1)(112.30, 1)(112.37, 1)(112.44, 1)(112.51, 1)(112.57, 1)(112.64, 1)(112.71, 1)
(112.78, 1)(112.84, 1)(112.91, 1)(112.98, 1)(113.05, 1)(113.11, 1)(113.18, 1)(113.25, 1)(113.32, 1)(113.39, 1)(113.45, 1)(113.52, 1)
(113.59, 1)(113.66, 1)(113.72, 1)(113.79, 1)(113.86, 1)(113.93, 1)(114.00, 1)(114.06, 1)(114.13, 1)(114.20, 1)(114.27, 1)(114.33, 1)
THE STIFF PARTICLE ENERGY EQUATION ASSUMPTION IS INITIATED FOR PARTICLE NO. 3 AT 114.60 CM. DOWN THE REACTOR
(114.40, 1)(114.47, 1)(114.54, 1)(114.60, 1)(117.04, 1)(117.65, 1)(118.26, 1)(118.87, 1)(119.48, 1)(120.09, 1)(120.70, 1)(121.31, 1)
(121.92, 1)(122.53, 1)(123.14, 1)(123.75, 1)(124.36, 1)(124.97, 1)(125.58, 1)(126.19, 1)(126.80, 1)(127.41, 1)(128.02, 1)(128.63, 1)
(129.24, 1)(129.84, 1)(130.45, 1)(132.89, 1)(133.50, 1)(134.11, 1)(134.72, 1)(135.33, 1)(135.94, 1)(136.55, 1)(137.16, 1)(137.77, 1)
(138.38, 1)(138.99, 1)(139.60, 1)(140.21, 1)(140.82, 1)(141.43, 1)(142.04, 1)(142.65, 1)(143.26, 1)(143.87, 1)(144.48, 1)(145.08, 1)
(145.69, 1)(146.30, 1)(146.91, 1)(147.52, 1)(148.13, 1)(148.74, 1)(149.35, 1)(149.96, 1)(150.57, 1)(151.18, 1)(151.79, 1)(152.40, 1)

AFTER  3 ITERATION(S) THROUGH THE REACTOR THE ROOT MEAN SQUARE OF ALL PARTICLE TEMPERATURES IS  247.644 DEGREES KELVIN
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THE ORDERED PAIR OF (X,# OF CORRECTORS APPLIED) FOLLOWS FOR EACH O.D.E. STEP
****************************************************************************
(  1.22,11)(  2.03, 1)(  2.24, 1)(  2.44, 1)(  2.64, 1)(  3.45, 1)(  3.66, 1)(  3.86, 1)(  4.06, 1)(  4.27, 1)(  4.47, 1)(  4.67, 1)
(  4.88, 1)(  5.08, 1)(  5.28, 1)(  5.49, 1)(  5.69, 1)(  5.89, 1)(  6.10, 1)(  6.30, 1)(  6.50, 1)(  6.71, 1)(  6.91, 1)(  7.11, 1)
(  7.32, 1)(  7.52, 1)(  7.72, 1)(  7.92, 1)(  8.13, 1)(  8.33, 1)(  8.53, 1)(  8.74, 1)(  8.94, 1)(  9.14, 1)(  9.35, 1)(  9.55, 1)
(  9.75, 1)(  9.96, 1)( 10.16, 1)( 10.36, 1)( 10.57, 1)( 10.77, 1)( 10.97, 1)( 11.18, 1)( 11.38, 1)( 11.58, 1)( 11.79, 1)( 11.99, 1)
( 12.19, 1)( 12.40, 1)( 12.60, 1)( 12.80, 1)( 13.00, 1)( 13.21, 1)( 13.41, 1)( 13.61, 1)( 13.82, 1)( 14.02, 1)( 14.22, 1)( 14.43, 1)
( 14.63, 1)( 14.83, 1)( 15.04, 1)( 15.24, 1)( 15.44, 1)( 15.65, 1)( 15.85, 1)( 16.05, 1)( 16.26, 1)( 16.46, 1)( 16.66, 1)( 16.87, 1)
( 17.07, 1)( 17.27, 1)( 17.48, 1)( 17.68, 1)( 17.88, 1)( 18.08, 1)( 18.29, 1)( 18.49, 1)( 18.69, 1)( 18.90, 1)( 19.10, 1)( 19.30, 1)
( 19.51, 1)( 19.71, 1)( 19.91, 1)( 20.12, 1)( 20.32, 1)( 20.52, 1)( 20.73, 1)( 20.93, 1)( 21.13, 1)( 21.34, 1)( 21.54, 1)( 21.74, 1)
( 21.95, 1)( 22.15, 1)( 22.35, 1)( 22.56, 1)( 22.76, 1)( 22.96, 1)( 23.16, 1)( 23.37, 1)( 23.57, 1)( 23.77, 1)( 23.98, 1)( 24.18, 1)
( 24.38, 1)( 24.59, 1)( 24.79, 1)( 24.99, 1)( 25.20, 1)( 25.40, 1)( 25.60, 1)( 25.81, 2)( 26.01, 1)( 26.21, 1)( 26.42, 1)( 26.62, 2)
( 26.82, 2)( 27.03, 1)( 27.23, 1)( 27.43, 1)( 27.64, 1)( 27.84, 1)( 28.04, 1)( 28.24, 1)( 28.45, 1)( 28.65, 2)( 28.85, 2)( 29.06, 2)
( 29.26, 1)( 29.46, 1)( 29.67, 2)( 29.87, 2)( 30.07, 1)( 30.28, 1)( 30.48, 1)( 30.68, 2)( 30.89, 2)( 31.09, 1)( 31.29, 1)( 31.50, 1)
( 31.70, 2)( 31.90, 2)( 32.11, 2)( 32.31, 1)( 32.51, 1)( 32.72, 2)( 32.92, 2)( 33.12, 2)( 33.32, 1)( 33.53, 1)( 33.73, 2)( 33.93, 2)
( 34.14, 2)( 34.34, 2)( 34.54, 1)( 34.75, 2)( 34.95, 3)( 35.76, 3)( 35.97, 3)( 36.17, 2)( 36.37, 1)( 36.58, 1)( 36.78, 2)( 36.98, 2)
( 37.19, 2)( 37.39, 2)( 37.59, 1)( 37.80, 2)( 38.00, 3)( 38.20, 2)( 38.40, 2)( 38.61, 1)( 38.81, 2)( 39.01, 3)( 39.22, 2)( 39.42, 1)
( 39.62, 1)( 39.83, 2)( 40.03, 2)( 40.23, 2)( 40.44, 2)( 40.64, 2)( 40.84, 2)( 41.05, 3)( 41.25, 2)( 41.45, 2)( 41.66, 1)( 41.86, 2)
( 42.06, 3)( 42.27, 2)( 42.47, 1)( 42.67, 1)( 42.88, 2)( 43.08, 2)( 43.28, 2)( 43.48, 2)( 43.69, 2)( 43.89, 2)( 44.09, 3)( 44.30, 2)
( 44.50, 2)( 44.70, 1)( 44.91, 2)( 45.11, 2)( 45.31, 2)( 45.52, 1)( 45.72, 1)( 45.92, 1)( 46.13, 2)( 46.33, 2)( 46.53, 2)( 46.74, 2)
( 46.94, 2)( 47.14, 2)( 47.35, 3)( 47.55, 2)( 47.75, 2)( 47.96, 1)( 48.16, 2)( 48.36, 2)( 48.56, 2)( 48.77, 1)( 48.97, 1)( 49.17, 2)
( 49.38, 2)( 49.58, 2)( 49.78, 2)( 49.99, 1)( 50.19, 2)( 50.39, 3)( 50.60, 2)( 50.80, 2)( 51.00, 1)( 51.21, 2)( 51.41, 2)( 51.61, 2)
( 51.82, 1)( 52.02, 1)( 52.22, 2)( 52.43, 2)( 52.63, 2)( 52.83, 2)( 53.04, 1)( 53.24, 2)( 53.44, 2)( 53.64, 2)( 53.85, 2)( 54.05, 1)
( 54.25, 2)( 54.46, 2)( 54.66, 2)( 54.86, 1)( 55.07, 1)( 55.27, 2)( 55.47, 2)( 55.68, 2)( 55.88, 2)( 56.08, 1)( 56.29, 2)( 56.49, 2)
( 56.69, 2)( 56.90, 2)( 57.10, 1)( 57.30, 2)( 57.51, 2)( 57.71, 2)( 57.91, 1)( 58.12, 1)( 58.32, 2)( 58.52, 2)( 58.72, 2)( 58.93, 1)
( 59.13, 1)( 59.33, 2)( 59.54, 2)( 59.74, 2)( 59.94, 2)( 60.15, 1)( 60.35, 2)( 60.55, 2)( 60.76, 2)( 60.96, 1)( 61.16, 1)( 61.37, 2)
( 61.57, 2)( 61.77, 2)( 61.98, 1)( 62.18, 1)( 62.38, 2)( 62.59, 2)( 62.79, 2)( 62.99, 1)( 63.20, 1)( 63.40, 2)( 63.60, 2)( 63.80, 2)
( 64.01, 1)( 64.21, 1)( 64.41, 2)( 64.62, 2)( 64.82, 2)( 65.02, 1)( 65.23, 1)( 65.43, 2)( 65.63, 2)( 65.84, 2)( 66.04, 1)( 66.24, 1)
( 66.45, 2)( 66.65, 2)( 66.85, 1)( 67.06, 1)( 67.26, 1)( 67.46, 1)( 67.67, 1)( 67.87, 1)( 68.07, 1)( 68.28, 1)( 68.48, 1)( 68.68, 2)
( 68.88, 1)( 69.09, 1)( 69.29, 1)( 69.49, 2)( 69.70, 2)( 69.90, 1)( 70.10, 1)( 70.31, 1)( 70.51, 1)( 70.71, 1)( 70.92, 1)( 71.12, 1)
( 71.32, 1)( 71.53, 1)( 71.73, 1)( 71.93, 1)( 72.14, 1)( 72.34, 1)( 72.54, 1)( 72.75, 1)( 72.95, 1)( 73.15, 1)( 73.36, 1)( 73.56, 1)
( 73.76, 1)( 73.96, 1)( 74.17, 1)( 74.37, 1)( 74.78, 1)( 74.88, 1)( 74.98, 1)( 75.08, 1)( 75.18, 1)( 75.29, 1)( 75.39, 1)( 75.49, 1)
( 75.59, 1)( 75.69, 1)( 75.79, 1)( 75.90, 1)( 76.00, 1)( 76.10, 1)( 76.20, 1)( 76.30, 1)( 76.40, 1)( 76.50, 1)( 76.61, 1)( 76.71, 1)
( 76.81, 1)( 76.91, 1)( 77.01, 1)( 77.11, 1)( 77.22, 1)( 77.32, 1)( 77.42, 1)( 77.52, 1)( 77.62, 1)( 77.72, 1)( 77.83, 1)( 77.93, 1)
( 78.03, 1)( 78.13, 1)( 78.23, 1)( 78.33, 1)( 78.44, 1)( 78.54, 1)( 78.64, 1)( 78.74, 1)( 78.84, 1)( 78.94, 1)( 79.04, 1)( 79.15, 1)
( 79.25, 1)( 79.35, 1)( 79.45, 1)( 79.55, 1)( 79.65, 1)( 79.76, 1)( 79.86, 1)( 79.96, 1)( 80.06, 1)( 80.16, 1)( 80.26, 1)( 80.37, 1)
( 80.47, 1)( 80.57, 1)( 80.67, 1)( 80.77, 1)( 80.87, 1)( 80.98, 1)( 81.08, 1)( 81.18, 1)( 81.28, 1)( 81.38, 1)( 81.48, 1)( 81.58, 1)
( 81.69, 1)( 81.79, 1)( 81.89, 1)( 81.99, 1)( 82.09, 1)( 82.19, 1)( 82.30, 1)( 82.40, 1)( 82.50, 1)( 82.60, 1)( 82.70, 1)( 82.80, 1)
( 82.91, 1)( 83.01, 1)( 83.11, 1)( 83.21, 1)( 83.31, 1)( 83.41, 1)( 83.52, 1)( 83.62, 1)( 83.72, 1)( 83.82, 1)( 83.92, 1)( 84.02, 1)
( 84.12, 1)( 84.23, 1)( 84.33, 1)( 84.43, 1)( 84.53, 1)( 84.63, 1)( 84.73, 1)( 84.84, 1)( 84.94, 1)( 85.04, 1)( 85.14, 1)( 85.24, 1)
( 85.34, 1)( 85.45, 1)( 85.55, 1)( 85.65, 1)( 85.75, 1)( 85.85, 1)( 85.95, 1)( 86.06, 1)( 86.16, 1)( 86.56, 1)( 86.66, 1)( 86.77, 1)
( 86.87, 1)( 86.97, 1)( 87.07, 1)( 87.17, 1)( 87.27, 1)( 87.68, 1)( 87.78, 1)( 87.88, 1)( 87.99, 1)( 88.09, 2)( 88.19, 1)( 88.29, 1)
( 88.39, 1)( 88.49, 1)( 88.60, 1)( 88.70, 1)( 88.80, 1)( 88.90, 1)( 89.00, 1)( 89.10, 2)( 89.20, 2)( 89.31, 2)( 89.41, 2)( 89.51, 2)
( 89.61, 1)( 89.71, 1)( 89.81, 2)( 89.92, 2)( 90.49, 1)( 90.56, 1)( 90.63, 1)( 90.69, 1)( 90.76, 1)( 90.83, 1)( 90.90, 1)( 90.97, 2)
( 91.03, 2)( 91.10, 2)( 91.17, 1)( 91.24, 1)( 91.30, 1)( 91.37, 1)( 91.44, 1)( 91.51, 1)( 91.58, 1)( 91.64, 1)( 91.71, 1)( 91.78, 1)
( 91.85, 1)( 91.91, 1)( 91.98, 1)( 92.05, 1)( 92.12, 1)( 92.19, 2)( 92.25, 2)( 92.32, 2)( 92.39, 2)( 92.46, 2)( 92.52, 1)( 92.59, 1)
( 92.66, 2)( 92.73, 2)( 92.79, 2)( 92.86, 3)( 92.93, 2)( 93.00, 1)( 93.07, 1)( 93.13, 1)( 93.20, 1)( 93.27, 1)( 93.34, 1)( 93.40, 2)
( 93.47, 3)( 93.54, 3)( 93.61, 2)( 93.68, 2)( 93.74, 2)( 93.81, 3)( 93.88, 2)( 93.95, 1)( 94.01, 3)( 94.08, 3)( 94.15, 2)( 94.22, 1)
( 94.28, 1)( 94.35, 1)( 94.42, 1)( 94.49, 1)( 94.56, 1)( 94.62, 1)( 94.69, 1)( 94.76, 1)( 94.83, 1)( 94.89, 3)( 94.96, 1)( 95.03, 1)
THE STIFF PARTICLE ENERGY EQUATION ASSUMPTION IS INITIATED FOR PARTICLE NO. 1 AT  95.64 CM. DOWN THE REACTOR
( 95.10, 2)( 95.17, 8)( 95.23, 9)( 95.30, 4)( 95.37,11)( 95.64,11)( 95.71, 1)( 95.77, 1)( 95.84, 1)( 95.91, 1)( 95.98, 1)( 96.05, 1)
( 96.11, 1)( 96.18, 1)( 96.25, 1)( 96.32, 1)( 96.38, 1)( 96.45, 1)( 96.52, 1)( 96.59, 1)( 96.66, 1)( 96.72, 1)( 96.79, 1)( 96.86, 1)
( 96.93, 1)( 96.99, 1)( 97.06, 1)( 97.13, 1)( 97.20, 1)( 97.27, 1)( 97.33, 1)( 97.40, 1)( 97.47, 1)( 97.54, 1)( 97.60, 1)( 97.67, 1)
( 97.74, 1)( 97.81, 1)( 97.87, 1)( 97.94, 1)( 98.01, 1)( 98.08, 1)( 98.15, 1)( 98.21, 1)( 98.28, 1)( 98.35, 1)( 98.42, 1)( 98.48, 1)
( 98.55, 1)( 98.62, 1)( 98.69, 1)( 98.76, 1)( 98.82, 1)( 98.89, 1)( 98.96, 1)( 99.03, 1)( 99.09, 1)( 99.16, 1)( 99.23, 1)( 99.30, 1)
( 99.36, 1)( 99.43, 1)( 99.50, 1)( 99.57, 1)( 99.64, 1)( 99.70, 1)( 99.77, 1)( 99.84, 1)( 99.91, 1)( 99.97, 1)(100.04, 1)(100.11, 1)
(100.18, 1)(100.25, 1)(100.31, 1)(100.38, 1)(100.45, 1)(100.52, 1)(100.58, 1)(100.65, 1)(100.72, 1)(100.79, 1)(100.85, 1)(100.92, 1)
(100.99, 1)(101.06, 1)(101.13, 1)(101.19, 1)(101.26, 1)(101.33, 1)(101.40, 1)(101.46, 1)(101.53, 1)(101.60, 1)(101.67, 1)(101.74, 1)
(101.80, 1)(101.87, 1)(101.94, 1)(102.01, 1)(102.07, 1)(102.14, 1)(102.21, 1)(102.28, 1)(102.35, 1)(102.41, 1)(102.48, 1)(102.55, 1)
THE STIFF PARTICLE ENERGY EQUATION ASSUMPTION IS INITIATED FOR PARTICLE NO. 2 AT 103.02 CM. DOWN THE REACTOR
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(102.62, 1)(102.68, 1)(102.75, 1)(102.82, 1)(102.89, 1)(102.95, 1)(103.02, 1)(103.09, 2)(103.16, 1)(103.23, 1)(103.29, 1)(103.36, 1)
(103.43, 1)(103.50, 1)(103.56, 1)(103.63, 1)(103.70, 1)(103.77, 1)(103.84, 1)(103.90, 1)(103.97, 1)(104.04, 1)(104.11, 1)(104.17, 1)
(104.24, 1)(104.31, 1)(104.38, 1)(104.44, 1)(104.51, 1)(104.58, 1)(104.65, 1)(104.72, 1)(104.78, 1)(104.85, 1)(104.92, 1)(104.99, 1)
(105.05, 1)(105.12, 1)(105.19, 1)(105.26, 1)(105.33, 1)(105.39, 1)(105.46, 1)(105.53, 1)(105.60, 1)(105.66, 1)(105.73, 1)(105.80, 1)
(105.87, 1)(105.94, 1)(106.00, 1)(106.07, 1)(106.14, 1)(106.21, 1)(106.27, 1)(106.34, 1)(106.41, 1)(106.48, 1)(106.54, 1)(106.61, 1)
(106.68, 1)(106.75, 1)(106.82, 1)(106.88, 1)(106.95, 1)(107.02, 1)(107.09, 1)(107.15, 1)(107.22, 1)(107.29, 1)(107.36, 1)(107.43, 1)
(107.49, 1)(107.56, 1)(107.63, 1)(107.70, 1)(107.76, 1)(107.83, 1)(107.90, 1)(107.97, 1)(108.03, 1)(108.10, 1)(108.17, 1)(108.24, 1)
(108.31, 1)(108.37, 1)(108.44, 1)(108.51, 1)(108.58, 1)(108.64, 1)(108.71, 1)(108.78, 1)(108.85, 1)(108.92, 1)(108.98, 1)(109.05, 1)
(109.12, 1)(109.19, 1)(109.25, 1)(109.32, 1)(109.39, 1)(109.46, 1)(109.52. 1)(109.59, 1)(109.66, 1)(109.73, 1)(109.80, 1)(109.86, 1)
(109.93, 1)(110.00, 1)(110.07, 1)(110.13, 1)(110.20, 1)(110.27, 1)(110.34, 1)(110.41, 1)(110.47, 1)(110.54, 1)(110.61, 1)(110.68, 1)
(110.74, 1)(110.81, 1)(110.88, 1)(110.95; 1)(111.02, 1)(111.08, 1)(111.15, 1)(111.22, 1)(111.29, 1)(111.35, 1)(111.42, 1)(111.49, 1)
(111.56, 1)(111.62, 1)(111.69, 1)(111.76, 1)(111.83, 1)(111.90, 1)(111.96, 1)(112.03, 1)(112.10, 1)(112.17, 1)(112.23, 1)(112.30, 1)
(112.37, 1)(112.44, 1)(112.51, 1)(112.57, 1)(112.64, 1)(112.71, 1)(112.78, 1)(112.84, 1)(112.91, 1)(112.98, 1)(113.05, 1)(113.11, 1)
THE STIFF PARTICLE ENERGY EQUATION ASSUMPTION IS INITIATED FOR PARTICLE NO. 3 AT 113.66 CM. DOWN THE REACTOR
(113.18, 1)(113.25, 1)(113.32, 1)(113.39, 1)(113.45, 1)(113.52, 1)(113.59, 1)(113.66, 1)(113.72, 1)(113.79, 1)(113.86, 1)(113.93, 1)
(114.00, 1)(116.43, 1)(117.04, 1)(117.65, 1)(118.26, 1)(118.87, 1)(119.48, 1)(120.09, 1)(120.70, 1)(121.31, 1)(121.92, 1)(122.53, 1)
(123.14, 1)(123.75, 1)(124.36, 1)(124.97, 1)(125.58, 1)(126.19, 1)(126.80, 1)(127.41, 1)(128.02, 1)(128.63, 1)(129.24, 1)(131.67, 1)
(132.28, 1)(132.89, 1)(133.50, 1)(134.11, 1)(134.72, 1)(135.33, 1)(135.94, 1)(136.55, 1)(137.16, 1)(137.77, 1)(138.38, 1)(138.99, 1)
(139.60, 1)(140.21, 1)(140.82, 1)(141.43, 1)(142.04, 1)(142.65, 1)(143.26, 1)(143.87, 1)(144.48, 1)(145.08, 1)(145.69, 1)(146.30, 1)
(146.91, 1)(147.52, 1)(148.13, 1)(148.74, 1)(149.35, 1)(149.96, 1)(150.57, 1)(151.18, 1)(151.79, 1)(152.40, 1)(

AFTER  4 ITERATION(S) THROUGH THE REACTOR THE ROOT MEAN SQUARE OF ALL PARTICLE TEMPERATURES IS   65.039 DEGREES KELVIN
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THE ORDERED PAIR OF (X,# OF CORRECTORS APPLIED) FOLLOWS FOR EACH O.D.E. STEP
******************************************************************************
(  1.22,11)(  2.03, 1)(  2.24, 1)(  2.44, 1)(  2.64, 1)(  3.45, 1)(  3.66, 1)(  3.86, 1)(  4.06, 1)(  4.27, 1)(  4.47, 1)(  4.67, 1)
(  4.88, 1)(  5.08, 1)(  5.28, 1)(  5.49, 1)(  5.69, 1)(  5.89, 1)(  6.10, 1)(  6.30, 1)(  6.50, 1)(  6.71, 1)(  6.91, 1)(  7.11, 1)
(  7.32, 1)(  7.52, 1)(  7.72, 1)(  7.92, 1)(  8.13, 1)(  8.33, 1)(  8.53, 1)(  8.74, 1)(  8.94, 1)(  9.14, 1)(  9.35, 1)(  9.55, 1)
(  9.75, 1)(  9.96, 1)( 10.16, 1)( 10.36, 1)( 10.57, 1)( 10.77, 1)( 10.97, 1)( 11.18, 1)( 11.38, 1)( 11.58, 1)( 11.79, 1)( 11.99, 1)
( 12.19, 1)( 12.40, 1)( 12.60, 1)( 12.80, 1)( 13.00, 1)( 13.21, 1)( 13.41, 1)( 13.61, 1)( 13.82, 1)( 14.02, 1)( 14.22, 1)( 14.43, 1)
( 14.63, 1)( 14.83, 1)( 15.04, 1)( 15.24, 1)( 15.44, 1)( 15.65, 1)( 15.85, 1)( 16.05, 1)( 16.26, 1)( 16.46, 1)( 16.66, 1)( 16.87, 1)
( 17.07, 1)( 17.27, 1)( 17.48, 1)( 17.68, 1)( 17.88, 1)( 18.08, 1)( 18.29, 1)( 18.49, 1)( 18.69, 1)( 18.90, 1)( 19.10, 1)( 19.30, 1)
( 19.51, 1)( 19.71, 1)( 19.91, 1)( 20.12, 1)( 20.32, 1)( 20.52, 1)( 20.73, 1)( 20.93, 1)( 21.13, 1)( 21.34, 1)( 21.54, 1)( 21.74, 1)
( 21.95, 1)( 22.15, 1)( 22.35, 1)( 22.56, 1)( 22.76, 1)( 22.96, 1)( 23.16, 1)( 23.37, 1)( 23.57, 1)( 23.77, 1)( 23.98, 1)( 24.18, 1)
( 24.38, 1)( 24.59, 1)( 24.79, 1)( 24.99, 1)( 25.20, 1)( 25.40, 1)( 25.60, 1)( 25.81, 2)( 26.01, 1)( 26.21, 1)( 26.42, 1)( 26.62, 2)
( 26.82, 2)( 27.03, 1)( 27.23, 1)( 27.43, 1)( 27.64, 1)( 27.84, 1)( 28.04, 1)( 28.24, 1)( 28.45, 1)( 28.65, 2)( 28.85, 2)( 29.06, 2)
( 29.26, 1)( 29.46, 1)( 29.67, 2)( 29.87, 2)( 30.07, 1)( 30.28, 1)( 30.48, 1)( 30.68, 2)( 30.89, 2)( 31.09, 2)( 31.29, 1)( 31.50, 1)
( 31.70, 2)( 31.90, 2)( 32.11, 2)( 32.31, 1)( 32.51, 1)( 32.72, 2)( 32.92, 2)( 33.12, 2)( 33.32, 1)( 33.53, 1)( 33.73, 2)( 33.93, 2)
( 34.14, 2)( 34.34, 2)( 34.54, 1)( 34.75, 2)( 34.95, 3)( 35.76, 3)( 35.97, 3)( 36.17, 2)( 36.37, 1)( 36.58, 1)( 36.78, 2)( 36.98, 2)
( 37.19, 2)( 37.39, 2)( 37.59, 1)( 37.80, 2)( 38.00, 3)( 38.20, 2)( 38.40, 2)( 38.61, 1)( 38.81, 2)( 39.01, 3)( 39.22, 2)( 39.42, 1)
( 39.62, 1)( 39.83, 2)( 40.03, 2)( 40.23, 2)( 40.44, 2)( 40.64, 2)( 40.84, 2)( 41.05, 3)( 41.25, 2)( 41.45, 2)( 41.66, 1)( 41.86, 2)
( 42.06, 3)( 42.27, 2)( 42.47, 1)( 42.67, 1)( 42.88, 2)( 43.08, 2)( 43.28, 2)( 43.48, 2)( 43.69, 2)( 43.89, 2)( 44.09, 3)( 44.30, 2)
( 44.50, 2)( 44.70, 1)( 44.91, 2)( 45.11, 2)( 45.31, 2)( 45.52, 1)( 45.72, 1)( 45.92, 1)( 46.13, 2)( 46.33, 2)( 46.53, 2)( 46.74, 2)
( 46.94, 2)( 47.14, 2)( 47.35, 3)( 47.55, 2)( 47.75, 2)( 47.96, 1)( 48.16, 2)( 48.36, 2)( 48.56, 2)( 48.77, 1)( 48.97, 1)( 49.17, 2)
( 49.38, 2)( 49.58, 2)( 49.78, 2)( 49.99, 1)( 50.19, 2)( 50.39, 3)( 50.60, 2)( 50.80, 2)( 51.00, 1)( 51.21, 2)( 51.41, 2)( 51.61, 2)
( 51.82, 1)( 52.02, 1)( 52.22, 2)( 52.43, 2)( 52.63, 2)( 52.83, 2)( 53.04, 1)( 53.24, 2)( 53.44, 2)( 53.64, 2)( 53.85, 2)( 54.05, 1)
( 54.25, 2)( 54.46, 2)( 54.66, 2)( 54.86, 1)( 55.07, 1)( 55.27, 2)( 55.47, 2)( 55.68, 2)( 55.88, 2)( 56.08, 1)( 56.29, 2)( 56.49, 2)
( 56.69, 2)( 56.90, 2)( 57.10, 1)( 57.30, 2)( 57.51, 2)( 57.71, 2)( 57.91, 1)( 58.12, 1)( 58.32, 2)( 58.52, 2)( 58.72, 2)( 58.93, 1)
( 59.13, 1)( 59.33, 2)( 59.54, 2)( 59.74, 2)( 59.94, 2)( 60.15, 1)( 60.35, 2)( 60.55, 2)( 60.76, 2)( 60.96, 1)( 61.16, 1)( 61.37, 2)
( 61.57, 2)( 61.77, 2)( 61.98, 1)( 62.18, 1)( 62.38, 2)( 62.59, 2)( 62.79, 2)( 62.99, 1)( 63.20, 1)( 63.40, 2)( 63.60, 2)( 63.80, 2)
( 64.01, 1)( 64.21, 1)( 64.41, 2)( 64.62, 2)( 64.82, 2)( 65.02, 1)( 65.23, 1)( 65.43, 2)( 65.63, 2)( 65.84, 2)( 66.04, 1)( 66.24, 1)
( 66.45, 2)( 66.65, 2)( 66.85, 1)( 67.06, 1)( 67.26, 1)( 67.46, 1)( 67.67, 1)( 67.87, 1)( 68.07, 1)( 68.28, 1)( 68.48, 1)( 68.68, 2)
( 68.88, 1)( 69.09, 1)( 69.29, 1)( 69.49, 2)( 69.70, 2)( 69.90, 1)( 70.10, 1)( 70.31, 1)( 70.51, 1)( 70.71, 1)( 70.92, 1)( 71.12, 1)
( 71.32, 1)( 71.53, 1)( 71.73, 1)( 71.93, 1)( 72.14, 1)( 72.34, 1)( 72.54, 1)( 72.75, 1)( 72.95, 1)( 73.15, 1)( 73.36, 1)( 73.56, 1)
( 73.76, 1)( 74.17, 1)( 74.27, 1)( 74.37, 1)( 74.47, 1)( 74.57, 1)( 74.68, 1)( 74.78, 1)( 74.88, 1)( 74.98, 1)( 75.08, 1)( 75.18, 1)
( 75.29, 1)( 75.39, 1)( 75.49, 1)( 75.59, 1)( 75.69, 1)( 75.79, 1)( 75.90, 1)( 76.00, 1)( 76.10, 1)( 76.20, 1)( 76.30, 1)( 76.40, 1)
( 76.50, 1)( 76.61, 1)( 76.71, 1)( 76.81, 1)( 76.91, 1)( 77.01, 1)( 77.11, 1)( 77.22, 1)( 77.32, 1)( 77.42, 1)( 77.52, 1)( 77.62, 1)
( 77.72, 1)( 77.83, 1)( 77.93, 1)( 78.03, 1)( 78.13, 1)( 78.23, 1)( 78.33, 1)( 78.44, 1)( 78.54, 1)( 78.64, 1)( 78.74, 1)( 78.84, 1)
( 78.94, 1)( 79.04, 1)( 79.15, 1)( 79.25, 1)( 79.35, 1)( 79.45, 1)( 79.55, 1)( 79.65, 1)( 79.76, 1)( 79.86, 1)( 79.96, 1)( 80.06, 1)
( 80.16, 1)( 80.26, 1)( 80.37, 1)( 80.47, 1)( 80.57, 1)( 80.67, 1)( 80.77, 1)( 80.87, 1)( 80.98, 1)( 81.08, 1)( 81.18, 1)( 81.28, 1)
( 81.38, 1)( 81.48, 1)( 81.58, 1)( 81.69, 1)( 81.79, 1)( 81.89, 1)( 81.99, 1)( 82.09, 1)( 82.19, 1)( 82.30, 1)( 82.40, 1)( 82.50, 1)
( 82.60, 1)( 82.70, 1)( 82.80, 1)( 82.91, 1)( 83.01, 1)( 83.11, 1)( 83.21, 1)( 83.31, 1)( 83.41, 1)( 83.52, 1)( 83.62, 1)( 83.72, 1)
( 83.82, 1)( 83.92, 1)( 84.02, 1)( 84.12, 1)( 84.23, 1)( 84.33, 1)( 84.43, 1)( 84.53, 1)( 84.63, 1)( 84.73, 1)( 84.84, 1)( 84.94, 1)
( 85.04, 1)( 85.14, 1)( 85.24, 1)( 85.34, 1)( 85.45, 1)( 85.55, 1)( 85.65, 1)( 85.75, 1)( 85.85, 2)( 86.26, 1)( 86.36, 1)( 86.46, 1)
( 86.56, 1)( 86.66, 1)( 86.77, 1)( 86.87, 2)( 86.97, 1)( 87.38, 1)( 87.48, 1)( 87.58, 1)( 87.68, 1)( 87.78, 1)( 87.88, 1)( 87.99, 1)
( 88.09, 2)( 88.19, 2)( 88.29, 1)( 88.39, 1)( 88.49, 1)( 88.60, 1)( 88.70, 1)( 88.80, 1)( 88.90, 1)( 89.00, 1)( 89.10, 2)( 89.20, 2)
( 89.31, 2)( 89.41, 2)( 89.51, 2)( 89.61, 1)( 89.88, 1)( 89.95, 1)( 90.02, 1)( 90.09, 1)( 90.15, 1)( 90.22, 1)( 90.29, 1)( 90.36, 1)
( 90.42, 1)( 90.49, 1)( 90.56, 1)( 90.63, 1)( 90.69, 1)( 90.76, 1)( 90.83, 1)( 90.90, 1)( 90.97, 2)( 91.03, 2)( 91.10, 1)( 91.17, 1)
( 91.24, 1)( 91.30, 1)( 91.37, 1)( 91.44, 1)( 91.51, 1)( 91.58, 1)( 91.64, 1)( 91.71, 1)( 91.78, 1)( 91.85, 1)( 91.91, 1)( 91.98, 1)
( 92.05, 1)( 92.12, 1)( 92.19, 2)( 92.25, 2)( 92.32, 2)( 92.39, 2)( 92.46, 2)( 92.52, 2)( 92.59, 1)( 92.66, 1)( 92.73, 2)( 92.79, 2)
( 92.86, 3)( 92.93, 2)( 93.00, 1)( 93.07, 1)( 93.13, 1)( 93.20, 1)( 93.27, 1)( 93.34, 1)( 93.40, 3)( 93.47, 3)( 93.54, 2)( 93.61, 2)
( 93.68, 3)( 93.74, 3)( 93.81, 1)( 93.88, 2)( 93.95, 4)( 94.01, 5)( 94.08, 6)( 94.15, 5)( 94.22, 4)( 94.28, 1)( 94.35, 3)( 94.42, 1)
THE STIFF PARTICLE ENERGY EQUATION ASSUMPTION IS INITIATED FOR PARTICLE NO. 1 AT  95.30 CM. DOWN THE REACTOR
( 94.49, 3)( 94.56, 3)( 94.62, 6)( 94.69, 9)( 94.76,10)( 94.83,10)( 94.89,11)( 94.96,11)( 95.03, 8)( 95.30,10)( 95.37, 2)( 95.44, 1)
( 95.50, 1)( 95.57, 1)( 95.64, 1)( 95.71, 1)( 95.77, 1)( 95.84, 1)( 95.91, 1)( 95.98, 1)( 96.05, 1)( 96.11, 1)( 96.18, 1)( 96.25, 1)
( 96.32, 1)( 96.38, 1)( 96.45, 1)( 96.52, 1)( 96.59, 1)( 96.66, 1)( 96.72, 1)( 96.79, 1)( 96.86, 1)( 96.93, 1)( 96.99, 1)( 97.06, 1)
( 97.13, 1)( 97.20, 1)( 97.27, 1)( 97.33, 1)( 97.40, 1)( 97.47, 1)( 97.54, 1)( 97.60, 1)( 97.67, 1)( 97.74, 1)( 97.81, 1)( 97.87, 1)
( 97.94, 1)( 98.01, 1)( 98.08, 1)( 98.15, 1)( 98.21, 1)( 98.28, 1)( 98.35, 1)( 98.42, 1)( 98.48, 1)( 98.55, 1)( 98.62, 1)( 98.69, 1)
( 98.76, 1)( 98.82, 1)( 98.89, 1)( 98.96, 1)( 99.03, 1)( 99.09, 1)( 99.16, 1)( 99.23, 1)( 99.30, 1)( 99.36, 1)( 99.43, 1)( 99.50, 1)
( 99.57, 1)( 99.64, 1)( 99.70, 1)( 99.77, 1)( 99.84, 1)( 99.91, 1)( 99.97, 1)(100.04, 1)(100.11, 1)(100.18, 1)(100.25, 1)(100.31, 1)
(100.38, 1)(100.45, 1)(100.52, 1)(100.58, 1)(100.65, 1)(100.72, 1)(100.79, 1)(100.85, 1)(100.92, 1)(100.99, 1)(101.06, 1)(101.13, 1)
(101.19, 1)(101.26, 1)(101.33, 1)(101.40, 1)(101.46, 1)(101.53, 1)(101.60, 1)(101.67, 1)(101.74, 1)(101.80, 1)(101.87, 1)(101.94, 1)
(102.01, 1)(102.07, 1)(102.14, 1)(102.21, 1)(102.28, 1)(102.35, 1)(102.41, 1)(102.48, 1)(102.55, 1)(102.62, 1)(102.68, 1)(102.75, 1)
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THE STIFF PARTICLE ENERGY EQUATION ASSUMPTION IS INITIATED FOR PARTICLE NO. 2 AT 103.02 CM. DOWN THE REACTOR
(102.82, 1)(102.89, 1)(102.95, 1)(103.02, 1)(103.09, 2)(103.16, 1)(103.23, 1)(103.29, 1)(103.36, 1)(103.43, 1)(103.50, 1)(103.56, 1)
(103.63, 1)(103.70, 1)(103.77, 1)(103.84, 1)(103.90, 1)(103.97, 1)(104.04, 1)(104.11, 1)(104.17, 1)(104.24, 1)(104.31, 1)(104.38, 1)
(104.44, 1)(104.51, 1)(104.58, 1)(104.65, 1)(104.72, 1)(104.78, 1)(104.85, 1)(104.92, 1)(104.99, 1)(105.05, 1)(105.12, 1)(105.19, 1)
(105.26, 1)(105.33, 1)(105.39, 1)(105.46, 1)(105.53, 1)(105.60, 1)(105.66, 1)(105.73, 1)(105.80, 1)(105.87, 1)(105.94, 1)(106.00, 1)
(106.07, 1)(106.14, 1)(106.21, 1)(106.27, 1)(106.34, 1)(106.41, 1)(106.48, 1)(106.54, 1)(106.61, 1)(106.68, 1)(106.75, 1)(106.82, 1)
(106.88, 1)(106.95, 1)(107.02, 1)(107.09, 1)(107.15, 1)(107.22, 1)(107.29, 1)(107.36, 1)(107.43, 1)(107.49, 1)(107.56, 1)(107.63, 1)
(107.70, 1)(107.76, 1)(107.83, 1)(107.90, 1)(107.97, 1)(108.03, 1)(108.10, 1)(108.17, 1)(108.24, 1)(108.31, 1)(108.37, 1)(108.44, 1)
(108.51, 1)(108.58, 1)(108.64, 1)(108.71, 1)(108.78, 1)(108.85, 1)(108.92, 1)(108.98, 1)(109.05, 1)(109.12, 1)(109.19, 1)(109.25, 1)
(109.32, 1)(109.39, 1)(109.46, 1)(109.52, 1)(109.59, 1)(109.66, 1)(109.73, 1)(109.80, 1)(109.86, 1)(109.93, 1)(110.00, 1)(110.07, 1)
(110.13, 1)(110.20, 1)(110.27, 1)(110.34, 1)(110.41, 1)(110.47, 1)(110.54, 1)(110.61, 1)(110.68, 1)(110.74, 1)(110.81, 1)(110.88, 1)
(110.95, 1)(111.02, 1)(111.08, 1)(111.15, 1)(111.22, 1)(111.29, 1)(111.35, 1)(111.42, 1)(111.49, 1)(111.56, 1)(111.62, 1)(111.69, 1)
(111.76, 1)(111.83, 1)(111.90, 1)(111.96, 1)(112.03, 1)(112.10, 1)(112.17, 1)(112.23, 1)(112.30, 1)(112.37, 1)(112.44, 1)(112.51, 1)
(112.57, 1)(112.64, 1)(112.71, 1)(112.78, 1)(112.84, 1)(112.91, 1)(112.98, 1)(113.05, 1)(113.11, 1)(113.18, 1)(113.25, 1)(113.32, 1)
THE STIFF PARTICLE ENERGY EQUATION ASSUMPTION IS INITIATED FOR PARTICLE NO. 3 AT 113.39 CM. DOWN THE REACTOR
(113.39, 1)(115.82, 1)(116.43, 1)(117.04, 1)(117.65, 1)(118.26, 1)(118.87, 1)(119.48, 1)(120.09, 1)(120.70, 1)(121.31, 1)(121.92, 1)
(122.53, 1)(123.14, 1)(123.75, 1)(124.36, 1)(124.97, 1)(125.58, 1)(126.19, 1)(126.80, 1)(127.41, 1)(128.02, 1)(128.63, 1)(129.24, 1)
(131.67, 1)(132.28, 1)(132.89, 1)(133.50, 1)(134.11, 1)(134.72, 1)(135.33, 1)(135.94, 1)(136.55, 1)(137.16, 1)(137.77, 1)(138.38, 1)
(138.99, 1)(139.60, 1)(140.21, 1)(140.82, 1)(141.43, 1)(142.04, 1)(142.65, 1)(143.26, 1)(143.87, 1)(144.48, 1)(145.08, 1)(145.69, 1)
(146.30, 1)(146.91, 1)(147.52, 1)(148.13, 1)(148.74, 1)(149.35, 1)(149.96, 1)(150.57, 1)(151.18, 1)(151.79, 1)(152.40, 1)(

AFTER  5 ITERATION(S) THROUGH THE REACTOR THE ROOT MEAN SQUARE OF ALL PARTICLE TEMPERATURES IS   13.091 DEGREES KELVIN
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THE ORDERED PAIR OF (X,# OF CORRECTORS APPLIED) FOLLOWS FOR EACH O.D.E. STEP

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(  1.22,11)(  2.03, 1)(  2.24, 1)(  2.44, 1)(  2.64, 1)(  3.45, 1)(  3.66, 1)(  3.86, 1)(  4.06, 1)(  4.27, 1)(  4.47, 1)(  4.67, 1)
(  4.88, 1)(  5.08, 1)(  5.28, 1)(  5.49, 1)(  5.69, 1)(  5.89, 1)(  6.10, 1)(  6.30, 1)(  6.50, 1)(  6.71, 1)(  6.91, 1)(  7.11, 1)
(  7.32, 1)(  7.52, 1)(  7.72, 1)(  7.92, 1)(  8.13, 1)(  8.33, 1)(  8.53, 1)(  8.74, 1)(  8.94, 1)(  9.14, 1)(  9.35, 1)(  9.55, 1)
(  9.75, 1)(  9.96, 1)( 10.16, 1)( 10.36, 1)( 10.57, 1)( 10.77, 1)( 10.97, 1)( 11.18, 1)( 11.38, 1)( 11.58, 1)( 11.79, 1)( 11.99, 1)
( 12.19, 1)( 12.40, 1)( 12.60, 1)( 12.80, 1)( 13.00, 1)( 13.21, 1)( 13.41, 1)( 13.61, 1)( 13.82, 1)( 14.02, 1)( 14.22, 1)( 14.43, 1)
( 14.63, 1)( 14.83, 1)( 15.04, 1)( 15.24, 1)( 15.44, 1)( 15.65, 1)( 15.85, 1)( 16.05, 1)( 16.26, 1)( 16.46, 1)( 16.66, 1)( 16.87, 1)
( 17.07, 1)( 17.27, 1)( 17.48, 1)( 17.68, 1)( 17.88, 1)( 18.08, 1)( 18.29, 1)( 18.49, 1)( 18.69, 1)( 18.90, 1)( 19.10, 1)( 19.30, 1)
( 19.51, 1)( 19.71, 1)( 19.91, 1)( 20.12, 1)( 20.32, 1)( 20.52, 1)( 20.73, 1)( 20.93, 1)( 21.13, 1)( 21.34, 1)( 21.54, 1)( 21.74, 1)
( 21.95, 1)( 22.15, 1)( 22.35, 1)( 22.56, 1)( 22.76, 1)( 22.96, 1)( 23.16, 1)( 23.37, 1)( 23.57, 1)( 23.77, 1)( 23.98, 1)( 24.18, 1)
( 24.38, 1)( 24.59, 1)( 24.79, 1)( 24.99, 1)( 25.20, 1)( 25.40, 1)( 25.60, 1)( 25.81, 2)( 26.01, 1)( 26.21, 1)( 26.42, 1)( 26.62, 2)
( 26.82, 2)( 27.03, 1)( 27.23, 1)( 27.43, 1)( 27.64, 1)( 27.84, 1)( 28.04, 1)( 28.24, 1)( 28.45, 1)( 28.65, 2)( 28.85, 2)( 29.06, 2)
( 29.26, 1)( 29.46, 1)( 29.67, 2)( 29.87, 2)( 30.07, 1)( 30.28, 1)( 30.48, 1)( 30.68, 2)( 30.89, 2)( 31.09, 2)( 31.29, 1)( 31.50, 1)
( 31.70, 2)( 31.90, 2)( 32.11, 2)( 32.31, 1)( 32.51, 1)( 32.72, 2)( 32.92, 2)( 33.12, 2)( 33.32, 1)( 33.53, 1)( 33.73, 2)( 33.93, 2)
( 34.14, 2)( 34.34, 2)( 34.54, 1)( 34.75, 2)( 34.95, 3)( 35.76, 3)( 35.97, 3)( 36.17, 2)( 36.37, 1)( 36.58, 1)( 36.78, 2)( 36.98, 2)
( 37.19, 2)( 37.39, 2)( 37.59, 1)( 37.80, 2)( 38.00, 3)( 38.20, 2)( 38.40, 2)( 38.61, 1)( 38.81, 2)( 39.01, 3)( 39.22, 2)( 39.42, 1)
( 39.62, 1)( 39.83, 2)( 40.03, 2)( 40.23, 2)( 40.44, 2)( 40.64, 2)( 40.84, 2)( 41.05, 3)( 41.25, 2)( 41.45, 2)( 41.66, 1)( 41.86, 2)
( 42.06, 3)( 42.27, 2)( 42.47, 1)( 42.67, 1)( 42.88, 2)( 43.08, 2)( 43.28, 2)( 43.48, 2)( 43.69, 2)( 43.89, 2)( 44.09, 3)( 44.30, 2)
( 44.50, 2)( 44.70, 1)( 44.91, 2)( 45.11, 3)( 45.31, 2)( 45.52, 1)( 45.72, 1)( 45.92, 1)( 46.13, 2)( 46.33, 2)( 46.53, 2)( 46.74, 2)
( 46.94, 2)( 47.14, 2)( 47.35, 3)( 47.55, 2)( 47.75, 2)( 47.96, 1)( 48.16, 2)( 48.36, 2)( 48.56, 2)( 48.77, 1)( 48.97, 1)( 49.17, 2)
( 49.38, 2)( 49.58, 2)( 49.78, 2)( 49.99, 1)( 50.19, 2)( 50.39, 3)( 50.60, 2)( 50.80, 2)( 51.00, 1)( 51.21, 2)( 51.41, 2)( 51.61, 2)
( 51.82, 1)( 52.02, 1)( 52.22, 2)( 52.43, 2)( 52.63, 2)( 52.83, 2)( 53.04, 1)( 53.24, 2)( 53.44, 2)( 53.64, 2)( 53.85, 2)( 54.05, 1)
( 54.25, 2)( 54.46, 2)( 54.66, 2)( 54.86, 1)( 55.07, 1)( 55.27, 2)( 55.47, 2)( 55.68, 2)( 55.88, 2)( 56.08, 1)( 56.29, 2)( 56.49, 2)
( 56.69, 2)( 56.90, 2)( 57.10, 1)( 57.30, 2)( 57.51, 2)( 57.71, 2)( 57.91, 1)( 58.12, 1)( 58.32, 2)( 58.52, 2)( 58.72, 2)( 58.93, 1)
( 59.13, 1)( 59.33, 2)( 59.54, 2)( 59.74, 2)( 59.94, 2)( 60.15, 1)( 60.35, 2)( 60.55, 2)( 60.76, 2)( 60.96, 1)( 61.16, 1)( 61.37, 2)
( 61.57, 2)( 61.77, 2)( 61.98, 1)( 62.18, 1)( 62.38, 2)( 62.59, 2)( 62.79, 2)( 62.99, 1)( 63.20, 1)( 63.40, 2)( 63.60, 2)( 63.80, 2)
( 64.01, 1)( 64.21, 1)( 64.41, 2)( 64.62, 2)( 64.82, 2)( 65.02, 1)( 65.23, 1)( 65.43, 2)( 65.63, 2)( 65.84, 2)( 66.04, 1)( 66.24, 1)
( 66.45, 2)( 66.65, 2)( 66.85, 1)( 67.06, 1)( 67.26, 1)( 67.46, 1)( 67.67, 1)( 67.87, 1)( 68.07, 1)( 68.28, 1)( 68.48, 1)( 68.68, 2)
( 68.88, 1)( 69.09, 1)( 69.29, 1)( 69.49, 2)( 69.70, 2)( 69.90, 1)( 70.10, 1)( 70.31, 1)( 70.51, 1)( 70.71, 1)( 70.92, 1)( 71.12, 1)
( 71.32, 1)( 71.53, 1)( 71.73, 1)( 71.93, 1)( 72.14, 1)( 72.34, 1)( 72.54, 1)( 72.75, 1)( 72.95, 1)( 73.15, 1)( 73.36, 1)( 73.56, 1)
( 73.76, 1)( 74.17, 1)( 74.27, 1)( 74.37, 1)( 74.47, 1)( 74.57, 1)( 74.68, 1)( 74.78, 1)( 74.88, 1)( 74.98, 1)( 75.08, 1)( 75.18, 1)
( 75.29, 1)( 75.39, 1)( 75.49, 1)( 75.59, 1)( 75.69, 1)( 75.79, 1)( 75.90, 1)( 76.00, 1)( 76.10, 1)( 76.20, 1)( 76.30, 1)( 76.40, 1)
( 76.50, 1)( 76.61, 1)( 76.71, 1)( 76.81, 1)( 76.91, 1)( 77.01, 1)( 77.11, 1)( 77.22, 1)( 77.32, 1)( 77.42, 1)( 77.52, 1)( 77.62, 1)
( 77.72, 1)( 77.83, 1)( 77.93, 1)( 78.03, 1)( 78.13, 1)( 78.23, 1)( 78.33, 1)( 78.44, 1)( 78.54, 1)( 78.64, 1)( 78.74, 1)( 78.84, 1)
( 78.94, 1)( 79.04, 1)( 79.15, 1)( 79.25, 1)( 79.35, 1)( 79.45, 1)( 79.55, 1)( 79.65, 1)( 79.76, 1)( 79.86, 1)( 79.96, 1)( 80.06, 1)
( 80.16, 1)( 80.26, 1)( 80.37, 1)( 80.47, 1)( 80.57, 1)( 80.67, 1)( 80.77, 1)( 80.87, 1)( 80.98, 1)( 81.08, 1)( 81.18, 1)( 81.28, 1)
( 81.38, 1)( 81.48, 1)( 81.58, 1)( 81.69, 1)( 81.79, 1)( 81.89, 1)( 81.99, 1)( 82.09, 1)( 82.19, 1)( 82.30, 1)( 82.40, 1)( 82.50, 1)
( 82.60, 1)( 82.70, 1)( 82.80, 1)( 82.91, 1)( 83.01, 1)( 83.11, 1)( 83.21, 1)( 83.31, 1)( 83.41, 1)( 83.52, 1)( 83.62, 1)( 83.72, 1)
( 83.82, 1)( 83.92, 1)( 84.02, 1)( 84.12, 1)( 84.23, 1)( 84.33, 1)( 84.43, 1)( 84.53, 1)( 84.63, 1)( 84.73, 1)( 84.84, 1)( 84.94, 1)
( 85.04, 1)( 85.14, 1)( 85.24, 1)( 85.34, 1)( 85.45, 1)( 85.55, 1)( 85.65, 1)( 85.75, 1)( 86.16, 1)( 86.26, 1)( 86.36, 1)( 86.46, 1)
( 86.56, 1)( 86.66, 1)( 86.77, 1)( 86.87, 2)( 86.97, 1)( 87.38, 1)( 87.48, 1)( 87.58, 1)( 87.68, 1)( 87.78, 1)( 87.88, 1)( 87.99, 1)
( 88.09, 2)( 88.19, 2)( 88.29, 1)( 88.39, 1)( 88.49, 1)( 88.60, 1)( 88.70, 1)( 88.80, 1)( 88.90, 1)( 89.00, 1)( 89.10, 2)( 89.20, 2)
( 89.31, 2)( 89.41, 2)( 89.88, 1)( 89.95, 1)( 90.02, 1)( 90.09, 1)( 90.15, 1)( 90.22, 1)( 90.29, 1)( 90.36, 1)( 90.42, 1)( 90.49, 1)
( 90.56, 1)( 90.63, 1)( 90.69, 1)( 90.76, 1)( 90.83, 1)( 90.90, 1)( 90.97, 2)( 91.03, 2)( 91.10, 1)( 91.17, 1)( 91.24, 1)( 91.30, 1)
( 91.37, 1)( 91.44, 1)( 91.51, 1)( 91.58, 1)( 91.64, 1)( 91.71, 1)( 91.78, 1)( 91.85, 1)( 91.91, 1)( 91.98, 1)( 92.05, 1)( 92.12, 1)
( 92.19, 2)( 92.25, 2)( 92.32, 2)( 92.39, 2)( 92.46, 2)( 92.52, 2)( 92.59, 1)( 92.66, 1)( 92.73, 2)( 92.79, 2)( 92.86, 3)( 92.93, 2)
( 93.00, 1)( 93.07, 1)( 93.13, 1)( 93.20, 1)( 93.27, 1)( 93.34, 1)( 93.40, 3)( 93.47, 3)( 93.54, 2)( 93.61, 2)( 93.68, 3)( 93.74, 3)
( 93.81, 1)( 93.88, 2)( 93.95, 4)( 94.01, 5)( 94.08, 6)( 94.15, 5)( 94.22, 4)( 94.28, 1)( 94.35, 3)( 94.42, 1)( 94.49, 4)( 94.56, 6)
THE STIFF PARTICLE ENERGY EQUATION ASSUMPTION IS INITIATED FOR PARTICLE NO. 1 AT  95.23 CM. DOWN THE REACTOR
( 94.62, 7)( 94.69, 5)( 94.76, 6)( 94.83,11)( 94.89,11)( 94.96, 1)( 95.23,11)( 95.30, 2)( 95.37, 1)( 95.44, 1)( 95.50, 1)( 95.57, 1)
( 95.64, 1)( 95.71, 1)( 95.77, 1)( 95.84, 1)( 95.91, 1)( 95.98, 1)( 96.05, 1)( 96.11, 1)( 96.18, 1)( 96.25, 1)( 96.32, 1)( 96.38, 1)
( 96.45, 1)( 96.52, 1)( 96.59, 1)( 96.66, 1)( 96.72, 1)( 96.79, 1)( 96.86, 1)( 96.93, 1)( 96.99, 1)( 97.06, 1)( 97.13, 1)( 97.20, 1)
( 97.27, 1)( 97.33, 1)( 97.40, 1)( 97.47, 1)( 97.54, 1)( 97.60, 1)( 97.67, 1)( 97.74, 1)( 97.81, 1)( 97.87, 1)( 97.94, 1)( 98.01, 1)
( 98.08, 1)( 98.15, 1)( 98.21, 1)( 98.28, 1)( 98.35, 1)( 98.42, 1)( 98.48, 1)( 98.55, 1)( 98.62, 1)( 98.69, 1)( 98.76, 1)( 98.82, 1)
( 98.89, 1)( 98.96, 1)( 99.03, 1)( 99.09, 1)( 99.16, 1)( 99.23, 1)( 99.30, 1)( 99.36, 1)( 99.43, 1)( 99.50, 1)( 99.57, 1)( 99.64, 1)
( 99.70, 1)( 99.77, 1)( 99.84, 1)( 99.91, 1)( 99.97, 1)(100.04, 1)(100.11, 1)(100.18, 1)(100.25, 1)(100.31, 1)(100.38, 1)(100.45, 1)
(100.52, 1)(100.58, 1)(100.65, 1)(100.72, 1)(100.79, 1)(100.85, 1)(100.92, 1)(100.99, 1)(101.06, 1)(101.13, 1)(101.19, 1)(101.26, 1)
(101.33, 1)(101.40, 1)(101.46, 1)(101.53, 1)(101.60, 1)(101.67, 1)(101.74, 1)(101.80, 1)(101.87, 1)(101.94, 1)(102.01, 1)(102.07, 1)
(102.14, 1)(102.21, 1)(102.28, 1)(102.35, 1)(102.41, 1)(102.48, 1)(102.55, 1)(102.62, 1)(102.68, 1)(102.75, 1)(102.82, 1)(102.89, 1)
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THE STIFF PARTICLE ENERGY EQUATION ASSUMPTION IS INITIATED FOR PARTICLE NO. 2 AT 103.02 CM. DOWN THE REACTOR
(102.95, 1)(103.02, 1)(103.09, 2)(103.16, 1)(103.23, 1)(103.29, 1)(103.36, 1)(103.43, 1)(103.50, 1)(103.56, 1)(103.63, 1)(103.70, 1)
(103.77, 1)(103.84, 1)(103.90, 1)(103.97, 1)(104.04, 1)(104.11, 1)(104.17, 1)(104.24, 1)(104.31, 1)(104.38, 1)(104.44, 1)(104.51, 1)
(104.58, 1)(104.65, 1)(104.72, 1)(104.78, 1)(104.85, 1)(104.92, 1)(104.99, 1)(105.05, 1)(105.12, 1)(105.19, 1)(105.26, 1)(105.33, 1)
(105.39, 1)(105.46, 1)(105.53, 1)(105.60, 1)(105.66, 1)(105.73, 1)(105.80, 1)(105.87, 1)(105.94, 1)(106.00, 1)(106.07, 1)(106.14, 1)
(106.21, 1)(106.27, 1)(106.34, 1)(106.41, 1)(106.48, 1)(106.54, 1)(106.61, 1)(106.68, 1)(106.75, 1)(106.82, 1)(106.88, 1)(106.95, 1)
(107.02, 1)(107.09, 1)(107.15, 1)(107.22, 1)(107.29, 1)(107.36, 1)(107.43, 1)(107.49, 1)(107.56, 1)(107.63, 1)(107.70, 1)(107.76, 1)
(107.83, 1)(107.90, 1)(107.97, 1)(108.03, 1)(108.10, 1)(108.17, 1)(108.24, 1)(108.31, 1)(108.37, 1)(108.44, 1)(108.51, 1)(108.58, 1)
(108.64, 1)(108.71, 1)(108.78, 1)(108.85, 1)(108.92, 1)(108.98, 1)(109.05, 1)(109.12, 1)(109.19, 1)(109.25, 1)(109.32, 1)(109.39, 1)
(109.46, 1)(109.52, 1)(109.59, 1)(109.66, 1)(109.73, 1)(109.80, 1)(109.86, 1)(109.93, 1)(110.00, 1)(110.07, 1)(110.13, 1)(110.20, 1)
(110.27, 1)(110.34, 1)(110.41, 1)(110.47, 1)(110.54, 1)(110.61, 1)(110.68, 1)(110.74, 1)(110.81, 1)(110.88, 1)(110.95, 1)(111.02, 1)
(111.08, 1)(111.15, 1)(111.22, 1)(111.29, 1)(111.35, 1)(111.42, 1)(111.49, 1)(111.56, 1)(111.62, 1)(111.69, 1)(111.76, 1)(111.83, 1)
(111.90, 1)(111.96, 1)(112.03, 1)(112.10, 1)(112.17, 1)(112.23, 1)(112.30, 1)(112.37, 1)(112.44, 1)(112.51, 1)(112.57, 1)(112.64, 1)
THE STIFF PARTICLE ENERGY EQUATION ASSUMPTION IS INITIATED FOR PARTICLE NO. 3 AT 113.39 CM. DOWN THE REACTOR
(112.71, 1)(112.78, 1)(112.84, 1)(112.91, 1)(112.98, 1)(113.05, 1)(113.11, 1)(113.18, 1)(113.25, 1)(113.32, 1)(113.39, 1)(115.82, 1)
(116.43, 1)(117.04, 1)(117.65, 1)(118.26, 1)(118.87, 1)(119.48, 1)(120.09, 1)(120.70, 1)(121.31, 1)(121.92, 1)(122.53, 1)(123.14, 1)
(123.75, 1)(124.36, 1)(124.97, 1)(125.58, 1)(126.19, 1)(126.80, 1)(127.41, 1)(128.02, 1)(128.63, 1)(129.24, 1)(131.67, 1)(132.28, 1)
(132.89, 1)(133.50, 1)(134.11, 1)(134.72, 1)(135.33, 1)(135.94, 1)(136.55, 1)(137.16, 1)(137.77, 1)(138.38, 1)(138.99, 1)(139.60, 1)
(140.21, 1)(140.82, 1)(141.43, 1)(142.04, 1)(142.65, 1)(143.26, 1)(143.87, 1)(144.48, 1)(145.08, 1)(145.69, 1)(146.30, 1)(146.91, 1)
(147.52, 1)(148.13, 1)(148.74, 1)(149.35, 1)(149.96, 1)(150.57, 1)(151.18, 1)(151.79, 1)(152.40, 1)(

AFTER  6 ITERATION(S) THROUGH THE REACTOR THE ROOT MEAN SQUARE OF ALL PARTICLE TEMPERATURES IS    2.480 DEGREES KELVIN
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BYU -- ONE DImensional Combustion Or Gasification model (1-DICOG): particle number 1

23-May-79

DISTANCE (cm)	GAS TEMP (kelvin)	PARTICLE TEMP (kelvin)	VELOCITY (cm/sec)	PARTICLE NO. DENS (#/cc)	PARTICLE DIA. (cm)	COAL MASS (gr)	CHAR MASS (gr)	H2O MASS (gr)	ASH MASS (gr)	PART MASS (gr)
0.00	356.6	355.6	2.86E+03	4.31E+04	2.00E-03	4.76E-09	0.00E+00	1.69E-10	5.17E-10	5.45E-09
0.61	366.7	357.2	2.70E+03	3.17E+04	2.00E-03	4.76E-09	2.32E-18	6.89E-12	5.17E-10	5.28E-09
1.22	361.3	359.8	2.49E+03	2.50E+04	2.00E-03	4.76E-09	6.56E-18	0.00E+00	5.17E-10	5.28E-09
1.83	357.3	361.8	2.27E+03	2.08E+04	2.00E-03	4.76E-09	1.21E-17	0.00E+00	5.17E-10	5.28E-09
2.44	355.9	363.6	2.08E+03	1.78E+04	2.00E-03	4.76E-09	1.90E-17	0.00E+00	5.17E-10	5.28E-09
3.05	356.8	365.4	1.92E+03	1.56E+04	2.00E-03	4.76E-09	2.75E-17	0.00E+00	5.17E-10	5.28E-09
3.66	359.7	367.5	1.79E+03	1.38E+04	2.00E-03	4.76E-09	3.81E-17	0.00E+00	5.17E-10	5.28E-09
4.27	363.3	369.9	1.68E+03	1.24E+04	2.00E-03	4.76E-09	5.12E-17	0.00E+00	5.17E-10	5.28E-09
4.88	367.1	372.9	1.57E+03	1.12E+04	2.00E-03	4.76E-09	6.80E-17	0.00E+00	5.17E-10	5.28E-09
5.49	370.8	376.2	1.48E+03	1.03E+04	2.00E-03	4.76E-09	9.00E-17	0.00E+00	5.17E-10	5.28E-09
6.10	374.6	379.9	1.39E+03	9.47E+03	2.00E-03	4.76E-09	1.19E-16	0.00E+00	5.17E-10	5.28E-09
6.71	378.1	383.8	1.32E+03	8.79E+03	2.00E-03	4.76E-09	1.58E-16	0.00E+00	5.17E-10	5.28E-09
7.32	381.6	387.8	1.25E+03	8.22E+03	2.00E-03	4.76E-09	2.11E-16	0.00E+00	5.17E-10	5.28E-09
7.92	384.9	392.0	1.18E+03	7.72E+03	2.00E-03	4.76E-09	2.82E-16	0.00E+00	5.17E-10	5.28E-09
8.53	388.1	396.1	1.12E+03	7.29E+03	2.00E-03	4.76E-09	3.77E-16	0.00E+00	5.17E-10	5.28E-09
9.14	391.2	400.2	1.07E+03	6.92E+03	2.00E-03	4.76E-09	5.04E-16	0.00E+00	5.17E-10	5.28E-09
9.75	394.1	404.2	1.02E+03	6.58E+03	2.00E-03	4.76E-09	6.71E-16	0.00E+00	5.17E-10	5.28E-09
10.36	397.0	408.1	9.70E+02	6.29E+03	2.00E-03	4.76E-09	8.88E-16	0.00E+00	5.17E-10	5.28E-09
10.97	399.8	411.8	9.26E+02	6.02E+03	2.00E-03	4.76E-09	1.17E-15	0.00E+00	5.17E-10	5.28E-09
11.58	402.5	415.4	8.84E+02	5.79E+03	2.00E-03	4.76E-09	1.52E-15	0.00E+00	5.17E-10	5.28E-09
12.19	405.2	418.8	8.46E+02	5.58E+03	2.00E-03	4.76E-09	1.96E-15	0.00E+00	5.17E-10	5.28E-09
12.80	407.7	422.1	8.09E+02	5.38E+03	2.00E-03	4.76E-09	2.51E-15	0.00E+00	5.17E-10	5.28E-09
13.41	410.3	425.2	7.75E+02	5.21E+03	2.00E-03	4.76E-09	3.19E-15	0.00E+00	5.17E-10	5.28E-09
14.02	412.8	428.2	7.43E+02	5.05E+03	2.00E-03	4.76E-09	4.00E-15	0.00E+00	5.17E-10	5.28E-09
14.63	415.2	431.2	7.13E+02	4.91E+03	2.00E-03	4.76E-09	4.99E-15	0.00E+00	5.17E-10	5.28E-09
15.24	417.7	434.0	6.84E+02	4.78E+03	2.00E-03	4.76E-09	6.16E-15	0.00E+00	5.17E-10	5.28E-09
15.85	420.1	436.7	6.57E+02	4.66E+03	2.00E-03	4.76E-09	7.56E-15	0.00E+00	5.17E-10	5.28E-09
16.46	422.5	439.4	6.31E+02	4.55E+03	2.00E-03	4.76E-09	9.21E-15	0.00E+00	5.17E-10	5.28E-09
17.07	424.9	442.1	6.07E+02	4.45E+03	2.00E-03	4.76E-09	1.12E-14	0.00E+00	5.17E-10	5.28E-09
17.68	427.3	444.7	5.84E+02	4.35E+03	2.00E-03	4.76E-09	1.34E-14	0.00E+00	5.17E-10	5.28E-09
18.29	429.8	447.3	5.62E+02	4.27E+03	2.00E-03	4.76E-09	1.61E-14	0.00E+00	5.17E-10	5.28E-09
18.90	432.2	449.9	5.41E+02	4.19E+03	2.00E-03	4.76E-09	1.92E-14	0.00E+00	5.17E-10	5.28E-09
19.51	434.7	452.4	5.21E+02	4.12E+03	2.00E-03	4.76E-09	2.28E-14	0.00E+00	5.17E-10	5.28E-09
20.12	437.1	455.0	5.01E+02	4.05E+03	2.00E-03	4.76E-09	2.70E-14	0.00E+00	5.17E-10	5.28E-09
20.73	439.7	457.6	4.83E+02	3.99E+03	2.00E-03	4.76E-09	3.19E-14	0.00E+00	5.17E-10	5.28E-09
21.34	442.2	460.2	4.66E+02	3.94E+03	2.00E-03	4.76E-09	3.75E-14	0.00E+00	5.17E-10	5.28E-09
21.95	444.9	462.8	4.49E+02	3.89E+03	2.00E-03	4.76E-09	4.40E-14	0.00E+00	5.17E-10	5.28E-09
22.56	447.5	465.5	4.33E+02	3.84E+03	2.00E-03	4.76E-09	5.16E-14	0.00E+00	5.17E-10	5.28E-09
23.16	450.3	468.3	4.18E+02	3.80E+03	2.00E-03	4.76E-09	6.03E-14	0.00E+00	5.17E-10	5.28E-09
23.77	453.1	471.1	4.03E+02	3.76E+03	2.00E-03	4.76E-09	7.05E-14	0.00E+00	5.17E-10	5.28E-09
24.38	456.0	474.0	3.89E+02	3.72E+03	2.00E-03	4.76E-09	8.23E-14	0.00E+00	5.17E-10	5.28E-09
24.99	459.0	476.9	3.75E+02	3.69E+03	2.00E-03	4.76E-09	9.60E-14	0.00E+00	5.17E-10	5.28E-09
25.60	462.0	480.0	3.62E+02	3.66E+03	2.00E-03	4.76E-09	1.12E-13	0.00E+00	5.17E-10	5.28E-09
26.21	465.2	483.1	3.50E+02	3.64E+03	2.00E-03	4.76E-09	1.31E-13	0.00E+00	5.17E-10	5.28E-09
26.82	468.5	486.3	3.37E+02	3.62E+03	2.00E-03	4.76E-09	1.52E-13	0.00E+00	5.17E-10	5.28E-09
27.43	471.9	489.7	3.26E+02	3.60E+03	2.00E-03	4.76E-09	1.78E-13	0.00E+00	5.17E-10	5.28E-09
28.04	475.5	493.2	3.15E+02	3.58E+03	2.00E-03	4.76E-09	2.08E-13	0.00E+00	5.17E-10	5.28E-09

28.65	479.2	496.8	3.04E+02	3.57E+03	2.00E-03	4.76E-09	2.44E-13	0.00E+00	5.17E-10	5.28E-09
29.26	483.1	500.6	2.93E+02	3.56E+03	2.00E-03	4.76E-09	2.85E-13	0.00E+00	5.17E-10	5.28E-09
29.87	487.2	504.5	2.83E+02	3.55E+03	2.00E-03	4.76E-09	3.35E-13	0.00E+00	5.17E-10	5.28E-09
30.48	491.5	508.7	2.73E+02	3.54E+03	2.00E-03	4.76E-09	3.95E-13	0.00E+00	5.17E-10	5.28E-09
31.09	496.0	513.1	2.64E+02	3.54E+03	2.00E-03	4.76E-09	4.66E-13	0.00E+00	5.17E-10	5.28E-09
31.70	500.7	517.7	2.55E+02	3.54E+03	2.00E-03	4.76E-09	5.52E-13	0.00E+00	5.17E-10	5.28E-09
32.31	505.7	522.5	2.46E+02	3.54E+03	2.00E-03	4.76E-09	6.56E-13	0.00E+00	5.17E-10	5.28E-09
32.92	511.0	527.6	2.37E+02	3.54E+03	2.00E-03	4.76E-09	7.83E-13	0.00E+00	5.17E-10	5.28E-09
33.53	516.7	533.1	2.29E+02	3.55E+03	2.00E-03	4.76E-09	9.38E-13	0.00E+00	5.17E-10	5.28E-09
34.14	522.7	538.8	2.21E+02	3.56E+03	2.00E-03	4.76E-09	1.13E-12	0.00E+00	5.17E-10	5.28E-09
34.75	529.1	545.0	2.13E+02	3.57E+03	2.00E-03	4.76E-09	1.37E-12	0.00E+00	5.17E-10	5.28E-09
35.36	534.4	551.0	2.11E+02	3.57E+03	2.00E-03	4.76E-09	1.66E-12	0.00E+00	5.17E-10	5.28E-09
35.97	537.0	554.5	2.12E+02	3.56E+03	2.00E-03	4.76E-09	2.01E-12	0.00E+00	5.17E-10	5.28E-09
36.58	539.6	557.1	2.13E+02	3.54E+03	2.00E-03	4.76E-09	2.38E-12	0.00E+00	5.17E-10	5.28E-09
37.19	542.1	559.6	2.14E+02	3.52E+03	2.00E-03	4.76E-09	2.77E-12	0.00E+00	5.17E-10	5.28E-09
37.80	544.7	562.2	2.15E+02	3.51E+03	2.00E-03	4.75E-09	3.20E-12	0.00E+00	5.17E-10	5.27E-09
38.40	547.4	564.7	2.16E+02	3.49E+03	2.00E-03	4.75E-09	3.65E-12	0.00E+00	5.17E-10	5.27E-09
39.01	550.0	567.3	2.17E+02	3.47E+03	2.00E-03	4.75E-09	4.13E-12	0.00E+00	5.17E-10	5.27E-09
39.62	552.7	570.0	2.18E+02	3.46E+03	2.00E-03	4.75E-09	4.65E-12	0.00E+00	5.17E-10	5.27E-09
40.23	555.4	572.6	2.19E+02	3.44E+03	2.00E-03	4.75E-09	5.20E-12	0.00E+00	5.17E-10	5.27E-09
40.84	558.1	575.3	2.20E+02	3.42E+03	2.00E-03	4.75E-09	5.79E-12	0.00E+00	5.17E-10	5.27E-09
41.45	560.9	578.0	2.21E+02	3.41E+03	2.00E-03	4.75E-09	6.43E-12	0.00E+00	5.17E-10	5.27E-09
42.06	563.6	580.6	2.22E+02	3.39E+03	2.00E-03	4.75E-09	7.10E-12	0.00E+00	5.17E-10	5.27E-09
42.67	566.4	583.4	2.23E+02	3.37E+03	2.00E-03	4.75E-09	7.82E-12	0.00E+00	5.17E-10	5.27E-09
43.28	569.1	586.1	2.24E+02	3.36E+03	2.00E-03	4.75E-09	8.59E-12	0.00E+00	5.17E-10	5.27E-09
43.89	571.9	588.8	2.26E+02	3.34E+03	2.00E-03	4.74E-09	9.41E-12	0.00E+00	5.17E-10	5.27E-09
44.50	574.7	591.6	2.27E+02	3.32E+03	2.00E-03	4.74E-09	1.03E-11	0.00E+00	5.17E-10	5.27E-09
45.11	577.6	594.4	2.28E+02	3.31E+03	2.00E-03	4.74E-09	1.12E-11	0.00E+00	5.17E-10	5.27E-09
45.72	580.4	597.2	2.29E+02	3.29E+03	2.00E-03	4.74E-09	1.22E-11	0.00E+00	5.17E-10	5.27E-09
46.33	583.3	600.0	2.30E+02	3.27E+03	2.00E-03	4.74E-09	1.33E-11	0.00E+00	5.17E-10	5.27E-09
46.94	586.2	602.8	2.31E+02	3.26E+03	2.00E-03	4.74E-09	1.44E-11	0.00E+00	5.17E-10	5.27E-09
47.55	589.1	605.6	2.32E+02	3.24E+03	2.00E-03	4.73E-09	1.56E-11	0.00E+00	5.17E-10	5.27E-09
48.16	592.0	608.5	2.33E+02	3.23E+03	2.00E-03	4.73E-09	1.69E-11	0.00E+00	5.17E-10	5.27E-09
48.77	595.0	611.4	2.35E+02	3.21E+03	2.00E-03	4.73E-09	1.83E-11	0.00E+00	5.17E-10	5.27E-09
49.38	597.9	614.3	2.36E+02	3.19E+03	2.00E-03	4.73E-09	1.98E-11	0.00E+00	5.17E-10	5.26E-09
49.99	601.0	617.3	2.37E+02	3.18E+03	2.00E-03	4.73E-09	2.13E-11	0.00E+00	5.17E-10	5.26E-09
50.60	604.0	620.2	2.38E+02	3.16E+03	2.00E-03	4.72E-09	2.30E-11	0.00E+00	5.17E-10	5.26E-09
51.21	607.1	623.2	2.39E+02	3.14E+03	2.00E-03	4.72E-09	2.47E-11	0.00E+00	5.17E-10	5.26E-09
51.82	610.2	626.3	2.41E+02	3.13E+03	2.00E-03	4.72E-09	2.66E-11	0.00E+00	5.17E-10	5.26E-09
52.43	613.3	629.4	2.42E+02	3.11E+03	2.00E-03	4.71E-09	2.86E-11	0.00E+00	5.17E-10	5.26E-09
53.04	616.5	632.5	2.43E+02	3.10E+03	2.00E-03	4.71E-09	3.08E-11	0.00E+00	5.17E-10	5.26E-09
53.64	619.7	635.6	2.45E+02	3.08E+03	2.00E-03	4.71E-09	3.30E-11	0.00E+00	5.17E-10	5.26E-09
54.25	623.0	638.8	2.46E+02	3.06E+03	2.00E-03	4.70E-09	3.55E-11	0.00E+00	5.17E-10	5.25E-09
54.86	626.3	642.0	2.47E+02	3.05E+03	2.00E-03	4.70E-09	3.80E-11	0.00E+00	5.17E-10	5.25E-09
55.47	629.6	645.3	2.48E+02	3.03E+03	2.00E-03	4.69E-09	4.08E-11	0.00E+00	5.17E-10	5.25E-09
56.08	633.0	648.6	2.50E+02	3.01E+03	2.00E-03	4.69E-09	4.37E-11	0.00E+00	5.17E-10	5.25E-09
56.69	636.5	652.0	2.51E+02	3.00E+03	2.00E-03	4.68E-09	4.69E-11	0.00E+00	5.17E-10	5.25E-09
57.30	640.0	655.4	2.53E+02	2.98E+03	2.00E-03	4.68E-09	5.02E-11	0.00E+00	5.17E-10	5.24E-09
57.91	643.6	658.9	2.54E+02	2.96E+03	2.00E-03	4.67E-09	5.38E-11	0.00E+00	5.17E-10	5.24E-09
58.52	647.3	662.5	2.56E+02	2.95E+03	2.00E-03	4.67E-09	5.76E-11	0.00E+00	5.17E-10	5.24E-09
59.13	651.0	666.1	2.57E+02	2.93E+03	2.00E-03	4.66E-09	6.16E-11	0.00E+00	5.17E-10	5.24E-09
59.74	654.8	669.8	2.59E+02	2.91E+03	2.00E-03	4.65E-09	6.59E-11	0.00E+00	5.17E-10	5.23E-09
60.35	658.7	673.6	2.60E+02	2.90E+03	2.00E-03	4.64E-09	7.06E-11	0.00E+00	5.17E-10	5.23E-09
60.96	662.6	677.4	2.62E+02	2.88E+03	2.01E-03	4.64E-09	7.55E-11	0.00E+00	5.17E-10	5.23E-09
61.57	666.7	681.4	2.63E+02	2.86E+03	2.01E-03	4.63E-09	8.08E-11	0.00E+00	5.17E-10	5.23E-09
62.18	670.9	685.4	2.65E+02	2.84E+03	2.01E-03	4.62E-09	8.64E-11	0.00E+00	5.17E-10	5.22E-09
62.79	675.2	689.5	2.67E+02	2.82E+03	2.01E-03	4.61E-09	9.25E-11	0.00E+00	5.17E-10	5.22E-09
63.40	679.5	693.8	2.68E+02	2.81E+03	2.01E-03	4.60E-09	9.90E-11	0.00E+00	5.17E-10	5.21E-09
64.01	684.1	698.2	2.70E+02	2.79E+03	2.01E-03	4.59E-09	1.06E-10	0.00E+00	5.17E-10	5.21E-09
64.62	688.7	702.7	2.72E+02	2.77E+03	2.01E-03	4.57E-09	1.13E-10	0.00E+00	5.17E-10	5.20E-09

65.23	693.5	707.3	2.74E+02	2.75E+03	2.01E-03	4.56E-09	1.22E-10	0.00E+00	5.17E-10	5.20E-09
65.84	698.5	712.1	2.76E+02	2.73E+03	2.01E-03	4.55E-09	1.30E-10	0.00E+00	5.17E-10	5.19E-09
66.45	703.6	717.1	2.78E+02	2.71E+03	2.01E-03	4.53E-09	1.39E-10	0.00E+00	5.17E-10	5.19E-09
67.06	708.9	722.2	2.80E+02	2.69E+03	2.01E-03	4.51E-09	1.50E-10	0.00E+00	5.17E-10	5.18E-09
67.67	714.5	727.5	2.83E+02	2.66E+03	2.01E-03	4.50E-09	1.60E-10	0.00E+00	5.17E-10	5.17E-09
68.28	720.2	733.1	2.85E+02	2.64E+03	2.01E-03	4.48E-09	1.72E-10	0.00E+00	5.17E-10	5.17E-09
68.88	726.2	738.8	2.87E+02	2.62E+03	2.01E-03	4.46E-09	1.85E-10	0.00E+00	5.17E-10	5.16E-09
69.49	732.4	744.8	2.90E+02	2.60E+03	2.01E-03	4.43E-09	1.99E-10	0.00E+00	5.17E-10	5.15E-09
70.10	739.0	751.1	2.93E+02	2.57E+03	2.01E-03	4.41E-09	2.14E-10	0.00E+00	5.17E-10	5.14E-09
70.71	745.8	757.6	2.95E+02	2.55E+03	2.02E-03	4.38E-09	2.30E-10	0.00E+00	5.17E-10	5.13E-09
71.32	753.0	764.5	2.98E+02	2.52E+03	2.02E-03	4.35E-09	2.48E-10	0.00E+00	5.17E-10	5.12E-09
71.93	760.6	771.7	3.01E+02	2.50E+03	2.02E-03	4.32E-09	2.67E-10	0.00E+00	5.17E-10	5.11E-09
72.54	768.6	779.3	3.05E+02	2.47E+03	2.02E-03	4.29E-09	2.89E-10	0.00E+00	5.17E-10	5.09E-09
73.15	777.1	787.4	3.08E+02	2.44E+03	2.02E-03	4.25E-09	3.12E-10	0.00E+00	5.17E-10	5.08E-09
73.76	786.1	796.0	3.12E+02	2.42E+03	2.02E-03	4.21E-09	3.38E-10	0.00E+00	5.17E-10	5.06E-09
74.37	794.9	804.3	3.15E+02	2.39E+03	2.03E-03	4.16E-09	3.65E-10	0.00E+00	5.17E-10	5.04E-09
74.98	805.1	814.0	3.20E+02	2.36E+03	2.03E-03	4.11E-09	3.96E-10	0.00E+00	5.17E-10	5.02E-09
75.59	816.0	824.3	3.24E+02	2.32E+03	2.03E-03	4.05E-09	4.31E-10	0.00E+00	5.17E-10	5.00E-09
76.20	827.8	835.5	3.29E+02	2.29E+03	2.03E-03	3.99E-09	4.71E-10	0.00E+00	5.17E-10	4.98E-09
76.81	840.5	847.4	3.34E+02	2.25E+03	2.04E-03	3.92E-09	5.15E-10	0.00E+00	5.17E-10	4.95E-09
77.42	854.3	860.4	3.40E+02	2.22E+03	2.04E-03	3.84E-09	5.64E-10	0.00E+00	5.17E-10	4.92E-09
78.03	869.4	874.6	3.46E+02	2.18E+03	2.04E-03	3.74E-09	6.20E-10	0.00E+00	5.17E-10	4.88E-09
78.64	885.9	890.0	3.53E+02	2.13E+03	2.05E-03	3.64E-09	6.83E-10	0.00E+00	5.17E-10	4.84E-09
79.25	904.0	907.0	3.61E+02	2.09E+03	2.05E-03	3.52E-09	7.56E-10	0.00E+00	5.17E-10	4.79E-09
79.86	924.0	925.7	3.69E+02	2.04E+03	2.06E-03	3.39E-09	8.38E-10	0.00E+00	5.17E-10	4.74E-09
80.47	946.3	946.5	3.78E+02	1.99E+03	2.06E-03	3.23E-09	9.33E-10	0.00E+00	5.17E-10	4.68E-09
81.08	971.1	969.6	3.89E+02	1.94E+03	2.07E-03	3.05E-09	1.04E-09	0.00E+00	5.17E-10	4.61E-09
81.69	999.0	995.6	4.01E+02	1.88E+03	2.08E-03	2.84E-09	1.17E-09	0.00E+00	5.17E-10	4.53E-09
82.30	1030.6	1024.9	4.14E+02	1.82E+03	2.09E-03	2.60E-09	1.31E-09	0.00E+00	5.17E-10	4.43E-09
82.91	1066.8	1058.3	4.29E+02	1.75E+03	2.10E-03	2.32E-09	1.48E-09	0.00E+00	5.17E-10	4.31E-09
83.52	1109.2	1097.2	4.47E+02	1.68E+03	2.12E-03	1.99E-09	1.66E-09	0.00E+00	5.17E-10	4.17E-09
84.12	1161.0	1144.1	4.69E+02	1.60E+03	2.13E-03	1.60E-09	1.88E-09	0.00E+00	5.17E-10	3.99E-09
84.73	1229.7	1204.7	4.99E+02	1.51E+03	2.15E-03	1.10E-09	2.11E-09	0.00E+00	5.17E-10	3.73E-09
85.34	1322.3	1291.1	5.41E+02	1.39E+03	2.18E-03	4.56E-10	2.34E-09	0.00E+00	5.17E-10	3.32E-09
85.95	1435.6	1398.5	5.87E+02	1.28E+03	2.20E-03	2.97E-11	2.41E-09	0.00E+00	5.17E-10	2.96E-09
86.56	1523.3	1487.9	6.24E+02	1.21E+03	2.20E-03	0.00E+00	2.31E-09	0.00E+00	5.17E-10	2.83E-09
87.17	1587.8	1556.8	6.52E+02	1.16E+03	2.20E-03	0.00E+00	2.17E-09	0.00E+00	5.17E-10	2.69E-09
87.78	1644.2	1610.6	6.76E+02	1.11E+03	2.20E-03	0.00E+00	2.02E-09	0.00E+00	5.17E-10	2.53E-09
88.39	1703.1	1666.9	7.01E+02	1.07E+03	2.20E-03	0.00E+00	1.85E-09	0.00E+00	5.17E-10	2.37E-09
89.00	1748.7	1714.0	7.20E+02	1.05E+03	2.20E-03	0.00E+00	1.68E-09	0.00E+00	5.17E-10	2.20E-09
89.61	1778.4	1744.7	7.32E+02	1.03E+03	2.20E-03	0.00E+00	1.51E-09	0.00E+00	5.17E-10	2.03E-09
90.22	1804.4	1769.4	7.43E+02	1.01E+03	2.20E-03	0.00E+00	1.35E-09	0.00E+00	5.17E-10	1.86E-09
90.83	1831.1	1794.6	7.54E+02	9.99E+02	2.20E-03	0.00E+00	1.18E-09	0.00E+00	5.17E-10	1.69E-09
91.44	1857.6	1819.6	7.65E+02	9.85E+02	2.20E-03	0.00E+00	1.01E-09	0.00E+00	5.17E-10	1.53E-09
92.05	1883.7	1844.2	7.76E+02	9.71E+02	2.20E-03	0.00E+00	8.41E-10	0.00E+00	5.17E-10	1.36E-09
92.66	1909.2	1868.2	7.86E+02	9.58E+02	2.20E-03	0.00E+00	6.77E-10	0.00E+00	5.17E-10	1.19E-09
93.27	1934.0	1891.4	7.96E+02	9.46E+02	2.20E-03	0.00E+00	5.14E-10	0.00E+00	5.17E-10	1.03E-09
93.88	1958.1	1913.9	8.06E+02	9.34E+02	2.20E-03	0.00E+00	3.55E-10	0.00E+00	5.17E-10	8.72E-10
94.49	1981.3	1935.7	8.16E+02	9.23E+02	2.20E-03	0.00E+00	1.99E-10	0.00E+00	5.17E-10	7.16E-10
95.10	2003.0	1956.3	8.25E+02	9.13E+02	2.20E-03	0.00E+00	4.91E-11	0.00E+00	5.17E-10	5.66E-10
95.71	2010.9	1964.4	8.28E+02	9.09E+02	2.20E-03	0.00E+00	0.00E+00	0.00E+00	5.17E-10	5.17E-10
96.32	2014.0	1967.3	8.30E+02	9.08E+02	2.20E-03	0.00E+00	0.00E+00	0.00E+00	5.17E-10	5.17E-10
96.93	2017.2	1970.2	8.31E+02	9.06E+02	2.20E-03	0.00E+00	0.00E+00	0.00E+00	5.17E-10	5.17E-10
97.54	2020.3	1973.1	8.32E+02	9.05E+02	2.20E-03	0.00E+00	0.00E+00	0.00E+00	5.17E-10	5.17E-10
98.15	2023.5	1975.9	8.33E+02	9.04E+02	2.20E-03	0.00E+00	0.00E+00	0.00E+00	5.17E-10	5.17E-10
98.76	2026.5	1978.7	8.35E+02	9.02E+02	2.20E-03	0.00E+00	0.00E+00	0.00E+00	5.17E-10	5.17E-10
99.36	2029.6	1981.5	8.36E+02	9.01E+02	2.20E-03	0.00E+00	0.00E+00	0.00E+00	5.17E-10	5.17E-10
99.97	2032.5	1984.2	8.37E+02	8.99E+02	2.20E-03	0.00E+00	0.00E+00	0.00E+00	5.17E-10	5.17E-10
100.58	2035.4	1986.8	8.38E+02	8.98E+02	2.20E-03	0.00E+00	0.00E+00	0.00E+00	5.17E-10	5.17E-10
101.19	2038.2	1989.3	8.40E+02	8.97E+02	2.20E-03	0.00E+00	0.00E+00	0.00E+00	5.17E-10	5.17E-10

101.80	2040.9	1991.8	8.41E+02	8.96E+02	2.20E-03	0.00E+00	0.00E+00	0.00E+00	5.17E-10	5.17E-10
102.41	2043.6	1994.2	8.42E+02	8.95E+02	2.20E-03	0.00E+00	0.00E+00	0.00E+00	5.17E-10	5.17E-10
103.02	2046.1	1996.6	8.43E+02	8.93E+02	2.20E-03	0.00E+00	0.00E+00	0.00E+00	5.17E-10	5.17E-10
103.63	2048.7	1999.0	8.44E+02	8.92E+02	2.20E-03	0.00E+00	0.00E+00	0.00E+00	5.17E-10	5.17E-10
104.24	2051.4	2001.3	8.45E+02	8.91E+02	2.20E-03	0.00E+00	0.00E+00	0.00E+00	5.17E-10	5.17E-10
104.85	2053.9	2003.7	8.46E+02	8.90E+02	2.20E-03	0.00E+00	0.00E+00	0.00E+00	5.17E-10	5.17E-10
105.46	2056.4	2005.9	8.47E+02	8.89E+02	2.20E-03	0.00E+00	0.00E+00	0.00E+00	5.17E-10	5.17E-10
106.07	2058.8	2008.1	8.48E+02	8.88E+02	2.20E-03	0.00E+00	0.00E+00	0.00E+00	5.17E-10	5.17E-10
106.68	2061.1	2010.2	8.49E+02	8.87E+02	2.20E-03	0.00E+00	0.00E+00	0.00E+00	5.17E-10	5.17E-10
107.29	2063.3	2012.2	8.50E+02	8.86E+02	2.20E-03	0.00E+00	0.00E+00	0.00E+00	5.17E-10	5.17E-10
107.90	2065.5	2014.2	8.51E+02	8.85E+02	2.20E-03	0.00E+00	0.00E+00	0.00E+00	5.17E-10	5.17E-10
108.51	2067.6	2016.1	8.52E+02	8.84E+02	2.20E-03	0.00E+00	0.00E+00	0.00E+00	5.17E-10	5.17E-10
109.12	2069.6	2017.9	8.53E+02	8.83E+02	2.20E-03	0.00E+00	0.00E+00	0.00E+00	5.17E-10	5.17E-10
109.73	2071.5	2019.7	8.53E+02	8.82E+02	2.20E-03	0.00E+00	0.00E+00	0.00E+00	5.17E-10	5.17E-10
110.34	2073.4	2021.3	8.54E+02	8.82E+02	2.20E-03	0.00E+00	0.00E+00	0.00E+00	5.17E-10	5.17E-10
110.95	2075.2	2023.0	8.55E+02	8.81E+02	2.20E-03	0.00E+00	0.00E+00	0.00E+00	5.17E-10	5.17E-10
111.56	2076.9	2024.5	8.56E+02	8.80E+02	2.20E-03	0.00E+00	0.00E+00	0.00E+00	5.17E-10	5.17E-10
112.17	2078.6	2026.0	8.56E+02	8.79E+02	2.20E-03	0.00E+00	0.00E+00	0.00E+00	5.17E-10	5.17E-10
112.78	2080.1	2027.5	8.57E+02	8.79E+02	2.20E-03	0.00E+00	0.00E+00	0.00E+00	5.17E-10	5.17E-10
113.39	2081.7	2028.9	8.58E+02	8.78E+02	2.20E-03	0.00E+00	0.00E+00	0.00E+00	5.17E-10	5.17E-10
114.00	2083.8	2030.8	8.59E+02	8.77E+02	2.20E-03	0.00E+00	0.00E+00	0.00E+00	5.17E-10	5.17E-10
114.60	2085.2	2032.1	8.59E+02	8.76E+02	2.20E-03	0.00E+00	0.00E+00	0.00E+00	5.17E-10	5.17E-10
115.21	2086.6	2033.3	8.60E+02	8.76E+02	2.20E-03	0.00E+00	0.00E+00	0.00E+00	5.17E-10	5.17E-10
115.82	2087.9	2034.5	8.60E+02	8.75E+02	2.20E-03	0.00E+00	0.00E+00	0.00E+00	5.17E-10	5.17E-10
116.43	2089.1	2035.6	8.61E+02	8.75E+02	2.20E-03	0.00E+00	0.00E+00	0.00E+00	5.17E-10	5.17E-10
117.04	2090.3	2036.6	8.61E+02	8.74E+02	2.20E-03	0.00E+00	0.00E+00	0.00E+00	5.17E-10	5.17E-10
117.65	2091.4	2037.6	8.62E+02	8.74E+02	2.20E-03	0.00E+00	0.00E+00	0.00E+00	5.17E-10	5.17E-10
118.26	2092.5	2038.6	8.62E+02	8.73E+02	2.20E-03	0.00E+00	0.00E+00	0.00E+00	5.17E-10	5.17E-10
118.87	2093.5	2039.5	8.63E+02	8.73E+02	2.20E-03	0.00E+00	0.00E+00	0.00E+00	5.17E-10	5.17E-10
119.48	2094.4	2040.4	8.63E+02	8.72E+02	2.20E-03	0.00E+00	0.00E+00	0.00E+00	5.17E-10	5.17E-10
120.09	2095.3	2041.2	8.64E+02	8.72E+02	2.20E-03	0.00E+00	0.00E+00	0.00E+00	5.17E-10	5.17E-10
120.70	2096.1	2041.9	8.64E+02	8.72E+02	2.20E-03	0.00E+00	0.00E+00	0.00E+00	5.17E-10	5.17E-10
121.31	2096.9	2042.6	8.64E+02	8.71E+02	2.20E-03	0.00E+00	0.00E+00	0.00E+00	5.17E-10	5.17E-10
121.92	2097.6	2043.3	8.65E+02	8.71E+02	2.20E-03	0.00E+00	0.00E+00	0.00E+00	5.17E-10	5.17E-10
122.53	2098.3	2043.9	8.65E+02	8.71E+02	2.20E-03	0.00E+00	0.00E+00	0.00E+00	5.17E-10	5.17E-10
123.14	2098.9	2044.4	8.65E+02	8.71E+02	2.20E-03	0.00E+00	0.00E+00	0.00E+00	5.17E-10	5.17E-10
123.75	2099.5	2044.9	8.65E+02	8.70E+02	2.20E-03	0.00E+00	0.00E+00	0.00E+00	5.17E-10	5.17E-10
124.36	2100.0	2045.4	8.66E+02	8.70E+02	2.20E-03	0.00E+00	0.00E+00	0.00E+00	5.17E-10	5.17E-10
124.97	2100.5	2045.8	8.66E+02	8.70E+02	2.20E-03	0.00E+00	0.00E+00	0.00E+00	5.17E-10	5.17E-10
125.58	2100.9	2046.2	8.66E+02	8.70E+02	2.20E-03	0.00E+00	0.00E+00	0.00E+00	5.17E-10	5.17E-10
126.19	2101.3	2046.6	8.66E+02	8.70E+02	2.20E-03	0.00E+00	0.00E+00	0.00E+00	5.17E-10	5.17E-10
126.80	2101.6	2046.8	8.66E+02	8.69E+02	2.20E-03	0.00E+00	0.00E+00	0.00E+00	5.17E-10	5.17E-10
127.41	2101.9	2047.1	8.66E+02	8.69E+02	2.20E-03	0.00E+00	0.00E+00	0.00E+00	5.17E-10	5.17E-10
128.02	2102.1	2047.3	8.66E+02	8.69E+02	2.20E-03	0.00E+00	0.00E+00	0.00E+00	5.17E-10	5.17E-10
128.63	2102.3	2047.5	8.67E+02	8.69E+02	2.20E-03	0.00E+00	0.00E+00	0.00E+00	5.17E-10	5.17E-10
129.24	2102.5	2047.7	8.67E+02	8.69E+02	2.20E-03	0.00E+00	0.00E+00	0.00E+00	5.17E-10	5.17E-10
129.84	2099.8	2045.3	8.66E+02	8.70E+02	2.20E-03	0.00E+00	0.00E+00	0.00E+00	5.17E-10	5.17E-10
130.45	2097.2	2042.9	8.64E+02	8.71E+02	2.20E-03	0.00E+00	0.00E+00	0.00E+00	5.17E-10	5.17E-10
131.06	2094.5	2040.6	8.63E+02	8.72E+02	2.20E-03	0.00E+00	0.00E+00	0.00E+00	5.17E-10	5.17E-10
131.67	2091.9	2038.1	8.62E+02	8.73E+02	2.20E-03	0.00E+00	0.00E+00	0.00E+00	5.17E-10	5.17E-10
132.28	2089.2	2035.7	8.61E+02	8.75E+02	2.20E-03	0.00E+00	0.00E+00	0.00E+00	5.17E-10	5.17E-10
132.89	2086.6	2033.4	8.60E+02	8.76E+02	2.20E-03	0.00E+00	0.00E+00	0.00E+00	5.17E-10	5.17E-10
133.50	2084.0	2031.1	8.59E+02	8.77E+02	2.20E-03	0.00E+00	0.00E+00	0.00E+00	5.17E-10	5.17E-10
134.11	2081.4	2028.5	8.58E+02	8.78E+02	2.20E-03	0.00E+00	0.00E+00	0.00E+00	5.17E-10	5.17E-10
134.72	2078.8	2026.2	8.57E+02	8.79E+02	2.20E-03	0.00E+00	0.00E+00	0.00E+00	5.17E-10	5.17E-10
135.33	2076.2	2023.9	8.56E+02	8.80E+02	2.20E-03	0.00E+00	0.00E+00	0.00E+00	5.17E-10	5.17E-10
135.94	2073.6	2021.5	8.55E+02	8.81E+02	2.20E-03	0.00E+00	0.00E+00	0.00E+00	5.17E-10	5.17E-10
136.55	2071.0	2019.2	8.53E+02	8.82E+02	2.20E-03	0.00E+00	0.00E+00	0.00E+00	5.17E-10	5.17E-10
137.16	2068.4	2016.7	8.52E+02	8.83E+02	2.20E-03	0.00E+00	0.00E+00	0.00E+00	5.17E-10	5.17E-10
137.77	2065.9	2014.4	8.51E+02	8.85E+02	2.20E-03	0.00E+00	0.00E+00	0.00E+00	5.17E-10	5.17E-10

138.38	2063.3	2012.1	8.50E+02	8.86E+02	2.20E-03	0.00E+00	0.00E+00	0.00E+00	5.17E-10	5.17E-10
138.99	2060.8	2009.8	8.49E+02	8.87E+02	2.20E-03	0.00E+00	0.00E+00	0.00E+00	5.17E-10	5.17E-10
139.60	2058.2	2007.6	8.48E+02	8.88E+02	2.20E-03	0.00E+00	0.00E+00	0.00E+00	5.17E-10	5.17E-10
140.21	2055.7	2005.1	8.47E+02	8.89E+02	2.20E-03	0.00E+00	0.00E+00	0.00E+00	5.17E-10	5.17E-10
140.82	2053.1	2002.8	8.46E+02	8.90E+02	2.20E-03	0.00E+00	0.00E+00	0.00E+00	5.17E-10	5.17E-10
141.43	2050.6	2000.6	8.45E+02	8.91E+02	2.20E-03	0.00E+00	0.00E+00	0.00E+00	5.17E-10	5.17E-10
142.04	2048.1	1998.3	8.44E+02	8.92E+02	2.20E-03	0.00E+00	0.00E+00	0.00E+00	5.17E-10	5.17E-10
142.65	2045.6	1996.1	8.43E+02	8.93E+02	2.20E-03	0.00E+00	0.00E+00	0.00E+00	5.17E-10	5.17E-10
143.26	2043.1	1993.6	8.42E+02	8.95E+02	2.20E-03	0.00E+00	0.00E+00	0.00E+00	5.17E-10	5.17E-10
143.87	2040.6	1991.4	8.41E+02	8.96E+02	2.20E-03	0.00E+00	0.00E+00	0.00E+00	5.17E-10	5.17E-10
144.48	2038.1	1989.2	8.40E+02	8.97E+02	2.20E-03	0.00E+00	0.00E+00	0.00E+00	5.17E-10	5.17E-10
145.08	2035.7	1986.9	8.39E+02	8.98E+02	2.20E-03	0.00E+00	0.00E+00	0.00E+00	5.17E-10	5.17E-10
145.69	2033.2	1984.7	8.38E+02	8.99E+02	2.20E-03	0.00E+00	0.00E+00	0.00E+00	5.17E-10	5.17E-10
146.30	2030.7	1982.3	8.37E+02	9.00E+02	2.20E-03	0.00E+00	0.00E+00	0.00E+00	5.17E-10	5.17E-10
146.91	2028.3	1980.1	8.36E+02	9.01E+02	2.20E-03	0.00E+00	0.00E+00	0.00E+00	5.17E-10	5.17E-10
147.52	2025.8	1977.9	8.35E+02	9.02E+02	2.20E-03	0.00E+00	0.00E+00	0.00E+00	5.17E-10	5.17E-10
148.13	2023.4	1975.7	8.34E+02	9.03E+02	2.20E-03	0.00E+00	0.00E+00	0.00E+00	5.17E-10	5.17E-10
148.74	2021.0	1973.5	8.33E+02	9.04E+02	2.20E-03	0.00E+00	0.00E+00	0.00E+00	5.17E-10	5.17E-10
149.35	2018.6	1971.2	8.32E+02	9.06E+02	2.20E-03	0.00E+00	0.00E+00	0.00E+00	5.17E-10	5.17E-10
149.96	2016.1	1969.0	8.31E+02	9.07E+02	2.20E-03	0.00E+00	0.00E+00	0.00E+00	5.17E-10	5.17E-10
150.57	2013.7	1966.8	8.30E+02	9.08E+02	2.20E-03	0.00E+00	0.00E+00	0.00E+00	5.17E-10	5.17E-10
151.18	2011.3	1964.7	8.29E+02	9.09E+02	2.20E-03	0.00E+00	0.00E+00	0.00E+00	5.17E-10	5.17E-10
151.79	2008.9	1962.5	8.28E+02	9.10E+02	2.20E-03	0.00E+00	0.00E+00	0.00E+00	5.17E-10	5.17E-10
152.40	2006.6	1960.1	8.27E+02	9.11E+02	2.20E-03	0.00E+00	0.00E+00	0.00E+00	5.17E-10	5.17E-10

BYU -- ONE DImensional Combustion Or Gasification model (1-DICOG): particle number 2

23-May-79

DISTANCE (cm)	GAS TEMP (kelvin)	PARTICLE TEMP (kelvin)	VELOCITY (cm/sec)	PARTICLE NO. DENS (#/cc)	PARTICLE DIA. (cm)	COAL MASS (gr)	CHAR MASS (gr)	H2O MASS (gr)	ASH MASS (gr)	PART MASS (gr)
0.00	356.6	355.6	2.86E+03	3.03E+03	4.80E-03	6.58E-08	0.00E+00	2.33E-09	7.15E-09	7.53E-08
0.61	366.7	356.2	2.70E+03	2.22E+03	4.80E-03	6.58E-08	3.09E-17	1.62E-09	7.15E-09	7.46E-08
1.22	361.3	357.3	2.49E+03	1.75E+03	4.80E-03	6.58E-08	8.26E-17	4.28E-10	7.15E-09	7.34E-08
1.83	357.3	358.4	2.27E+03	1.46E+03	4.80E-03	6.58E-08	1.44E-16	0.00E+00	7.15E-09	7.29E-08
2.44	355.9	359.6	2.08E+03	1.25E+03	4.80E-03	6.58E-08	2.19E-16	0.00E+00	7.15E-09	7.29E-08
3.05	356.8	360.9	1.92E+03	1.09E+03	4.80E-03	6.58E-08	3.07E-16	0.00E+00	7.15E-09	7.29E-08
3.66	359.7	362.4	1.79E+03	9.68E+02	4.80E-03	6.58E-08	4.13E-16	0.00E+00	7.15E-09	7.29E-08
4.27	363.3	364.1	1.68E+03	8.68E+02	4.80E-03	6.58E-08	5.39E-16	0.00E+00	7.15E-09	7.29E-08
4.88	367.1	366.0	1.57E+03	7.87E+02	4.80E-03	6.58E-08	6.92E-16	0.00E+00	7.15E-09	7.29E-08
5.49	370.8	368.0	1.48E+03	7.20E+02	4.80E-03	6.58E-08	8.79E-16	0.00E+00	7.15E-09	7.29E-08
6.10	374.6	370.3	1.39E+03	6.64E+02	4.80E-03	6.58E-08	1.11E-15	0.00E+00	7.15E-09	7.29E-08
6.71	378.1	372.9	1.32E+03	6.17E+02	4.80E-03	6.58E-08	1.39E-15	0.00E+00	7.15E-09	7.29E-08
7.32	381.6	375.6	1.25E+03	5.77E+02	4.80E-03	6.58E-08	1.75E-15	0.00E+00	7.15E-09	7.29E-08
7.92	384.9	378.5	1.18E+03	5.42E+02	4.80E-03	6.58E-08	2.20E-15	0.00E+00	7.15E-09	7.29E-08
8.53	388.1	381.6	1.12E+03	5.12E+02	4.80E-03	6.58E-08	2.77E-15	0.00E+00	7.15E-09	7.29E-08
9.14	391.2	384.9	1.07E+03	4.85E+02	4.80E-03	6.58E-08	3.51E-15	0.00E+00	7.15E-09	7.29E-08
9.75	394.1	388.4	1.02E+03	4.62E+02	4.80E-03	6.58E-08	4.46E-15	0.00E+00	7.15E-09	7.29E-08
10.36	397.0	392.0	9.70E+02	4.41E+02	4.80E-03	6.58E-08	5.69E-15	0.00E+00	7.15E-09	7.29E-08
10.97	399.8	395.8	9.26E+02	4.23E+02	4.80E-03	6.58E-08	7.28E-15	0.00E+00	7.15E-09	7.29E-08
11.58	402.5	399.6	8.84E+02	4.06E+02	4.80E-03	6.58E-08	9.36E-15	0.00E+00	7.15E-09	7.29E-08
12.19	405.2	403.6	8.46E+02	3.91E+02	4.80E-03	6.58E-08	1.21E-14	0.00E+00	7.15E-09	7.29E-08
12.80	407.7	407.7	8.09E+02	3.78E+02	4.80E-03	6.58E-08	1.56E-14	0.00E+00	7.15E-09	7.29E-08
13.41	410.3	411.9	7.75E+02	3.66E+02	4.80E-03	6.58E-08	2.02E-14	0.00E+00	7.15E-09	7.29E-08
14.02	412.8	416.1	7.43E+02	3.55E+02	4.80E-03	6.58E-08	2.61E-14	0.00E+00	7.15E-09	7.29E-08
14.63	415.2	420.4	7.13E+02	3.44E+02	4.80E-03	6.58E-08	3.39E-14	0.00E+00	7.15E-09	7.29E-08
15.24	417.7	424.7	6.84E+02	3.35E+02	4.80E-03	6.58E-08	4.39E-14	0.00E+00	7.15E-09	7.29E-08
15.85	420.1	429.0	6.57E+02	3.27E+02	4.80E-03	6.58E-08	5.68E-14	0.00E+00	7.15E-09	7.29E-08
16.46	422.5	433.3	6.31E+02	3.19E+02	4.80E-03	6.58E-08	7.33E-14	0.00E+00	7.15E-09	7.29E-08
17.07	424.9	437.6	6.07E+02	3.12E+02	4.80E-03	6.58E-08	9.43E-14	0.00E+00	7.15E-09	7.29E-08
17.68	427.3	441.8	5.84E+02	3.06E+02	4.80E-03	6.58E-08	1.21E-13	0.00E+00	7.15E-09	7.29E-08
18.29	429.8	446.1	5.62E+02	3.00E+02	4.80E-03	6.58E-08	1.55E-13	0.00E+00	7.15E-09	7.29E-08
18.90	432.2	450.3	5.41E+02	2.94E+02	4.80E-03	6.58E-08	1.97E-13	0.00E+00	7.15E-09	7.29E-08
19.51	434.7	454.4	5.21E+02	2.89E+02	4.80E-03	6.58E-08	2.50E-13	0.00E+00	7.15E-09	7.29E-08
20.12	437.1	458.5	5.01E+02	2.84E+02	4.80E-03	6.58E-08	3.15E-13	0.00E+00	7.15E-09	7.29E-08
20.73	439.7	462.6	4.83E+02	2.80E+02	4.80E-03	6.58E-08	3.95E-13	0.00E+00	7.15E-09	7.29E-08
21.34	442.2	466.6	4.66E+02	2.76E+02	4.80E-03	6.58E-08	4.94E-13	0.00E+00	7.15E-09	7.29E-08
21.95	444.9	470.5	4.49E+02	2.73E+02	4.80E-03	6.58E-08	6.14E-13	0.00E+00	7.15E-09	7.29E-08
22.56	447.5	474.4	4.33E+02	2.69E+02	4.80E-03	6.58E-08	7.60E-13	0.00E+00	7.15E-09	7.29E-08
23.16	450.3	478.2	4.18E+02	2.66E+02	4.80E-03	6.58E-08	9.37E-13	0.00E+00	7.15E-09	7.29E-08
23.77	453.1	482.0	4.03E+02	2.64E+02	4.80E-03	6.58E-08	1.15E-12	0.00E+00	7.15E-09	7.29E-08
24.38	456.0	485.8	3.89E+02	2.61E+02	4.80E-03	6.58E-08	1.40E-12	0.00E+00	7.15E-09	7.29E-08
24.99	459.0	489.5	3.75E+02	2.59E+02	4.80E-03	6.58E-08	1.70E-12	0.00E+00	7.15E-09	7.29E-08
25.60	462.0	493.3	3.62E+02	2.57E+02	4.80E-03	6.58E-08	2.07E-12	0.00E+00	7.15E-09	7.29E-08
26.21	465.2	497.0	3.50E+02	2.55E+02	4.80E-03	6.58E-08	2.49E-12	0.00E+00	7.15E-09	7.29E-08
26.82	468.5	500.8	3.37E+02	2.54E+02	4.80E-03	6.58E-08	3.00E-12	0.00E+00	7.15E-09	7.29E-08
27.43	471.9	504.5	3.26E+02	2.52E+02	4.80E-03	6.58E-08	3.60E-12	0.00E+00	7.15E-09	7.29E-08
28.04	475.5	508.3	3.15E+02	2.51E+02	4.80E-03	6.58E-08	4.31E-12	0.00E+00	7.15E-09	7.29E-08

28.65	479.2	512.2	3.04E+02	2.50E+02	4.80E-03	6.58E-08	5.15E-12	0.00E+00	7.15E-09	7.29E-08
29.26	483.1	516.2	2.93E+02	2.50E+02	4.80E-03	6.58E-08	6.14E-12	0.00E+00	7.15E-09	7.29E-08
29.87	487.2	520.2	2.83E+02	2.49E+02	4.80E-03	6.58E-08	7.31E-12	0.00E+00	7.15E-09	7.29E-08
30.48	491.5	524.4	2.73E+02	2.49E+02	4.80E-03	6.58E-08	8.70E-12	0.00E+00	7.15E-09	7.29E-08
31.09	496.0	528.7	2.64E+02	2.48E+02	4.80E-03	6.58E-08	1.03E-11	0.00E+00	7.15E-09	7.29E-08
31.70	500.7	533.2	2.55E+02	2.48E+02	4.80E-03	6.58E-08	1.23E-11	0.00E+00	7.15E-09	7.29E-08
32.31	505.7	537.9	2.46E+02	2.48E+02	4.80E-03	6.58E-08	1.47E-11	0.00E+00	7.15E-09	7.29E-08
32.92	511.0	542.8	2.37E+02	2.49E+02	4.80E-03	6.58E-08	1.75E-11	0.00E+00	7.15E-09	7.29E-08
33.53	516.7	547.9	2.29E+02	2.49E+02	4.80E-03	6.58E-08	2.09E-11	0.00E+00	7.15E-09	7.29E-08
34.14	522.7	553.3	2.21E+02	2.50E+02	4.80E-03	6.57E-08	2.50E-11	0.00E+00	7.15E-09	7.29E-08
34.75	529.1	559.1	2.13E+02	2.50E+02	4.80E-03	6.57E-08	3.00E-11	0.00E+00	7.15E-09	7.29E-08
35.36	534.4	565.0	2.11E+02	2.51E+02	4.80E-03	6.57E-08	3.61E-11	0.00E+00	7.15E-09	7.29E-08
35.97	537.0	570.2	2.12E+02	2.50E+02	4.80E-03	6.57E-08	4.33E-11	0.00E+00	7.15E-09	7.29E-08
36.58	539.6	574.5	2.13E+02	2.48E+02	4.80E-03	6.57E-08	5.14E-11	0.00E+00	7.15E-09	7.29E-08
37.19	542.1	578.2	2.14E+02	2.47E+02	4.80E-03	6.57E-08	6.04E-11	0.00E+00	7.15E-09	7.29E-08
37.80	544.7	581.6	2.15E+02	2.46E+02	4.80E-03	6.57E-08	7.02E-11	0.00E+00	7.15E-09	7.29E-08
38.40	547.4	584.6	2.16E+02	2.45E+02	4.80E-03	6.57E-08	8.08E-11	0.00E+00	7.15E-09	7.29E-08
39.01	550.0	587.5	2.17E+02	2.44E+02	4.80E-03	6.56E-08	9.23E-11	0.00E+00	7.15E-09	7.29E-08
39.62	552.7	590.3	2.18E+02	2.42E+02	4.80E-03	6.56E-08	1.04E-10	0.00E+00	7.15E-09	7.29E-08
40.23	555.4	593.1	2.19E+02	2.41E+02	4.80E-03	6.56E-08	1.18E-10	0.00E+00	7.15E-09	7.29E-08
40.84	558.1	595.7	2.20E+02	2.40E+02	4.80E-03	6.56E-08	1.31E-10	0.00E+00	7.15E-09	7.29E-08
41.45	560.9	598.4	2.21E+02	2.39E+02	4.80E-03	6.56E-08	1.46E-10	0.00E+00	7.15E-09	7.28E-08
42.06	563.6	601.0	2.22E+02	2.38E+02	4.80E-03	6.55E-08	1.62E-10	0.00E+00	7.15E-09	7.28E-08
42.67	566.4	603.7	2.23E+02	2.37E+02	4.80E-03	6.55E-08	1.78E-10	0.00E+00	7.15E-09	7.28E-08
43.28	569.1	606.3	2.24E+02	2.35E+02	4.80E-03	6.55E-08	1.96E-10	0.00E+00	7.15E-09	7.28E-08
43.89	571.9	609.0	2.26E+02	2.34E+02	4.80E-03	6.54E-08	2.15E-10	0.00E+00	7.15E-09	7.28E-08
44.50	574.7	611.6	2.27E+02	2.33E+02	4.80E-03	6.54E-08	2.35E-10	0.00E+00	7.15E-09	7.28E-08
45.11	577.6	614.3	2.28E+02	2.32E+02	4.80E-03	6.54E-08	2.56E-10	0.00E+00	7.15E-09	7.28E-08
45.72	580.4	617.0	2.29E+02	2.31E+02	4.80E-03	6.53E-08	2.78E-10	0.00E+00	7.15E-09	7.28E-08
46.33	583.3	619.7	2.30E+02	2.30E+02	4.80E-03	6.53E-08	3.01E-10	0.00E+00	7.15E-09	7.27E-08
46.94	586.2	622.4	2.31E+02	2.29E+02	4.80E-03	6.53E-08	3.26E-10	0.00E+00	7.15E-09	7.27E-08
47.55	589.1	625.1	2.32E+02	2.27E+02	4.80E-03	6.52E-08	3.53E-10	0.00E+00	7.15E-09	7.27E-08
48.16	592.0	627.9	2.33E+02	2.26E+02	4.80E-03	6.52E-08	3.80E-10	0.00E+00	7.15E-09	7.27E-08
48.77	595.0	630.6	2.35E+02	2.25E+02	4.80E-03	6.51E-08	4.10E-10	0.00E+00	7.15E-09	7.27E-08
49.38	597.9	633.4	2.36E+02	2.24E+02	4.81E-03	6.51E-08	4.41E-10	0.00E+00	7.15E-09	7.27E-08
49.99	601.0	636.2	2.37E+02	2.23E+02	4.81E-03	6.50E-08	4.74E-10	0.00E+00	7.15E-09	7.26E-08
50.60	604.0	639.1	2.38E+02	2.22E+02	4.81E-03	6.50E-08	5.09E-10	0.00E+00	7.15E-09	7.26E-08
51.21	607.1	641.9	2.39E+02	2.21E+02	4.81E-03	6.49E-08	5.46E-10	0.00E+00	7.15E-09	7.26E-08
51.82	610.2	644.8	2.41E+02	2.20E+02	4.81E-03	6.48E-08	5.85E-10	0.00E+00	7.15E-09	7.26E-08
52.43	613.3	647.7	2.42E+02	2.18E+02	4.81E-03	6.48E-08	6.26E-10	0.00E+00	7.15E-09	7.25E-08
53.04	616.5	650.7	2.43E+02	2.17E+02	4.81E-03	6.47E-08	6.70E-10	0.00E+00	7.15E-09	7.25E-08
53.64	619.7	653.7	2.45E+02	2.16E+02	4.81E-03	6.46E-08	7.16E-10	0.00E+00	7.15E-09	7.25E-08
54.25	623.0	656.7	2.46E+02	2.15E+02	4.81E-03	6.45E-08	7.65E-10	0.00E+00	7.15E-09	7.25E-08
54.86	626.3	659.7	2.47E+02	2.14E+02	4.81E-03	6.45E-08	8.16E-10	0.00E+00	7.15E-09	7.24E-08
55.47	629.6	662.8	2.48E+02	2.13E+02	4.81E-03	6.44E-08	8.71E-10	0.00E+00	7.15E-09	7.24E-08
56.08	633.0	666.0	2.50E+02	2.12E+02	4.81E-03	6.43E-08	9.28E-10	0.00E+00	7.15E-09	7.23E-08
56.69	636.5	669.1	2.51E+02	2.10E+02	4.81E-03	6.42E-08	9.89E-10	0.00E+00	7.15E-09	7.23E-08
57.30	640.0	672.4	2.53E+02	2.09E+02	4.81E-03	6.41E-08	1.05E-09	0.00E+00	7.15E-09	7.23E-08
57.91	643.6	675.7	2.54E+02	2.08E+02	4.81E-03	6.40E-08	1.12E-09	0.00E+00	7.15E-09	7.22E-08
58.52	647.3	679.0	2.56E+02	2.07E+02	4.81E-03	6.38E-08	1.19E-09	0.00E+00	7.15E-09	7.22E-08
59.13	651.0	682.4	2.57E+02	2.06E+02	4.82E-03	6.37E-08	1.27E-09	0.00E+00	7.15E-09	7.21E-08
59.74	654.8	685.8	2.59E+02	2.04E+02	4.82E-03	6.36E-08	1.35E-09	0.00E+00	7.15E-09	7.21E-08
60.35	658.7	689.3	2.60E+02	2.03E+02	4.82E-03	6.34E-08	1.44E-09	0.00E+00	7.15E-09	7.20E-08
60.96	662.6	692.9	2.62E+02	2.02E+02	4.82E-03	6.33E-08	1.53E-09	0.00E+00	7.15E-09	7.20E-08
61.57	666.7	696.6	2.63E+02	2.01E+02	4.82E-03	6.31E-08	1.62E-09	0.00E+00	7.15E-09	7.19E-08
62.18	670.9	700.3	2.65E+02	1.99E+02	4.82E-03	6.30E-08	1.73E-09	0.00E+00	7.15E-09	7.18E-08
62.79	675.2	704.2	2.67E+02	1.98E+02	4.82E-03	6.28E-08	1.83E-09	0.00E+00	7.15E-09	7.18E-08
63.40	679.5	708.1	2.68E+02	1.97E+02	4.82E-03	6.26E-08	1.95E-09	0.00E+00	7.15E-09	7.17E-08
64.01	684.1	712.1	2.70E+02	1.96E+02	4.82E-03	6.24E-08	2.07E-09	0.00E+00	7.15E-09	7.16E-08
64.62	688.7	716.2	2.72E+02	1.94E+02	4.83E-03	6.22E-08	2.20E-09	0.00E+00	7.15E-09	7.15E-08

65.23	693.5	720.5	2.74E+02	1.93E+02	4.83E-03	6.20E-08	2.34E-09	0.00E+00	7.15E-09	7.14E-08
65.84	698.5	724.9	2.76E+02	1.91E+02	4.83E-03	6.17E-08	2.49E-09	0.00E+00	7.15E-09	7.14E-08
66.45	703.6	729.4	2.78E+02	1.90E+02	4.83E-03	6.15E-08	2.64E-09	0.00E+00	7.15E-09	7.13E-08
67.06	708.9	734.0	2.80E+02	1.88E+02	4.83E-03	6.12E-08	2.81E-09	0.00E+00	7.15E-09	7.11E-08
67.67	714.5	738.8	2.83E+02	1.87E+02	4.84E-03	6.09E-08	2.99E-09	0.00E+00	7.15E-09	7.10E-08
68.28	720.2	743.8	2.85E+02	1.85E+02	4.84E-03	6.06E-08	3.18E-09	0.00E+00	7.15E-09	7.09E-08
68.88	726.2	748.9	2.87E+02	1.84E+02	4.84E-03	6.02E-08	3.38E-09	0.00E+00	7.15E-09	7.08E-08
69.49	732.4	754.3	2.90E+02	1.82E+02	4.84E-03	5.99E-08	3.60E-09	0.00E+00	7.15E-09	7.06E-08
70.10	739.0	759.9	2.93E+02	1.81E+02	4.85E-03	5.95E-08	3.84E-09	0.00E+00	7.15E-09	7.05E-08
70.71	745.8	765.7	2.95E+02	1.79E+02	4.85E-03	5.91E-08	4.09E-09	0.00E+00	7.15E-09	7.03E-08
71.32	753.0	771.8	2.98E+02	1.77E+02	4.85E-03	5.86E-08	4.36E-09	0.00E+00	7.15E-09	7.02E-08
71.93	760.6	778.1	3.01E+02	1.75E+02	4.86E-03	5.82E-08	4.65E-09	0.00E+00	7.15E-09	7.00E-08
72.54	768.6	784.8	3.05E+02	1.73E+02	4.86E-03	5.77E-08	4.96E-09	0.00E+00	7.15E-09	6.98E-08
73.15	777.1	791.9	3.08E+02	1.72E+02	4.86E-03	5.71E-08	5.30E-09	0.00E+00	7.15E-09	6.96E-08
73.76	786.1	799.3	3.12E+02	1.69E+02	4.87E-03	5.65E-08	5.67E-09	0.00E+00	7.15E-09	6.93E-08
74.37	794.9	806.5	3.15E+02	1.68E+02	4.87E-03	5.59E-08	6.04E-09	0.00E+00	7.15E-09	6.91E-08
74.98	805.1	814.8	3.20E+02	1.65E+02	4.88E-03	5.52E-08	6.47E-09	0.00E+00	7.15E-09	6.88E-08
75.59	816.0	823.6	3.24E+02	1.63E+02	4.88E-03	5.44E-08	6.94E-09	0.00E+00	7.15E-09	6.85E-08
76.20	827.8	833.1	3.29E+02	1.61E+02	4.89E-03	5.36E-08	7.46E-09	0.00E+00	7.15E-09	6.82E-08
76.81	840.5	843.2	3.34E+02	1.58E+02	4.90E-03	5.26E-08	8.02E-09	0.00E+00	7.15E-09	6.78E-08
77.42	854.3	854.1	3.40E+02	1.55E+02	4.90E-03	5.16E-08	8.65E-09	0.00E+00	7.15E-09	6.74E-08
78.03	869.4	865.9	3.46E+02	1.53E+02	4.91E-03	5.05E-08	9.34E-09	0.00E+00	7.15E-09	6.70E-08
78.64	885.9	878.6	3.53E+02	1.50E+02	4.92E-03	4.92E-08	1.01E-08	0.00E+00	7.15E-09	6.65E-08
79.25	904.0	892.6	3.61E+02	1.47E+02	4.93E-03	4.78E-08	1.09E-08	0.00E+00	7.15E-09	6.59E-08
79.86	924.0	907.9	3.69E+02	1.43E+02	4.94E-03	4.63E-08	1.19E-08	0.00E+00	7.15E-09	6.53E-08
80.47	946.3	924.7	3.78E+02	1.40E+02	4.96E-03	4.45E-08	1.30E-08	0.00E+00	7.15E-09	6.46E-08
81.08	971.1	943.3	3.89E+02	1.36E+02	4.97E-03	4.26E-08	1.41E-08	0.00E+00	7.15E-09	6.39E-08
81.69	999.0	964.1	4.01E+02	1.32E+02	4.99E-03	4.04E-08	1.55E-08	0.00E+00	7.15E-09	6.30E-08
82.30	1030.6	987.3	4.14E+02	1.28E+02	5.00E-03	3.79E-08	1.70E-08	0.00E+00	7.15E-09	6.20E-08
82.91	1066.8	1013.6	4.29E+02	1.23E+02	5.02E-03	3.50E-08	1.87E-08	0.00E+00	7.15E-09	6.09E-08
83.52	1109.2	1043.6	4.47E+02	1.18E+02	5.05E-03	3.18E-08	2.06E-08	0.00E+00	7.15E-09	5.96E-08
84.12	1161.0	1078.6	4.69E+02	1.13E+02	5.08E-03	2.80E-08	2.28E-08	0.00E+00	7.15E-09	5.80E-08
84.73	1229.7	1121.1	4.99E+02	1.06E+02	5.11E-03	2.37E-08	2.53E-08	0.00E+00	7.15E-09	5.61E-08
85.34	1328.3	1176.2	5.41E+02	9.78E+01	5.15E-03	1.82E-08	2.80E-08	0.00E+00	7.15E-09	5.34E-08
85.95	1435.6	1247.8	5.87E+02	9.01E+01	5.20E-03	1.09E-08	3.10E-08	0.00E+00	7.15E-09	4.91E-08
86.56	1523.3	1330.2	6.24E+02	8.47E+01	5.26E-03	2.93E-09	3.35E-08	0.00E+00	7.15E-09	4.36E-08
87.17	1587.8	1417.8	6.52E+02	8.11E+01	5.28E-03	8.32E-11	3.40E-08	0.00E+00	7.15E-09	4.13E-08
87.78	1644.2	1492.6	6.76E+02	7.82E+01	5.28E-03	0.00E+00	3.36E-08	0.00E+00	7.15E-09	4.07E-08
88.39	1703.1	1557.1	7.01E+02	7.54E+01	5.28E-03	0.00E+00	3.31E-08	0.00E+00	7.15E-09	4.02E-08
89.00	1748.7	1613.3	7.20E+02	7.34E+01	5.28E-03	0.00E+00	3.25E-08	0.00E+00	7.15E-09	3.96E-08
89.61	1778.4	1658.1	7.32E+02	7.22E+01	5.28E-03	0.00E+00	3.18E-08	0.00E+00	7.15E-09	3.90E-08
90.22	1804.4	1692.0	7.43E+02	7.11E+01	5.28E-03	0.00E+00	3.12E-08	0.00E+00	7.15E-09	3.83E-08
90.83	1831.1	1721.4	7.54E+02	7.01E+01	5.28E-03	0.00E+00	3.05E-08	0.00E+00	7.15E-09	3.77E-08
91.44	1857.6	1747.7	7.65E+02	6.91E+01	5.28E-03	0.00E+00	2.99E-08	0.00E+00	7.15E-09	3.70E-08
92.05	1883.7	1772.2	7.76E+02	6.81E+01	5.28E-03	0.00E+00	2.92E-08	0.00E+00	7.15E-09	3.64E-08
92.66	1909.2	1795.6	7.86E+02	6.72E+01	5.28E-03	0.00E+00	2.86E-08	0.00E+00	7.15E-09	3.58E-08
93.27	1934.0	1818.1	7.96E+02	6.64E+01	5.28E-03	0.00E+00	2.80E-08	0.00E+00	7.15E-09	3.51E-08
93.88	1958.1	1839.7	8.06E+02	6.55E+01	5.28E-03	0.00E+00	2.74E-08	0.00E+00	7.15E-09	3.45E-08
94.49	1981.3	1860.6	8.16E+02	6.48E+01	5.28E-03	0.00E+00	2.68E-08	0.00E+00	7.15E-09	3.39E-08
95.10	2003.0	1880.5	8.25E+02	6.41E+01	5.28E-03	0.00E+00	2.62E-08	0.00E+00	7.15E-09	3.33E-08
95.71	2010.9	1896.4	8.28E+02	6.38E+01	5.28E-03	0.00E+00	2.56E-08	0.00E+00	7.15E-09	3.28E-08
96.32	2014.0	1905.5	8.30E+02	6.37E+01	5.28E-03	0.00E+00	2.50E-08	0.00E+00	7.15E-09	3.22E-08
96.93	2017.2	1911.0	8.31E+02	6.36E+01	5.28E-03	0.00E+00	2.44E-08	0.00E+00	7.15E-09	3.16E-08
97.54	2020.3	1914.9	8.32E+02	6.35E+01	5.28E-03	0.00E+00	2.39E-08	0.00E+00	7.15E-09	3.10E-08
98.15	2023.5	1918.1	8.33E+02	6.34E+01	5.28E-03	0.00E+00	2.33E-08	0.00E+00	7.15E-09	3.05E-08
98.76	2026.5	1921.0	8.35E+02	6.33E+01	5.28E-03	0.00E+00	2.27E-08	0.00E+00	7.15E-09	2.99E-08
99.36	2029.6	1923.7	8.36E+02	6.32E+01	5.28E-03	0.00E+00	2.22E-08	0.00E+00	7.15E-09	2.93E-08
99.97	2032.5	1926.3	8.37E+02	6.31E+01	5.28E-03	0.00E+00	2.16E-08	0.00E+00	7.15E-09	2.88E-08
100.58	2035.4	1928.8	8.38E+02	6.30E+01	5.28E-03	0.00E+00	2.11E-08	0.00E+00	7.15E-09	2.82E-08
101.19	2038.2	1931.2	8.40E+02	6.29E+01	5.28E-03	0.00E+00	2.05E-08	0.00E+00	7.15E-09	2.77E-08

101.80	2040.9	1933.6	8.41E+02	6.29E+01	5.28E-03	0.00E+00	2.00E-08	0.00E+00	7.15E-09	2.71E-08
102.41	2043.6	1935.9	8.42E+02	6.28E+01	5.28E-03	0.00E+00	1.95E-08	0.00E+00	7.15E-09	2.66E-08
103.02	2046.1	1938.1	8.43E+02	6.27E+01	5.28E-03	0.00E+00	1.89E-08	0.00E+00	7.15E-09	2.61E-08
103.63	2048.7	1957.7	8.44E+02	6.26E+01	5.28E-03	0.00E+00	1.84E-08	0.00E+00	7.15E-09	2.56E-08
104.24	2051.4	1959.6	8.45E+02	6.25E+01	5.28E-03	0.00E+00	1.79E-08	0.00E+00	7.15E-09	2.50E-08
104.85	2053.9	1961.6	8.46E+02	6.25E+01	5.28E-03	0.00E+00	1.74E-08	0.00E+00	7.15E-09	2.45E-08
105.46	2056.4	1963.4	8.47E+02	6.24E+01	5.28E-03	0.00E+00	1.68E-08	0.00E+00	7.15E-09	2.40E-08
106.07	2058.8	1965.2	8.48E+02	6.23E+01	5.28E-03	0.00E+00	1.63E-08	0.00E+00	7.15E-09	2.35E-08
106.68	2061.1	1966.9	8.49E+02	6.22E+01	5.28E-03	0.00E+00	1.58E-08	0.00E+00	7.15E-09	2.30E-08
107.29	2063.3	1968.6	8.50E+02	6.22E+01	5.28E-03	0.00E+00	1.53E-08	0.00E+00	7.15E-09	2.25E-08
107.90	2065.5	1970.2	8.51E+02	6.21E+01	5.28E-03	0.00E+00	1.48E-08	0.00E+00	7.15E-09	2.20E-08
108.51	2067.6	1971.7	8.52E+02	6.20E+01	5.28E-03	0.00E+00	1.43E-08	0.00E+00	7.15E-09	2.15E-08
109.12	2069.6	1973.2	8.53E+02	6.20E+01	5.28E-03	0.00E+00	1.38E-08	0.00E+00	7.15E-09	2.10E-08
109.73	2071.5	1974.7	8.53E+02	6.19E+01	5.28E-03	0.00E+00	1.33E-08	0.00E+00	7.15E-09	2.05E-08
110.34	2073.4	1976.0	8.54E+02	6.19E+01	5.28E-03	0.00E+00	1.29E-08	0.00E+00	7.15E-09	2.00E-08
110.95	2075.2	1977.4	8.55E+02	6.18E+01	5.28E-03	0.00E+00	1.24E-08	0.00E+00	7.15E-09	1.95E-08
111.56	2076.9	1978.6	8.56E+02	6.18E+01	5.28E-03	0.00E+00	1.19E-08	0.00E+00	7.15E-09	1.91E-08
112.17	2078.6	1979.8	8.56E+02	6.17E+01	5.28E-03	0.00E+00	1.15E-08	0.00E+00	7.15E-09	1.86E-08
112.78	2080.1	1981.0	8.57E+02	6.17E+01	5.28E-03	0.00E+00	1.10E-08	0.00E+00	7.15E-09	1.81E-08
113.39	2081.7	1982.1	8.58E+02	6.16E+01	5.28E-03	0.00E+00	1.05E-08	0.00E+00	7.15E-09	1.77E-08
114.00	2083.8	1983.7	8.59E+02	6.15E+01	5.28E-03	0.00E+00	9.89E-09	0.00E+00	7.15E-09	1.70E-08
114.60	2085.2	1984.6	8.59E+02	6.15E+01	5.28E-03	0.00E+00	9.44E-09	0.00E+00	7.15E-09	1.66E-08
115.21	2086.6	1985.6	8.60E+02	6.15E+01	5.28E-03	0.00E+00	9.00E-09	0.00E+00	7.15E-09	1.62E-08
115.82	2087.9	1986.5	8.60E+02	6.14E+01	5.28E-03	0.00E+00	8.57E-09	0.00E+00	7.15E-09	1.57E-08
116.43	2089.1	1987.4	8.61E+02	6.14E+01	5.28E-03	0.00E+00	8.14E-09	0.00E+00	7.15E-09	1.53E-08
117.04	2090.3	1988.2	8.61E+02	6.13E+01	5.28E-03	0.00E+00	7.71E-09	0.00E+00	7.15E-09	1.49E-08
117.65	2091.4	1988.9	8.62E+02	6.13E+01	5.28E-03	0.00E+00	7.29E-09	0.00E+00	7.15E-09	1.44E-08
118.26	2092.5	1989.6	8.62E+02	6.13E+01	5.28E-03	0.00E+00	6.87E-09	0.00E+00	7.15E-09	1.40E-08
118.87	2093.5	1990.5	8.63E+02	6.13E+01	5.28E-03	0.00E+00	6.45E-09	0.00E+00	7.15E-09	1.36E-08
119.48	2094.4	1991.1	8.63E+02	6.12E+01	5.28E-03	0.00E+00	6.04E-09	0.00E+00	7.15E-09	1.32E-08
120.09	2095.3	1991.7	8.64E+02	6.12E+01	5.28E-03	0.00E+00	5.64E-09	0.00E+00	7.15E-09	1.28E-08
120.70	2096.1	1992.2	8.64E+02	6.12E+01	5.28E-03	0.00E+00	5.23E-09	0.00E+00	7.15E-09	1.24E-08
121.31	2096.9	1992.7	8.64E+02	6.11E+01	5.28E-03	0.00E+00	4.84E-09	0.00E+00	7.15E-09	1.20E-08
121.92	2097.6	1993.3	8.65E+02	6.11E+01	5.28E-03	0.00E+00	4.44E-09	0.00E+00	7.15E-09	1.16E-08
122.53	2098.3	1993.7	8.65E+02	6.11E+01	5.28E-03	0.00E+00	4.05E-09	0.00E+00	7.15E-09	1.12E-08
123.14	2098.9	1994.1	8.65E+02	6.11E+01	5.28E-03	0.00E+00	3.66E-09	0.00E+00	7.15E-09	1.08E-08
123.75	2099.5	1994.4	8.65E+02	6.11E+01	5.28E-03	0.00E+00	3.28E-09	0.00E+00	7.15E-09	1.04E-08
124.36	2100.0	1994.7	8.66E+02	6.11E+01	5.28E-03	0.00E+00	2.90E-09	0.00E+00	7.15E-09	1.01E-08
124.97	2100.5	1995.0	8.66E+02	6.10E+01	5.28E-03	0.00E+00	2.53E-09	0.00E+00	7.15E-09	9.68E-09
125.58	2100.9	1995.3	8.66E+02	6.10E+01	5.28E-03	0.00E+00	2.16E-09	0.00E+00	7.15E-09	9.31E-09
126.19	2101.3	1995.5	8.66E+02	6.10E+01	5.28E-03	0.00E+00	1.79E-09	0.00E+00	7.15E-09	8.94E-09
126.80	2101.6	1995.6	8.66E+02	6.10E+01	5.28E-03	0.00E+00	1.43E-09	0.00E+00	7.15E-09	8.58E-09
127.41	2101.9	1995.7	8.66E+02	6.10E+01	5.28E-03	0.00E+00	1.07E-09	0.00E+00	7.15E-09	8.22E-09
128.02	2102.1	1995.8	8.66E+02	6.10E+01	5.28E-03	0.00E+00	7.11E-10	0.00E+00	7.15E-09	7.86E-09
128.63	2102.3	1995.9	8.67E+02	6.10E+01	5.28E-03	0.00E+00	3.58E-10	0.00E+00	7.15E-09	7.51E-09
129.24	2102.5	1996.5	8.67E+02	6.10E+01	5.28E-03	0.00E+00	8.85E-12	0.00E+00	7.15E-09	7.16E-09
129.84	2099.8	1985.2	8.66E+02	6.11E+01	5.28E-03	0.00E+00	0.00E+00	0.00E+00	7.15E-09	7.15E-09
130.45	2097.2	1983.1	8.64E+02	6.11E+01	5.28E-03	0.00E+00	0.00E+00	0.00E+00	7.15E-09	7.15E-09
131.06	2094.5	1981.0	8.63E+02	6.12E+01	5.28E-03	0.00E+00	0.00E+00	0.00E+00	7.15E-09	7.15E-09
131.67	2091.9	1978.7	8.62E+02	6.13E+01	5.28E-03	0.00E+00	0.00E+00	0.00E+00	7.15E-09	7.15E-09
132.28	2089.2	1976.7	8.61E+02	6.14E+01	5.28E-03	0.00E+00	0.00E+00	0.00E+00	7.15E-09	7.15E-09
132.89	2086.6	1974.6	8.60E+02	6.14E+01	5.28E-03	0.00E+00	0.00E+00	0.00E+00	7.15E-09	7.15E-09
133.50	2084.0	1972.5	8.59E+02	6.15E+01	5.28E-03	0.00E+00	0.00E+00	0.00E+00	7.15E-09	7.15E-09
134.11	2081.4	1970.0	8.58E+02	6.16E+01	5.28E-03	0.00E+00	0.00E+00	0.00E+00	7.15E-09	7.15E-09
134.72	2078.8	1968.0	8.57E+02	6.17E+01	5.28E-03	0.00E+00	0.00E+00	0.00E+00	7.15E-09	7.15E-09
135.33	2076.2	1965.9	8.56E+02	6.18E+01	5.28E-03	0.00E+00	0.00E+00	0.00E+00	7.15E-09	7.15E-09
135.94	2073.6	1963.9	8.55E+02	6.18E+01	5.28E-03	0.00E+00	0.00E+00	0.00E+00	7.15E-09	7.15E-09
136.55	2071.0	1961.8	8.53E+02	6.19E+01	5.28E-03	0.00E+00	0.00E+00	0.00E+00	7.15E-09	7.15E-09
137.16	2068.4	1959.4	8.52E+02	6.20E+01	5.28E-03	0.00E+00	0.00E+00	0.00E+00	7.15E-09	7.15E-09
137.77	2065.9	1957.3	8.51E+02	6.21E+01	5.28E-03	0.00E+00	0.00E+00	0.00E+00	7.15E-09	7.15E-09

138.38	2063.3	1955.3	8.50E+02	6.22E+01	5.28E-03	0.00E+00	0.00E+00	0.00E+00	7.15E-09	7.15E-09
138.99	2060.8	1953.3	8.49E+02	6.22E+01	5.28E-03	0.00E+00	0.00E+00	0.00E+00	7.15E-09	7.15E-09
139.60	2058.2	1951.3	8.48E+02	6.23E+01	5.28E-03	0.00E+00	0.00E+00	0.00E+00	7.15E-09	7.15E-09
140.21	2055.7	1948.8	8.47E+02	6.24E+01	5.28E-03	0.00E+00	0.00E+00	0.00E+00	7.15E-09	7.15E-09
140.82	2053.1	1946.8	8.46E+02	6.25E+01	5.28E-03	0.00E+00	0.00E+00	0.00E+00	7.15E-09	7.15E-09
141.43	2050.6	1944.8	8.45E+02	6.25E+01	5.28E-03	0.00E+00	0.00E+00	0.00E+00	7.15E-09	7.15E-09
142.04	2048.1	1942.8	8.44E+02	6.26E+01	5.28E-03	0.00E+00	0.00E+00	0.00E+00	7.15E-09	7.15E-09
142.65	2045.6	1940.9	8.43E+02	6.27E+01	5.28E-03	0.00E+00	0.00E+00	0.00E+00	7.15E-09	7.15E-09
143.26	2043.1	1938.5	8.42E+02	6.28E+01	5.28E-03	0.00E+00	0.00E+00	0.00E+00	7.15E-09	7.15E-09
143.87	2040.6	1936.5	8.41E+02	6.28E+01	5.28E-03	0.00E+00	0.00E+00	0.00E+00	7.15E-09	7.15E-09
144.48	2038.1	1934.5	8.40E+02	6.29E+01	5.28E-03	0.00E+00	0.00E+00	0.00E+00	7.15E-09	7.15E-09
145.08	2035.7	1932.5	8.39E+02	6.30E+01	5.28E-03	0.00E+00	0.00E+00	0.00E+00	7.15E-09	7.15E-09
145.69	2033.2	1930.6	8.38E+02	6.31E+01	5.28E-03	0.00E+00	0.00E+00	0.00E+00	7.15E-09	7.15E-09
146.30	2030.7	1928.2	8.37E+02	6.32E+01	5.28E-03	0.00E+00	0.00E+00	0.00E+00	7.15E-09	7.15E-09
146.91	2028.3	1926.2	8.36E+02	6.32E+01	5.28E-03	0.00E+00	0.00E+00	0.00E+00	7.15E-09	7.15E-09
147.52	2025.8	1924.3	8.35E+02	6.33E+01	5.28E-03	0.00E+00	0.00E+00	0.00E+00	7.15E-09	7.15E-09
148.13	2023.4	1922.3	8.34E+02	6.34E+01	5.28E-03	0.00E+00	0.00E+00	0.00E+00	7.15E-09	7.15E-09
148.74	2021.0	1920.4	8.33E+02	6.35E+01	5.28E-03	0.00E+00	0.00E+00	0.00E+00	7.15E-09	7.15E-09
149.35	2018.6	1918.1	8.32E+02	6.35E+01	5.28E-03	0.00E+00	0.00E+00	0.00E+00	7.15E-09	7.15E-09
149.96	2016.1	1916.1	8.31E+02	6.36E+01	5.28E-03	0.00E+00	0.00E+00	0.00E+00	7.15E-09	7.15E-09
150.57	2013.7	1914.2	8.30E+02	6.37E+01	5.28E-03	0.00E+00	0.00E+00	0.00E+00	7.15E-09	7.15E-09
151.18	2011.3	1912.3	8.29E+02	6.38E+01	5.28E-03	0.00E+00	0.00E+00	0.00E+00	7.15E-09	7.15E-09
151.79	2008.9	1910.4	8.28E+02	6.38E+01	5.28E-03	0.00E+00	0.00E+00	0.00E+00	7.15E-09	7.15E-09
152.40	2006.6	1908.0	8.27E+02	6.39E+01	5.28E-03	0.00E+00	0.00E+00	0.00E+00	7.15E-09	7.15E-09

BYU -- ONE DImensional Combustion Or Gasification model (1-DICOG): particle number 3

23-May-79

DISTANCE (cm)	GAS TEMP (kelvin)	PARTICLE TEMP (kelvin)	VELOCITY (cm/sec)	PARTICLE NO. DENS (#/cc)	PARTICLE DIA. (cm)	COAL MASS (gr)	CHAR MASS (gr)	H2O MASS (gr)	ASH MASS (gr)	PART MASS (gr)
0.00	356.6	355.6	2.86E+03	5.97E+02	8.00E-03	3.05E-07	0.00E+00	1.08E-08	3.31E-08	3.49E-07
0.61	366.7	356.0	2.70E+03	4.39E+02	8.00E-03	3.05E-07	1.42E-16	9.62E-09	3.31E-08	3.48E-07
1.22	361.3	356.6	2.49E+03	3.46E+02	8.00E-03	3.05E-07	3.74E-16	7.69E-09	3.31E-08	3.46E-07
1.83	357.3	357.3	2.27E+03	2.88E+02	8.00E-03	3.05E-07	6.43E-16	5.47E-09	3.31E-08	3.44E-07
2.44	355.9	358.0	2.08E+03	2.47E+02	8.00E-03	3.05E-07	9.56E-16	2.90E-09	3.31E-08	3.41E-07
3.05	356.8	358.9	1.92E+03	2.16E+02	8.00E-03	3.05E-07	1.32E-15	3.32E-10	3.31E-08	3.38E-07
3.66	359.7	359.9	1.79E+03	1.91E+02	8.00E-03	3.05E-07	1.74E-15	0.00E+00	3.31E-08	3.38E-07
4.27	363.3	360.9	1.68E+03	1.71E+02	8.00E-03	3.05E-07	2.22E-15	0.00E+00	3.31E-08	3.38E-07
4.88	367.1	362.1	1.57E+03	1.55E+02	8.00E-03	3.05E-07	2.78E-15	0.00E+00	3.31E-08	3.38E-07
5.49	370.8	363.4	1.48E+03	1.42E+02	8.00E-03	3.05E-07	3.44E-15	0.00E+00	3.31E-08	3.38E-07
6.10	374.6	364.9	1.39E+03	1.31E+02	8.00E-03	3.05E-07	4.20E-15	0.00E+00	3.31E-08	3.38E-07
6.71	378.1	366.5	1.32E+03	1.22E+02	8.00E-03	3.05E-07	5.09E-15	0.00E+00	3.31E-08	3.38E-07
7.32	381.6	368.2	1.25E+03	1.14E+02	8.00E-03	3.05E-07	6.15E-15	0.00E+00	3.31E-08	3.38E-07
7.92	384.9	370.0	1.18E+03	1.07E+02	8.00E-03	3.05E-07	7.41E-15	0.00E+00	3.31E-08	3.38E-07
8.53	388.1	372.0	1.12E+03	1.01E+02	8.00E-03	3.05E-07	8.92E-15	0.00E+00	3.31E-08	3.38E-07
9.14	391.2	374.1	1.07E+03	9.58E+01	8.00E-03	3.05E-07	1.07E-14	0.00E+00	3.31E-08	3.38E-07
9.75	394.1	376.4	1.02E+03	9.12E+01	8.00E-03	3.05E-07	1.29E-14	0.00E+00	3.31E-08	3.38E-07
10.36	397.0	378.7	9.70E+02	8.71E+01	8.00E-03	3.05E-07	1.56E-14	0.00E+00	3.31E-08	3.38E-07
10.97	399.8	381.3	9.26E+02	8.34E+01	8.00E-03	3.05E-07	1.88E-14	0.00E+00	3.31E-08	3.38E-07
11.58	402.5	383.9	8.84E+02	8.01E+01	8.00E-03	3.05E-07	2.28E-14	0.00E+00	3.31E-08	3.38E-07
12.19	405.2	386.7	8.46E+02	7.72E+01	8.00E-03	3.05E-07	2.77E-14	0.00E+00	3.31E-08	3.38E-07
12.80	407.7	389.7	8.09E+02	7.46E+01	8.00E-03	3.05E-07	3.38E-14	0.00E+00	3.31E-08	3.38E-07
13.41	410.3	392.7	7.75E+02	7.22E+01	8.00E-03	3.05E-07	4.14E-14	0.00E+00	3.31E-08	3.38E-07
14.02	412.8	395.9	7.43E+02	7.00E+01	8.00E-03	3.05E-07	5.09E-14	0.00E+00	3.31E-08	3.38E-07
14.63	415.2	399.2	7.13E+02	6.80E+01	8.00E-03	3.05E-07	6.29E-14	0.00E+00	3.31E-08	3.38E-07
15.24	417.7	402.7	6.84E+02	6.62E+01	8.00E-03	3.05E-07	7.79E-14	0.00E+00	3.31E-08	3.38E-07
15.85	420.1	406.2	6.57E+02	6.45E+01	8.00E-03	3.05E-07	9.68E-14	0.00E+00	3.31E-08	3.38E-07
16.46	422.5	409.9	6.31E+02	6.30E+01	8.00E-03	3.05E-07	1.21E-13	0.00E+00	3.31E-08	3.38E-07
17.07	424.9	413.7	6.07E+02	6.16E+01	8.00E-03	3.05E-07	1.51E-13	0.00E+00	3.31E-08	3.38E-07
17.68	427.3	417.5	5.84E+02	6.03E+01	8.00E-03	3.05E-07	1.90E-13	0.00E+00	3.31E-08	3.38E-07
18.29	429.8	421.5	5.62E+02	5.91E+01	8.00E-03	3.05E-07	2.38E-13	0.00E+00	3.31E-08	3.38E-07
18.90	432.2	425.6	5.41E+02	5.80E+01	8.00E-03	3.05E-07	3.01E-13	0.00E+00	3.31E-08	3.38E-07
19.51	434.7	429.8	5.21E+02	5.71E+01	8.00E-03	3.05E-07	3.80E-13	0.00E+00	3.31E-08	3.38E-07
20.12	437.1	434.1	5.01E+02	5.61E+01	8.00E-03	3.05E-07	4.80E-13	0.00E+00	3.31E-08	3.38E-07
20.73	439.7	438.4	4.83E+02	5.53E+01	8.00E-03	3.05E-07	6.08E-13	0.00E+00	3.31E-08	3.38E-07
21.34	442.2	442.9	4.66E+02	5.45E+01	8.00E-03	3.05E-07	7.71E-13	0.00E+00	3.31E-08	3.38E-07
21.95	444.9	447.4	4.49E+02	5.38E+01	8.00E-03	3.05E-07	9.77E-13	0.00E+00	3.31E-08	3.38E-07
22.56	447.5	451.9	4.33E+02	5.32E+01	8.00E-03	3.05E-07	1.24E-12	0.00E+00	3.31E-08	3.38E-07
23.16	450.3	456.6	4.18E+02	5.26E+01	8.00E-03	3.05E-07	1.57E-12	0.00E+00	3.31E-08	3.38E-07
23.77	453.1	461.3	4.03E+02	5.21E+01	8.00E-03	3.05E-07	1.99E-12	0.00E+00	3.31E-08	3.38E-07
24.38	456.0	466.1	3.89E+02	5.16E+01	8.00E-03	3.05E-07	2.52E-12	0.00E+00	3.31E-08	3.38E-07
24.99	459.0	470.9	3.75E+02	5.11E+01	8.00E-03	3.05E-07	3.19E-12	0.00E+00	3.31E-08	3.38E-07
25.60	462.0	475.8	3.62E+02	5.07E+01	8.00E-03	3.05E-07	4.03E-12	0.00E+00	3.31E-08	3.38E-07
26.21	465.2	480.7	3.50E+02	5.04E+01	8.00E-03	3.05E-07	5.09E-12	0.00E+00	3.31E-08	3.38E-07
26.82	468.5	485.7	3.37E+02	5.01E+01	8.00E-03	3.05E-07	6.41E-12	0.00E+00	3.31E-08	3.38E-07
27.43	471.9	490.8	3.26E+02	4.98E+01	8.00E-03	3.05E-07	8.07E-12	0.00E+00	3.31E-08	3.38E-07
28.04	475.5	495.9	3.15E+02	4.96E+01	8.00E-03	3.05E-07	1.01E-11	0.00E+00	3.31E-08	3.38E-07

28.65	479.2	501.0	3.04E+02	4.94E+01	8.00E-03	3.05E-07	1.27E-11	0.00E+00	3.31E-08	3.38E-07
29.26	483.1	506.3	2.93E+02	4.92E+01	8.00E-03	3.05E-07	1.59E-11	0.00E+00	3.31E-08	3.38E-07
29.87	487.2	511.6	2.83E+02	4.91E+01	8.00E-03	3.05E-07	1.99E-11	0.00E+00	3.31E-08	3.38E-07
30.48	491.5	516.9	2.73E+02	4.90E+01	8.00E-03	3.05E-07	2.48E-11	0.00E+00	3.31E-08	3.38E-07
31.09	496.0	522.4	2.64E+02	4.90E+01	8.00E-03	3.05E-07	3.10E-11	0.00E+00	3.31E-08	3.38E-07
31.70	500.7	527.9	2.55E+02	4.90E+01	8.00E-03	3.05E-07	3.85E-11	0.00E+00	3.31E-08	3.38E-07
32.31	505.7	533.5	2.46E+02	4.90E+01	8.00E-03	3.05E-07	4.79E-11	0.00E+00	3.31E-08	3.38E-07
32.92	511.0	539.3	2.37E+02	4.91E+01	8.00E-03	3.05E-07	5.95E-11	0.00E+00	3.31E-08	3.38E-07
33.53	516.7	545.2	2.29E+02	4.91E+01	8.00E-03	3.05E-07	7.39E-11	0.00E+00	3.31E-08	3.38E-07
34.14	522.7	551.3	2.21E+02	4.93E+01	8.00E-03	3.05E-07	9.17E-11	0.00E+00	3.31E-08	3.38E-07
34.75	529.1	557.6	2.13E+02	4.94E+01	8.00E-03	3.05E-07	1.14E-10	0.00E+00	3.31E-08	3.38E-07
35.36	534.4	564.0	2.11E+02	4.95E+01	8.00E-03	3.05E-07	1.41E-10	0.00E+00	3.31E-08	3.38E-07
35.97	537.0	570.1	2.12E+02	4.93E+01	8.00E-03	3.05E-07	1.74E-10	0.00E+00	3.31E-08	3.38E-07
36.58	539.6	575.7	2.13E+02	4.90E+01	8.00E-03	3.05E-07	2.12E-10	0.00E+00	3.31E-08	3.38E-07
37.19	542.1	580.9	2.14E+02	4.88E+01	8.00E-03	3.05E-07	2.56E-10	0.00E+00	3.31E-08	3.38E-07
37.80	544.7	585.7	2.15E+02	4.86E+01	8.00E-03	3.04E-07	3.06E-10	0.00E+00	3.31E-08	3.38E-07
38.40	547.4	590.2	2.16E+02	4.83E+01	8.00E-03	3.04E-07	3.62E-10	0.00E+00	3.31E-08	3.38E-07
39.01	550.0	594.5	2.17E+02	4.81E+01	8.00E-03	3.04E-07	4.24E-10	0.00E+00	3.31E-08	3.38E-07
39.62	552.7	598.5	2.18E+02	4.79E+01	8.00E-03	3.04E-07	4.92E-10	0.00E+00	3.31E-08	3.38E-07
40.23	555.4	602.3	2.19E+02	4.76E+01	8.00E-03	3.04E-07	5.68E-10	0.00E+00	3.31E-08	3.38E-07
40.84	558.1	606.0	2.20E+02	4.74E+01	8.00E-03	3.04E-07	6.49E-10	0.00E+00	3.31E-08	3.38E-07
41.45	560.9	609.5	2.21E+02	4.72E+01	8.00E-03	3.04E-07	7.38E-10	0.00E+00	3.31E-08	3.38E-07
42.06	563.6	612.9	2.22E+02	4.69E+01	8.00E-03	3.04E-07	8.34E-10	0.00E+00	3.31E-08	3.38E-07
42.67	566.4	616.1	2.23E+02	4.67E+01	8.00E-03	3.03E-07	9.37E-10	0.00E+00	3.31E-08	3.38E-07
43.28	569.1	619.3	2.24E+02	4.65E+01	8.00E-03	3.03E-07	1.05E-09	0.00E+00	3.31E-08	3.37E-07
43.89	571.9	622.4	2.26E+02	4.62E+01	8.01E-03	3.03E-07	1.17E-09	0.00E+00	3.31E-08	3.37E-07
44.50	574.7	625.5	2.27E+02	4.60E+01	8.01E-03	3.03E-07	1.29E-09	0.00E+00	3.31E-08	3.37E-07
45.11	577.6	628.4	2.28E+02	4.58E+01	8.01E-03	3.03E-07	1.43E-09	0.00E+00	3.31E-08	3.37E-07
45.72	580.4	631.4	2.29E+02	4.56E+01	8.01E-03	3.02E-07	1.57E-09	0.00E+00	3.31E-08	3.37E-07
46.33	583.3	634.3	2.30E+02	4.53E+01	8.01E-03	3.02E-07	1.72E-09	0.00E+00	3.31E-08	3.37E-07
46.94	586.2	637.1	2.31E+02	4.51E+01	8.01E-03	3.02E-07	1.88E-09	0.00E+00	3.31E-08	3.37E-07
47.55	589.1	640.0	2.32E+02	4.49E+01	8.01E-03	3.02E-07	2.05E-09	0.00E+00	3.31E-08	3.37E-07
48.16	592.0	642.8	2.33E+02	4.47E+01	8.01E-03	3.01E-07	2.23E-09	0.00E+00	3.31E-08	3.37E-07
48.77	595.0	645.6	2.35E+02	4.44E+01	8.01E-03	3.01E-07	2.42E-09	0.00E+00	3.31E-08	3.37E-07
49.38	597.9	648.4	2.36E+02	4.42E+01	8.01E-03	3.01E-07	2.62E-09	0.00E+00	3.31E-08	3.36E-07
49.99	601.0	651.2	2.37E+02	4.40E+01	8.01E-03	3.00E-07	2.83E-09	0.00E+00	3.31E-08	3.36E-07
50.60	604.0	654.0	2.38E+02	4.38E+01	8.01E-03	3.00E-07	3.05E-09	0.00E+00	3.31E-08	3.36E-07
51.21	607.1	656.8	2.39E+02	4.36E+01	8.01E-03	3.00E-07	3.28E-09	0.00E+00	3.31E-08	3.36E-07
51.82	610.2	659.6	2.41E+02	4.33E+01	8.02E-03	2.99E-07	3.53E-09	0.00E+00	3.31E-08	3.36E-07
52.43	613.3	662.4	2.42E+02	4.31E+01	8.02E-03	2.99E-07	3.79E-09	0.00E+00	3.31E-08	3.36E-07
53.04	616.5	665.3	2.43E+02	4.29E+01	8.02E-03	2.98E-07	4.06E-09	0.00E+00	3.31E-08	3.36E-07
53.64	619.7	668.1	2.45E+02	4.27E+01	8.02E-03	2.98E-07	4.34E-09	0.00E+00	3.31E-08	3.35E-07
54.25	623.0	671.0	2.46E+02	4.24E+01	8.02E-03	2.97E-07	4.64E-09	0.00E+00	3.31E-08	3.35E-07
54.86	626.3	673.8	2.47E+02	4.22E+01	8.02E-03	2.97E-07	4.96E-09	0.00E+00	3.31E-08	3.35E-07
55.47	629.6	676.8	2.48E+02	4.20E+01	8.02E-03	2.96E-07	5.29E-09	0.00E+00	3.31E-08	3.35E-07
56.08	633.0	679.7	2.50E+02	4.17E+01	8.02E-03	2.96E-07	5.64E-09	0.00E+00	3.31E-08	3.34E-07
56.69	636.5	682.7	2.51E+02	4.15E+01	8.03E-03	2.95E-07	6.00E-09	0.00E+00	3.31E-08	3.34E-07
57.30	640.0	685.7	2.53E+02	4.13E+01	8.03E-03	2.95E-07	6.39E-09	0.00E+00	3.31E-08	3.34E-07
57.91	643.6	688.7	2.54E+02	4.11E+01	8.03E-03	2.94E-07	6.79E-09	0.00E+00	3.31E-08	3.34E-07
58.52	647.3	691.8	2.56E+02	4.08E+01	8.03E-03	2.93E-07	7.22E-09	0.00E+00	3.31E-08	3.33E-07
59.13	651.0	694.9	2.57E+02	4.06E+01	8.03E-03	2.92E-07	7.66E-09	0.00E+00	3.31E-08	3.33E-07
59.74	654.8	698.0	2.59E+02	4.03E+01	8.03E-03	2.92E-07	8.13E-09	0.00E+00	3.31E-08	3.33E-07
60.35	658.7	701.3	2.60E+02	4.01E+01	8.04E-03	2.91E-07	8.62E-09	0.00E+00	3.31E-08	3.33E-07
60.96	662.6	704.5	2.62E+02	3.99E+01	8.04E-03	2.90E-07	9.13E-09	0.00E+00	3.31E-08	3.32E-07
61.57	666.7	707.8	2.63E+02	3.96E+01	8.04E-03	2.89E-07	9.68E-09	0.00E+00	3.31E-08	3.32E-07
62.18	670.9	711.2	2.65E+02	3.94E+01	8.04E-03	2.88E-07	1.02E-08	0.00E+00	3.31E-08	3.32E-07
62.79	675.2	714.7	2.67E+02	3.91E+01	8.05E-03	2.87E-07	1.08E-08	0.00E+00	3.31E-08	3.31E-07
63.40	679.5	718.2	2.68E+02	3.88E+01	8.05E-03	2.86E-07	1.15E-08	0.00E+00	3.31E-08	3.31E-07
64.01	684.1	721.8	2.70E+02	3.86E+01	8.05E-03	2.85E-07	1.21E-08	0.00E+00	3.31E-08	3.30E-07
64.62	688.7	725.4	2.72E+02	3.83E+01	8.06E-03	2.84E-07	1.28E-08	0.00E+00	3.31E-08	3.30E-07

65.23	693.5	729.2	2.74E+02	3.80E+01	8.06E-03	2.83E-07	1.36E-08	0.00E+00	3.31E-08	3.29E-07
65.84	698.5	733.0	2.76E+02	3.78E+01	8.06E-03	2.81E-07	1.43E-08	0.00E+00	3.31E-08	3.29E-07
66.45	703.6	737.0	2.78E+02	3.75E+01	8.07E-03	2.80E-07	1.52E-08	0.00E+00	3.31E-08	3.28E-07
67.06	708.9	741.0	2.80E+02	3.72E+01	8.07E-03	2.79E-07	1.60E-08	0.00E+00	3.31E-08	3.28E-07
67.67	714.5	745.2	2.83E+02	3.69E+01	8.07E-03	2.77E-07	1.69E-08	0.00E+00	3.31E-08	3.27E-07
68.28	720.2	749.5	2.85E+02	3.66E+01	8.08E-03	2.76E-07	1.79E-08	0.00E+00	3.31E-08	3.27E-07
68.88	726.2	753.9	2.87E+02	3.63E+01	8.08E-03	2.74E-07	1.89E-08	0.00E+00	3.31E-08	3.26E-07
69.49	732.4	758.5	2.90E+02	3.60E+01	8.09E-03	2.72E-07	1.99E-08	0.00E+00	3.31E-08	3.25E-07
70.10	739.0	763.3	2.93E+02	3.56E+01	8.09E-03	2.70E-07	2.11E-08	0.00E+00	3.31E-08	3.25E-07
70.71	745.8	768.2	2.95E+02	3.53E+01	8.10E-03	2.68E-07	2.23E-08	0.00E+00	3.31E-08	3.24E-07
71.32	753.0	773.3	2.98E+02	3.50E+01	8.10E-03	2.66E-07	2.35E-08	0.00E+00	3.31E-08	3.23E-07
71.93	760.6	778.6	3.01E+02	3.46E+01	8.11E-03	2.64E-07	2.49E-08	0.00E+00	3.31E-08	3.22E-07
72.54	768.6	784.2	3.05E+02	3.42E+01	8.11E-03	2.62E-07	2.63E-08	0.00E+00	3.31E-08	3.21E-07
73.15	777.1	790.0	3.08E+02	3.38E+01	8.12E-03	2.59E-07	2.78E-08	0.00E+00	3.31E-08	3.20E-07
73.76	786.1	796.1	3.12E+02	3.34E+01	8.13E-03	2.57E-07	2.94E-08	0.00E+00	3.31E-08	3.19E-07
74.37	794.9	801.9	3.15E+02	3.31E+01	8.13E-03	2.54E-07	3.10E-08	0.00E+00	3.31E-08	3.18E-07
74.98	805.1	808.6	3.20E+02	3.26E+01	8.14E-03	2.51E-07	3.28E-08	0.00E+00	3.31E-08	3.17E-07
75.59	816.0	815.7	3.24E+02	3.22E+01	8.15E-03	2.48E-07	3.48E-08	0.00E+00	3.31E-08	3.16E-07
76.20	827.8	823.2	3.29E+02	3.17E+01	8.16E-03	2.45E-07	3.69E-08	0.00E+00	3.31E-08	3.15E-07
76.81	840.5	831.2	3.34E+02	3.12E+01	8.17E-03	2.41E-07	3.91E-08	0.00E+00	3.31E-08	3.13E-07
77.42	854.3	839.7	3.40E+02	3.07E+01	8.18E-03	2.37E-07	4.16E-08	0.00E+00	3.31E-08	3.12E-07
78.03	869.4	848.8	3.46E+02	3.01E+01	8.19E-03	2.33E-07	4.42E-08	0.00E+00	3.31E-08	3.10E-07
78.64	885.9	858.5	3.53E+02	2.95E+01	8.20E-03	2.28E-07	4.70E-08	0.00E+00	3.31E-08	3.08E-07
79.25	904.0	869.1	3.61E+02	2.89E+01	8.22E-03	2.23E-07	5.01E-08	0.00E+00	3.31E-08	3.06E-07
79.86	924.0	880.5	3.69E+02	2.83E+01	8.23E-03	2.17E-07	5.34E-08	0.00E+00	3.31E-08	3.04E-07
80.47	946.3	893.0	3.78E+02	2.76E+01	8.25E-03	2.12E-07	5.70E-08	0.00E+00	3.31E-08	3.02E-07
81.08	971.1	906.6	3.89E+02	2.68E+01	8.26E-03	2.05E-07	6.10E-08	0.00E+00	3.31E-08	2.99E-07
81.69	999.0	921.5	4.01E+02	2.60E+01	8.28E-03	1.98E-07	6.53E-08	0.00E+00	3.31E-08	2.96E-07
82.30	1030.6	938.1	4.14E+02	2.52E+01	8.30E-03	1.90E-07	7.01E-08	0.00E+00	3.31E-08	2.93E-07
82.91	1066.8	956.5	4.29E+02	2.43E+01	8.32E-03	1.81E-07	7.54E-08	0.00E+00	3.31E-08	2.90E-07
83.52	1109.2	977.1	4.47E+02	2.33E+01	8.35E-03	1.72E-07	8.12E-08	0.00E+00	3.31E-08	2.86E-07
84.12	1161.0	1000.6	4.69E+02	2.22E+01	8.38E-03	1.61E-07	8.77E-08	0.00E+00	3.31E-08	2.82E-07
84.73	1229.7	1028.0	4.99E+02	2.09E+01	8.41E-03	1.49E-07	9.48E-08	0.00E+00	3.31E-08	2.77E-07
85.34	1328.3	1061.4	5.41E+02	1.93E+01	8.44E-03	1.36E-07	1.03E-07	0.00E+00	3.31E-08	2.71E-07
85.95	1435.6	1102.6	5.87E+02	1.78E+01	8.49E-03	1.20E-07	1.12E-07	0.00E+00	3.31E-08	2.65E-07
86.56	1523.3	1149.3	6.24E+02	1.67E+01	8.54E-03	1.00E-07	1.22E-07	0.00E+00	3.31E-08	2.55E-07
87.17	1587.8	1198.0	6.52E+02	1.60E+01	8.60E-03	7.55E-08	1.34E-07	0.00E+00	3.31E-08	2.42E-07
87.78	1644.2	1246.8	6.76E+02	1.54E+01	8.68E-03	4.59E-08	1.46E-07	0.00E+00	3.31E-08	2.25E-07
88.39	1703.1	1299.2	7.01E+02	1.49E+01	8.75E-03	1.80E-08	1.55E-07	0.00E+00	3.31E-08	2.06E-07
89.00	1748.7	1360.2	7.20E+02	1.45E+01	8.79E-03	2.63E-09	1.59E-07	0.00E+00	3.31E-08	1.95E-07
89.61	1778.4	1424.7	7.32E+02	1.42E+01	8.80E-03	3.93E-11	1.59E-07	0.00E+00	3.31E-08	1.92E-07
90.22	1804.4	1481.0	7.43E+02	1.40E+01	8.80E-03	0.00E+00	1.58E-07	0.00E+00	3.31E-08	1.92E-07
90.83	1831.1	1531.7	7.54E+02	1.38E+01	8.80E-03	0.00E+00	1.58E-07	0.00E+00	3.31E-08	1.91E-07
91.44	1857.6	1576.3	7.65E+02	1.36E+01	8.80E-03	0.00E+00	1.57E-07	0.00E+00	3.31E-08	1.90E-07
92.05	1883.7	1616.1	7.76E+02	1.34E+01	8.80E-03	0.00E+00	1.55E-07	0.00E+00	3.31E-08	1.89E-07
92.66	1909.2	1651.8	7.86E+02	1.33E+01	8.80E-03	0.00E+00	1.54E-07	0.00E+00	3.31E-08	1.87E-07
93.27	1934.0	1684.1	7.96E+02	1.31E+01	8.80E-03	0.00E+00	1.53E-07	0.00E+00	3.31E-08	1.86E-07
93.88	1958.1	1713.7	8.06E+02	1.29E+01	8.80E-03	0.00E+00	1.52E-07	0.00E+00	3.31E-08	1.85E-07
94.49	1981.3	1740.9	8.16E+02	1.28E+01	8.80E-03	0.00E+00	1.51E-07	0.00E+00	3.31E-08	1.84E-07
95.10	2003.0	1766.1	8.25E+02	1.26E+01	8.80E-03	0.00E+00	1.50E-07	0.00E+00	3.31E-08	1.83E-07
95.71	2010.9	1788.2	8.28E+02	1.26E+01	8.80E-03	0.00E+00	1.49E-07	0.00E+00	3.31E-08	1.82E-07
96.32	2014.0	1806.2	8.30E+02	1.26E+01	8.80E-03	0.00E+00	1.48E-07	0.00E+00	3.31E-08	1.81E-07
96.93	2017.2	1820.6	8.31E+02	1.26E+01	8.80E-03	0.00E+00	1.47E-07	0.00E+00	3.31E-08	1.80E-07
97.54	2020.3	1832.3	8.32E+02	1.25E+01	8.80E-03	0.00E+00	1.45E-07	0.00E+00	3.31E-08	1.78E-07
98.15	2023.5	1841.8	8.33E+02	1.25E+01	8.80E-03	0.00E+00	1.44E-07	0.00E+00	3.31E-08	1.77E-07
98.76	2026.5	1849.6	8.35E+02	1.25E+01	8.80E-03	0.00E+00	1.43E-07	0.00E+00	3.31E-08	1.76E-07
99.36	2029.6	1856.2	8.36E+02	1.25E+01	8.80E-03	0.00E+00	1.42E-07	0.00E+00	3.31E-08	1.75E-07
99.97	2032.5	1861.7	8.37E+02	1.25E+01	8.80E-03	0.00E+00	1.41E-07	0.00E+00	3.31E-08	1.74E-07
100.58	2035.4	1866.5	8.38E+02	1.24E+01	8.80E-03	0.00E+00	1.40E-07	0.00E+00	3.31E-08	1.73E-07
101.19	2038.2	1870.6	8.40E+02	1.24E+01	8.80E-03	0.00E+00	1.39E-07	0.00E+00	3.31E-08	1.72E-07

101.80	2040.9	1874.2	8.41E+02	1.24E+01	8.80E-03	0.00E+00	1.38E-07	0.00E+00	3.31E-08	1.71E-07
102.41	2043.6	1877.5	8.42E+02	1.24E+01	8.80E-03	0.00E+00	1.37E-07	0.00E+00	3.31E-08	1.70E-07
103.02	2046.1	1880.4	8.43E+02	1.24E+01	8.80E-03	0.00E+00	1.35E-07	0.00E+00	3.31E-08	1.69E-07
103.63	2048.7	1883.2	8.44E+02	1.24E+01	8.80E-03	0.00E+00	1.34E-07	0.00E+00	3.31E-08	1.68E-07
104.24	2051.4	1885.7	8.45E+02	1.23E+01	8.80E-03	0.00E+00	1.33E-07	0.00E+00	3.31E-08	1.66E-07
104.85	2053.9	1888.1	8.46E+02	1.23E+01	8.80E-03	0.00E+00	1.32E-07	0.00E+00	3.31E-08	1.65E-07
105.46	2056.4	1890.4	8.47E+02	1.23E+01	8.80E-03	0.00E+00	1.31E-07	0.00E+00	3.31E-08	1.64E-07
106.07	2058.8	1892.6	8.48E+02	1.23E+01	8.80E-03	0.00E+00	1.30E-07	0.00E+00	3.31E-08	1.63E-07
106.68	2061.1	1894.7	8.49E+02	1.23E+01	8.80E-03	0.00E+00	1.29E-07	0.00E+00	3.31E-08	1.62E-07
107.29	2063.3	1896.7	8.50E+02	1.23E+01	8.80E-03	0.00E+00	1.28E-07	0.00E+00	3.31E-08	1.61E-07
107.90	2065.5	1898.6	8.51E+02	1.23E+01	8.80E-03	0.00E+00	1.27E-07	0.00E+00	3.31E-08	1.60E-07
108.51	2067.6	1900.4	8.52E+02	1.22E+01	8.80E-03	0.00E+00	1.26E-07	0.00E+00	3.31E-08	1.59E-07
109.12	2069.6	1902.2	8.53E+02	1.22E+01	8.80E-03	0.00E+00	1.25E-07	0.00E+00	3.31E-08	1.58E-07
109.73	2071.5	1903.9	8.53E+02	1.22E+01	8.80E-03	0.00E+00	1.24E-07	0.00E+00	3.31E-08	1.57E-07
110.34	2073.4	1905.6	8.54E+02	1.22E+01	8.80E-03	0.00E+00	1.23E-07	0.00E+00	3.31E-08	1.56E-07
110.95	2075.2	1907.1	8.55E+02	1.22E+01	8.80E-03	0.00E+00	1.22E-07	0.00E+00	3.31E-08	1.56E-07
111.56	2076.9	1908.6	8.56E+02	1.22E+01	8.80E-03	0.00E+00	1.21E-07	0.00E+00	3.31E-08	1.55E-07
112.17	2078.6	1910.1	8.56E+02	1.22E+01	8.80E-03	0.00E+00	1.21E-07	0.00E+00	3.31E-08	1.54E-07
112.78	2080.1	1911.5	8.57E+02	1.22E+01	8.80E-03	0.00E+00	1.20E-07	0.00E+00	3.31E-08	1.53E-07
113.39	2081.7	1912.8	8.58E+02	1.22E+01	8.80E-03	0.00E+00	1.19E-07	0.00E+00	3.31E-08	1.52E-07
114.00	2083.8	1933.0	8.59E+02	1.21E+01	8.80E-03	0.00E+00	1.17E-07	0.00E+00	3.31E-08	1.50E-07
114.60	2085.2	1933.8	8.59E+02	1.21E+01	8.80E-03	0.00E+00	1.16E-07	0.00E+00	3.31E-08	1.50E-07
115.21	2086.6	1934.6	8.60E+02	1.21E+01	8.80E-03	0.00E+00	1.16E-07	0.00E+00	3.31E-08	1.49E-07
115.82	2087.9	1935.5	8.60E+02	1.21E+01	8.80E-03	0.00E+00	1.15E-07	0.00E+00	3.31E-08	1.48E-07
116.43	2089.1	1936.2	8.61E+02	1.21E+01	8.80E-03	0.00E+00	1.14E-07	0.00E+00	3.31E-08	1.47E-07
117.04	2090.3	1936.9	8.61E+02	1.21E+01	8.80E-03	0.00E+00	1.13E-07	0.00E+00	3.31E-08	1.46E-07
117.65	2091.4	1937.6	8.62E+02	1.21E+01	8.80E-03	0.00E+00	1.12E-07	0.00E+00	3.31E-08	1.45E-07
118.26	2092.5	1938.2	8.62E+02	1.21E+01	8.80E-03	0.00E+00	1.11E-07	0.00E+00	3.31E-08	1.44E-07
118.87	2093.5	1938.9	8.63E+02	1.21E+01	8.80E-03	0.00E+00	1.10E-07	0.00E+00	3.31E-08	1.44E-07
119.48	2094.4	1939.5	8.63E+02	1.21E+01	8.80E-03	0.00E+00	1.10E-07	0.00E+00	3.31E-08	1.43E-07
120.09	2095.3	1940.0	8.64E+02	1.21E+01	8.80E-03	0.00E+00	1.09E-07	0.00E+00	3.31E-08	1.42E-07
120.70	2096.1	1940.4	8.64E+02	1.21E+01	8.80E-03	0.00E+00	1.08E-07	0.00E+00	3.31E-08	1.41E-07
121.31	2096.9	1940.8	8.64E+02	1.21E+01	8.80E-03	0.00E+00	1.07E-07	0.00E+00	3.31E-08	1.40E-07
121.92	2097.6	1941.4	8.65E+02	1.21E+01	8.80E-03	0.00E+00	1.06E-07	0.00E+00	3.31E-08	1.39E-07
122.53	2098.3	1941.7	8.65E+02	1.21E+01	8.80E-03	0.00E+00	1.06E-07	0.00E+00	3.31E-08	1.39E-07
123.14	2098.9	1942.0	8.65E+02	1.21E+01	8.80E-03	0.00E+00	1.05E-07	0.00E+00	3.31E-08	1.38E-07
123.75	2099.5	1942.3	8.65E+02	1.21E+01	8.80E-03	0.00E+00	1.04E-07	0.00E+00	3.31E-08	1.37E-07
124.36	2100.0	1942.5	8.66E+02	1.20E+01	8.80E-03	0.00E+00	1.03E-07	0.00E+00	3.31E-08	1.36E-07
124.97	2100.5	1942.8	8.66E+02	1.20E+01	8.80E-03	0.00E+00	1.02E-07	0.00E+00	3.31E-08	1.36E-07
125.58	2100.9	1943.0	8.66E+02	1.20E+01	8.80E-03	0.00E+00	1.02E-07	0.00E+00	3.31E-08	1.35E-07
126.19	2101.3	1943.2	8.66E+02	1.20E+01	8.80E-03	0.00E+00	1.01E-07	0.00E+00	3.31E-08	1.34E-07
126.80	2101.6	1943.3	8.66E+02	1.20E+01	8.80E-03	0.00E+00	1.00E-07	0.00E+00	3.31E-08	1.33E-07
127.41	2101.9	1943.4	8.66E+02	1.20E+01	8.80E-03	0.00E+00	9.95E-08	0.00E+00	3.31E-08	1.33E-07
128.02	2102.1	1943.5	8.66E+02	1.20E+01	8.80E-03	0.00E+00	9.87E-08	0.00E+00	3.31E-08	1.32E-07
128.63	2102.3	1943.5	8.67E+02	1.20E+01	8.80E-03	0.00E+00	9.80E-08	0.00E+00	3.31E-08	1.31E-07
129.24	2102.5	1943.6	8.67E+02	1.20E+01	8.80E-03	0.00E+00	9.73E-08	0.00E+00	3.31E-08	1.30E-07
129.84	2099.8	1941.6	8.66E+02	1.20E+01	8.80E-03	0.00E+00	9.66E-08	0.00E+00	3.31E-08	1.30E-07
130.45	2097.2	1939.8	8.64E+02	1.21E+01	8.80E-03	0.00E+00	9.59E-08	0.00E+00	3.31E-08	1.29E-07
131.06	2094.5	1937.9	8.63E+02	1.21E+01	8.80E-03	0.00E+00	9.52E-08	0.00E+00	3.31E-08	1.28E-07
131.67	2091.9	1935.8	8.62E+02	1.21E+01	8.80E-03	0.00E+00	9.45E-08	0.00E+00	3.31E-08	1.28E-07
132.28	2089.2	1933.9	8.61E+02	1.21E+01	8.80E-03	0.00E+00	9.38E-08	0.00E+00	3.31E-08	1.27E-07
132.89	2086.6	1932.0	8.60E+02	1.21E+01	8.80E-03	0.00E+00	9.31E-08	0.00E+00	3.31E-08	1.26E-07
133.50	2084.0	1930.3	8.59E+02	1.21E+01	8.80E-03	0.00E+00	9.24E-08	0.00E+00	3.31E-08	1.26E-07
134.11	2081.4	1927.8	8.58E+02	1.22E+01	8.80E-03	0.00E+00	9.17E-08	0.00E+00	3.31E-08	1.25E-07
134.72	2078.8	1925.9	8.57E+02	1.22E+01	8.80E-03	0.00E+00	9.11E-08	0.00E+00	3.31E-08	1.24E-07
135.33	2076.2	1924.1	8.56E+02	1.22E+01	8.80E-03	0.00E+00	9.04E-08	0.00E+00	3.31E-08	1.23E-07
135.94	2073.6	1922.2	8.55E+02	1.22E+01	8.80E-03	0.00E+00	8.97E-08	0.00E+00	3.31E-08	1.23E-07
136.55	2071.0	1920.5	8.53E+02	1.22E+01	8.80E-03	0.00E+00	8.90E-08	0.00E+00	3.31E-08	1.22E-07
137.16	2068.4	1918.0	8.52E+02	1.22E+01	8.80E-03	0.00E+00	8.83E-08	0.00E+00	3.31E-08	1.21E-07
137.77	2065.9	1916.2	8.51E+02	1.23E+01	8.80E-03	0.00E+00	8.77E-08	0.00E+00	3.31E-08	1.21E-07

138.38	2063.3	1914.4	8.50E+02	1.23E+01	8.80E-03	0.00E+00	8.70E-08	0.00E+00	3.31E-08	1.20E-07
138.99	2060.8	1912.6	8.49E+02	1.23E+01	8.80E-03	0.00E+00	8.63E-08	0.00E+00	3.31E-08	1.19E-07
139.60	2058.2	1910.8	8.48E+02	1.23E+01	8.80E-03	0.00E+00	8.56E-08	0.00E+00	3.31E-08	1.19E-07
140.21	2055.7	1908.4	8.47E+02	1.23E+01	8.80E-03	0.00E+00	8.50E-08	0.00E+00	3.31E-08	1.18E-07
140.82	2053.1	1906.6	8.46E+02	1.23E+01	8.80E-03	0.00E+00	8.43E-08	0.00E+00	3.31E-08	1.17E-07
141.43	2050.6	1904.8	8.45E+02	1.23E+01	8.80E-03	0.00E+00	8.36E-08	0.00E+00	3.31E-08	1.17E-07
142.04	2048.1	1903.0	8.44E+02	1.24E+01	8.80E-03	0.00E+00	8.30E-08	0.00E+00	3.31E-08	1.16E-07
142.65	2045.6	1901.2	8.43E+02	1.24E+01	8.80E-03	0.00E+00	8.23E-08	0.00E+00	3.31E-08	1.15E-07
143.26	2043.1	1898.8	8.42E+02	1.24E+01	8.80E-03	0.00E+00	8.17E-08	0.00E+00	3.31E-08	1.15E-07
143.87	2040.6	1897.1	8.41E+02	1.24E+01	8.80E-03	0.00E+00	8.10E-08	0.00E+00	3.31E-08	1.14E-07
144.48	2038.1	1895.3	8.40E+02	1.24E+01	8.80E-03	0.00E+00	8.04E-08	0.00E+00	3.31E-08	1.13E-07
145.08	2035.7	1893.5	8.39E+02	1.24E+01	8.80E-03	0.00E+00	7.97E-08	0.00E+00	3.31E-08	1.13E-07
145.69	2033.2	1891.8	8.38E+02	1.24E+01	8.80E-03	0.00E+00	7.91E-08	0.00E+00	3.31E-08	1.12E-07
146.30	2030.7	1889.4	8.37E+02	1.25E+01	8.80E-03	0.00E+00	7.84E-08	0.00E+00	3.31E-08	1.12E-07
146.91	2028.3	1887.6	8.36E+02	1.25E+01	8.80E-03	0.00E+00	7.78E-08	0.00E+00	3.31E-08	1.11E-07
147.52	2025.8	1885.9	8.35E+02	1.25E+01	8.80E-03	0.00E+00	7.71E-08	0.00E+00	3.31E-08	1.10E-07
148.13	2023.4	1864.1	8.34E+02	1.25E+01	8.80E-03	0.00E+00	7.65E-08	0.00E+00	3.31E-08	1.10E-07
148.74	2021.0	1882.4	8.33E+02	1.25E+01	8.80E-03	0.00E+00	7.59E-08	0.00E+00	3.31E-08	1.09E-07
149.35	2018.6	1880.1	8.32E+02	1.25E+01	8.80E-03	0.00E+00	7.52E-08	0.00E+00	3.31E-08	1.08E-07
149.96	2016.1	1878.3	8.31E+02	1.26E+01	8.80E-03	0.00E+00	7.46E-08	0.00E+00	3.31E-08	1.08E-07
150.57	2013.7	1876.6	8.30E+02	1.26E+01	8.80E-03	0.00E+00	7.40E-08	0.00E+00	3.31E-08	1.07E-07
151.18	2011.3	1874.8	8.29E+02	1.26E+01	8.80E-03	0.00E+00	7.34E-08	0.00E+00	3.31E-08	1.06E-07
151.79	2008.9	1873.1	8.28E+02	1.26E+01	8.80E-03	0.00E+00	7.27E-08	0.00E+00	3.31E-08	1.06E-07
152.40	2006.6	1870.8	8.27E+02	1.26E+01	8.80E-03	0.00E+00	7.21E-08	0.00E+00	3.31E-08	1.05E-07

BYU -- ONE DImensional Combustion Or Gasification model (1-DICOG); total particle phase

23-May-79

DISTANCE (cm)	COAL	CHAR	H2O	ASH	TOTAL
	(component mass/initial particle mass)				
0.00	.87407	.00000	.03100	.09494	1.00000
0.61	.87407	0.00000	.01630	.09494	.98530
1.22	.87134	0.00000	.00875	.09494	.97502
1.83	.87039	0.00000	.00485	.09494	.97018
2.44	.86994	0.00000	.00257	.09494	.96745
3.05	.86970	0.00000	.00029	.09494	.96492
3.66	.86948	0.00000	.00000	.09494	.96442
4.27	.86932	0.00000	.00000	.09494	.96425
4.88	.86919	0.00000	.00000	.09494	.96412
5.49	.86909	0.00000	.00000	.09494	.96402
6.10	.86901	0.00000	.00000	.09494	.96395
6.71	.86895	0.00000	.00000	.09494	.96388
7.32	.86890	0.00000	.00000	.09494	.96383
7.92	.86886	0.00000	.00000	.09494	.96379
8.53	.86883	0.00000	.00000	.09494	.96376
9.14	.86880	0.00000	.00000	.09494	.96373
9.75	.86877	0.00000	.00000	.09494	.96371
10.36	.86876	0.00000	.00000	.09494	.96369
10.97	.86874	0.00000	.00000	.09494	.96367
11.58	.86873	0.00000	.00000	.09494	.96366
12.19	.86871	0.00000	.00000	.09494	.96365
12.80	.86870	0.00000	.00000	.09494	.96364
13.41	.86869	0.00000	.00000	.09494	.96363
14.02	.86869	0.00000	.00000	.09494	.96362
14.63	.86868	0.00000	.00000	.09494	.96361
15.24	.86867	0.00000	.00000	.09494	.96361
15.85	.86867	0.00000	.00000	.09494	.96360
16.46	.86866	0.00000	.00000	.09494	.96360
17.07	.86866	0.00000	.00000	.09494	.96359
17.68	.86865	0.00000	.00000	.09494	.96359
18.29	.86865	0.00000	.00000	.09494	.96359
18.90	.86865	0.00000	.00000	.09494	.96358
19.51	.86864	0.00000	.00000	.09494	.96358
20.12	.86864	0.00000	.00000	.09494	.96358
20.73	.86864	0.00000	.00000	.09494	.96358
21.34	.86863	.00001	.00000	.09494	.96357
21.95	.86863	.00001	.00000	.09494	.96357
22.56	.86863	.00001	.00000	.09494	.96357
23.16	.86862	.00001	.00000	.09494	.96357
23.77	.86862	.00001	.00000	.09494	.96356
24.38	.86861	.00001	.00000	.09494	.96356
24.99	.86861	.00002	.00000	.09494	.96356
25.60	.86860	.00002	.00000	.09494	.96356
26.21	.86859	.00002	.00000	.09494	.96355
26.82	.86858	.00003	.00000	.09494	.96355
27.43	.86857	.00003	.00000	.09494	.96354
28.04	.86856	.00004	.00000	.09494	.96354
28.65	.86855	.00005	.00000	.09494	.96353

29.26	.86853	.00006	.00000	.09494	.96353
29.87	.86851	.00007	.00000	.09494	.96352
30.48	.86849	.00009	.00000	.09494	.96351
31.09	.86846	.00010	.00000	.09494	.96350
31.70	.86843	.00012	.00000	.09494	.96349
32.31	.86838	.00015	.00000	.09494	.96347
32.92	.86833	.00018	.00000	.09494	.96345
33.53	.86827	.00022	.00000	.09494	.96343
34.14	.86820	.00027	.00000	.09494	.96340
34.75	.86810	.00032	.00000	.09494	.96336
35.36	.86799	.00039	.00000	.09494	.96331
35.97	.86785	.00048	.00000	.09494	.96326
36.58	.86770	.00057	.00000	.09494	.96320
37.19	.86753	.00067	.00000	.09494	.96314
37.80	.86734	.00079	.00000	.09494	.96306
38.40	.86713	.00092	.00000	.09494	.96298
39.01	.86691	.00105	.00000	.09494	.96289
39.62	.86666	.00120	.00000	.09494	.96280
40.23	.86640	.00136	.00000	.09494	.96270
40.84	.86612	.00153	.00000	.09494	.96259
41.45	.86581	.00172	.00000	.09494	.96247
42.06	.86549	.00192	.00000	.09494	.96234
42.67	.86514	.00213	.00000	.09494	.96221
43.28	.86477	.00235	.00000	.09494	.96206
43.89	.86438	.00259	.00000	.09494	.96191
44.50	.86396	.00285	.00000	.09494	.96174
45.11	.86351	.00312	.00000	.09494	.96157
45.72	.86304	.00341	.00000	.09494	.96138
46.33	.86253	.00372	.00000	.09494	.96119
46.94	.86200	.00405	.00000	.09494	.96098
47.55	.86143	.00439	.00000	.09494	.96076
48.16	.86083	.00476	.00000	.09494	.96052
48.77	.86020	.00514	.00000	.09494	.96028
49.38	.85953	.00555	.00000	.09494	.96002
49.99	.85882	.00599	.00000	.09494	.95974
50.60	.85806	.00645	.00000	.09494	.95945
51.21	.85727	.00693	.00000	.09494	.95914
51.82	.85643	.00744	.00000	.09494	.95881
52.43	.85554	.00798	.00000	.09494	.95846
53.04	.85460	.00856	.00000	.09494	.95810
53.64	.85361	.00916	.00000	.09494	.95771
54.25	.85257	.00980	.00000	.09494	.95730
54.86	.85146	.01047	.00000	.09494	.95687
55.47	.85029	.01119	.00000	.09494	.95641
56.08	.84906	.01194	.00000	.09494	.95593
56.69	.84775	.01274	.00000	.09494	.95542
57.30	.84637	.01358	.00000	.09494	.95489
57.91	.84491	.01447	.00000	.09494	.95432
58.52	.84337	.01541	.00000	.09494	.95371
59.13	.84174	.01640	.00000	.09494	.95308
59.74	.84001	.01746	.00000	.09494	.95241
60.35	.83819	.01857	.00000	.09494	.95169
60.96	.83626	.01975	.00000	.09494	.95094
61.57	.83421	.02100	.00000	.09494	.95014
62.18	.83204	.02232	.00000	.09494	.94930
62.79	.82974	.02372	.00000	.09494	.94840
63.40	.82730	.02521	.00000	.09494	.94745
64.01	.82472	.02679	.00000	.09494	.94644
64.62	.82197	.02846	.00000	.09494	.94537
65.23	.81905	.03025	.00000	.09494	.94423

65.84	.81594	.03214	.00000	.09494	.94302
66.45	.81263	.03416	.00000	.09494	.94173
67.06	.80911	.03631	.00000	.09494	.94035
67.67	.80535	.03860	.00000	.09494	.93889
68.28	.80134	.04105	.00000	.09494	.93732
68.88	.79704	.04367	.00000	.09494	.93565
69.49	.79245	.04647	.00000	.09494	.93386
70.10	.78752	.04948	.00000	.09494	.93193
70.71	.78223	.05271	.00000	.09494	.92987
71.32	.77654	.05618	.00000	.09494	.92765
71.93	.77040	.05992	.00000	.09494	.92526
72.54	.76378	.06396	.00000	.09494	.92268
73.15	.75662	.06833	.00000	.09494	.91988
73.76	.74885	.07307	.00000	.09494	.91686
74.37	.74113	.07778	.00000	.09494	.91385
74.98	.73200	.08335	.00000	.09494	.91028
75.59	.72201	.08944	.00000	.09494	.90639
76.20	.71107	.09612	.00000	.09494	.90212
76.81	.69904	.10346	.00000	.09494	.89743
77.42	.68576	.11156	.00000	.09494	.89225
78.03	.67106	.12052	.00000	.09494	.88651
78.64	.65471	.13049	.00000	.09494	.88013
79.25	.63646	.14162	.00000	.09494	.87301
79.86	.61600	.15408	.00000	.09494	.86502
80.47	.59298	.16809	.00000	.09494	.85601
81.08	.56698	.18390	.00000	.09494	.84581
81.69	.53751	.20176	.00000	.09494	.83420
82.30	.50397	.22199	.00000	.09494	.82090
82.91	.46567	.24487	.00000	.09494	.80547
83.52	.42160	.27070	.00000	.09494	.78724
84.12	.37015	.29970	.00000	.09494	.76479
84.73	.30799	.33201	.00000	.09494	.73494
85.34	.23076	.36629	.00000	.09494	.69199
85.95	.15663	.39213	.00000	.09494	.64370
86.56	.10186	.40588	.00000	.09494	.60267
87.17	.06715	.40940	.00000	.09494	.57148
87.78	.04059	.40806	.00000	.09494	.54359
88.39	.01591	.40355	.00000	.09494	.51439
89.00	.00233	.39385	.00000	.09494	.49111
89.61	.00003	.38020	.00000	.09494	.47517
90.22	.00000	.36607	.00000	.09494	.46100
90.83	.00000	.35143	.00000	.09494	.44636
91.44	.00000	.33680	.00000	.09494	.43173
92.05	.00000	.32227	.00000	.09494	.41720
92.66	.00000	.30790	.00000	.09494	.40283
93.27	.00000	.29374	.00000	.09494	.38867
93.88	.00000	.27982	.00000	.09494	.37475
94.49	.00000	.26617	.00000	.09494	.36111
95.10	.00000	.25300	.00000	.09494	.34793
95.71	.00000	.24630	.00000	.09494	.34124
96.32	.00000	.24273	.00000	.09494	.33766
96.93	.00000	.23915	.00000	.09494	.33409
97.54	.00000	.23559	.00000	.09494	.33052
98.15	.00000	.23205	.00000	.09494	.32698
98.76	.00000	.22853	.00000	.09494	.32347
99.36	.00000	.22504	.00000	.09494	.31997
99.97	.00000	.22157	.00000	.09494	.31651
100.58	.00000	.21814	.00000	.09494	.31307
101.19	.00000	.21473	.00000	.09494	.30967
101.80	.00000	.21136	.00000	.09494	.30629

102.41	.00000	.20801	.00000	.09494	.30294
103.02	.00000	.20469	.00000	.09494	.29963
103.63	.00000	.20138	.00000	.09494	.29632
104.24	.00000	.19808	.00000	.09494	.29302
104.85	.00000	.19481	.00000	.09494	.28975
105.46	.00000	.19157	.00000	.09494	.28651
106.07	.00000	.18837	.00000	.09494	.28330
106.68	.00000	.18519	.00000	.09494	.28013
107.29	.00000	.18205	.00000	.09494	.27698
107.90	.00000	.17893	.00000	.09494	.27387
108.51	.00000	.17585	.00000	.09494	.27078
109.12	.00000	.17279	.00000	.09494	.26773
109.73	.00000	.16977	.00000	.09494	.26470
110.34	.00000	.16677	.00000	.09494	.26171
110.95	.00000	.16381	.00000	.09494	.25874
111.56	.00000	.16087	.00000	.09494	.25581
112.17	.00000	.15796	.00000	.09494	.25290
112.78	.00000	.15508	.00000	.09494	.25002
113.39	.00000	.15223	.00000	.09494	.24717
114.00	.00000	.14815	.00000	.09494	.24309
114.60	.00000	.14536	.00000	.09494	.24029
115.21	.00000	.14260	.00000	.09494	.23753
115.82	.00000	.13986	.00000	.09494	.23479
116.43	.00000	.13715	.00000	.09494	.23208
117.04	.00000	.13446	.00000	.09494	.22940
117.65	.00000	.13181	.00000	.09494	.22674
118.26	.00000	.12918	.00000	.09494	.22411
118.87	.00000	.12658	.00000	.09494	.22151
119.48	.00000	.12400	.00000	.09494	.21893
120.09	.00000	.12145	.00000	.09494	.21638
120.70	.00000	.11892	.00000	.09494	.21386
121.31	.00000	.11642	.00000	.09494	.21136
121.92	.00000	.11395	.00000	.09494	.20888
122.53	.00000	.11150	.00000	.09494	.20643
123.14	.00000	.10907	.00000	.09494	.20400
123.75	.00000	.10667	.00000	.09494	.20160
124.36	.00000	.10429	.00000	.09494	.19923
124.97	.00000	.10194	.00000	.09494	.19687
125.58	.00000	.09961	.00000	.09494	.19454
126.19	.00000	.09730	.00000	.09494	.19224
126.80	.00000	.09502	.00000	.09494	.18996
127.41	.00000	.09276	.00000	.09494	.18770
128.02	.00000	.09052	.00000	.09494	.18546
128.63	.00000	.08831	.00000	.09494	.18324
129.24	.00000	.08612	.00000	.09494	.18105
129.84	.00000	.08545	.00000	.09494	.18039
130.45	.00000	.08483	.00000	.09494	.17977
131.06	.00000	.08421	.00000	.09494	.17915
131.67	.00000	.08360	.00000	.09494	.17853
132.28	.00000	.08298	.00000	.09494	.17791
132.89	.00000	.08236	.00000	.09494	.17730
133.50	.00000	.08175	.00000	.09494	.17669
134.11	.00000	.08114	.00000	.09494	.17608
134.72	.00000	.08054	.00000	.09494	.17547
135.33	.00000	.07993	.00000	.09494	.17486
135.94	.00000	.07933	.00000	.09494	.17426
136.55	.00000	.07872	.00000	.09494	.17366
137.16	.00000	.07812	.00000	.09494	.17306
137.77	.00000	.07753	.00000	.09494	.17246
138.38	.00000	.07693	.00000	.09494	.17187

138.99	.00000	.07634	.00000	.09494	.17127
139.60	.00000	.07574	.00000	.09494	.17068
140.21	.00000	.07515	.00000	.09494	.17009
140.82	.00000	.07457	.00000	.09494	.16950
141.43	.00000	.07398	.00000	.09494	.16892
142.04	.00000	.07340	.00000	.09494	.16833
142.65	.00000	.07282	.00000	.09494	.16775
143.26	.00000	.07224	.00000	.09494	.16717
143.87	.00000	.07166	.00000	.09494	.16659
144.48	.00000	.07108	.00000	.09494	.16602
145.08	.00000	.07051	.00000	.09494	.16544
145.69	.00000	.06994	.00000	.09494	.16487
146.30	.00000	.06937	.00000	.09494	.16430
146.91	.00000	.06880	.00000	.09494	.16374
147.52	.00000	.06823	.00000	.09494	.16317
148.13	.00000	.06767	.00000	.09494	.16260
148.74	.00000	.06711	.00000	.09494	.16204
149.35	.00000	.06655	.00000	.09494	.16148
149.96	.00000	.06599	.00000	.09494	.16092
150.57	.00000	.06543	.00000	.09494	.16037
151.18	.00000	.06488	.00000	.09494	.15981
151.79	.00000	.06432	.00000	.09494	.15926
152.40	.00000	.06377	.00000	.09494	.15871

BYU -- ONE DImensional Combustion Or Gasification model (1-DICOG): gas phase mole fractions

23-May-79

DISTANCE (cm)	FLOW RATE (cc/sec)	AR	CO	O2	N2	CO2	H2O	H2	CH4	SO2	NO
0.61	7.76E+03	.04684	.00000	.20185	.73481	.00000	.01650	.00000	.00000	.00000	.00000
1.22	9.80E+03	.03804	.00000	.20231	.74180	.00000	.01785	.00000	.00000	.00000	.00000
1.83	1.18E+04	.03262	.00000	.20294	.74744	.00000	.01700	.00000	.00000	.00000	.00000
2.44	1.37E+04	.02893	.00000	.20353	.75190	.00000	.01563	.00000	.00000	.00000	.00000
3.05	1.57E+04	.02626	.00000	.20401	.75531	.00000	.01442	.00000	.00000	.00000	.00000
3.66	1.77E+04	.02424	.00000	.20451	.75838	.00000	.01287	.00000	.00000	.00000	.00000
4.27	1.98E+04	.02265	.00000	.20489	.76080	.00000	.01166	.00000	.00000	.00000	.00000
4.88	2.18E+04	.02137	.00000	.20521	.76274	.00000	.01067	.00000	.00000	.00000	.00000
5.49	2.38E+04	.02032	.00000	.20546	.76435	.00000	.00987	.00000	.00000	.00000	.00000
6.10	2.58E+04	.01944	.00000	.20568	.76569	.00000	.00919	.00000	.00000	.00000	.00000
6.71	2.78E+04	.01869	.00000	.20586	.76682	.00000	.00862	.00000	.00000	.00000	.00000
7.32	2.97E+04	.01805	.00000	.20602	.76779	.00000	.00813	.00000	.00000	.00000	.00000
7.92	3.16E+04	.01750	.00000	.20615	.76863	.00000	.00771	.00000	.00000	.00000	.00000
8.53	3.35E+04	.01702	.00000	.20627	.76937	.00000	.00734	.00000	.00000	.00000	.00000
9.14	3.53E+04	.01660	.00000	.20637	.77001	.00000	.00701	.00000	.00000	.00000	.00000
9.75	3.71E+04	.01622	.00000	.20647	.77058	.00000	.00673	.00000	.00000	.00000	.00000
10.36	3.89E+04	.01589	.00000	.20655	.77109	.00000	.00647	.00000	.00000	.00000	.00000
10.97	4.05E+04	.01559	.00000	.20662	.77154	.00000	.00624	.00000	.00000	.00000	.00000
11.58	4.22E+04	.01533	.00000	.20668	.77194	.00000	.00604	.00000	.00000	.00000	.00000
12.19	4.38E+04	.01509	.00000	.20674	.77231	.00000	.00586	.00000	.00000	.00000	.00000
12.80	4.54E+04	.01487	.00000	.20680	.77264	.00000	.00569	.00000	.00000	.00000	.00000
13.41	4.69E+04	.01468	.00000	.20684	.77293	.00000	.00554	.00000	.00000	.00000	.00000
14.02	4.83E+04	.01450	.00000	.20689	.77320	.00000	.00541	.00000	.00000	.00000	.00000
14.63	4.98E+04	.01434	.00000	.20693	.77344	.00000	.00529	.00000	.00000	.00000	.00000
15.24	5.11E+04	.01420	.00000	.20696	.77366	.00000	.00517	.00000	.00000	.00000	.00000
15.85	5.24E+04	.01407	.00000	.20699	.77386	.00000	.00507	.00000	.00000	.00000	.00000
16.46	5.37E+04	.01395	.00000	.20702	.77405	.00000	.00498	.00000	.00000	.00000	.00000
17.07	5.49E+04	.01384	.00000	.20705	.77421	.00000	.00490	.00000	.00000	.00000	.00000
17.68	5.61E+04	.01374	.00000	.20707	.77436	.00000	.00483	.00000	.00000	.00000	.00000
18.29	5.72E+04	.01365	.00000	.20709	.77449	.00000	.00476	.00000	.00000	.00000	.00000
18.90	5.83E+04	.01358	.00000	.20711	.77461	.00000	.00470	.00000	.00000	.00000	.00000
19.51	5.93E+04	.01350	.00000	.20713	.77472	.00000	.00464	.00000	.00000	.00000	.00000
20.12	6.02E+04	.01344	.00000	.20714	.77481	.00000	.00460	.00000	.00000	.00000	.00000
20.73	6.12E+04	.01339	.00000	.20716	.77490	.00000	.00455	.00000	.00000	.00000	.00000
21.34	6.20E+04	.01334	.00000	.20717	.77497	.00000	.00452	.00000	.00000	.00000	.00000
21.95	6.28E+04	.01330	.00000	.20718	.77504	.00000	.00448	.00000	.00000	.00000	.00000
22.56	6.36E+04	.01326	.00000	.20719	.77509	.00000	.00446	.00000	.00000	.00000	.00000
23.16	6.43E+04	.01323	.00000	.20720	.77513	.00000	.00444	.00000	.00000	.00000	.00000
23.77	6.50E+04	.01321	.00000	.20720	.77517	.00000	.00442	.00000	.00000	.00000	.00000
24.38	6.56E+04	.01319	.00000	.20721	.77520	.00000	.00440	.00000	.00000	.00000	.00000
24.99	6.61E+04	.01318	.00000	.20721	.77521	.00000	.00440	.00000	.00000	.00000	.00000
25.60	6.67E+04	.01317	.00000	.20721	.77522	.00000	.00439	.00000	.00000	.00000	.00000
26.21	6.71E+04	.01317	.00000	.20721	.77522	.00000	.00439	.00000	.00000	.00000	.00000
26.82	6.75E+04	.01318	.00000	.20721	.77521	.00000	.00440	.00000	.00000	.00000	.00000
27.43	6.79E+04	.01319	.00000	.20720	.77520	.00000	.00441	.00000	.00000	.00000	.00000
28.04	6.82E+04	.01321	.00000	.20720	.77517	.00000	.00442	.00000	.00000	.00000	.00000
28.65	6.85E+04	.01323	.00000	.20719	.77513	.00000	.00444	.00000	.00000	.00000	.00000
29.26	6.87E+04	.01326	.00000	.20718	.77509	.00000	.00446	.00000	.00000	.00000	.00000

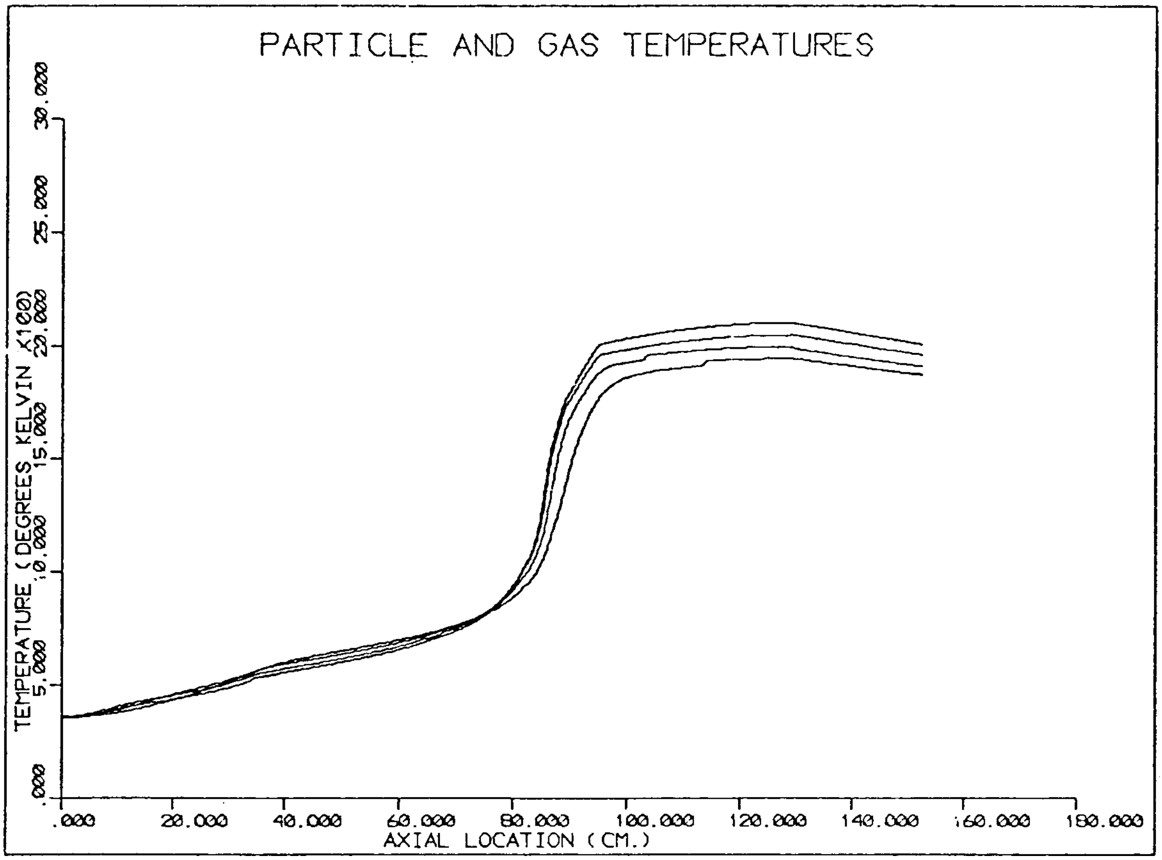
29.87	6.86E+04	.01329	.00000	.20717	.77504	.00000	.00449	.00000	.00000	.00000	.00000
30.48	6.90E+04	.01333	.00000	.20716	.77497	.00001	.00452	.00000	.00000	.00000	.00000
31.09	6.90E+04	.01338	.00000	.20715	.77490	.00001	.00456	.00000	.00000	.00000	.00000
31.70	6.90E+04	.01344	.00000	.20713	.77481	.00001	.00461	.00000	.00000	.00000	.00000
32.31	6.90E+04	.01350	.00000	.20711	.77472	.00001	.00466	.00000	.00000	.00000	.00000
32.92	6.89E+04	.01357	.00000	.20709	.77461	.00001	.00472	.00000	.00000	.00000	.00000
33.53	6.88E+04	.01365	.00000	.20707	.77449	.00001	.00478	.00000	.00000	.00000	.00000
34.14	6.87E+04	.01374	.00000	.20704	.77435	.00002	.00485	.00000	.00000	.00000	.00000
34.75	6.84E+04	.01383	.00000	.20701	.77420	.00002	.00494	.00000	.00000	.00000	.00000
35.36	6.84E+04	.01390	.00000	.20698	.77409	.00003	.00500	.00000	.00000	.00000	.00000
35.97	6.87E+04	.01391	.00000	.20697	.77407	.00003	.00502	.00000	.00000	.00000	.00000
36.58	6.90E+04	.01391	.00000	.20696	.77407	.00004	.00503	.00000	.00000	.00000	.00000
37.19	6.93E+04	.01391	.00000	.20694	.77406	.00005	.00504	.00000	.00000	.00000	.00000
37.80	6.96E+04	.01391	.00000	.20693	.77405	.00005	.00506	.00000	.00000	.00000	.00000
38.40	7.00E+04	.01391	.00000	.20691	.77405	.00006	.00507	.00000	.00000	.00000	.00000
39.01	7.03E+04	.01391	.00000	.20689	.77404	.00007	.00509	.00000	.00000	.00000	.00000
39.62	7.07E+04	.01391	.00000	.20687	.77403	.00008	.00511	.00000	.00000	.00000	.00000
40.23	7.10E+04	.01391	.00000	.20685	.77402	.00009	.00513	.00000	.00000	.00000	.00000
40.84	7.14E+04	.01391	.00000	.20683	.77401	.00010	.00515	.00000	.00000	.00000	.00000
41.45	7.17E+04	.01391	.00000	.20680	.77400	.00012	.00518	.00000	.00000	.00000	.00000
42.06	7.21E+04	.01391	.00000	.20677	.77398	.00013	.00520	.00000	.00000	.00000	.00000
42.67	7.24E+04	.01391	.00000	.20675	.77397	.00015	.00523	.00000	.00000	.00000	.00000
43.28	7.28E+04	.01391	.00000	.20671	.77396	.00016	.00526	.00000	.00000	.00000	.00000
43.89	7.31E+04	.01391	.00000	.20668	.77394	.00018	.00529	.00000	.00000	.00000	.00000
44.50	7.35E+04	.01391	.00000	.20665	.77393	.00020	.00532	.00000	.00000	.00000	.00000
45.11	7.39E+04	.01390	.00000	.20661	.77391	.00021	.00536	.00000	.00000	.00000	.00000
45.72	7.42E+04	.01390	.00000	.20657	.77389	.00023	.00540	.00000	.00000	.00000	.00000
46.33	7.46E+04	.01390	.00000	.20653	.77387	.00025	.00544	.00000	.00000	.00000	.00000
46.94	7.50E+04	.01390	.00000	.20649	.77385	.00028	.00548	.00000	.00000	.00000	.00000
47.55	7.53E+04	.01390	.00000	.20644	.77383	.00030	.00552	.00000	.00000	.00000	.00000
48.16	7.57E+04	.01390	.00000	.20639	.77381	.00033	.00557	.00000	.00000	.00000	.00000
48.77	7.61E+04	.01390	.00000	.20634	.77378	.00035	.00562	.00000	.00000	.00000	.00000
49.38	7.65E+04	.01390	.00000	.20628	.77376	.00038	.00568	.00000	.00000	.00000	.00000
49.99	7.69E+04	.01390	.00000	.20622	.77373	.00041	.00573	.00000	.00000	.00000	.00000
50.60	7.73E+04	.01390	.00000	.20616	.77370	.00044	.00579	.00000	.00000	.00001	.00000
51.21	7.77E+04	.01390	.00000	.20609	.77367	.00047	.00585	.00000	.00000	.00001	.00000
51.82	7.81E+04	.01390	.00000	.20602	.77364	.00051	.00592	.00000	.00000	.00001	.00000
52.43	7.85E+04	.01390	.00000	.20595	.77361	.00055	.00599	.00000	.00000	.00001	.00000
53.04	7.89E+04	.01390	.00000	.20587	.77357	.00059	.00606	.00000	.00000	.00001	.00000
53.64	7.93E+04	.01390	.00000	.20579	.77353	.00063	.00614	.00000	.00000	.00001	.00000
54.25	7.97E+04	.01390	.00000	.20571	.77349	.00067	.00623	.00000	.00000	.00001	.00000
54.86	8.01E+04	.01390	.00000	.20561	.77345	.00072	.00631	.00000	.00000	.00001	.00000
55.47	8.06E+04	.01390	.00000	.20552	.77341	.00077	.00641	.00000	.00000	.00001	.00000
56.08	8.10E+04	.01389	.00000	.20542	.77336	.00082	.00650	.00000	.00000	.00001	.00000
56.69	8.15E+04	.01389	.00000	.20531	.77331	.00087	.00661	.00000	.00000	.00001	.00000
57.30	8.19E+04	.01389	.00000	.20519	.77326	.00093	.00672	.00000	.00000	.00001	.00000
57.91	8.24E+04	.01389	.00000	.20507	.77320	.00099	.00683	.00000	.00000	.00001	.00000
58.52	8.29E+04	.01389	.00000	.20495	.77314	.00105	.00695	.00000	.00000	.00001	.00000
59.13	8.33E+04	.01389	.00000	.20481	.77308	.00112	.00708	.00000	.00000	.00001	.00000
59.74	8.38E+04	.01389	.00000	.20467	.77302	.00119	.00722	.00000	.00000	.00001	.00000
60.35	8.43E+04	.01389	.00000	.20452	.77295	.00127	.00736	.00000	.00000	.00002	.00000
60.96	8.49E+04	.01389	.00000	.20436	.77287	.00135	.00752	.00000	.00000	.00002	.00000
61.57	8.54E+04	.01388	.00000	.20419	.77280	.00144	.00768	.00000	.00000	.00002	.00000
62.18	8.59E+04	.01388	.00000	.20401	.77271	.00153	.00785	.00000	.00000	.00002	.00000
62.79	8.65E+04	.01388	.00000	.20382	.77263	.00162	.00803	.00000	.00000	.00002	.00000
63.40	8.71E+04	.01388	.00000	.20362	.77253	.00172	.00822	.00000	.00000	.00002	.00000
64.01	8.77E+04	.01388	.00000	.20341	.77244	.00183	.00843	.00000	.00000	.00002	.00000
64.62	8.83E+04	.01388	.00000	.20318	.77233	.00194	.00865	.00000	.00000	.00002	.00000
65.23	8.89E+04	.01387	.00000	.20294	.77222	.00207	.00888	.00000	.00000	.00002	.00000
65.84	8.95E+04	.01387	.00000	.20268	.77210	.00220	.00912	.00000	.00000	.00003	.00000

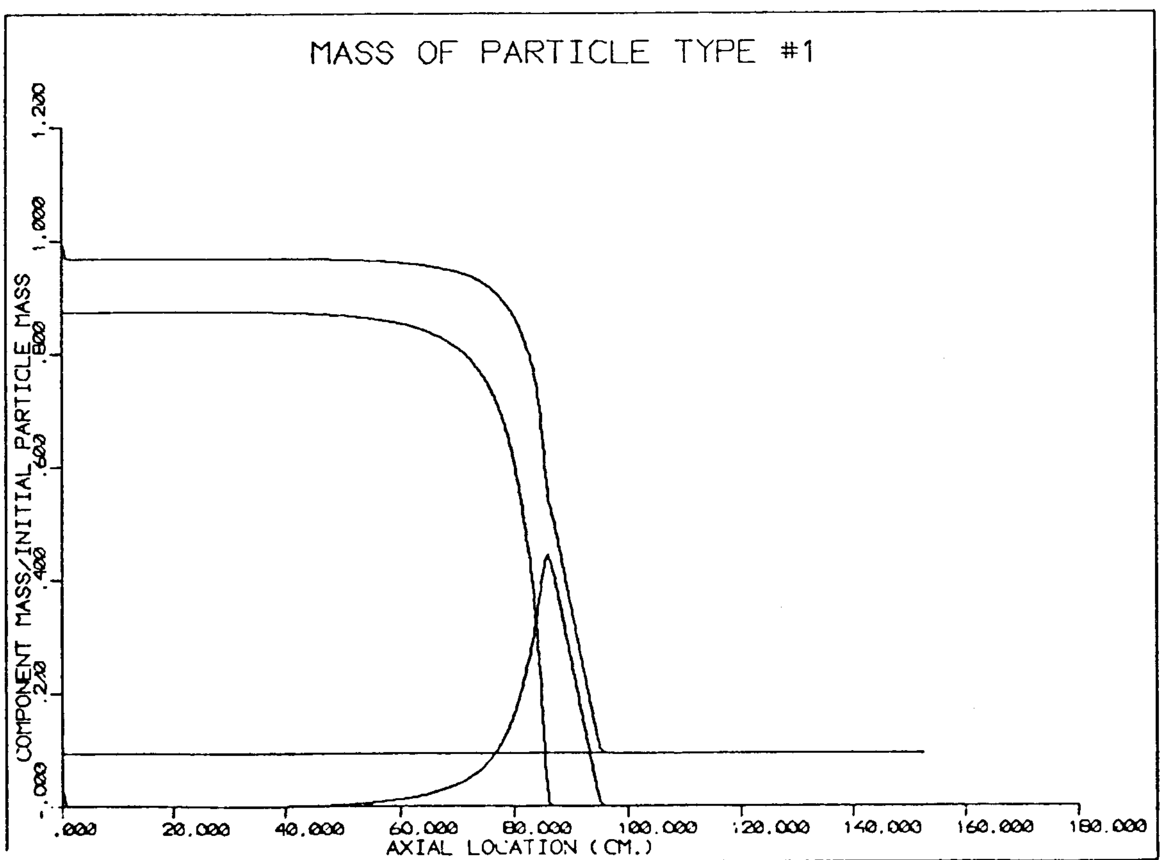
66.45	9.02E+04	.01387	.00000	.20241	.77198	.00233	.00938	.00000	.00000	.00003	.00000
67.06	9.09E+04	.01387	.00000	.20212	.77184	.00248	.00966	.00000	.00000	.00003	.00000
67.67	9.16E+04	.01386	.00000	.20181	.77170	.00264	.00996	.00000	.00000	.00003	.00000
68.28	9.24E+04	.01386	.00000	.20148	.77155	.00280	.01027	.00000	.00000	.00003	.00000
68.88	9.32E+04	.01386	.00000	.20113	.77139	.00298	.01061	.00000	.00000	.00004	.00000
69.49	9.40E+04	.01385	.00000	.20075	.77121	.00317	.01097	.00000	.00000	.00004	.00000
70.10	9.49E+04	.01385	.00000	.20035	.77103	.00337	.01136	.00000	.00000	.00004	.00000
70.71	9.58E+04	.01385	.00000	.19991	.77083	.00359	.01178	.00000	.00000	.00004	.00000
71.32	9.67E+04	.01384	.00000	.19945	.77061	.00383	.01222	.00000	.00000	.00005	.00000
71.93	9.77E+04	.01384	.00000	.19894	.77038	.00408	.01270	.00000	.00000	.00005	.00000
72.54	9.88E+04	.01383	.00000	.19840	.77013	.00436	.01322	.00000	.00000	.00005	.00000
73.15	9.99E+04	.01383	.00000	.19781	.76986	.00465	.01379	.00000	.00000	.00006	.00000
73.76	1.01E+05	.01382	.00000	.19718	.76957	.00497	.01439	.00000	.00000	.00006	.00000
74.37	1.02E+05	.01382	.00000	.19655	.76928	.00529	.01500	.00000	.00000	.00006	.00000
74.98	1.04E+05	.01381	.00000	.19580	.76893	.00567	.01571	.00000	.00000	.00007	.00000
75.59	1.05E+05	.01380	.00000	.19498	.76856	.00608	.01649	.00000	.00000	.00007	.00000
76.20	1.07E+05	.01380	.00000	.19409	.76815	.00653	.01735	.00000	.00000	.00008	.00000
76.81	1.08E+05	.01379	.00000	.19311	.76770	.00703	.01829	.00000	.00000	.00008	.00000
77.42	1.10E+05	.01378	.00000	.19203	.76720	.00757	.01932	.00000	.00000	.00009	.00001
78.03	1.12E+05	.01377	.00000	.19084	.76665	.00817	.02047	.00000	.00000	.00010	.00001
78.64	1.14E+05	.01376	.00000	.18951	.76604	.00885	.02174	.00000	.00000	.00011	.00001
79.25	1.17E+05	.01375	.00000	.18803	.76536	.00959	.02315	.00000	.00000	.00011	.00001
79.86	1.20E+05	.01373	.00000	.18637	.76460	.01043	.02473	.00000	.00000	.00012	.00001
80.47	1.23E+05	.01371	.00000	.18451	.76374	.01137	.02651	.00000	.00000	.00014	.00002
81.08	1.26E+05	.01370	.00000	.18240	.76278	.01244	.02851	.00000	.00000	.00015	.00002
81.69	1.30E+05	.01368	.00000	.18000	.76169	.01366	.03078	.00000	.00000	.00016	.00003
82.30	1.34E+05	.01365	.00000	.17727	.76045	.01507	.03334	.00000	.00000	.00018	.00004
82.91	1.39E+05	.01363	.00000	.17410	.75903	.01671	.03627	.00000	.00000	.00020	.00006
83.52	1.45E+05	.01360	.00000	.17036	.75741	.01871	.03961	.00000	.00000	.00022	.00009
84.12	1.52E+05	.01356	.00000	.16575	.75552	.02128	.04351	.00000	.00000	.00024	.00014
84.73	1.62E+05	.01352	.00000	.15961	.75323	.02496	.04818	.00000	.00000	.00027	.00023
85.34	1.75E+05	.01347	.00000	.15072	.75035	.03077	.05395	.00000	.00000	.00031	.00043
85.95	1.90E+05	.01342	.00000	.14077	.74756	.03771	.05943	.00000	.00000	.00034	.00077
86.56	2.02E+05	.01338	.00000	.13228	.74544	.04394	.06344	.00000	.00000	.00037	.00115
87.17	2.11E+05	.01336	.00000	.12575	.74405	.04899	.06598	.00000	.00000	.00038	.00149
87.78	2.19E+05	.01334	.00000	.11986	.74294	.05370	.06792	.00000	.00000	.00040	.00184
88.39	2.27E+05	.01333	.00001	.11366	.74187	.05876	.06971	.00000	.00000	.00041	.00224
89.00	2.33E+05	.01332	.00002	.10868	.74122	.06305	.07070	.00001	.00000	.00041	.00259
89.61	2.37E+05	.01332	.00003	.10521	.74101	.06631	.07086	.00001	.00000	.00041	.00283
90.22	2.41E+05	.01332	.00005	.10212	.74090	.06929	.07086	.00001	.00000	.00041	.00304
90.83	2.45E+05	.01332	.00007	.09892	.74078	.07237	.07086	.00002	.00000	.00041	.00327
91.44	2.48E+05	.01332	.00009	.09572	.74065	.07544	.07085	.00002	.00000	.00041	.00350
92.05	2.52E+05	.01332	.00013	.09255	.74052	.07848	.07084	.00003	.00000	.00041	.00373
92.66	2.55E+05	.01332	.00017	.08941	.74039	.08147	.07084	.00003	.00000	.00041	.00396
93.27	2.58E+05	.01332	.00022	.08633	.74025	.08441	.07082	.00004	.00000	.00041	.00418
93.88	2.62E+05	.01331	.00029	.08331	.74012	.08729	.07081	.00005	.00000	.00041	.00440
94.49	2.65E+05	.01331	.00037	.08036	.73998	.09009	.07080	.00007	.00000	.00041	.00461
95.10	2.68E+05	.01331	.00047	.07757	.73984	.09274	.07078	.00008	.00000	.00041	.00480
95.71	2.69E+05	.01331	.00051	.07628	.73979	.09398	.07077	.00008	.00000	.00041	.00487
96.32	2.69E+05	.01331	.00053	.07552	.73977	.09471	.07077	.00009	.00000	.00041	.00488
96.93	2.69E+05	.01331	.00055	.07477	.73976	.09545	.07077	.00009	.00000	.00041	.00490
97.54	2.70E+05	.01331	.00057	.07402	.73974	.09618	.07076	.00009	.00000	.00041	.00492
98.15	2.70E+05	.01331	.00059	.07327	.73972	.09690	.07076	.00009	.00000	.00041	.00493
98.76	2.71E+05	.01331	.00062	.07253	.73970	.09762	.07076	.00010	.00000	.00041	.00495
99.36	2.71E+05	.01331	.00064	.07180	.73969	.09834	.07075	.00010	.00000	.00041	.00496
99.97	2.72E+05	.01331	.00066	.07107	.73967	.09904	.07075	.00010	.00000	.00041	.00497
100.58	2.72E+05	.01331	.00069	.07035	.73966	.09975	.07074	.00010	.00000	.00041	.00499
101.19	2.72E+05	.01331	.00071	.06964	.73964	.10044	.07074	.00011	.00000	.00041	.00500
101.80	2.73E+05	.01331	.00074	.06893	.73962	.10113	.07074	.00011	.00000	.00041	.00501
102.41	2.73E+05	.01331	.00076	.06823	.73961	.10181	.07073	.00011	.00000	.00041	.00502

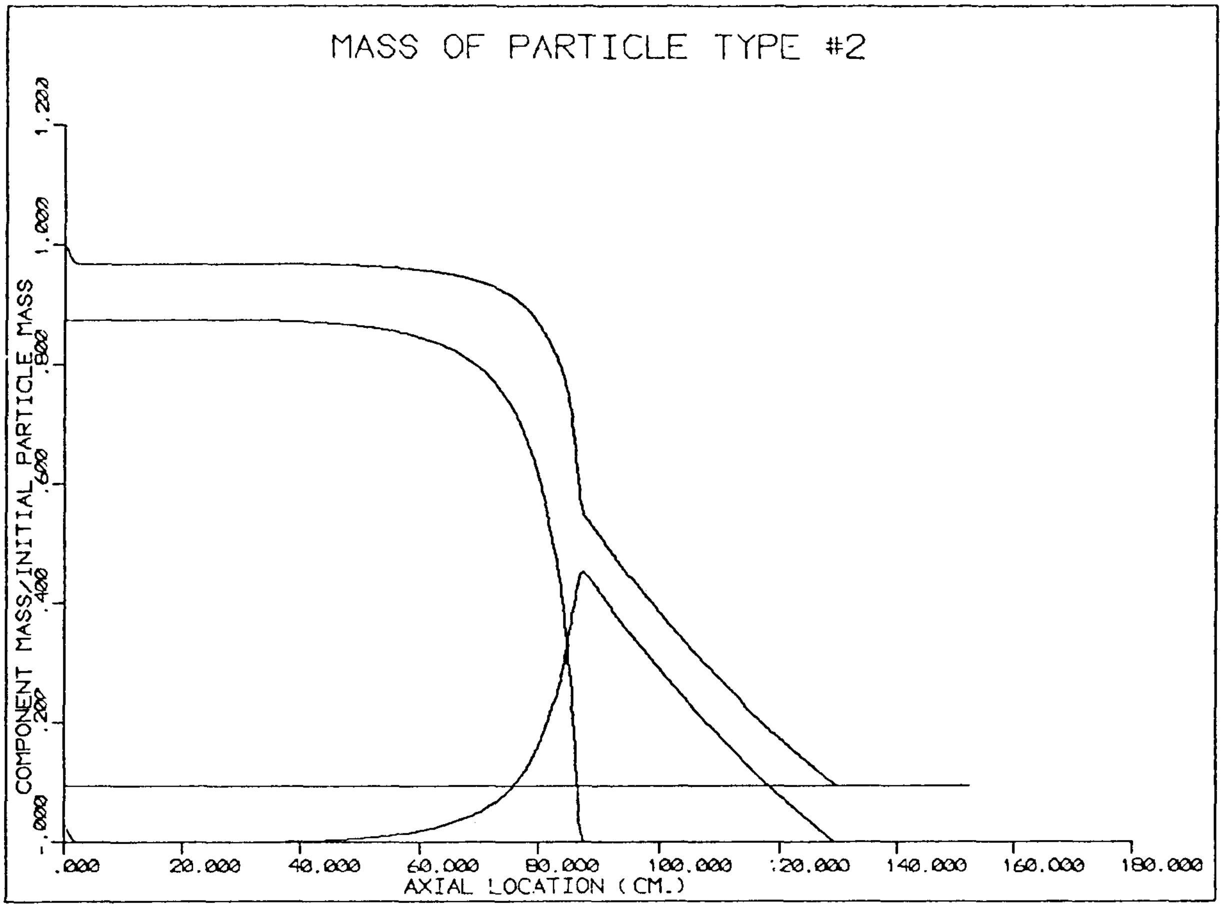
103.02	2.73E+05	.01331	.00079	.06754	.73960	.10249	.07073	.00012	.00000	.00041	.00502
103.63	2.74E+05	.01331	.00081	.06685	.73958	.10316	.07073	.00012	.00000	.00041	.00503
104.24	2.74E+05	.01331	.00084	.06616	.73957	.10383	.07072	.00012	.00000	.00041	.00504
104.85	2.74E+05	.01331	.00087	.06548	.73955	.10449	.07072	.00012	.00000	.00041	.00505
105.46	2.75E+05	.01331	.00089	.06480	.73954	.10515	.07071	.00013	.00000	.00041	.00505
106.07	2.75E+05	.01331	.00092	.06414	.73952	.10580	.07071	.00013	.00000	.00041	.00506
106.68	2.75E+05	.01331	.00095	.06348	.73951	.10644	.07071	.00013	.00000	.00041	.00506
107.29	2.76E+05	.01331	.00098	.06282	.73950	.10708	.07070	.00014	.00000	.00041	.00506
107.90	2.76E+05	.01331	.00100	.06218	.73949	.10771	.07070	.00014	.00000	.00041	.00507
108.51	2.76E+05	.01331	.00103	.06154	.73947	.10833	.07069	.00014	.00000	.00041	.00507
109.12	2.77E+05	.01331	.00106	.06091	.73946	.10895	.07069	.00014	.00000	.00041	.00507
109.73	2.77E+05	.01331	.00109	.06028	.73945	.10956	.07069	.00015	.00000	.00041	.00506
110.34	2.77E+05	.01331	.00111	.05967	.73944	.11016	.07068	.00015	.00000	.00041	.00506
110.95	2.77E+05	.01331	.00114	.05905	.73943	.11076	.07068	.00015	.00000	.00041	.00506
111.56	2.78E+05	.01331	.00117	.05845	.73942	.11135	.07068	.00015	.00000	.00041	.00506
112.17	2.78E+05	.01331	.00120	.05785	.73941	.11194	.07067	.00016	.00000	.00041	.00505
112.78	2.78E+05	.01331	.00122	.05726	.73941	.11252	.07067	.00016	.00000	.00041	.00504
113.39	2.78E+05	.01331	.00125	.05667	.73940	.11309	.07067	.00016	.00000	.00041	.00504
114.00	2.78E+05	.01331	.00129	.05584	.73939	.11391	.07066	.00017	.00000	.00041	.00503
114.60	2.79E+05	.01331	.00132	.05526	.73938	.11447	.07066	.00017	.00000	.00041	.00502
115.21	2.79E+05	.01331	.00135	.05470	.73937	.11503	.07065	.00017	.00000	.00041	.00501
115.82	2.79E+05	.01331	.00137	.05414	.73937	.11558	.07065	.00017	.00000	.00041	.00500
116.43	2.79E+05	.01331	.00140	.05358	.73936	.11612	.07065	.00018	.00000	.00041	.00499
117.04	2.79E+05	.01331	.00143	.05303	.73936	.11666	.07064	.00018	.00000	.00041	.00498
117.65	2.79E+05	.01331	.00145	.05249	.73935	.11720	.07064	.00018	.00000	.00041	.00497
118.26	2.80E+05	.01331	.00148	.05196	.73935	.11772	.07064	.00018	.00000	.00041	.00495
118.87	2.80E+05	.01331	.00150	.05143	.73934	.11825	.07063	.00018	.00000	.00041	.00494
119.48	2.80E+05	.01331	.00153	.05090	.73934	.11877	.07063	.00019	.00000	.00041	.00493
120.09	2.80E+05	.01331	.00155	.05038	.73934	.11928	.07063	.00019	.00000	.00041	.00491
120.70	2.80E+05	.01331	.00158	.04987	.73934	.11979	.07062	.00019	.00000	.00041	.00490
121.31	2.80E+05	.01330	.00160	.04936	.73933	.12029	.07062	.00019	.00000	.00041	.00488
121.92	2.80E+05	.01330	.00163	.04886	.73933	.12079	.07062	.00019	.00000	.00041	.00487
122.53	2.80E+05	.01330	.00165	.04836	.73933	.12128	.07061	.00020	.00000	.00041	.00485
123.14	2.81E+05	.01330	.00167	.04787	.73933	.12177	.07061	.00020	.00000	.00041	.00483
123.75	2.81E+05	.01330	.00170	.04738	.73933	.12225	.07061	.00020	.00000	.00041	.00481
124.36	2.81E+05	.01330	.00172	.04690	.73933	.12273	.07061	.00020	.00000	.00041	.00480
124.97	2.81E+05	.01330	.00174	.04642	.73933	.12321	.07060	.00020	.00000	.00041	.00478
125.58	2.81E+05	.01330	.00176	.04595	.73933	.12368	.07060	.00021	.00000	.00041	.00476
126.19	2.81E+05	.01330	.00178	.04548	.73934	.12414	.07060	.00021	.00000	.00041	.00474
126.80	2.81E+05	.01330	.00180	.04502	.73934	.12460	.07060	.00021	.00000	.00041	.00472
127.41	2.81E+05	.01330	.00182	.04456	.73934	.12506	.07060	.00021	.00000	.00041	.00470
128.02	2.81E+05	.01330	.00184	.04411	.73934	.12551	.07059	.00021	.00000	.00041	.00467
128.63	2.81E+05	.01330	.00186	.04366	.73935	.12596	.07059	.00021	.00000	.00041	.00465
129.24	2.81E+05	.01330	.00188	.04322	.73935	.12640	.07059	.00021	.00000	.00041	.00463
129.84	2.81E+05	.01330	.00185	.04309	.73938	.12657	.07059	.00021	.00000	.00041	.00459
130.45	2.80E+05	.01330	.00181	.04296	.73941	.12674	.07060	.00021	.00000	.00041	.00456
131.06	2.80E+05	.01330	.00178	.04283	.73945	.12690	.07060	.00020	.00000	.00041	.00452
131.67	2.80E+05	.01330	.00175	.04270	.73948	.12706	.07061	.00020	.00000	.00041	.00449
132.28	2.79E+05	.01330	.00172	.04257	.73950	.12723	.07061	.00020	.00000	.00041	.00445
132.89	2.79E+05	.01330	.00169	.04244	.73954	.12739	.07062	.00019	.00000	.00041	.00441
133.50	2.79E+05	.01330	.00166	.04232	.73957	.12755	.07062	.00019	.00000	.00041	.00438
134.11	2.78E+05	.01330	.00163	.04219	.73959	.12771	.07063	.00019	.00000	.00041	.00434
134.72	2.78E+05	.01330	.00161	.04206	.73962	.12787	.07063	.00018	.00000	.00041	.00431
135.33	2.77E+05	.01331	.00158	.04194	.73965	.12802	.07063	.00018	.00000	.00041	.00427
135.94	2.77E+05	.01331	.00155	.04181	.73968	.12818	.07064	.00018	.00000	.00041	.00424
136.55	2.77E+05	.01331	.00152	.04169	.73971	.12834	.07064	.00018	.00000	.00041	.00421
137.16	2.76E+05	.01331	.00150	.04156	.73974	.12849	.07065	.00017	.00000	.00041	.00417
137.77	2.76E+05	.01331	.00147	.04144	.73976	.12865	.07065	.00017	.00000	.00041	.00414
138.38	2.76E+05	.01331	.00145	.04132	.73979	.12880	.07065	.00017	.00000	.00041	.00411
138.99	2.75E+05	.01331	.00142	.04119	.73982	.12895	.07066	.00016	.00000	.00041	.00407

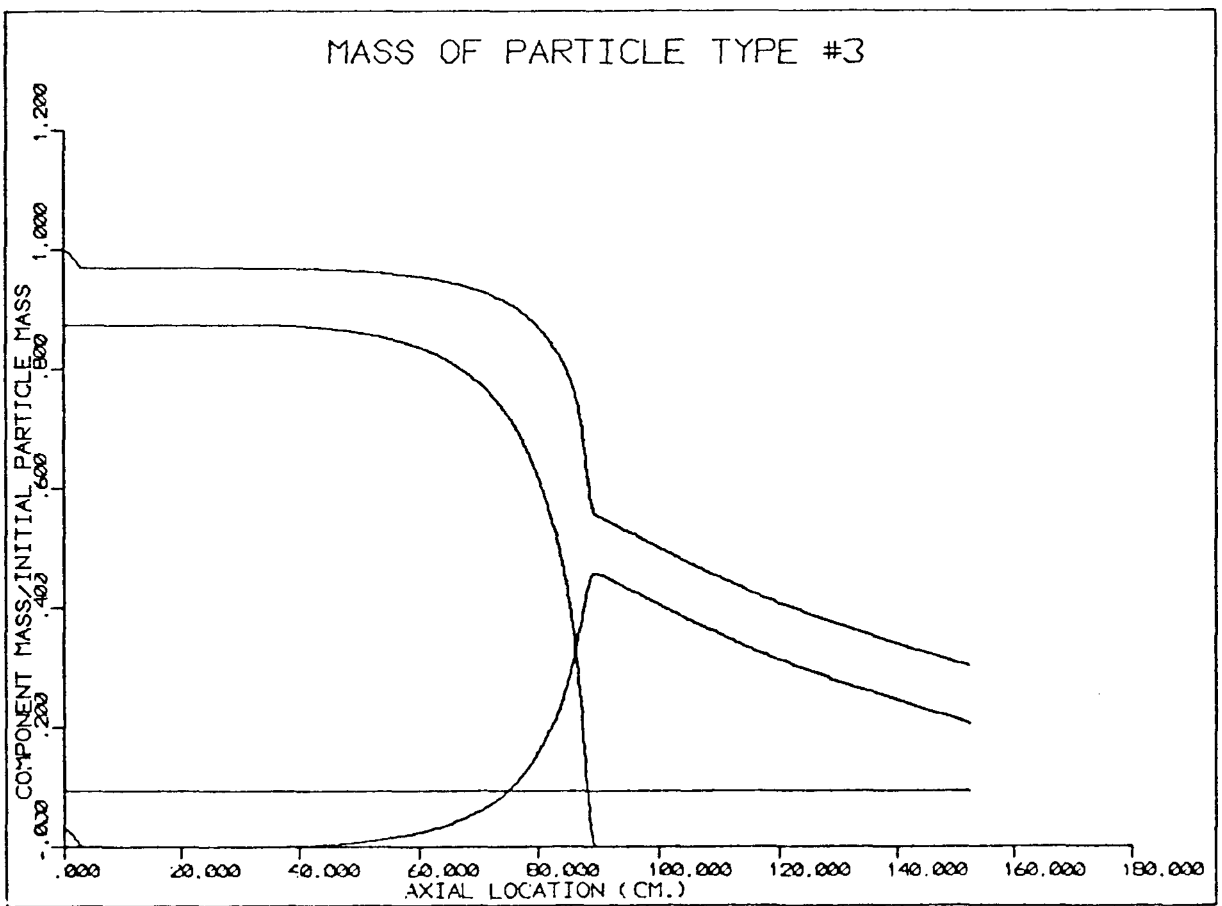
139.60	2.75E+05	.01331	.00140	.04107	.73984	.12910	.07066	.00016	.00000	.00041	.00404
140.21	2.75E+05	.01331	.00137	.04095	.73987	.12925	.07066	.00016	.00000	.00041	.00401
140.82	2.74E+05	.01331	.00135	.04083	.73989	.12940	.07067	.00016	.00000	.00041	.00398
141.43	2.74E+05	.01331	.00133	.04071	.73992	.12955	.07067	.00015	.00000	.00041	.00395
142.04	2.74E+05	.01331	.00130	.04059	.73994	.12970	.07067	.00015	.00000	.00041	.00392
142.65	2.73E+05	.01331	.00128	.04047	.73997	.12985	.07068	.00015	.00000	.00041	.00388
143.26	2.73E+05	.01331	.00126	.04035	.73999	.12999	.07068	.00015	.00000	.00041	.00385
143.87	2.73E+05	.01331	.00124	.04023	.74002	.13014	.07068	.00014	.00000	.00041	.00382
144.48	2.72E+05	.01331	.00122	.04011	.74004	.13028	.07069	.00014	.00000	.00041	.00379
145.08	2.72E+05	.01331	.00120	.04000	.74007	.13043	.07069	.00014	.00000	.00041	.00376
145.69	2.72E+05	.01331	.00117	.03988	.74009	.13057	.07069	.00014	.00000	.00041	.00373
146.30	2.71E+05	.01331	.00115	.03976	.74011	.13071	.07070	.00013	.00000	.00041	.00370
146.91	2.71E+05	.01331	.00113	.03965	.74013	.13085	.07070	.00013	.00000	.00041	.00368
147.52	2.71E+05	.01331	.00112	.03953	.74016	.13100	.07070	.00013	.00000	.00041	.00365
148.13	2.70E+05	.01331	.00110	.03942	.74018	.13113	.07071	.00013	.00000	.00041	.00362
148.74	2.70E+05	.01331	.00108	.03930	.74020	.13127	.07071	.00013	.00000	.00041	.00359
149.35	2.70E+05	.01331	.00106	.03919	.74022	.13141	.07071	.00012	.00000	.00041	.00356
149.96	2.69E+05	.01331	.00104	.03907	.74024	.13155	.07071	.00012	.00000	.00041	.00353
150.57	2.69E+05	.01331	.00102	.03896	.74027	.13169	.07072	.00012	.00000	.00041	.00351
151.18	2.69E+05	.01331	.00100	.03885	.74029	.13182	.07072	.00012	.00000	.00041	.00348
151.79	2.68E+05	.01331	.00099	.03873	.74031	.13196	.07072	.00012	.00000	.00041	.00345
152.40	2.68E+05	.01331	.00097	.03862	.74033	.13209	.07072	.00011	.00000	.00041	.00342

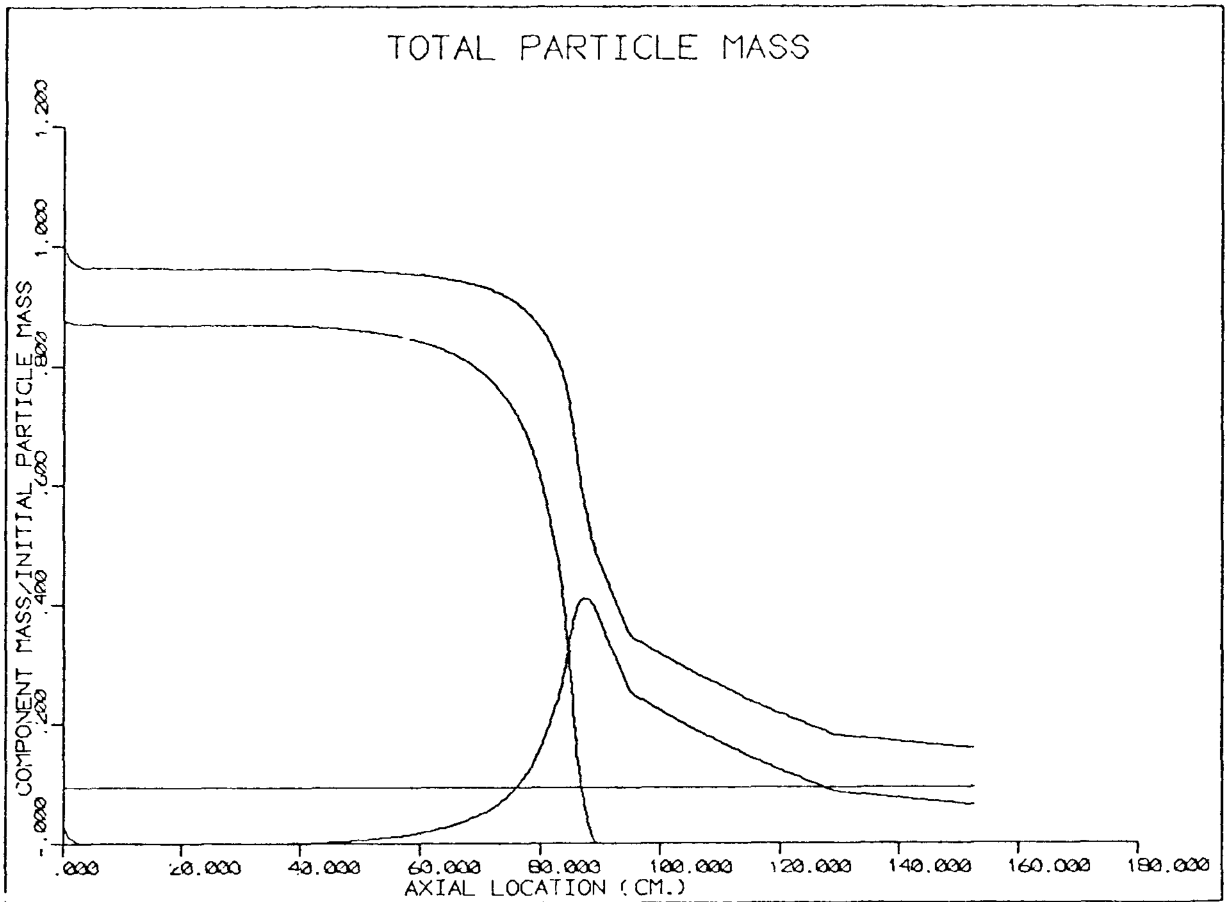
OUTPUT PLOTS FOR SAMPLE CALCULATIONS

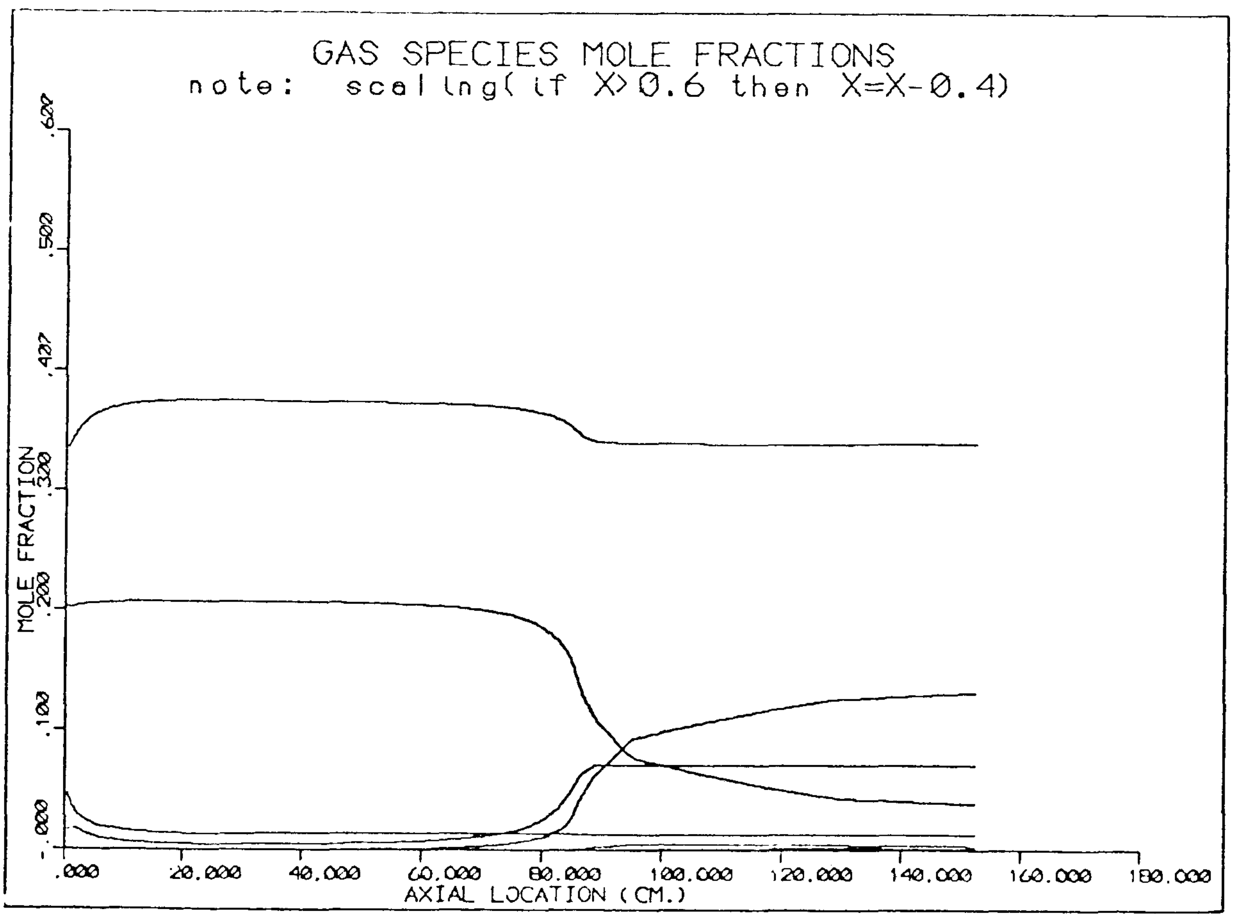





MASS OF PARTICLE TYPE #2
COMPONENT MASS/INITIAL PARTICLE MASS
-.000
.200
.400
.600
.800
1.000
1.200
.000
20.000
40.000
60.000
80.000
100.000
120.000
140.000
160.000
180.000
AXIAL LOCATION (CM.)


MASS OF PARTICLE TYPE #3
COMPONENT MASS/INITIAL PARTICLE MASS
-.000
.200
.400
.600
.800
1.000
1.200
.000
20.000
40.000
60.000
80.000
100.000
120.000
140.000
160.000
180.000
AXIAL LOCATION (CM.)


TOTAL PARTICLE MASS
COMPONENT MASS/INITIAL PARTICLE MASS
AXIAL LOCATION (CM.)


GAS SPECIES MOLE FRACTIONS
note: scaling(if X>0.6 then X=X-0.4)
MOLE FRACTION
AXIAL LOCATION (CM.)

Appendix B

1-DICOG PROGRAM FORTRAN LISTING


```
      COMMON/EDNUM/RHOG,CPG,TG,CPI(20),X(20),CO(5),HGAS,EDNAME(9),
     1OXYD(5),GMW,QMASS(9,20),WTM(20)
      COMMON/TRUBLE/INDX,ITRBLE
      COMMON /RADI/T0(255,5),N0(5),D0(5),SIGMA,PI,E(5),IT(255),H0(5)
     1,NUMRDR,DEL,IRAD,TOOLD(5)
      COMMON /GENRAL/ALPHAA(5),S(20),KG,MUG,DS,
     1TPJJ(5),YY(5,5),PRTCLS,SPECIE,
     2ELEMNT,CRXN,HRXN,HH(5),HW(5),RGC
      COMMON /LAST/GASTMN,TMIN(5),IQ0J(255,5)
      COMMON /DIFEQN/OMEGAK(9),ALPHA(5),ALPHAC(5),ALPHAH(5),
     1ALPHAW(5),N(5),H(5),QF(5),QCB,QZ(5),P,V,HG(5),RK(5,9),
     2RL(5,20),RM(5,20),RC(5),RH(5),RW(5),RR(5),W(5),WG,AREA,PRESSR
      COMMON /ODEVAL/XDIS,XTRMNL,VALINT(42),ODESTP
      COMMON /APR77/DELTPJ,DELRRJ,ALEN,JFAR,HM,DIFMW,ICNVLM,
     1TTEST,SUMSQ,ITRSYS,GAST(255),OSPRR,NPROP,ARMAX,AMIN,SQDIF
      COMMON/CONVER/ITRMAX,DYNAMO(3),DYNTEM,DYNFLG,DYNFLO
      REAL N,N0
      INTEGER PRTCLS,ELEMNT,CRXN,BUG,ODESTP,DYNAMO,DYNFLG,DYNFLO
     1,OSPRR,ODEST0,OSPRR0
C
C
C*****INITIALIZATION
C
      ITRBLE=0
      CALL INPUT
      CALL VALUE
      ITRSYS=0
      ODEST0=ODESTP
      OSPRR0=OSPRR
      HGAS0=HGAS
      GMW0=GMW
C
C*****INITIALIZATION AND REINITIALIZATION FOR SECOND ITERATION OR MORE
C
20    ITRSYS=ITRSYS+1
      IDISP=0
      SUMSQ=0.0
      XDIS=0.0
      DYNFLG=0
      DYNFLO=DYNFLG
      ODESTP=ODEST0
      OSPRR=OSPRR0
      HGAS=HGAS0
      GMW=GMW0
      IF(IRAD.NE.1)CALL RINTS
      DO 25 J=1,PRTCLS
      N(J)=N0(J)
      TPJJ(J)=TMIN(J)
25    H(J)=H0(J)
      P=PRESSR
30    CALL SOLVE(IDISP,JX)
C
C*****RESTART INFORMATION WHEN CHANGING STEP SIZE OR SIMPLY RESTARTING
```

```
C
        IF(JX.GT.3)JX=JX-1
        IDISP=IDISP+JX
        IF(DYNFLO.NE.0.OR.DYNFLG.NE.1)GO TO 35
        DYNFLO=DYNFLG
        ODESTP=ODESTO*DYNAMO(1)
        OSPRR=OSPRRO*DYNAMO(1)
        IDISP=IDISP*DYNAMO(1)
35      IF(DYNFLO.NE.1.OR.DYNFLG.NE.2)GO TO 40
        DYNFLO=DYNFLG
        ODESTP=ODESTO*DYNAMO(2)
        OSPRR=OSPRRO*DYNAMO(2)
        IDISP=(IDISP/DYNAMO(1))*DYNAMO(2)
40      IF(DYNFLO.NE.2.OR.DYNFLG.NE.3)GO TO 45
        DYNFLO=DYNFLG
        ODESTP=ODESTO/DYNAMO(3)
        OSPRR=OSPRRO/DYNAMO(3)
        IDISP=(IDISP/DYNAMO(2))/DYNAMO(3)
45      IF(IDISP.LT.(ODESTP-1))GO TO 30
C
C*****TERMINATION
C
        SUMSQ=SQRT(SUMSQ/(FLOAT(NUMRDR)+FLOAT(PRTCLS)))
        WRITE(3,100)ITRSYS,SUMSQ
        CALL RESTRT(0)
        IF(SUMSQ.GT.SQDIF.AND.ITRSYS.LT.ITRMAX)GO TO 20
        CALL OUTPUT
        STOP
100     FORMAT(7H0AFTER ,I2,86H ITERATION(S) THROUGH THE REACTOR THE ROOT
       1 MEAN SQUARE OF ALL PARTICLE TEMPERATURES IS,F9.3,15H DEGREES
       2 KELVIN)
        END
```

```
      SUBROUTINE ASCALE(X,N,S,XIV,DX,XFV)
C  SCALE IS INCREMENTED IN MULTIPLES OF 1,2,5 OR 6 FROM .01 TO 600
C  OVERRANGE MAKES DX.LT.0.0
      DIMENSION X(N)
C  FIND THE MAX AND MIN VALUES OF THE DATA
      XMAX=X(1)
      XMIN=X(1)
      DO 10 I=2,N
      IF(X(I).GT.XMAX) XMAX=X(I)
      IF(X(I).LT.XMIN) XMIN=X(I)
10    CONTINUE
C  CALCULATE MINIMUM SCALE VALUE AND SCALE INCREMENT
      XIV=AINT(XMIN)
      DX=.0001
      DO 20 I=1,7
      DO 15 J=1,5
      XI=XIV
      IF(J.EQ.2) DX=2.*DX
      IF(J.EQ.3) DX=(DX/2.)*2.5
      IF(J.EQ.4) DX=(DX/2.5)*5.
      IF(J.EQ.5) DX=(DX/5.)*6.
      Y=AINT(XI/DX)
      XI=Y*DX
      IF(Y.EQ.0.0) XI=DX
      IF(XI.GT.XMIN) XI=XI-DX
      IF(XI+S*DX.GE.XMAX) GOTO 30
15    CONTINUE
20    DX=(DX/6.0)*10.0
30    XIV=XI
      IF(DX.LT.1000.0) GO TO 101
      DX=-1*DX/2.
101   XFV=XIV+S*DX
      RETURN
      END
```

```
      SUBROUTINE AUX1
      COMMON/STIFF/ISASUM,ISTIFF(5),STIFVL
      COMMON /LAST/GASTMN,TMIN(5),IQOJ(255,5)
      COMMON/EDNUM/RHOG,CPG,TG,CPI(20),X(20),CO(5),HGAS,EDNAME(9),
     1OXYO(5),GMW,QMASS(9,20),WTM(20)
      COMMON /APR77/DELTPJ,DELRRJ,ALEN,JFAR,HM,DIFMW,ICNVLM,
     1TTEST,SUMSQ,ITRSYS,GAST(255),OSPRR,NPROP,ARMAX,AMIN,SQDIF
      COMMON /IO/DDUCT,DYDXM,AGSTPD,CPVC(3,5,5),HFV(5,5),DELHV(5,5),
     1INTCPV(5,5),QRBJ(5)
      COMMON/MORE/D01(255,5),N01(255,5),ALFA0(255,5),ALFA0C(255,5),
     1ALFA0H(255,5),ALFA0W(255,5),ALFA0A(255,5),X0(255,20),WVG(255)
      COMMON /ADD/CCP(5,4,3)
      COMMON /AREA13/ALFAC0(5),GAMMA,EK(20),XI(5),AMJ(5,5),
     1EMJ(5,5),KVD(5,5),TB,D(5),RHOC(5),RHO(5),DELTA(20),DIFM(20)
     2,ALFAH0(5),ALFAW0(5),ALFAA0(5)
      COMMON /AREA2/K(20),MU(20),SHRINK,HH0(5),HW0(5),EB,ELAM,
     1EUCKEN
      COMMON /AREA4/AL(5,5),EL(5,5),MH,PHIJWK(5,9),
     1PHIL(5),PHIKL(9,5),PHIVK(5,9,5),KEQ,EMM(5,5)
      COMMON /AREA5/NPRINT,TNIRP,CHECK,BUG
      COMMON /RADI/T0(255,5),N0(5),D0(5),SIGMA,PI,E(5),IT(255),H0(5)
     1,NUMRDR,DEL,IRAD,TOOLD(5)
      COMMON /GENRAL/ALPHAA(5),S(20),KG,MUG,DS,
     1TPJJ(5),YY(5,5),PRTCLS,SPECIE,
     2ELEMNT,CRXN,HRXN,HH(5),HW(5),RGC
      COMMON/GNRAL2/NAME1(20),NAME2(20)
      COMMON /DIFEQN/OMEGAK(9),ALPHA(5),ALPHAC(5),ALPHAH(5),
     1ALPHAW(5),N(5),H(5),QF(5),QCB,QZ(5),P,V,HG(5),RK(5,9),
     2RL(5,20),RM(5,20),RC(5),RH(5),RW(5),RR(5),W(5),WG,AREA,PRESSR
      COMMON /ODEVAL/XDIS,XTRMNL,VALINT(42),ODESTP
      INTEGER PRTCLS,ELEMNT,SPECIE,BUG,CRXN,SHRINK,ODESTP,OSPRR
      REAL IT,IQOJ,N,N0,MH,N01,HOLD,INTCPV,CP(5)
      DIMENSION HOLD(5),RHOSIG(5)
C
C*****RADIATION REGIONS
C
      IQ=IFIX(FLOAT(JFAR)/FLOAT(OSPRR))+1
      IF(JFAR.EQ.ODESTP)IQ=NUMRDR
      IF(IRAD.NE.1)GO TO 2
      SAJ=0.0
      DO 1 J=1,PRTCLS
      IF(XDIS.EQ.0.0)D(J)=D0(J)
      AJ=(PI/4.0)*E(J)*N(J)*D(J)**2
1     SAJ=AJ+SAJ
2     CONTINUE
C
C*****TOTAL PARTICLE COMPONENT MASS
C
      DO 50 J=1,PRTCLS
      ALPHA(J)=ALPHAC(J)+ALPHAH(J)+ALPHAW(J)+ALPHAA(J)
C
C*****PARTICLE DIAMETER
C
```

```
      IF(ALFACO(J).NE.0.0)D(J)=DO(J)*(1.0+GAMMA*((ALFACO(J)-
     1ALPHAC(J))/ALFACO(J)))
      IF(ALFACO(J).EQ.0.0)D(J)=DO(J)
      IF(SHRINK.EQ.1.AND.ALFACO(J).EQ.0.0)RHOSIG(J)=
     16.0*(ALFAHO(J)+ALFAWO(J)+ALFAAO(J))/(PI*DO(J)**3)
      IF(SHRINK.EQ.1.AND.ALPHAC(J).NE.0.0)RHOSIG(J)=6.0*ALPHA(J)/(PI
     1*D(J)**3)
      IF(SHRINK.EQ.1.AND.ALPHAC(J).EQ.0.0)D(J)=(6.0*ALPHA(J)/(PI
     1*RHOSIG(J)))**(1./3.)
      IF(ALFAAO(J).EQ.0.0.AND.D(J).LT.1.0E-12)D(J)=1.0E-12
C
C*****PARTICLE DENSITY
C
      RHOC(J)=ALPHAC(J)*N(J)
      RHOHJ=ALPHAH(J)*N(J)
      RHOWJ=ALPHAW(J)*N(J)
      RHOAJ=ALPHAA(J)*N(J)
      RHO(J)=RHOC(J)+RHOHJ+RHOWJ+RHOAJ
C
C*****PARTICLE MASS FRACTIONS
C
      OMEGAC=ALPHAC(J)/ALPHA(J)
      OMEGAH=ALPHAH(J)/ALPHA(J)
      OMEGAW=ALPHAW(J)/ALPHA(J)
      OMEGAA=ALPHAA(J)/ALPHA(J)
C
C*****RADIATIVE HEAT TRANSFER WITHIN THE REACTOR
C
      QF(J)=PI/4.0*IT(IQ)*N(J)*D(J)**2*E(J)-IQ0J(IQ,J)/
     1 ALEN*FLOAT(NUMRDR)
      IF(IRAD.NE.1) GO TO 3
      IF(IQ.LT.NUMRDR)DTDX=(TO(IQ+1,J)-TOOLD(J))*NUMRDR/ALEN
      QF(J)=-16.0*SIGMA*TOOLD(J)**3*DTDX/(3.0*SAJ*ALEN/FLOAT(NUMRDR))
3     CONTINUE
C
C*****PARTICLE TEMPERATURE -- DOWN TO STATEMENT NUMBER 30
C     NOTE:  THE FOLLOWIND DO LOOP IS NECCESARY AS A TRIAL AND ERROR
C            APPROACH TO GETTING THE PARTICLE TEMPERATURE SINCE THE
C            HEAT CAPACITY MUST BE KNOWN FIRST AND SINCE HEAT CAPACITY
C            IS A FUNCTION OF TEMPERATURE.
C
      TMP=TPJJ(J)
      TJ0=TMP
C
C*****STIFF EQUATION ASSUMPTION?
C
      IF(ISASUM.LE.0.OR.ISTIFF(J).NE.1) GO TO 5
      C=QZ(J)/(TJ0-TG0)
      R=(4.*SIGMA*EB/DS)*(1.-EXP(-ELAM*(PI/4.)*(DS/2.)*N(J)*D(J)**2))
      F=QF(J)+R*TB**4+C*TG-RR(J)*HOLD(J)
      CC=F/C
      DD=R/C
      DO 4 L=1,20
```

```
      TPJJ0=TMP
      TMP=CC-DD*TMP**4
      IF(ABS(TMP-TPJJ0).LE.DELTPJ)GO TO 5
4     CONTINUE
5     DO 10 L=1,20
      TPJJ0=TMP
C
C*****HEAT CAPACITIES
C
      CPCJ=CCP(J,1,1)+CCP(J,1,2)*TMP+CCP(J,1,3)*TMP**2
      CPHJ=CCP(J,2,1)+CCP(J,2,2)*TMP+CCP(J,2,3)*TMP**2
      CPWJ=CCP(J,3,1)+CCP(J,3,2)*TMP+CCP(J,3,3)*TMP**2
      CPAJ=CCP(J,4,1)+CCP(J,4,2)*TMP+CCP(J,4,3)*TMP**2
      CP(J)=OMEGAC*CPCJ+OMEGAH*CPHJ+OMEGAW*CPWJ+OMEGAA*CPAJ
C
C*****INITIALIZING PAST PARTICLE ENTHALPY
C
      IF(XDIS.LE.0.0)HOLD(J)=H(J)
C
C*****CALCULATING PARTICLE ENTHALPY WHEN THE PSSA STIFF ASSUMPTION IS USED
C
      IF(ISASUM.GT.0.AND.ISTIFF(J).EQ.1)H(J)=HOLD(J)+CP(J)*(TMP-TJ0)
C
C*****PARTICLE TEMPERATURE
C
      TMP=TJ0+(H(J)-HOLD(J))/CP(J)
C
C*****DEBUG
C
      IF (TNIRP.EQ.1.0.AND.BUG.GE.2)
     1     WRITE(3,340)CPCJ,CPHJ,CPWJ,CPAJ,CP(J)
      IF (TNIRP.EQ.1.0.AND.BUG.GE.2)
     1     WRITE(3,350)TMP,H(J),HOLD(J)
C
C*****TEST FOR CONVERGENCE
C
      IF(ABS(TMP-TPJJ0).LE.DELTPJ)GO TO 20
10    CONTINUE
20    TPJJ(J)=TMP
C
C*****DEBUG
C
      IF (TNIRP.EQ.1.0.AND.BUG.GE.2)
     1WRITE(3,310) J,RHOC(J),RHOHJ,RHOWJ,RHOAJ,RHO(J)
      IF (TNIRP.EQ.1.0.AND.BUG.GE.1)
     1WRITE(3,330) OMEGAC,OMEGAH,OMEGAW,OMEGAA
C
C*****RESETTING OLD ENTHALPY
C
30    HOLD(J)=H(J)
C
C*****CHAR AND WATER ENTHALPY
C
```

```
      T1=298.0
      T2=TPJJ(J)
      DT1=T2-T1
      DT2=(T2**2-T1**2)/2.0
      DT3=(T2**3-T1**3)/3.0
      HH(J)=CCP(J,2,1)*DT1+CCP(J,2,2)*DT2+CCP(J,2,3)*DT3+HH0(J)
      HW(J)=CCP(J,3,1)*DT1+CCP(J,3,2)*DT2+CCP(J,3,3)*DT3+HW0(J)
C
C*****INTEGRAL OF HEAT CAPACITY FROM 298KTO PRESENT TEMPERATURE
C     TO BE USED IN AUX3
C
      DO 40 M1=1,CRXN
40    INTCPV(J,M1)=CPVC(1,J,M1)*DT1+CPVC(2,J,M1)*DT2+CPVC(3,J,M1)*DT3
C
C*****RADIATIVE HEAT TRANSFER TO SURROUNDINGS
C
      QRBJ(J)=4.0*SIGMA*EB*(TPJJ(J)**4-TB**4)/DS*(1.0-EXP(-ELAM*PI/
     14.0*DS/2.0*N(J)*D(J)**2))
C
C*****DEBUG
C
      IF(TNIRP.EQ.1.0.AND.BUG.GE.1)WRITE(3,370)J,QRBJ(J),QF(J)
      IF(TNIRP.EQ.1.0.AND.BUG.GE.2)WRITE(3,360)J,HH(J),HW(J)
50    CONTINUE
C
C*****SAVING OLD GAS TEMPERATURE
C
      TG0=TG
C
C*****FORMAT STATEMENTS
C
310   FORMAT(1H ,3HJ =,I2,4X,9HRHOC(J) =,E12.5,4X,9HRHOH(J) =,E12.5,4X,
     19HRHOW(J) =,E12.5,4X,9HRHOA(J) =,E12.5,4X,4X,9HRHO(J) = ,E12.5)
320   FORMAT(1H0,10X,6HSUMI =,E12.4,10X,6HSUMK =,E12.4)
330   FORMAT(8H OMEGAC=,E12.5,8H OMEGAH=,E12.5,8H OMEGAW=,E12.5,
     18H OMEGAA=,E12.5)
340   FORMAT(6H CPCJ=,E12.5,6H CPHJ=,E12.5,6H CPWJ=,E12.5,6H CPAJ=,
     1E12.5,7H CP(J)=,E12.5)
350   FORMAT(6H T(J)=,E12.5,6H H(J)=,E12.5,8H HOLD(J),E12.5)
360   FORMAT(4H J =,I2,4X,4X,7HHH(J) =,E12.5,4X,7HHW(J) =,E12.5)
370   FORMAT(4H J =,I2,8X,10HQRBJ(J) = ,E12.5,8X,8HQF(J) = ,E12.5)
      RETURN
      END
```

```
      SUBROUTINE AUX2PR
C
C****NOTE:  AUX2PR IS A MODULAR SUBROUTINE WHICH CALCULATES THE PHYSICAL
C     PROPERTIES, TRANSPORT DATA, ETC. THAT DO NOT CHANGE SIGNIFICANTLY
C  FROM ONE POINT TO THE NEXT THROUGH THE REACTOR.  THIS ALLOWS UPDATING
C     TO TAKE PLACE ONLY PERIODICALLY (AS SPECIFIED BY INPUT) AND NOT
C     NECESSARILY AT EVERY O.D.E. STEP.
C
      COMMON /APR77/DELTPJ,DELRRJ,ALEN,JFAR,HM,DIFMW,ICNVLM,
     1TTEST,SUMSQ,ITRSYS,GAST(255),OSPRR,NPROP,ARMAX,AMIN,SQDIF
      COMMON /IO/DDUCT,DYDXM,AGSTPD,CPVC(3,5,5),HFV(5,5),DELHV(5,5),
     1INTCPV(5,5),QRBJ(5)
      COMMON/MORE/D01(255,5),N01(255,5),ALFA0(255,5),ALFA0C(255,5),
     1ALFA0H(255,5),ALFA0W(255,5),ALFA0A(255,5),X0(255,20),WVG(255)
      COMMON /ADD/CCP(5,4,3)
      COMMON /AREA13/ALFAC0(5),GAMMA,EK(20),XI(5),AMJ(5,5),
     1EMJ(5,5),KVD(5,5),TB,D(5),RHOC(5),RHO(5),DELTA(20),DIFM(20)
     2,ALFAH0(5),ALFAW0(5),ALFAA0(5)
      COMMON /AREA2/K(20),MU(20),SHRINK,HH0(5),HW0(5),EB,ELAM,
     1EUCKEN
      COMMON /AREA4/AL(5,5),EL(5,5),MH,PHIJWK(5,9),
     1PHIL(5),PHIKL(9,5),PHIVK(5,9,5),KEQ,EMM(5,5)
      COMMON /AREA5/NPRINT,TNIRP,CHECK,BUG
      COMMON /GENRAL/ALPHAA(5),S(20),KG,MUG,DS,
     1TPJJ(5),YY(5,5),PRTCLS,SPECIE,
     2ELEMNT,CRXN,HRXN,HH(5),HW(5),RGC
      COMMON/GNRAL2/NAME1(20),NAME2(20)
      COMMON /DIFEQN/OMEGAK(9),ALPHA(5),ALPHAC(5),ALPHAH(5),
     1ALPHAW(5),N(5),H(5),QF(5),QCB,QZ(5),P,V,HG(5),RK(5,9),
     2RL(5,20),RM(5,20),RC(5),RH(5),RW(5),RR(5),W(5),WG,AREA,PRESSR
      COMMON /EDNUM/RHOG,CPG,TG,CPI(20),X(20),CO(5),HGAS,EDNAME(9),
     1OXYD(5),GMW,QMASS(9,20),WTM(20)
      INTEGER PRTCLS,SPECIE,EUCKEN,BUG,EDNAME,H2O,CO2,O2
      REAL KG,MUG,K,MU,MH,N
      DATA H2O/'H2O'/,CO2/'CO2'/,O2/'O2'/
C
C*****COLLISION INTEGRAL FOR VISCOSITY
C
      DO 10  I1=1,SPECIE
      TEK=TG/EK(I1)
      COLMU=SIGMAM(TEK,DELTA(I1))
C
C*****DEBUG
C
      IF (TNIRP.EQ.1.0.AND.BUG.GE.4) WRITE(3,410) NAME1(I1),NAME2(I1),
     1COLMU
C
C*****SPECIE VISCOSITY AND THERMAL CONDUCTIVITY
C
      MU(I1)=2.67E-05*SQRT(WTM(I1)*TG)/(S(I1)**2*COLMU)
      K(I1)=1.25*(CPI(I1)+RGC/(2.0*WTM(I1)))*MU(I1)
      IF (EUCKEN.EQ.1) K(I1)=(CPI(I1)+1.25*RGC/WTM(I1))*MU(I1)
C
```

```
C*****DEBUG
C
10     IF (TNIRP.EQ.1.0.AND.BUG.GE.3) WRITE(3,310) NAME1(I1),NAME2(I1),
      1K(I1),MU(I1)
C
C*****MIXTURE VISCOSITY AND THERMAL CONDUCTIVITY
C
       SUMXMU=0.0
       SUMXK=0.0
       DO 20  I2=1,SPECIE
       SUMXFI=0.0
       DO 30  K1=1,SPECIE
       PHIIK=.3535534*SQRT(1.0/(1.0+WTM(I2)/WTM(K1)))*(1.0+SQRT(MU(I2)
      1/MU(K1))*(WTM(K1)/WTM(I2))**(0.25))**2
C
C*****DEBUG
C
       IF (TNIRP.EQ.1.0.AND.BUG.GE.4) WRITE(3,420) I2,K1,PHIIK
30     SUMXFI=SUMXFI+X(K1)*PHIIK
       IF(X(I2).LT.1.0E-30)GO TO 20
       SUMXK=SUMXK+X(I2)*K(I2)/SUMXFI
       SUMXMU=SUMXMU+X(I2)*MU(I2)/SUMXFI
20     CONTINUE
       KG=SUMXK
       MUG=SUMXMU
C
C*****DEBUG
C
       IF (TNIRP.EQ.1.0.AND.BUG.GE.2)WRITE(3,220)KG,MUG
C
C*****CONVECTIVE HEAT TRANSFER COEFICIENT FROM GAS TO WALL
C
       REG=DS*WG/(ARMAX*MUG)
       PRG=CPG*MUG/KG
       HM=0.023*KG/DS*REG**(0.8)*PRG**(1.0/3.0)
C
C*****DEBUG
C
       IF (TNIRP.EQ.1.0.AND.BUG.GE.4) WRITE(3,440) PRG,REG,HM
C
C*****DIFFUSIVITIES
C
       DIFMW=0.0
       DO 50  I1=1,SPECIE
       IF(NAME1(I1).NE.H2O.AND.NAME1(I1).NE.CO2.AND.
      1NAME1(I1).NE.O2)GO TO 50
       SUMXD=0.0
       DO 40   KI=1,SPECIE
       IF (I1.EQ.KI) GO TO 40
       TEK=TG/SQRT(EK(I1)*EK(KI))
       COLDIF=SIGMAD(TEK)
       DIF=0.00186*TG**(1.5)*SQRT(1.0/WTM(I1)+1.0/WTM(KI))/(P*((S(I1)+
      1S(KI))/2.0)**2*COLDIF)
```

```
      IF(TNIRP.EQ.1.0.AND.BUG.GE.4)WRITE(3,510)NAME1(I1),NAME2(I1),
     1NAME1(KI),NAME2(KI),COLDIF,DIF
      SUMXD=SUMXD+X(KI)/DIF
40    CONTINUE
      DIFM(I1)=(1.0-X(I1))/SUMXD
      IF(TNIRP.EQ.1.0.AND.BUG.GE.4)WRITE(3,515)NAME1(I1),NAME2(I1),
     1DIFM(I1)
      IF(NAME1(I1).NE.H2O)GO TO 50
      DIFMW=DIFM(I1)
50    CONTINUE
410   FORMAT(1H ,2A6,10X,30HVISCOSITY COLLISION INTEGRAL =,F10.4)
420   FORMAT(1H ,3HI =,I4,4X,3HK =,I4,4X,23HINTERACTION PARAMETER =,
     1E12.5)
440   FORMAT(1H ,16HPRANDTL NUMBER =,E12.5,10X,17HREYNOLDS NUMBER =,E12.
     15,10X,6HHBAR =,E12.5)
310   FORMAT(1H ,2A6,10X,22HTHERMAL CONDUCTIVITY =,E12.5,10X,
     111HVISCOSITY =,E12.5)
510   FORMAT(1H ,4A6,32HDIFFUSIVITY COLLISION INTEGRAL =,F10.4,4X,5HDIF
     1=,E12.5)
515   FORMAT(1H ,2A6,24HDIFFUSIVITY IN MIXTURE= ,E12.5)
220   FORMAT(1H ,3HKG=,E12.5,5H MUG=,E12.5)
      RETURN
      END
```

```
      SUBROUTINE AUX3
      COMMON /APR77/DELTPJ,DELRRJ,ALEN,JFAR,HM,DIFMW,ICNVLM,
     1TTEST,SUMSQ,ITRSYS,GAST(255),OSPRR,NPROP,ARMAX,AMIN,SQDIF
      COMMON /IO/DDUCT,DYDXM,AGSTPD,CPVC(3,5,5),HFV(5,5),DELHV(5,5),
     1INTCPV(5,5),QRBJ(5)
      COMMON /H2OP/IVPFLG,VPRCOF(5)
      COMMON /ADD/CCP(5,4,3)
      COMMON /AREA13/ALFACO(5),GAMMA,EK(20),XI(5),AMJ(5,5),
     1EMJ(5,5),KVD(5,5),TB,D(5),RHOC(5),RHO(5),DELTA(20),DIFM(20)
     2,ALFAHO(5),ALFAWO(5),ALFAAO(5)
      COMMON /AREA4/AL(5,5),EL(5,5),MH,PHIJWK(5,9),
     1PHIL(5),PHIKL(9,5),PHIVK(5,9,5),KEQ,EMM(5,5)
      COMMON /AREA5/NPRINT,TNIRP,CHECK,BUG
      COMMON /ODEVAL/XDIS,XTRMNL,VALINT(42),ODESTP
      COMMON /EDNUM/RHOG,CPG,TG,CPI(20),X(20),CO(5),HGAS,EDNAME(9),
     1OXYD(5),GMW,QMASS(9,20),WTM(20)
      COMMON /RADI/TO(255,5),NO(5),DO(5),SIGMA,PI,E(5),IT(255),HO(5)
     1,NUMRDR,DEL,IRAD,TOOLD(5)
      COMMON /DIFEQN/OMEGAK(9),ALPHA(5),ALPHAC(5),ALPHAH(5),
     1ALPHAW(5),N(5),H(5),QF(5),QCB,QZ(5),P,V,HG(5),RK(5,9),
     2RL(5,20),RM(5,20),RC(5),RH(5),RW(5),RR(5),W(5),WG,AREA,PRESSR
      COMMON /GENRAL/ALPHAA(5),S(20),KG,MUG,DS,
     1TPJJ(5),YY(5,5),PRTCLS,SPECIE,
     2ELEMNT,CRXN,HRXN,HH(5),HW(5),RGC
      COMMON/GNRAL2/NAME1(20),NAME2(20)
      INTEGER PRTCLS,SPECIE,BUG,HRXN,CRXN,EDNAME,ELEMNT,ODESTP,
     1OXYD,OSPRR
      DOUBLE PRECISION DENOM,BJJ,BJMJ,BJWJ
      REAL KCJ(5),KVD,N,KG,KMJ,NAME1,NAME2,NJ,MHC,KL,MH,INTCPV
      DIMENSION RCJ(5),RHJL(5),RVJ(5)
      DATA H2O/4HH2O /,CO2/4HCO2 /,O2/4HO2  /
C
C*****PICKING OUT H2O MOLE FRACTION
C
      XM=0.0
      DO 5 I=1,SPECIE
      IF(NAME1(I).NE.H2O)GO TO 5
      XM=X(I)
5     CONTINUE
C
C*****HEAT TRANSFER TO THE WALL BY CONVECTION
C
      QCB=4.0*HM*(TG-TB)/DS
      IF(TNIRP.EQ.1.0.AND.BUG.GE.1)WRITE(3,200)QCB
C
C*****IDEAL GAS CONCENTRATION
C
      CG=P/(82.057*TG)
      IF (TNIRP.EQ.1.0.AND.BUG.GE.3) WRITE(3,420) CG
C
C*****THE REMAINDER OF THE CALCULATIONS IN THIS SUBROUTINE ARE DONE FOR
C     EACH PARTICLE.
C
```

```
      DO 10 J=1,PRTCLS
C
C*****COMPUTATIONAL INITIALIZATION
C
      DJ=D(J)
      NJ=N(J)
      TJ=TPJJ(J)
      RRJ=RR(J)
      IF(XDIS.EQ.0.0)RRJ=0.0
      RHOJ=RHO(J)
C
C*****PARTICLE AREA
C
      AJ=PI*DJ**2
C
C*****MORE INITIALIZATION
C
      SRHJM=0.0
      SRVJM=0.0
      SRHVJM=0.0
      RC(J)=0.0
C
C*****COAL REACTION RATES (PYROLYSIS)
C
      IF(ALPHAC(J).LE.0.0)GO TO 21
      DO 20 M1=1,CRXN
      KMJ=AMJ(J,M1)*EXP(-EMJ(J,M1)/(RGC*TJ))
      RVJ(M1)=KMJ*YY(J,M1)*RHOC(J)
      IF (TNIRP.EQ.1.0.AND.BUG.GE.3) WRITE(3,440) J,M1,KMJ,RVJ(M1)
      RHJM=RVJ(M1)*(1.0-YY(J,M1))/YY(J,M1)
      RCJM= (RHJM+RVJ(M1))
      IF (TNIRP.EQ.1.0.AND.BUG.GE.2) WRITE(3,311) J,M1,RHJM,RCJM
      SRHJM=SRHJM+RHJM
      SRVJM=SRVJM+RVJ(M1)
      SRHVJM=SRHVJM+(RVJ(M1)*(INTCPV(J,M1)+HFV(J,M1)))
20    RC(J)=RC(J)-RCJM
      GO TO 23
21    DO 22 M1=1,CRXN
22    RVJ(M1)=0.0
23    IF (TNIRP.EQ.1.0.AND.BUG.GE.1) WRITE(3,211) J,I2,RC(J)
C
C*****THE FOLLOWING DO LOOP IS NEEDED SINCE MANY OF THE PARAMETERS ARE
C     DEPENDANT ON TOTAL REACTION RATE AND TOTAL REACTION RATE IN TURN
C     IS DEPENDANT ON EACH OF THESE PARAMETERS.  IN OTHER WORDS IT IS A
C     TRIAL AND ERROR SOLTION FOR REACTION RATES.
C
      DO 47 IR=1,20
      RHL=0.0
      RRO=RRJ
C
C*****HEAT TRANSFER BLOWING PARAMETER AND CORRECTION FACTOR
C
      BJ=RRJ*CPG/(2.0*PI*DJ*KG*NJ)
```

```
      IF (TNIRP.EQ.1.0.AND.BUG.GE.2) WRITE(3,310) J,BJ
      FAC=1.0
      IF(BJ.LE.1.0E-7)GO TO 91
      BJJ=BJ
      DENOM=DEXP(BJJ)-1.0
      FAC=BJ/DENOM
91    CONTINUE
C
C*****MASS TRANSFER BLOWING PARAMETER AND CORRECTION FACTOR FOR EACH OXIDIZER
C
      DO 90 L=1,HRXN
      I=OXYD(L)
      BJM=RRJ/(2.0*PI*DIFM(I)*RHOG*DJ*NJ)
      IF(TNIRP.EQ.1.0.AND.BUG.GE.2)WRITE(3,309)J,BJM
      FACM=1.0
      IF(BJM.LT.1.0E-7)GO TO 65
      BJMJ=BJM
      DENOM=DEXP(BJMJ)-1.0
      FACM=BJM/DENOM
65    CONTINUE
C
C*****MASS TRANSFER COEFFICIENTS
C
      IF(X(I).NE.0.0)GO TO 69
      KCJ(L)=1.0
      GO TO 90
69    KCJ(L)=2.0*DIFM(I)*FACM/DJ
90    CONTINUE
C
C*****CONVECTIVE - CONDUCTIVE HEAT TRANSFER BETWEEN THE GAS AND PARTICLE
C
      QZ(J)=2.0*PI*FAC*KG*DJ*NJ*(TJ-TG)
C
C*****WATER VAPORIZATION RATE
C
      IF(ALPHAW(J).LE.0.0)GO TO 50
      IF(IVPFLG.EQ.0)PEJ=10.0**(7.9484-(1656.39/(226.86+(TJ-273.0
     1))))/760.0
      IF(IVPFLG.NE.0)PEJ=VPRCOF(1)+VPRCOF(2)*TJ+VPRCOF(3)*TJ
     1**2+VPRCOF(4)*TJ**3+VPRCOF(5)*TJ**4
      XWJ=PEJ/P
      IF(XWJ.GT.1.0)XWJ=1.0
      IF (TNIRP.EQ.1.0.AND.BUG.GE.3) WRITE(3,430) J,AJ,PEJ,XWJ
      BJW=RRJ/(2.0*PI*DIFMW*RHOG*DJ*NJ)
      FACW=1.0
      IF(BJW.LT.1.0E-7)GO TO 57
      BJWJ=BJW
      DENOM=DEXP(BJWJ)-1.0
      FACW=BJW/DENOM
57    CONTINUE
      RWJ=2.0*PI*FACW*CG*DJ*NJ*18.01*(XWJ-XM)*DIFMW + XWJ*RRJ
      GO TO 44
50    RWJ=0.0
```

```
44    CONTINUE
C
C*****CHAR REACTION RATES FOR EACH OXIDIZER
C
      DO 45 L=1,HRXN
      LL=OXYD(L)
      IF(ALPHAH(J).LE.0.0.AND.ALPHAC(J).LE.0.0)GO TO 49
      KL=EXP(ALOG(AL(J,L))+EMM(J,L)*ALOG(TJ)-EL(J,L)/(RGC*TJ))
      IF (KEQ.EQ.1.AND.NAME1(LL).EQ.O2)KL=-1.68*TJ+1.32E-3*TJ*TJ
      IF(KL.LT.1.0E-30)GO TO 49
      RHJL(L)=(AJ*NJ)**2*MH*PHIL(L)*GMW*KCJ(L)*KL*XI(J)*CO(L)*CG/
     1(GMW*AJ*NJ*CG*(XI(J)*KL+KCJ(L))+RRJ)
      IF(RHJL(L).LT.0.0)GO TO 49
      GO TO 46
49    RHJL(L)=0.0
46    IF (TNIRP.EQ.1.0.AND.BUG.GE.3) WRITE(3,421) J,L,KL
      IF (TNIRP.EQ.1.0.AND.BUG.GE.2) WRITE(3,330) J,L,RHJL(L)
45    RHL=RHL+RHJL(L)
C
C*****TOTAL REACTION RATE
C
      RRJ=RHL+SRVJM+RWJ
      IF(RRJ.LT.0.0)RRJ=0.0
      IF(RRJ.EQ.0.0.AND.RRO.EQ.0.0)GO TO 48
      IF(RRJ.EQ.0.0.AND.RRO.NE.0.0)GO TO 47
      IF(ABS((RRO-RRJ)/RRJ).LT.DELRRJ)GO TO 48
47    CONTINUE
48    CONTINUE
      RW(J)=RWJ
      IF (TNIRP.EQ.1.0.AND.BUG.GE.1) WRITE(3,210) J,RW(J),QZ(J)
      IF(TNIRP.EQ.1.0.AND.BUG.GE.2)WRITE(3,230)RHL,SRHJM,SRVJM,SRHVJM
C
C*****ELEMENTAL REACTION RATES FROM STOICHIOMETRIC COEFFICIENTS
C
      DO 11 K=1,ELEMNT
      RK(J,K)=RW(J)*PHIJWK(J,K)
      SMPHIL=0.0
      DO 51 L=1,HRXN
51    SMPHIL=SMPHIL+PHIKL(K,L)*RHJL(L)
      RK(J,K)=RK(J,K)+SMPHIL
      SMPHIV=0.0
      DO 61 M3=1,CRXN
61    SMPHIV=SMPHIV+PHIVK(J,K,M3)*RVJ(M3)
      RK(J,K)=RK(J,K)+SMPHIV
      IF (TNIRP.EQ.1.0.AND.BUG.GE.1) WRITE(3,220) J,K,RK(J,K)
11    CONTINUE
C
C*****TOTAL CHAR REACTION RATE
C
      RH(J)=SRHJM-RHL
      IF(ALPHAC(J).LE.0.0.AND.ALPHAH(J).LE.0.0)RH(J)=0.0
C
C*****ENTHALPY OF REACTION PRODUCTS FROM PARTICLE GIVEN TO GAS
```

```
C
        IF(RRJ.EQ.0.0)HG(J)=0.0
        IF(RRJ.EQ.0.0)GO TO 12
        HG(J)=(SRHVJM+RHL*HH(J)+RW(J)*HW(J))/RRJ
12      RR(J)=RRJ
        IF (TNIRP.EQ.1.0.AND.BUG.GE.1) WRITE(3,240) J,RR(J),RH(J),HG(J)
10      CONTINUE
421     FORMAT(1H ,4HJ =,I2,4X,3HL =,I2,4X,4HKL =,E12.5)
311     FORMAT(1H ,3HJ =,I2,4X,3HM =,I2,4X,6HRHJM =,E12.5,4X,6HRCJM =,
       1E12.5)
320     FORMAT(1H ,3HM =,I2,4X,6HRHCM =,E12.5)
330     FORMAT(1H ,3HJ =,I2,4X,3HL =,I2,4X,6HRHJL =,E12.5)
211     FORMAT(1H ,3HJ =,I2,4X,3HI =,I3,4X,7HRC(J) =,E12.5,4X)
220     FORMAT(1H ,3HJ =,I2,4X,3HK =,I2,4X,9HRK(J,K) =,E12.5)
230     FORMAT(1H ,4HRHL=,E12.5,7H SRHJM=,E12.5,7H SRVJM=,E12.5,7HSRVHJM=,
       1E12.5)
240     FORMAT(1H ,3HJ =,I2,4X,7HRR(J) =,E12.5,4X,7HRH(J) =,E12.5,4X,
       17HHG(J) =,E12.5)
200     FORMAT(1H ,4HQCB=,E12.5)
420     FORMAT(1H ,19HGAS CONCENTRATION =,E12.5)
430     FORMAT(1H ,3HJ =,I2,4X,6HA(J) =,E12.5,4X,5HPEJ =,E12.5,4X,5HXWJ =,
       1E12.5)
440     FORMAT(1H ,3HJ =,I2,4X,3HM =,I2,4X,5HKMJ =,E12.5,4X,
       19HRV(J,M)= ,E12.5)
309     FORMAT(1H ,3HJ =,I2,4X,7HBM(J) =,E12.5)
310     FORMAT(1H ,3HJ =,I2,4X,6HB(J) =,E12.5)
210     FORMAT(1H ,3HJ =,I2,4X,7HRW(J) =,E12.5,4X,7HQZ(J) =,E12.5)
        RETURN
        END
```

```
      SUBROUTINE DIFF(YT,VECFUN,DX)
      COMMON /APR77/DELTPJ,DELRRJ,ALEN,JFAR,HM,DIFMW,ICNVLM,
     1TTEST,SUMSQ,ITRSYS,GAST(255),OSPRR,NPROP,ARMAX,AMIN,SQDIF
      COMMON /IO/DDUCT,DYDXM,AGSTPD,CPVC(3,5,5),HFV(5,5),DELHV(5,5),
     1INTCPV(5,5),QRBJ(5)
      COMMON /RADI/TO(255,5),NO(5),DO(5),SIGMA,PI,E(5),IT(255),HO(5)
     1,NUMRDR,DEL,IRAD,TOOLD(5)
      COMMON /ODEVAL/XDIS,XTRMNL,VALINT(42),ODESTP
      COMMON /GENRAL/ALPHAA(5),S(20),KG,MUG,DS,
     1TPJJ(5),YY(5,5),PRTCLS,SPECIE,
     2ELEMNT,CRXN,HRXN,HH(5),HW(5),RGC
      COMMON/GNRAL2/NAME1(20),NAME2(20)
      COMMON /EDNUM/RHOG,CPG,TG,CPI(20),X(20),CO(5),HGAS,EDNAME(9),
     1OXYD(5),GMW,QMASS(9,20),WTM(20)
      COMMON /DIFEQN/OMEGAK(9),ALPHA(5),ALPHAC(5),ALPHAH(5),
     1ALPHAW(5),N(5),H(5),QF(5),QCB,QZ(5),P,V,HG(5),RK(5,9),
     2RL(5,20),RM(5,20),RC(5),RH(5),RW(5),RR(5),W(5),WG,AREA,PRESSR
      COMMON /CONST/OSGKM(9),OPGKMN(9),SJMC(3,5),PJMC(4,5),SJH(5),
     1PJHN(5),SGMC(3),PGMC(4),PGHN,SGHI,PGX,PJX(5)
      COMMON /AREA5/NPRINT,TNIRP,CHECK,BUG
      DIMENSION YT(42),VECFUN(42),SGKM(9),PGKM(9),SJM(5),PJM(5)
     1,OPGKM(9),PJH(5)
      REAL N
      INTEGER ELEMNT,PRTCLS,CRXN,BUG,EDNAME,ODESTP
C
C*****INITIALIZATION
C
      KK=ELEMNT
      J=PRTCLS
      TNIRP=0.0
      JFAR=IFIX(XDIS*FLOAT(ODESTP)/ALEN)
      IF(MOD(JFAR,NPRINT).EQ.0.OR.XDIS.EQ.0.0)TNIRP=1.0
      SWITCH=0.0
      IF(TNIRP.EQ.1.0.AND.BUG.GE.1)SWITCH=1.0
      AZ=ARMAX
C
C*****REINITIALIZATION FOR BEGINING OF REACTOR
C
      IF(XDIS.NE.0.0)GO TO 113
      PGHI=PGHN
      DO 111 L=1,KK
111   OPGKM(L)=OPGKMN(L)
      DO 112 IC=1,J
112   PJH(IC)=PJHN(IC)
C
C*****CALCULATION OF RECIRCULATION AND SECONDARY MIXING PARAMETERS
C     FIRST EVERYTHING IS ZEROED OUT.
C
113   SGM=0.0
      PGM=0.0
      DO 1 L=1,KK
      SGKM(L)=0.0
1     PGKM(L)=0.0
```

```
      DO 2 IC=1,J
      SJM(IC)=0.0
2     PJM(IC)=0.0
C
C*****THEN IF WE ARE NOT YET OUTSIDE THE SPECIFIED MIXING REGION WE
C     CALCULATE THE MIXING PARAMETERS.
C
      IF(XDIS.GE.AGSTPD)GO TO 6
      AZ=PI*(DDUCT/2.0+DYDXM*XDIS)**2
      SGM=SGMC(1)*XDIS*XDIS+SGMC(2)*XDIS+SGMC(3)
      PGM=PGMC(1)*XDIS**3+PGMC(2)*XDIS*XDIS+PGMC(3)*XDIS+PGMC(4)
      DO 3 L=1,KK
      SGKM(L)=OSGKM(L)*SGM
3     PGKM(L)=OPGKM(L)*PGM
      DO 4 IC=1,J
      SJM(IC)=SJMC(1,IC)*XDIS*XDIS+SJMC(2,IC)*XDIS+SJMC(3,IC)
4     PJM(IC)=PJMC(1,IC)*XDIS**3+PJMC(2,IC)*XDIS*XDIS+PJMC(3,IC)
     1*XDIS+PJMC(4,IC)
C
C*****DEBUG
C
6     IF(SWITCH.EQ.1.0)WRITE(3,210)AZ
C
C*****NOW WE BEGIN THE ACTUAL FUNCTION OF THIS SUBROUTINE WHICH IS TO
C     EVALUATE EACH FUNCTION AT THIS PARTICULAR LOCATION IN THE REACTOR
C
      AREA=AZ
      CALL RODEVL(YT,ELEMNT,PRTCLS)
      CALL EDWRDS
C
C*****NOTE THAT VELOCITY, NUMBER PARTICLE DENSITY AND SECONDARY AND
C      RECIRCULATION ENTHALPIES MUST BE HANDLED HERE INSTEAD OF
C      IN RODEVL SINCE THEY REQUIRE INFORMATION WHICH MUST
C      COME FROM EDWRDS.
C
      V=WG/(RHOG*AREA)
      DO 5 IC=1,J
      IDX=IC+ELEMNT+2*PRTCLS+1
5     N(IC)=YT(IDX)/(V*AZ)
      SGH=SGHI+HGAS-CPG*(TG-298)
      PGH=PHGI+HGAS-CPG*(TG-298)
C
C*****DEBUG
C
      IF(SWITCH.EQ.1.0)WRITE(3,240)V,(N(JX),JX=1,PRTCLS)
C
C*****EVALUATING THE AUXILIARY EQUATIONS
C
      CALL AUX1
      IF(MOD(JFAR,NPROP).EQ.0.OR.JFAR.EQ.1)CALL AUX2PR
      CALL AUX3
C
C*****TEST FOR THE LOCATION IN THE REACTOR TO SEE IF WE SHOULD BE SAVING
```

```
C      THE PROPERTIES NEEDED FOR RECIRCULATION FOR THE NEXT SYSTEM
C      ITERATION.
C
       IF((XDIS.LT.(PGX-DX/2.)).OR.(XDIS.GE.(PGX+DX/2.)))GO TO 8
       PGHN=CPG*(TC-298) HGAS
       DO 7 L=1,KK
7      OPGKMN(L)=OMEGAK(L)
8      DO 9 IC=1,J
       IF((XDIS.LT.(PJX(IC)-DX/2.)).OR.(XDIS.GE.(PJX(IC)+DX/2.)))GO TO 9
       PJHN(IC)=H(IC)
9      CONTINUE
C
C*****NOW UPDATE EACH OF THE DIFFERENTIAL EQUATIONS AND SAVE THEM IN VECFUN.
C
       AB=AZ
       DO 10 L=1,KK
       SUM1=0.0
       DO 11 IC=1,J
11     SUM1=SUM1+RK(IC,L)
10     VECFUN(L)=AZ*SUM1+SGKM(L)+PGKM(L)
       DO 20 L=KK+1,KK+J
       IDX=L-KK
20     VECFUN(L)=-AZ*RR(IDX)+SJM(IDX)+PJM(IDX)
       SUM1=0.0
       SUM2=0.0
       L=KK+J+1
       DO 31 IC=1,J
       SUM1=SUM1+QZ(IC)
31     SUM2=SUM2+RR(IC)*HG(IC)
       VECFUN(L)=SGH*SGM+PGH*PGM+AZ*(SUM1+SUM2)-AB*QCB
       DO 40 L=KK+J+2,KK+2*J+1
       IDX=L-(KK+J+1)
40     VECFUN(L)=SJM(IDX)*SJH(IDX)+PJM(IDX)*PJH(IDX)+AZ*(QF(IDX)-
      1QZ(IDX)-RR(IDX)*H(IDX))-AB*QRBJ(IDX)
       DO 60 L=KK+2*J+2,KK+3*J+1
       IDX=L-(KK+2*J+1)
60     VECFUN(L)=(PJM(IDX)+SJM(IDX))/ALPHA(IDX)
       L=KK+3*J+2
       SUM1=0.0
       DO 81 IC=1,J
81     SUM1=SUM1+RR(IC)
       VECFUN(L)=AZ*SUM1+SGM+PGM
       DO 90 IDX=1,J
       L1=KK+3*J+2+IDX
       L2=L1+J
       L3=L2+J
       VECFUN(L1)=RC(IDX)/(N(IDX)*V)
       VECFUN(L2)=RH(IDX)/(N(IDX)*V)
       VECFUN(L3)=-RW(IDX)/(N(IDX)*V)
90     CONTINUE
210    FORMAT(5H AZ= ,E12.5)
240    FORMAT(4H V= ,E12.4,7H N(J)= ,5E12.4)
       RETURN
```

```
00160         END
```

```
      SUBROUTINE EDWRDS
      COMMON /APR77/DELTPJ,DELRRJ,ALEN,JFAR,HM,DIFMW,ICNVLM,
     1TTEST,SUMSQ,ITRSYS,GAST(255),OSPRR,NRPOP,ARMAX,AMIN,SQDIF
      COMMON /EDWIN/QMOLWT(10),MELM(40),YINT(20)
      COMMON /GENRAL/ALPHAA(5),S(20),KG,MUG,DS,
     1TPJJ(5),YY(5,5),PRTCLS,SPECIE,
     2ELEMNT,CRXN,HRXN,HH(5),HW(5),RGC
      COMMON /DIFEQN/OMEGAK(9),ALPHA(5),ALPHAC(5),ALPHAH(5),
     1ALPHAW(5),N(5),HZZ(5),QF(5),QCB,QZ(5),P,V,HG(5),RK(5,9),
     2RL(5,20),RM(5,20),RC(5),RH(5),RW(5),RR(5),W(5),WG,AREA,PRESSR
      COMMON /EDNUM/RHOG,CPG,TG,CPI(20),X(20),CO(5),HGAS,EDNAME(9),
     1OXYD(5),GMW,QMASS(9,20),WTM(20)
      COMMON/ODEVAL/XDIS,XTRMNL,VALINT(42),ODESTP
      COMMON/AZ/A(20,11),                                    RTOTO
      COMMON/AZ1/ANS(23),                                    SCH,
     2          ATMOS
      COMMON/AZ2/              IMBALA,                          SR(20)
      COMMON/AZ3/B(11),                          NCONV,         TANS(23),
     5          BMIN,                          NCTXP,
     6          CBAR,
     7                                         NEQ,
     8          D,             ITE,         NGIN,
     9                         ITER,           NKIN,          TO
      COMMON/BZ/               ITT,            NKINC,         TOL,
     1                                         NLEL,          TOLMAX,
     2                         K2,             NM,            TOLT,
     3          EL(23,24),     K3,                            U(20),
     4          ENTRPY,        LB,             NN,            Y(20),
     5                                                        YBAR,
     6          H(20),        LITER,                         YBC,
     7          HBAR,          LKDROP,                        YC(20),
     8          HC,
     9          HI,            LV,             NSIN,          YR(20)
      COMMON/CZ/HR(20),       MAJOR,                         Z(20,10)
      COMMON/CZ1/IDKIN(20),                     NT,
     2                         MPD,
     3          IDSIN(20),    MPDP,
     4          IEV(11),                       R,          IEVN(11)
      COMMON/EZ/                                   CBAG,  ATWT(40),  WTG
      DIMENSION
     1                                                       QE(10,40),
     2                         ICOL(10),       MONTH(12),     QEI(11),
     3          COI(9),                                       QMOL(9),
     4          DENS(10),      IDU(9),
     5          EC(9),                         NAME1(10),     SPIM(9),
     6          ECMAX(9),                      NAME2(10),
     7          ECMIN(9),                       PCT(10),
     8          ET(9,9),                                      VOL(9),
     9          ECONST(9),     KU(9)
      INTEGER ELEMNT,SPECIE
      EQUIVALENCE (QMASS(1,2),ET(1,1)),      (QMASS(1,11),COI(1)),
     1            (QMASS(1,12),EC(1)),       (QMASS(1,13),ECMAX(1)),
     2            (QMASS(1,14),ECMIN(1)),    (QMASS(1,15),ECONST(1)),
```

```
     3              (QMASS(1,16),IDU(1)),     (QMASS(1,17),KU(1)),
     4              (QMASS(1,18),SPIM(1))
      DIMENSION NAMEM(20,4),QEM(20,4),KCHARG(20),IMPT(20)
      EQUIVALENCE (A(1,1),NAMEM(1,1)),(A(1,5),QEM(1,1)),
     1(YC(1),KCHARG(1)),(Y(1),IMPT(1))
      DATA R/1.98726/,NCHNG/20/,LITER/50/
      IF(XDIS.NE.0.0)GO TO 620
C
C                 THIS AREA SETS UP THE PROBLEM
C                 WHEN NEVER DONE PREVIOUSLY...
C
      NPROP=ELEMNT
      DO 1 I=1,ELEMNT
      DO 1 J=1,ELEMNT
      QE(I,J)=0.0
      IF(I.EQ.J)QE(I,I)=1.0
1      CONTINUE
      DO 400 I=1,SPECIE
      Y(I)=YINT(I)
400   IDSIN(I)=I
      NN=SPECIE
      NP=0
C      NP EQUAL NUMBER OF CONDENSIBLES IN THE SYSTEM
      NT=NN+NP
      NGIN=SPECIE
      NSIN=NT
      NLEL=ELEMNT
C
C                  EXECUTE THE PROBLEM.
C
C                  EXHAUST SPECIES NEEDED.
C
  510 NM=0
      LKDROP=3
      DO 530 J=1,NLEL
      DO 515 K=1,NPROP
      IF (QE(K,J)) 515,515,520
  515 CONTINUE
      GO TO 530
  520 NM=NM+1
  525 IEV(NM)=MELM(J)
      IEVN(NM) = J
  530 CONTINUE
      NMP1=NM+1
  550 CONTINUE
      ICALDA=0
      NKIN=0
  555 TO=3500.0
      ICP=1
      IHOT = 1
      ATMOS=P
      NFROZN=0
C
```

```
C                       JUGGLE A VOLUME OF MASSIVE MOLES.
C
  620 SUMVOL=0.0
      SUMMOL=0.0
      SUMMAS=0.0
      DO 645 J=1,NPROP
  640 SUMMAS=SUMMAS+QMASS(J,1)
      VOL(J)=QMASS(J,1)
      SUMVOL=SUMVOL+VOL(J)
      QMOL(J)=QMASS(J,1)/QMOLWT(J)
      SUMMOL=SUMMOL+QMOL(J)
645   CONTINUE
      DO 650 J=1,NPROP
      PCT(J)=(100.0*QMASS(J,1))/SUMMAS
650   CONTINUE
      HI=HGAS*100.0
      NM=NMP1-1
      BLKDNS=SUMMAS/SUMVOL
      QM1=SUMMAS/SUMMOL
      BTOT=0.0
      DO 665 J=1,NM
      DO 655 L=1,NLEL
      K=L
      IF (IEV(J).EQ.MELM(L)) GO TO 660
  655 CONTINUE
  660 B(J)=0.0
      DO 665 I=1,NPROP
      B(J)=B(J)+QE(I,K)*PCT(I)/QMOLWT(I)
  665 BTOT=BTOT+B(J)
      BMIN=B(1)
      DO 670 J=1,NM
  670 BMIN=AMIN1(B(J),BMIN)
C
C                       FIND CHAMBER CONDITIONS.
C
  720 NCTXP=0
      ANS(1)=10.0
      ANS(23)=10.0
  725 CALL EQUIL
  955 IF (ITE.GE.LITER) WRITE(3,1000)
      IF (ITE.GE.LITER) WRITE(5,1000)
      IF (ITE.GE.LITER) CALL TRBLE
1000   FORMAT(24H EDWRDS DID NOT CONVERGE)

      RETURN
      END
```

```
      SUBROUTINE EQUIL
      INTEGER ELEMNT,SPECIE,BUG,HRXN,OXYD
      COMMON/GENRAL/ALPHAA(5),S(20),KG,MUG,DS,
     1TPJJ(5),YY(5,5),PRTCLS,SPECIE,
     2ELEMNT,CRXN,HRXN,HH(5),HW(5),RGC
      COMMON/GNRAL2/NAME1(20),NAME2(20)
      COMMON /EDNUM/RHOG,CPG,TG,CPI(20),X(20),CO(5),HGAS,EDNAME(9),
     1OXYD(5),GMW,QMASS(9,20),WTM(20)
      COMMON /AREA5/NPRINT,TNIRP,CHECK,BUG
      COMMON /DIFEQN/OMEGAK(9),ALPHA(5),ALPHAC(5),ALPHAH(5),
     1ALPHAW(5),N(5),HZZ(5),QF(5),QCB,QZ(5),P,V,HG(5),RK(5,9),
     2RL(5,20),RM(5,20),RC(5),RH(5),RW(5),RR(5),W(5),WG,AREA,PRESSR
      COMMON/AZ/A(20,11),                               RTOTO
      COMMON/AZ1/ANS(23),                               SCH,
     2          ATMOS
      COMMON/AZ2/              IMBALA,                     SR(20)
      COMMON/AZ3/B(11),                      NCONV,        TANS(23),
     5          BMIN,                       NCTXP,
     6          CBAR,
     7                                      NEQ,
     8          D,            ITE,       NGIN,
     9                        ITER,         NKIN,         TO
      COMMON/BZ/              ITT,          NKINC,        TOL,
     1                                      NLEL,         TOLMAX,
     2                        K2,           NM,           TOLT,
     3          EL(23,24),    K3,                         U(20),
     4          ENTRPY,       LB,           NN,           Y(20),
     5                                                    YBAR,
     6          H(20),       LITER,                      YBC,
     7          HBAR,         LKDROP,                     YC(20),
     8          HC,
     9          HI,           LV,           NSIN,         YR(20)
      COMMON/CZ/HR(20),      MAJOR,                      Z(20,10)
      COMMON/CZ1/IDKIN(20),                  NT,
     2                        MPD,
     3          IDSIN(20),   MPDP,
     4          IEV(11),                    R,          IEVN(11)
      COMMON/EZ/                                CBAG,  ATWT(40),   WTG
      TOLMAX=.0001
      IF (BMIN.LT..001) TOLMAX=.1*BMIN
      TOL=TOLMAX
      TOLT=1.1*TOL
      ITER=0
    5 NEQ=2
   25 K2=NEQ-1
   30 NM1=NEQ+1
      NML=NM+NEQ
      K3=NEQ
      NCONV=-1
   35 IF (ITER.GT.1.OR.NCTXP.NE.0) GO TO 50
      IF (ITER-1) 45,40,50
   40 NEQ=2
      K2=1
```

```
      ANS(K2)=50.0
      NM1=3
      NML=NM+2
      K3=2
      NCONV=-1
      GO TO 50
   45 NEQ=1
      K2=23
      ANS(K2)=50.0
      NM1=2
      NML=NM+1
      K3=1
      NCONV=-1
   50 LV=NML+NKIN
      LB=LV+1
      CALL SETUP1
      CALL SLE
      NCONV=0
      CALL TOY
      ITER=ITER+1
      IF (ITER.GT.LITER) GO TO 55
      IF(NCONV.EQ.0)CALL SETUP1
      IF (NCONV.EQ.0) GO TO 55
      GO TO 35
55      CALL SETUP1
C
C      NOW WE DETERMINE IF THE SOLUTION STRADDLES A PHASE TRANSITION
C       MAKING USE OF THE FACT THAT A SOLID+LIQUID PAIR HAS THE
C        SAME FORMULA
C
      MPDP=MPD
      MPD=0
      IF (NKIN.LE.0) GO TO 90
      IF (NKIN.LT.NM) GO TO 60
      MPD=1
      GO TO 90
   60 DO 80 I=1,NKIN
      IF (I-NKIN) 65,85,85
   65 IP1=I+1
      IDKINI=IDKIN(I)
      DO 75 J=IP1,NKIN
      IDKINJ=IDKIN(J)
      DO 70 K=1,NM
      IF (A(IDKINI,K)-A(IDKINJ,K)) 75,70,75
   70 CONTINUE
      MPD=1
      GO TO 85
   75 CONTINUE
   80 CONTINUE
   85 CONTINUE
C
C                    CHAMBER AND TEMPERATURE SOLUTIONS.
C                    SAVE THE CHAMBER SOLUTION FOR INTIAL CONDITIONS ON
```

```
C                       THE NEXT PROBLEM.
C
   90 CONTINUE
      HC=HBAR
      CBC=CBAR
      EPSLON=0.0
      CF=0.0
      PEAEM=0.0
      SCH=ENTRPY
95    CONTINUE
      DO 100 I=1,NT
  100 YC(I)=Y(I)
      NKINC=NKIN
      IF(NKIN.LE.0) GO TO 140
      DO 105 I=1,NKIN
105      CONTINUE
  140 PSI=14.696*ATMOS
      TG=TO
      HGAS=HBAR/100.0
      RHOG=ATMOS/(YBAR*TO*.82057)
      GMW = WTG/YBAR
      CPG=CBAG/100.0
      ITE=ITER
C
C                       EXHAUST PRODUCTS STORED IN 'YOUT
C
      DO 170 I=1,HRXN
       CO(I)=0.0
170    CONTINUE
  160 DO 165 I=1,NT
      DO 175 IJ=1,HRXN
      IK=OXYD(IJ)
175   CO(IJ)=Y(IK)*RHOG/100.0
165    X(I)=Y(I)/YBAR
      IF(TNIRP.NE.1.0.OR.BUG.LT.2)GO TO 151
      WRITE(3,220)(CO(IXX),IXX=1,HRXN)
220      FORMAT(8H CO(I)= ,5(1X,E12.5,1X))
      WRITE(3,230)
230      FORMAT(5X,1HI,7X,4HX(I),8X,4HNAME,12X,5HMW(I),11X,5HCP(I))
      DO 152 IX=1,NN
152      WRITE(3,240)IX,X(IX),NAME1(IX),NAME2(IX),WTM(IX),CPI(IX)
240      FORMAT(2X,I3,E12.5,3X,2A6,3X,E12.5,3X,E12.5)
      WRITE(3,250) TG
  250   FORMAT(19H GAS TEMPERATURE = ,E12.5,15H DEGREES KELVIN)
      WRITE (3,260) HGAS
  260   FORMAT(16H GAS ENTHAPLY = ,E12.5,7H CAL/GM)
      WRITE(3,270) RHOG
  270   FORMAT(15H GAS DENSITY = ,E12.5,13H GM/CUBIC CM.)
      WRITE(3,280) GMW
  280   FORMAT(21H GAS MOLECULAR WT. = ,E12.5)
      WRITE(3,290) CPG
  290   FORMAT(21H GAS HEAT CAPACITY = ,E12.5,16H CAL/GM DEGREE K)
151     CONTINUE
```

```
      RETURN
      END
```

```
      SUBROUTINE FIND (ARG,ANS,X,Y,NPTS,I)
C
C      J. ANDERSON      6-1-65
C             EXTRAPOLATES FOR VALUES OUT OF TABLE RANGE
C             REMEMBERS LAST ARG VALUE AND BEGINS SEARCH FROM THAT VALUE
C             CALLING SEQUENCE IS .....
C
C                CALL FIND (ARG,ANS,X,Y,NPTS,MEM)
C
C                    ARG IS THE ARGUMENT
C                    ANS CONTAINS RESULT ON EXIT
C                    X IS ONE DIMENSIONAL ARRAY OF INDEP. VARIABLE
C                    Y IS ONE DIMENSIONAL ARRAY OF DEP. VARIABLE
C                    NPTS IS NUMBER OF TABLE ENTRIES
C                    MEM SHOULD BE INITIALIZED TO 1 - AFTER FIRST
C                      CALL THE SUBROUTINE WILL PRESERVE VALUES IN IT
C
      DIMENSION X(50), Y(50)
    1 IF (X(I)-ARG)    4,2,2
    2 I=I-1
      IF (I-1) 3,3,1
    3 I=1
      GO TO 8
    4 IF (X(I+1)-ARG) 5,7,7
    5 I=I+1
      IF (I-NPTS)    4,6,6
    6 I=NPTS-1
      GO TO 9
    7 ANS=Y(I)+(Y(I+1)-Y(I))*(ARG-X(I))/(X(I+1)-X(I))
      RETURN
8     ANS = Y(1)
      RETURN
9     ANS = Y(NPTS)
      RETURN
      END
```

```
      SUBROUTINE GRPH(X,Y,NDATA,EX,EY,ASCX,NX,ASCY,NY,IP)
C  X,Y:  ELEMENTS OF THE ORDERED PAIR (X,Y)
C  NDATA: NUMBER OF ORDERED PAIRS
C  EX,EY:  ERROR IN THE X AND Y VALUES
C  ASCX(NX), ASCY(NY):  ARRAYS CONTAINING THE LABLES OF THE AXES
C  IP.LT.0:  NEW GRAPH,  IP.GT.0:  NEW CURVE, SAME GRAPH
C  IP.EQ.0:  END GRAPH
C  THIS ROUTINE IS SELF SCALING (IT USES ASCALE)
      COMMON/TRUBLE/INDX,ITRBLE
      DIMENSION X(NDATA),Y(NDATA),ASCX(1),ASCY(1)
      DATA IPLOTS/0/
      IF(IP.GE.0) GO TO 20
C  PLOT BORDERS
      IF(IPLOTS.EQ.0) CALL PLOTS(KPLOTS)
      IPLOTS=1
      CALL PLOT(0.0,1.0,-3)
      CALL PLOT(0.0,8.5,2)
      CALL PLOT(11.0,8.5,1)
      CALL PLOT(11.0,0.0,1)
      CALL PLOT(0.0,0.0,1)
      CALL PLOT(.4,.4,-3)
      CALL PLOT(0.0,7.5,2)
      CALL PLOT(10.2,7.5,1)
      CALL PLOT(10.2,0.0,1)
      CALL PLOT(0.0,0.0,1)
      CALL ASCALE(X,NDATA,9.,XMIN,DX,XMAX)
      CALL ASCALE(Y,NDATA,6.,YMIN,DY,YMAX)
C  PLOT AXES
      CALL PLOT(.5,.5,-3)
      NX=-1.0*NX
      IF(ITRBLE.NE.1)CALL AXIS(0.0,0.0,ASCX,NX,9.0,0.0,XMIN,DX)
      IF(ITRBLE.NE.1)CALL AXIS(0.0,0.0,ASCY,NY,6.0,90.0,YMIN,DY)
      NX=-NX
C  PLOT ZERO LINES
      IF(XMIN.GE.0.0) GO TO 10
      IF(XMAX.LT.0.0) GO TO 10
      XZ=-1.*XMIN/DX
      CALL PLOT(XZ,0.,3)
      CALL PLOT(XZ,6.,2)
10    IF(YMIN.GE.0.0) GO TO 20
      IF(YMAX.LT.0.0) GO TO 20
      YZ=-1.*YMIN/DY
      CALL PLOT(9.,YZ,3)
      CALL PLOT(0.,YZ,2)
C  PLOT DATA AND ERROR
20    XE=EX/DX
      YE=EY/DY
      IPEN=3
      DO 30 I=1,NDATA
      IF(X(I).LT.XMIN.OR.X(I).GT.XMAX) GO TO 30
      IF(Y(I).LT.YMIN.OR.Y(I).GT.YMAX) GO TO 30
      XT=(X(I)-XMIN)/DX
      YT=(Y(I)-YMIN)/DY
```

```
      CALL PLOT(XT,YT,IPEN)
      IPEN=2
      IF(YE.LT.0.05) GO TO 30
      XA=XT+XE/2.
      XB=XT-XE/2.0
      YA=YT+YE/2.0
      YB=YT-YE/2.0
      CALL PLOT(XA,YA,3)
      CALL PLOT(XB,YA,2)
      CALL PLOT(XT,YA,3)
      CALL PLOT(XT,YT,2)
      CALL PLOT(XA,YB,3)
      CALL PLOT(XB,YB,2)
      CALL PLOT(XT,YB,3)
      CALL PLOT(XT,YT,2)
30    CONTINUE
      IF(IP.EQ.0) CALL PLOT(20.,-2.5,-3)
101   RETURN
      END
```

```
      SUBROUTINE INPUT
      COMMON/AZ/A(20,11),                                      RTOTO
      COMMON/AZ2/                 IMBALA,                          SR(20)
      COMMON/CZ/HR(20),        MAJOR,                          Z(20,10)
      COMMON/EZ/                                   CBAG,  ATWT(40),  WTG
      COMMON/CONVER/ITRMAX,DYNAMO(3),DYNTEM,DYNFLG,DYNFLO
      COMMON/STIFF/ISASUM,ISTIFF(5),STIFVL
      COMMON/JAN78/V0,FUR
      COMMON /APR77/DELTPJ,DELRRJ,ALEN,JFAR,HM,DIFMW,ICNVLM,
     1TTEST,SUMSQ,ITRSYS,GAST(255),OSPRR,NPROP,ARMAX,AMIN,SQDIF
      COMMON /EDWIN/QMOLWT(10),MELM(40),YINT(20)
      COMMON /LAST/GASTMN,TMIN(5),IQOJ(255,5)
      COMMON /IO/DDUCT,DYDXM,AGSTPD,CPVC(3,5,5),HFV(5,5),DELHV(5,5),
     1INTCPV(5,5),QRBJ(5)
      COMMON /H2OP/IVPFLG,VPRCOF(5)
      COMMON/MORE/D01(255,5),N01(255,5),ALFA0(255,5),ALFA0C(255,5),
     1ALFA0H(255,5),ALFA0W(255,5),ALFA0A(255,5),X0(255,20),WVG(255)
      COMMON /AREA13/ALFAC0(5),GAMMA,EK(20),XI(5),AMJ(5,5),
     1EMJ(5,5),KVD(5,5),TB,D(5),RHOC(5),RHO(5),DELTA(20),DIFM(20)
     2,ALFAH0(5),ALFAW0(5),ALFAA0(5)
      COMMON /AREA2/K(20),MU(20),SHRINK,HH0(5),HW0(5),EB,ELAM,
     1EUCKEN
      COMMON /AREA4/AL(5,5),EL(5,5),MH,PHIJWK(5,9),
     1PHIL(5),PHIKL(9,5),PHIVK(5,9,5),KEQ,EMM(5,5)
      COMMON /AREA5/NPRINT,TNIRP,CHECK,BUG
      COMMON /GENRAL/ALPHAA(5),S(20),KG,MUG,DS,
     1TPJJ(5),YY(5,5),PRTCLS,SPECIE,
     2ELEMNT,CRXN,HRXN,HH(5),HW(5),RGC
      COMMON /RADI/T0(255,5),N0(5),D0(5),SIGMA,PI,E(5),IT(255),H0(5)
     1,NUMRDR,DEL,IRAD,TOOLD(5)
      COMMON /DIFEQN/OMEGAK(9),ALPHA(5),ALPHAC(5),ALPHAH(5),
     1ALPHAW(5),N(5),H(5),QF(5),QCB,QZ(5),P,V,HG(5),RK(5,9),
     2RL(5,20),RM(5,20),RC(5),RH(5),RW(5),RR(5),W(5),WG,AREA,PRESSR
      COMMON /EDNUM/RHOG,CPG,TG,CPI(20),X(20),CO(5),HGAS,EDNAME(9),
     1OXYD(5),GMW,QMASS(9,20),WTM(20)
      COMMON /ADD/CCP(5,4,3)
      COMMON/GNRAL2/NAME1(20),NAME2(20)
      COMMON /ODEVAL/XDIS,XTRMNL,VALINT(42),ODESTP
      COMMON /CONST/OSGKM(9),OPGKM(9),SJMC(3,5),PJMC(4,5),SJH(5),
     1PJH(5),SGMC(3),PGMC(4),PGH,SGH,PGX,PJX(5)
      INTEGER PRTCLS,SPECIE,ELEMNT,CRXN,HRXN,EUCKEN,BUG,ODESTP,
     1EDNAME,OSPRR,OXYD,DYNAMO,RSTRT,D3TST,DYNM3,SHRINK
      REAL N1,N,N0,MH,COMENT(10,20),MODH,MODS,N01
      REAL XBEGIN(5),TMAX(5),D1(5),XCHNG(5)
      DATA BLNK/5H     /
      DATA PI/3.14159/,SIGMA/1.355E-12/,RGC/1.987/
C
C*****OPENING THE INPUT FILE ON DISC
C
      CALL OPEN
C
C*****READING ALL INPUT INFORMATION
C
```

```
      READ(1,5)NCARD
      IF(NCARD .EQ.0)GO TO 11
      DO 10 I=1,NCARD
10    READ(1,15)(COMENT(I,J),J=1,20)
11    READ(1,5)ODESTP,OSPRR,DYNAMO(1),DYNAMO(2),DYNAMO(3),NPRINT
      READ(1,5)ELEMNT,SPECIE,PRTCLS,CRXN,HRXN,ICNVLM,ITRMAX,NPROP,
     1BUG,ISASUM,EUCKEN,KEQ,SHRINK,IRAD
      READ(1,25)DYNTEM,SQDIF,DELTPJ,DELRRJ,TTEST,STIFVL,FUR
      READ(1,25)GMW,HGAS,RHOG,WG,P
      READ(1,25)SGH,(SGMC(I),I=1,3)
      READ(1,25)PGX,PGH,(PGMC(I),I=1,4)
      DO 40 J=1,PRTCLS
      READ(1,25)D1(J),E(J),H(J),XI(J),W(J)
      READ(1,25)ALPHAA(J),ALPHAC(J),ALPHAH(J),ALPHAW(J),HHO(J),HWO(J)
      READ(1,25) TMIN(J),XBEGIN(J),TMAX(J),XCHNG(J)
      READ(1,25)SJH(J),(SJMC(I,J),I=1,3)
      READ(1,25)PJX(J),PJH(J),(PJMC(I,J),I=1,4)
      DO 30 M=1,CRXN
      READ(1,25)AMJ(J,M),EMJ(J,M),YY(J,M)
30    READ(1,25)(CPVC(I,J,M),I=1,3),HFV(J,M)
      DO 32 L=1,HRXN
32    READ(1,25)AL(J,L),EL(J,L),EMM(J,L)
      READ(1,25)(PHIJWK(J,KI),KI=1,ELEMNT)
      DO 35 KI=1,ELEMNT
35    READ(1,25)(PHIVK(J,KI,M),M=1,CRXN)
      READ(1,27)((CCP(J,NI1,NI2),NI2=1,3),NI1=1,4)
40    CONTINUE
      DO 50 KI=1,ELEMNT
      READ(1,55)EDNAME(KI),ATWT(KI),OMEGAK(KI),OSGKM(KI),OPGKM(KI)
      READ(1,25)(PHIKL(KI,L),L=1,HRXN)
50    CONTINUE
      DO 60 I=1,SPECIE
      READ(1,65)NAME1(I),NAME2(I),S(I),EK(I),DELTA(I),YINT(I)
      READ(1,25)(A(I,IX),IX=1,ELEMNT)
      READ(1,25)HR(I),SR(I)
      READ(1,25)(Z(I,IX),IX=1,5)
      READ(1,25)(Z(I,IX),IX=6,10)
60    CONTINUE
      READ(1,25)DDUCT,DS,ALEN,AGANGL,EB,TB
      READ(1,25)ELAM,GAMMA,MH
      READ(1,5)(OXYD(L),L=1,HRXN)
      READ(1,25)(PHIL(L),L=1,HRXN)
      READ(1,26)IVPFLG,(VPRCOF(I),I=1,5)
      READ(1,5)RSTRT
C
C*****SETTING UP ALL DEFAULT VALUES
C     AND CALCULATING INITIAL VALUES FROM INPUT CONDITIONS
C
      IF (NPRINT.LE.0) NPRINT=15
      IF (SQDIF.LE.0.0) SQDIF=0.01
      IF (STIFVL.LE.0.0) STIFVL=0.001
      IF (EUCKEN.NE.1) EUCKEN=0
      IF (SHRINK.NE.1) SHRINK=0
```

```
      IF (IRAD.NE.1) IRAD=0
      IF ((FUR.LE.0.0).OR.(FUR.GT.1.0)) FUR=1.0
      NUMRDR=ODESTP/OSPRR
      ODESTP=NUMRDR*OSPRR
      IF(DYNAMO(3).GT.OSPRR)DYNAMO(3)=OSPRR
      D3TST=OSPRR/DYNAMO(3)
      IF(MOD(OSPRR,D3TST).EQ.0)GO TO 61
      DYNM3=1
      IF(FLOAT(DYNAMO(3))/FLOAT(OSPRR).GT.0.5)DYNM3=OSPRR
      DYNAMO(3)=DYNM3
      GO TO 62
61    DYNAMO(3)=OSPRR/D3TST
62    CONTINUE
      DEL=ALEN/FLOAT(NUMRDR)
      AMIN=PI*(DDUCT/2.0)**2
      ANGLE=AGANGL
      AGANGL=AGANGL*PI/180.0
      ARMAX=PI*(DS/2.0)**2
      PRESSR=P
      DYDXM=SIN(AGANGL)/COS(AGANGL)
      IF(ANGLE.EQ.0.0) AGSTPD=0.0
      IF(ANGLE.EQ.0.0)GO TO 74
      AGSTPD=(DS-DDUCT)/(2.0*DYDXM)
74    IF(ODESTP.LT.NUMRDR)ODESTP=NUMRDR
      V=WG/(RHOG*AMIN)
      V0=V
      DO 1021 J1=1,PRTCLS
      ALPHA(J1)=ALPHAA(J1)+ALPHAC(J1)+ALPHAH(J1)+ALPHAW(J1)
      N(J1)=W(J1)*RHOG/(WG*ALPHA(J1))
      ALFAC0(J1)=ALPHAC(J1)
      ALFAH0(J1)=ALPHAH(J1)
      ALFAW0(J1)=ALPHAW(J1)
      ALFAA0(J1)=ALPHAA(J1)
      X5=E(J1)
      IF(X5.EQ.0.0)E(J1)=1.0
      CONN=N(J1)*TMIN(J1)
      SLOPET=(TMAX(J1)-TMIN(J1))/(XCHNG(J1)-XBEGIN(J1))
      DO 68 INCI=1,NUMRDR
      INCIZ7=INCI
      CONT=(FLOAT(INCIZ7-1)+.5)*DEL
      IF(CONT.GE.XCHNG(J1))GO TO 66
      IF(CONT.LT.XBEGIN(J1))GO TO 63
      T0(INCI,J1)=TMIN(J1)+SLOPET*(CONT-XBEGIN(J1))
      GO TO 67
63    T0(INCI,J1)=TMIN(J1)
      GO TO 67
66    T0(INCI,J1)=TMAX(J1)
67    N01(INCI,J1)=CONN/T0(INCI,J1)
68    D01(INCI,J1)=D1(J1)
      N0(J1)=N(J1)
      D0(J1)=D1(J1)
      H0(J1)=H(J1)
1021  CONTINUE
```

```
      DO 75 KI=1,ELEMNT
      QMOLWT(KI)=ATWT(KI)
      MELM(KI)=EDNAME(KI)
75    CONTINUE
C
C*****WRITING OUT ALL INPUT VALUES IN SAME ORDER AS READ IN
C
      WRITE(3,399)
      DO 201 I=1,NCARD
201   WRITE(3,400)(COMENT(I,KI),KI=1,20)
      WRITE(3,403)
      WRITE(3,405)ODESTP,OSPRR,DYNAMO(1),DYNAMO(2),DYNAMO(3),NPRINT,
     1ELEMNT,SPECIE,PRTCLS,CRXN,HRXN,ICNVLM,ITRMAX,NPROP
      WRITE(3,406)BUG
      IF(ISASUM.GT.0)WRITE(3,409)ISASUM
      IF(EUCKEN.EQ.1)WRITE(3,407)
      IF(EUCKEN.NE.1)WRITE(3,408)
      IF(KEQ.EQ.1)WRITE(3,459)
      IF(SHRINK.EQ.1)WRITE(3,410)
      IF(IRAD.EQ.1)WRITE(3,414)
      WRITE(3,411)DYNTEM,SQDIF,DELTPJ,DELRRJ,TTEST
      IF(ISASUM.GT.0)WRITE(3,412)STIFVL
      IF(FUR.NE.1.0)WRITE(3,413)FUR
      WRITE(3,415)
      WRITE(3,420)GMW,HGAS,RHOG,WG,P
      WRITE(3,423)
      WRITE(3,425)SGH,(SGMC(I),I=1,3)
      WRITE(3,424)
      WRITE(3,426)PGX,PGH,(PGMC(I),I=1,4)
      DO 430 J=1,PRTCLS
      WRITE(3,433)J
      WRITE(3,435)D1(J),E(J),H(J),XI(J),W(J)
      WRITE(3,440)ALPHAA(J),ALPHAC(J),ALPHAH(J),ALPHAW(J),HHO(J),HWO(J)
      WRITE(3,445)TMIN(J),XBEGIN(J),TMAX(J),XCHNG(J)
      WRITE(3,423)
      WRITE(3,425)SJH(J),(SJMC(I,J),I=1,3)
      WRITE(3,424)
      WRITE(3,426)PJX(J),PJH(J),(PJMC(I,J),I=1,4)
      WRITE(3,451)
      DO 453 M=1,CRXN
453   WRITE(3,455)M,AMJ(J,M),EMJ(J,M),YY(J,M)
      DO 454 M=1,CRXN
454   WRITE(3,458)(CPVC(I,J,M),I=1,3),HFV(J,M)
      WRITE(3,456)
      DO 457 L=1,HRXN
457   WRITE(3,460)L,AL(J,L),EL(J,L),EMM(J,L)
      IF(KEQ.EQ.1)WRITE(3,459)
      WRITE(3,464)
      WRITE(3,465)(EDNAME(KI),PHIJWK(J,KI),KI=1,ELEMNT)
      WRITE(3,467)
      WRITE(3,470)((EDNAME(KI),M,PHIVK(J,KI,M),KI=1,ELEMNT),M=1,CRXN)
430   WRITE(3,475)((CCP(J,NI1,NI2),NI2=1,3),NI1=1,4)
      WRITE(3,477)(L,L=1,HRXN)
```

```
      WRITE(3,478)
      DO 431 KI=1,ELEMNT
431   WRITE(3,480) EDNAME(KI),ATWT(KI),OMEGAK(KI),OSGKM(KI),OPGKM(KI),
     1(PHIKL(KI,L),L=1,HRXN)
      WRITE(3,482)(EDNAME(IX),IX=1,ELEMNT)
      DO 432 I=1,SPECIE
432   WRITE(3,485)NAME1(I),NAME2(I),S(I),EK(I),DELTA(I),YINT(I),
     1(A(I,IX),IX=1,ELEMNT)
      WRITE(3,487)
      DO 436 I=1,SPECIE
436   WRITE(3,490)NAME1(I),NAME2(I),HR(I),SR(I),(Z(I,IX),IX=1,10)
      WRITE(3,399)
      WRITE(3,495)DDUCT,DS,ALEN,ANGLE,EB,TB
      WRITE(3,500)ELAM,GAMMA,MH
      WRITE(3,509)
      DO 505 L=1,HRXN
      LL=OXYD(L)
505   WRITE(3,510)L,NAME1(LL),NAME2(LL),PHIL(L)
      IF(IVPFLG.EQ.0)GO TO 520
      WRITE(3,515)(VPRCOF(I),I=1,5)
520   CONTINUE
      IF(RSTRT.EQ.1)CALL RESTRT(RSTRT)
      RETURN
5     FORMAT(16I5)
15    FORMAT(20A4)
25    FORMAT(8E10.3)
26    FORMAT(I5,5X,7E10.3)
27    FORMAT(3E10.4)
55    FORMAT(A2,8X,7E10.3)
65    FORMAT(2A4,2X,7E10.3)
399   FORMAT(1H1)
400   FORMAT(1H ,20A4)
403   FORMAT(1H-,32HRUN PARAMETERS******************)
405   FORMAT(1H0,10X,30HINITIAL NUMBER OF O.D.E. STEPS,20X,I5/11X,44HNUM
     1BER OF INITIAL STEPS PER RADIATION REGION,6X,I5/11X,36HDYNAMIC REG
     2ION MULTIPLICATION FACTOR,14X,I5/11X,44HMULTIPLICATION FACTOR AFTE
     3R DEVOLATILIZATION,6X,I5/11X,34HDIVISION FACTOR AFTER CHAR BURNOUT
     4,16X,I5/11X,25HNUMBER OF STEPS PER PRINT,25X,I5/11X,18HNUMBER OF E
     5LEMENTS,32X,I5/11X,17HNUMBER OF SPECIES,33X,I5/11X,30HNUMBER OF PA
     6RTICLE TYPES/SIZES,20X,I5/11X,24HNUMBER OF COAL REACTIONS,26X,I5/1
     71X,24HNUMBER OF CHAR REACTIONS,26X,I5/11X,28HMAXIMUM NUMBER OF COR
     8RECTORS,22X,I5/11X,35HMAXIMUM NUMBER OF SYSTEM ITERATIONS,15X,I5/1
     91X,42HNUMBER OF STEPS PER PHY. PROP. CALCULATION,8X,I5)
406    FORMAT(11X,11HDEBUG LEVEL,39X,I5)
407    FORMAT(11X,55HTHERMAL CONDUCTIVITY CALCULATIONS USE
     1 EUCKEN CORRECTION)
408    FORMAT(11X,62HTHERMAL CONDUCTIVITY CALCULATIONS USE
     1 SAGE-GALLOWAY CORRECTION)
409    FORMAT(11X,46HSTIFF PARTICLE ENERGY EQUATION ASSUMPTION USED,4X,
     1I5)
410    FORMAT(11X,49HSHRINKING PARTICLE ASSUMPTION DURING CHAR BURNOUT)
411    FORMAT(11X,42HDYNAMIC REGION INITIATION TEMP.(DEGREES K),8X,F11.2/
     111X,46HMAXIMUM ACCEPTABLE ROOT MEAN SQUARE(DEGREES K),4X,F11.2/11X
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      2,33HTEMP. CHANGE TOLERANCE(DEGREES K),17X,F11.8/11X,45HTOTAL PARTI
      3CLE REACTION RATE CHANGE TOLERANCE,5X,F11.8/11X,37HCORRECTOR CONVE
      4RGENCE SLOPE TOLERANCE,13X,F11.8)
412    FORMAT(11X,42HTOLERANCE FOR STIFF ASSUMPTION APPLICATION,8X,F11.8)
413    FORMAT(11X,23HUNDER RELAXATION FACTOR,27X,F11.8)
414    FORMAT(11X,45HDIFFUSION APPROXIMATION FOR RADIATION IS USED)
415    FORMAT(1H-,31HGAS PARAMETERS*****************/1H0,14X,
      113HGAS MOLECULAR,2X,19HENTHALPY OF THE GAS2X,18HDENSITY OF THE GAS
      2,4X,14HMASS FLOW RATE,9X,8HPRESSURE/19X,6HWEIGHT/17X,9H(G/GMOLE),
      3 9X,7H(CAL/G),12X,9H(G/CM**3),13X,7H(G/SEC),14X,5H(ATM))
420    FORMAT(1H ,14X,F10.4,F17.4,9X,E12.5, 2(10X,F10.4))
423    FORMAT(1H0,34X,11HENTHALPY OF,27X,17HMASS ADDITON RATE/34X,13HTHE
      1 SECONDARY,27X,14HFROM SECONDARY/37X,7H(CAL/G),32X,10H(G/CM-SEC))
424    FORMAT(1H0,14X,12HDISTANCE FOR,8X,11HENTHALPY OF,27X,18HMASS ADD
      1ITION RATE/14X,13HRECIRCULATION,7X,13HRECIRCULATION,25X,18HFROM
      2 RECIRCULATION/13X,15HPROPERTIES (CM),9X,7H(CAL/G),32X,10H(G/
      3CM-SEC))
425    FORMAT(1H ,22X,F20.4,20X,F10.4,7HX**2 + ,F8.4,5HX  + ,F8.4)
426    FORMAT(1H ,2X,2(F20.4),10X,F10.4,7HX**3 + ,F8.4,7HX**2 + ,F8.4
      1,4HX + ,F8.4)
433    FORMAT(26H1PARAMETERS FOR THE NUMBER,I2,21H PARTICLE PHASE******)
435    FORMAT(1H-,14X,8HDIAMETER,7X,10HEMISSIVITY,7X,8HENTHALPY,5X,
      112HSURFACE AREA,3X,14HMASS FLOW RATE/17X,4H(CM),27X,7H(CAL/G),8X,6
      2HFACTOR,10X,7H(G/SEC)/12X,2(F10.4,6X),F10.4,5X,E12.5,3X,F10.4)
440    FORMAT(1H-,13X,8HASH MASS,6X,9HCOAL MASS,4X,9HCHAR MASS,5X,10HWATE
      1R MASS,4X,9HCHAR REF.,3X,10HWATER REF./70X,8HENTHALPY,4X,
      28HENTHALPY/17X,3H(G),11X,3H(G),11X,3H(G),11X,3H(G),
      39X,7H(CAL/G),6X,7H(CAL/G)/11X,3(E12.5,2X),E12.5,4X,2(F10.4,5X))
445    FORMAT(1H-,10X,20HSTARTING TEMPERATURE,6X,13HDISTANCE TEMP,6X,15HI
      1NITIAL MAXIMUM,4X,20HDISTANCE INITIAL MAX,/38X,11HRISE BEGINS,
      27X,15HTEMP IS REACHED/20X,3H(K),17X,4H(CM),15X,3H(K),18X,4H(CM)/
      316X,4(F10.4,10X))
450    FORMAT(1H-,11X,18HMASS ADDITION RATE,3X,18HMASS ADDITION RATE,7X,
      111HENTHALPY IN,10X,11HENTHALPY IN/14X,14HFROM SECONDARY,5X,
      218HFROM RECIRCULATION,8X,9HSECONDARY,10X,13HRECIRCULATION,/13X,
      310H(G/CM-SEC),14X,10H(G/CM-SEC),13X,7H(CAL/G),14X,7H(CAL/G)/13X,
      44(E12.5,10X))
451    FORMAT(1H-,10X,46HPARAMETERS FOR EACH COAL REACTION AND PARTICLE//
      1/12X,8HREACTION,5X,14HPYROLYSIS PRE-,6X,17HACTIVATION ENERGY,6X,
      213HMASS FRACTION/23X,18HEXPONENTIAL FACTOR
      3,8X,11HIN REACTION/27X,7H(1/SEC),15X,13H(CAL/GMOLE-K))
455    FORMAT(12X,I4,8X,E12.5,15X,F10.4, 5X,F10.4,11X,E12.5)
456    FORMAT(1H-,10X,46HPARAMETERS FOR EACH CHAR REACTION AND PARTICLE///
      112X,8HREACTION,2X,21HSURFACE REACTION PRE-,5X,17HACTIVATION ENERGY
      2,7X,1HM/24X,18HEXPONENTIAL FACTOR/24X,13H(CM/SEC-K**M),12X,11H(CAL
      3/GMOLE))
458    FORMAT(1H0,45X,15HCP COEFFICIENTS,25X,1HH/87X,3HFVJ/51X,7H(CAL/G)/
      130X,3(E10.3,5X),8X,F10.3)
459    FORMAT(11X,66HTHE K EQUATION OF FIELD ET. AL. IS USED FOR CHAR
      1 OXIDATION WITH O2)
460    FORMAT(13X,I3,7X,E12.5,15X,F10.4,10X,F5.2)
464    FORMAT(1H1,10X,82HSTOICHIOMETRIC COEFFICIENT FOR JTH PARTICLE TO K
      1TH ELEMENT IN MOISTURE EVAPORATION/1H0,12X,7HELEMENT,5X,11HCOEFFIC
```

```
         2IENT)
  465    FORMAT(14X,A2,5X,F10.4)
  467    FORMAT(1H-,10X,93HSTOICHIOMETRIC COEFFICIENT FOR JTH PARTICLE TO K
        1TH ELEMENT IN MTH REACTION (DEVOLATILIZATION)/1H0,12X,7HELEMENT,3X
        2,8HREACTION,8X,11HCOEFFICIENT)
  470    FORMAT(14X,A2,9X,I2,9X,F10.4)
  475    FORMAT(1H-,10X,52HCOEFFICIENTS FOR QUADRATIC EQUATION OF HEAT CAPA
        1CITY/1H-,11X,9HCOAL PART,10X,1H1,19X,1H2,19X,1H3/14X,4HCOAL,8X,[illegible]
        23(E10.3,10X)/14X,4HCHAR,8X,3(E10.3,10X)/14X,5HWATER,7X,[illegible],
        33(E10.3,10X)/15X,3HASH,8X,3(E10.3,10X))
  477    FORMAT(35H1ELEMENT PARAMETERS*****************///12X,7HELEMENT,3X,
        110HATOMIC WT.,3X,12HINITIAL MASS,1X,13HMASS FRACTION,2X,13HMASS FR
        2ACTION,12X,45HSTOICHIOMETRIC COEFFECIENTS FROM LTH REACTION/36X,8H
        3FRACTION,7X,7HIN SEC.,6X,10HIN RECIRC.,3X,5(6X,I1,7X))
  478    FORMAT(50X,10H(G/CM-SEC),4X,10H(G/CM-SEC))
  480    FORMAT(1H ,14X,A2,1X,9(1X,F12.5,1X))
  482    FORMAT(34H-SPECIES PARAMETERS****************//13X,7HSPECIES,4X,
        19HCOLLISION,5X,9HEPSILON/K7X,5HDELTA,7X,11HMOL FRAC IN,14X,31HNUMB
        2ER OF ELEMENTS IN A SPECIES/24X,8HDIAMETER,46X,10(1X,A2,2X)/40X,3H
        3(A),11X,3H(K))
  485    FORMAT(1H ,12X,2A4,4(2X,F10.5,2X),10(1X,F2.0,2X))
  487    FORMAT(1H0,11X,7HSPECIES,10X,8HENTHALPY,5X,
        17HENTROPY,25X,32HHEAT CAPACITY COEFF. FOR EDWARDS/)
  490    FORMAT(15X,2A4,1X,2(1X,F12.5,1X)/2(66X,5(F10.4,2X)/).
  495    FORMAT(33H-PHYSICAL PARAMETERS**************/1H0,10X,
        116HDIAMETER OF DUCT,3X,19HDIAMETER OF CHAMBER,2X,14HREACTOR LENGTH
        2,2X,17HGROWTH AREA ANGLE,2X,17HEMISSIVITY OF THE,3X,
        318HTEMPERATURE OF THE/17X,4H(CM),16X,4H(CM),
        415X,4H(CM),12X,9H(DEGREES),8X,4HWALL,15X,8HWALL (K)/
        51H ,6X,3(5X,F10.4,5X),1X,F10.4,2X,2(5X,F10.4,5X))
  500    FORMAT(1H-,T40,12X,10HABSORBTION,5X,8HPARTICLE,7X,9HMOLECULAR/T40,
        112X,10HEFFICIENCY,5X,8HSWELLING,5X,14HWEIGHT OF CHAR/T40,
        242X,9H(G/GMOLE)/T40,10X,F10.4,5X,3(F10.4,5X))
  509    FORMAT(32H-CHAR REACTION DATA**************/1H0,11X,8HREACTION,
        14X,8HOXYDIZER,8X,14HSTOICHIOMETRIC/41X,11HCOEFFICIENT)
  510    FORMAT(1H0,14X,I1,8X,2A4,7X,F10.4)
  515    FORMAT(34H-VAPOR PRESSURE CURVE COEFFICIENTS/,10X,
        123H A+BX+CX**2+DX**3+EX**4/1H0,10X,5(2X,F10.4,2X))
         END
```

```
      SUBROUTINE LGND (ASTRG,NA,NL)
C  ASTRG(NA):  ARRAY OF CHARS TO BE PRINTED (44 CHARS MAX)
C              CHARACTER SIZE:  3/16 X 9/64 IN.
C  NA:  NUMBER OF CHARS AND SPACES IN ASTRG
C  NA.LT.0,RETURN:  ASTRG HAD MORE THAN 44 CHARS
C  NL:  LINE NUMBER  (1: 1ST LINE, 2: 2ND, ETC.)
C       LINES ARE PRINTED IN 1/4 IN. STEPS
C  NL.LT.0:  END GRAPH AFTER THIS LINE
      DIMENSION ASTRG(1)
      IF(NA.LE.44) GO TO 10
      NA=-NA
      RETURN
10    NLT=ABS(NL)
      X=4.5-(NA*.1875)/2.0
      Y=6.8125-NLT*.25
      CALL SYMBOL(X,Y,0.1875,ASTRG,0.0,NA)
      IF(NL.LT.0) CALL PLOT(12.,-2.5,-3)
      RETURN
      END
```

```
      SUBROUTINE OPEN
C
C*****OPENING THE DATA FILE ON DISC ON THE DEC-10
C
      DOUBLE PRECISION DATFIL
      TYPE 5
5     FORMAT(25H0ENTER INPUT FILE NAME:  $)
      READ(5,10)DATFIL
10    FORMAT(A10)
      OPEN(UNIT=1,FILE=DATFIL,ACCESS='SEQIN')
      RETURN
      END
```

```
      SUBROUTINE OUTPUT
      COMMON/IO/DDUCT,DYDXM,AGSTPD,CPVC(3,5,5),HFV(5,5),DELHV(5,5),
     1INTCPV(5,5),QRBJ(5)
      COMMON/GNRAL2/NAME1(20),NAME2(20)
      COMMON/MORE/D01(255,5),N01(255,5),ALFA0(255,5),ALFA0C(255,5),
     1ALFA0H(255,5),ALFA0W(255,5),ALFA0A(255,5),X0(255,20),WVG(255)
      COMMON /AREA13/ALFAC0(5),GAMMA,EK(20),XI(5),AMJ(5,5),
     1EMJ(5,5),KVD(5,5),TB,D(5),RHOC(5),RHO(5),DELTA(20),DIFM(20)
     2,ALFAH0(5),ALFAW0(5),ALFAA0(5)
      COMMON /RADI/T0(255,5),N0(5),D0(5),SIGMA,PI,E(5),IT(255),H0(5)
     1,NUMRDR,DEL,IRAD,TOOLD(5)
      COMMON /GENRAL/ALPHAA(5),S(20),KG,MUG,DS,
     1TPJJ(5),YY(5,5),PRTCLS,SPECIE,
     2ELEMNT,CRXN,HRXN,HH(5),HW(5),RGC
      COMMON /LAST/GASTMN,TMIN(5),IQ0J(255,5)
      COMMON /APR77/DELTPJ,DELRRJ,ALEN,JFAR,HM,DIFMW,ICNVLM,
     1TTEST,SUMSQ,ITRSYS,GAST(255),OSPRR,NPROP,ARMAX,AMIN,SQDIF
      COMMON/JAN78/V0,FUR
      DIMENSION X(255),Y(255),ASCX(5),ASCY1(9),ASTRG1(8),NORM(5)
     1,ASCY2(9),ASTRG2(4),SPAXX(3),SPAXY(3),ASCY3(4),ASTRG3(7),
     2ASTRG4(10),ASTRG5(6),ASTRG6(6),ASTRG7(6),ASTRG8(6),ASTRG9(6),
     3ASTR10(5),TODAY(2)
      INTEGER PRTCLS,SPECIE,P
      REAL N0,N01,NORM
      DATA ASCX/20HAXIAL LOCATION (CM.)/,NX/20/
      DATA ASCY1/33HTEMPERATURE (DEGREES KELVIN X100)/,NY1/33/
      DATA ASTRG1/29HPARTICLE AND GAS TEMPERATURES/,NA1/29/
      DATA ASCY2/36HCOMPONENT MASS/INITIAL PARTICLE MASS/,NY2/36/
      DATA ASTRG2/13HPARTICLE MASS/,NA2/13/
      DATA ASCY3/13HMOLE FRACTION/,NY3/13/
      DATA ASTRG3/26HGAS SPECIES MOLE FRACTIONS/,NA3/26/
      DATA ASTRG4/37Hnote:  scaling(if X>0.6 then X=X-0.4)/,NA4/37/
      DATA ASTRG5/24HMASS OF PARTICLE TYPE #1/,NA5/24/
      DATA ASTRG6/24HMASS OF PARTICLE TYPE #2/,NA6/24/
      DATA ASTRG7/24HMASS OF PARTICLE TYPE #3/,NA7/24/
      DATA ASTRG8/24HMASS OF PARTICLE TYPE #4/,NA8/24/
      DATA ASTRG9/24HMASS OF PARTICLE TYPE #5/,NA9/24/
      DATA ASTR10/19HTOTAL PARTICLE MASS/,N10/19/
C
C*****THIS SUBROUTINE PRINTS AND PLOTS ALL OUTPUT INFORMATION
C
C
C*****FINDING TODAY'S DATE
C
      CALL DATE(TODAY)
C
C*****FINDING THE NORMALIZED X-POSITION DOWN THE REACTOR
C
      XX=0.0
      X(1)=XX
      DELX=ALEN/FLOAT(NUMRDR)
      DO 10 IO=2,NUMRDR+1
      XX=XX+DELX
```

```
10     X(IO)=XX
C
C*****INITIALIZING AND WRITING OUT PARTICLE SPECS
C
       TNORM=0.0
       TC0=0.0
       TH0=0.0
       TW0=0.0
       TA0=0.0
       DO 30 J=1,PRTCLS
       NORM(J)=ALFAC0(J)+ALFAH0(J)+ALFAW0(J)+ALFAA0(J)
       TC0=TC0+ALFAC0(J)*N01(1,J)*WVG(1)
       TH0=TH0+ALFAH0(J)*N01(1,J)*WVG(1)
       TW0=TW0+ALFAW0(J)*N01(1,J)*WVG(1)
       TA0=TA0+ALFAA0(J)*N01(1,J)*WVG(1)
       WRITE(3,100)
       WRITE(3,101)J
       WRITE(3,105)(TODAY(ID),ID=1,2)
       WRITE(3,110)
       WRITE(3,120)
       WRITE(3,110)
       WRITE(3,140)X(1),GASTMN,TMIN(J),V0,N0(J),D0(J),ALFAC0(J)
      1,ALFAH0(J),ALFAW0(J),ALFAA0(J),NORM(J)
       DO 20 IO=1,NUMRDR
       A=ARMAX
       IF(X(IO+1).LT.AGSTPD)A=PI*(DDUCT/2.0+DYDXM*X(IO+1))**2
       V=WVG(IO)/A
       WRITE(3,140)X(IO+1),GAST(IO),T0(IO,J),V,N01(IO,J),D01(IO,J),
      1ALFA0C(IO,J),ALFA0H(IO,J),ALFA0W(IO,J),ALFA0A(IO,J),ALFA0(IO,J)
20     CONTINUE
30     CONTINUE
       TNORM=TC0+TH0+TW0+TA0
C*****TOTAL
       WRITE(3,100)
       WRITE(3,103)
       WRITE(3,105) (TODAY(ID),ID=1,2)
       WRITE(3,110)
       WRITE(3,125)
       WRITE(3,110)
       TC=TC0/TNORM
       TH=TH0/TNORM
       TW=TW0/TNORM
       TA=TA0/TNORM
       TP=1.0
       WRITE(3,160) X(1),TC,TH,TW,TA,TP
       DO 36 IO=1,NUMRDR
       TC=0.0
       TH=0.0
       TW=0.0
       TP=0.0
       DO 35 J=1,PRTCLS
       TC=TC+ALFA0C(IO,J)*N01(IO,J)
       TH=TH+ALFA0H(IO,J)*N01(IO,J)
```

```
   35 TW=TW+ALFAOW(IO,J)*NO1(IO,J)
      TC=TC*WVG(IO)/TNORM
      TH=TH*WVG(IO)/TNORM
      TW=TW*WVG(IO)/TNORM
      TP=TC+TH+TW+TA
      WRITE(3,160)X(IO+1),TC,TH,TW,TA,TP
   36 CONTINUE
C
C*****WRITING OUT GAS PHASE SPECS
C
      I=1
40    CONTINUE
      NS=10
      IF(SPECIE.LE.10)NS=SPECIE
      IF(I.EQ.2)NS=SPECIE
      WRITE(3,100)
      WRITE(3,102)
      WRITE(3,105)(TODAY(ID),ID=1,2)
      WRITE(3,110)
      IF(I.EQ.1)WRITE(3,130)(NAME1(IS),NAME2(IS),IS=1,NS)
      IF(I.EQ.2)WRITE(3,130)(NAME1(IS),NAME2(IS),IS=11,NS)
      WRITE(3,135)
      WRITE(3,110)
      DO 50 IO=1,NUMRDR
      IF(I.EQ.1)WRITE(3,150)X(IO+1),WVG(IO),(XO(IO,IS),IS=1,NS)
      IF(I.EQ.2)WRITE(3,150)X(IO+1),WVG(IO),(XO(IO,IS),IS=11,NS)
50    CONTINUE
      IF(SPECIE.GT.10)I=I+1
      IF(I.EQ.2)GO TO 40
C
C*****PLOTTING OUT TEMPERATURE PROFILES
C
      Y(1)=GASTMN/100.0
      DO 55 IO=1,NUMRDR
      IOO=IO+1
55    Y(IOO)=GAST(IO)/100.0
      CALL GRPH(X,Y,NUMRDR+1,0.,0.,ASCX,NX,ASCY1,NY1,-1)
      DO 65 J=1,PRTCLS
      Y(1)=TMIN(J)/100.0
      DO 60 IO=1,NUMRDR
      IOO=IO+1
60    Y(IOO)=TO(IO,J)/100.0
65    CALL GRPH(X,Y,NUMRDR+1,0.,0.,ASCX,NX,ASCY1,NY1,1)
      CALL LGND(ASTRG1,NA1,-1)
C
C*****PLOTTING PARTICLE MASS FOR EACH PARTICLE
C
      P=PRTCLS+1
      L=P
      IF(PRTCLS.EQ.1)L=1
      DO 95 J=1,L
C
C*****SCALING FOR PARTICLE MASS
```

```
C
67    SPAXX(1)=0.0
      SPAXX(2)=0.0
      SPAXX(3)=ALEN
      SPAXY(1)=0.98
      SPAXY(2)=0.0
      SPAXY(3)=0.0
      CALL GRPH(SPAXX,SPAXY,3,0.,0.,ASCX,NX,ASCY2,NY2,-1)
      Y(1)=1.0
      DO 70 IO=1,NUMRDR
      IOO=IO+1
      IF(J.NE.P)Y(IOO)=ALFAO(IO,J)/NORM(J)
      IF(J.NE.P)GO TO 70
      Y(IOO)=0.0
      DO 69 K=1,PRTCLS
69    Y(IOO)=Y(IOO)+ALFAO(IO,K)*NO1(IO,K)*WVG(IO)/TNORM
70    CONTINUE
      CALL GRPH(X,Y,NUMRDR+1,0.,0.,ASCX,NX,ASCY2,NY2,1)
      IF(J.NE.P)Y(1)=ALFACO(J)/NORM(J)
      IF(J.EQ.P)Y(1)=TCO/TNORM
      DO 75 IO=1,NUMRDR
      IOO=IO+1
      IF(J.NE.P)Y(IOO)=ALFAOC(IO,J)/NORM(J)
      IF(J.NE.P)GO TO 75
      Y(IOO)=0.0
      DO 74 K=1,PRTCLS
74    Y(IOO)=Y(IOO)+ALFAOC(IO,K)*NO1(IO,K)*WVG(IO)/TNORM
75    CONTINUE
      CALL GRPH(X,Y,NUMRDR+1,0.,0.,ASCX,NX,ASCY2,NY2,1)
      IF(J.NE.P)Y(1)=ALFAHO(J)/NORM(J)
      IF(J.EQ.P)Y(1)=THO/TNORM
      DO 80 IO=1,NUMRDR
      IOO=IO+1
      IF(J.NE.P)Y(IOO)=ALFAOH(IO,J)/NORM(J)
      IF(J.NE.P)GO TO 80
      Y(IOO)=0.0
      DO 79 K=1,PRTCLS
79    Y(IOO)=Y(IOO)+ALFAOH(IO,K)*NO1(IO,K)*WVG(IO)/TNORM
80    CONTINUE
      CALL GRPH(X,Y,NUMRDR+1,0.,0.,ASCX,NX,ASCY2,NY2,1)
      IF(J.NE.P)Y(1)=ALFAWO(J)/NORM(J)
      IF(J.EQ.P)Y(1)=TWO/TNORM
      DO 85 IO=1,NUMRDR
      IOO=IO+1
      IF(J.NE.P)Y(IOO)=ALFAOW(IO,J)/NORM(J)
      IF(J.NE.P)GO TO 85
      Y(IOO)=0.0
      DO 84 K=1,PRTCLS
84    Y(IOO)=Y(IOO)+ALFAOW(IO,K)*NO1(IO,K)*WVG(IO)/TNORM
85    CONTINUE
      CALL GRPH(X,Y,NUMRDR+1,0.,0.,ASCX,NX,ASCY2,NY2,1)
      IF(J.NE.P)Y(1)=ALFAAO(J)/NORM(J)
      IF(J.EQ.P)Y(1)=TAO/TNORM
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```
      DO 90 IO=1,NUMRDR
      IOO=IO+1
      IF(J.NE.P)Y(IOO)=ALFA0A(IO,J)/NORM(J)
      IF(J.NE.P)GO TO 90
      Y(IOO)=0.0
      DO 89 K=1,PRTCLS
89    Y(IOO)=Y(IOO)+ALFA0A(IO,K)*N01(IO,K)*WVG(IO)/TNORM
90    CONTINUE
      CALL GRPH(X,Y,NUMRDR+1,0.,0.,ASCX,NX,ASCY2,NY2.1)
      IF(J.EQ.P)CALL LGND(ASTR10,N10,-1)
      IF(J.EQ.P) GO TO 95
      IF(PRTCLS.EQ.1)CALL LGND(ASTRG2,NA2,-1)
      IF(PRTCLS.EQ.1)GO TO 95
      IF(J.EQ.1)CALL LGND(ASTRG5,NA5,-1)
      IF(J.EQ.2)CALL LGND(ASTRG6,NA6,-1)
      IF(J.EQ.3)CALL LGND(ASTRG7,NA7,-1)
      IF(J.EQ.4)CALL LGND(ASTRG8,NA8,-1)
      IF(J.EQ.5)CALL LGND(ASTRG9,NA9,-1)
95    CONTINUE
C
C*****SCALING FOR GAS PHASE MOLE FRACTIONS
C
      SPAXX(1)=0.0
      SPAXX(2)=0.0
      SPAXX(3)=ALEN
      SPAXY(1)=0.58
      SPAXY(2)=0.0
      SPAXY(3)=0.0
      CALL GRPH(SPAXX,SPAXY,3,0.,0.,ASCX,NX,ASCY3,NY3,-1)
C
C*****PLOTTING GAS PHASE MOLE FRACTIONS
C
      DO 96 IO=1,NUMRDR
96    X(IO)=X(IO+1)
      DO 98 IS=1,SPECIE
      DO 97 IO=1,NUMRDR
      Y(IO)=X0(IO,IS)
97    IF(X0(IO,IS).GT.0.6)Y(IO)=X0(IO,IS)-0.4
      CALL GRPH(X,Y,NUMRDR,0.,0.,ASCX,NX,ASCY3,NY3,1)
98    CONTINUE
      CALL LGND(ASTRG3,NA3,1)
      CALL LGND(ASTRG4,NA4,-2)
      RETURN
100   FORMAT(1H1)
101   FORMAT(1H0,23X,83HBYU -- ONE DImensional Combustion Or Gasificatio
     1n model (1-DICOG): particle number ,I1)
102   FORMAT(1H0,20X,91HBYU -- ONE DImensional Combustion Or Gasificatio
     1n model (1-DICOG): gas phase mole fractions)
103   FORMAT(1H0,20X,87HBYU -- ONE DImensional Combustion Or Gasificatio
     1n model (1-DICOG): total particle phase)
105   FORMAT(1H0,62X,2A5)
110     FORMAT(1H0,129(1H*))
120   FORMAT(1H0,11X,8HDISTANCE,5X,3HGAS,4X,8HPARTICLE,2X,8HVELOCITY,
```

```
     12X,8HPARTICLE,2X,8HPARTICLE,4X,4HCOAL,6X,4HCHAR,7X,3HH2O,7X,
     23HASH,6X,4HPART/24X,4HTEMP,6X,4HTEMP,14X,8HNO. DENS,4X,4HDIA.,
     35(6X,4HMASS)/14X,4H(cm),4X,8H(kelvin),2X,8H(kelvin),2X,8H(cm/sec)
     43X,6H(#/cc),5X,4H(cm),5(6X,4H(gr)))
125   FORMAT(1H0,29X,8HDISTANCE,6X,4HCOAL,8X,4HCHAR,8X,3HH2O,9X,3HASH,
     17X,5HTOTAL/31X,4H(cm),14X,38H(component mass/initial particle mass
     1))
130   FORMAT(1H0,7X,8HDISTANCE,3X,10HFLOW  RATE,3X,10(1X,2A4,1X))
135   FORMAT(10X,4H(cm),6X,8H(cc/sec))
140   FORMAT(13X,F6.2,4X,F6.1,4X,F6.1,2X,1PE9.2,7(1X,1PE9.2))
150   FORMAT(9X,F6.2,4X,1PE9.2,2X,10(2X,0PF6.5,2X))
160   FORMAT(30X,F6.2,5X,5(F7.5,5X))
      END
```

```
      SUBROUTINE PROFIL(J,IDISP)
      COMMON /TRUBLE/INDX,ITRBLE
      COMMON /EDNUM/RHOG,CPG,TG,CPI(20),X(20),CO(5),HGAS,EDNAME(9),
     1OXYD(5),GMW,QMASS(9,20),WTM(20)
      COMMON /AREA13/ALFACO(5),GAMMA,EK(20),XI(5),AMJ(5,5),
     1EMJ(5,5),KVD(5,5),TB,D(5),RHOC(5),RHO(5),DELTA(20),DIFM(20)
     2,ALFAHO(5),ALFAWO(5),ALFAAO(5)
      COMMON /DIFEQN/OMEGAK(9),ALPHA(5),ALPHAC(5),ALPHAH(5),
     1ALPHAW(5),NN(5),H(5),QF(5),QCB,QZ(5),P,V,HG(5),RK(5,9),
     2RL(5,20),RM(5,20),RC(5),RH(5),RW(5),RR(5),W(5),WG,AREA,PRESSR
      COMMON/MORE/D01(255,5),N01(255,5),ALFA0(255,5),ALFA0C(255,5),
     1ALFA0H(255,5),ALFA0W(255,5),ALFA0A(255,5),X0(255,20),WVG(255)
      COMMON /RADI/T0(255,5),N0(5),D0(5),SIGMA,PI,E(5),IT(255),H0(5)
     1,NUMRDR,DEL,IRAD,TOOLD(5)
      COMMON /GENRAL/ALPHAA(5),S(20),KG,MUG,DS,
     1TPJJ(5),YY(5,5),PRTCLS,SPECIE,
     2ELEMNT,CRXN,HRXN,HH(5),HW(5),RGC
      COMMON /ODEVAL/XDIS,XTRMNL,VALINT(42),ODESTP
      COMMON /APR77/DELTPJ,DELRRJ,ALEN,JFAR,HM,DIFMW,ICNVLM,
     1TTEST,SUMSQ,ITRSYS,GAST(255),OSPRR,NPROP,ARMAX,AMIN,SQDIF
      REAL NN,N01
      INTEGER PRTCLS,OSPRR,SPECIE,ODESTP
C
C*****THIS SUBROUTINE SAVES ALL THE PROFILES WHICH WILL BE OUTPUT IN
C     THEIR APPROPRIATE ARRAYS IN PREPERATION FOR PRINTOUT AND PLOTTING.
C     IN ADDITION SOME OF THE PROFILES PREPARED HERE ARE USED FOR THE
C     NEXT PASS THROUGH THE REACTOR IN CALCULATING INITIAL PROFILES FOR
C     RINTS.  IT SHOULD BE NOTED THAT VALUES ARE ONLY STORED FOR THE
C     RADIATIONL REGIONS.  THIS MEANS THAT THE VALUES CALCULATED AT EACH
C     O.D.E. STEP ARE AVERAGED(LINEARLY) TO OBTAIN VALUES FOR THE
C     RADIATION REGION IN QUESTION.
C
      IF(XDIS.NE.0.0)GO TO 30
C
C*****INITIALIZATIONL AT THE BEGINING OF THE REACTOR
C     I.E.-- ZEROING OUT THE INITIAL RADIATION REGION
C     NOTE: THE PAST VALUES OF THE ARRAYS ARE NEEDED LATER IN THIS
C           SUBROUTINE FOR CALCULATING THE ROOT MEAN SQUARE.
C
      SUMSQ=0.0
      GAST(1)=0.0
      WVG(1)=0.0
      DO 5 IJ=1,PRTCLS
      TOOLD(IJ)=T0(1,IJ)
      N01(1,IJ)=0.0
      D01(1,IJ)=0.0
      T0(1,IJ)=0.0
      ALFA0(1,IJ)=0.0
      ALFA0C(1,IJ)=0.0
      ALFA0H(1,IJ)=0.0
      ALFA0W(1,IJ)=0.0
      ALFA0A(1,IJ)=0.0
5     CONTINUE
```

```
       DO 10 IS=1,SPECIE
 10    XO(1,IS)=0.0
       GO TO 1000
 30    CONTINUE
C
C*****ZEROING OUT THE PRESENT STORAGE LOCATION IN THE ARRAY WHEN WE
C     ARE THROUGH WITH IT IN CALCULATION THE ROOT MEAN SQUARE AND ARE
C     READY TO START FILLING IT UP AGAIN WITH PRESENT VALUES.
C     TIMET IS ALSO CALLED AT THIS POINT TO SEE IF THE TIME OF DAY IS
C     ACCEPTABLE TO CONTINUE EXECUTION.
C
C
       JM=J-1+IDISP
       INDX=JM/OSPRR+1
       IF(MOD(JM,OSPRR).NE.0.OR.JM.EQ.0)GO TO 80
       GAST(INDX)=0.0
       WVG(INDX)=0.0
       DO 70 IJ=1,PRTCLS
       SUMSQ=SUMSQ+(TOOLD(IJ)-TO(INDX-1,IJ))**2
       TOOLD(IJ)=TO(INDX,IJ)
       NO1(INDX,IJ)=0.0
       DO1(INDX,IJ)=0.0
       TO(INDX,IJ)=0.0
       ALFAO(INDX,IJ)=0.0
       ALFAOC(INDX,IJ)=0.0
       ALFAOH(INDX,IJ)=0.0
       ALFAOW(INDX,IJ)=0.0
       ALFAOA(INDX,IJ)=0.0
 70    CONTINUE
       DO 75 IS=1,SPECIE
 75    XO(INDX,IS)=0.0
       CALL TIMET
 80    CONTINUE
C
C*****AVERAGING THE O.D.E. STEP VALUES AND STORING THEM IN THE ARRAYS
C
       GAST(INDX)=GAST(INDX)+TG/FLOAT(OSPRR)
       WVG(INDX)=WVG(INDX)+(WG/RHOG)/FLOAT(OSPRR)
       DO 90 IJ=1,PRTCLS
       NO1(INDX,IJ)=NO1(INDX,IJ)+NN(IJ)/FLOAT(OSPRR)
       DO1(INDX,IJ)=DO1(INDX,IJ)+D(IJ)/FLOAT(OSPRR)
       TO(INDX,IJ)=TO(INDX,IJ)+TPJJ(IJ)/FLOAT(OSPRR)
       ALFAO(INDX,IJ)=ALFAO(INDX,IJ)+ALPHA(IJ)/FLOAT(OSPRR)
       ALFAOC(INDX,IJ)=ALFAOC(INDX,IJ)+ALPHAC(IJ)/FLOAT(OSPRR)
       ALFAOH(INDX,IJ)=ALFAOH(INDX,IJ)+ALPHAH(IJ)/FLOAT(OSPRR)
       ALFAOW(INDX,IJ)=ALFAOW(INDX,IJ)+ALPHAW(IJ)/FLOAT(OSPRR)
       ALFAOA(INDX,IJ)=ALFAOA(INDX,IJ)+ALPHAA(IJ)/FLOAT(OSPRR)
 90    CONTINUE
       DO 100 IS=1,SPECIE
       IF(X(IS).LT.1.0E-30)GO TO 100
       XO(INDX,IS)=XO(INDX,IS)+X(IS)/FLOAT(OSPRR)
 100   CONTINUE
C
```

```
C*****PICKING UP THE LAST VALUE FOR ROOT MEAN SQUARE CALCULATIONS
C
      IF(J.NE.(ODESTP-IDISP))GO TO 1000
      DO 999 IJ=1,PRTCLS
999   SUMSQ=SUMSQ+(TOOLD(IJ)-TO(INDX,IJ))**2
1000  RETURN
      END
```

```
      SUBROUTINE RESTRT(RSTRT)
      COMMON/GENRAL/ALPHAA(5),S(20),KG,MUG,DS,
     1TPJJ(5),YY(5,5),PRTCLS,SPECIE,
     2ELEMNT,CRXN,HRXN,HH(5),HW(5),RGC
      COMMON/RADI/T0(255,5),N0(5),D0(5),SIGMA,PI,E(5),IT(255),H0(5)
     1,NUMRDR,DEL,IRAD,TOOLD(5)
      COMMON/MORE/D01(255,5),N01(255,5),ALFA0(255,5),ALFA0C(255,5),
     1ALFA0H(255,5),ALFA0W(255,5),ALFA0A(255,5),X0(255,20),WVG(255)
      COMMON/CONST/OSGKM(9),OPGKM(9),SJMC(3,5),PJMC(4,5),SJH(5),
     1PJH(5),SGMC(3),PGMC(4),PGH,SGH,PGX,PJX(5)
      INTEGER RADCHK,ELEMNT,PRTCLS
C
C*****THIS SUBROUTINE DOES ALL THE WORK NECESSARY FOR READING AND WRITING
C     INFORMATION NECESSARY FOR A RESTART.
C
      IF(RSTRT.EQ.0)GO TO 100
C
C*****IF RESTART DATA IS GOING TO BE USED IN INPUT AND RINTS FOR AN
C     INITIAL PROFILE THIS AREA DOES THE WORK.
C
      OPEN(UNIT=21,FILE='RESTRT',ACCESS='SEQIN')
      READ(21)RADCHK
      IF(RADCHK.NE.NUMRDR)CLOSE(UNIT=21)
      IF(RADCHK.NE.NUMRDR)RETURN
      WRITE(3,200)
      READ(21)PGH,(OPGKM(I),I=1,ELEMNT),(PJH(I),I=1,PRTCLS)
      DO 10 L=1,PRTCLS
      READ(21)(T0(I,L),I=1,NUMRDR)
      READ(21)(N01(I,L),I=1,NUMRDR)
10    READ(21)(D01(I,L),I=1,NUMRDR)
      CLOSE(UNIT=21)
      RETURN
C
C*****THIS AREA WRITES OUT ALL THE INFORMATION NECESSARY FOR A RESTART
C     AFTER ONE OR MORE PASSES THROUGH THE REACTOR.
C
100   OPEN(UNIT=21,FILE='RESTRT',ACCESS='SEQOUT')
      WRITE(21)NUMRDR
      WRITE(21)PGH,(OPGKM(I),I=1,ELEMNT),(PJH(I),I=1,PRTCLS)
      DO 110 L=1,PRTCLS
      WRITE(21)(T0(I,L),I=1,NUMRDR)
      WRITE(21)(N01(I,L),I=1,NUMRDR)
110   WRITE(21)(D01(I,L),I=1,NUMRDR)
      CLOSE(UNIT=21)
      RETURN
200   FORMAT(1H0/1H0/1H0/1H0,102H****************THIS RUN WILL USE RESTAR
     1T DATA FOR INITIAL PROFILES*******************************************')
      END
```

```
      SUBROUTINE RINTS
      COMMON /LAST/GASTMN,TMIN(5),IQ0J(255,5)
      COMMON/MORE/D01(255,5),N01(255,5),ALFA0(255,5),ALFA0C(255,5),
     1ALFA0H(255,5),ALFA0W(255,5),ALFA0A(255,5),X0(255,20),WVG(255)
      COMMON /RADI/T0(255,5),N0(5),D0(5),SIGMA,PI,E(5),IT(255),H0(5)
     1,NUMRDR,DEL,IRAD,TOOLD(5)
      COMMON /AREA5/NPRINT,TNIRP,CHECK,BUG
      COMMON /GENRAL/ALPHAA(5),S(20),KG,MUG,DS,
     1TPJJ(5),YY(5,5),PRTCLS,SPECIE,
     2ELEMNT,CRXN,HRXN,HH(5),HW(5),RGC
      COMMON /APR77/DELTPJ,DELRRJ,ALEN,JFAR,HM,DIFMW,ICNVLM,
     1TTEST,SUMSQ,ITRSYS,GAST(255),OSPRR,NPROP,ARMAX,AMIN,SQDIF
      INTEGER RADREM,Q,P,BUG,PRTCLS
      REAL N0,IT,SUMA(255),IQ0J,SUMI0P(255),N01
C
C*****THIS SUBROUTINE IS A COMPACT CALCULATION OF INTENSITIES ETC.
C     WHICH ARE NEEDED FOR THE RADIATION CALCULATIONS WITHIN THE
C     REACTOR. IT IS FOR THIS SUBROUTINE ALONE THAT AN INITIAL OR
C     A PAST TEMPERATURE PROFILE, NUMBER PARTICLE DENSITY PROFILE
C     AND DIAMETER PROFILE OF THE PARTICLES IS NEEDED BEFORE CAL-
C     CULATIONS CAN BEGIN.  THESE INTIAL PROFILES COME FROM INPUT
C     OR FROM RESTRT, OR OF COURSE FROM THE IMMEDIATLY PAST CALCU-
C     LATION.  THESE VALUES ARE USED IN AUX1 AND AUX3.
C
      PI4=PI/4.0
      DELX=ALEN/FLOAT(NUMRDR)
      DO 10 P=1,NUMRDR
      SUMA(P)=0.0
      SUMI0P(P)=0.0
      DO 20 J=1,PRTCLS
      AJ=PI4*E(J)*N01(P,J)*D01(P,J)**2
      AJT=AJ*T0(P,J)**4
      IF (BUG.GE.5) WRITE(3,410) P,J,AJ,AJT
      SUMA(P)=SUMA(P)+AJ
      IQ0J(P,J)=AJT*SIGMA*DELX
   20 SUMI0P(P)=SUMI0P(P)+IQ0J(P,J)
   10 IF (BUG.GE.2) WRITE(3,310) P,SUMI0P(P)
      DO 40 Q=1,NUMRDR
      SUMIPQ=0.0
      SUMPQR=0.0
      SUMPQL=0.0
      IF (Q.EQ.1) GO TO 42
      M3=Q-1
      DO 41 I=1,M3
   41 SUMPQL=SUMPQL+SUMA(I)*DELX
   42 CONTINUE
      DO 50 P=1,NUMRDR
      IF (P-Q) 45,50,55
   45 IF(P.EQ.1)GO TO 44
      SUMPQL=SUMPQL-SUMA(P-1)*DELX
   44 SUMPQ=SUMPQL
      GO TO 70
   55 SUMPQR=SUMPQR+SUMA(P)*DELX
```

```
      SUMPQ=SUMPQR
70    IF(SUMPQ.GT.85.0)SUMPQ=85.0
      SUMIPQ=SUMIPQ+SUMIOP(P)*EXP(-SUMPQ)
      IF (BUG.GE.5) WRITE(3,320) P,Q,SUMIPQ
50    CONTINUE
      IT(Q)=SUMIPQ
40    IF (BUG.GE.2) WRITE(3,330) Q,IT(Q)
410   FORMAT(1H ,3HP =,I4,4X,3HK =,I4,4X,3HJ =,I4,4X,4HAJ =,E12.5,
     15X,5HAJT= ,E12.5)
310   FORMAT(1H ,3HP =,I4,4X,11HSUMIOP(P) =,E12.5)
320   FORMAT(1H ,3HP =,I4,4X,3HQ =,I4,4X,8HSUMIPQ =,E12.5)
330   FORMAT(1H ,3HQ =,I4,4X,7HIT(Q) =,E12.5)
      IF(BUG.GE.6)STOP
      RETURN
      END
```

```
      SUBROUTINE RODEVL(YZ,KK,J)
      COMMON /LAST/GASTMN,TMIN(5),IQOJ(255,5)
      COMMON /ODEVAL/XDIS,XTRMNL,VALINT(42),ODESTP
      COMMON /DIFEQN/OMEGAK(9),ALPHA(5),ALPHAC(5),ALPHAH(5),
     1ALPHAW(5),N(5),H(5),QF(5),QC8,QZ(5),P,V,HG(5),RK(5,9),
     2RL(5,20),RM(5,20),RC(5),RH(5),RW(5),RR(5),W(5),WG,AREA,PRESSR
      COMMON /EDNUM/RHOG,CPG,TG,CPI(20),X(20),CO(5),HGAS,EDNAME(9),
     1OXYD(5),GMW,QMASS(9,20),WTM(20)
      COMMON /AREAS/NPRINT,TNIRP,CHECK,BUG
      REAL YZ(42)
      INTEGER BUG,EDNAME
C
C*****RODEVL(RETURN O.D.E. VALUES) TAKES THE DIFFERENTIAL EQUATION FUNCTIONS
C     WHICH ARE PREDICTED IN SOLVE IN EITHER A PREDICTOR OR CORRECTOR
C     OR A RUNGE-KUTTA METHOD AND EXTRACTS THE INDIVIDUAL VALUES OF
C     THE MODEL PARAMETERS.  THIS IS TRUE OF ALL PARAMETERS APPEARING
C     IN THE DIFFERENTIAL EQUATIONS EXCEPT FOR VELOCITY AND NUMBER
C     PARTICLE DENSITY.  THESE TWO SPECIAL CASES REQUIRE INFORMATION
C     FROM EDWROS BEFORE THEY CAN BE UPDATED SO THEY ARE HANDLED
C     SEPERATELY IN DIFF.
C
      IA=KK+3*J+2
      WG=YZ(IA)
      DO 10 IC=1,KK
 10   OMEGAK(IC)=YZ(IC)/WG
      IBIG=1
      SUBT=0.0
      AMFRAC=0.0
      DO 80 IK=1,KK
      IF(OMEGAK(IK).LE.AMFRAC)GO TO 81
      IBIG=IK
      AMFRAC=OMEGAK(IK)
 81   QMASS(IK,1)=OMEGAK(IK)
      IF(OMEGAK(IK).GT.0.000001)GO TO 80
      QMASS(IK,1)=.000001
      SUBT=SUBT+.000001
 80   CONTINUE
      QMASS(IBIG,1)=QMASS(IBIG,1)-SUBT
      DO 20 IC=1,J
      IDX=IC+KK
 20   W(IC)=YZ(IDX)
      IB=KK+J+1
      HGAS=YZ(IB)/WG
      DO 30 IC=1,J
      IDX=IC+KK+J+1
 30   H(IC)=YZ(IDX)/W(IC)
      DO 60 IC=1,J
      IDX1=IC+KK+3*J+2
      IDX2=IDX1+J
      IDX3=IDX2+J
      ALPHAC(IC)=YZ(IDX1)
      ALPHAH(IC)=YZ(IDX2)
      ALPHAW(IC)=YZ(IDX3)
```

```
      IF(ALPHAC(IC).LT.1.0E-30)ALPHAC(IC)=0.0
      IF(ALPHAH(IC).LT.1.0E-30.AND.ALPHAC(IC).EQ.0.0)ALPHAH(IC)=0.0
60    IF(ALPHAW(IC).LT.1.0E-30)ALPHAW(IC)=0.0
      IF(TNIRP.NE.1.0.OR.BUG.LT.1)GO TO 70
      WRITE(3,100)WG,P,AREA,HGAS
100   FORMAT(5H WG= ,E12.5,4H P= ,E12.5,7H AREA= ,
     1E12.5,7H HGAS= ,E12.5)
      WRITE(3,110)(OMEGAK(IX),IX=1,KK)
110   FORMAT(12H OMEGAK(K)= ,8(1X,E12.5,1X))
      WRITE(3,130)
130   FORMAT(6X,1HJ,8X,4HW(J),10X,4HH(J),10X,9HALPHAC(J),
     15X,23HAPPHAH(J)      ALPHAW(J))
      DO 90 IX=1,J
90    WRITE(3,140)IX,W(IX),H(IX),ALPHAC(IX),ALPHAH(IX),ALPHAW(IX)
140   FORMAT(6X,I1,5(1X,E12.5,1X))
70    RETURN
      END
```

```
         SUBROUTINE SETUP1
         INTEGER ELEMNT,SPECIE
         COMMON /EDNUM/RHOG,CPG,TG,CPI(20),X(20),CO(5),HGAS,EDNAME(9),
        1OXYD(5),GMW,QMASS(9,20),WTM(20)
         COMMON /DIFEQN/OMEGAK(9),ALPHA(5),ALPHAC(5),ALPHAH(5),
        1ALPHAW(5),NX(5),HZZ(5),QF(5),QCB,QZ(5),P,V,HG(5),RK(5,9),
        2RL(5,20),RM(5,20),RC(5),RH(5),RW(5),RR(5),W(5),WG,AREA,PRESSR
         COMMON/AZ/A(20,11),                                    RTOTO
         COMMON/AZ1/ANS(23),                                    SCH,
        2          ATMOS
         COMMON/AZ2/              IMBALA,                          SR(20)
         COMMON/AZ3/B(11),                     NCONV,          TANS(23),
        5          BMIN,                      NCTXP,
        6          CBAR,
        7                                     NEQ,
        8          D,             ITE,      NGIN,
        9                         ITER,       NKIN,          TO
         COMMON/BZ/               ITT,        NKINC,         TOL,
        1                                     NLEL,          TOLMAX,
        2                         K2,         NM,            TOLT,
        3          EL(23,24),     K3,                        U(20),
        4          ENTRPY,        LB,         NN,            Y(20),
        5                                                    YBAR,
        6          H(20),       LITER,                      YBC,
        7          HBAR,         LKDROP,                     YC(20),
        8          HC,
        9          HI,            LV,         NSIN,          YR(20)
         COMMON/CZ/HR(20),       MAJOR,                     Z(20,10)
         COMMON/CZ1/IDKIN(20),                 NT,
        2                         MPD,
        3          IDSIN(20),    MPDP,
        4          IEV(11),                   R,            IEVN(11)
         COMMON/EZ/                                 CBAG,  ATWT(40),   WTG
         DIMENSION C(20),        SUMAAY(20),  YH(20),
        1          S(20),                     YLN(20),      HS(20)
         DATA NCOUNT/0/
         IERR=0
         IF (NCONV.EQ.0.AND.NCOUNT.LE.1) GO TO 370
       5 NM1=NEQ+1
         NML=NEQ+NM
         NC1=NML+1
         IF (TO.LT.50.0) TO=50.0
         RTO=TO*1.98726
         RTOTO=TO*RTO
         CBAR=0.0
         HBAR=0.0
         LKDROP=LKDROP+1
         IMPLE=1
         TTO=TO/1000.0
         IF (ABS(ANS(K2)).GT.(.001*TO)) MAJOR=0
         IF (TO.LE.6000.0) GO TO 10
         IERR=1
         IMPLE=2
```

```
   10 IF (MAJOR.EQ.1) GO TO 15
      IF (ABS(TO-TCEN).GT.(0.1*TCEN)) IMPLE=2
      IF (ABS(TO-TPREV).GT.(.001*TCEN)) GO TO 15
      IF (IMBALA.EQ.1) GO TO 15
      IMPLE=3
      MAJOR=1
      TOL=0.1*TOLMAX
   15 IF (ITER.GT.1) GO TO 20
      IF (NCTXP.EQ.0.OR.NCTXP.EQ.4) IMPLE=3
   20 IF (LKDROP.EQ.8) IMPLE=3
      IF (NCONV.EQ.(-1)) GO TO 25
      IF (NCOUNT.LE.1) GO TO 25
      NCONV=-1
      IMPLE=3
   25 IF (IMPLE.EQ.3) LKDROP=0
      GO TO (30,35,35), IMPLE
   30 C1=TO-TPREV
      C2=ALOG(TO/TPREV)
      GO TO 50
   35 IF (TO-1200.0) 40,45,45
C
C             START SETUP OF COEFF. FOR UNDER 1200.0
C
   40 TSWTCH=-1.0
      C0=TO/1000.0
      C1=C0*C0
      C2=C0*C1
      C3=C0*C2
      C4=ALOG(C0)-0.18232
      C5=C0-1.2
      C6=0.5*(C1-1.44)
      C7=0.33333333*(C2-1.728)
      C8=0.25*(C3-2.0736)
      C9=.2*(C0*C3-2.48832)
      GO TO 50
C
C     END UNDER 1200.0 COEFF. SETUP   START OF OVER 1200.0 COEFF. SETUP
C
   45 TSWTCH=1.0
      IF (TO.GT.6000.) TO=6000.
      C0=1000.0/TO
      C1=C0*C0
      C2=C0*C1
      C3=C0*C2
      C4=(TO/1000.0)-1.2
      C5=ALOG(TO/1000.0)-0.18232
      C6=0.83333333-1000.0/TO
      C7=0.5*(0.69444444-C1)
      C8=0.33333333*(0.57870370-C2)
      C9=0.25*(0.48225308-C3)
C
C                          END OVER 1200.0 COEFFECIENT SETUP
C
```

```
   50 IRE=0
      GO TO(125,125,55)IMPLE
C
C                  FULL BLOWN SOLUTION FOR TOTAL NUMBER OF SPECIES
C                  CONSIDERED.  IMPLE=3.
C
   55 ISTOP=NT
      GO TO 155
   60 IF (ITER.LT.1) GO TO 85
      BLOGAT=ALOG(ATMOS)
C
C                  TEST FOR ADDING GASES TO THE SOLUTION.
C
      DO 70 I=1,NN
      IF (Y(I).GE.TOLT) GO TO 70
      SUMAPI=0.0
      DO 65 J=1,NM
      J1=J+NEQP
   65 SUMAPI=SUMAPI+ANS(J1)*A(I,J)
      EXPP=SUMAPI-BLOGAT-HS(I)
      IF( ABS(EXPP) .LT. 85.0 ) GO TO 64
      IF( EXPP ) 61,61, 62
61    EXPP = -85.0
      GO TO 64
62    EXPP = 85.0
64    CONTINUE
      Y(I)=YBAR*EXP(EXPP)
63    CONTINUE
      IF (Y(I).LT.TOL) GO TO 70
      Y(I)=TOL
      IRE=1
   70 CONTINUE
85    NKIN=0
  100 IF (IRE.NE.0) GO TO 105
      IF (NCONV) 185,370,370
C
C                  COUNT THE NUMBER OF GASES IN THE SYSTEM.
C
  105 NCONV=-1
  110 NGIN=0
      DO 120 I=1,NN
      IF (Y(I).LT.TOL) GO TO 120
  115 NGIN=NGIN+1
      IDSIN(NGIN)=I
  120 CONTINUE
C
C                  COUNT THE NUMBER OF SPECIES IN FOR ALL IMPLE VALUES
C
  125 NSIN=NGIN
  135 LV=NML+NKIN
      LB=LV+1
      GO TO (140,150,185), IMPLE
C
```

```
C                       QUICK CALCULATIONS OF H AND S FOR IMPLE=1.
C
   140 DO 145 J=1,NSIN
       I=IDSIN(J)
       H(I)=H(I)+C(I)*C1
       S(I)=S(I)+C(I)*C2
   145 HS(I)=(H(I)/RTO)-(S(I)/R)
       GO TO 185
C
C                       CALCULATE H AND S FOR ONLY THE SPECIES IN THE
C                       SOLUTION AT THE PRESENT TIME.  IMPLE=2.
C
   150 ISTOP=NSIN
C
C                       CALCULATE H AND S FOR IMPLE=2 OR IMPLE=3.
C
   155 IF (TSWTCH) 160,170,170
   160 DO 165 J=1,ISTOP
       I=J
       IF (IMPLE.EQ.2) I=IDSIN(J)
       C(I)=Z(I,6)+Z(I,7)*C0+Z(I,8)*C1+Z(I,9)*C2+Z(I,10)*C3
       S(I)=SR(I)+Z(I,6)*C4+Z(I,7)*C5+Z(I,8)*C6+Z(I,9)*C7+Z(I,10)*C8
       H(I)=HR(I)+Z(I,6)*C5+Z(I,7)*C6+Z(I,8)*C7+Z(I,9)*C8+Z(I,10)*C9
       H(I)=1000.0*H(I)
       HS(I)=(H(I)/RTO)-(S(I)/R)
   165 CONTINUE
       GO TO 180
   170 DO 175 J=1,ISTOP
       I=J
       IF (IMPLE.EQ.2) I=IDSIN(J)
       C(I)=Z(I,1)+Z(I,2)*C0+Z(I,3)*C1+Z(I,4)*C2+Z(I,5)*C3
       S(I)=SR(I)+Z(I,1)*C5+Z(I,2)*C6+Z(I,3)*C7+Z(I,4)*C8+Z(I,5)*C9
       H(I)=HR(I)+Z(I,1)*C4+Z(I,2)*C5+Z(I,3)*C6+Z(I,4)*C7+Z(I,5)*C8
       H(I)=1000.0*H(I)
       HS(I)=(H(I)/RTO)-(S(I)/R)
       IF (IERR.EQ.0) GO TO 175
       H(I)=H(I)+C(I)*(TTO-6.)*1000.
       S(I)=S(I)+C(I)*ALOG(TTO/6.)
       HS(I)=(H(I)/RTO)-(S(I)/R)
   175 CONTINUE
   180 CONTINUE
C
C                       BRANCH BACK FOR IMPLE=3.
C
       IF (IMPLE.EQ.3) GO TO 60
C
C                       ALL IMPLE'S WIND UP HERE SO CALCULATE THE REST
C                       OF THE GARBAGE FOR EACH ITERATION.
C
   185 NEQP=NEQ
       TCEN=TO
   190 YBAR=0.0
       WTG = 0.0
```

```
      NMM = NM
      DO 195 J=1,NGIN
      I=IDSIN(J)
      WM = 0.0
      DO 192 K = 1,NMM
      M = IEVN(K)
192   WM = WM + A(I,K)*ATWT(M)
      WTM(I)=WM
      CPI(I)=C(I)/WM
      WTG = WTG + Y(I)*WM
  195 YBAR=YBAR+Y(I)
      PYLN=ALOG(ATMOS/YBAR)
      TOLT=TOL
      TO=TTO*1000.0
      SUMYU=0.0
      DO 200 J=1,NGIN
      I=IDSIN(J)
      CBAR=CBAR+C(I)*Y(I)
      YH(I)=Y(I)*H(I)
      HBAR=HBAR+YH(I)
      IF( Y(I) ) 196, 196, 197
196   YLN(I) = -1.0E-37
      GO TO 198
197   YLN(I)=ALOG(Y(I))
198   U(I)=HS(I)+PYLN+YLN(I)
  200 SUMYU=SUMYU+Y(I)*U(I)
      SUMYH=HBAR
      CBAG = CBAR
      IF (NKIN.LT.1) GO TO 210
      N=NGIN+1
      DO 205 J=N,NSIN
      I=IDSIN(J)
      CBAR=CBAR+C(I)*Y(I)
  205 HBAR=HBAR+H(I)*Y(I)
  210 IMBAL=0
C
C                START SETTING UP THE ELEMENTS OF THE 'EL' ARRAY.
C
  225 DO 275 M=NM1,NML
      MT=M-NEQ
      SUMAY=0.0
      SUMAYH=0.0
      SUMAYU=0.0
      DO 230 K=1,MT
  230 SUMAAY(K)=0.0
      DO 240 J=1,NGIN
      I=IDSIN(J)
      AY=A(I,MT)*Y(I)
      IF (AY.EQ.0.0) GO TO 240
      SUMAY=SUMAY+AY
      SUMAYH=SUMAYH+AY*H(I)
      SUMAYU=SUMAYU+AY*U(I)
      DO 235 K=1,MT
```

```
      235 SUMAAY(K)=SUMAAY(K)+A(I,K)*AY
      240 CONTINUE
          TSMAY=SUMAY
          DEN = TSMAY
          IF( ABS(DEN) .LT. 1.0E-37) DEN = 1.0
          BRAY = B(MT)/DEN
      250 IF ((TSMAY-B(MT)).LT.(.2*B(MT))) GO TO 265
          IMBAL=1
      255 DO 260 J=1,NSIN
          I=IDSIN(J)
          IF (A(I,MT).EQ.(0.0)) GO TO 260
          Y(I)=BRAY*Y(I)
      260 CONTINUE
          GO TO 275
      265 EL(M,K3)=SUMAY
          EL(M,K2)=SUMAYH/RTOTO
          EL(M,LB)=B(MT)+SUMAYU
          DO 270 M1=NM1,M
          K=M1-NEQ
      270 EL(M,M1)=SUMAAY(K)
      275 CONTINUE
C
C                     BRANCH BACK FOR ANY IMBALANCES.
C
          IF (IMBAL.EQ.1) GO TO 190
          EL(K3,K3)=0.0
          EL(K3,K2)=SUMYH/RTOTO
          EL(K3,LB)=SUMYU
C
C                     FLIP THE SMALL ARRAY.
C
      310 LVM1=LV-1
          DO 315 I=K3,LVM1
          DO 315 J=I,LVM1
      315 EL(I,J+1)=EL(J+1,I)
C
C                     CHAMBER AND AREA RATIO SOLUTIONS.
C
      335 SUMYHH=0.0
          SUMYHU=0.0
          DO 340 J=1,NGIN
          I=IDSIN(J)
          SUMYHH=SUMYHH+YH(I)*H(I)
      340 SUMYHU=SUMYHU+YH(I)*U(I)
C
C                     CHAMBER SOLUTION ONLY.
C
          DO 345 I=K3,LV
      345 EL(K2,I)=EL(I,K2)*RTOTO
          EL(K2,LB)=HI+SUMYHU
          EL(K2,K2)=CBAR+SUMYHH/RTOTO
          EL(K2,K3)=SUMYH
          GO TO 405
```

```
C
C                     AREA RATIO SOLUTION ONLY.
C
C
C     GET ENTROPY SEEING AS WE HAVE REACHED CONVERGANCE
C
  370 ENTRPY=YBAR*R*ALOG(YBAR/ATMOS)
      YRYLNS=0.0
      DO 375 J=1,NGIN
      I=IDSIN(J)
      YRYLN=Y(I)*R*YLN(I)
      YRYLNS=YRYLNS+YRYLN
  375 ENTRPY=ENTRPY+Y(I)*S(I)-YRYLN
      IF (NCTXP.EQ.0) YRYLNC=YRYLNS
      IF (NKIN) 390,390,380
  380 DO 385 J=1,NKIN
      K=IDKIN(J)
  385 ENTRPY=ENTRPY+Y(K)*S(K)
  390 IF (NCTXP.EQ.0.OR.NCTXP.EQ.4) GO TO 405
      IF (ABS(ENTRPY-SCH).GT.0.002) NCONV=-1
      GO TO 405
  405 TPREV=TO
  415 RETURN
C
C
      END
```

```
      FUNCTION SIGMAD(TEK)
      DIMENSION ABC(3,3)
      DATA (ABC(I,1),I=1,3)/0.36934,-0.48595,0.02574/
      DATA (ABC(I,2),I=1,3)/0.343,-0.44203,0.07549/
      DATA (ABC(I,3),I=1,3)/0.09454,-0.17612,0.00272/
      IF (TEK.LT.0.3) TEK=0.3
      IF (TEK.GT.100.0) TEK=100.0
      M=1
      IF (1.55.LE.TEK.AND.TEK.LT.7.0) M=2
      IF (TEK.GT.7.0) M=3
      ALOGT=ALOG(TEK)
      SIGMAD=EXP(ABC(1,M)+ALOGT*(ABC(2,M)+ALOGT*ABC(3,M)))
      RETURN
      END
```

```
      FUNCTION SIGMAM(TEK,DEL)
      DIMENSION DELTA(8),AM(8,3),BM(8,3),CM(8,3)
      DATA (DELTA(I),I=1,8)/0.0,0.25,0.5,0.75,1.0,1.5,2.0,2.5/
      DATA (AM(I,1),I=1,8)/0.47395,0.47808,0.50119,0.54668,0.60910,
     10.45351,0.89016,1.01037/
      DATA (AM(I,2),I=1,8)/0.43969,0.44882,0.48192,0.53732,0.60815,
     10.76710,0.91660,1.04383/
      DATA (AM(I,3),I=1,8)/0.16152,0.16285,0.17807,0.20258,0.23287,
     10.31112,0.41063,0.52600/
      DATA (BM(I,1),I=1,8)/-0.53203,-0.51551,-0.49752,-0.49670,-0.51945,
     1-0.57471,-0.60747,-0.62594/
      DATA (BM(I,2),I=1,8)/-0.44832,-0.45212,-0.47283,-0.50951,-0.55388,
     1-0.64309,-0.70603,-0.73772/
      DATA (BM(I,3),I=1,8)/-0.15835,-0.15840,-0.16626,-0.17878,-0.16314,
     1-0.23119,-0.27807,-0.33159/
      DATA (CM(I,1),I=1,8)/-0.05410,-0.04057,-0.01404,0.01,0.01832,
     10.01467,0.00901,0.00461/
      DATA (CM(I,2),I=1,8)/0.07758,0.07756,0.08067,0.08685,0.09367,
     10.10489,0.10718,0.10078/
      DATA (CM(I,3),I=1,8)/0.00186,0.00178,0.00281,0.00442,0.00627,
     10.01075,0.01625,0.02242/
      DATA IDEL/1/
      IF (DEL.GT.2.5) DEL=2.5
      IF (TEK.LT.0.1) TEK=0.1
      IF (TEK.GT.100.0) TEK=100.0
      M=1
      IF (TEK.LT.9.0.AND.1.4.LE.TEK) M=2
      IF (TEK.GE.9.0) M=3
      ALOGT=ALOG(TEK)
      CALL FIND (DEL,A,DELTA,AM(1,M),8,IDEL)
      CALL FIND (DEL,B,DELTA,BM(1,M),8,IDEL)
      CALL FIND (DEL,C,DELTA,CM(1,M),8,IDEL)
      SIGMAM=EXP(A+ALOGT*(B+C*ALOGT))
      RETURN
      END
```

```
      SUBROUTINE SLE
      COMMON/XZ/P,HGAS,GMW,ELEMNT,SPECIE
      INTEGER ELEMNT,SPECIE
      COMMON/AZ/A(20,11),                                RTOTO
      COMMON/AZ1/ANS(23),                                SCH,
     2         ATMOS
      COMMON/AZ2/              IMBALA,                      SR(20)
      COMMON/AZ3/B(11),                       NCONV,        TANS(23),
     5         BMIN,                         NCTXP,
     6         CBAR,
     7                                       NEQ,
     8         D,             ITE,        NGIN,
     9                        ITER,          NKIN,         TO
      COMMON/BZ/              ITT,           NKINC,        TOL,
     1                                       NLEL,         TOLMAX,
     2                        K2,            NM,           TOLT,
     3         EL(23,24),     K3,                          U(20),
     4         ENTRPY,        LB,            NN,           Y(20),
     5                                                     YBAR,
     6         H(20),        LITER,                       YBC,
     7         HBAR,          LKDROP,                      YC(20),
     8         HC,
     9         HI,            LV,            NSIN,         YR(20)
      COMMON/CZ/HR(20),      MAJOR,                       Z(20,10)
      COMMON/CZ1/IDKIN(20),                   NT,
     2                        MPD,
     3         IDSIN(20),    MPDP,
     4         IEV(11),                      R,           IEVN(11)
      DIMENSION NORDER(23),MORDER(24)
      DO 5 I=1,LB
      NORDER(I)=I
    5 MORDER(I)=I
      DO 50 L=1,LV
      DIVB=0.0
      DO 10 I=L,LV
      IN=NORDER(I)
      DO 10 J=L,LV
      JN=MORDER(J)
      IF(ABS(DIVB).GT.ABS(EL(IN,JN))) GO TO 10
      DIVB=EL(IN,JN)
      IT=IN
      JT=JN
      IFROM=I
      JFROM=J
   10 CONTINUE
      NORDER(IFROM)=NORDER(L)
      NORDER(L)=IT
      MORDER(JFROM)=MORDER(L)
      MORDER(L)=JT
   35 DO 40 J=L,LB
      JN=MORDER(J)
   40 EL(IT,JN)=EL(IT,JN)/DIVB
      IF(L.GE.LV)GO TO 55
```

```
      MN=L+1
      DO 50 I=MN,LV
      IN=NORDER(I)
      FMULT=EL(IN,JT)
      DO 50 J=MN,LB
      JN=MORDER(J)
   50 EL(IN,JN)=EL(IN,JN)-EL(IT,JN)*FMULT
   55 I=LV
      SIGMA=0.0
   60 IN=NORDER(I)
      JN=MORDER(I)
      ANS(JN)=EL(IN,LB)-SIGMA
      IF(I.LE.1) GO TO 70
      IN=NORDER(I-1)
      SIGMA=0.0
      DO 65 J=I,LV
      JN=MORDER(J)
   65 SIGMA=SIGMA+EL(IN,JN)*ANS(JN)
      I=I-1
      GO TO 60
   70 CONTINUE
      RETURN
      END
```

```
      SUBROUTINE SOLVE(IDISP,J)
      COMMON/CONVER/ITRMAX,DYNAMO(3),DYNTEM,DYNFLG,DYNFLO
      COMMON/STIFF/ISASUM,ISTIFF(5),STIFVL
      COMMON/IO/DDUCT,DYDXM,AGSTPD,CPVC(3,5,5),HFV(5,5),DELHV(5,5),
     1INTCPV(5,5),QRBJ(5)
      COMMON /LAST/GASTMN,TMIN(5),IQ0J(255,5)
      COMMON /DIFEQN/OMEGAK(9),ALPHA(5),ALPHAC(5),ALPHAH(5),
     1ALPHAW(5),NN(5),HXZ(5),QF(5),QCB,QZ(5),P,V,HG(5),RK(5,9),
     2RL(5,20),RM(5,20),RC(5),RH(5),RW(5),RR(5),W(5),WG,AREA,PRESSR
      COMMON /AREA13/ALFAC0(5),GAMMA,EK(20),XI(5),AMJ(5,5),
     1EMJ(5,5),KVD(5,5),TB,D(5),RHOC(5),RHO(5),DELTA(20),DIFM(20)
     2,ALFAH0(5),ALFAW0(5),ALFAA0(5)
      COMMON/MORE/D01(255,5),N01(255,5),ALFA0(255,5),ALFA0C(255,5),
     1ALFA0H(255,5),ALFA0W(255,5),ALFA0A(255,5),X0(255,20),WVG(255)
      COMMON /RADI/T0(255,5),N0(5),D0(5),SIGMA,PI,E(5),IT(255),H0(5)
     1,NUMRDR,DEL,IRAD,TOOLD(5)
      COMMON /ODEVAL/X,XTRMNL,VALINT(42),ODESTP
      COMMON /AREA5/NPRINT,TNIRP,CHECK,BUG
      COMMON /GENRAL/ALPHAA(5),S(20),KG,MUG,DS,
     1TPJJ(5),YY(5,5),PRTCLS,SPECIE,
     2ELEMNT,CRXN,HRXN,HH(5),HW(5),RGC
      COMMON /EDNUM/RHOG,CPG,TG,CPI(20),XX(20),CO(5),HGAS,EDNAME(9),
     1OXYD(5),GMW,QMASS(9,20),WTM(20)
      COMMON /APR77/DELTPJ,DELRRJ,ALEN,JFAR,HM,DIFMW,ICNVLM,
     1TTEST,SUMSQ,ITRSYS,GAST(255),OSPRR,NPROP,ARMAX,AMIN,SQDIF
      COMMON /JAN78/V0,FUR
C NUMERICAL TREATMENT OF A SYSTEM OF FIRST ORDER DIFFERENTIAL EQUATIONS.
C RUNGE-KUTTA FOURTH ORDER IS USED FOR STARTING THE NUMERICAL SOLUTION.
C ADAMS-MOULTON PREDICTOR CORRECTOR IS USED TO CONTINUE THE  SOLUTION.
C
C THE REQUIRED VECTOR FUNCTION IS INPUT BY THE SUBROUTINE DIFF(YT,VECFUN,H).
C
C
C INPUT VARIABLES
C       N= THE NUMBER OF EQUATIONS IN THE SYSTEM
C       X = THE INITIAL VALUE OF INDEPENDENT VARIABLE
C       X1= THE TERMINAL VALUE F INDEPENDENT VARIABLE
C       VALINT(I),I=1,N = THE INITIAL VALUES OF THE DEPENDENT VARIABLES.
C       ODESTP = THE TOTAL NUMBER OF STEPS IN THE NUMERICAL TREATMENT
C                 NOTE:  TO HELP SPEED CALCULATIONS SOLVE ALLOWS FOR
C                 CHANGING STEP SIZE (ODESTP) IN DIFFERENT REGIONS OF THE
C                 REACTOR:
C                              1) UP TO BEGINNING OF DYNAMIC REGION AT A SPECIFIED
C                                 TEMPERATURE.
C                              2) UP TO COMPLETION OF PYROLYSIS.
C                              3) UP TO INITIATION OF STIFF ASSUMPTION IF LEVEL 2
C                              4) UP TO CHAR BURNOUT
C                 IT IS IMPORTANT TO REALIZE THAT CHANGING STEP SIZE CAN ONLY
C                 TAKE PLACE AT THE BEGINNING OF A RADIATION REGION -- REGARDLESS
C                 OF THE STEP SIZE OF THE DIFFERENTIAL EQUATIONS STEPS (ODESTP).
C
C
C
```

```
C
      REAL YT(42),K(42,4),F(42,4),YZ(42),VECFUN(42),AWOLD(5),AHOLD(5)
     1,XCORR(12),ACOLD(5),YTO(42)
      INTEGER BUG,ODESTP,PRTCLS,OSPRR,ELEMNT,NCORR(12),CPOINT,OSTIFF(5)
     1,DYNAMO,DYNFLG,DYNFLO
C
C*****PRINT SWITCH AND INITIALIZATION
C
      NRUTER=0
      SWITCH=0.0
      IF(BUG.GE.1)SWITCH=1.0
      N=ELEMNT+6*PRTCLS+2
      DO 4 IJ=1,PRTCLS
      AWOLD(IJ)=0.0
      ACOLD(IJ)=0.0
      AHOLD(IJ)=0.0
      IF(X.EQ.0.0.AND.ALPHAW(IJ).NE.0.0)AWOLD(IJ)=1.0
      IF(X.EQ.0.0.AND.ALPHAC(IJ).NE.0.0)ACOLD(IJ)=1.0
4     IF(X.EQ.0.0.AND.ALPHAH(IJ).NE.0.0)AHOLD(IJ)=1.0
      X1=ALEN
C
C*****INITIALIZATION WHEN WE'RE AT THE BEGINING OF THE REACTOR
C
      IF (X.NE.0.0) GO TO 7
      NCORCT=1
      CPOINT=0
      ICDYN=0
      IHDYN=0
      DO 3 IJ=1,PRTCLS
      IF(ALFACO(IJ).EQ.0.0)ICDYN=ICDYN+1
3     ISTIFF(IJ)=0
      IF(BUG.EQ.0)WRITE(3,270)
      DO   10 I=1,N
      YZ(I)=VALINT(I)
   10  YT(I) = YZ(I)
      H = (X1-X)/FLOAT(ODESTP)
      H1=H
      CALL PROFIL(J,IDISP)
C
C*****INITIALIZATION WHEN RESTARTING INTEGRATION.
C     EXPLAINATION:  WHEN THERE ARE SHARP DISCONTINUITIES IN THE
C     DIFFERENTIAL EQUATIONS THE NUMERICAL SOLUTION WOULD HAVE
C     DIFFICULTIES WITH ITS FOUR BACK POINTS AND TRYING TO PREDICT
C     THE NEXT VALUE.  THE WAY WE HANDLE THIS PROBLEM IS TO RESTART
C     THE DIFFERENTIAL EQUATION SOLUTION AS IF WE WERE STARTING THE
C     INTEGRATION WITH A NEW INTEGRAL.  THIS RESTART OCCURS WHEN
C         1) MOISTURE IS COMPLETELY EVAPORATED FROM PARTICLE
C         2) MIXING IS COMPLETE
C         3) PYROLYSIS IS COMPLETE
C         4) CHAR COMBUSTION IS COMPLETE
C
7     IF(X.EQ.0.0) GO TO 5
      DO 9 I=1,N
```

```
9       YT(I)=YZ(I)
5       CONTINUE
        IF(SWITCH.EQ.0.0)GO TO 8
        WRITE(3,211)
        WRITE(3,212)(YT(IX),IX=1,N)
C
C*****RUNGE-KUTTA FOURTH ORDER
C
8       DO 1000 J=1,3
C
C*****COMPUTE K1 = H*F(X,Y)
C
        CALL DIFF(YT,VECFUN,H)
        IF(X.EQ.0.0)GASTMN=TG
        DO 15 I=1,N
     15 K(I,1) = H*VECFUN(I)
C
C*****COMPUTE X+H/2 AND Y+K1/2
C
        X = X + H/2.
        DO   20 I=1,N
     20 YT(I) = YZ(I) + K(I,1)/2.
C
C*****COMPUTE K2 = H*F(X+H/2,Y+K1/2)
C
        CALL DIFF(YT,VECFUN,H)
        DO 25 I=1,N
     25 K(I,2) = H*VECFUN(I)
C
C*****COMPUTE Y+K2/2
C
        DO   30 I=1,N
     30 YT(I) = YZ(I) + K(I,2)/2.
C
C*****COMPUTE K3 = H*F(X+H/2,Y+K2/2)
C
        CALL DIFF(YT,VECFUN,H)
        DO 35 I=1,N
     35 K(I,3) = H*VECFUN(I)
C
C*****COMPUTE X+H AND Y+K3
C
        X = X + H/2.
        DO   40 I=1,N
     40 YT(I) = YZ(I) + K(I,3)
C
C*****COMPUTE K4 = H*F(X+H,Y+K3)
C
        CALL DIFF(YT,VECFUN,H)
        DO 50 I=1,N
     50 K(I,4) = H*VECFUN(I)
C
C*****COMPUTE Y(X+H)= Y(X) + (K1+2K2+2K3+K4)/6
```

```
C
      DO   60 I=1,N
      YT(I) = YZ(I) + (K(I,1)+2.*K(I,2)+2.*K(I,3)+K(I,4))/6.
   60 YZ(I) = YT(I)
C
C*****SAVE FUNCTION EVALUATIONS FOR USE IN PREDICTOR CORRECTOR
C
      DO   70 I=1,N
   70 F(I,J) = K(I,1)
      JJ=J
C
C*****PROFIL PREPARES INFORMATION FOR OUTPUT
C
      CALL PROFIL(JJ,IDISP)
C
C*****DEBUG
C
      IF(SWITCH.EQ.0.0)GO TO 999
      WRITE(3,219)
      WRITE(3,220)(YT(IX),(K(IX,JX),JX=1,4),IX=1,N)
      WRITE(3,250)X,TG,(TPJJ(IJ),IJ=1,PRTCLS)
C
C*****TEST FOR RESTART AT COMPLETION OF MIXING
C
999   IF(X.LT.AGSTPD.OR.CPOINT.EQ.1) GO TO 138
      CPOINT=1
      NRUTER=1
138   DO 145 IJ=1,PRTCLS
      IW=IJ+ELEMNT+2+5*PRTCLS
      IC=IJ+ELEMNT+2+3*PRTCLS
      IH=IJ+ELEMNT+2+4*PRTCLS
C
C*****TEST FOR RESTART DUE TO DISAPPEARANCE OF MOISTURE FROM THE PARTICLE
C
      IF(YT(IW).GT.0.0.OR.AWOLD(IJ).LE.0.0)GO TO 140
      YZ(IW)=0.0
      RW(IJ)=0.0
      NRUTER=1
C
C*****TEST FOR RESTART DUE TO COMPLETION OF PYROLYSIS
C
140   IF(YT(IC).GT.0.0.OR.ACOLD(IJ).LE.0.0)GO TO 142
      YZ(IC)=0.0
      RC(IJ)=0.0
      ICDYN=ICDYN+1
      NRUTER=1
C
C*****TEST FOR RESTART DUE TO COMPLETION OF CHAR OXIDATION (CHAR BURNOUT)
C
142   IF(YT(IH).GT.0.0.OR.AHOLD(IJ).LE.0.0)GO TO 144
      YZ(IH)=0.0
      RH(IJ)=0.0
      IF(ISASUM.LT.2)IHDYN=IHDYN+1
```

```
      NRUTER=1
C
C*****RESETTING OLD ALPHA VALUES
C
144   AWOLD(IJ)=ALPHAW(IJ)
      ACOLD(IJ)=ALPHAC(IJ)
      AHOLD(IJ)=ALPHAH(IJ)
C
C*****TEST FOR CHANGE IN STEP SIZE DUE TO INITIATION OF DYNAMIC REGION
C
      IF((TPJJ(IJ).LT.DYNTEM.OR.DYNFLG.GE.1).OR.MOD((J+IDISP),OSPRR)
     1.NE.0)GO TO 145
      DYNFLG=1
      IF(DYNAMO(1).LE.1)DYNFLO=DYNFLG
      IF(DYNAMO(1).LE.1)GO TO 145
      H=H1/FLOAT(DYNAMO(1))
      RETURN
145   CONTINUE
C
C*****TEST FOR CHANGE IN STEP SIZE DUE TO COMPLETION OF PYROLYSIS
C
      IF((ICDYN.NE.PRTCLS.OR.DYNFLG.NE.1).OR.MOD((J+IDISP),
     1OSPRR).NE.0)GO TO 146
      DYNFLG=2
      IF(DYNAMO(1).EQ.DYNAMO(2))DYNFLO=DYNFLG
      IF(DYNAMO(1).EQ.DYNAMO(2))GO TO 146
      H=H1/FLOAT(DYNAMO(2))
      RETURN
C
C*****TEST FOR CHANGE IN STEP SIZE DUE TO COMPLETIN OF CHAR OXYDATION
C
146   IF((IHDYN.NE.PRTCLS.OR.DYNFLG.NE.2).OR.MOD((J+IDISP),
     1OSPRR).NE.0)GO TO 147
      DYNFLG=3
      IF((DYNAMO(2).EQ.DYNAMO(3)).AND.DYNAMO(3).LE.1)DYNFLO=DYNFLG
      IF((DYNAMO(2).EQ.DYNAMO(3)).AND.DYNAMO(3).LE.1)GO TO 147
      H=H1*FLOAT(DYNAMO(3))
      RETURN
147   CONTINUE
      IF(NRUTER.EQ.1)RETURN
 1000 CONTINUE
C
C*****DEBUG
C
      IF(SWITCH.EQ.0.0)GO TO 75
      WRITE(3,229)
      WRITE(3,230)((F(IX,JX),JX=1,3),IX=1,N)
C
C*****EVALUATE FUNCTION AT (XN,YN)
C
75    CALL DIFF(YT,VECFUN,H)
      DO   80 I=1,N
   80 F(I,4) = H*VECFUN(I)
```

```
C
C*****PREDICTOR CORRECTOR PACKAGE
C
      DO 2000 J=4,(ODESTP-IDISP)
C
C*****ADAMS-BASHFORTH PREDICTOR
C
      DO    90 I=1,N
   90 YT(I) = YZ(I)+(55.*F(I,4)-59.*F(I,3)+37.*F(I,2)-9.*F(I,1))/24.
C
C*****THE FOLLOWING SET OF TESTS FOR RESTART AND STEP SIZE CHANGE ARE
C     SIMILAIR TO THE PRECEDING SET IN THE RUNGE-KUTTA SECTION.
C     NOTE THAT THIS SET OF TESTS IS APPLIED IMMEDIATELY AFTER THE
C     PREDICTOR BUT BEFORE AN EVALUATION.  IN A WAY THIS ALLOWS THE
C     PROGRAM TO LOOK AHEAD AND TRY TO DETERMINE IF THE NEXT STEP WILL
C     CAUSE ANY PROBLEMS AND IF IT MIGHT THE TESTS ARE INITIATED TO
C     RETURN TO THE MAIN PROGRAM AND RESTART OR MAKE APPROPRIATE STEP
C     SIZE CHANGES BEFORE TAKING THE STEP.
C
C
C*****TEST FOR COMPLETION OF MIXING.
C
      IF((X+H).LT.AGSTPD.OR.CPOINT.EQ.1)GO TO 148
      CPOINT=1
      NRUTER=1
148   DO 155 IJ=1,PRTCLS
      IW=IJ+ELEMNT+2+5*PRTCLS
      IC=IJ+ELEMNT+2+3*PRTCLS
      IH=IJ+ELEMNT+2+4*PRTCLS
C
C*****TEST FOR COMPLETION OF MOISTURE EVAPORATION.
C
      IF(ALPHAW(IJ).LE.0.0.AND.AWOLD(IJ).GT.0.0)YT(IW)=0.0
      IF(YT(IW).GT.0.0.OR.AWOLD(IJ).LE.0.0)GO TO 150
      YZ(IW)=0.0
      RW(IJ)=0.0
      NRUTER=1
C
C*****TEST FOR COMPLETION OF PYROLYSIS.
C
150   IF(ALPHAC(IJ).LE.0.0.AND.ACOLD(IJ).GT.0.0)YT(IC)=0.0
      IF(YT(IC).GT.0.0.OR.ACOLD(IJ).LE.0.0)GO TO 152
      YZ(IC)=0.0
      RC(IJ)=0.0
      ICDYN=ICDYN+1
      NRUTER=1
C
C*****TEST FOR COMPLETION OF CHAR BURNOUT.
C
152   IF(ALPHAH(IJ).LE.0.0.AND.AHOLD(IJ).GT.0.0)YT(IH)=0.0
      IF(YT(IH).GT.0.0.OR.AHOLD(IJ).LE.0.0)GO TO 154
      YZ(IH)=0.0
      RH(IJ)=0.0
```

```
      IF(ISASUM.LT.2)IHDYN=IHDYN+1
      NRUTER=1
C
C*****UPDATING OLD ALPHA VALUES.
C
154   AWOLD(IJ)=ALPHAW(IJ)
      ACOLD(IJ)=ALPHAC(IJ)
      AHOLD(IJ)=ALPHAH(IJ)
C
C*****TEST FOR STEP SIZE CHANGE DUE TO INITIATION OF DYNAMIC REGION.
C
      IF((TPJJ(IJ).LT.DYNTEM.OR.DYNFLG.GE.1).OR.MOD((J+IDISP-1),
     1OSPRR).NE.0)GO TO 155
      DYNFLG=1
      IF(DYNAMO(1).LE.1)DYNFLO=DYNFLG
      IF(DYNAMO(1).LE.1)GO TO 155
      H=H1/FLOAT(DYNAMO(1))
      RETURN
155   CONTINUE
C
C*****TEST FOR STEP SIZE CHANGE INITIATION DUE TO COMPLETION OF PYROLYSIS.
C
      IF((ICDYN.NE.PRTCLS.OR.DYNFLG.NE.1).OR.MOD((J+IDISP-1),
     1OSPRR).NE.0)GO TO 156
      DYNFLG=2
      IF(DYNAMO(1).EQ.DYNAMO(2))DYNFLO=DYNFLG
      IF(DYNAMO(1).EQ.DYNAMO(2))GO TO 156
      H=H1/FLOAT(DYNAMO(2))
      RETURN
C
C*****TEST FOR STEP SIZE CHANGE INITIATION DUE TO CHAR BURNOUT.
C
156   IF((IHDYN.NE.PRTCLS.OR.DYNFLG.NE.2).OR.MOD((J+IDISP-1),
     1OSPRR).NE.0)GO TO 157
      DYNFLG=3
      IF((DYNAMO(2).EQ.DYNAMO(3)).AND.DYNAMO(3).LE.1)DYNFLO=DYNFLG
      IF((DYNAMO(2).EQ.DYNAMO(3)).AND.DYNAMO(3).LE.1)GO TO 157
      H=H1*FLOAT(DYNAMO(3))
      RETURN
157   CONTINUE
C
C*****RETURN IF ANY OF THE ABOVE CRITERION ARE MEET
C
      IF(NRUTER.EQ.1)RETURN
C
C*****MOVE DOWN THE REACTOR.
C
      X = X + H
C
C*****SAVE PREVIOUSLY COMPUTED FUNCTION EVALUATIONS
C
      DO  100 I=1,N
      F(I,1) = F(I,2)
```

```
            F(I,2) = F(I,3)
        100 F(I,3) = F(I,4)
      C
      C*****EVALUATE FUNCTION AT (XN+1,YN+1(0))
      C
            CALL DIFF(YT,VECFUN,H)
            DO  110 I=1,N
        110 F(I,4) = H*VECFUN(I)
      C
      C*****GET THE SUM OF THE SLOPES OF THE PARTICLE ENERGIES FOR USE LATTER ON.
      C
            IPE=ELEMNT+PRTCLS+1
            SUMT=0.0
            DO 116 IJ=1,PRTCLS
            IJPE=IJ+IPE
      116   SUMT=SUMT+F(IJPE,4)
            SUMT=SUMT/FLOAT(PRTCLS)
      C
      C*****ADAMS-MOULTON CORRECTOR WITH UNDER RELAXATION WHEN REPEATING CORRECTOR
      C
            ICONV=ICNVLM
      115   IFLAG=0
            SUMTO=SUMT
            DO  120 I=1,N
            YTO(I)=YT(I)
            YT(I) = YZ(I)+(9.*F(I,4)+19.*F(I,3)-5.*F(I,2)+F(I,1))/24.
            IF(ICONV.LT.ICNVLM)YT(I)=FUR*YT(I)+(1.0-FUR)*YTO(I)
        120 CONTINUE
      C
      C*****EVALUATE FUNCTION AT (XN+1,YN+1(1))
      C
            CALL DIFF(YT,VECFUN,H)
            DO  130 I=1,N
        130 F(I,4) = H*VECFUN(I)
      C
      C*****DEBUG
      C
            IF(SWITCH.EQ.0.0)GO TO 135
            IF(BUG.LE.2.AND.TNIRP.EQ.0.0)GO TO 134
            WRITE(3,239)
            WRITE(3,2395)X
            WRITE(3,240)(F(IX,4),YT(IX),IX=1,N)
      134   WRITE(3,250)X,TG,(TPJJ(IJ),IJ=1,PRTCLS)
      C
      C*****TEST: IS SLOPE OF THE PARCTICLE ENERGY CHANGING?
      C     TEST: DO WE WANT TO APPLY THE STIFF EQUATION ASSUMPTION AND IF
      C           SO, AT WHAT LEVEL?
      C     THIS ALL AMOUNTS TO SUM NUMERICAL GIMMICKRY WHICH IS VERY IMPORTANT.
      C     IN THIS SYSTEM IT IS FOUND THAT THE PARTICLE ENERGY IS A VERY SENSITIVE
      C     MEASURE OF THE STABILITY OF THE SYSTEM OF DIFFERENTIAL EQUATIONS.
      C     THUS IF THE SLOPE OF THE PARTICLE ENERGY IS CHANGING DRASTICALLY FROM
      C     PREDICTOR TO CORRECTOR THEN WE APPLY ANOTHER CORRECTOR AND ANOTHER
      C     EVALUATION.  THEN WE TEST TO SEE IF IT STILL CHANGED DRASTICALLY OR NOT
```

```
C      TO DETERMINE WHETHER STILL ANOTHER CORRECT, EVALUATE STEP SHOULD BE
C      APPLIED.  THIS CONTINUES UNTIL AN EXTERNALLY SPECIFIED MAXIMUM NUMBER
C      OF CORRECTORS IS REACHED.  THE STIFF EQUATION ASSUMPTION IS A NEAT ,
C      WAY OF SIDE STEPPING NUMERICAL STIFFNESS.  IN THIS SYSTEM STIFFNESS
C      IS ONLY REACHED WHEN THE PARTICLE ENERGY STOPS CHANGING SIGNIFICANTLY.
C      AT THAT POINT THE DIFFERENCE BETWEEN THE PARTICLE AND THE GAS TEMPERATUE
C      IS MADE CONSTANT AND WE STOP USING THE NOW STIFF PARTICLE ENERGY
C      EQUATION.  WHEN A LEVEL 2 STIFF PARTICLE ENERGY ASSUMPTION IS USED
C      WE ALSO CHANGE STEP SIZE WHEN STIFFNESS OCCURS  JUST AS IF CHAR
C      BURNOUT HAD BEEN REACHED.
C
C
135    SUMT=0.0
       DO 117 IJ=1,PRTCLS
       IJPE=IJ+IPE
       IF(ISASUM.GT.0.AND.ISTIFF(IJ).EQ.1.AND.ICONV.EQ.ICNVLM)
      1  SUMTO=SUMTO-F(IJPE,3)/FLOAT(PRTCLS)
       IF(ISASUM.GT.0.AND.ISTIFF(IJ).EQ.1)GO TO 117
       SUMT=SUMT+F(IJPE,4)
117    CONTINUE
       SUMT=SUMT/FLOAT(PRTCLS)
       IF(SUMT.EQ.0.0)GO TO 118
       IF(ABS((SUMT-SUMTO)/SUMT).GT.TTEST)IFLAG=1
118    ICONV=ICONV-1
       IF(IFLAG.EQ.1.AND.ICONV.GE.0)GO TO 115
       DO 136 I=1,N
136    YZ(I)=YT(I)
       JJ=J
       CALL PROFIL(JJ,IDISP)
       NCORR(NCORCT)=ICNVLM-ICONV
       XCORR(NCORCT)=X
       IF(BUG.EQ.0.AND.(NCORCT.EQ.12.OR.J.EQ.(ODESTP-IDISP)))
      1WRITE(3,260)(XCORR(IX),NCORR(IX),IX=1,NCORCT)
       NCORCT=1+NCORCT
       IF(NCORCT.EQ.13)NCORCT=1
       IF(ISASUM.LT.1)GO TO 131
       DO 137 IJ=1,PRTCLS
       OSTIFF(IJ)=ISTIFF(IJ)
       IF(ISTIFF(IJ).EQ.1.OR.(ABS(QF(IJ)-QRBJ(IJ)-QZ(IJ))).LT.STIFVL)
      1          GO TO 210
       GO TO 137
210    IF(X.LE.AGSTPD)GO TO 137
       ISTIFF(IJ)=1
       IF(OSTIFF(IJ).NE.0.OR.ISTIFF(IJ).NE.1)GO TO 137
       WRITE(3,280)IJ,X
       IF(ISASUM.GT.1)IHDYN=IHDYN+1
137    CONTINUE
131    CONTINUE
 2000  CONTINUE
       RETURN
211    FORMAT(21X,6HY(I)= )
212    FORMAT(1H ,9(1X,E12.5,1X)/)
219    FORMAT(5X,5HYT(I),9X,6HK(I,1),8X,6HK(I,2),8X,6HK(I,3),8X,
```

```
     16HK(I,4))
220   FORMAT(1H ,5(1X,E12.5,1X))
229   FORMAT(5X,6HF(I,1),8X,6HF(I,2),8X,6HF(I,3))
230   FORMAT(1H ,3(1X,E12.5,1X)/)
239   FORMAT(7X,1HX,11X,6HF(1,4),8X,5HYT(1),9X,6HF(2,4),8X,
     15HYT(2),9X,42HETC.......................................)
2395  FORMAT(1H ,E12.5)
240   FORMAT(11(13X,8(1X,E12.5,1X)/))
250   FORMAT(20X,7HAT X = ,F6.2,3HCM.,5X,12HGAS TEMP. = ,F10.2,
     11HK,5X,19HPARTICLE TEMPS (K):,5F10.2)
260   FORMAT(1H ,12(1H(,F6.2,1H,,I2,1H)))
270   FORMAT(77H1THE ORDERED PAIR OF (X,# OF CORRECTORS APPLIED) FOLLOWS
     1 FOR EACH O.D.E. STEP,/,75H **************************************
     2************************************)
280   FORMAT(77H THE STIFF PARTICLE ENERGY EQUATION ASSUMPTION IS INITIA
     1TED FOR PARTICLE NO. ,I1,4H AT ,F6.2,21H CM. DOWN THE REACTOR)
      END
```

```
      SUBROUTINE TIMET
C---THIS SUBROUTINE WILL ACCEPT A TIME OF DAY AND IF THE CURRENT TIME
C   OF DAY AT RUN TIME IS BEYOND THE ACCEPTED AMOUNT THEN THE PROGRAM
C   WILL TERMINATE.
C
      INTEGER H,HT
      IF(IN.EQ.1)GO TO 12
      TYPE 5
5     FORMAT(54H ENTER LATEST ACCEPTABLE TIME (24 HR CLOCK)--HH:MM  --$)
      READ(5,10)H,M
10    FORMAT(I2,1X,I2)
      IN=1
12    CALL TIME(T)
      DECODE(5,10,T)HT,MT
      IF(HT.LT.H)GO TO 25
      IF(MT.LT.M)GO TO 25
      WRITE(5,20)T
20    FORMAT(47H EXECUTION TERMINATED SINCE THE TIME OF DAY IS ,A5)
      CALL TRBLE
25    RETURN
      END
```

```
      SUBROUTINE TOY
      COMMON/AZ/A(20,11),                                        RTOTO
      COMMON/AZ1/ ANS(23),                                      SCH,
     2          ATMOS
      COMMON/AZ2/                IMBALA,                         SR(20)
      COMMON/AZ3/B(11),                         NCONV,          TANS(23),
     5          BMIN,                          NCTXP,
     6          CBAR,
     7                                         NEQ,
     8          D,             ITE,         NGIN,
     9                         ITER,           NKIN,            TO
      COMMON/BZ/               ITT,            NKINC,           TOL,
     1                                         NLEL,            TOLMAX,
     2                         K2,             NM,              TOLT,
     3         -EL(23,24),     K3,                              U(20),
     4          ENTRPY,        LB,             NN,              Y(20),
     5                                                          YBAR,
     6          H(20),        LITER,                           YBC,
     7          HBAR,          LKDROP,                          YC(20),
     8          HC,
     9          HI,            LV,             NSIN,            YR(20)
      COMMON/CZ/HR(20),       MAJOR,                           Z(20,10)
      COMMON/CZ1/IDKIN(20),                     NT,
     2                        MPD,
     3          IDSIN(20),    MPDP,
     4          IEV(11),                       R,              IEVN(11)
      DATA DELPO/.01/,DELTO/.01/,DELXY/.0001/,DELPI/.001/
      SLIMIT=1.0E-30
      NKINT=NKIN
      KINSM=-1
      SMLRA=1.0
      AK=ANS(K2)/RTOTO
      PMPO=0.0
      RPMPA=0.0
      IF(NEQ.EQ.1)ANS(K2)=0.0
   25 RAT=ANS(K2)/TO
      IF (ABS(RAT).LT.(0.09)) GO TO 40
      IF (RAT) 30,40,35
   30 ANS(K2)=TO*(-0.09)
      GO TO 40
   35 ANS(K2)=0.09*TO
C
C                  FIND THE LARGEST SMALL RATIO FOR GASES.
C
   40 DO 50 KK=1,NGIN
      I=IDSIN(KK)
      SUMAPI=0.0
      DO 45 J=1,NM
      J1=J+NEQ
   45 SUMAPI=SUMAPI+ANS(J1)*A(I,J)
      YR(I)=ANS(K3)-U(I)+SUMAPI+AK*H(I)-RPMPA
      IF( YR(I) .GT. 0.0 .OR. Y(I) .LE. SLIMIT) GO TO 50
      IMBALA=1
```

```
      SMLRAT=.99/(1.0-YR(I))
      IF (SMLRAT.GE.SMLRA) GO TO 50
      SMLRA=SMLRAT
   50 CONTINUE
C
C                          RATIO NEW MOLES FOR GASES.
C
   60 JJ=0
      DO 70 KK=1,NGIN
      I=IDSIN(KK)
      Y(I)=Y(I)*(1.0+SMLRA*(YR(I)-1.0))
      IF (Y(I).GE.TOL) GO TO 65
C
C                          DROP THE GAS SPECIE FROM SOLUTION.
C
      Y(I)=0.0
      GO TO 70
   65 JJ=JJ+1
      IDSIN(JJ)=I
   70 CONTINUE
      NGIN=JJ
      IF (JJ.EQ.0) NGIN=1
   80 I1=NEQ+1
      I2=I1+NM-1+NKIN
   85 DO 100 I=I1,I2
      IF (ABS(TANS(I)-ANS(I))-DFLPI) 95,90,90
   90 NCONV=-1
95      CONTINUE
  100 TANS(I)=ANS(I)
C
C                          CONVERGENCE CRITERIA TESTS.
C
      IF (MAJOR.EQ.0) GO TO 105
      IF (ABS(ANS(K2)).GE.DELTO) GO TO 105
      IF (ABS(ANS(K3)-1.0).GE.DELXY) GO TO 105
      IF (NEQ.NE.3) GO TO 110
      IF (ABS(ANS(1))-DELPO) 110,105,105
  105 NCONV=-1
  110 TO=TO+ANS(K2)
      ATMOS=ATMOS+PMPO
      IMBALA=0
      IF (TO.LT.0.0) TO=0.002
      IF (ATMOS.LT.0.0) ATMOS=0.02
  115 RETURN
C
C
  120 FORMAT (10X,3HTOY)
  125 FORMAT (8(1X,A6,1H=,F8.5))
      END
```

```
      SUBROUTINE TRBLE
C
C     A SUBROUTINE TO GET OUTPUT AND KILL THE PROGRAM WHEN IT GETS IN TROUBLE
C
      COMMON/ODEVAL/XDIS,XTRMNL,VALINT(42),ODESTP
      COMMON/TRUBLE/INDX,ITRBLE
      COMMON/RADI/T0(255,5),N0(5),D0(5),SIGMA,PI,E(5),IT(255),H0(5)
     1,NUMRDR,DEL,IRAD,T0OLD(5)
      COMMON/ APR77/DELTPJ,DELRRJ,ALEN
      ITRBLE=1
      TYPE 100,XDIS
      WRITE(3,100)XDIS
      NUMRDR=INDX-1
      ALEN=NUMRDR*DEL
      CALL OUTPUT
100   FORMAT(12H-TROUBLE AT ,F6.2,21H CM. DOWN THE REACTOR)
      STOP
      END
```

```
      SUBROUTINE VALUE
      COMMON /APR77/DELTPJ,DELRRJ,ALEN,JFAR,HM,DIFMW,ICNVLM,
     1TTEST,SUMSQ,ITRSYS,GAST(255),OSPRR,NPROP,ARMAX,AMIN,SQDIF
      COMMON /ODEVAL/XDIS,XTRMNL,VALINT(42),ODESTP
      COMMON /GENRAL/ALPHAA(5),S(20),KG,MUG,DS,
     1TPJJ(5),YY(5,5),PRTCLS,SPECIE,
     2ELEMNT,CRXN,HRXN,HH(5),HW(5),RGC
      COMMON/GNRAL2/NAME1(20),NAME2(20)
      COMMON /DIFEQN/OMEGAK(9),ALPHA(5),ALPHAC(5),ALPHAH(5),
     1ALPHAW(5),N(5),H(5),QF(5),QCB,QZ(5),P,V,HG(5),RK(5,9),
     2RL(5,20),RM(5,20),RC(5),RH(5),RW(5),RR(5),W(5),WG,AREA,PRESSR
      COMMON /EDNUM/RHOG,CPG,TG,CPI(20),X(20),CO(5),HGAS,EDNAME(9),
     1OXYD(5),GMW,QMASS(9,20),WTM(20)
      INTEGER PRTCLS,ELEMNT,SPECIE,CRXN,EDNAME
      REAL N
C
C*****THIS SUBROUTINE SETS UP ALL THE INITIAL VALUES NEEDED FOR
C     THE PREDICTOR-CORRECTOR DIFFERENTIAL EQUATION SOLUTION.
C     THESE VALUES ARE THEN STORED IN VALINT(42).
C
      DO 10 K1=1,ELEMNT
10    VALINT(K1)=WG*OMEGAK(K1)
      M2=ELEMNT+1
      M3=ELEMNT+PRTCLS
      DO 11 J1=M2,M3
      J=J1-ELEMNT
11    VALINT(J1)=W(J)
      IA=ELEMNT+PRTCLS+1
      VALINT(IA)=WG*HGAS
      M2=ELEMNT+PRTCLS+2
      M3=ELEMNT+2*PRTCLS+1
      DO 12 J1=M2,M3
      J=J1-(ELEMNT+PRTCLS+1)
12    VALINT(J1)=W(J)*H(J)
      M2=ELEMNT+2*PRTCLS+2
      M3=ELEMNT+3*PRTCLS+1
      DO 13 J1=M2,M3
      J=J1-(ELEMNT+2*PRTCLS+1)
13    VALINT(J1)=V*N(J)*AMIN
      IA=ELEMNT+3*PRTCLS+2
      VALINT(IA)=WG
      M2=ELEMNT+3*PRTCLS+3
      M3=ELEMNT+4*PRTCLS+2
      DO 15 J1=M2,M3
      J=J1-(ELEMNT+3*PRTCLS+2)
      VALINT(J1)=ALPHAC(J)
      J2=J1+PRTCLS
      VALINT(J2)=ALPHAH(J)
      J3=J2+PRTCLS
15    VALINT(J3)=ALPHAW(J)
      RETURN
      END
```

APPENDIX C

Thermochemical data for a wide variety of chemical species are required input for 1-DICOG. These data include reference enthalpy, reference entropy and heat capacity coefficients. For 1-DICOG computations performed at Brigham Young University, these parameters have generally been obtained from the data compilation of the EDWARDS thermochemical program (39). In turn, these data were generally obtained from the JANAF thermochemical tables. In order to assist the user, data from Reference 39 for several of the more relevant chemical species for propagating flames are summarized in this appendix. Data for 51 species are included. Most are hydrocarbons, while O, H, N, S and Si-containing species are also reported. Table C-1 provides a definition of the various data columns, while Table C-2 summarizes these thermochemical data.

TABLE C-1

DEFINITION OF ENTRIES IN THERMOCHEMICAL DATA TABLE

Enthalpy at 1200 K (Kcal/gmole) $H_{1200} = H_{298} + \int_{298}^{1200} C_p dT$

Number of elements in species

Entropy at 1200 K $S_{1200} = S_{298} + \int_{298}^{1200} \frac{C_p}{T} dT$ (cal/gmole - K)

Importance code

Elemental composition of the species

Ionic charge

Species name

```
C 1.  H 1.   -0.    -0.    -0    20     2  148.6820   53.8529       CH
     11.0963   -8.7294   28.6231  -49.4959   27.2901               126
      7.1769   -1.1289    1.1386    1.4885    -.8919             12 67
```

Species order number

Date last updated

Z_1, Z_2, Z_3, Z_4, Z_5 for $C_p \approx f(T)$ $T \geq 1200$ K,
Cp is in (cal/gmole · K), $C_p = \sum_{i=0}^{4} Z_{i+1} (1000/T)^i$

Z_1, Z_2, Z_3, Z_4, Z_5 for $C_p = f(t)$ $T < 1200$ K,
Cp is in (cal/gmole · K), $C_p = \sum_{i=0}^{4} Z_{i+1} (T/1000)^i$

Importance Code

00 = Very important gas	75 = Ordinary solid species
10 = Somewhat important gas	76 = Ordinary liquid species
20 = Ordinary gas species	80 = Important solid species
30 = Minor gas species	81 = Important liquid species

TABLE C-2

THERMOCHEMICAL DATA FOR SELECTED CHEMICAL SPECIES (Ref. 39)

C 1.	H 1.	-0.	-0.	-0 20	2 148.6820	53.8529	CH	
	11.0963	-8.7294	28.6231	-49.4959	27.2901			126
	7.1769	-1.1289	1.1386	1.4885	-.8919			12 67
C 1.	H 1.	N 1.	-0.	-0 20	3 42.1828	62.8468	CHN	
	15.2434	1.8755	-16.8188	19.5803	-8.0666			132
	4.6340	18.9621	-23.9757	17.2927	-4.9071			12 69
C 1.	H 1.	O 1.	-0.	0 30	3 19.7540	67.4750	CHO	
	15.1173	-6.7024	10.4998	-12.9785	5.6361			134
	8.2363	-4.9887	22.9333	-20.9570	6.2576			12 70
C 1.	H 2.	-0.	-0.	-0 30	2 101.3120	59.6360	CH2	
	14.2815	1.2507	-13.2541	13.7633	-5.3053			135
	7.9753	-1.4636	10.7907	-8.9782	2.5554			12 72
C 1.	H 2.	O 1.	-0.	-0 20	3 -16.3003	68.6165	CH2O	
	19.8380	.4866	-10.7249	5.8798	-.6320			139
	7.4712	-4.3840	34.5523	-32.5894	9.7654			3 61
C 1.	H 3.	-0.	-0.	-0 20	2 46.0347	62.7556	CH3	
	19.8198	.8401	-16.2918	12.3426	-2.5675			140
	6.6837	9.1229	-1.8892	.4556	-.2838			6 69
C 1.	H 4.	-0.	-0.	-0 20	2 -5.1606	62.4344	CH4	
	25.7473	1.2222	-22.0015	15.0340	-2.7867			145
	7.4307	-6.3982	44.3471	-39.8204	11.5976			3 61
C 1.	N 1.	-0.	-0.	-0 20	2 110.8413	58.7514	CN	
	9.4169	25.4727	-120.0550	178.1924	-87.5608			147
	7.6308	-5.2858	13.0671	-10.1486	2.7333			6 69
C 1.	O 1.	-0.	-0.	-0 10	2 -19.6215	57.4999	CO	
	9.6744	-4.2373	9.0746	-12.0826	5.6376			153
	7.5994	-4.8661	11.5395	-8.5080	2.1666			3 61
C 1.	O 1.	S 1.	-0.	-0 20	3 -21.7061	72.2478	COS	
	17.1359	-11.6948	26.3510	-31.7470	13.8840			154
	4.5713	25.9918	-32.8967	21.6287	-5.6733			3 61
C 1.	O 2.	-0.	-0.	-0 10	2 -83.4226	66.7552	CO2	
	16.9476	-12.9426	31.5939	-40.9050	18.7665			155
	4.4269	19.8206	-19.3181	10.4840	-2.4332			3 61
C 2.	H 1.	-0.	-0.	-0 30	2 124.0789	64.5162	C2H	
	14.1456	28.7952	-124.1832	173.9470	-82.7927			952
	5.0723	18.1857	-22.5959	16.0230	-4.5081			12 66
C 2.	H 2.	-0.	-0.	-0 20	2 67.3992	67.3772	C2H2	
	25.3511	-22.9443	42.8352	-52.8723	24.5897			165
	2.2156	42.0345	-59.0289	43.1920	-12.0946			3 61
C 2.	H 4.	-0.	-0.	-0 20	2 29.3345	76.0505	C2H4	
	31.7065	1.2707	-23.4483	16.0964	-3.1221			166
	1.6350	31.5873	-7.5583	-6.7478	3.5218			9 65
C 2.	H 4.	O 1.	-0.	-0 30	3 7.8430	86.6526	C2H4O	
	37.6688	1.2606	-24.2979	15.8614	-2.9578			167
	-1.8289	51.5980	-23.6962	-2.1593	3.5566			9 65
CO 1.	-0.	-0.	-0.	-0 20	1 107.0557	51.3473	CO	
	13.7502	-63.5756	192.0777	-243.6459	110.4042			997
	2.9773	13.5238	-20.9454	14.3872	-3.6537			9 67
H 1.	-0.	-0.	0.	0 20	1 56.5830	34.3090	H	
	4.9680	-0.0000	0.0000	-0.0000	0.0000			288
	4.9680	-0.0000	0.0000	-0.0000	0.0000			07 75
H 1.	O 1.	-0.	-0.	0 20	2 15.9830	53.8470	HO	
	10.4006	-7.8575	13.6006	-16.7214	8.1607			300
	8.3779	-7.2606	13.7350	-10.8105	3.2783			12 70
H 2.	-0.	-0.	-0.	-0 0	1 6.4048	41.0349	H2	
	12.8548	-23.8674	52.9484	-61.0990	27.0132			304
	6.1563	4.6572	-9.6723	8.7834	-2.7044			3 61
H 2.	O 1.	-0.	-0.	-0 0	2 -49.5570	57.4463	H2O	
	15.5208	-6.7693	.7168	-2.1223	2.6974			309

	8.0455	-1.8538	7.2725	-4.7628	1.1489		3 61
H 2.	O 2.	-0. -0.	-0 30	2 -20.1375	73.9745	H2O2	
	17.4433	-5.7557	24.7797	-41.6068	20.3816		310
	3.8051	30.5698	-35.1344	20.2595	-4.4805		12 60
H 2.	S 1.	-0. -0.	-0 20	2 4.0633	62.3988	H2S	
	16.1636	-11.5781	21.5242	-28.1551	13.3205		313
	7.8488	-1.2480	9.7461	-6.9585	1.5540		12 65
H 3.	N 1.	-0. -0.	-0 20	2 -.3763	61.4113	H3N	
	28.6650	-57.9455	128.1207	-147.0536	62.9049		314
	6.9777	2.2529	13.0714	-12.6480	3.8128		9 65
N 1.	O 1.	-0. -0.	-0 20	2 28.5411	60.8811	NO	
	9.6120	-3.4797	7.1128	-9.1987	4.1679		351
	8.1959	-7.8995	18.6061	-14.9907	4.2114		6 63
N 1.	O 2.	-0. -0.	-0 20	2 18.1762	72.5308	NO2	
	13.9064	.0495	-1.9801	.3637	.1327		352
	6.4906	6.9902	5.6850	-10.6396	3.9407		9 64
N 2.	-0.	-0. -0.	-0 0	1 6.7187	55.9578	N2	
	9.7325	-4.9604	11.2348	-15.2917	7.2885		360
	7.5309	-4.0828	8.9494	-5.9095	1.3277		2 61
N 2.	O 1.	-0. -0.	-0 20	2 30.4321	68.5678	N2O	
	14.8993	.0745	-2.8842	.9113	.1206		361
	4.8717	19.5613	-19.5098	10.6848	-2.4944		12 64
O 1.	-0.	-0. 0.	0 20	1 64.1030	45.5270	O	
	6.5063	-11.2484	30.3127	-35.3996	15.1363		381
	6.0377	-4.3190	7.0253	-5.1596	1.4154		07 75
O 2.	-0.	-0. -0.	-0 10	1 7.1149	59.7320	O2	
	10.7994	-1.0300	-16.8890	32.3940	-17.5193		389
	7.1663	-3.3897	12.9769	-12.1542	3.7360		2 61
O 2.	S 1.	-0. -0.	-0 10	2 -60.0788	75.4643	O2S	
	16.0201	-11.0806	25.7165	-30.4358	13.0862		391
	5.9938	14.2911	-8.3110	.0191	1.0272		6 61
S 1.	-0.	-0. -0.	-0 20	1 71.0570	47.5460	S	
	5.5345	2.0554	-16.2242	27.7989	-14.4921		424
	4.3786	10.0034	-26.2304	25.5022	-8.4940		6 71
C 1.	-0.	-0. -0.	-0 75	1 3.8831	6.8097	C(GRAPHITE)	
	8.3590	-16.9179	46.1293	-57.0516	25.2313		111
	-1.3182	13.8272	-8.9229	.6866	.8785		3 61
C 1.	SI 1.	-0. -0.	-0 75	2 -8.1943	17.4991	CSI(C)	
	13.3313	5.9169	-28.1704	37.5808	-17.5698		967
	-3.7576	52.3970	-75.5179	52.4643	-14.0109		3 67
C 1.	SI 1.	-0. -0.	-0 75	2 -7.8100	17.4482	CSI(C)	
	13.8546	7.2903	-40.5070	58.6620	-28.6105		159
	-4.0167	54.0007	-78.9907	55.4776	-14.9196		3 67
C 1.	SI 1.	-0. -0.	-0 76	2 1.7387	22.1706	CSI(L)	
	20.4721	-65.4217	265.8848	-431.2995	230.2591		732
	-6.9888	73.7410	-121.0145	91.4087	-25.7120		12 62
CA 1.	O 1.	-0. -0.	0 80	2 -140.7730	25.7160	CAO(C)	
	21.9378	-164.8799	751.8131	-1227.7795	659.7266		1125
	-2.6477	77.1953	-151.4812	130.8390	-40.9659		6 73
CA 1.	O 1.	-0. -0.	-0 76	2 -122.1890	31.4780	CAO(L)	
	-14.3162	232.4233	-643.5790	737.6251	-303.0620		1126
	2.9855	38.5998	-62.2836	46.5261	-12.9822		6 73
CA 1.	S 1.	-0. -0.	0 75	2 -102.2360	30.6260	CAS(C)	
	11.2024	62.7453	-215.3163	268.3116	-115.8028		1138
	1.0493	67.0475	-145.8728	135.1104	-44.2035		12 71
CS 1.	-0.	-0. -0.	-0 75	1 8.0085	32.5830	CS(C)	
	9.0000	0.0000	0.0000	0.0000	-0.0000		1036
	.1903	44.3756	-81.5957	64.8712	-18.8362		6 68
CS 1.	-0.	-0. -0.	-0 76	1 7.2119	32.4099	CS(L)	
	7.5965	-.6132	2.6331	-4.4440	2.2691		1037

9.4088	-9.4134	16.2393	-12.2846	3.4580					6 68
O 2. SI 1.	-0.	-0.	-0	80	2	-203.0249	31.1969	O2SI(C)	
17.4194	10.6043	-38.9722	49.3371	-22.1372					991
-28.8169	196.5277	-330.4013	249.6179	-70.1979					6 67
O 2. SI 1.	-0.	-0.	-0	76	2	-201.9826	31.6643	O2SI(L)	
27.3920	-76.7732	292.8746	-447.7383	227.0980					393
-.5593	55.7166	-75.4259	50.0228	-12.9394					6 67
S 1. -0.	-0.	-0.	-0	75	1	7.6890	18.5335	S(C)	
17.4444	12.5422	-5.7026	-76.9714	67.0189					422
3.0531	8.7177	-3.6585	3.0558	-.9205					12 65
S 1. -0.	-0.	-0.	-0	76	1	7.4932	19.5903	S(L)	
7.6940	-0.0000	0.0000	-0.0000	0.0000					423
-3.7030	69.4416	-139.1975	114.7737	-33.6687					12 65
S 2. SI 1.	-0.	-0.	0	75	2	-33.1830	46.3320	S2SI(C)	
24.8711	-22.9432	99.9160	-169.0095	90.5579					427
17.4255	3.8655	-.6445	-.9953	.7459					6 72
S 2. SI 1.	-0.	-0.	0	76	2	-31.2780	47.7250	S2SI(L)	
21.7500	0.0000	-0.0000	0.0000	-0.0000					428
13.4714	36.0502	-91.2332	102.1707	-38.7092					6 72
SI 1. -0.	-0.	-0.	-0	75	1	5.3294	12.4773	SI(C)	
6.2791	19.5157	-64.8911	75.0192	-29.8269					431
1.5307	17.5413	-27.9681	21.1647	-5.9722					12 66
SI 1. -0.	-0.	-0.	-0	76	1	17.4480	19.6804	SI(L)	
6.5000	0.0000	0.0000	0.0000	-0.0000					432
6.5000	0.0000	0.0000	0.0000	-0.0000					3 67

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