Documentation for MF-FIRE, A Multifrequency Radiative Transfer Version of FIRE

G.A. Moses, T.J. McCarville, and R.R. Peterson

March 1982
(revised December 1982, August 1984)

UWFDM-458

Computer Phys. Comm. **36**, 249 (1985).

Documentation for MF-FIRE, A Multifrequency Radiative Transfer Version of FIRE

G.A. Moses, T.J. McCarville, and R.R. Peterson

Fusion Technology Institute
University of Wisconsin
1500 Engineering Drive
Madison, WI 53706

http://fti.neep.wisc.edu

March 1982 (revised December 1982, August 1984)

UWFDM-458

Computer Phys. Comm. **36**, 249 (1985).

Documentation for MF-FIRE, A Multifrequency Radiative Transfer Version of FIRE

G.A. Moses

T.J. McCarville

R.R. Peterson

Fusion Engineering Program
Nuclear Engineering Department
University of Wisconsin
Madison, WI 53706

March 1982

(Revised December 1982)

(Revised August 1984)

UWFDM-458

MF-FIRE - A MULTIFREQUENCY RADIATIVE TRANSFER HYDRODYNAMICS CODE

G.A. MOSES, T.J. McCARVILLE and R.R. PETERSON

Nuclear Engineering Department, University of Wisconsin, Madison, WI 53706

PROGRAM SUMMARY

Title of program: MF-FIRE

Catalogue number:

Program obtainable from: CPC Program Library, Queen's University of Belfast, N. Ireland (see application form in this issue)

Computer for which the program is designed and others on which is it operable:

Computer: Sperry 1100/82; Installation: University of Wisconsin Computing Center

Operating system or monitor under which the program is executed: Sperry 1180 Time/Sharing EXEC

Programming language used: FORTRAN 66

High speed storage required: 80,000 words

No. of bits in a word: 36

Overlay structure: Yes

No. of magnetic tapes required: None

Other peripherals used: Line printer, ten disk files

No. of cards in combined program and test deck: 13,623

Card punching code: ASCII

CPC Library subprograms used: MIXERG

Reference to other published version of this program:

Keywords: radiation hydrodynamics, x-ray attenuation, high temperature gas dynamics

Nature of the Physical Problem

Inertial confinement fusion target explosions emit energy in the form of neutrons, x-rays, and ionic debris. If the explosion is contained in a vessel filled with gas, the x-rays and ionic debris are stopped in the gas, forming a microfireball [1]. The MF-FIRE code computes the attenuation of the target x-rays and debris in this gas and computes the radiation-hydrodynamic response of the microfireball.

Method of Solution

The deposition of target x-rays into the gas is computed with an exponential attenuation model. A table of x-ray attenuation coefficients for atoms with atomic numbers ranging from 1 to 100 and x-ray energies ranging from 0.01 keV to 1 MeV is supplied with this version of the code [2]. The gas near the target is ionized beyond the level caused by the initial temperature of the gas so that the photoelectric attenuation coefficient is reduced for subsequent x-rays. The x-ray deposition model used by the MF-FIRE code accounts for the reduction in the attenuation coefficient with increasing ionization [3].

The internal energy and momentum transferred from the target debris to the gas are computed from the results of an ion transport code. The results of the ion transport code are fit to analytic functions, and these analytic functions are used to estimate the rates at which internal energy and momentum are deposited as functions of time and space [3].

The MF-FIRE code simulates the response of a gas confined within a pressure vessel to the deposition of target x-rays and ions by solving the one-dimensional equations of radiation hydrodynamics in Lagrangian coordinates using standard finite difference methods. The radiative transfer is treated in the non-equilibrium multifrequency diffusion approximation. An earlier published version of the FIRE code [4] used only a one-temperature approximation for the radiative transfer. Tabulated equations of state and tabulated multifrequency mean Planck and Rosseland opacities are computed using the MIXERG [5] atomic physics code.

Restrictions on the Complexity of Problem

The MF-FIRE code assumes one-dimensional symmetry in computing the interaction of the target x-rays and ions with the gas, and also in computing the gas response. The gas can be divided into a maximum of 50 Lagrangian zones, and either planar, cylindrical or spherical geometry can be assumed. Up to 20 frequency groups can be used for the radiative transfer calculation.

The gas is assumed to be composed of only one atomic number in computing the x-ray deposition. At present, the model for computing the reduction in the photoelectric attenuation coefficient with increasing ionization is only used if the gas is neon, argon, xenon or nitrogen. To compute the reduction in the attenuation coefficient for additional gases, the binding energy of the K, L and M shell electrons of the neutral gas and the number of electrons in each shell must be added to the subroutine EDATA. Ion stopping data is only supplied for projectile ions Au, Fe, Si, He, T, D, and H in gases of Ar, Xe, and He.

Typical Running Time

The CPU time required to compute the deposition of target x-rays and ions into the gas is minimal compared to the time required to compute the hydrodynamic response. On the Univac 1100/82, the CPU time required to compute the gas response is about 2 x 10^{-3} s/zone•cycle.

Unusual Features of the Program

The MF-FIRE code is written in FORTRAN 66 with two exceptions: (1) NAMELIST input and (2) the manner in which the COMMON blocks are used. The COMMON blocks are listed only at the beginning of the program, where they are equated to INCLUDE statements. Thereafter, the INCLUDE statements are used to represent the COMMON blocks. The use of INCLUDE statements abbreviates the listing of a program that uses the same COMMON blocks in many subroutines, because an INCLUDE statement occupies only one line, whereas a COMMON block might occupy many lines. Most computer systems have a feature similar to the INCLUDE statement described here and it is recommended that the user make use of this feature in his system.

References

[1] R.R. Peterson and G.A. Moses, "Target Explosion Generated Fireballs in the Nitrogen Filled Target Chamber of the Light Ion Fusion Target Development Facility," Nucl. Tech./Fusion 4, 860 (1983).

[2] K.G. Adams and F. Biggs, Sandia Lab., SC-RR-72-0683, Albuquerque, NM (Dec. 1973).

[3] T.J. McCarville, G.A. Moses and G.L. Kulcinski, "A Model for the Deposition of X-Rays and Pellet Debris from Inertial Confinement Fusion Targets into a Cavity Gas," University of Wisconsin Fusion Engineering Program Report UWFDM-406 (April 1981).

[4] T.J. McCarville, R.R. Peterson and G.A. Moses, "FIRE - A Code for Computing the Response of an Inertial Confinement Fusion Cavity Gas to a Target Explosion," Comp. Phys. Comm. 28, 367 (1983).

[5] R.R. Peterson and G.A. Moses, "MIXERG - An Equation of State and Opacity Computer Code," Comp. Phys. Comm. 28, 405 (1983).

LONG WRITE-UP

Contents

1. Introduction 1

2. Target X-Ray Deposition 1

3. The Equation of Motion 3

4. The Energy Equations 8

    4.1 Two-Temperature Option 8

    4.2 Multifrequency Option 19

5. The Equation of State and Opacity Tables 23

6. The Energy Conservation Check 26

7. The Time Step Control 28

8. The Subroutines and Their Functions 29

9. Input/Output Units and Storage Requirements 32

10. The Common Blocks 33

11. The Input Variables 54

12. Input Data Requirements 70

13. Example Calculations Using MF-FIRE 71

1. Introduction

The FIRE code [1,2] was developed to simulate the response of a gas to the x-rays and ionic debris emanating from an exploding inertial confinement fusion target. The code computes target x-ray attenuation and ion slowing down in gases. It also computes the gas response using a one-dimensional plasma-hydrodynamics model with the major energy transfer mechanism being radiative transfer. This radiative transfer can be modeled in three different ways. The first is a two temperature (2-T) approximation where the plasma and radiation are characterized by their own unique temperatures, $T_P(r,t)$ and $T_R(r,t)$. The radiation temperature is treated as a "color temperature" for purposes of the opacity determination, and is not necessarily related to the fourth root of the radiation energy density [2]. The radiation energy density is the quantity that is actually transported. The second method is similar to the first but in this case the temperature is assumed to be the fourth root of the energy density. This is the standard approximation. To this FIRE code we have added the third option of treating the radiation in a multifrequency group approximation (thus the MF-FIRE code) and this will be discussed in this paper. This paper is very similar to Ref. [1] with the addition of multifrequency radiative transfer and a correction to the Lagrangian form of the PdV work term in the radiation diffusion equation. Although these changes and additions are straightforward in principle, they are far too complex to publish as a program adaptation.

2. Target X-Ray Deposition

The time required for the deposition of target x-rays into the cavity gas ($\sim 10^{-8}$ s) is much shorter than the hydrodynamic response time, so the gas is stationary as the x-rays are deposited. Hence, the thermodynamic state of the gas after x-ray deposition can be used as an initial condition in computing the gas response to the exploding target. The code assumes exponential x-ray attenuation, which should be adequate for most target x-ray spectra [3]. As the code is presently written, gases composed of only one element can be used to attenuate the x-rays. A table of attenuation coefficients for elements with atomic numbers ranging from 1 to 100 and x-ray energies ranging from 0.01 to 1000 keV are provided with the MF-FIRE code [4].

The initial x-rays that are photoabsorbed by the gas reduce the number of bound electrons available to interact with subsequent x-rays, so the attenuation coefficient decreases as x-rays are deposited. A method of modifying the photoelectric attenuation coefficient of the gas to account for increasing ionization has been developed for the MF-FIRE code [3]. By counting the number of electrons ejected from each electron shell as the x-rays are deposited, the contribution to the photoelectric attenuation coefficient from each shell can be reduced by an amount proportional to the number of missing electrons. Additionally, the number of electrons lost due to the initial gas temperature is included even though this effect is usually very small. Although simple, this model does at least give the correct attenuation for the limiting cases of a completely neutral and completely ionized atom. The accuracy of this model at intermediate levels of ionization has not been determined. In this version of the code, the model for computing the reduction in photoelectric absorption can only be used with neon, argon, xenon or nitrogen gas. To extend the model to other gases, the number of electrons in each shell of the neutral atom and the energies of the K, L, and M shells must be added to the EDATA subroutine.

The x-ray spectrum emitted by the target can be assumed to be Planckian, or an arbitrary histogram can be input. In either case, the code divides the x-ray spectrum into energy groups, giving each group a constant energy width. The x-rays in each group are then attenuated as if they were monoenergetic.

3. The Equation of Motion

The equations solved by the MF-FIRE code are written in the Lagrangian coordinate system, i.e. the equations describe a point that moves with the local fluid velocity. The advantage of this coordinate system is that the mass flux is zero, so the conservation equations are simplified considerably. The code can automatically choose a suitable Lagrangian mesh from the vessel geometry and dimensions input by the user if desired. Either planar, cylindrical, or spherical coordinates can be assumed. The units used by the MF-FIRE code are

length - cm
time - second
mass - gram
speed - cm/s
energy - Joule
temperature - eV
pressure - J/cm^3 = MPa
charge - esu

Figure 1 illustrates the index system used to denote spatial boundaries. The Lagrangian mass of each zone, $m_{o_{j-1/2}}$, is defined by integrating

$$dm_o = \rho(r)\, r^{\delta-1}\, dr \qquad (1)$$

from boundary j-1 to j, where ρ is the mass density and r is the spatial coordinate. The symbol δ denotes planar (δ=1), cylindrical (δ=2), or spherical coordinates (δ=3). The Lagrangian mass is a constant for each zone, so it is a convenient replacement for the product $\rho(r)r^{\delta-1}dr$ when writing the conservation equations in finite difference form. The average Lagrangian mass of two zones, m_{o_j}, will appear in the finite difference form of the equation of motion, and is defined as

$$m_{o_j} = \frac{\left(m_{o_{j+1/2}} + m_{o_{j-1/2}}\right)}{2} \; . \tag{2}$$

and

$$\Delta m_{o_j} = m_{o_{j+1/2}} - m_{o_{j-1/2}} \; .$$

In Lagrangian coordinates, the equation of motion is

$$\frac{\partial u}{\partial t} = -V \frac{\partial}{\partial r} (P + q) - \frac{V}{V_d} \frac{\partial u_{dr}}{\partial t} \; , \tag{3}$$

where: V is the specific volume of the gas,

V_d is the specific volume of the debris,

u is the radial velocity of the gas,

u_{dr} is the radial velocity of the debris,

P is the sum of the gas and radiation pressure,

q is the artificial viscosity [5],

and where it has been assumed that $V_d >> V$. The explicit, finite difference form of Eq. (3) that is solved by the MF-FIRE code is

$$\frac{u_j^{n+1/2} - u_j^{n-1/2}}{\Delta t^n} = - \frac{(r_j^n)^{\delta-1}\left[\Delta P_j^n + \Delta q_j^{n-1/2}\right]}{\Delta m_{o_j}} + \frac{1}{G\Delta m_{o_j}} \frac{\Delta MOM_j^n}{\Delta t^n} \; , \tag{4}$$

where: $G = 1$ for $\delta=1$ (planar coordinates),

$G = 2\pi$ for $\delta=2$ (cylindrical coordinates),

$G = 4\pi$ for $\delta=3$ (spherical coordinates),

and ΔMOM_j^n is the momentum lost by the debris during Δt^n.

The superscript n is the time index. The terms in brackets are defined as

$$\Delta P_j^n = P_{j+1/2}^n - P_{j-1/2}^n \quad \text{and} \quad \Delta q_j^{n-1/2} = q_{j+1/2}^{n-1/2} - q_{j-1/2}^{n-1/2} \quad . \tag{5}$$

The artificial viscosity is a function of the zone specific volume, so to make Eq. (4) explicit, Δq_j is evaluated at $t^{n-1/2}$. The artificial viscosity used is

$$\begin{aligned} q_{j-1/2}^{n-1/2} &= 0 && \text{for } \dot{V}_{j-1/2}^{n-1/2} > 0 \quad , \\ &= \frac{\sqrt{2}\left(u_j^{n-1/2} - u_{j-1}^{n-1/2}\right)}{V_{j-1/2}^{n-1/2}} && \text{for } \dot{V}_{j-1/2}^{n-1/2} < 0 \quad . \end{aligned} \tag{6}$$

The quantity $\dot{V}$ is the time rate of change of the specific volume.

The gas pressure, P_P, is computed from the perfect gas law,

$$P_{P\,j\pm1/2}^n = 1.602 \times 10^{-19} \left(1 + Z_{j\pm1/2}^n\right) * n_{P\,j\pm1/2}^n * T_{P\,j\pm1/2}^n \quad , \tag{7}$$

where: Z is the charge state of the gas,

n_P is the number density of gas atoms,

T_p is the gas temperature.

The radiation pressure, P_R, is computed from the radiation energy density, E_R, by

$$P^n_{R_{j\pm1/2}} = \frac{1}{3} (E_R)^n_{j\pm1/2} \quad , \tag{8}$$

where the radiation energy density has been assumed to be isotropic. Although in some instances the radiation field may not be isotropic, the radiation pressure is very small compared to the gas pressure for the temperature and densities of interest here, so the assumption of an isotropic radiation field does not affect the gas motion.

After solving Eq. (4) for $u^{n+1/2}_j$, the new radii are computed from

$$r^{n+1}_j = r^n_j + u^{n+1/2}_j \Delta t^{n+1/2} \quad . \tag{9}$$

New specific volumes and other quantities are then computed in preparation for the next time step.

To evaluate the momentum imparted by the target debris, the debris is assumed to consist of only one element. The initial energy spectrum can be Maxwellian or Gaussian, or an arbitrary histogram can be input. The code divides the initial energy spectrum into energy groups that have equally spaced increments in velocity, and assigns an equal fraction of the debris mass to each group. The total momentum deposited into a gas zone is the sum of the contributions from each group. However, to simplify the notation in the equations that follow, the index denoting the energy group will be omitted. The momentum imparted by the debris, in finite difference form, is

$$\Delta MOM^n_j = \Delta m^n_{d_{j-1/2}} \left(u^{n+1/2}_{dr} - u^{n-1/2}_{dr}\right) \quad . \tag{10}$$

The quantity $\Delta m^n_{d_{j-1/2}}$ is the debris mass in zone j-1/2, and is evaluated from analytic functions that are programmed into the code [3]. The analytic functions simulate ion transport in the gas. The quantities $u^{n\pm1/2}_{dr}$ are the average radial speed of ions in an energy group, so are independent of the spatial index. Equation (10) can be written in the form evaluated by the code by noting that at time $t^{n+1/2}$,

$$u^{n+1/2}_{dr} = u^{n-1/2}_{dr} + (\frac{du_{dr}}{dt})^{n-1/2} \Delta t^n \quad . \tag{11}$$

The time derivative $\dot{u}_{dr}$ has been written as a total derivative because the average deceleration of each energy group is independent of the spatial index. The deceleration is also evaluated from the analytic expressions that are programmed into the code. Combining Eqs. (10) and (11) gives the expression evaluated in the code,

$$\Delta MOM^n_j = \Delta m^n_{d_{j-1/2}} (\frac{du_{dr}}{dt})^{n-1/2} \Delta t^n \quad . \tag{12}$$

The analytic expressions that are programmed into the MF-FIRE code and used to evaluate the deceleration and spatial distribution of the debris are functions of the average radial distance that the debris travel through the gas, r_d. From the expression

$$u^{n+1/2}_{dr} = \frac{r^{n+1}_d - r^n_d}{\Delta t^{n+1/2}} \quad , \tag{13}$$

and Eq. (11), the distance the debris have traveled through the gas (in the Lagrangian reference frame), is

$$r_d^{n+1} = r_d^n + \Delta t^{n+1/2} \, u_{dr}^{n-1/2} + \left(\frac{du_{dr}}{dt}\right)^{n-1/2} \Delta t^n \Delta t^{n+1/2} \quad . \tag{14}$$

4. The Energy Equations

4.1 Two-Temperature Option

Because of the high temperatures encountered in the gas (up to hundreds of eV), thermal radiation can be the dominant energy transport mechanism. The MF-FIRE code uses flux limited diffusion to model radiation transport. The absorption and emission of thermal radiation are strongly temperature dependent, so the radiation diffusion equation is solved simultaneously with the plasma temperature equation. The equations solved by the MF-FIRE code are

$$C_v \frac{\partial T_P}{\partial t} = \frac{\partial}{\partial m_o} \left(r^{\delta-1} \kappa_P \frac{\partial T_P}{\partial r}\right) - \frac{\partial P_P}{\partial T_P} \dot{V} T_P - q\dot{V} + \omega_R E_R - \omega_P T_P + S \tag{15-a}$$

$$V \frac{\partial E_R}{\partial t} = \frac{\partial}{\partial m_o} \left(r^{\delta-1} \kappa_R \frac{\partial E_R}{\partial r}\right) - \frac{4}{3} E_R \dot{V} - \omega_R E_R + \omega_P T_P \tag{15-b}$$

where: C_v is the specific heat at constant volume,

κ_P is the gas thermal conductivity,

κ_R is the radiation thermal conductivity,

ω_R is the radiation absorption coefficient,

ω_P is the radiation emission coefficient,

S is the rate that internal energy is added by the debris.

In writing Eq. (15-a), the thermodynamic identity [6]

$$\frac{\partial E_P}{\partial t} + P_P \dot{V} = C_v \frac{\partial T_P}{\partial t} + \frac{\partial P_P}{\partial T_P} \dot{V} T_P \tag{16}$$

was used to replace $\frac{\partial E_P}{\partial t}$ and $P_P \dot{V}$ with terms involving T_P. To simplify the notation in the finite difference equations that follow, the time index of quantities evaluated at $t^{n+1/2}$ will be omitted. In fully implicit finite difference form, Eqs. (15-a) and (15-b) are

$$C_{v_{j-1/2}} \frac{T^{n+1}_{P_{j-1/2}} - T^{n}_{P_{j-1/2}}}{\Delta t^{n+1/2}} = \frac{1}{\Delta m_{o_{j-1/2}}} \left[\frac{r^{\delta-1}_{j}}{(\frac{\Delta r}{\kappa_P})_j} \left(T^{n+1}_{P_{j+1/2}} - T^{n+1}_{P_{j-1/2}}\right) - \frac{r^{\delta-1}_{j-1}}{(\frac{\Delta r}{\kappa_P})_{j-1}} \left(T^{n+1}_{P_{j-1/2}} - T^{n+1}_{P_{j-3/2}}\right)\right] - \left(\frac{\partial P_P}{\partial T_P}\right)_{j-1/2} \dot{V}_{j-1/2}\, T^{n+1}_{P_{j-1/2}}$$
$$- q_{j-1/2}\, \dot{V}_{j-1/2} + \omega_{R_{j-1/2}} E^{n+1}_{R_{j-1/2}} - \omega_{P_{j-1/2}} T^{n+1}_{P_{j-1/2}} + S^{n}_{j-1/2} \tag{17-a}$$

and

$$V^{n+1/2}_{j-1/2} \frac{E^{n+1}_{R_{j-1/2}} - E^{n}_{R_{j-1/2}}}{\Delta t^{n+1/2}} = \frac{1}{\Delta m_{o_{j-1/2}}} \left[\frac{r^{\delta-1}_{j}}{(\frac{\Delta r}{\kappa_R})_j + \frac{\Delta E_{R_j}}{F_{R_j}}} \left(E^{n+1}_{R_{j+1/2}} - E^{n+1}_{R_{j-1/2}}\right) - \frac{r^{\delta-1}_{j-1}}{(\frac{\Delta r}{\kappa_R})_{j-1} + \frac{\Delta E_{R_{j-1}}}{F_{R_{j-1}}}} \left(E^{n+1}_{R_{j-1/2}} - E^{n+1}_{R_{j-3/2}}\right)\right] - E^{n+1}_{R_{j-1/2}} \frac{4}{3} \dot{V}_{n-1/2}$$
$$- \omega_{R_{j-1/2}} E^{n+1}_{R_{j-1/2}} + \omega_{P_{j-1/2}} T^{n+1}_{P_{j-1/2}} \quad . \tag{17-b}$$

The denominators of the terms in square brackets represent the resistance per unit area to thermal and radiative diffusion between zone centers. For instance,

$$(\frac{\Delta r}{\kappa_P})_j = \frac{1}{2}\left(\frac{r_{j+1} - r_j}{K_P^+} + \frac{r_j - r_{j-1}}{K_P^-}\right) \quad , \tag{18}$$

and so on for $(\frac{\Delta r}{\kappa_P})_{j-1}$, $(\frac{\Delta r}{\kappa_R})_j$, and $(\frac{\Delta r}{\kappa_R})_{j-1}$. Equations (17-a) and (17-b) can be written in matrix form as

$$\begin{aligned}\underline{\underline{\alpha}}_{j-1/2}\,(\underline{\theta}^{n+1}_{j-1/2} - \underline{\theta}^{n}_{j-1/2}) &= \underline{\underline{a}}_j\,(\underline{\theta}^{n+1}_{j+1/2} - \underline{\theta}^{n+1}_{j-1/2}) - \underline{\underline{a}}_{j-1}\,(\underline{\theta}^{n+1}_{j-1/2} - \underline{\theta}^{n+1}_{j-3/2}) \\ &- \underline{\underline{\gamma}}_{j-1/2}\,\underline{\theta}^{n+1}_{j-1/2} - \underline{\underline{\omega}}_{j-1/2}\,\underline{\theta}^{n+1}_{j-1/2} + \underline{\beta}_{j-1/2}\end{aligned} \tag{19}$$

where

$$\underline{\underline{\alpha}}_{j-1/2} = \begin{pmatrix} C_{v_{j-1/2}} & 0 \\ 0 & V_{j-1/2} \end{pmatrix} \frac{\Delta m_{o_{j-1/2}}}{\Delta t^{n+1/2}} \quad ,$$

$$\underline{\underline{a}}_j = \begin{pmatrix} r_j^{\delta-1}/(\Delta r/K_P)_j & 0 \\ 0 & r_j^{\delta-1}/[(\Delta r/\kappa_R)_j + \Delta E_{R_j}/F_{R_j}) \end{pmatrix} \quad ,$$

$$\underline{\underline{\gamma}}_{j-1/2} = \begin{pmatrix} (\partial P_P/\partial T_P)_{j-1/2}\dot{V}_{j-1/2} & 0 \\ 0 & 4\dot{V}_{j-1/2}/3 \end{pmatrix} \Delta m_{o_{j-1/2}} \quad ,$$

$$\underline{\underline{\omega}}_{j-1/2} = \begin{pmatrix} \omega_P & -\omega_R \\ -\omega_P & \omega_R \end{pmatrix}_{j-1/2} \Delta m_{o_{j-1/2}} \quad ,$$

$$\underline{\beta}_{j-1/2} = \begin{pmatrix} -q_{j-1/2}\,\dot{V}_{j-1/2} + S^{n}_{j-1/2} \\ \\ 0 \end{pmatrix} \quad \Delta m_{0_{j-1/2}} \quad ,$$

and
$$\underline{\theta}^{n+1}_{j-1/2} = \begin{pmatrix} T^{n+1}_{P_{j-1/2}} \\ \\ E^{n+1}_{R_{j-1/2}} \end{pmatrix} \quad .$$

A more compact matrix equation can be written by redefining the coefficients as follows:

$$\underline{\underline{A}}_{j-1/2} = \underline{\underline{a}}_{j} \quad ,$$

$$\underline{\underline{B}}_{j-1/2} = \underline{\underline{\alpha}}_{j-1/2} + \underline{\underline{a}}_{j} + \underline{\underline{a}}_{j-1} + \underline{\underline{\gamma}}_{j-1/2} + \underline{\underline{\omega}}_{j-1/2} \quad ,$$

$$\underline{\underline{C}}_{j-1/2} = \underline{\underline{a}}_{j-1} \quad ,$$

$$\underline{D}_{j-1/2} = \underline{\underline{\alpha}}_{j-1/2}\,\underline{\theta}^{n}_{j-1/2} + \underline{\beta}_{j-1/2} \quad .$$

With these redefinitions, Eq. (19) becomes

$$-\underline{\underline{A}}_{j-1/2}\,\underline{\theta}^{n+1}_{j+1/2} + \underline{\underline{B}}_{j-1/2}\,\underline{\theta}^{n+1}_{j-1/2} - \underline{\underline{C}}_{j-1/2}\,\underline{\theta}^{n+1}_{j-3/2} = \underline{D}_{j-1/2} \quad . \qquad (20)$$

If JMAX is the number of zone boundaries, then Eq. (20) represents a JMAX by JMAX tridiagonal matrix equation that has two by two matrices for elements. If the coefficients of Eq. (20) are evaluated at t^n, it can be solved by

Gaussian elimination. Solutions can be shown to be of the form [7]

$$\begin{aligned} \underline{\theta}^{n+1}_{j-1/2} &= \underline{\underline{E}}_{j-1/2}\,\underline{\theta}^{n+1}_{j+1/2} + \underline{F}_{j-1/2} \quad , \quad \text{for } 1 \leqslant j < \text{JMAX} \\ \underline{\theta}^{n+1}_{\text{JMAX}+1/2} &= \text{BOUNDARY CONDITIONS} \quad , \quad \text{for } j = \text{JMAX} \ . \end{aligned} \tag{21}$$

The $\underline{\underline{E}}$ matrix and $\underline{F}$ vector can be related to known quantities by decreasing the spatial index of Eq. (21) by one, and substituted into Eq. (20). One finds that

$$\begin{aligned} \underline{\underline{E}}_{j-1/2} &= (\underline{\underline{B}}_{j-1/2} - \underline{\underline{C}}_{j-1/2} * \underline{\underline{E}}_{j-3/2})^{-1} * \underline{\underline{A}}_{j-1/2} \ , \\ &\text{and} \\ \underline{F}_{j-1/2} &= (\underline{\underline{B}}_{j-1/2} - \underline{\underline{C}}_{j-1/2} * \underline{\underline{E}}_{j-3/2})^{-1} * (\underline{D}_{j-1/2} + \underline{\underline{C}}_{j-1/2} * \underline{F}_{j-3/2}) \end{aligned} \tag{22}$$

for $2 \leqslant j < \text{JMAX}$, and

$$\underline{\underline{E}}_{1/2} = (\underline{\underline{B}}_{1/2})^{-1} * \underline{\underline{A}}_{1/2} \ ,$$

$$\underline{F}_{1/2} = (\underline{\underline{B}}_{1/2})^{-1} * \underline{D}_{1/2} \ ,$$

for $j=1$. To solve Eq. (21), a sweep is made from the first zone out to the wall to evaluate $\underline{\underline{E}}$ and $\underline{F}$, and then back to the center to evaluate the components of the $\underline{\theta}^{n+1}$ vector.

The expression for the thermal conductivity of the plasma, κ_p, that is used in the MF-FIRE code is the theoretical expression developed for electrons' interaction with stationary ions [8]. The theoretical expression includes an experimentally determined constant to prevent κ_P from diverging as the average ionization state approaches zero. The expression is

$$\kappa_P = 20 \left(\frac{2}{\pi}\right)^{3/2} \frac{T_P^{5/2}}{\sqrt{m_e}\, e^4 \, (Z + 4) \ln \Lambda} , \qquad (23)$$

where: e is the electron charge,

m_e is the electron mass,

$\ln \Lambda$ is the Coulomb logarithm.

To save computational effort, the Coulomb logarithm is computed from a curve fit that has an accuracy better than 10% for ln Λ greater than 5. In finite difference form, the thermal conductivities are

$$\kappa^{\pm}_{P_j} = \frac{1.22 \times 10^2 \, T^2_{P_j} \, T^{1/2}_{P_{j\pm1/2}}}{(4 + Z_{j\pm1/2}) \ln \Lambda_{j\pm1/2}} . \qquad (24)$$

The T_P^2 terms are evaluated at the zone boundaries rather than the zone centers to enhance the numerical accuracy of the solution.

The expression for the radiation conductivity that is used in the 2-T option is a frequency averaged value. If the radiation mean free path is much smaller than the gradients in the radiation energy density, then the frequency dependent radiation flux, $q_{R\nu}$, is given by [9]

$$q_{R\nu} = \frac{-\,\ell_\nu(T_P)c}{3} \frac{\partial E_{R\nu}}{\partial r} , \qquad (25)$$

where: ℓ_ν is the frequency dependent radiation mean free path,

$E_{R\nu}$ is the frequency dependent radiation energy density,

c is the speed of light.

The frequency averaged conductivity is obtained by integrating Eq. (25) over frequency. The frequency dependence of ℓ_ν is known from theoretical models of radiation absorption, but in general the frequency dependence of $E_{R\nu}$ is not known prior to solving the frequency dependent radiation transport equations. For the 2-T radiation diffusion model used in the MF-FIRE code, there are two options for estimating $E_{R\nu}$. In the first option [2] the frequency dependence of $E_{R\nu}$ is assumed to be a dilute Planckian, that is

$$E_{R\nu} = \varepsilon V \, \frac{8\pi h\nu^3}{c^3} \, \frac{1}{\exp\left(\frac{h\nu}{T_R}\right) - 1} \quad , \tag{26}$$

where ε is a proportionality factor and T_R is the radiation temperature. The radiation temperature is defined so as to reflect the temperature of the gas that emitted the radiation occupying the point of interest. The radiation temperature at a point is evaluated by averaging the temperature of the transported radiation, the temperature of the emitted radiation, and the temperature of the radiation already present. In finite difference form, this average is

$$T^{n+1}_{R_{j+1/2}} = \frac{W_1 * T^{n+1/2}_{R_{j-1/2}} + W_2 * T^{n+1/2}_{R_{j+3/2}} + W_3 * T^{n+1/2}_{P_{j+1/2}} + W_4 * T^{n+1/2}_{R_{j+1/2}}}{W_1 + W_2 + W_3 + W_4} \qquad 1<j<\mathrm{JMAX} \tag{27}$$

where the weighting functions are defined as

$$\begin{aligned} W_1 &= \left(\frac{q_R r^{\delta-1} \Delta t}{\Delta m_o}\right)^{n+1/2}_{j-1/2} && \text{if } q_{R_{j-1/2}} > 0 \\ &= 0 && \text{if } q_{R_{j-1/2}} < 0 \end{aligned} \tag{28}$$

$$W_2 = 0 \qquad \text{if } q_{R_{j+3/2}} > 0$$

$$= \left(\frac{q_R r^{\delta-1} \Delta t}{\Delta m_o}\right)^{n+1/2}_{j+3/2} \qquad \text{if } q_{R_{j+3/2}} < 0 \tag{29}$$

$$W_3 = (\omega_P T_P \Delta t)^{n+1/2}_{j+1/2} \tag{30}$$

$$W_4 = (E_R)^{n+1/2}_{j+1/2} \quad . \tag{31}$$

In the second option the radiation temperature is simply computed as

$$T_R = \left(\frac{E_R c}{4\sigma}\right)^{1/4} \quad ,$$

where σ is the Stefan-Boltzman constant. The frequency averaged radiation flux across zone boundaries is represented by q_R in Eqs. (28) and (29), which after integrating Eq. (25) over frequency can be written as

$$q_R = - \frac{\ell(T_P,T_R) c}{3} \frac{\partial E_R}{\partial r} \quad , \tag{32}$$

where $$\ell(T_P,T_R) = \frac{15}{4\pi^4} \int_o^\infty \ell_\nu(T_P) \frac{U^4 e^{-U}}{(1 - e^{-U})^2} dU \quad , \tag{33}$$

and $$U(T_R) = \frac{h\nu}{T_R} \quad . \tag{34}$$

Equation (33) defines the Rosseland mean free path (including spontaneous emission [9]), and is a function of the plasma density, the local plasma temperature, and the local radiation temperature. From Eq. (32), the frequency averaged radiation conductivity can be written in finite difference form as

$$\kappa_{R_j}^{\pm} = 10^{10} \, V_{j\pm1/2} \, / \, \sigma_{R_{j\pm1/2}} \tag{35}$$

where $\sigma_{R_{j\pm1/2}}$ is the Rosseland opacity (cm^2/g).

If the Rosseland mean free path is larger than the spatial zoning, then radiation may stream from zone to zone without being absorbed. In this case the diffusion model overestimates the radiation flux, and must be modified with a flux limiter. This flux limiter has been included in Eq. (17-b) where it is referred to as F_{R_j} and $F_{R_{j+1}}$. The maximum radiation flux, cE_R, occurs when the radiation intensity of free streaming radiation approaches complete anisotropy. If the radiation intensity is completely isotropic, then the flux limit is $cE_R/4$. This latter expression is used in the MF-FIRE code. In finite difference form, the flux limit is

$$\begin{aligned} F_j &= 3.75 \times 10^9 \left[(E_R)_{j+1/2}^{n+1/2} + (E_R)_{j-1/2}^{n+1/2} \right] & 1 < j < JMAX \\ F_{JMAX} &= 7.5 \times 10^9 \, (E_R)_{JMAX+1/2}^{n+1/2} & j = JMAX \quad . \end{aligned} \tag{36}$$

The expression for the absorption coefficient used in the MF-FIRE code can be obtained by integrating the frequency dependent absorption rate over frequency. From the definition of the radiation opacity, the frequency dependent absorption rate is

$$\omega_{R\nu} E_{R\nu} = cE_{R\nu} \sigma_\nu (T_p) \quad . \tag{37}$$

Using Eq. (26) to integrate Eq. (37) over frequency results in (including spontaneous emission)

$$\omega_R E_R = cE_R\sigma_P(T_R,T_P) \qquad (38)$$

where $$\rho\sigma_P(T_P,T_R) = \frac{15}{\pi^4}\int_0^\infty \frac{U^3(T_R)\ dU}{\ell_\nu(T_P)(e^{U(T_R)} - 1)} \quad , \qquad (39)$$

and $$U(T_R) = \frac{h\nu}{T_R} \quad . \qquad (40)$$

Equation (39) defines the nonequilibrium Planck opacity, which is the inverse of the frequency averaged distance that radiation with a temperature T_R will travel in a plasma at temperature T_P before being absorbed. The finite difference form of the absorption coefficient is

$$\omega_{R\,j-1/2}^{n+1/2} = 3 \times 10^{10}\ \sigma_P(T_R,T_P)_{j-1/2}^{n+1/2} \quad . \qquad (41)$$

The expression for the radiation emission coefficient that is used in the MF-FIRE code is obtained by assuming that the plasma is in local thermodynamic equilibrium (LTE) [10]. The plasma is in LTE if the electrons and ions are in collisional equilibrium with each other. The radiation spectrum emitted by a plasma in LTE has a Planckian frequency distribution, because the electron-ion recombination processes are the same as those that occur in a blackbody. Then the frequency dependent emission rate can be written as

$$\omega_{P\nu}T_P = \frac{cV}{\ell_\nu(T_P)}\,\frac{8\pi h\nu^3}{c^3}\,\frac{1}{\exp\left(\frac{h\nu}{T_P}\right) - 1} \quad . \qquad (42)$$

Averaging Eq. (42) over frequency yields

$$\omega_P T_P = 4\sigma T_P^4\ \sigma_P(T_P) \quad , \qquad (43)$$

where
$$\rho\sigma_P(T_P) = \frac{15}{\pi^4} \int_0^\infty \frac{U^3(T_P)\, dU}{\ell_\nu(T_P)(e^{U(T_P)} - 1)} , \tag{44}$$

and
$$U(T_P) = \frac{h\nu}{T_P} . \tag{45}$$

Equation (43) defines the equilibrium Planck opacity, which is the inverse of the average distance that radiation at a temperature T_P will travel in a plasma at temperature T_P before being absorbed. The finite difference form of the emission rate is

$$\omega_{P\,j-1/2}^{n+1/2} = 4.12 \times 10^5 \; [T_P^3 \; \sigma_P(T_P)]_{j-1/2}^{n+1/2} . \tag{46}$$

An expression for the internal energy deposition rate from target debris can be obtained by equating the decrease in debris kinetic energy to the increase in the kinetic and internal energy of the gas:

$$- \frac{1}{V_d} u_d \frac{\partial u_d}{\partial t} = \frac{S}{V} + \frac{u}{V} \left(\frac{\partial u}{\partial t}\right)_{P=0} , \tag{47}$$

where u_d is the speed of the debris ions, and the quantity in parenthesis is the acceleration of the gas in the radial direction due to the debris alone, that is, excluding the pressure forces. From conservation of debris momentum it is clear that

$$\frac{1}{V} \left(\frac{\partial u}{\partial t}\right)_{P=0} = - \frac{1}{V_d} \frac{\partial u_{dr}}{\partial t} . \tag{48}$$

Note that $u_{dr} < u_d$ if the trajectory of the debris ions is not straight as they slow down in the plasma (such as when the ions scatter off the plasma nuclei). Combining Eqs. (47) and (48) and solving for the internal energy source term gives

$$S = - \frac{V}{V_d} u_d \frac{\partial u_d}{\partial t} + \frac{V}{V_d} u \frac{\partial u_{dr}}{\partial t} \quad . \qquad (49)$$

In finite difference form, Eq. (49) is

$$S^n_{j-1/2} = - \frac{\Delta m_{d_{j-1/2}}}{\Delta m_{o_{j-1/2}}} \frac{\Delta KE^n_{d_{j-1/2}}}{\Delta t^{n-1/2}} + \frac{u_d^{n+1/2}}{\Delta m_{o_{j-1/2}}} \frac{\Delta MOM^n_{j-1/2}}{\Delta t^{n+1/2}} \quad , \qquad (50)$$

where ΔKE_d is the change in debris kinetic energy during Δt^n. The change in debris kinetic energy, the change in debris momentum, and the debris mass are all evaluated from the analytic functions implemented in the MF-FIRE code to simulate ion transport in the plasma [3].

4.2 Multifrequency Option

In the multifrequency option we have rewritten Eqs. (15-a) and (15-b) as

$$C_v \frac{\partial T_P}{\partial t} = \frac{\partial}{\partial m_o} \left(r^{\delta-1} \kappa_P \frac{\partial T_P}{\partial r}\right) - \frac{\partial P_P}{\partial T_P} \dot{V} T_P - q\dot{V} + A - J + S \qquad (51\text{-a})$$

$$V \frac{\partial E^g_R}{\partial t} = \frac{\partial}{\partial m_o} \left(r^{\delta-1} \kappa^g_R \frac{\partial E^g_R}{\partial r}\right) - \frac{4}{3} E^g_R \dot{V} - c\sigma^g_P E^g_R + J^g \qquad g = 1,\ldots,G \qquad (51\text{-b})$$

where: C_v is the specific heat at constant volume,

κ_P is the plasma thermal conductivity,

κ^g_R is the radiation conductivity for frequency group g,

J^g is the rate of radiation emitted by the plasma into group g,

S is the rate of internal energy added to the plasma by the debris,

σ^g_P is the Planck opacity for group g.

$$E_R^g = \int_{h\nu_g}^{h\nu_{g+1}} dh\nu \; E_R(r,h\nu,t) \tag{52}$$

$$A^g = c\sigma_P^g \; E_R^g \tag{53}$$

$$J^g = \frac{8\pi k T_P^4}{c^2 h^3} \sigma_P^g \int_{x_g}^{x_{g+1}} dx \; \frac{x^3}{e^x - 1} \quad ; \quad x = \frac{h\nu}{kT_P} \tag{54}$$

$$K_R^g = \frac{cV}{3\sigma_R^g} \tag{55}$$

σ_R^g = Rosseland opacity for group g (cm^2/g)

$$A = \sum_{g=1}^{G} A^g \tag{56}$$

$$J = \sum_{g=1}^{G} J^g \quad . \tag{57}$$

This set of G+1 equations is not solved simultaneously as in the 2-T model. Instead the multigroup equations are first solved individually and the terms A and J are computed. These terms are then explicitly included in the plasma temperature diffusion equation which is solved next. This different treatment of the multifrequency equations in no way affects the way that the 2-T method is solved in MF-FIRE. This leads to a very slight inefficiency in the number of subroutines but does not affect the execution time. The coding is kept very concise by doing this.

The multigroup equations are written in finite difference form as

$$\frac{E^{g,n+1}_{R_{j-1/2}} - E^{g,n}_{R_{j-1/2}}}{\Delta t^{n+1/2}} = \frac{1}{\Delta m_{o_{j-1/2}}} \Bigg[\frac{r_j^{\delta-1}}{(\frac{\Delta r}{\kappa_R^g}) + (\frac{\Delta E_R^g}{F_R^g})_j} (E^{g,n+1}_{R_{j+1/2}} - E^{g,n+1}_{R_{j-1/2}})$$

$$- \frac{r_{j-1}^{\delta-1}}{(\frac{\Delta r}{\kappa^g_R})_{j-1} + (\frac{\Delta E^g_R}{F^g_R})_{j-1}} (E^{g,n+1}_{R_{j-1/2}} - E^{g,n+1}_{R_{j-3/2}})\Bigg] - E^{g,n+1}_{R_{j-1/2}} \frac{4}{3}\dot{V}_{n-1/2} \qquad (58)$$

$$- c\sigma^g_{P_{j-1/2}} E^{g,n+1}_R + J^{g,n+1}_R$$

for group g. This is reduced using the notation

$$\alpha_{j-1/2}(E^{g,n+1}_{R_{j-1/2}} - E^{g,n}_{R_{j-1/2}}) = a_j(E^{g,n+1}_{R_{j+1/2}} - E^{g,n+1}_{R_{j-1/2}}) - a_{j-1}(E^{g,n+1}_{R_{j-1/2}} - E^{g,n+1}_{R_{j-3/2}})$$

$$- \gamma_{j-1/2}E^{g,n+1}_{R_{j-1/2}} - \omega_{j-1/2}E^{g,n+1}_{R_{j-1/2}} + \beta_{j-1/2} \qquad (59)$$

where: $\alpha_{j-1/2} = V_{j-1/2}\, \Delta m_{o_{j-1/2}}/\Delta t^{n-1/2}$

$a_j = r^{\delta-1}/((\Delta r/\kappa^g_R)_j + \Delta E^g_{R_j}/F^g_{R_j})$

$\gamma_{j-1/2} = (4\, \dot{V}_{j-1/2}/3)\, \Delta m_{o_{j-1/2}}$

$\omega_{j-1/2} = c\sigma^g_{P_{j-1/2}}\, \Delta m_{o_{j-1/2}}$

$$\beta_{j-1/2} = J^g_{j-1/2} \, \Delta m_{o_{j-1/2}} \quad .$$

The coefficients α, a, γ, ω, and β should be evaluated at $t^{n+1/2}$. However, values at that time are not yet known so they are evaluated at t^n. These terms are regrouped in the familiar form

$$-A_{j-1/2} E^{g,n+1}_{R_{j+1/2}} + B_{j-1/2} E^{g,n+1}_{R_{j-1/2}} - C_{j-1/2} E^{g,n+1}_{R_{j-3/2}} = D_{j-1/2} \tag{60}$$

where: $A_{j-1/2} = a_j$

$$B_{j-1/2} = \alpha_{j-1/2} + a_j + a_{j-1} + \gamma_{j-1/2} + \omega_{j-1/2}$$

$$C_{j-1/2} = a_{j-1}$$

$$D_{j-1/2} = \alpha_{j-1/2} E^{g,n}_{R_{j-1/2}} + \beta_{j-1/2} \quad .$$

We then express the solution as

$$E^{g,n+1}_{R_{j-1/2}} = EE_{j-1/2} * E^{g,n+1}_{R_{j+1/2}} + FF_{j-1/2} \qquad 1 \leqslant j \leqslant JMAX$$

$$E^{n+1}_{R_{JMAX+1/2}} = E_{R_{BC}} \qquad \text{Boundary Condition} \quad . \tag{61}$$

Then we can compute

$$EE_{j-1/2} = A_{j-1/2}/(B_{j-1/2} - C_{j-1/2} * EE_{j-3/2}) \tag{62}$$

$$FF_{j-1/2} = (D_{j-1/2} + C_{j-1/2} * FF_{j-3/2})/(B_{j-1/2} - C_{j-1/2} * EE_{j-3/2}) \tag{63}$$

for $2 < j \leqslant \text{JMAX}$ and

$$EE_{1/2} = A_{1/2}/B_{1/2} \tag{64}$$

$$FF_{1/2} = D_{1/2}/B_{1/2} \tag{65}$$

for $j = 1$.

Once the radiation specific energies have been computed, then the absorption is computed as

$$A^g_{j-1/2} = c\sigma^g_{P_{j-1/2}} E^{g,n+1}_{R_{j-1/2}} \tag{66}$$

$$A_{j-1/2} = \sum_{g=1}^{G} A^g_{j-1/2} \quad . \tag{67}$$

The source term in the plasma temperature equation is then computed as

$$\beta_{j-1/2} = \beta^{old}_{j-1/2} + (A - J)_{j-1/2} \, \Delta m_{o_{j-1/2}} \tag{68}$$

where $\beta^{old}_{j-1/2}$ is the value computed in the 2-T description in part 4.1. The single plasma temperature equation is solved using the same standard implicit finite difference technique described for the 2-T and multifrequency diffusion equations.

5. The Equation of State and Opacity Tables

There are six quantities that must be supplied in tabular form by the user of the MF-FIRE code. These are

$Z(n_P,T_P)$	Charge State
$E_P(n_P,T_P)$	Specific Internal Energy
$\sigma_R(n_P,T_P,T_R)$	Rosseland Opacity
$\sigma_P(n_P,T_P,T_R)$	Planck Opacity
$\sigma_R^g(n_P,T_P)$	Multigroup Rosseland Opacity
$\sigma_P^g(n_P,T_P)$	Multigroup Planck Opacity

These tables are generated for MF-FIRE by the MIXERG code [11]. Logarithmic interpolation is used to interpolate between points in the tables. For instance, the charge state is stored as $\log Z(\log n_P, \log T_P)$. In what follows, the indices associated with the dependent variables are

$$K - \log T_R \quad ,$$

$$L - \log T_P \quad ,$$

$$M - \log n_P \quad .$$

Points in the two-dimensional tables can be represented as a two-dimensional grid, as shown in Fig. 2. The indices with stars denote the location of a quantity located between points in the table, for instance $\log Z(L^*,M^*)$. To compute the desired quantity we first interpolate along the M axis:

$$\log Z(L,M^*) = \log Z(L,M) + \frac{\log Z(L,M+1) - \log Z(L,M)}{\log n_P(M+1) - \log n_P(M)} * (\log n_P - \log n_P(M)) \quad , \tag{69}$$

$$\log Z(L+1,M^*) = \log Z(L+1,M) + \frac{\log Z(L+1,M+1) - \log Z(L+1,M)}{\log n_P(M+1) - \log n_P(M)} * (\log n_P - \log n_P(M)) \quad , \tag{70}$$

where n_p is the number density corresponding to $\log Z(L^*,M^*)$. Now interpolating along the L axis,

$$\log Z(L^*,M^*) = \log (L,M^*) + \frac{\log Z(L+1,M^*) - \log Z(L,M^*)}{\log T_p(L+1) - \log T_p(L)} * (\log T_p - \log T_p(L)) \; , \tag{71}$$

where T_p is the temperature corresponding to $\log Z(L^*,M^*)$.

The grids used to interpolate in the three-dimensional tables are shown in Fig. 3. First we interpolate for $\log \sigma(M,K^*,L^*)$ and $\log \sigma(M+1,K^*,L^*)$ in the manner prescribed above. Then interpolating in the third dimension,

$$\log \sigma(M^*,K^*,L^*) = \log \sigma(M,K^*,L^*) + \frac{\log \sigma(M+1,K^*,L^*) - \log \sigma(M,K^*,L^*)}{\log n_p(M+1) - \log n_p(M)} (\log n_p - \log n_p(M)) \; . \tag{72}$$

If the plasma temperature computed by solving the energy equations is less than the lowest temperature in the equation of state tables, then the code automatically computes Z and E_p by interpolating between the bounds of the table and the values for a perfect un-ionized gas. This procedure preserves the accuracy of the calculation at low temperatures. The number density, n_p, should never exceed the bounds of the tables, or inaccurate results will be obtained.

The multigroup tables are treated like G two-dimensional tables where G is the number of groups.

6. The Energy Conservation Check

At the end of each time step, a check is made to insure that the difference equations are conserving energy. This is done by integrating the energy equations over time and space. The two energy equations can be written as

$$\dot{E}_P + P_P\dot{V} = \dot{S}_P + \dot{Q}_{PR} + Q_{DP} \tag{73}$$

$$\dot{E}_R + P_R\dot{V} = \dot{S}_R - \dot{Q}_{PR} + Q_{DR} \tag{74}$$

where: $\dot{Q}_{PR} = \omega_R E_R - \omega_P T_P$

$\dot{Q}_{Dx} = \frac{\partial}{\partial m_o} r^{\delta-1} \kappa_x \frac{\partial(T_P \text{ or } E_R)}{\partial r}$ where x = P or R ,

S_P = source of internal energy,

S_R = source of radiation (S_R = 0 in this version of the code).

After integration over space and time these equations take the form

GAS $$e_P^{n+1} + T^{n+1} = e_P^o + T^o + H_P^{n+1} + E_{RP}^{n+1} - F_P^{n+1} - W_P^{n+1} - G_R^{n+1} \tag{75}$$

RADIATION $$e_R^{n+1} = e_R^o + H_R^{n+1} - E_{RP}^{n+1} - F_R^{n+1} - W_R^{n+1} + G_R^{n+1} \tag{76}$$

TOTAL $$e^{n+1} + T^{n+1} = e^o + T^o + H^{n+1} - F^{n+1} - W^{n+1} \tag{77}$$

The physical definitions of each term are:

e_x -- total internal energy of the gas or radiation.

T -- total kinetic energy of the gas.

H_x -- total source of energy to the gas or radiation.

E_{RP} -- total radiation energy exchanged between the gas to the radiation field.

W_x -- total work done on the outer boundary by the gas or radiation. These are zero in the MF-FIRE code because the outer edge of the gas is stationary.

F_x -- total energy conducted to the first wall from the gas or radiation.

G_R -- work exchanged between the gas and radiation.

Each of these terms are given in finite difference form as follows:

$$e_x^{n+1} = \sum_{j=1}^{JMAX} (E_x)_{j-1/2}^{n+1} \, \Delta m_{o_{j-1/2}} \tag{78}$$

$$T^{n+1} = \frac{1}{4} \Delta m_{o_{JMAX-1/2}} (u_{JMAX}^{n+1/2})^2 + \frac{1}{2} \sum_{j=1}^{JMAX} \Delta m_{o_j} (u_j^{n+1/2})^2 \tag{79}$$

$$H_x^{n+1} = H_x^n + \Delta t^{n+1/2} \sum_{j=1}^{JMAX} (S_x)_{j-1/2}^{n+1/2} \, \Delta m_{o_{j-1/2}} \tag{80}$$

$$E_{RP}^{n+1} = E_{RP}^n + \Delta t^{n+1/2} \sum_{j=1}^{JMAX} (\dot{Q}_{RP})_{j-1/2}^{n+1/2} \, \Delta m_{o_{j-1/2}} \tag{81}$$

$$\begin{aligned} G_R^{n+1} = G_R^n &+ \Delta t^{n+1/2} \sum_{j=1}^{JMAX} u_j^{n+1/2} \, (r^{\delta-1})_j^{n+1/2} \, (P_{R_{j+1/2}}^{n+1/2} - P_{R_{j-1/2}}^{n+1/2}) \\ &+ \Delta t^{n+1/2} \, u_{JMAX}^{n+1/2} \, (r^{\delta-1})_{JMAX}^{n+1/2} \, [P_{R_{JMAX+1}}^{n+1/2} - P_{R_{JMAX-1}}^{n+1/2}]/2 \end{aligned} \tag{82}$$

$$W_x^{n+1} = W_x^n + \Delta t^{n+1/2} \left(u_{JMAX}^{n+1/2} \left(r^{\delta-1}\right)_{JMAX}^{n+1/2} P_{x_{JMAX}}^{n+1/2}\right) \tag{83}$$

$$F_P^{n+1} = F_P^n + \Delta t^{n+1/2} \left[\frac{r^{\delta-1}}{\left(\frac{\Delta r}{K_P}\right)}\right]_{JMAX}^{n+1/2} \left(T_{P_{JMAX+1/2}}^{n+1/2} - T_{P_{JMAX-1/2}}^{n+1/2}\right) \tag{84}$$

$$F_R^{n+1} = F_R^n + \Delta t^{n+1/2} \left[\frac{r^{\delta-1}}{\left(\frac{\Delta r}{K_R}\right) + \frac{\Delta E_R}{F_R}}\right]_{JMAX}^{n+1/2} \left(E_{R_{JMAX+1/2}}^{n+1/2} - E_{R_{JMAX-1/2}}^{n+1/2}\right) \tag{85}$$

The calculations made by the MF-FIRE code do not conserve energy exactly because of the nonlinear equations of state and the finite number of interpolation points in the tables. The calculations usually conserve energy to within better than 10%.

7. The Time Step Control

After each time step, the next time step is determined from a set of stability and accuracy constraints. The new time step is determined by

$$\Delta t^{n+3/2} = \mathrm{Max}\left[\Delta t_{min}, \mathrm{Min}\left(\Delta t_{max}, \frac{K_1}{R_1^{n+1}}, \frac{K_2 \Delta t^{n+1/2}}{R_2^{n+1}}, \frac{K_3 \Delta t^{n+1/2}}{R_3^{n+1}}, \frac{K_4 \Delta t^{n+1/2}}{R_4^{n+1}}\right)\right] \tag{86}$$

where: $$R_1^{n+1} = \mathrm{Max}\left[\left(V_{j-1/2}^{n+1} P_{j-1/2}^{n+1}\right)^{1/2} / \Delta r_{j-1/2}^{n+1/2}\right] \tag{87}$$

$$R_2^{n+1} = \mathrm{Max}\left[\left(V_{j-1/2}^{n+1} - V_{j-1/2}^{n}\right) / V_{j-1/2}^{n+1/2}\right] \tag{88}$$

$$R_3^{n+1} = \mathrm{Max}\left[\left(E_{R_{j-1/2}}^{n+1} - E_{R_{j-1/2}}^{n}\right) / E_{R_{j-1/2}}^{n+1/2}\right] \tag{89}$$

$$R_4^{n+1} = \text{Max}[(T_{P_{j-1/2}}^{n+1} - T_{P_{j-1/2}}^{n})/T_{P_{j-1/2}}^{n+1/2}] \quad . \tag{90}$$

The maximum values of R_1, R_2, R_3, and R_4 are found by sweeping over the zones. The input parameters K_1, K_2, K_3, and K_4 determine the severity of each constraint. The default value for K_1, K_2 and K_4 is 0.05. The default value of K_3 is set to 1.0×10^{35}, which in effect removes the radiation energy as a time step constraint. The radiation diffusion equation is solved using a fully implicit differencing scheme and is stable for large time steps. The time step can of course be constrained using the change in radiation energy density by simply inputting a different value for K_3.

8. The Subroutines and Their Functions

The MF-FIRE code is written in FORTRAN 66, and can be run on any mainframe computer. It is written in a top-down modular style, as shown in Fig. 4. Each subroutine performs a specific function. These functions are briefly described below:

Subroutine Name	Functon of Subroutine
ABCDEF -	computes the $\underline{\underline{A}}$, $\underline{\underline{B}}$, $\underline{\underline{C}}$, $\underline{D}$, $\underline{\underline{E}}$, and $\underline{F}$ matrices and vectors used to solve the energy transfer equations when using the 2-T option.
ABCPLS -	computes A, B, C, D, E, and F coefficients used to solve the plasma temperature equation when using the multifrequency radiation option.
ABCRAD -	computes A, B, C, D, E, and F coefficients used to solve the radiation energy equation for a specified frequency group when using the multifrequency radiation option.
CLEAR -	sets all common blocks to zero before the start of a calculation.

CROS -	searches through the x-ray cross section table and computes the cross section of the gas.
DISTRB -	computes the kinetic energy and momentum lost by the debris in each zone during a time step.
DUMP -	writes all common blocks on unit 2 at the end of a calculation.
DYNDEP -	computes the x-ray deposition and the new absorption cross section of each zone.
ECHECK -	computes the integrals used in the energy conservation check.
EDATA -	provides the electron shell structure of the gas for the x-ray deposition calculation.
EMISSN -	computes the frequency dependent radiation emission when using the multifrequency radiation option.
ENERGY -	computes T_P, E_R, and then T_R.
EOS,EOS1 -	computes the equation of state quantities.
GASDEP -	computes the temperature of the gas after x-ray deposition.
HYDRO -	solves the equation of motion for the fluid velocity, new zone radii, Δr's, zone volumes, and specific volumes.
INITD -	reads LOWEN namelist input and initializes the debris deposition calculation.
INITIA -	reads namelist input and calls other initialization routines.
INIT1 -	sets variable default values before reading input.
INIT2,4,5 -	computes initial conditions and writes a summary of the initial conditions to unit 6.
KAPPA -	computes plasma and radiation thermal conductivity and the radiation flux limit, in the 2-T approximation.
LLAM -	computes log lambda.
MAIN -	calls other routines to form the loop for one time step.
MATRIX -	computes $\underline{\underline{a}}$, $\underline{\underline{\alpha}}$, $\underline{\underline{\gamma}}$, and $\underline{\underline{\omega}}$ matrices for use in the energy transfer calculation, in the 2-T approximation.
NUMDEN -	computes number densities from the specific volume.

OMEGA - computes the radiation emission and absorption coefficients, in the 2-T approximation.

OUT,OUT1 - writes output to unit 6 at the end of specified time cycles.

PCOND - computes the plasma conductivity when using the multifrequency radiation option.

PLSCOF - computes α, γ, a, and β coefficients used to solve the plasma temperature equation when using the multifrequency radiation option.

POINT,POINT1 - finds pointers in the equation of state tables.

QUE - computes the artificial viscosity.

QUIT - wraps up the calculation at the end.

RADCOF - computes α, γ, ω, a, and β coefficients used to solve the radiation energy equation for a specified frequency group when using the multifrequency radiation option.

RADTR - controls the multifrequency radiation calculation by calling EMISSN and ABCRAD and then computes the total radiation energy density and radiation temperature when using the multifrequency radiation option.

RCOND - computes the radiation conductivity for a specified frequency group when using the multifrequency radiation option.

SHIFT - shifts values of variables at (n+1) to variables at (n) at the end of a time step.

SPECFL - computes the debris spectrum.

SPECP - computes the x-ray spectrum.

STOPS - computes the total kinetic energy and momentum lost by the debris during each time step.

TABLE2,TABLE1 - TABLE3 interpolates in the equation of state tables using the pointers.

TEMPBC - computes the plasma temperature and radiation specific energy boundary conditions.

TIMING - computes a new time step and determines whether the calculation is over.

UNREAD - reads in the common blocks from unit 4 at the beginning of a restarted calculation.

WBIN - writes binary output to unit 8 for postprocessing.

ZONER - computes the Lagrangian zoning automatically.

9. Input/Output Units and Storage Requirements

The MF-FIRE code uses ten different I/O units. These units are listed below along with their specific function.

Unit #	Function
2	MF-FIRE writes all common blocks to this unit at the end of a calculation to allow a restart.
3	MF-FIRE reads the equation of state tables from this unit.
4	MF-FIRE reads the common blocks from this unit at the beginning of a restart calculation.
5	MF-FIRE reads the namelist input from this unit.
6	MF-FIRE writes lineprinter output to this unit.
8	MF-FIRE writes binary output to this unit for postprocessing into plots.
9	MF-FIRE writes the times corresponding to the stored heat fluxes on this unit.
10	MF-FIRE writes the radiation heat fluxes to the wall on this unit.
11	MF-FIRE reads target x-ray attenuation cross section data from this unit.
12	MF-FIRE writes the pellet x-ray spectrum reaching the wall on this unit.

MF-FIRE requires about 80,000 words of memory storage on a UNIVAC 1100/82 computer and executes at a rate of approximately 2-5 msec/zone•cycle.

When adding a variable to the common blocks, the block length (set in INITIA) must be changed so that DUMP and UNREAD will write and read the correct number of words for a restart. Notice that the lengths are measured in double words. This must be changed to single words if single precision is used. All of the variables should be changed to single precision if a 64 bit word length computer is used.

10. The Common Blocks

Nearly all of the real variables in the common blocks are in double precision, giving about 14 decimal places of accuracy on an IBM or UNIVAC computer. All real constants are specified with the "D" scientific notation (i.e., 1.=1.D0) to insure that all calculations are performed in double precision. The IBM FORTRAN G and H compilers will not define constants as double precision unless the "D" notation is used.

For many of the variables, the second to the last letter indicates whether the variable is at a zone center or zone boundary, and the last letter denotes the time level. The suffixes are:

1 -- zone boundary
2 -- zone center
A -- t^{n+1}
B -- $t^{n+1/2}$
C -- t^{n}
D -- $t^{n-1/2}$

The letter R will appear in a variable name if the quantity is associated with the radiation field, and N if the quantity is associated with the plasma. Thus TR2B(J) is the radiation temperature in the center of zone j at time $t^{n+1/2}$, and U1D(J) is the fluid velocity on the zone j boundary at time $t^{n-1/2}$. The variables are grouped in common blocks so that a subroutine will find most of the variables that it needs in fewer than all of the blocks. The common blocks are listed below along with their meaning and units. A * superscript denotes mandatory input variables, and a ** superscript denotes a variable with a default value.

Common Blocks

COMMON/TIME/

1)	TA	t^{n+1}	times (s)
2)	TB	$t^{n+1/2}$	
3)	TC	t^{n}	
4)	TD	$t^{n-1/2}$	
5)	DTB**	$\Delta t^{n+1/2}$	
6)	DTC	$\Delta t^{n} = (\Delta t^{n+1/2} + \Delta t^{n-1/2})/2$	
7)	DT	$\Delta t^{n+3/2}$, the new time step	
8)	TMAX*	Total time for the simulation	
9)	DTMIN**	Min allowed time step	
10)	DTMAX**	Max allowed time step	

COMMON/TEMPER/

1)	TN2A	$(T_P)^{n+1}_{j-1/2}$	Plasma temperatures (eV)
2)	TN2B	$(T_P)^{n+1/2}_{j-1/2}$	
3)	TN2C*	$(T_P)^{n}_{j-1/2}$	
4)	TN1B	$(T_P)^{n+1/2}_{j}$	
5)	TNSQ2B	$\sqrt{(T_P)^{n+1/2}_{j-1/2}}$	$(eV)^{1/2}$
6)	TR2A	$(T_R)^{n+1}_{j-1/2}$	Radiation temperatures (eV)

7)	TR2B	$(T_R)^{n+1/2}_{j-1/2}$
8)	TR2C*	$(T_R)^{n}_{j-1/2}$
9)	TR1B	$(T_R)^{n+1/2}_{j}$
10)	TBC**	temperature boundary condition (eV)

COMMON/CNTROL/

1)	CON**	real constants used in FIRE
2)	TGR0W**	max percentage that Δt can increase in one cycle
3)	TEDIT**	time at which output freq. switches from IO(1) to IO(11) (s)
4)	GEOFAC	a geometry factor; 1, 2π, 4π
5)	TSCC**	Courant condition time step control
6)	TSCV**	$\Delta V/V$ time step control
7)	R1	worst case for Courant condition
8)	R2	worst case for $\Delta V/V$
9)	R3N	worst case for $\Delta T_P/T_P$
10)	T1	temporary vectors to be used for any purpose within a subroutine
11)	T2	
12)	T3	
13)	T4	
14)	IDELTA**	1 = cartesian 2 = cylindrical 3 = spherical
15)	IDELM1	0 = cartesian 1 = cylindrical 2 = spherical
16)	NCYCLE	time cycle index

17)	NMAX*	max number of time steps	
18)	JMAX*	max number of spatial zones	
19)	JMAXM1	JMAX-1	used for indexing
20)	JMAXP1	JMAX+1	
21)	JMAXP2	JMAX+2	
22)	ISW**	control switches	
23)	ILUNIT	output units for flux quantities	
24)	JCOUR	zone # of Courant condition worst case	
25)	JSPVOL	zone # of $\Delta V/V$ worst case	
26)	JNTEMP	zone # of $\Delta T_P/T_P$ worst case	
27)	INDEX	a vector used for output indexing	
28)	IZONE	zone # of worst case of Courant, $\Delta V/V$, $\Delta T_P/T_P$	
29)	ITYPE	1 = Courant 2 = $\Delta V/V$ 3 = $\Delta E_R/E_R$ 4 = $\Delta T_P/T_P$ worst restriction	
30)	IITYPE	0 = physical -1 = min Δt 1 = max Δt	
31)	IEDIT**	intermediate output cycle frequencies	
32)	IIZONE	zone # of worst case if the Δt is Δt_{max} or Δt_{min}	
33)	ICOND	principal time step constraint	
34)	ICOND2	secondary time step constraint if primary is Δt_{min} or Δt_{max}	
35)	NVMAX	time step of maximum compression	
36)	IUNIT	cm^2, radian-cm, steradian for δ = 1, 2, 3	
37)	JVMAX	zone # of maximum compression	
38)	TSCTN**	$\Delta T_P/T_P$ time step control	
39)	IO*	primary output frequency vector	
40)	IOBIN**	output frequency of binary output	
41)	RADIUS**	the radius of the first wall (41-47 are for automatic zoning option)	

42)	PMASS**	the mass of the pellet
43)	RI**	the radius of the first zone, #1
44)	RO**	the inner radius of the last zone, #JMAX
45)	RO2	not used
46)	NI**	the number of zones in the inner constant mass region
47)	NO**	the number of zones in the outer constant mass region
48)	RATIO	mass ratio between successive zones in transition region
49)	NFG**	the number of frequency groups
50)	R3R	worst case for $\Delta E_R/E_R$
51)	TSCTR*	$\Delta E_R/E_R$ time step control
52)	JRTEMP	zone # of $\Delta E_R/E_R$ worst case

COMMON/HYDROD/

1)	U1D	$u_j^{n-1/2}$	fluid velocity (cm/s)
2)	U1B**	$u_j^{n+1/2}$	
3)	DR2B	$\Delta r_{j-1/2}^{n+1/2}$	zone widths (cm)
4)	DR2A	$\Delta r_{j-1/2}^{n+1}$	
5)	R1C	r_j^n	radius (cm)
6)	R1B	$r_j^{n+1/2}$	
7)	R1A	r_j^{n+1}	
8)	RS1C	$(r_j^n)^{\delta-1}$	
9)	RS1B	$(r_j^{n+1/2})^{\delta-1}$	
10)	RS1A	$(r_j^{n+1})^{\delta-1}$	
11)	PR2C	$(P_R)_{j-1/2}^n$	radiation pressure (J/cm^3)
12)	PR2B	$(P_R)_{j-1/2}^{n+1/2}$	
13)	PR2A	$(P_R)_{j-1/2}^{n+1}$	
14)	PN2C	$(P_P)_{j-1/2}^n$	gas pressure (J/cm^3)
15)	PN2B	$(P_P)_{j-1/2}^{n+1/2}$	
16)	PN2A	$(P_P)_{j-1/2}^{n+1}$	

17)	P2C	$P^{n}_{j-1/2}$	total pressure (J/cm^3)		
18)	P2A	$P^{n+1}_{j-1/2}$			
19)	V2C	$V^{n}_{j-1/2}$	specific volume (cm^3/g)		
20)	V2B	$V^{n+1/2}_{j-1/2}$			
21)	V2A	$V^{n+1}_{j-1/2}$			
22)	VO		initial specific volume		
23)	COMPR		VO/V compression		
24)	VDOT2B	$V^{n+1/2}_{j-1/2}$	time derivative of sp. volume (cm^3/g-s)		
25)	DMASS2	$\Delta m_{o_{j-1/2}}$	Lagrangian mass	$\delta=1$ $\delta=2$ $\delta=3$	g/cm^2 g/cm-radian g/steradian
26)	DMASS1	$\Delta m_{o_j} = (\Delta m_{o_{j-1/2}} + \Delta m_{o_{j+1/2}})/2$			
27)	Q2B	$q^{n+1/2}_{j-1/2}$	artificial viscosity (J/cm^3)		
28)	VMAX		max compression		
29)	TAVMAX		time of max compression (s)		
30)	VOL2B	$V^{n+1/2}_{j-1/2}$	zone volume (cm^3)		
31)	VOL2A	$V^{n+1/2}_{j-1/2}$			

COMMON/ESCOM/

1)	ER2C	$E^{n}_{R_{j-1/2}}$	radiation energy density (J/cm^3)
2)	ENT2B	$(C_v)^{n+1/2}_{j-1/2}$	plasma specific heat (J/eV-g)
3)	ER2B	$E^{n+1/2}_{R_{j-1/2}}$	radiation energy density (J/cm^3)
4)	PNT2B	$(P_p)_{T_{j-1/2}}^{n+1/2}$	temperature derivative of gas pressure (J/cm^3-eV)
5)	ER2A	$(E_R)^{n+1}_{j-1/2}$	radiation energy density (J/cm^3)
6)	EN2A	$(E_p)^{n+1}_{j-1/2}$	plasma specific internal energy (J/g)
7)	DE2A	$(n_e)^{n+1}_{j-1/2}$	electron number density (1/cm^3)
8)	DN2A	$(n_p)^{n+1}_{j-1/2}$	ion number density
9)	DE2B**	$(n_e)^{n+1/2}_{j-1/2}$	electron number density
10)	DN2B*	$(n_p)^{n+1/2}_{j-1/2}$	ion number density
11)	ATW2B*	$A^{n+1/2}_{j-1/2}$	average ion atomic weight (amu)
12)	ZT2B	$\partial Z/\partial T^{n+1/2}_{j-1/2}$	temperature derivative of average charge (esu/eV)
13)	Z2B**	$Z^{n+1/2}_{j-1/2}$	average charge (esu)
14)	ZSQ2B	$(Z^{n+1/2}_{j-1/2})^2$	average squared charge (esu)^2
15)	VBC**		specific volume boundary condition (cm^3/g)

16)	AD	coefficients defining the grid for the equations of state
17)	AT	
18)	BD	
19)	BT	
20)	EBC	radiation energy density boundary condition
21)	TN2AL	log $(T_{P_{j-1/2}}^{n+1})$
22)	TR2AL	log $(T_{R_{j-1/2}}^{n+1})$
23)	DN2AL	log $(n_{P_{j-1/2}}^{n+1})$
24)	KEOS	vectors used for indexing into the equation of state tables
25)	LEOS	
26)	MEOS	
27)	EPSLON	a parameter that indicates how far out of equilibrium the radiation energy density is

COMMON/ESCOM1/

1)	ZTAB	plasma charge state table
2)	ENTAB	plasma specific internal energy table
3)	RMFTAB	Planck opacity table
4)	ROSTAB	Rosseland opacity table
5)	HEADER	character description of EOS tables

COMMON/COEFF/

1)	ROSS2B	$(\sigma_R)^{n+1/2}_{j-1/2}$	Rosseland opacity (cm^2/g)
2)	KANM1B	$(\kappa^-_P)^{n+1/2}_{j}$	plasma thermal conductivity (J/cm-eV-s)
3)	KANP1B	$(\kappa^+_P)^{n+1/2}_{j}$	
4)	KARM1B	$(\kappa^-_R)^{n+1/2}_{j}$	radiation thermal conductivity (cm^2/s)
5)	KARP1B	$(\kappa^+_R)^{n+1/2}_{j}$	
6)	OMP2B	$(\omega_P)^{n+1/2}_{j-1/2}$	plasma emission coefficient (J/eV-g-s)
7)	OMR2B	$(\omega_R)^{n+1/2}_{j-1/2}$	plasma absorption coefficient ($cm^3/s-g$)
8)	RMFP2B	$(\sigma_P)^{n+1/2}_{j-1/2}$	Planck opacity (cm^2/g)
9)	RMFT2B	$(\sigma_P)^{n+1/2}_{j-1/2}$	Planck opacity for $T_P = T_R$ (cm^2/g)
10)	SND2B	$\Delta KE^n_{d_{j-1/2}}$	change in debris kinetic energy during Δt^n (ergs)
11)	SHOK2B		shock heating (J/gm/s)
12)	LAMN2B	$(\ell n \Lambda_{ei})^{n+1/2}_{j-1/2}$	Spitzer log Λ
13)	FLIM1B		radiation flux limit ($J/cm^2 \cdot s$)
14)	RFLU1B		diffusion flux ($J/cm^2 \cdot s$)
15)	SNDI2B	$S^n_{j-1/2}$	the interal energy source term (J/gm/s)

COMMON/COEFF1/

1)	BET12B	$(\beta_1)_{j-1/2}^{n+1/2}$	Beta Vector
2)	BET22B	$(\beta_2)_{j-1/2}^{n+1/2}$	
3)	AL112B	$(\alpha_{11})_{j-1/2}^{n+1/2}$	Diagonal Elements of Alpha Matrix
4)	AL222B	$(\alpha_{22})_{j-1/2}^{n+1/2}$	
5)	OM112B	$(\omega_{11})_{j-1/2}^{n+1/2}$	Diagonal Elements of Omega Matrix
6)	OM222B	$(\omega_{22})_{j-1/2}^{n+1/2}$	
7)	GM112B	$(\gamma_{11})_{j-1/2}^{n+1/2}$	Diagonal Elements of Gamma Matrix
8)	GM222B	$(\gamma_{22})_{j-1/2}^{n+1/2}$	
9)	AA111B	$(a_{11})_{j}^{n+1/2}$	Diagonal Elements of "a" Matrix
10)	AA221B	$(a_{22})_{j}^{n+1/2}$	
11)	OM122B	$(\omega_{12})_{j-1/2}^{n+1/2}$	Off Diagonal Elements of Omega Matrix
12)	OM212B	$(\omega_{21})_{j-1/2}^{n+1/2}$	

COMMON/COEFF2/

1)	E11	(E_{11})	All Elements of the "E" Matrix
2)	E12	(E_{12})	
3)	E21	(E_{21})	
4)	E22	(E_{22})	
5)	F1	(F_1)	Both Components of the "F" Vector
6)	F2	(F_2)	
7)	B11	(B_{11})	All Elements of the "B" Matrix
8)	B12	(B_{12})	
9)	B21	(B_{21})	
10)	B22	(B_{22})	
11)	D1	(D_1)	Both Elements of the "D" Vector
12)	D2	(D_2)	

COMMON/ECKCOM/

1)	T1A	$(T)_j^{n+1}$	kinetic energy of fluid (J/x)
2)	GGGE2A	$(G_e)_{j-1/2}^{n+1}$	radiation-gas work (J/x)
3)	HHHR2B	$(H_R)_{j-1/2}^{n+1/2}$	radiation source (J/x)
4)	HHHN2B	$(H_P)_{j-1/2}^{n+1/2}$	gas source (J/x)
5)	EEEC2A	$(E_c)_{j-1/2}^{n+1}$	radiation-gas energy exchange (J/x)
6)	EEEERO	E_{R_o}	total initial radiation internal energy (J/x)
7)	EEEENO	E_{P_o}	total initial gas internal energy (J/x)
8)	EEEEER	$(E_R)^{n+1}$	total radiation internal energy (J/x)
9)	EEEEEN	$(E_P)^{n+1}$	total gas internal energy (J/x)
10)	TTTTTT	$(T)^{n+1}$	total fluid kinetic energy (J/x)
11)	HHHHHR	$(H_R)^{n+1}$	total radiation source (J/x)
12)	HHHHHN	$(H_P)^{n+1}$	total gas source (J/x)
13)	EEEEEC	$(E_c)^{n+1}$	total radiation-gas energy exchanged (J/x)
14)	GGGGGE	$(G_e)^{n+1}$	total radiation-gas work (J/x)
15)	WWWWWR	$(W_R)^{n+1}$	total work done on radiation (J/x)
16)	WWWWWN	$(W_P)^{n+1}$	total work done on gas (J/x)

17)	FFFFFR	$(F_R)^{n+1}$	total radiation heat lost across outer boundary (J/x)
18)	FFFFFN	$(F_p)^{n+1}$	total gas heat lost across outer boundary (J/x)
19)	WWWWR	$(W_R)^{n+1}$	total work done on radiation on last cycle (J/x)
20)	WWWWN	$(W_p)^{n+1}$	total work done on gas on last cycle (J/x)
21)	FFFFR	$(f_R)^{n+1}$	total radiation lost at outer bd. on last cycle (J/x)
22)	FFFFN	$(f_p)^{n+1}$	total gas energy lost at outer bd. on last cycle (J/x)
23)	HHHHR	$(h_R)^{n+1}$	total radiation source on last cycle (J/x)
24)	HHHHN	$(h_p)^{n+1}$	total gas source on last cycle (J/x)
25)	EEEEC	$(e_c)^{n+1}$	total radiation-gas heat exchange on last cycle (J/x)
26)	GGGGE	$(g_e)^{n+1}$	total work to maintain one fluid on last cycle (J/x)
27)	ENLHS	left side of gas energy balance equation (J/x)	
28)	ETLHS	left side of total energy balance equation (J/x)	
29)	ERRHS	right side of radiation energy balance equation (J/x)	
30)	ENRHS	right side of gas energy balance equation (J/x)	
31)	ETRHS	right side of total energy balance equation (J/x)	
32)	TTTTNO	initial kinetic energy (J/x)	

33)	PMAX	maximum pressure at the wall (J/cm^3)
34)	TPMAX	time of maximum pressure (s)
35)	FMAX	maximum radiation heat flux at the wall (J/cm^2-s)
36)	TFMAX	time of maximum heat flux (s)
37)	FSAVE	heat fluxes at first wall (J/cm^2-s)
38)	PSAVE	pressures at first wall (J/cm^3)
39)	TSAVE	times of heat fluxes and pressures (s)
40)	NPMAX	time step of max. pressure
41)	NSAVE	index into FSAVE, PSAVE, and TSAVE
42)	NFMAX	time step of max. heat flux
43)	NDUMMY	rounds out the common block to an even number of words

where $\delta=1$ $x = cm^2$

$\delta=2$ x = cm-radian

$\delta=3$ x = steradian

COMMON/XRAY/

1)	COEF	coefficients computed from x-ray cross section tables
2)	ELIM	a vector used in computing the x-ray cross sections
3)	ONEZOA	a coefficient used on computing th**e x-ray scattering cross section
4)	JK**	the number of energy groups in the x-ray spectra
5)	DE	the width of the energy groups in the x-ray spectra (keV)
6)	KEV**	the blackbody temperature of a blackbody x-ray spectra (keV)
7)	FLUX**	the total energy in x-rays input by the user (J)
8)	SUMFLU	the energy in the x-ray spectra computed by FIRE (J)
9)	E	the energy of the x-rays in each group (keV)
10)	F	the energy in each x-ray group (J/keV)
11)	NUM	a number generated by the code in searching through the x-ray cross section tables
12)	U	x-ray attenuation coefficients computed from tables (cm^2/g)
13)	EDGE	the minimum x-ray energy required for absorption by electrons in each shell (keV)
14)	SHELEL	the number of electrons in each shell
15)	IZ**	the atomic number of the plasma
16)	KEDGE	the number of shells the plasma atoms have
17)	TN2AL1	$\log (T^o_{p_{j-1/2}})$ logs of the initial gas temperatures
18)	DN2AL1	$\log (n^o_{p_{j-1/2}})$ logs of the initial gas densities
19)	LEOS1	an index corresponding to TN2AL1
20)	MEOS1	an index corresponding to DN2AL1

21)	XAMP**	the amplitude of an input x-ray spectrum (J/keV)
22)	XEHIST**	the energy of the x-rays in each group of the input spectrum (keV)
23)	TOTAL	the x-ray energy absorbed by the plasma (Joules)

COMMON/DRIV2/

1)	FF	the number of debris projectiles in each energy group
2)	VSTAR	a constant used in computing the deceleration of each energy group
3)	AMP**	the amplitudes of energy groups in an arbitrary histogram spectrum (J/keV)
4)	NMHIST**	the number of energy groups in the spectra
5)	EHIST**	the kinetic energy of the debris in each energy group (keV)
6)	GAUSIG**	the standard deviation of a Gaussian energy spectrum (keV)
7)	EMN**	the characteristic energy of a Maxwellian energy spectrum (keV)
8)	ISPEC**	1, a Maxwellian spectrum is set up
		2, a Gaussian spectrum is set up
		3, an arbitrary histogram monoenergentic pulse is input
9)	EMIN	the minimum energy of the spectra (keV)
10)	EMAX	the maximum energy of the spectra (keV)
11)	FL**	the total number of debris projectiles
12)	PROGR	the projected range of the debris in each energy group if the gas is stationary (cm)
13)	SIGMA	the standard deviation in projected range for each group if the gas is stationary (cm)
14)	MARK	-1, the energy of a group has become insignificant
		0, the debris in a group has passed into the wall
		1, the kinetic energy and momentum of a group imparted to the gas are computed
15)	J1B	the indexes of zones containing the projected ranges of the debris groups
16)	SPEMIN	the debris speed below which MARK is set to -1 for a group (cm/s)

17)	SMASS**	the mass of each debris projectile (amu)
18)	SPEED	the speed of the debris in each energy group (cm/s)
19)	RSAVE	(r^{o}_{j}) the initial positions of the zones (cm)
20)	DIS	the distance between the average projected range and the last zone boundary crossed (cm)
21)	C1	constants used in computing the deceleration and spatial profile of the debris
22)	C2	
23)	C3	
24)	C4	
25)	SND	the kinetic energy lost by each debris group during a time step (ergs)
26)	DMOM	the momentum lost by each debris group during a time step (g-cm/s)
27)	RP	the average projected range of each debris group (cm)
28)	IRIPT	an element of the vector J1B
29)	TIME	the time that the average projected range of each group passes into the wall (s)
30)	DMOM1D	the momentum imparted to each zone during a time step (g/cm/s)
31)	DR2D	$(\Delta r^{n-1/2}_{j-1/2})$ this vector is used to correct DIS for motion of zones
32)	SIGMAL	constants used to compute the range straggling of each group

COMMON/MFRAD/

1)	ERFD2A	frequency dependent radiation specific energy at t^{n+1} (J/g)
2)	ERFD2C	frequency dependent radiation specific energy at t^{n} (J/g)
3)	SRFD2B	frequency dependent radiation emission term at $t^{n+1/2}$ (J/g•s)
4)	SR2B	frequency dependent Rosseland opacity (cm^{-1})
5)	SP2B	frequency dependent Planck opacity (cm^{-1})
6)	SER2B	frequency integrated radiation absorption (J/g•s)
7)	SRE2B	frequency integrated radiation emission term (J/g•s)
8)	HNU1	boundaries of frequency groups (keV)
9)	HNU2	centers of frequency groups (keV)
10)	RFDOUT	frequency dependent radiation energy flux at first wall on a given time cycle (J)
11)	RFDINT	time integrated frequency dependent radiation energy flux at first wall up through a given time cycle (J)

11. The Input Variables

The MF-FIRE code reads namelist input from I/O unit 5. The variables that must appear in the namelist called INPUT are given in Table 1. Real variables are denoted by RV, and integer variables by IV. The variables with default values are given in Table 2, and they need not appear in the namelist unless another value is desired. Table 3 contains the variables used for an x-ray deposition calculation. Table 4 contains the variables used if the automatic zoning option is specified. Table 5 contains the variables used to run a debris deposition calculation. These are the only variables that appear in the namelist called LOWEN. Table 6 contains definitions of the integer switches used to control the code. Table 7 lists the real constants used by the code that can be changed by input. Table 8 gives the intermediate output vector that allows all internally computed quantities to be output for debugging.

Table 1. Input Variables

Variable	Type	Default Value	Description
JMAX	(IV)	---	Number of spatial zones 3 $\leqslant$ JMAX $\leqslant$ 53
NMAX	(IV)	---	Maximum number of time steps
TMAX	(RV)	---	Maximum problem time (s)
IO	(IV)	---	Output frequencies IO(1) -- hydrodynamics IO(2) -- energy IO(3) -- mfp's and # densities IO(4) -- short edit IO(5) -- multifrequency radiation IO(11) -- same as IO(1)-(5) except after IO(12) time TEDIT (see TEDIT description) IO(13) IO(14) IO(15)
DR2B	(RV)	---	Δr of each zone (cm) (DR2B is only input if automatic zoning is not used)
DN2B	(RV)	---	Plasma number density (cm^{-3})
TN2C	(RV)	---	Plasma temperature (eV)
TR2C	(RV)	---	Radiation temperature (eV)
ATW2B	(RV)	---	Atomic weight (amu)

Table 2. Optional Input Variables

Variable	Type	Default Value	Description
IDELTA	(IV)	3	Geometry = 1 planar = 2 cylindrical = 3 spherical
DTB	(RV)	10^{-12}	Initial time step (s)
DTMIN	(RV)	10^{-1}*DTB	Minimum time step (s)
DTMAX	(RV)	10^{-2}*TMAX	Maximum time step (s)
TSCC	(RV)	5×10^{-2}	Time Step Controls - Courant
TSCV	(RV)	5×10^{-2}	- $\Delta V/V$
TSCTR	(RV)	1×10^{35}	- $\Delta E_R/E_R$
TSCTN	(RV)	5×10^{-2}	- $\Delta T_P/T_P$
TEDIT	(IV)	-1	If TEDIT ≠ 0 then before time TEDIT IO(1)-(4) are used and after IEDIT IO(11)-(14) are used as output frequencies
IOBIN	(IV)	-1	Binary output frequency written to unit 8 for postprocessing
TGROW	(RV)	1.5	Time step is allowed to increase no more than TGROW*DTB on each successive cycle
TBC	(RV)	2.5×10^{-2}	Temperature boundary condition (eV)
VBC	(RV)	0.1	Specific volume boundary condition (cm^3/g)
U1B	(RV)	0	Initial velocity (cm/s)
IRS	(IV)	0	Restart calculation flag = 0 Normal calculation = 1 Restarted calculation
JK	(IV)	25	See Table 3
ISW	(IV)	---	See Table 6 for definitions of these switches
CON	(IV)	---	See Table 7 for the definitions of these numerical coefficients

Variable	Type	Default Value	Description
IEDIT	(IV)	-1	See Table 8 for the definitions of these intermediate output frequencies
ROSS2B	(RV)	---	Rosseland opacity must be input if ISW(12)=1 or ISW(15)=1
RMFP2B	(RV)	---	Planck opacity must be input if ISW(12)=1 or ISW(14)=1
RMFT2B	(RV)	---	Planck opacity for $T_R = T_p$ must be input if ISW(12)=1 or ISW(14)=1
NFG	(IV)	0	Number of frequency groups for a multi-frequency radiation calculation. If NFG=0 then the 2-T option is used. $0 \leq NFG \leq 20$.

Table 3. Input Variables for X-Ray Deposition

Variable	Type	Default Value	Description
FLUX	(RV)	---	The total energy of a blackbody x-ray spectrum in Joules
JK	(IV)	25	The number of energy groups in the x-ray spectrum ⩽ 20 for arbitrary histogram ⩽ 100 for a blackbody spectrum
IZ	(IV)	---	The atomic number of the gas
KEV	(RV)	---	The blackbody temperature of a blackbody x-ray spectrum
XEHIST	(RV)	---	The bounds of energy groups in an arbitrary histogram in keV, JK+1 boundaries, lowest to highest, equal group widths are required
XAMP	(RV)	---	The amplitude of the groups of an arbitrary histogram in J/keV, JK amplitudes

Table 4. Input Variables for Automatic Zoning

Variable	Type	Default Value	Description
NI	(IV)	---	Number of zones in the inner, constant mass region
RI	(RV)	---	The radius of the first zone (cm)
NO	(IV)	---	Number of zones in the outer, constant mass region
RO	(RV)	---	The radius of the inner boundary of the outermost zone (cm)
RADIUS	(RV)	---	The radius of the first wall (cm)
PMASS	(RV)	---	The pellet mass (g)

Table 5. Input Variables for Ion Deposition

Variable	Type	Default Value	Description
ISPEC	(IV)	---	The type of energy spectra: ISPEC=1 - Maxwellian =2 - Gaussian =3 - histogram or monoenergetic pulse
NMHIST	(IV)	---	The number of energy groups in the histogram (=1 for a monoenergetic pulse)
AMP	(RV)	---	The amplitude of energy groups in a histogram (not needed for a monoenergetic pulse; see EHIST) (J/keV)
EHIST	(RV)	---	The energy of the ions if a monoenergetic pulse is used (keV)
EMN	(RV)	---	The characteristic energy if a Maxwellian energy spectrum is used (keV)
GAUSIG	(RV)	---	The standard deviation if a Gaussian energy spectrum is used (keV)
SMASS	(RV)	---	The atomic weight of the debris ions (amu)
FL	(RV)	---	The number of debris ions
REFRO	(RV)	---	The reference density for which the parameters listed below were computed (atoms/cm^3)
ENGY1	(RV)	---	The initial energy of a pulse of debris ions (keV)
RP1	(RV)	---	The final, average projected range corresponding to ENGY1 (cm)
SIG1	(RV)	---	The final, standard deviation in average projected range corresponding to ENGY1 (cm)
PATH1	(RV)	---	The final path length corresponding to ENGY1 (cm)
ENGY	(RV)	---	An intermediate energy of the pulse with initial energy ENGY1 (keV)
RP	(RV)	---	The average projected range at energy ENGY (cm)

Variable	Type	Default Value	Description
SIG	(RV)	---	The standard deviation in average projected range at energy ENGY (cm)
PATH	(RV)	---	The path length of the pulse at energy ENGY (cm)
ENGY2	(RV)	---	The initial energy of a pulse of debris ions (keV) (must be other than ENGY1)
RP2	(RV)	---	The final, average projected range corresponding to ENGY2 (cm)
SIG2	(RV)	---	The final, standard deviation in average projected range corresponding to ENGY2 (cm)

Listed below are some input parameters for various ions slowing down in argon, xenon, and helium. Input parameters for other ion-gas combinations can be generated using the RASE4 [12] code.

Input Values for Ions Slowing Down in Argon

Applicable Energy Range (keV)	ION	GAS	REFRO (/cm^3)	RP1 (cm)	SIG1 (cm)	PATH1 (cm)	ENGY1 (keV)	RP (cm)	SIG (cm)	PATH (cm)	ENGY (keV)	RP2 (cm)	SIG2 (cm)	ENGY2 (keV)
1-100	Au	Ar	2.68D22	3.22D-6	9.8 D-7	3.41D-6	50.D0	1.97D-6	8.6 D-7	2. D-6	20.D0	1.52D-6	4.9 D-7	20.D0
1-100	Fe	Ar	2.68D22	3.74D-6	1.64D-6	4.47D-6	30.D0	1.89D-6	1. D-6	1.96D-6	20.D0	2.64D-6	1.18D-6	20.D0
1-100	Si	Ar	2.68D22	1.04D-5	4.81D-6	1.46D-5	50.D0	8.44D-6	3.7 D-6	9.61D-6	20.D0	4.3 D-6	2.21D-6	20.D0
.1-10	He	Ar	2.68D22	7.38D-6	5.71D-6	2.28D-5	5.D0	7.09D-6	4.05D-6	1.22D-5	2.D0	2.9 D-6	2.8 D-6	2.D0
.1-10	T	Ar	2.68D22	1.64D-5	1.14D-5	4.8 D-5	5.D0	1.54D-5	7.72D-6	2.52D-5	2.D0	6.0 D-6	5.7 D-6	2.D0
.1-10	D	Ar	2.68D22	1.55D-5	1.07D-5	4.7 D-5	5.D0	1.43D-5	6.87D-6	2.31D-5	2.D0	5.9 D-6	5.6 D-6	2.D0
.1-10	H	Ar	2.68D22	1.37D-5	8.9 D-6	4.0 D-5	5.D0	1.21D-5	5.08D-6	1.81D-5	2.D0	5.4 D-6	5.0 D-6	2.D0

Input Values for Ions Slowing Down in Xenon

Applicable Energy Range (keV)	ION	GAS	REFRO (/cm^3)	RP1 (cm)	SIG1 (cm)	PATH1 (cm)	ENGY1 (keV)	RP (cm)	SIG (cm)	PATH (cm)	ENGY (keV)	RP2 (cm)	SIG2 (cm)	ENGY2 (keV)
1-100	Au	Xe	2.68D22	1.6 D-6	7.1 D-7	1.9 D-6	50	1.1 D-6	6.4 D-7	1.2 D-6	20	7.8 D-7	3.6 D-7	20
1-100	Fe	Xe	2.68D22	3.1 D-6	2.0 D-6	5.7 D-6	50	2.8 D-6	1.5 D-6	3.6 D-6	20	1.5 D-6	1.0 D-6	20
1-100	Si	Xe	2.68D22	5.0 D-6	3.9 D-6	1.3 D-5	50	4.8 D-6	2.8 D-6	7.4 D-6	20	2.2 D-6	2.0 D-6	20
.1-10	He	Xe	2.68D22	3.4 D-6	4.8 D-6	2.4 D-5	5	3.4 D-6	3.7 D-6	1.1 D-5	2	1.5 D-6	2.7 D-6	2
.1-10	T	Xe	2.68D22	6.9 D-6	9.3 D-6	4.8 D-5	5	6.9 D-6	7.2 D-6	2.3 D-5	2	2.8 D-6	5.1 D-6	2
.1-10	D	Xe	2.68D22	6.7 D-6	8.7 D-6	4.5 D-5	5	6.7 D-6	6.6 D-6	2.1 D-5	2	2.8 D-6	5.0 D-6	2
.1-10	H	Xe	2.68D22	6.3 D-6	7.3 D-6	3.6 D-5	5	6.2 D-6	5.2 D-6	1.6 D-5	2	2.6 D-6	4.2 D-6	2

<u>Input Values for Ions Slowing Down in Helium</u>

Applicable Energy Range (keV)	ION	GAS	REFRO (/cm^3)	RP1 (cm)	SIG1 (cm)	PATH1 (cm)	ENGY1 (keV)	RP (cm)	SIG (cm)	PATH (cm)	ENGY (keV)	RP2 (cm)	SIG2 (cm)	ENGY2 (keV)
1-100	Au	H	2.68D22	6.06D-5	3.0 D-6	6.07D-5	50	3.0 D-5	1.5 D-6	3.1 D-5	25	3.2 D-5	1.7 D-6	20
1-100	Fe	H	2.68D22	6.5 D-5	6.0 D-6	6.57D-5	50	3.2 D-5	3.0 D-6	3.3 D-5	25	3.1 D-5	2.9 D-6	20
1-100	Si	H	2.68D22	9.1 D-5	1.1 D-6	9.2 D-5	50	4.5 D-5	5.0 D-4	4.6 D-5	25	3.7 D-5	4.9 D-6	20
.1-10	He	H	2.68D22	1.1 D-4	3.0 D-5	1.2 D-4	5	5. D-5	1.5 D-5	5.1 D-5	2.5	4.0 D-5	1.4 D-5	2
.1-10	T	H	2.68D22	5.0 D-5	2.3 D-5	1.1 D-4	5	2.5 D-5	1.1 D-5	2.6 D-5	2.5	2.2 D-5	1.3 D-5	2
.1-10	D	H	2.68D22	4.5 D-5	1.7 D-5	9.9 D-5	5	2.2 D-5	8.5 D-6	4.9 D-5	2.5	2.0 D-5	1.1 D-5	2
.1-10	H	H	2.68D22	3.8 D-5	1.1 D-5	8.1 D-5	5	1.9 D-5	5.0 D-6	4.0 D-5	2.5	1.8 D-5	8.1 D-6	2

Table 6. Control Switches

ISW	Description	
1	= 0*	$T_R \sim E_R^{1/4}$
	= 1	$T_R \sim$ dilute Planckian
2	= 10*	number of constant time steps used at the beginning of a calculation
3	not used	
4	= 0*	user specifies zoning with DR2B
	= 1	automatic zoning (see Table XII-4)
5	= 20*	frequency of tabulation of overpressure and heat flux at the first wall
6	= 0*	hydrodynamic motion is computed
	= 1	no hydro motion -- allows a pure temperature diffusion problem
7	not used	
8	= 0*	no pellet debris deposition
	= 1	pellet debris expands into the gas
9	not used	
10	= 1*	frequency of time step calculation
11	= 0*	X-ray deposition is computed
	= 1	calculation begins from input temperatures
12	= 0*	equation of state tables are used
	= 1	ideal gas equation of state is used. RMFP2B, RMFT2B, ROSS2B, and CON(5) must be input via &INPUT
13	= 20/NFG	number of subgroups to divide frequency groups into when doing the integration
14	= 0*	Planck opacity is computed from tables
	= 1	Planck opacity is computed as a constant
15	= 0*	Rosseland opacity is computed from tables
	= 1	Rosseland opacity is inputted as a constant

*Denotes the default value.

Table 7. Real Constants Used in MF-FIRE

CON	Default	Description
1	1.2175×10^2	gas thermal conductivity
2	1×10^{10}	radiation thermal conductivity
3	0.1	the percentage by which the radiation can be out of equilibrium before the nonequilibrium mean free path is used in the absorption term
4	1×10^{-6}	small term to avoid zero divide in flux limited radiation conduction term AA221B
5	0	if non-zero then it is used as a constant value of log Λ. Normally log Λ is computed.
6	1.37×10^{-5}	$4\sigma/c$
7	4.12×10^5	radiation emission term
8	3×10^{10}	radiation absorption term
9	1.602×10^{-19}	gas pressure
10	3×10^{10}	radiation flux limit
11		not used
12	1.602×10^{-19}	gas pressure derivative
13		not used
14	2.403×10^{-19}	gas specific heat
15	2.403×10^{-19}	gas specific internal energy
16	1.37×10^{-5}	radiation specific internal energy
17	0.0	up-stream average parameter
18	1.0	ion shock heating term
19		not used
20		not used
21	1.414	artificial viscosity coefficient
22	3×10^{10}	multifrequency radiation absorption term

23	6.334918×10^4	multifrequency radiation emission term
24	10^{10}	multifrequency radiation conductivity term
25	3×10^{10}	multifrequency radiation flux limit
26	1×10^{-20}	minimum allowable multifrequency radiation specific energy

Table 8. Description of the Intermediate Output Switches in IEDIT

IEDIT	Subroutine	Variables
1	ABCDEF	A11, A22, B11, B12, B21, B22, C11, C22, D1, D2, E11, E12, E21, E22, F1, F2
2	MATRIX	AL112B, AL222B
3	MATRIX	OM112B, OM122B, OM212B, OM222B
4	MATRIX	GM112B, GM222B
5	MATRIX	AA111B, AA221B
6	MATRIX	BET12B, BET22B
10	OMEGA	OMR2B, OMP2B
11	KAPPA	KARM1B, KARP1B, KANM1B, KANP1B, LAMN2B, FLIM1B
14	HYDRO	U1B, R1A, R1B, DR2A, DR2B, RS1A, RS1B, V2A, V2B, VDOT2B
15	QUE	Q2B
16	TEMPBC	T1(1) → T1(9), TR2A (JMAXP1), TN2A (JMAXP1)
17	RADTR	ER2A, ERFD2A
19	NUMDEN	DN2B, DE2B, DN2A, DE2A
20	EMISSN	SRE2B, SRFD2B
21	ABCRAD	A22, B22, C22, D2, E22, F2
22	RADCOF	AL222B
23	RADCOF	GM222B
24	RADCOF	AA221B
25	RADCOF	BET22B
26	RCOND	KARM1B, KARP1B, FLIM1B
27	PLSCOF	AL112B
28	PLSCOF	GM112B
29	PLSCOF	AA111B

30	PLSCOF	BET12B
31	PCOND	KANM1B, KANP1B, LAMN2B
32	ABCPLS	A11, B11, C11, D1, E11, F1
33	RADCOF	OM222B
80	STOPS	ICOUNT, IRIPT, DTC, TIMLEF, SPEED, DELTAT, DISLEF, DELTA1, DELTA2, DELTAR, DIS, RP, TA
85	STOPS	IRIPT, TIMLEF, SPEED, DELTAT, DISLEF, DELTA1, DELTA2, DELTAR, DIS, RP, TA

12. Input Data Files

In addition to the NAMELIST input described in Section 11, MF-FIRE requires equation of state data and x-ray deposition data to be read in through units 3 and 11, respectively. Therefore, before one executes MF-FIRE, one must create files 3 and 11 and fill them with data that is in the proper form.

The x-ray deposition data is the same for all MF-FIRE runs. The source tape for MF-FIRE includes this file and one must only copy it into file 11 before executing MF-FIRE.

The equation of state data is dependent on the gas species and the range of densities and temperatures one is considering. One way of creating this data is to use the computer code MIXERG [11]. The data file created by MIXERG for the examples quoted in this paper is included on the MF-FIRE source tape. The files created by MIXERG are not in the proper form for use in MF-FIRE. A source listing for PREP, a code for converting the output of MIXERG for use in MF-FIRE, is included on the source tape. To execute this code, one must copy the file created by MIXERG into file 11 and create a NAMELIST input file titled INIT which contains the approximate average number density for the MF-FIRE problem, DENAV. PREP creates a file 10 which contains the equation of state input for MF-FIRE. The first line of file 10 is a heading that one may change by modifying the source code for PREP. This heading is printed out during the MF-FIRE run and is usually used to identify the gas species for which the equation of state information has been calculated. File 10 must then be copied into file 3.

A sample runstream, which shows by example how to create files 3 and 11, has also been included on the MF-FIRE source tape.

13. Examples Calculations Using MF-FIRE

Example 1:

In this example the MF-FIRE code is used to simulate the response of a gas that fills a 3.0 meter spherical chamber to an ICF target explosion. The target is assumed to emit 22 MJ of x-rays in a spectrum that is shown in Fig. 5. The ionic debris is assumed to consist of 0.1 gram of iron ions, each with an initial energy of 176 keV making a total debris energy of 5 MJ. These values for x-ray and debris energies are what one might expect for a target with a yield of 100 MJ. The ambient density of the argon gas is 3.55 x 10^{17} cm^{-3} (10 torr at room temperature) and the ambient temperature is 0.0925 eV. In this first example, we use the 2-T approximation to radiative transfer. The input file and some selected output are shown in Fig. 6.

Most of the output from the test run is self explanatory. After the initial conditions are printed out, the x-ray flux that reaches the first wall is summarized. Next, some parameters relevant to the deposition of the debris are printed out. Following that is the output from cyclic calculations of the gas response. Quantities associated with the radiation field are indicated by the letter R, such as RTEMP for the radiation temperature; whereas quantities associated with the gas are indicated by ION, such as ION→R for the net amount of energy transferred into the radiation field. A summary of the heat flux and overpressure at the first wall follows the output from cyclic calculations of the gas response, and the last items printed out are some parameters relevant to the target debris spectra.

The output of the MF-FIRE code can be more easily digested with the aid of computer graphics. The computer graphics programs that have been written to process the output are not provided because they were designed specifically for a Univac operating system.

R-T plots, and snapshot plots of temperature, pressure, etc. are given in Figs. 7-13.

Example 2:

This test is the same problem as in Example 1 except that the multifrequency radiative transfer option is used. The only two changes that need be made between this run and the previous one are the inclusion of

NFG=20

IO(5)=200

in the input file. The MIXERG code produces both 2-T and multifrequency data and puts these in the same file. MF-FIRE simply selects the data that is appropriate for the options that are specified. The input and selected output for this problem are given in Fig. 14. Graphical output is shown in Figs. 15-21. The reader will note that the results for this calculation with 20 group radiative transfer are significantly different from the results of the Example 1 calculation. For example, the 20 group calculation predicts that the radiant energy will arrive at the outside boundary of the gas in a very short time; in fact, the time axis of Fig. 16 must be logrithmic for the heat flux curve to be visible. On the other hand, the heat flux at the edge of the gas reaches a maximum much later in the two-temperature calculation, as shown in Fig. 8. The reasons for this and other differences between the 20 group and two-temperature calculations are discussed elsewhere [13].

Acknowledgment

This work was supported in part by Los Alamos National Laboratory, Los Alamos, NM, and Sandia National Laboratory, Albuquerque, NM, under contract to the United States Department of Energy.

References

[1] T.J. McCarville, R.R. Peterson, and G.A. Moses, "FIRE - A Code for Computing the Response of an Inertial Confinement Fusion Cavity Gas to a Target Explosion," Comp. Phys. Comm. 28, 367 (1983).

[2] T.J. McCarville, G.A. Moses, G.L. Kulcinski, and I.O. Bohachevsky, "Improvement of the Two Temperature Radiative Transfer Model," Nucl. Tech./Fusion 5, 5 (1984).

[3] T.J. McCarville, G.A. Moses, and G.L. Kulcinski, "A Model for Depositing Inertial Confinement Fusion X-Rays and Pellet Debris Into a Cavity Gas," University of Wisconsin Fusion Engineering Program Report UWFDM-406, April 1981.

[4] K.G. Adams and F. Biggs, "Efficient Computer Access to Sandia Photon Cross Sections II," SC-RR-71-0507, Sandia Laboratory, Albuquerque, NM, December 1971.

[5] J. Von Neumann and R. Richtmyer, "A Method for the Numerical Calculation of Hydrodynamic Shocks," J. Appl. Phys. 21, 232 (1950).

[6] R. Kidder and W. Barnes, "WAZER - A One-Dimensional, Two-Temperature Hydrodynamic Code," UCRL-50583, Lawrence Radiation Laboratory, Livermore, California.

[7] R.D. Richtmyer and K.W. Morton, Difference Methods for Initial Value Problems, Interscience Publishers, New York, (1967) 200.

[8] L. Spitzer, Physics of Fully Ionized Gases, Second Edition, Interscience Publishers, New York, (1962) 144.

[9] Y.B. Zel'dovich and Y.P. Raizer, Physics of Shock Waves and Other High Temperature Hydrodynamic Phenomena, W.D. Hayes and P.F. Probstein, eds., Academic Press, New York, (1966) Vol. 1, Chapt. 2.

[10] G.C. Pomraning, The Equations of Radiation Hydrodynamics, Pergamon Press, New York, (1973).

[11] R.R. Peterson and G.A. Moses, "MIXERG - An Equation of State and Opacity Computer Code," Comp. Phys. Comm. 28, 405 (1983).

[12] D.K. Brice, "Ion Implantation Range and Energy Deposition Codes COREL, RASE4, DAMG2," SAND-75-0622, Sandia Laboratory, Albuquerque, NM, 1977.

[13] M. Uesaka, R. Peterson and G. Moses, "Equilibrium and Non-Equilibrium Microfireball Behavior in Light Ion Fusion Systems," submitted to Nuclear Fusion for publication.

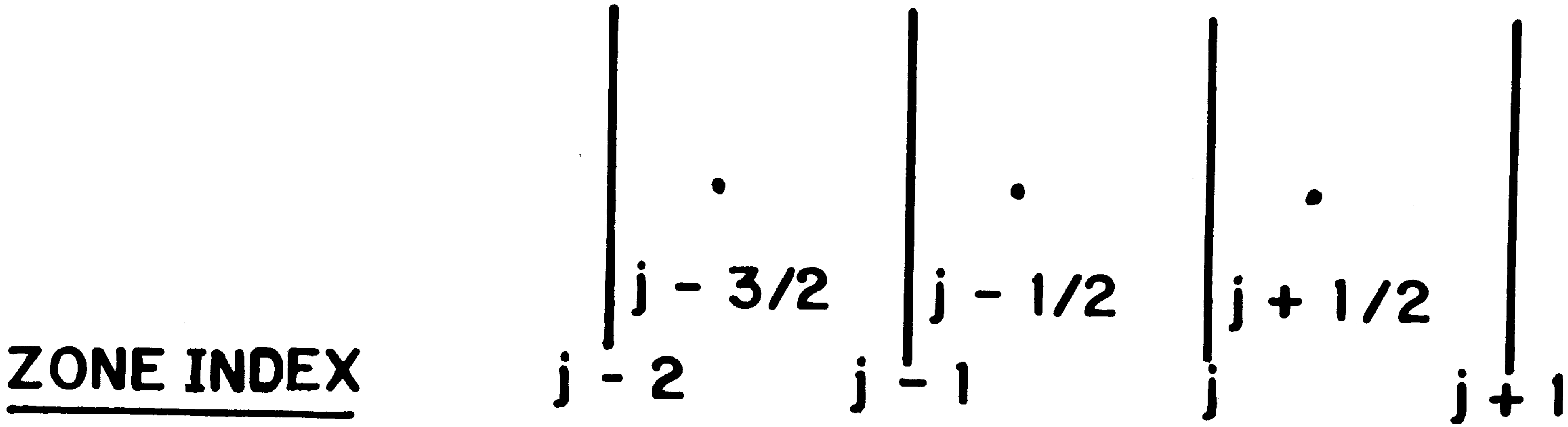
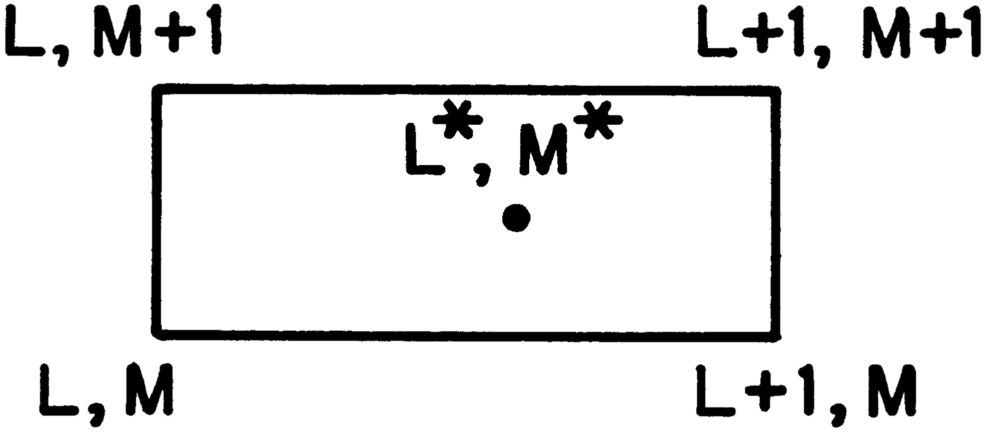


Figure 1. The index system used to denote spatial boundaries.

Figure 2. The indices used to interpolate in a two-dimensional grid.



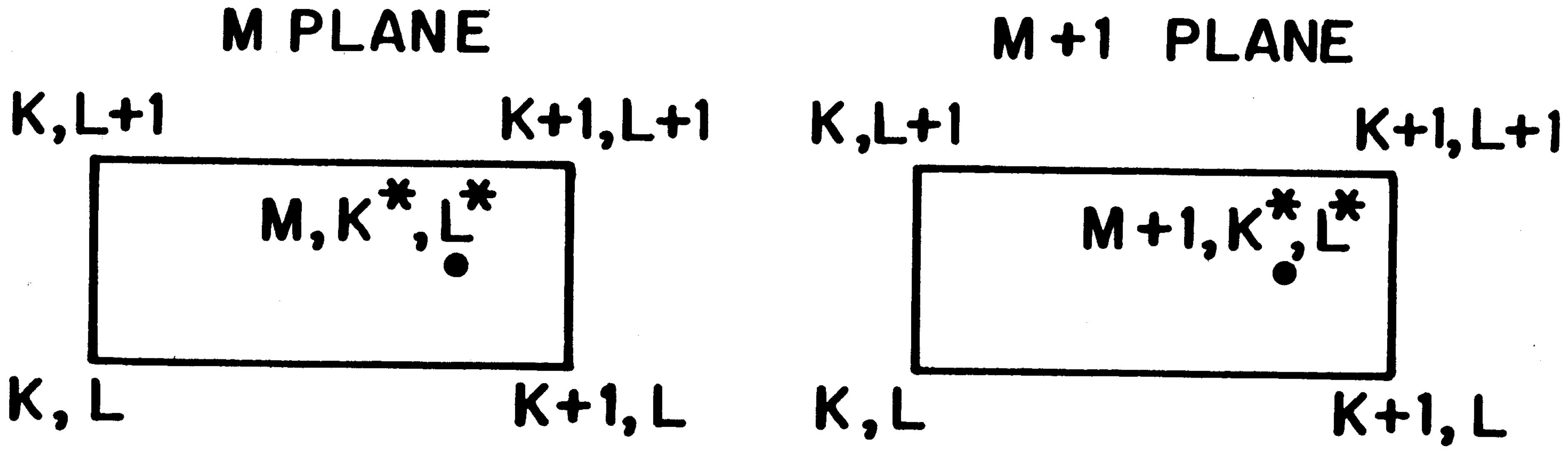


Figure 3. The indices used to interpolate in the three-dimensional tables.

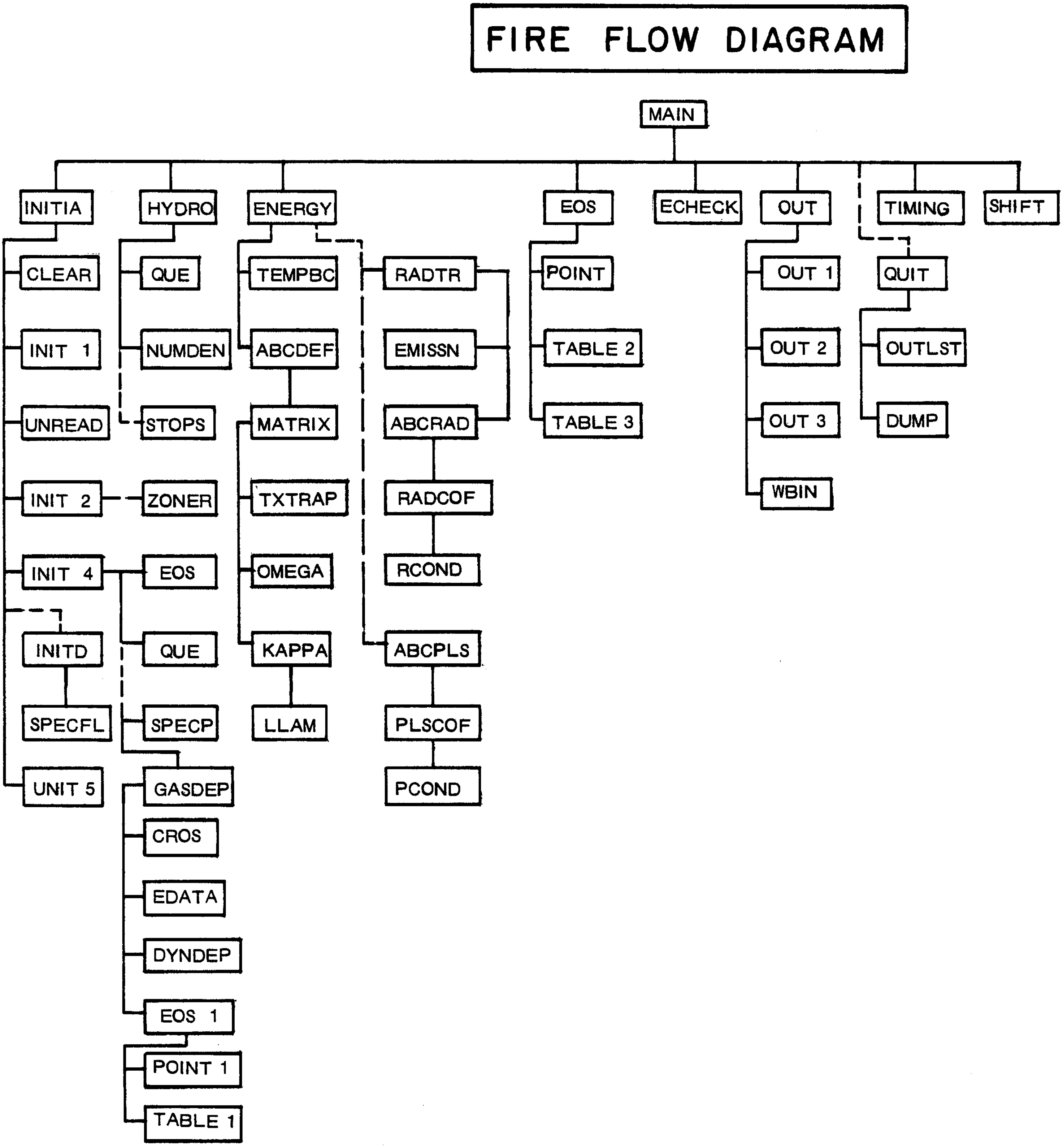


Figure 4. The flow diagram of the MF-FIRE code. The dotted lines indicate conditional routes.

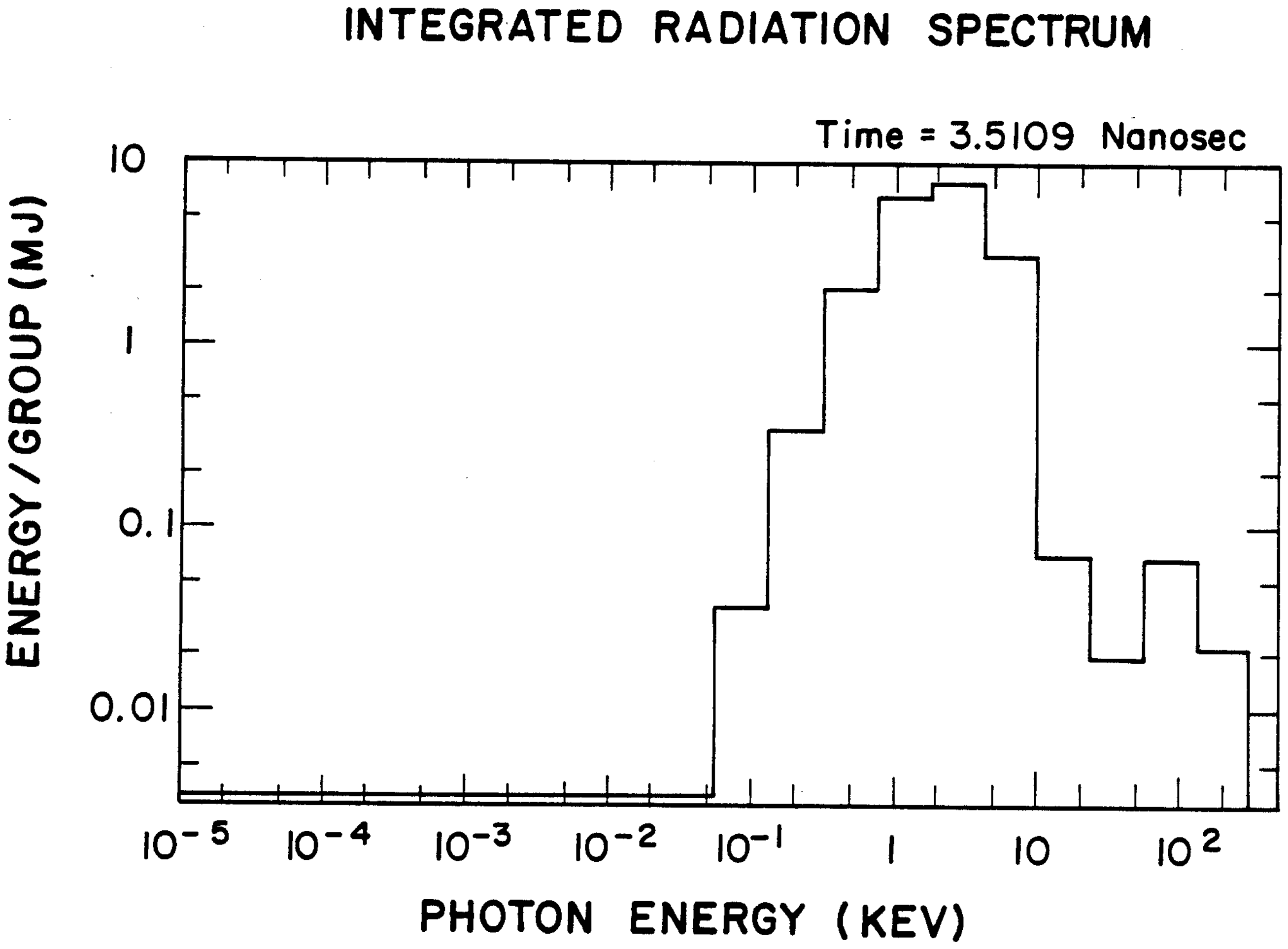


Figure 5. Spectrum of x-rays emitted by target.

Figure 6. Printed output for the example problem with two-temperature radiative transfer.

```
BANK AND SEGMENT INDEX VALUES

     *BODY|SEG-NAME|          000000000002      *COMM|SEG-NAME|          000000000003     *INIT|SEG-NAME|          000000000001
     *MAIN|SEG-NAME|          000000000000
SYS$*RLIB$. LEVEL 31
END MAP.  ERRORS: 0  TIME: 14.786  STORAGE: 18831/4/042777/0101777
@PACK MFFIRE.
FURPUR 28R3A U01 SLIB27 04/05/84 18:04:09
END PACK. TEXT=44,TOC=2,SYM=72,REL=56
@ . *********************************************
@ . COPY THE X-RAY DEPOSITION DATA INTO THE PROPER TEMPORARY FILE
@ . *********************************************
@COPY XRAY*ATOM.,11.
     8 BLOCKS COPIED.
@ . *********************************************
@ . LIST THE NAMELIST INPUT FILE
@ . *********************************************
@ELT,L MFFIRE.LIBRA
ELT 8R1-M1 S74Q1C 04/05/84 18:04:10 (4)
    1.          00        &INPUT
    2.          00          JMAX=50,
    3.          04          NMAX=10000,
    4.          00          TMAX=1.5D-3,
    5.          00          DN2B=50*3.55D17,
    6.          00          TN2C=50*.0925D0,
    7.          00          TR2C=50*.0925D0,
    8.          00          ATW2B=50*40.D0,
    9.          02          IO=4*200,
   10.          02          IOBIN=10,
   11.          00          NI=3,
   12.          00          RI=4.D0,
   13.          01          NO=15,
   14.          00          RO=294.7D0,
   15.          01          RADIUS=300.D0,
   16.          01          PMASS=0.1D0,
   17.          01          FLUX=22.D6,
   18.          01          JK=20,
   19.          01          IZ=18,
   20.          01          XEHIST=0.D0,.5D0,1.D0,1.5D0,2.D0,2.5D0,3.D0,3.5D0,4.D0,4.5D0,5.D0,
   21.          01                 5.5D0,6.D0,6.5D0,7.D0,7.5D0,8.D0,8.5D0,9.D0,9.5D0,10.D0,
   22.          01          XAMP=2.72D6,6.02D6,7.D6,5.46D6,4*3.52D6,1.88D6,11*5.88D5,
   23.          01          ISW(1)=0,
   24.          01          ISW(4)=1,
   25.          02          ISW(5)=10,
   26.          01          ISW(8)=1,
   27.          01          ISW(11)=0,
   28.          01        &END
   29.          01        &LOWEN
   30.          01          ISPEC=3,
   31.          01          NMHIST=1,
   32.          01          EHIST=176.D0,
   33.          01          SMASS=207.D0,
   34.          01          FL=1.77D20,
   35.          01          REFRO=2.68D22,
   36.          01          ENGY1=50.D0,
   37.          01          RP1=3.22D-6,
   38.          01          SIG1=9.8D-7,
```

```
    39.          01        PATH1=3.41D-6,
    40.          01        ENGY=20.D0,
    41.          01        RP=1.97D-6,
    42.          01        SIG=8.6D-7,
    43.          01        PATH=2.D-6,
    44.          01        ENGY2=20.D0,
    45.          01        RP2=1.52D-6,
    46.          01        SIG2=4.9D-7,
    47.          01      &END

END ELT.  ERRORS: NONE. TIME:  0.177 SEC. IMAGE COUNT: 47
@ . **********************************************
@ . EXECUTE MFFIRE
@ . ***********************************************
@XQT DUM.MFFIRE
```

```
***********************************************************
*                                                         *
*    FIRE - A CODE TO COMPUTE THE RESPONSE OF CAVITY-     *
*    GASES TO FUSION PELLET DEBRIS 2/19/79                *
*                                                         *
*    WRITTEN BY GREGORY A. MOSES & ROBERT R. PETERSON     *
*                                                         *
***********************************************************



SPHERICAL GEOMETRY - ENERGY QUANTITIES ARE ABSOLUTE


NO. OF ZONES..........................              50
OUTER BOUNDARY(CM)....................     3.0000+002

STARTING TIME(S)......................     0.0000-001
STARTING CYCLE........................              1
NO. OF TIME CYCLES....................          10000
MAX. PROBLEM TIME(S)..................     1.5000-003
TIME STEP FOR FIRST  10 CYCLES(S).....     1.0000-012
MIN. TIME STEP(S).....................     1.0000-013
MAX. TIME STEP(S).....................     1.5000-005
TIME STEP GROWTH LIMIT................     1.5000+000
TIME STEP CONTROL PARAMETERS..........
    COURANT...........................     5.0000-002
    PERCENT V CHANGE..................     5.0000-002
    PERCENT TN CHANGE.................     5.0000-002
    PERCENT ER CHANGE.................     1.0000+035


TEMPERATURE BC.(EV)...................    2.5000-002


PRIMARY OUTPUT FREQUENCIES

HYDRODYNAMICS.....  200
ENERGY............  200
NUMBER DENSITIES..  200
SHORT EDIT........  200
MULTI-FREQ RAD....   -1

BINARY OUTPUT.....   10
```

```
                 INTERMEDIATE VARIABLE FREQUENCIES - IEDIT

( 1)  -1   ( 2)  -1   ( 3)  -1   ( 4)  -1   ( 5)  -1   ( 6)  -1   ( 7)  -1   ( 8)  -1   ( 9)  -1   (10)  -1
(11)  -1   (12)  -1   (13)  -1   (14)  -1   (15)  -1   (16)  -1   (17)  -1   (18)  -1   (19)  -1   (20)  -1
(21)  -1   (22)  -1   (23)  -1   (24)  -1   (25)  -1   (26)  -1   (27)  -1   (28)  -1   (29)  -1   (30)  -1
(31)  -1   (32)  -1   (33)  -1   (34)  -1   (35)  -1   (36)  -1   (37)  -1   (38)  -1   (39)  -1   (40)  -1
(41)  -1   (42)  -1   (43)  -1   (44)  -1   (45)  -1   (46)  -1   (47)  -1   (48)  -1   (49)  -1   (50)  -1
(51)  -1   (52)  -1   (53)  -1   (54)  -1   (55)  -1   (56)  -1   (57)  -1   (58)  -1   (59)  -1   (60)  -1
(61)   1   (62)  -1   (63)  -1   (64)  -1   (65)  -1   (66)  -1   (67)  -1   (68)  -1   (69)  -1   (70)  -1
(71)  -1   (72)  -1   (73)  -1   (74)  -1   (75)  -1   (76)  -1   (77)  -1   (78)  -1   (79)  -1   (80)  -1
(81)  -1   (82)  -1   (83)  -1   (84)  -1   (85)  -1   (86)  -1   (87)  -1   (88)  -1   (89)  -1   (90)  -1
(91)  -1   (92)  -1   (93)  -1   (94)  -1   (95)  -1   (96)  -1   (97)  -1   (98)  -1   (99)  -1   (


 #   RADIUS      ZONE WIDTH  MASS DENS   MASS        E DENSITY   ION DENSITY R TEMP      ION TEMP    ATOMIC WT   CHARGE
     (CM)        (CM)        (G/CM3)     (G/     )   (1/CM3)     (1/CM3)     (EV)        (EV)        (AMU)       (ESU)

 0   0.0000-001
 1   4.0000+000  4.0000+000  3.9663-004  1.0633-001  8.8084+019  5.9717+018  9.2500-002  2.1481+002  4.0000+001  1.4750+001
 2   1.0448+001  6.4483+000  2.3578-005  1.0633-001  5.0657+018  3.5500+017  9.2500-002  1.9620+002  4.0000+001  1.4270+001
 3   1.3040+001  2.5914+000  2.3578-005  1.0633-001  4.6645+018  3.5500+017  9.2500-002  1.5812+002  4.0000+001  1.3139+001
 4   1.5264+001  2.2247+000  2.3578-005  1.3229-001  3.5124+018  3.5500+017  9.2500-002  8.7228+001  4.0000+001  9.8942+000
 5   1.7350+001  2.0860+000  2.3578-005  1.6458-001  3.1043+018  3.5500+017  9.2500-002  6.3515+001  4.0000+001  8.7446+000
 6   1.9396+001  2.0452+000  2.3578-005  2.0477-001  2.8725+018  3.5500+017  9.2500-002  4.5084+001  4.0000+001  8.0915+000
 7   2.1455+001  2.0593+000  2.3578-005  2.5476-001  2.7862+018  3.5500+017  9.2500-002  2.5915+001  4.0000+001  7.8485+000
 8   2.3565+001  2.1097+000  2.3578-005  3.1696-001  2.5090+018  3.5500+017  9.2500-002  1.8176+001  4.0000+001  7.0676+000
 9   2.5752+001  2.1875+000  2.3578-005  3.9434-001  2.2208+018  3.5500+017  9.2500-002  1.4249+001  4.0000+001  6.2557+000
10   2.8040+001  2.2876+000  2.3578-005  4.9061-001  1.9673+018  3.5500+017  9.2500-002  1.1533+001  4.0000+001  5.5416+000
11   3.0447+001  2.4076+000  2.3578-005  6.1039-001  1.7225+018  3.5500+017  9.2500-002  9.5574+000  4.0000+001  4.8521+000
12   3.2993+001  2.5460+000  2.3578-005  7.5941-001  1.5277+018  3.5500+017  9.2500-002  8.0658+000  4.0000+001  4.3034+000
13   3.5695+001  2.7021+000  2.3578-005  9.4481-001  1.3352+018  3.5500+017  9.2500-002  6.9357+000  4.0000+001  3.7611+000
14   3.8571+001  2.8758+000  2.3578-005  1.1755+000  1.1779+018  3.5500+017  9.2500-002  6.0282+000  4.0000+001  3.3180+000
15   4.1638+001  3.0673+000  2.3578-005  1.4625+000  1.0361+018  3.5500+017  9.2500-002  5.1376+000  4.0000+001  2.9185+000
16   4.4916+001  3.2773+000  2.3578-005  1.8195+000  9.0559+017  3.5500+017  9.2500-002  4.2353+000  4.0000+001  2.5509+000
17   4.8422+001  3.5063+000  2.3578-005  2.2637+000  7.9054+017  3.5500+017  9.2500-002  3.5954+000  4.0000+001  2.2269+000
18   5.2177+001  3.7553+000  2.3578-005  2.8164+000  6.7786+017  3.5500+017  9.2500-002  3.1204+000  4.0000+001  1.9095+000
19   5.6203+001  4.0254+000  2.3578-005  3.5040+000  5.8218+017  3.5500+017  9.2500-002  2.7122+000  4.0000+001  1.6399+000
20   6.0520+001  4.3178+000  2.3578-005  4.3595+000  4.8620+017  3.5500+017  9.2500-002  2.4130+000  4.0000+001  1.3696+000
21   6.5154+001  4.6339+000  2.3578-005  5.4238+000  4.0546+017  3.5500+017  9.2500-002  2.1760+000  4.0000+001  1.1421+000
22   7.0130+001  4.9753+000  2.3578-005  6.7479+000  3.3744+017  3.5500+017  9.2500-002  1.9600+000  4.0000+001  9.5054-001
23   7.5473+001  5.3437+000  2.3578-005  8.3954+000  2.7643+017  3.5500+017  9.2500-002  1.7580+000  4.0000+001  7.7868-001
24   8.1214+001  5.7410+000  2.3578-005  1.0445+001  2.1337+017  3.5500+017  9.2500-002  1.5592+000  4.0000+001  6.0104-001
25   8.7383+001  6.1691+000  2.3578-005  1.2995+001  1.6558+017  3.5500+017  9.2500-002  1.3864+000  4.0000+001  4.6641-001
26   9.4014+001  6.6303+000  2.3578-005  1.6168+001  1.2753+017  3.5500+017  9.2500-002  1.2297+000  4.0000+001  3.5924-001
27   1.0114+002  7.1270+000  2.3578-005  2.0115+001  9.4600+016  3.5500+017  9.2500-002  1.1105+000  4.0000+001  2.6648-001
28   1.0880+002  7.6618+000  2.3578-005  2.5026+001  6.9816+016  3.5500+017  9.2500-002  1.0011+000  4.0000+001  1.9666-001
29   1.1704+002  8.2375+000  2.3578-005  3.1136+001  5.1311+016  3.5500+017  9.2500-002  9.0113-001  4.0000+001  1.4454-001
30   1.2590+002  8.8570+000  2.3578-005  3.8737+001  3.1346+016  3.5500+017  9.2500-002  8.2435-001  4.0000+001  8.8299-002
31   1.3542+002  9.5237+000  2.3578-005  4.8194+001  1.4164+016  3.5500+017  9.2500-002  7.6871-001  4.0000+001  3.9899-002
32   1.4566+002  1.0241+001  2.3578-005  5.9961+001  6.3742+015  3.5500+017  9.2500-002  7.1657-001  4.0000+001  1.7956-002
33   1.5667+002  1.1013+001  2.3578-005  7.4599+001  2.8719+015  3.5500+017  9.2500-002  6.6803-001  4.0000+001  8.0900-003
34   1.6852+002  1.1843+001  2.3578-005  9.2812+001  1.3416+015  3.5500+017  9.2500-002  6.2477-001  4.0000+001  3.7791-003
35   1.8125+002  1.2737+001  2.3578-005  1.1547+002  6.2723+014  3.5500+017  9.2500-002  5.8435-001  4.0000+001  1.7669-003
36   1.9415+002  1.2891+001  2.3578-005  1.3462+002  1.7391+010  3.5500+017  9.2500-002  4.8447-001  4.0000+001  4.8988-008
```

```
37  2.0586+002  1.1712+001  2.3578-005  1.3885+002  1.2433+006  3.5500+017  9.2500-002  4.0963-001  4.0000+001  3.5022-012
38  2.1637+002  1.0512+001  2.3578-005  1.3885+002  2.8599+005  3.5500+017  9.2500-002  3.5621-001  4.0000+001  8.0560-013
39  2.2595+002  9.5795+000  2.3578-005  1.3885+002  2.5365+005  3.5500+017  9.2500-002  3.1593-001  4.0000+001  7.1449-013
40  2.3478+002  8.8296+000  2.3578-005  1.3885+002  2.3175+005  3.5500+017  9.2500-002  2.8865-001  4.0000+001  6.5280-013
41  2.4299+002  8.2111+000  2.3578-005  1.3885+002  2.1350+005  3.5500+017  9.2500-002  2.6593-001  4.0000+001  6.0142-013
42  2.5068+002  7.6908+000  2.3578-005  1.3885+002  1.9892+005  3.5500+017  9.2500-002  2.4776-001  4.0000+001  5.6033-013
43  2.5793+002  7.2458+000  2.3578-005  1.3885+002  1.8701+005  3.5500+017  9.2500-002  2.3293-001  4.0000+001  5.2678-013
44  2.6479+002  6.8601+000  2.3578-005  1.3885+002  1.7677+005  3.5500+017  9.2500-002  2.2017-001  4.0000+001  4.9794-013
45  2.7131+002  6.5219+000  2.3578-005  1.3885+002  1.6743+005  3.5500+017  9.2500-002  2.0854-001  4.0000+001  4.7163-013
46  2.7753+002  6.2226+000  2.3578-005  1.3885+002  1.6186+005  3.5500+017  9.2500-002  2.0161-001  4.0000+001  4.5595-013
47  2.8349+002  5.9554+000  2.3578-005  1.3885+002  1.5575+005  3.5500+017  9.2500-002  1.9400-001  4.0000+001  4.3873-013
48  2.8920+002  5.7152+000  2.3578-005  1.3885+002  1.5043+005  3.5500+017  9.2500-002  1.8737-001  4.0000+001  4.2376-013
49  2.9470+002  5.4978+000  2.3578-005  1.3885+002  1.4577+005  3.5500+017  9.2500-002  1.8156-001  4.0000+001  4.1062-013
50  3.0000+002  5.3000+000  2.3578-005  1.3885+002  1.4165+005  3.5500+017  9.2500-002  1.7643-001  4.0000+001  3.9901-013
                                        2.6667+003

 #    R PRESS     ION PRESS    R INT ENE   ION INT ENE VELOCITY
     (J/CM3)      (J/CM3)     (J/     )   (J/     )   (CM/S)

 0                                                    0.0000-001
 1  3.3463-010  3.2367+003  2.6913-007  2.5014+006  0.0000-001
 2  3.3463-010  1.7038+002  4.5272-006  2.2488+006  0.0000-001
 3  3.3463-010  1.2714+002  4.5272-006  1.7310+006  0.0000-001
 4  3.3463-010  5.4043+001  5.6325-006  9.0195+005  0.0000-001
 5  3.3463-010  3.5199+001  7.0076-006  7.1222+005  0.0000-001
 6  3.3463-010  2.3310+001  8.7185-006  6.0751+005  0.0000-001
 7  3.3463-010  1.3041+001  1.0847-005  5.5136+005  0.0000-001
 8  3.3463-010  8.3395+000  1.3495-005  5.0584+005  0.0000-001
 9  3.3463-010  5.8797+000  1.6790-005  4.7321+005  0.0000-001
10  3.3463-010  4.2905+000  2.0889-005  4.4964+005  0.0000-001
11  3.3463-010  3.1808+000  2.5989-005  4.2968+005  0.0000-001
12  3.3463-010  2.4327+000  3.2334-005  4.2124+005  0.0000-001
13  3.3463-010  1.8780+000  4.0228-005  4.0646+005  0.0000-001
14  3.3463-010  1.4803+000  5.0049-005  3.9918+005  0.0000-001
15  3.3463-010  1.1449+000  6.2268-005  3.9276+005  0.0000-001
16  3.3463-010  8.5530-001  7.7471-005  3.8638+005  0.0000-001
17  3.3463-010  6.5981-001  9.6384-005  3.8446+005  0.0000-001
18  3.3463-010  5.1632-001  1.1992-004  3.7859+005  0.0000-001
19  3.3463-010  4.0720-001  1.4919-004  3.7372+005  0.0000-001
20  3.3463-010  3.2517-001  1.8562-004  3.6483+005  0.0000-001
21  3.3463-010  2.6509-001  2.3093-004  3.5877+005  0.0000-001
22  3.3463-010  2.1742-001  2.8731-004  3.5187+005  0.0000-001
23  3.3463-010  1.7783-001  3.5746-004  3.4346+005  0.0000-001
24  3.3463-010  1.4197-001  4.4473-004  3.3442+005  0.0000-001
25  3.3463-010  1.1562-001  5.5330-004  3.2727+005  0.0000-001
26  3.3463-010  9.5059-002  6.8838-004  3.1835+005  0.0000-001
27  3.3463-010  7.9983-002  8.5645-004  3.0982+005  0.0000-001
28  3.3463-010  6.8127-002  1.0655-003  3.0026+005  0.0000-001
29  3.3463-010  5.8656-002  1.3257-003  2.9000+005  0.0000-001
30  3.3463-010  5.1021-002  1.6493-003  2.8263+005  0.0000-001
31  3.3463-010  4.5461-002  2.0520-003  2.7554+005  0.0000-001
32  3.3463-010  4.1484-002  2.5530-003  2.6830+005  0.0000-001
33  3.3463-010  3.8299-002  3.1763-003  2.6134+005  0.0000-001
34  3.3463-010  3.5665-002  3.9517-003  2.5740+005  0.0000-001
35  3.3463-010  3.3291-002  4.9165-003  2.5358+005  0.0000-001
36  3.3463-010  2.7553-002  5.7319-003  2.3903+005  0.0000-001
37  3.3463-010  2.3296-002  5.9119-003  2.0545+005  0.0000-001
```

```
38  3.3463-010  2.0258-002  5.9119-003  1.7895+005  0.0000-001
39  3.3463-010  1.7967-002  5.9119-003  1.5871+005  0.0000-001
40  3.3463-010  1.6416-002  5.9119-003  1.4501+005  0.0000-001
41  3.3463-010  1.5124-002  5.9119-003  1.3359+005  0.0000-001
42  3.3463-010  1.4090-002  5.9119-003  1.2446+005  0.0000-001
43  3.3463-010  1.3247-002  5.9119-003  1.1701+005  0.0000-001
44  3.3463-010  1.2521-002  5.9119-003  1.1061+005  0.0000-001
45  3.3463-010  1.1860-002  5.9119-003  1.0476+005  0.0000-001
46  3.3463-010  1.1466-002  5.9119-003  1.0128+005  0.0000-001
47  3.3463-010  1.1033-002  5.9119-003  9.7455+004  0.0000-001
48  3.3463-010  1.0656-002  5.9119-003  9.4129+004  0.0000-001
49  3.3463-010  1.0326-002  5.9119-003  9.1211+004  0.0000-001
50  3.3463-010  1.0034-002  5.9119-003  8.8632+004  0.0000-001
                            1.1354-001  2.1144+007  0.0000-001
```

```
                 COEFFICIENTS USED IN FIRE - CON

ION THERMAL COND.........( 1)  1.2175+002        R THERMAL COND...........( 2)  1.0000+010
RAD. EQ. COND............( 3)  1.0000-001        FLUX LIMIT EPSILON TERM..( 4)  1.0000-030
CONST LOG LAMBDA.........( 5)  0.0000-001        4*SIGMA/C................( 6)  1.3713-005
PLASMA EMISS. COEF.......( 7)  4.1138+005        PLASMA ABSORP. COEF......( 8)  3.0000+010
ION PRESS(I.GAS).........( 9)  1.6020-019                                 (10)  3.0000+010
                         (11)  0.0000-001        ION PRESS DERIV(I.GAS)...(12)  1.6020-019
                         (13)  0.0000-001        ION SP HEAT(I.GAS).......(14)  2.4030-019
ION INT ENERGY(I.GAS)....(15)  2.4030-019        RAD SP. ENERGY COEF......(16)  1.3713-005
UP-STREAM AVE PARAMETER..(17)  0.0000-001        ION SHOCK HEATING........(18)  1.0000+000
                         (19)  0.0000-001                                 (20)  0.0000-001
ARTIFICIAL VISCOSITY.....(21)  1.4140+000        MULTI-FREQ RAD ABSORPTION(22)  3.0000+010
MULTI-FREQ RAD EMISSION..(23)  6.3349+004        MULTI-FREQ RAD CONDUCT...(24)  1.0000+010
MULTI-FREQ RAD FLUX LIM..(25)  3.0000+010        MIN INIT M-F RAD ENERGY..(26)  1.0000-020
                         (27)  0.0000-001                                 (28)  0.0000-001
                         (29)  0.0000-001                                 (30)  0.0000-001
                         (31)  0.0000-001


                 CALCULATION OPTIONS USED IN FIRE - ISW

     RADIATION TEMPERATURE OP.( 1)   0                NO. OF CONST TIME STEPS..( 2)  10
                              ( 3)   0                AUTOMATIC ZONING.........( 4)   1
     FREQ OF WALL OUTPUT......( 5)  10                HYDRODYNAMIC MOTION......( 6)   0
                              ( 7)   0                ION DEPOSITION SOURCE....( 8)   1
                              ( 9)   0                FREQ. OF DTB CALCULATION.(10)   1
     AUTOMATIC XRAY DEPOSITION(11)   0                EQN OF STATE OPTION......(12)   0
     NO. FREQ. GR. SUB-DIVNS..(13)   0                ARBITRARY RADIATION OPC..(14)   0
     ARBITRARY ROSSELAND OPC..(15)   0                                         (16)   0
                              (17)   0                                         (18)   0
                              (19)   0

                 EQUATION OF STATE TABLE INDICES


                 DENSITY SLOPE.......    5.0000-001
                 DENSITY BASE........    1.5431+001
                 TEMPERATURE SLOPE...    1.6299-001
                 TEMPERATURE BASE....   -3.9794-001
                 MIN DENSITY(1/CM3)..    2.7002+015
                 MAX DENSITY(1/CM3)..    8.5389+019
                 MIN TEMPERATURE(EV)     4.0000-001
                 MAX TEMPERATURE(EV)     4.9999+002

                 ARGON
```

```
THE BLACKBODY TEMPERATURE WAS 0.0000-001 KEV FOR THE X-RAYS
THE X-RAY SPECTRA CONTAINED 2.1814+007 JOULES
THE X-RAY ENERGY DEPOSITED WAS 2.0227+007 JOULES


************ XRAY FLUX TO WALL ************

ENERGY  ENERGY          EXITING        ATTENUATION
GROUP                   ENERGY         COEFFICIENT
          (KEV)         (J/KEV)          (/CM)

   1     2.5000-001    3.5364-150     5.2430+004
   2     7.5000-001    6.2392-013     6.3279+003
   3     1.2500+000    3.5904+001     1.7468+003
   4     1.7500+000    3.2292+004     7.2999+002
   5     2.2500+000    2.4989+005     3.7467+002
   6     2.7500+000    7.5998+005     2.1659+002
   7     3.2500+000    3.5253+002     1.3003+003
   8     3.7500+000    5.5689+003     9.0637+002
   9     4.2500+000    1.7530+004     6.5454+002
  10     4.7500+000    1.7936+004     4.8715+002
  11     5.2500+000    4.0693+004     3.7194+002
  12     5.7500+000    7.2908+004     2.9022+002
  13     6.2500+000    1.1161+005     2.3072+002
  14     6.7500+000    1.5336+005     1.8640+002
  15     7.2500+000    1.9534+005     1.5273+002
  16     7.7500+000    2.3557+005     1.2669+002
  17     8.2500+000    2.7292+005     1.0625+002
  18     8.7500+000    3.0688+005     8.9980+001
  19     9.2500+000    3.3732+005     7.6869+001
  20     9.7500+000    3.6435+005     6.6187+001


              INITIAL CONDITIONS FOR PROJECTILES

   INITIAL  INITIAL    FINAL    FINAL   NUMBER
 #  ENERGY    SPEED    RANGE  STD.DEV. PARTICLES
    (KEV)   CM/SEC     (CM)     (CM)

 1 1.76+002 4.05+007 4.05-002 1.08-002 1.77+020

   4.98+000 MJ TOTAL                    1.77+020 PARTICLES TOTAL
SLOW DEBRIS TURNED OFF AT CYCLE 166
```

```
   CYCLE        TIME(S)      DELTA T(S)      CRITERION(TN/T) IN ZONE (39) OTHERWISE (TN/T) IN ZONE (39)
     600        1.7313-004   3.4077-006

 #  RADIUS      ZONE WIDTH  MASS DENS   COMPRESSION VELOCITY    R TEMP      ION TEMP    R PRESS     ION PRESS   ART VISC
    (CM)        (CM)        (G/CM3)     (VO/V)      (CM/S)      (EV)        (EV)        (J/CM3)     (J/CM3)     (J/CM3)

 0  0.0000-001                                      0.0000-001
 1  9.7167+000  9.7167+000  2.7670-005  6.9763-002  1.9062+004  1.1936+000  1.1898+000  9.2770-006  1.0451-001  0.0000-001
 2  1.2300+001  2.5833+000  2.6905-005  1.1411+000  1.1169+004  1.1936+000  1.1920+000  9.2769-006  1.0207-001  3.3496-004
 3  1.4157+001  1.8573+000  2.5990-005  1.1023+000  4.9819+003  1.1936+000  1.1926+000  9.2768-006  9.8859-002  1.9819-004
 4  1.6012+001  1.8548+000  2.4912-005  1.0565+000  9.3719+002  1.1936+000  1.1926+000  9.2767-006  9.4941-002  8.1235-005
 5  1.7915+001  1.9034+000  2.3886-005  1.0131+000 -1.6009+003  1.1936+000  1.1925+000  9.2766-006  9.1206-002  3.0693-005
 6  1.9893+001  1.9775+000  2.3036-005  9.7702-001 -5.4060+003  1.1936+000  1.1928+000  9.2765-006  8.8158-002  6.6430-005
 7  2.1988+001  2.0949+000  2.2050-005  9.3520-001 -1.1895+004  1.1936+000  1.1933+000  9.2764-006  8.4636-002  1.8439-004
 8  2.4268+001  2.2804+000  2.0660-005  8.7625-001 -2.1781+004  1.1936+000  1.1940+000  9.2763-006  7.9636-002  3.9975-004
 9  2.6818+001  2.5493+000  1.8851-005  7.9951-001 -3.6699+004  1.1935+000  1.1949+000  9.2761-006  7.3091-002  8.2723-004
10  2.9734+001  2.9168+000  1.6726-005  7.0939-001 -5.6614+004  1.1935+000  1.1961+000  9.2759-006  6.5286-002  1.3036-003
11  3.3153+001  3.4183+000  1.4358-005  6.0896-001 -7.8669+004  1.1935+000  1.1971+000  9.2757-006  5.6436-002  1.3711-003
12  3.7228+001  4.0756+000  1.1960-005  5.0726-001 -9.7903+004  1.1935+000  1.1978+000  9.2754-006  4.7370-002  8.7000-004
13  4.1690+001  4.4618+000  1.0811-005  4.5852-001 -9.7960+004  1.1935+000  1.1962+000  9.2752-006  4.2876-002  7.1804-009
14  4.6441+001  4.7511+000  1.0130-005  4.2962-001 -8.4330+004  1.1935+000  1.1948+000  9.2749-006  4.0183-002  3.7548-004
15  5.1224+001  4.7826+000  1.0196-005  4.3245-001 -7.0320+004  1.1935+000  1.1943+000  9.2747-006  4.0406-002  4.0005-004
16  5.6152+001  4.9281+000  1.0186-005  4.3202-001 -5.3712+004  1.1935+000  1.1937+000  9.2745-006  4.0329-002  0.0000-001
17  6.1173+001  5.0212+000  1.0419-005  4.4189-001 -3.7340+004  1.1935+000  1.1933+000  9.2742-006  4.1191-002  0.0000-001
18  6.6213+001  5.0400+000  1.0956-005  4.6465-001 -1.5719+004  1.1935+000  1.1923+000  9.2739-006  4.3167-002  0.0000-001
19  7.1244+001  5.0307+000  1.1729-005  4.9745-001  1.6185+003  1.1935+000  1.1922+000  9.2737-006  4.6092-002  0.0000-001
20  7.6219+001  4.9752+000  1.2822-005  5.4379-001  2.4260+004  1.1935+000  1.1912+000  9.2734-006  5.0148-002  0.0000-001
21  8.1174+001  4.9546+000  1.4061-005  5.9638-001  4.2203+004  1.1934+000  1.1911+000  9.2730-006  5.4814-002  0.0000-001
22  8.6043+001  4.8699+000  1.5769-005  6.6882-001  6.7934+004  1.1934+000  1.1899+000  9.2726-006  6.1121-002  0.0000-001
23  9.0857+001  4.8135+000  1.7736-005  7.5224-001  8.2872+004  1.1934+000  1.1903+000  9.2721-006  6.8512-002  0.0000-001
24  9.5665+001  4.8082+000  1.9871-005  8.4278-001  1.1378+005  1.1934+000  1.1889+000  9.2716-006  7.6171-002  0.0000-001
25  1.0019+002  4.5216+000  2.3846-005  1.0113+000  1.2387+005  1.1934+000  1.1901+000  9.2709-006  9.0749-002  0.0000-001
26  1.0544+002  5.2511+000  2.3174-005  9.8286-001  9.9548+004  1.1934+000  1.1926+000  9.2700-006  8.8642-002  2.7289-003
27  1.1209+002  6.6512+000  2.0338-005  8.6257-001  6.9643+004  1.1933+000  1.1929+000  9.2687-006  7.8329-002  3.6184-003
28  1.1995+002  7.8645+000  1.8805-005  7.9754-001  5.9533+004  1.1933+000  1.1919+000  9.2669-006  7.2606-002  3.8422-004
29  1.2855+002  8.5916+000  1.8673-005  7.9195-001  6.1497+004  1.1932+000  1.1914+000  9.2647-006  7.2064-002  0.0000-001
30  1.3768+002  9.1325+000  1.9043-005  8.0763-001  6.3596+004  1.1931+000  1.1913+000  9.2619-006  7.3409-002  0.0000-001
31  1.4739+002  9.7100+000  1.9434-005  8.2426-001  6.7976+004  1.1930+000  1.1911+000  9.2585-006  7.4823-002  0.0000-001
32  1.5750+002  1.0110+001  2.0301-005  8.6103-001  7.1153+004  1.1928+000  1.1910+000  9.2542-006  7.7978-002  0.0000-001
33  1.6813+002  1.0629+001  2.1062-005  8.9329-001  7.7474+004  1.1927+000  1.1907+000  9.2487-006  8.0717-002  0.0000-001
34  1.7938+002  1.1249+001  2.1740-005  9.2203-001  8.0673+004  1.1924+000  1.1906+000  9.2416-006  8.3169-002  0.0000-001
35  1.9124+002  1.1865+001  2.2546-005  9.5621-001  8.7567+004  1.1921+000  1.1902+000  9.2323-006  8.6047-002  0.0000-001
36  2.0287+002  1.1627+001  2.3722-005  1.0061+000  9.1806+004  1.1917+000  1.1899+000  9.2201-006  9.0267-002  0.0000-001
37  2.1296+002  1.0092+001  2.5322-005  1.0740+000  1.0308+005  1.1912+000  1.1891+000  9.2045-006  9.5942-002  0.0000-001
38  2.2126+002  8.2962+000  2.8252-005  1.1982+000  1.0849+005  1.1675+000  1.1668+000  8.4936-006  1.0312-001  0.0000-001
39  2.2852+002  7.2605+000  3.0089-005  1.2761+000  7.1091+004  8.3937-001  1.0443+000  2.2689-006  9.1674-002  8.3515-003
40  2.3638+002  7.8644+000  2.6000-005  1.1027+000  3.1308+004  7.7755-001  6.8184-001  1.6707-006  4.3185-002  8.1630-003
41  2.4427+002  7.8893+000  2.4247-005  1.0284+000  2.3241+004  7.6102-001  5.8676-001  1.5332-006  3.4382-002  3.1509-004
42  2.5173+002  7.4582+000  2.4086-005  1.0215+000  1.9237+004  7.3070-001  4.6302-001  1.3030-006  2.6902-002  7.7149-005
43  2.5869+002  6.9648+000  2.4355-005  1.0330+000  1.1749+004  7.0662-001  3.5036-001  1.1396-006  2.0584-002  2.7260-004
44  2.6544+002  6.7468+000  2.3844-005  1.0113+000  8.4712+003  6.9897-001  3.0313-001  1.0910-006  1.7435-002  5.1189-005
45  2.7190+002  6.4603+000  2.3693-005  1.0049+000  8.7699+003  6.9657-001  2.7914-001  1.0761-006  1.5954-002  0.0000-001
46  2.7807+002  6.1724+000  2.3672-005  1.0040+000  8.1492+003  6.6265-001  2.5434-001  8.8136-007  1.4523-002  1.8234-006
47  2.8391+002  5.8355+000  2.3980-005  1.0171+000  5.1582+003  6.6153-001  2.2505-001  8.7540-007  1.3018-002  4.2858-005
```

```
48  2.8957+002  5.6604+000  2.3741-005  1.0069+000  3.9934+003  6.6153-001  2.1666-001  8.7539-007  1.2408-002  6.4388-006
49  2.9495+002  5.3854+000  2.4019-005  1.0187+000  2.5268+003  6.4928-001  2.0981-001  8.1234-007  1.2156-002  1.0325-005
50  3.0000+002  5.0459+000  2.4745-005  1.0495+000  0.0000-001  6.3894-001  2.0055-001  7.6179-007  1.1970-002  3.1562-005
                                                                2.5000-002  2.5000-002


 #  R ENERGY    ION ENERGY  KIN ENERGY  R SOURCE    ION SOURCE  ION->R EX   FLUX LIM    HEAT FLUX
    (J/     )   (J/     )   (J/     )   (J/     )   (J/     )   (J/     )   (J/CM2-S)   (J/CM2-S)
 0                          0.0000-001
 1  1.0695-001  1.8888+003  1.9317+000  0.0000-001  0.0000-001  2.3358+001  2.1393+005  3.7815+003
 2  1.0999-001  1.9050+003  6.6316-001  0.0000-001  0.0000-001  3.8404+001  2.1392+005  6.0135+003
 3  1.1386-001  1.9172+003  1.4806-001  0.0000-001  0.0000-001  4.2652+001  2.1392+005  7.5526+003
 4  1.4779-001  2.3998+003  6.5188-003  0.0000-001  0.0000-001  5.1772+001  2.1392+005  8.7635+003
 5  1.9176-001  3.0035+003  2.3664-002  0.0000-001  0.0000-001  6.2833+001  2.1392+005  9.7921+003
 6  2.4737-001  3.7591+003  3.3574-001  0.0000-001  0.0000-001  8.3477+001  2.1391+005  1.0981+004
 7  3.2152-001  4.7124+003  2.0222+000  0.0000-001  0.0000-001  1.1450+002  2.1391+005  1.2414+004
 8  4.2693-001  5.9272+003  8.4360+000  0.0000-001  0.0000-001  1.5628+002  2.1391+005  1.3995+004
 9  5.8213-001  7.4870+003  2.9796+001  0.0000-001  0.0000-001  2.1590+002  2.1390+005  1.5699+004
10  8.1625-001  9.4764+003  8.8220+001  0.0000-001  0.0000-001  3.0157+002  2.1390+005  1.7538+004
11  1.1830+000  1.2013+004  2.1194+002  0.0000-001  0.0000-001  3.9991+002  2.1389+005  1.9180+004
12  1.7668+000  1.5267+004  4.0837+002  0.0000-001  0.0000-001  4.8472+002  2.1388+005  1.9918+004
13  2.4318+000  1.9140+004  5.0867+002  0.0000-001  0.0000-001  5.0756+002  2.1388+005  2.0022+004
14  3.2289+000  2.3910+004  4.6900+002  0.0000-001  0.0000-001  5.2858+002  2.1387+005  1.9688+004
15  3.9908+000  2.9693+004  4.0572+002  0.0000-001  0.0000-001  6.2892+002  2.1387+005  1.9745+004
16  4.9699+000  3.6897+004  2.9451+002  0.0000-001  0.0000-001  7.1176+002  2.1386+005  1.9775+004
17  6.0450+000  4.5754+004  1.7708+002  0.0000-001  0.0000-001  8.4166+002  2.1385+005  2.0035+004
18  7.1522+000  5.6495+004  3.9043+001  0.0000-001  0.0000-001  9.0996+002  2.1385+005  2.0286+004
19  8.3114+000  6.9755+004  5.1496-001  0.0000-001  0.0000-001  1.1223+003  2.1384+005  2.0923+004
20  9.4591+000  8.5776+004  1.4395+002  0.0000-001  0.0000-001  1.1876+003  2.1383+005  2.1523+004
21  1.0730+001  1.0565+005  5.4198+002  0.0000-001  0.0000-001  1.4727+003  2.1382+005  2.2501+004
22  1.1904+001  1.2954+005  1.7472+003  0.0000-001  0.0000-001  1.4335+003  2.1381+005  2.3193+004
23  1.3167+001  1.5929+005  3.2348+003  0.0000-001  0.0000-001  2.0602+003  2.1379+005  2.4829+004
24  1.4620+001  1.9442+005  7.5862+003  0.0000-001  0.0000-001  1.5866+003  2.1378+005  2.5318+004
25  1.5157+001  2.3608+005  1.1186+004  0.0000-001  0.0000-001  3.3469+003  2.1376+005  2.9207+004
26  1.9402+001  2.9647+005  8.9888+003  0.0000-001  0.0000-001  6.6132+003  2.1373+005  3.6631+004
27  2.7501+001  3.7618+005  5.4735+003  0.0000-001  0.0000-001  8.4057+003  2.1369+005  4.3963+004
28  3.6998+001  4.7251+005  4.9761+003  0.0000-001  0.0000-001  8.8831+003  2.1363+005  4.9277+004
29  4.6345+001  5.8781+005  6.6062+003  0.0000-001  0.0000-001  1.0160+004  2.1357+005  5.4174+004
30  5.6523+001  7.2909+005  8.7898+003  0.0000-001  0.0000-001  1.2640+004  2.1349+005  5.9785+004
31  6.8879+001  9.0405+005  1.2494+004  0.0000-001  0.0000-001  1.5417+004  2.1339+005  6.5881+004
32  8.1997+001  1.1173+006  1.7031+004  0.0000-001  0.0000-001  1.9276+004  2.1326+005  7.3265+004
33  9.8274+001  1.3818+006  2.5121+004  0.0000-001  0.0000-001  2.3341+004  2.1309+005  8.1414+004
34  1.1836+002  1.7108+006  3.3888+004  0.0000-001  0.0000-001  2.9452+004  2.1288+005  9.1136+004
35  1.4185+002  2.1154+006  4.7942+004  0.0000-001  0.0000-001  3.5525+004  2.1260+005  1.0175+005
36  1.5697+002  2.4463+006  5.7622+004  0.0000-001  0.0000-001  4.1527+004  2.1224+005  1.1654+005
37  1.5141+002  2.4950+006  7.3772+004  0.0000-001  0.0000-001  3.9768+004  2.0056+005  1.9846+005
38  1.2523+002  2.3449+006  8.1709+004  0.0000-001  0.0000-001 -3.4016+004  1.1652+005  1.1647+005
39  3.1410+001  1.7715+006  3.5086+004  0.0000-001  0.0000-001 -1.3735+005  3.8119+004  3.8111+004
40  2.6767+001  5.1791+005  6.8051+003  0.0000-001  0.0000-001 -1.6670+004  3.0866+004  3.0866+004
41  2.6339+001  3.0920+005  3.7499+003  0.0000-001  0.0000-001 -5.6931+003  2.7091+004  2.7091+004
42  2.2535+001  2.3468+005  2.5692+003  0.0000-001  0.0000-001 -3.6396+003  2.3119+004  2.3119+004
43  1.9490+001  1.7602+005  9.5835+002  0.0000-001  0.0000-001 -1.7973+003  2.1046+004  2.1046+004
44  1.9060+001  1.5229+005  4.9820+002  0.0000-001  0.0000-001 -1.0945+003  2.0427+004  2.0427+004
45  1.8919+001  1.4024+005  5.3395+002  0.0000-001  0.0000-001 -9.3347+002  1.8403+004  1.8403+004
46  1.5509+001  1.2778+005  4.6104+002  0.0000-001  0.0000-001 -7.2882+002  1.6475+004  1.6475+004
47  1.5206+001  1.1306+005  1.8472+002  0.0000-001  0.0000-001 -3.7202+002  1.6421+004  1.6421+004
48  1.5359+001  1.0885+005  1.1071+002  0.0000-001  0.0000-001 -3.6412+002  1.5817+004  1.5817+004
```

```
49   1.4088+001  1.0541+005  4.4327+001  0.0000-001  0.0000-001 -3.3789+002  1.4741+004  1.4741+004
50   1.2824+001  1.0075+005  0.0000-001  0.0000-001  0.0000-001 -2.4699+002  1.4270+004  1.4270+004

                             ENERGY CONSERVATION CHECK -- UNITS ARE (J/     )

     INT ENE     T KE        INT ENE(0)  T BDFLUX    T I->R EX   T SOURCE    BDFLUX      I->R EX     SOURCE

R    1.4844+003              1.1354-001  2.2993+006  2.3029+006  0.0000-001  6.6058+004  6.6076+004  0.0000-001
I    2.2098+007  4.6250+005  2.1144+007  6.1671-005              2.8222+006  1.3844-006              0.0000-001

                             RADIATION     1.4844+003     9.9472+002
                             ION           2.2560+007     2.1666+007
                             TOTAL         2.2562+007     2.1667+007

 #   E DENSITY   ION DENSITY CHARGE      ROSS OPC    PLK OPC     EQM T OPC    EPSILON
     (1/CM3)     (1/CM3)     (ESU)       (CM2/G)     (CM2/G)   (CM2/G)

 1   1.3431+017  4.1664+017  3.1593-001  3.5974+000  6.4058+003  6.2653+003  1.0032+000
 2   1.3257+017  4.0512+017  3.1944-001  3.6810+000  6.4002+003  6.3410+003  1.0013+000
 3   1.2927+017  3.9135+017  3.2215-001  3.7039+000  6.3932+003  6.3579+003  1.0008+000
 4   1.2485+017  3.7510+017  3.2481-001  3.6990+000  6.3848+003  6.3473+003  1.0008+000
 5   1.2062+017  3.5967+017  3.2744-001  3.6922+000  6.3764+003  6.3351+003  1.0009+000
 6   1.1735+017  3.4687+017  3.3006-001  3.7026+000  6.3691+003  6.3398+003  1.0007+000
 7   1.1359+017  3.3202+017  3.3339-001  3.7223+000  6.3604+003  6.3522+003  1.0002+000
 8   1.0808+017  3.1109+017  3.3827-001  3.7455+000  6.3473+003  6.3649+003  9.9960-001
 9   1.0073+017  2.8385+017  3.4518-001  3.7750+000  6.3290+003  6.3796+003  9.9886-001
10   9.1352+016  2.5185+017  3.5286-001  3.7784+000  6.1874+003  6.2801+003  9.9787-001
11   8.0340+016  2.1620+017  3.6113-001  3.7315+000  5.9078+003  6.0330+003  9.9699-001
12   6.8654+016  1.8009+017  3.7078-001  3.6522+000  5.5890+003  5.7288+003  9.9645-001
13   6.2574+016  1.6279+017  3.7439-001  3.5382+000  5.4239+003  5.5098+003  9.9773-001
14   5.8848+016  1.5253+017  3.7632-001  3.4531+000  5.3215+003  5.3628+003  9.9888-001
15   5.9102+016  1.5353+017  3.7549-001  3.4384+000  5.3330+003  5.3588+003  9.9930-001
16   5.8904+016  1.5338+017  3.7494-001  3.4160+000  5.3327+003  5.3396+003  9.9981-001
17   5.9981+016  1.5688+017  3.7341-001  3.4137+000  5.3696+003  5.3643+003  1.0001+000
18   6.2430+016  1.6497+017  3.6995-001  3.4043+000  5.4529+003  5.4159+003  1.0010+000
19   6.6189+016  1.7661+017  3.6648-001  3.4349+000  5.5651+003  5.5231+003  1.0011+000
20   7.1248+016  1.9306+017  3.6123-001  3.4446+000  5.7164+003  5.6396+003  1.0019+000
21   7.7139+016  2.1173+017  3.5676-001  3.4903+000  5.8754+003  5.7940+003  1.0020+000
22   8.4852+016  2.3745+017  3.5037-001  3.5073+000  6.0800+003  5.9542+003  1.0030+000
23   9.4051+016  2.6707+017  3.4532-001  3.5862+000  6.2953+003  6.1805+003  1.0026+000
24   1.0242+017  2.9921+017  3.3667-001  3.5428+000  6.3355+003  6.1674+003  1.0038+000
25   1.1940+017  3.5906+017  3.2566-001  3.6006+000  6.3701+003  6.2475+003  1.0028+000
26   1.1787+017  3.4894+017  3.2956-001  3.6981+000  6.3634+003  6.3360+003  1.0006+000
27   1.0616+017  3.0624+017  3.3841-001  3.7010+000  6.3368+003  6.3205+003  1.0003+000
28   9.9256+016  2.8315+017  3.4290-001  3.6579+000  6.3201+003  6.2691+003  1.0011+000
29   9.8493+016  2.8117+017  3.4292-001  3.6357+000  6.3168+003  6.2470+003  1.0015+000
30   1.0004+017  2.8673+017  3.4152-001  3.6337+000  6.3179+003  6.2476+003  1.0015+000
31   1.0163+017  2.9263+017  3.3998-001  3.6279+000  6.3185+003  6.2447+003  1.0016+000
32   1.0524+017  3.0569+017  3.3697-001  3.6267+000  6.3229+003  6.2492+003  1.0016+000
33   1.0830+017  3.1714+017  3.3428-001  3.6181+000  6.3250+003  6.2457+003  1.0016+000
34   1.1107+017  3.2735+017  3.3209-001  3.6158+000  6.3245+003  6.2474+003  1.0016+000
35   1.1422+017  3.3948+017  3.2936-001  3.6027+000  6.3232+003  6.2394+003  1.0016+000
36   1.1889+017  3.5719+017  3.2579-001  3.5940+000  6.3218+003  6.2373+003  1.0016+000
37   1.2497+017  3.8129+017  3.2096-001  3.5684+000  6.3198+003  6.2207+003  1.0018+000
```

```
38   1.2415+017  4.2540+017  2.9676-001  2.8089+000  6.3220+003  5.4618+003  1.0006+000
39   8.5368+016  4.5306+017  2.0950-001  6.8647-001  5.4641+003  2.4169+003  8.0376-001
40   3.3687+015  3.9150+017  9.8437-003  6.0288-004  3.9633+002  3.0129+001  1.1404+000
41   6.2564+014  3.6510+017  1.8307-003  2.8933-005  1.4557+002  3.7493+000  1.2970+000
42   5.6804+008  3.6267+017  3.7122-009  3.0289-008  1.0968+002  3.8381-002  1.5781+000
43   2.8698+005  3.6673+017  7.9236-013  4.0624-010  6.4555+001  1.4022-003  2.0169+000
44   2.4414+005  3.5904+017  6.8554-013  3.9678-010  4.1715+001  1.4022-003  2.3059+000
45   2.2378+005  3.5676+017  6.3130-013  3.9372-010  3.6199+001  1.4022-003  2.4954+000
46   2.0384+005  3.5645+017  5.7521-013  3.9269-010  3.4610+001  1.4022-003  2.6054+000
47   1.8298+005  3.6108+017  5.0896-013  3.7662-010  1.8060+001  1.4022-003  2.9395+000
48   1.7450+005  3.5748+017  4.8998-013  3.7667-010  1.7666+001  1.4022-003  3.0534+000
49   1.7096+005  3.6167+017  4.7450-013  3.7602-010  1.7665+001  1.4022-003  3.0947+000
50   1.6838+005  3.7259+017  4.5355-013  3.6881-010  1.3847+001  1.4022-003  3.1860+000


SHORT EDIT
TOTAL ENERGY RADIATED TO THE WALL(J)..........  2.3+006
ENERGY RADIATED TO THE WALL ON THIS TIME STEP.  6.6+004
PRESSURE AT THE WALL(J/CM3)...................  1.2-002
HEAT FLUX AT THE WALL(J/CM2-S)................  1.4+004


               1       8      15      22      29      36      43      50
 RADIUS   9.7+000 2.4+001 5.1+001 8.6+001 1.3+002 2.0+002 2.6+002 3.0+002
VELOCITY  1.9+004-2.2+004-7.0+004 6.8+004 6.1+004 9.2+004 1.2+004 0.0-001
 I TEMP   1.2+000 1.2+000 1.2+000 1.2+000 1.2+000 1.2+000 3.5-001 2.0-001
 R TEMP   1.2+000 1.2+000 1.2+000 1.2+000 1.2+000 1.2+000 7.1-001 6.4-001
 P  MFP   6.4+003 6.3+003 5.3+003 6.1+003 6.3+003 6.3+003 6.5+001 1.4+001
 R  MFP   3.6+000 3.7+000 3.4+000 3.5+000 3.6+000 3.6+000 4.1-010 3.7-010


ENERGY CONSERVATION

      INT ENE + KIN ENE = RHS =     INT ENE O-T BDFLUX +T SOURCE+-T I->R EX

   R    1.5+003             9.9+002   1.1-001   2.3+006   0.0-001  -2.3+006
   I    2.2+007   4.6+005   2.2+007   2.1+007   6.2-005   2.8+006   2.3+006
   T    2.3+007             2.2+007
```

```
 CYCLE       TIME(S)       DELTA T(S)       CRITERION( V/V) IN ZONE (23) OTHERWISE ( V/V) IN ZONE (23)
   802       1.5033-003    3.7295-006

 #  RADIUS      ZONE WIDTH   MASS DENS    COMPRESSION VELOCITY     R TEMP       ION TEMP     R PRESS      ION PRESS    ART VISC
    (CM)        (CM)         (G/CM3)      (V0/V)      (CM/S)       (EV)         (EV)         (J/CM3)      (J/CM3)      (J/CM3)

 0  0.0000-001                                        0.0000-001
 1  1.4478+001  1.4478+001   8.3644-006   2.1089-002  6.7111+003   4.3444-001   6.2609-001   1.6283-007   1.2664-002   0.0000-001
 2  1.8277+001  3.7993+000   8.2659-006   3.5057-001  4.5469+003   4.3444-001   6.2493-001   1.6283-007   1.2491-002   0.0000-001
 3  2.0934+001  2.6564+000   8.2742-006   3.5093-001  3.5552+003   4.3444-001   6.2500-001   1.6283-007   1.2505-002   0.0000-001
 4  2.3503+001  2.5698+000   8.2890-006   3.5155-001  3.5799+003   4.3444-001   6.2510-001   1.6283-007   1.2529-002   0.0000-001
 5  2.6072+001  2.5685+000   8.2916-006   3.5166-001  4.2949+003   4.3444-001   6.2502-001   1.6283-007   1.2532-002   0.0000-001
 6  2.8696+001  2.6245+000   8.2732-006   3.5088-001  4.8667+003   4.3444-001   6.2468-001   1.6283-007   1.2497-002   0.0000-001
 7  3.1419+001  2.7221+000   8.2378-006   3.4938-001  4.9238+003   4.3444-001   6.2410-001   1.6283-007   1.2431-002   0.0000-001
 8  3.4271+001  2.8519+000   8.1931-006   3.4749-001  4.4237+003   4.3444-001   6.2337-001   1.6283-007   1.2349-002   0.0000-001
 9  3.7271+001  3.0009+000   8.1676-006   3.4640-001  3.4583+003   4.3444-001   6.2283-001   1.6283-007   1.2299-002   1.5216-006
10  4.0433+001  3.1617+000   8.1760-006   3.4676-001  2.6225+003   4.3444-001   6.2263-001   1.6283-007   1.2308-002   1.1418-006
11  4.3769+001  3.3363+000   8.2096-006   3.4819-001  2.2295+003   4.3444-001   6.2267-001   1.6283-007   1.2359-002   2.5343-007
12  4.7309+001  3.5392+000   8.2296-006   3.4903-001  1.9045+003   4.3444-001   6.2248-001   1.6283-007   1.2386-002   1.7384-007
13  5.1086+001  3.7778+000   8.2185-006   3.4856-001  1.2766+003   4.3444-001   6.2185-001   1.6283-007   1.2356-002   6.4765-007
14  5.5105+001  4.0188+000   8.2524-006   3.5000-001  3.2780+002   4.3444-001   6.2153-001   1.6283-007   1.2401-002   1.4849-006
15  5.9331+001  4.2259+000   8.4080-006   3.5660-001 -7.8838+002   4.3444-001   6.2272-001   1.6283-007   1.2660-002   2.0933-006
16  6.3785+001  4.4542+000   8.5746-006   3.6367-001 -2.1903+003   4.3444-001   6.2377-001   1.6283-007   1.2933-002   3.3671-006
17  6.8529+001  4.7433+000   8.6735-006   3.6786-001 -2.3871+003   4.3444-001   6.2428-001   1.6283-007   1.3094-002   6.7166-008
18  7.3559+001  5.0301+000   8.8242-006   3.7425-001 -3.2412+003   4.3444-001   6.2512-001   1.6283-007   1.3340-002   1.2865-006
19  7.8877+001  5.3185+000   9.0213-006   3.8261-001 -6.5376+003   4.3444-001   6.2656-001   1.6283-007   1.3671-002   1.9573-005
20  8.4396+001  5.5189+000   9.4283-006   3.9987-001 -2.0102+004   4.3444-001   6.3083-001   1.6283-007   1.4390-002   3.4503-004
21  8.9613+001  5.2167+000   1.0926-005   4.6342-001 -5.7803+004   4.3444-001   6.4598-001   1.6283-007   1.7102-002   3.0588-003
22  9.3961+001  4.3484+000   1.4655-005   6.2155-001 -1.0593+005   4.3444-001   6.7798-001   1.6283-007   2.4195-002   6.6270-003
23  9.7423+001  3.4622+000   2.1071-005   8.9366-001 -1.4402+005   4.3444-001   7.1265-001   1.6283-007   3.6859-002   5.9589-003
24  1.0047+002  3.0417+000   2.7910-005   1.1837+000 -1.5960+005   4.3444-001   7.3165-001   1.6283-007   5.0314-002   1.3344-003
25  1.0377+002  3.3026+000   3.0025-005   1.2734+000 -1.5106+005   4.3444-001   7.2668-001   1.6283-007   5.3647-002   4.3729-004
26  1.0778+002  4.0123+000   2.8657-005   1.2154+000 -1.3917+005   4.3444-001   7.1170-001   1.6283-007   4.9959-002   0.0000-001
27  1.1248+002  4.7002+000   2.8075-005   1.1907+000 -1.3019+005   4.3444-001   7.0121-001   1.6283-007   4.8113-002   4.5166-004
28  1.1787+002  5.3932+000   2.7831-005   1.1804+000 -1.2256+005   4.3444-001   6.9256-001   1.6283-007   4.7027-002   3.2358-004
29  1.2397+002  6.1010+000   2.7767-005   1.1777+000 -1.1680+005   4.3444-001   6.8532-001   1.6283-007   4.6370-002   1.8415-004
30  1.3070+002  6.7237+000   2.8268-005   1.1989+000 -1.1262+005   4.3444-001   6.8042-001   1.6283-007   4.6829-002   9.8141-005
31  1.3819+002  7.4939+000   2.8306-005   1.2005+000 -1.0274+005   4.3444-001   6.7563-001   1.6283-007   4.6528-002   5.5227-004
32  1.4672+002  8.5324+000   2.7547-005   1.1683+000 -9.1442+004   4.3444-001   6.6691-001   1.6283-007   4.4648-002   7.0343-004
33  1.5632+002  9.5928+000   2.6946-005   1.1428+000 -8.1139+004   4.3443-001   6.5872-001   1.6280-007   4.3097-002   5.7188-004
34  1.6701+002  1.0692+001   2.6422-005   1.1206+000 -7.1655+004   4.3427-001   6.5287-001   1.6258-007   4.1859-002   4.7508-004
35  1.7880+002  1.1792+001   2.6056-005   1.1051+000 -6.1225+004   4.3344-001   6.4616-001   1.6133-007   4.0830-002   0.0000-001
36  1.9153+002  1.2731+001   2.4533-005   1.0405+000 -5.6956+004   4.3099-001   6.3600-001   1.5772-007   3.7809-002   8.9363-005
37  2.0359+002  1.2058+001   2.3470-005   9.9541-001 -5.1169+004   4.2597-001   6.2611-001   1.5049-007   3.5585-002   1.5710-004
38  2.1479+002  1.1202+001   2.2534-005   9.5573-001 -4.6563+004   4.1587-001   6.1584-001   1.3672-007   3.3585-002   9.5591-005
39  2.2521+002  1.0415+001   2.1914-005   9.2943-001 -3.8777+004   3.9861-001   6.0769-001   1.1540-007   3.2215-002   0.0000-001
40  2.3463+002  9.4236+000   2.2177-005   9.4057-001 -3.2492+004   3.8071-001   6.0418-001   9.6023-008   3.2406-002   0.0000-001
41  2.4354+002  8.9072+000   2.1699-005   9.2030-001 -2.9333+004   3.7335-001   5.9762-001   8.8809-008   3.1355-002   0.0000-001
42  2.5196+002  8.4245+000   2.1366-005   9.0616-001 -2.3640+004   3.7180-001   5.9182-001   8.7342-008   3.0566-002   0.0000-001
43  2.5960+002  7.6332+000   2.2124-005   9.3832-001 -1.7135+004   3.7152-001   5.9089-001   8.7080-008   3.1599-002   0.0000-001
44  2.6668+002  7.0801+000   2.2537-005   9.5586-001 -1.6145+004   3.7130-001   5.8753-001   8.6877-008   3.2002-002   0.0000-001
45  2.7344+002  6.7601+000   2.2411-005   9.5048-001 -1.5238+004   3.7128-001   5.8445-001   8.6862-008   3.1652-002   0.0000-001
46  2.7970+002  6.2588+000   2.3080-005   9.7886-001 -1.0532+004   3.7057-001   5.7787-001   8.6197-008   3.2208-002   0.0000-001
47  2.8529+002  5.5951+000   2.4745-005   1.0495+000 -6.0206+003   3.5929-001   5.4812-001   7.6172-008   3.2720-002   0.0000-001
```

```
48  2.9048+002  5.1930+000  2.5672-005  1.0888+000 -5.1941+003  3.5929-001  5.4075-001  7.6167-008  3.3488-002  0.0000-001
49  2.9545+002  4.9705+000  2.5899-005  1.0984+000 -3.4286+003  3.5859-001  5.2858-001  7.5579-008  3.3022-002  0.0000-001
50  3.0000+002  4.5463+000  2.7418-005  1.1628+000  0.0000-001  3.5381-001  4.9564-001  7.1632-008  3.2780-002  0.0000-001
                                                                2.5000-002  2.5000-002


 #  R ENERGY    ION ENERGY  KIN ENERGY  R SOURCE    ION SOURCE  ION->R EX   FLUX LIM    HEAT FLUX
    (J/     )   (J/     )   (J/     )   (J/     )   (J/     )   (J/     )   (J/CM2-S)   (J/CM2-S)
 0                          0.0000-001
 1  6.2096-003  2.9578+002  2.3944-001  0.0000-001  0.0000-001  2.4023-001  3.7091+003  1.2820+001
 2  6.2836-003  2.9374+002  1.0991-001  0.0000-001  0.0000-001  2.2940-001  3.7091+003  1.5398+001
 3  6.2773-003  2.9387+002  7.5401-002  0.0000-001  0.0000-001  2.2973-001  3.7091+003  1.7432+001
 4  7.7959-003  3.6584+002  9.5115-002  0.0000-001  0.0000-001  2.8747-001  3.7091+003  1.9563+001
 5  9.6962-003  4.5495+002  1.7033-001  0.0000-001  0.0000-001  3.5779-001  3.7091+003  2.1710+001
 6  1.2090-002  5.6488+002  2.7209-001  0.0000-001  0.0000-001  4.4056-001  3.7091+003  2.3773+001
 7  1.5107-002  7.0040+002  3.4651-001  0.0000-001  0.0000-001  5.3798-001  3.7091+003  2.5740+001
 8  1.8897-002  8.6765+002  3.4798-001  0.0000-001  0.0000-001  6.5379-001  3.7091+003  2.7631+001
 9  2.3584-002  1.0760+003  2.6460-001  0.0000-001  0.0000-001  7.9896-001  3.7091+003  2.9556+001
10  2.9312-002  1.3372+003  1.8930-001  0.0000-001  0.0000-001  9.8830-001  3.7091+003  3.1674+001
11  3.6319-002  1.6642+003  1.7023-001  0.0000-001  0.0000-001  1.2323+000  3.7091+003  3.4026+001
12  4.5076-002  2.0684+003  1.5453-001  0.0000-001  0.0000-001  1.5249+000  3.7091+003  3.6516+001
13  5.6157-002  2.5640+003  8.6391-002  0.0000-001  0.0000-001  1.8609+000  3.7091+003  3.9029+001
14  6.9580-002  3.1844+003  7.0863-003  0.0000-001  0.0000-001  2.2913+000  3.7091+003  4.1683+001
15  8.4965-002  3.9905+003  5.0997-002  0.0000-001  0.0000-001  2.9483+000  3.7091+003  4.4968+001
16  1.0365-001  4.9971+003  4.8971-001  0.0000-001  0.0000-001  3.7779+000  3.7091+003  4.9016+001
17  1.2749-001  6.2372+003  7.2369-001  0.0000-001  0.0000-001  4.7830+000  3.7091+003  5.3612+001
18  1.5591-001  7.8002+003  1.6600+000  0.0000-001  0.0000-001  6.0873+000  3.7091+003  5.8590+001
19  1.8973-001  9.7903+003  8.4022+000  0.0000-001  0.0000-001  7.8566+000  3.7091+003  6.3773+001
20  2.2586-001  1.2494+004  9.8829+001  0.0000-001  0.0000-001  1.0825+001  3.7091+003  6.8091+001
21  2.4248-001  1.6988+004  1.0167+003  0.0000-001  0.0000-001  1.9407+001  3.7091+003  7.7221+001
22  2.2492-001  2.5349+004  4.2482+003  0.0000-001  0.0000-001  5.4141+001  3.7091+003  1.2167+002
23  1.9463-001  3.7314+004  9.7693+003  0.0000-001  0.0000-001  1.6179+002  3.7091+003  2.7830+002
24  1.8281-001  4.9227+004  1.4927+004  0.0000-001  0.0000-001  3.3362+002  3.7091+003  6.6625+002
25  2.1142-001  5.9318+004  1.6637+004  0.0000-001  0.0000-001  3.9417+002  3.7091+003  1.2287+003
26  2.7559-001  6.9147+004  1.7568+004  0.0000-001  0.0000-001  3.4454+002  3.7091+003  1.6982+003
27  3.4998-001  8.1975+004  1.9128+004  0.0000-001  0.0000-001  3.2949+002  3.7091+003  2.0448+003
28  4.3925-001  9.7852+004  2.1090+004  0.0000-001  0.0000-001  3.2982+002  3.7091+003  2.3204+003
29  5.4774-001  1.1748+005  2.3829+004  0.0000-001  0.0000-001  3.4096+002  3.7091+003  2.5497+003
30  6.6938-001  1.4240+005  2.7567+004  0.0000-001  0.0000-001  3.7370+002  3.7091+003  2.9607+003
31  8.3171-001  1.7295+005  2.8543+004  0.0000-001  0.0000-001  4.1425+002  3.7091+003  3.6211+003
32  1.0632+000  2.0631+005  2.8129+004  0.0000-001  0.0000-001  4.1119+002  3.7088+003  3.7055+003
33  1.3522+000  2.4648+005  2.7554+004  0.0000-001  0.0000-001  4.1142+002  3.7058+003  3.7055+003
34  1.7132+000  2.9781+005  2.6736+004  0.0000-001  0.0000-001  4.3705+002  3.6877+003  3.6877+003
35  2.1449+000  3.5792+005  2.3437+004  0.0000-001  0.0000-001  4.5341+002  3.6269+003  3.6269+003
36  2.5964+000  3.9643+005  2.2178+004  0.0000-001  0.0000-001  3.9663+002  3.4884+003  3.4884+003
37  2.6710+000  3.8805+005  1.8177+004  0.0000-001  0.0000-001  3.0952+002  3.2211+003  3.2211+003
38  2.5273+000  3.6686+005  1.5052+004  0.0000-001  0.0000-001  2.2963+002  2.7961+003  2.7961+003
39  2.1935+000  3.5040+005  1.0439+004  0.0000-001  0.0000-001  1.8110+002  2.3423+003  2.3423+003
40  1.8036+000  3.4320+005  7.3292+003  0.0000-001  0.0000-001  1.6297+002  2.0684+003  2.0684+003
41  1.7048+000  3.3044+005  5.9735+003  0.0000-001  0.0000-001  1.3307+002  1.9832+003  1.9832+003
42  1.7028+000  3.1936+005  3.8798+003  0.0000-001  0.0000-001  1.1171+002  1.9660+003  1.9660+003
43  1.6395+000  3.1738+005  2.0383+003  0.0000-001  0.0000-001  1.0881+002  1.9611+003  1.9611+003
44  1.6057+000  3.1098+005  1.8096+003  0.0000-001  0.0000-001  9.7158+001  1.9588+003  1.9587+003
45  1.6145+000  3.0532+005  1.6120+003  0.0000-001  0.0000-001  8.8162+001  1.9510+003  1.9510+003
46  1.5557+000  2.9864+005  7.7006+002  0.0000-001  0.0000-001  7.2346+001  1.8311+003  1.8311+003
47  1.2822+000  2.8178+005  2.5165+002  0.0000-001  0.0000-001  2.2414+001  1.7188+003  1.7188+003
48  1.2359+000  2.7758+005  1.8730+002  0.0000-001  0.0000-001  1.5977+001  1.7122+003  1.7122+003
```

```
49  1.2156+000  2.7080+005  8.1612+001  0.0000-001  0.0000-001  9.5485+000  1.6612+003  1.6612+003
50  1.0883+000  2.5247+005  0.0000-001  0.0000-001  0.0000-001  2.1127+000  1.6167+003  1.6167+003

                            ENERGY CONSERVATION CHECK -- UNITS ARE (J/     )

    INT ENE     T KE        INT ENE(0)  T BDFLUX    T I->R EX   T SOURCE    BDFLUX      I->R EX     SOURCE

R   3.8110+001              1.1354-001  1.7787+007  1.7789+007  0.0000-001  6.7982+003  6.7981+003  0.0000-001
I   6.8493+006  3.8007+005  2.1144+007  7.6248-001              2.8222+006  6.6877-004              0.0000-001

                            RADIATION     3.8110+001     -4.5919+002
                            ION           7.2293+006      6.1791+006
                            TOTAL         7.2294+006      6.1786+006

 #  E DENSITY   ION DENSITY CHARGE      ROSS OPC    PLK OPC     EQM T OPC    EPSILON
    (1/CM3)     (1/CM3)     (ESU)       (CM2/G)     (CM2/G)   (CM2/G)

 1  3.2239+014  1.2595+017  2.5164-003  1.0777-004  5.1778-002  9.4291+000  6.9390-001
 2  3.0441+014  1.2446+017  2.4361-003  1.0372-004  5.0491-002  9.1879+000  6.9519-001
 3  3.0519+014  1.2459+017  2.4417-003  1.0398-004  5.0574-002  9.2034+000  6.9510-001
 4  3.0767+014  1.2481+017  2.4498-003  1.0432-004  5.0683-002  9.2239+000  6.9499-001
 5  3.0817+014  1.2485+017  2.4463-003  1.0405-004  5.0596-002  9.2076+000  6.9508-001
 6  3.0467+014  1.2457+017  2.4251-003  1.0287-004  5.0220-002  9.1370+000  6.9546-001
 7  2.9822+014  1.2404+017  2.3890-003  1.0093-004  4.9596-002  9.0201+000  6.9610-001
 8  2.9028+014  1.2337+017  2.3439-003  9.8519-005  4.8816-002  8.8738+000  6.9692-001
 9  2.8483+014  1.2298+017  2.3122-003  9.6749-005  4.8239-002  8.7657+000  6.9753-001
10  2.8414+014  1.2311+017  2.3045-003  9.6116-005  4.8033-002  8.7270+000  6.9775-001
11  2.8670+014  1.2362+017  2.3131-003  9.6236-005  4.8075-002  8.7348+000  6.9770-001
12  2.8678+014  1.2392+017  2.3081-003  9.5633-005  4.7879-002  8.6980+000  6.9791-001
13  2.8208+014  1.2375+017  2.2758-003  9.3649-005  4.7227-002  8.5757+000  6.9862-001
14  2.8187+014  1.2426+017  2.2674-003  9.2647-005  4.6898-002  8.5140+000  6.9898-001
15  2.9814+014  1.2660+017  2.3552-003  9.6341-005  4.8121-002  8.7435+000  6.9766-001
16  3.1484+014  1.2911+017  2.4410-003  9.9735-005  4.9233-002  8.9521+000  6.9648-001
17  3.2538+014  1.3060+017  2.4873-003  1.0144-004  4.9788-002  9.0562+000  6.9591-001
18  3.4043+014  1.3287+017  2.5614-003  1.0426-004  5.0697-002  9.2266+000  6.9498-001
19  3.6233+014  1.3584+017  2.6798-003  1.0933-004  5.2311-002  9.5292+000  6.9337-001
20  4.1733+014  1.4197+017  3.0132-003  1.2575-004  5.7360-002  1.0475+001  6.8868-001
21  6.8004+014  1.6453+017  4.4731-003  2.0471-004  7.9130-002  1.4534+001  6.7253-001
22  1.8773+015  2.2067+017  9.5170-003  5.4914-004  1.5243-001  2.7935+001  6.4079-001
23  5.2962+015  3.1727+017  1.7575-002  1.4577-003  2.9976-001  5.3754+001  6.0961-001
24  8.8704+015  4.2026+017  2.1419-002  2.3066-003  4.2826-001  7.5311+001  5.9378-001
25  8.9064+015  4.5210+017  1.9303-002  1.9746-003  3.9042-001  6.9043+001  5.9785-001
26  6.7987+015  4.3150+017  1.5478-002  1.3189-003  2.9435-001  5.2827+001  6.1043-001
27  5.6271+015  4.2274+017  1.3166-002  9.8526-004  2.4069-001  4.3563+001  6.1956-001
28  4.8413+015  4.1906+017  1.1465-002  7.7025-004  2.0341-001  3.7025+001  6.2729-001
29  4.2764+015  4.1810+017  1.0179-002  6.2456-004  1.7640-001  3.2232+001  6.3392-001
30  3.9778+015  4.2565+017  9.3162-003  5.3921-004  1.6002-001  2.9302+001  6.3849-001
31  3.6862+015  4.2621+017  8.5913-003  4.6819-004  1.4541-001  2.6672+001  6.4302-001
32  3.1245+015  4.1480+017  7.4841-003  3.6273-004  1.2192-001  2.2409+001  6.5143-001
33  2.6742+015  4.0573+017  6.5565-003  2.8428-004  1.0313-001  1.8969+001  6.5950-001
34  2.3847+015  3.9785+017  5.9666-003  2.3835-004  9.1329-002  1.6801+001  6.6518-001
35  2.1024+015  3.9234+017  5.3330-003  1.9412-004  7.9023-002  1.4591+001  6.7079-001
36  1.6862+015  3.6940+017  4.5569-003  1.4217-004  6.2036-002  1.1729+001  6.7767-001
37  1.3741+015  3.5340+017  3.8794-003  1.0428-004  4.6110-002  9.4347+000  6.8034-001
```

```
 38  1.1103+015  3.3931+017  3.2665-003  7.5153-005  3.0632-002  7.4819+000  6.7529-001
 39  9.4027+014  3.2997+017  2.8389-003  5.7911-005  1.7294-002  6.1968+000  6.5595-001
 40  8.8664+014  3.3393+017  2.6455-003  5.2108-005  8.4616-003  5.7066+000  6.3013-001
 41  7.7180+014  3.2673+017  2.3578-003  4.1809-005  7.0324-003  4.8831+000  6.2472-001
 42  6.8601+014  3.2171+017  2.1239-003  3.4319-005  5.9606-003  4.2449+000  6.2822-001
 43  6.8906+014  3.3313+017  2.0573-003  3.3218-005  5.8035-003  4.1496+000  6.2874-001
 44  6.5024+014  3.3936+017  1.9140-003  2.9590-005  5.2687-003  3.8217+000  6.3196-001
 45  6.1049+014  3.3745+017  1.8073-003  2.6607-005  4.8196-003  3.5417+000  6.3527-001
 46  4.3056+014  3.4752+017  1.1197-003  1.9674-005  4.4077-003  2.9349+000  6.4127-001
 47  2.2207+013  3.7260+017  5.3986-005  4.0177-006  3.7389-003  1.1229+000  6.5550-001
 48  9.7350+012  3.8656+017  2.4729-005  2.6731-006  3.5847-003  8.7166-001  6.6442-001
 49  2.7552+012  3.8997+017  6.7667-006  1.3476-006  3.3394-003  5.6519-001  6.7841-001
 50  7.8586+010  4.1284+017  1.7302-007  1.9408-007  2.7333-003  1.5866-001  7.1385-001


SHORT EDIT
TOTAL ENERGY RADIATED TO THE WALL(J)..........  1.8+007
ENERGY RADIATED TO THE WALL ON THIS TIME STEP.  6.8+003
PRESSURE AT THE WALL(J/CM3)..................  3.3-002
HEAT FLUX AT THE WALL(J/CM2-S)...............  1.6+003


                1       8      15      22      29      36      43      50
 RADIUS   1.4+001 3.4+001 5.9+001 9.4+001 1.2+002 1.9+002 2.6+002 3.0+002
VELOCITY  6.7+003 4.4+003-7.9+002-1.1+005-1.2+005-5.7+004-1.7+004 0.0-001
 I TEMP   6.3-001 6.2-001 6.2-001 6.8-001 6.9-001 6.4-001 5.9-001 5.0-001
 R TEMP   4.3-001 4.3-001 4.3-001 4.3-001 4.3-001 4.3-001 3.7-001 3.5-001
 P   MFP  5.2-002 4.9-002 4.8-002 1.5-001 1.8-001 6.2-002 5.8-003 2.7-003
 R   MFP  1.1-004 9.9-005 9.6-005 5.5-004 6.2-004 1.4-004 3,3-005 1.9-007


ENERGY CONSERVATION

      INT ENE + KIN ENE = RHS =      INT ENE 0-T BDFLUX +T SOURCE+-T I->R EX

   R    3.8+001              -4.6+002   1.1-001    1.8+007    0.0-001   -1.8+007
   I    6.8+006    3.8+005    6.2+006   2.1+007    7.6-001    2.8+006    1.8+007
   T    7.2+006               6.2+006
```

```
MAX OVER-PRESSURE=  1.6030-001 (J/CM3)  TIME=  4.9540-004 (S)  CYCLE= 661


MAX HEAT FLUX=  7.6142+004 (J/CM2*S)   TIME=  9.5513-006 (S)   CYCLE= 465


PRESSURE AND HEAT FLUX AT THE FIRST WALL


TIME(S)
  1.0000-11   1.2062-10   6.5193-10   1.5070-09   2.1707-09   2.7694-09   3.3155-09   4.0224-09   4.6799-09   5.5559-09
  6.4066-09   7.9221-09   9.6365-09   1.3336-08   1.6750-08   2.3110-08   2.9458-08   3.8525-08   5.0206-08   6.6275-08
  8.6298-08   1.1284-07   1.4687-07   1.8741-07   2.3463-07   3.0039-07   3.6458-07   4.6762-07   5.6215-07   7.2852-07
  8.7178-07   1.0333-06   1.1824-06   1.3449-06   1.5261-06   1.7170-06   1.9676-06   2.2374-06   2.5983-06   2.9915-06
  3.5054-06   4.0979-06   4.8169-06   5.7608-06   6.9792-06   8.5854-06   1.0590-05   1.3381-05   1.6754-05   2.2070-05
  2.7724-05   3.6235-05   4.6078-05   5.7362-05   7.2114-05   8.7181-05   1.0292-04   1.2370-04   1.4825-04   1.7313-04
  2.0670-04   2.4860-04   3.0476-04   3.8218-04   4.4307-04   4.8711-04   5.6025-04   6.1559-04   6.7422-04   7.4108-04
  8.1515-04   9.1060-04   1.0176-03   1.1160-03   1.1976-03   1.2783-03   1.3476-03   1.4051-03   1.4542-03   1.4958-03
  0.0000

PRESSURE(J/CM3)
  1.0035-02   1.0035-02   1.0035-02   1.0035-02   1.0035-02   1.0035-02   1.0035-02   1.0035-02   1.0035-02   1.0035-02
  1.0035-02   1.0035-02   1.0035-02   1.0035-02   1.0035-02   1.0035-02   1.0035-02   1.0035-02   1.0035-02   1.0035-02
  1.0035-02   1.0035-02   1.0035-02   1.0035-02   1.0035-02   1.0035-02   1.0035-02   1.0035-02   1.0035-02   1.0035-02
  1.0036-02   1.0036-02   1.0037-02   1.0038-02   1.0038-02   1.0040-02   1.0040-02   1.0041-02   1.0042-02   1.0043-02
  1.0043-02   1.0043-02   1.0045-02   1.0045-02   1.0046-02   1.0047-02   1.0054-02   1.0057-02   1.0061-02   1.0070-02
  1.0081-02   1.0107-02   1.0154-02   1.0202-02   1.0318-02   1.0446-02   1.0594-02   1.0899-02   1.1416-02   1.1970-02
  1.3388-02   1.5943-02   2.2070-02   4.5115-02   8.8119-02   1.5757-01   9.9727-02   7.7527-02   6.7123-02   5.8872-02
  5.2923-02   4.7082-02   4.2738-02   3.9111-02   3.7852-02   3.7250-02   3.6540-02   3.5678-02   3.4680-02   3.3078-02
  0.0000

HEAT FLUX(J/CM2*S)
  1.4978+01   1.4903+01   1.4621+01   1.4207+01   1.3953+01   1.3635+01   1.3341+01   1.3005+01   1.2714+01   1.2439+01
  1.2242+01   1.2577+01   1.4063+01   4.0719+01   1.5854+02   1.6161+03   4.6524+03   6.7726+03   6.7800+03   6.3281+03
  6.5143+03   6.6822+03   6.9896+03   8.0549+03   8.2199+03   1.0379+04   9.2888+03   1.5037+04   6.2884+03   7.6627+03
  4.6565+03   7.5646+03   7.8969+03   1.6534+04   5.4774+03   7.1525+03   4.7186+03   1.9479+04   1.0229+04   4.5274+03
  2.5600+03   2.4852+04   9.0437+03   1.1735+03   1.0197+03   1.1879+04   1.0276+03   4.8142+03   1.8026+03   2.9120+04
  9.3662+03   2.8630+03   6.6935+03   8.9887+03   9.5354+02   1.4767+04   5.6288+03   2.7718+04   1.9759+04   1.7140+04
  1.7901+04   1.7908+04   2.5380+04   2.4170+04   2.2648+04   2.8355+04   2.2255+04   1.6128+04   1.1853+04   8.8331+03
  6.7380+03   4.8701+03   3.3023+03   2.5551+03   2.3012+03   2.0944+03   1.9002+03   1.7683+03   1.6814+03   1.6220+03
  0.0000


        DEBRIS SPECTRA
     NO. OF   ENERGY POSITION TIME OF
       IONS  PER ION           ARRIVAL
               (KEV)              (SEC)

  1 1.77+020 7.63+001 2.40-002 0.00-001

  TOTAL PROJECTILES =  1.77+020      TOTAL ENERGY LEFT =  2.16+000 MJ
@BRKPT PRINT$


***EOF***      170 PAGES COST     $5.10   PROJ BALANCE   $1364.62 USER BALANCE    $384.01
```

Figure 7. Positions of Lagrangian zone boundaries as functions of time for the example problem with two-temperature radiative transfer.

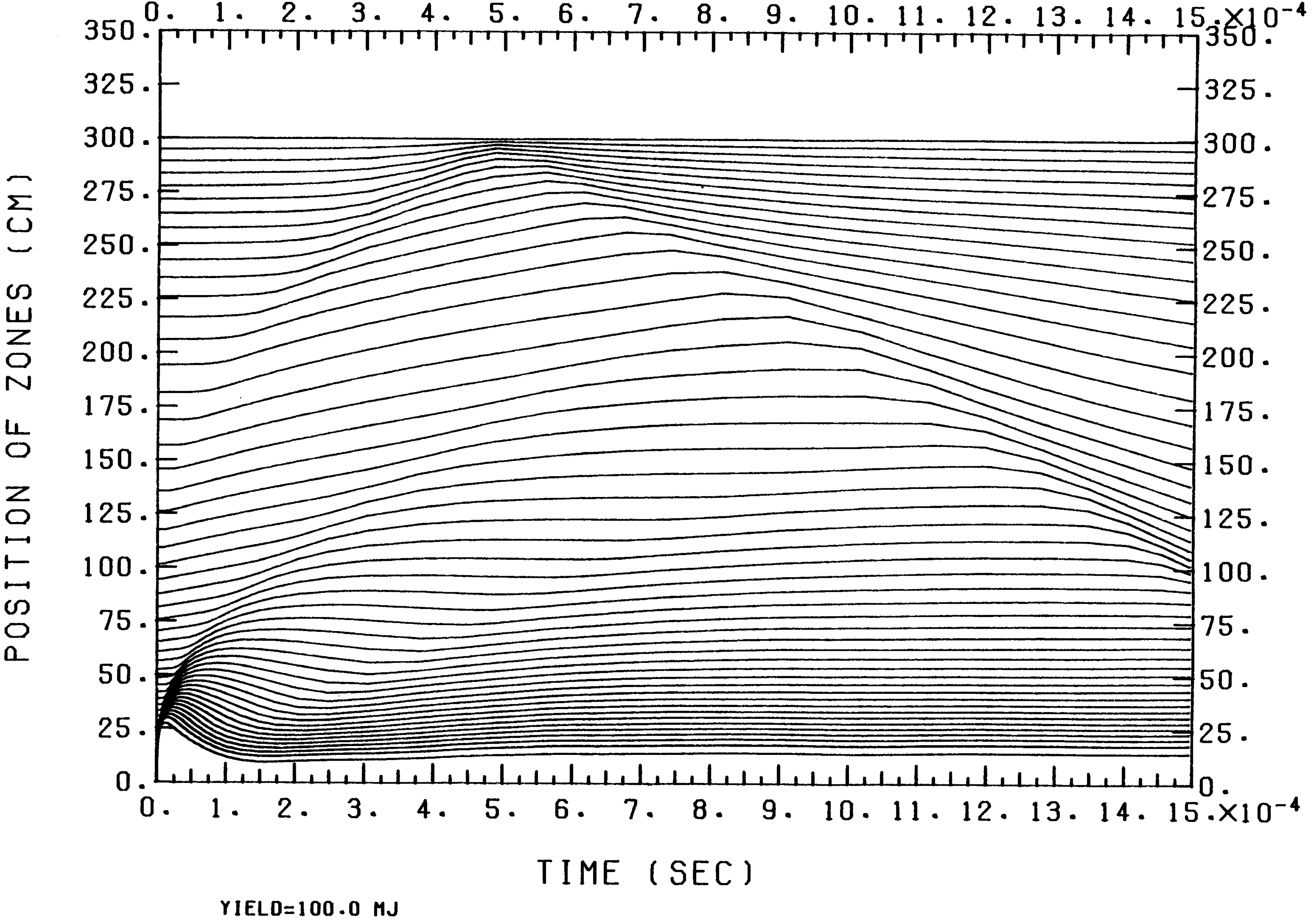


Figure 8. Gas pressure and heat flux versus time on the wall at the outer boundary of the gas for the example problem with two-temperature radiative transfer.

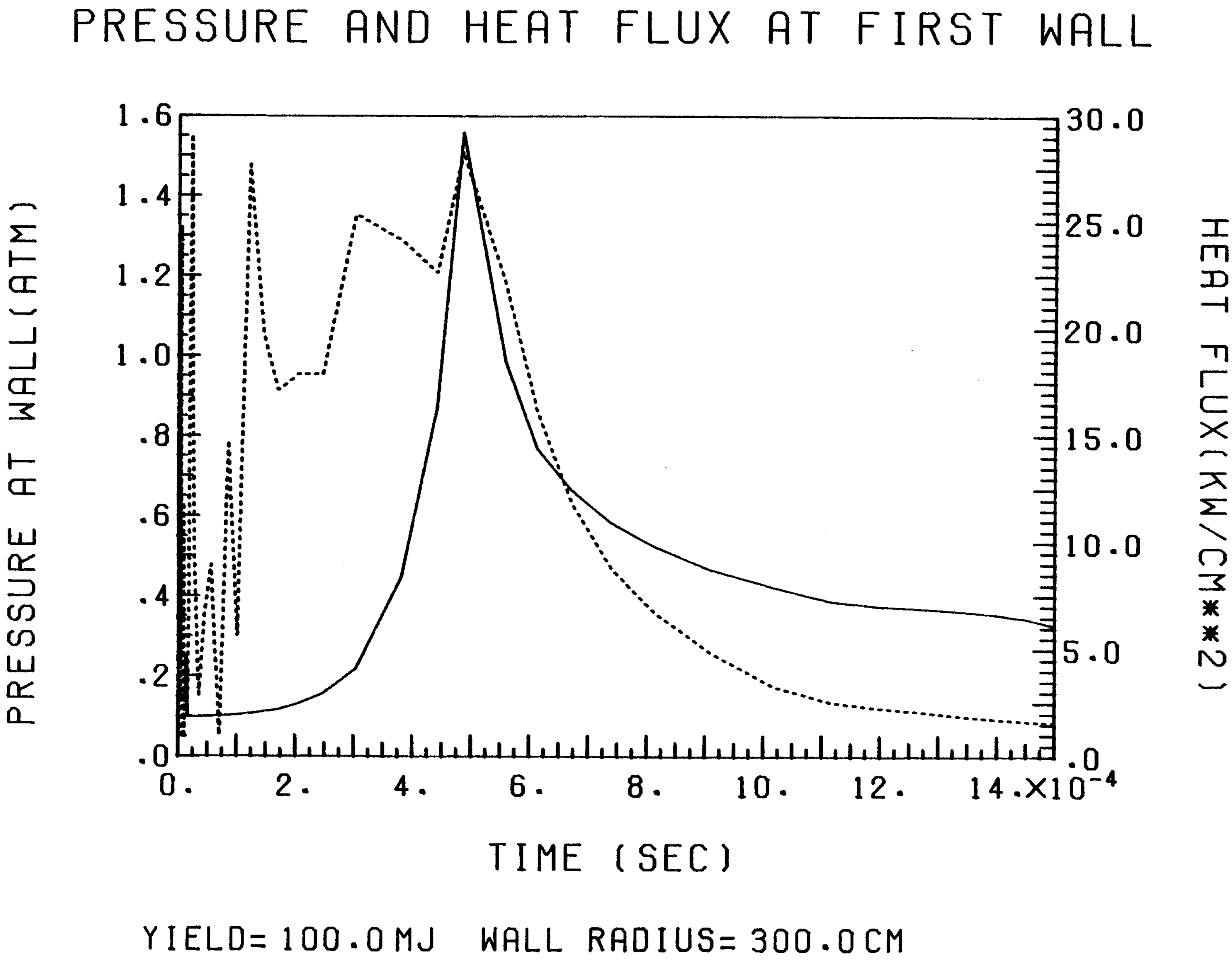


Figure 9. The gas pressure profile for the example problem with two-temperature radiative transfer.

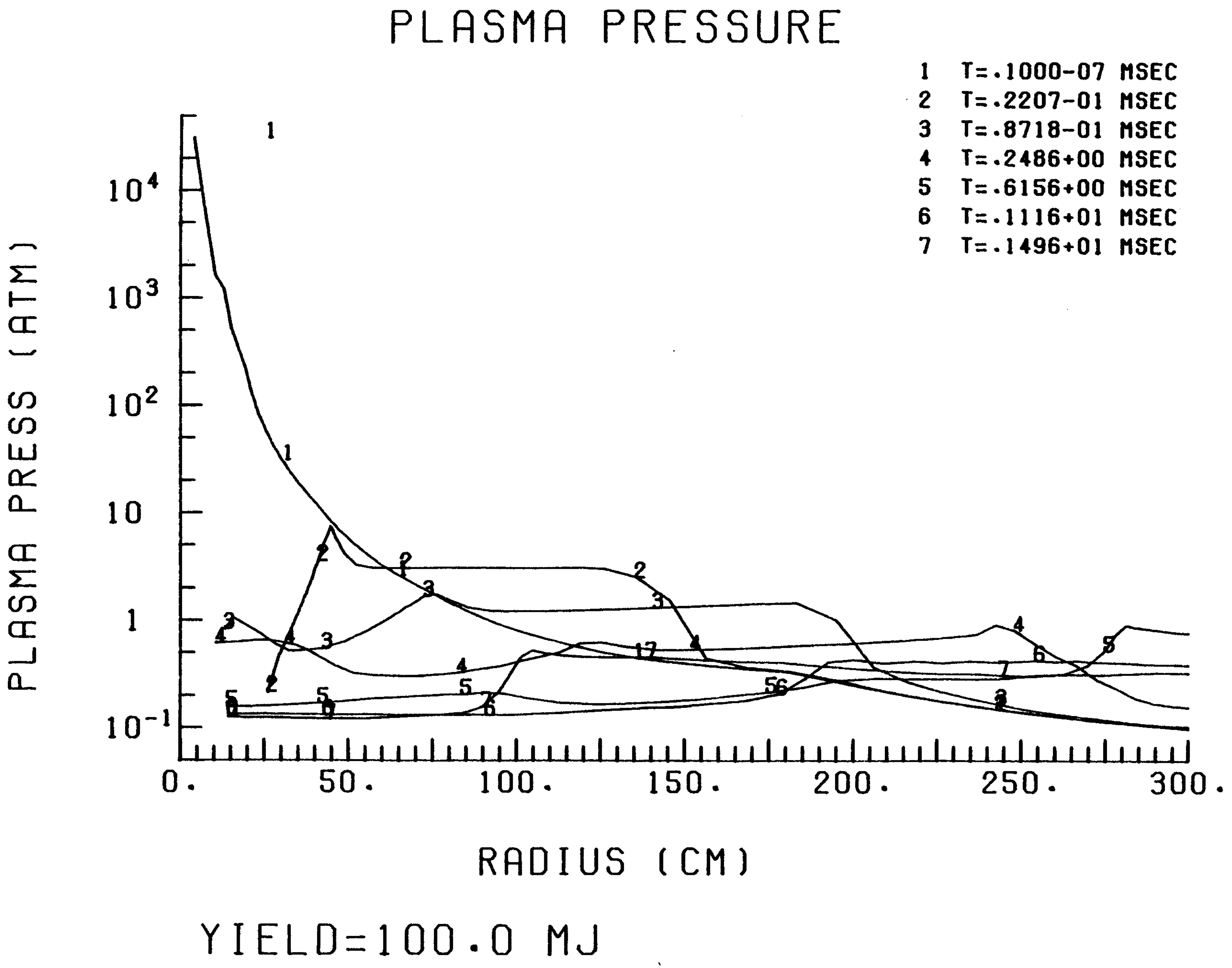


Figure 10. The gas temperature profile for the example problem with two-temperature radiative transfer.

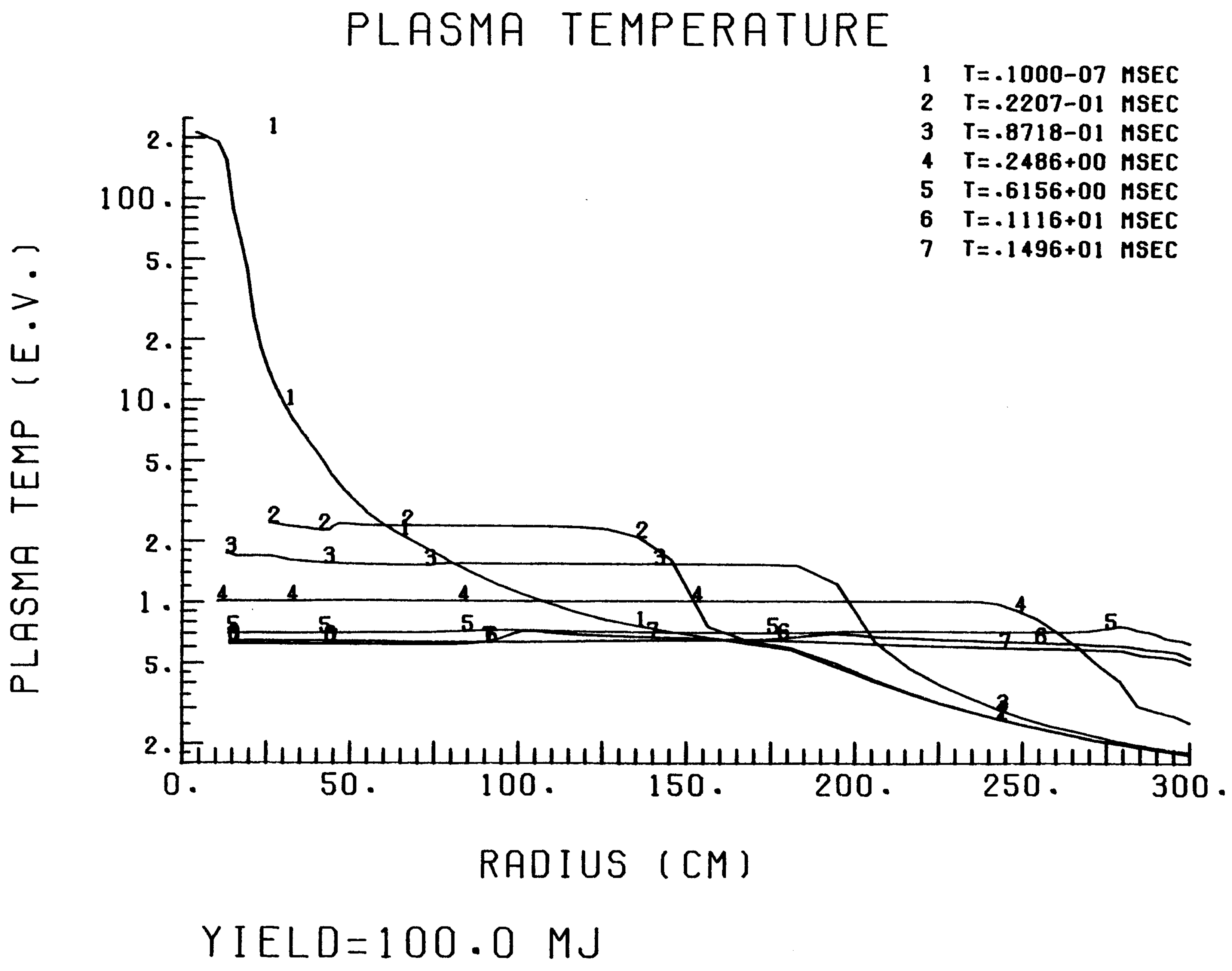


Figure 11. The radiation temperature profile for the example problem with two-temperature radiative transfer.

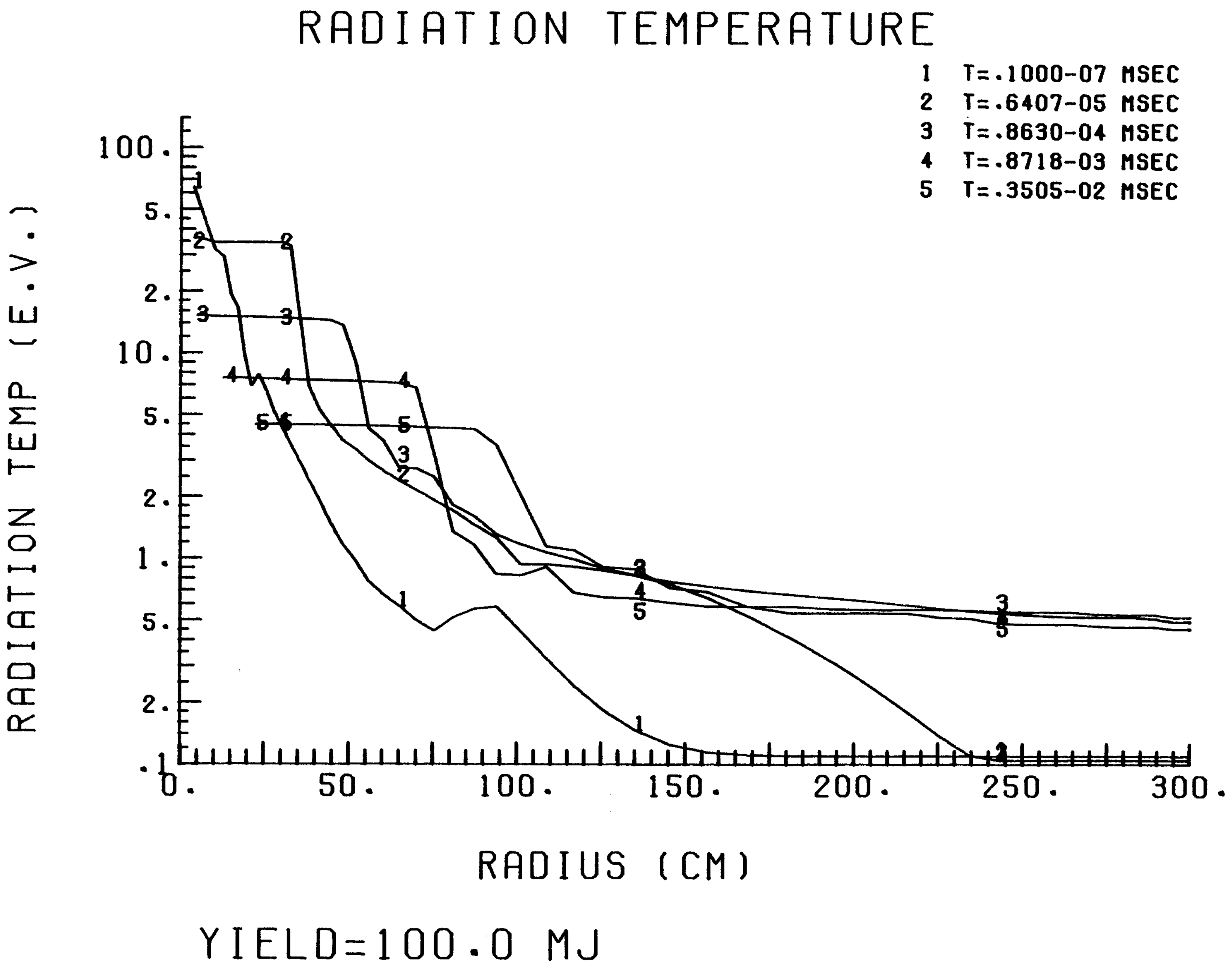


Figure 12. The mass density profiles at various times for the example problem with two-temperature radiative transfer.

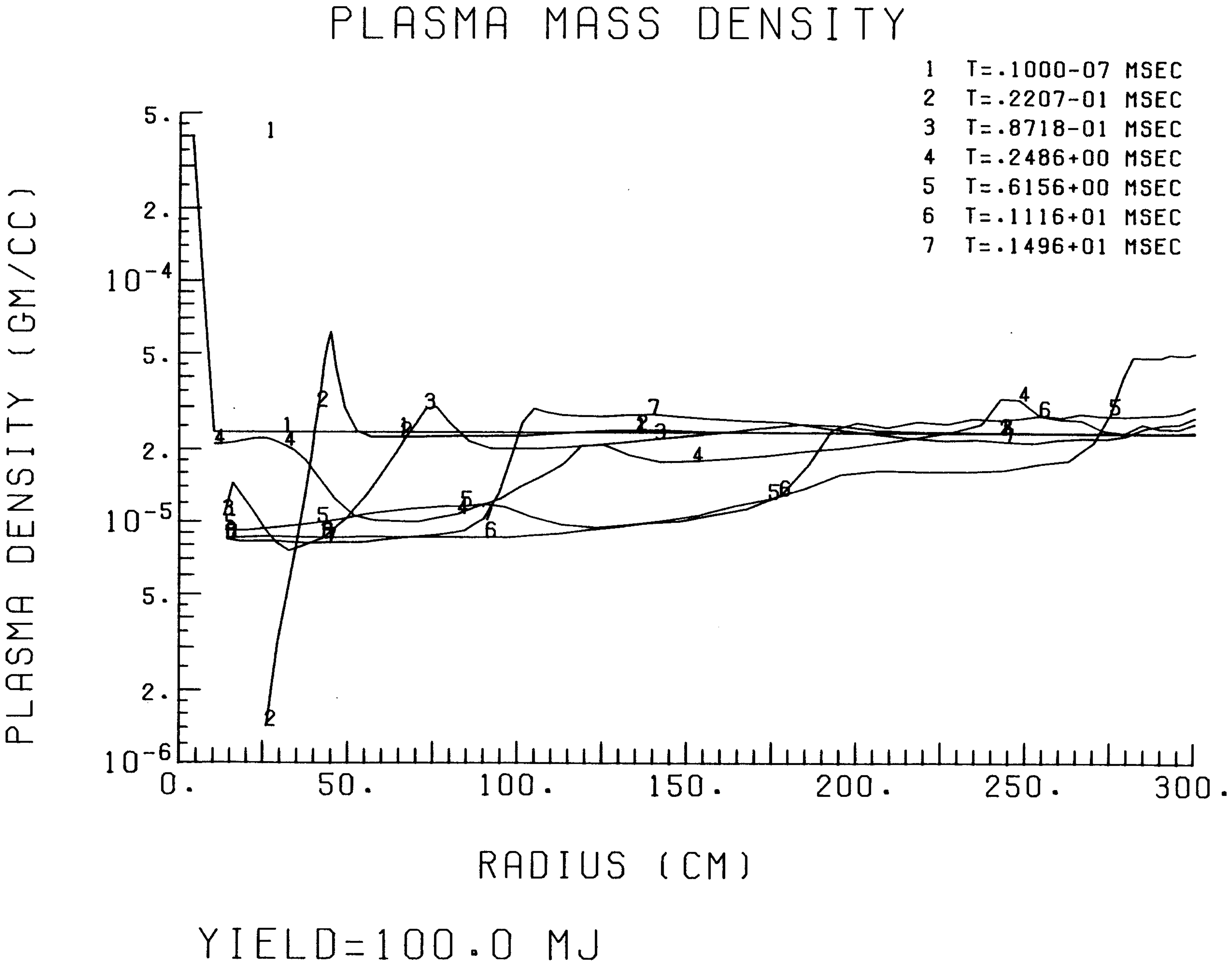


Figure 13. Profiles of the fluid velocity of the gas at various times for the example problem with two-temperature radiative transfer.

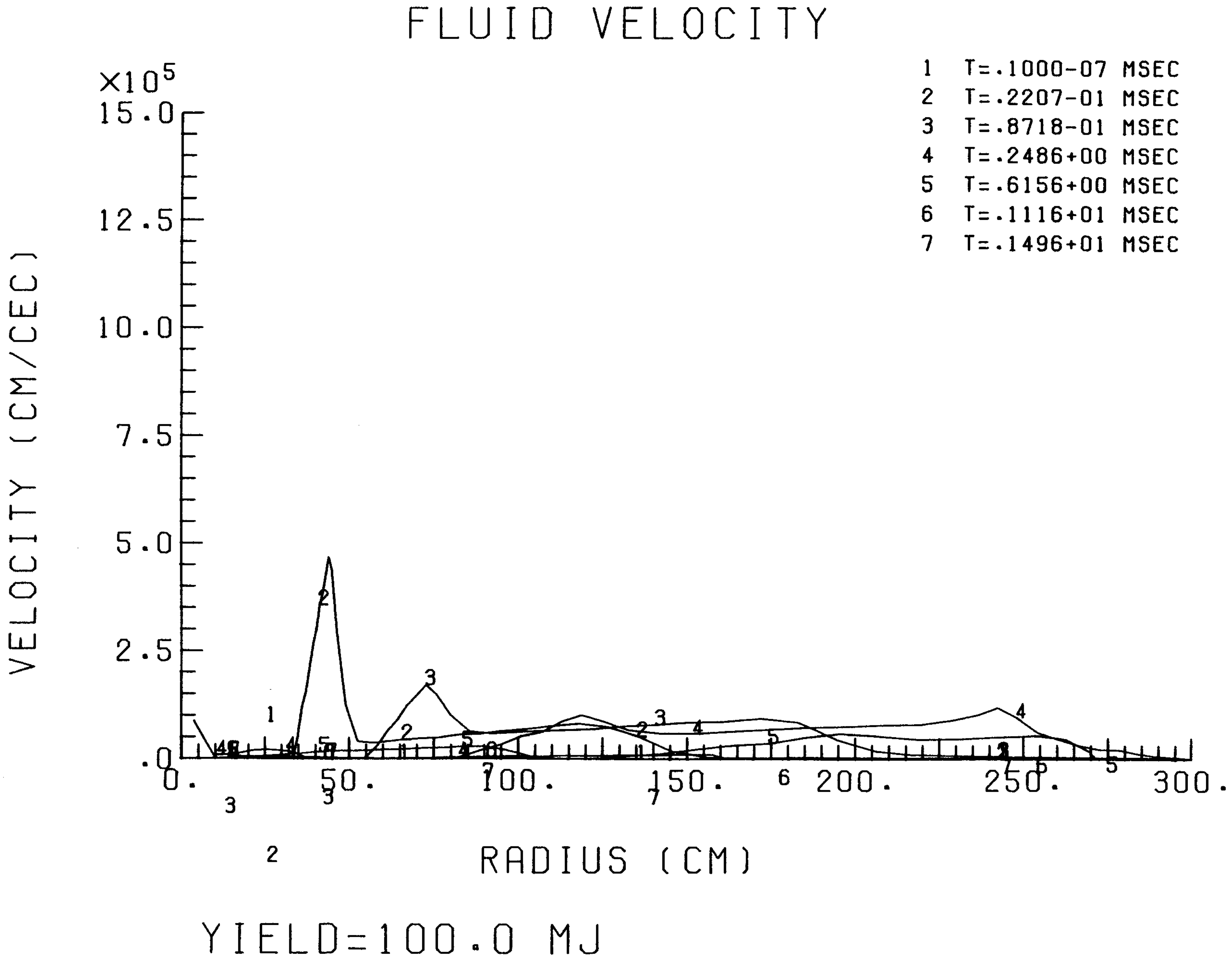


Figure 14. Printed output for the example problem with 20 group radiative transfer.

```
*  *  *  *  *  *  SPERRY 1180 TIME/SHARING EXEC --- MULTI-PROCESSOR SYSTEM --- VER.  MACC 38.19  SITE *  MACC      *  *  *  *  *  *
RUNID: XC2843        PROJECT: 12902        USER: 566804039          CREATED ON APR 11, 1984 AT 21:05:28   INPUT DEVICE:
            FILE NAME: FILE                     PART NUMBER: 01       PRINTED ON APR 11, 1984 AT 21:31:05   OUTPUT DEVICE: NAPR2


@ELT,L MFFIRE.LIBRA2
ELT 8R1-M1 S74Q1C 04/11/84 21:05:29 (4)
     1.          00       &INPUT
     2.          00         JMAX=50,
     3.          00         NMAX=10000,
     4.          00         TMAX=1.5D-3,
     5.          00         DN2B=50*3.55D17,
     6.          00         TN2C=50*.0925D0,
     7.          00         TR2C=50*.0925D0,
     8.          00         ATW2B=50*40.D0,
     9.          04         IO=5*200,
    10.          00         IOBIN=20,
    11.          00         NI=3,
    12.          00         RI=4.D0,
    13.          01         NO=15,
    14.          00         RO=294.7D0,
    15.          01         RADIUS=300.D0,
    16.          01         PMASS=0.1D0,
    17.          01         FLUX=22.D6,
    18.          01         JK=20,
    19.          01         IZ=18,
    20.          01         XEHIST=0.D0,.5D0,1.D0,1.5D0,2.D0,2.5D0,3.D0,3.5D0,4.D0,4.5D0,5.D0,
    21.          01                  5.5D0,6.D0,6.5D0,7.D0,7.5D0,8.D0,8.5D0,9.D0,9.5D0,10.D0,
    22.          01         XAMP=2.72D6,6.02D6,7.D6,5.46D6,4*3.52D6,1.88D6,11*5.88D5,
    23.          01         ISW(1)=0,
    24.          01         ISW(4)=1,
    25.          01         ISW(8)=1,
    26.          01         ISW(11)=0,
    27.          02         NFG=20,
    28.          01       &END
    29.          01       &LOWEN
    30.          01         ISPEC=3,
    31.          01         NMHIST=1,
    32.          01         EHIST=176.D0,
    33.          01         SMASS=207.D0,
    34.          01         FL=1.77D20,
    35.          01         REFRO=2.68D22,
    36.          01         ENGY1=50.D0,
    37.          01         RP1=3.22D-6,
    38.          01         SIG1=9.8D-7,
    39.          01         PATH1=3.41D-6,
    40.          01         ENGY=20.D0,
    41.          01         RP=1.97D-6,
    42.          01         SIG=8.6D-7,
    43.          01         PATH=2.D-6,
    44.          01         ENGY2=20.D0,
    45.          01         RP2=1.52D-6,
    46.          01         SIG2=4.9D-7,
    47.          01       &END

END ELT.  ERRORS: NONE. TIME:  0.134 SEC. IMAGE COUNT: 47
@ . ********************************************
@ . EXECUTE MFFIRE
```

```
**********************************************************
*                                                        *
*    FIRE - A CODE TO COMPUTE THE RESPONSE OF CAVITY-    *
*    GASES TO FUSION PELLET DEBRIS 2/19/79               *
*                                                        *
*    WRITTEN BY GREGORY A. MOSES & ROBERT R. PETERSON    *
*                                                        *
**********************************************************



SPHERICAL GEOMETRY - ENERGY QUANTITIES ARE ABSOLUTE


NO. OF ZONES.........................          50
OUTER BOUNDARY(CM)...................  3.0000+002

STARTING TIME(S).....................  0.0000-001
STARTING CYCLE.......................           1
NO. OF TIME CYCLES...................       10000
MAX. PROBLEM TIME(S).................  1.5000-003
TIME STEP FOR FIRST  10 CYCLES(S)....  1.0000-012
MIN. TIME STEP(S)....................  1.0000-013
MAX. TIME STEP(S)....................  1.5000-005
TIME STEP GROWTH LIMIT...............  1.5000+000
TIME STEP CONTROL PARAMETERS.........
    COURANT..........................  5.0000-002
    PERCENT V CHANGE.................  5.0000-002
    PERCENT TN CHANGE................  5.0000-002
    PERCENT ER CHANGE................  1.0000+035


TEMPERATURE BC.(EV)..................  2.5000-002


PRIMARY OUTPUT FREQUENCIES

HYDRODYNAMICS.....  200
ENERGY............  200
NUMBER DENSITIES..  200
SHORT EDIT........  200
MULTI-FREQ RAD....  200

BINARY OUTPUT.....   20
```

```
                         INTERMEDIATE VARIABLE FREQUENCIES - IEDIT

  ( 1)  -1    ( 2)  -1    ( 3)  -1    ( 4)  -1    ( 5)  -1    ( 6)  -1    ( 7)  -1    ( 8)  -1    ( 9)  -1    (10)  -1
  (11)  -1    (12)  -1    (13)  -1    (14)  -1    (15)  -1    (16)  -1    (17)  -1    (18)  -1    (19)  -1    (20)  -1
  (21)  -1    (22)  -1    (23)  -1    (24)  -1    (25)  -1    (26)  -1    (27)  -1    (28)  -1    (29)  -1    (30)  -1
  (31)  -1    (32)  -1    (33)  -1    (34)  -1    (35)  -1    (36)  -1    (37)  -1    (38)  -1    (39)  -1    (40)  -1
  (41)  -1    (42)  -1    (43)  -1    (44)  -1    (45)  -1    (46)  -1    (47)  -1    (48)  -1    (49)  -1    (50)  -1
  (51)  -1    (52)  -1    (53)  -1    (54)  -1    (55)  -1    (56)  -1    (57)  -1    (58)  -1    (59)  -1    (60)  -1
  (61)  -1    (62)  -1    (63)  -1    (64)  -1    (65)  -1    (66)  -1    (67)  -1    (68)  -1    (69)  -1    (70)  -1
  (71)  -1    (72)  -1    (73)  -1    (74)  -1    (75)  -1    (76)  -1    (77)  -1    (78)  -1    (79)  -1    (80)  -1
  (81)  -1    (82)  -1    (83)  -1    (84)  -1    (85)  -1    (86)  -1    (87)  -1    (88)  -1    (89)  -1    (90)  -1
  (91)  -1    (92)  -1    (93)  -1    (94)  -1    (95)  -1    (96)  -1    (97)  -1    (98)  -1    (99)  -1    (


 #   RADIUS      ZONE WIDTH  MASS DENS   MASS          E DENSITY   ION DENSITY R TEMP      ION TEMP    ATOMIC WT   CHARGE
     (CM)        (CM)        (G/CM3)     (G/      )    (1/CM3)     (1/CM3)     (EV)        (EV)        (AMU)       (ESU)

 0   0.0000-001
 1   4.0000+000  4.0000+000  3.9663-004  1.0633-001  8.8084+019  5.9717+018  9.2500-002  2.1481+002  4.0000+001  1.4750+001
 2   1.0448+001  6.4483+000  2.3578-005  1.0633-001  5.0657+018  3.5500+017  9.2500-002  1.9620+002  4.0000+001  1.4270+001
 3   1.3040+001  2.5914+000  2.3578-005  1.0633-001  4.6645+018  3.5500+017  9.2500-002  1.5812+002  4.0000+001  1.3139+001
 4   1.5264+001  2.2247+000  2.3578-005  1.3229-001  3.5124+018  3.5500+017  9.2500-002  8.7228+001  4.0000+001  9.8942+000
 5   1.7350+001  2.0860+000  2.3578-005  1.6458-001  3.1043+018  3.5500+017  9.2500-002  6.3515+001  4.0000+001  8.7446+000
 6   1.9396+001  2.0452+000  2.3578-005  2.0477-001  2.8725+018  3.5500+017  9.2500-002  4.5084+001  4.0000+001  8.0915+000
 7   2.1455+001  2.0593+000  2.3578-005  2.5476-001  2.7862+018  3.5500+017  9.2500-002  2.5915+001  4.0000+001  7.8485+000
 8   2.3565+001  2.1097+000  2.3578-005  3.1696-001  2.5090+018  3.5500+017  9.2500-002  1.8176+001  4.0000+001  7.0676+000
 9   2.5752+001  2.1875+000  2.3578-005  3.9434-001  2.2208+018  3.5500+017  9.2500-002  1.4249+001  4.0000+001  6.2557+000
10   2.8040+001  2.2876+000  2.3578-005  4.9061-001  1.9673+018  3.5500+017  9.2500-002  1.1533+001  4.0000+001  5.5416+000
11   3.0447+001  2.4076+000  2.3578-005  6.1039-001  1.7225+018  3.5500+017  9.2500-002  9.5574+000  4.0000+001  4.8521+000
12   3.2993+001  2.5460+000  2.3578-005  7.5941-001  1.5277+018  3.5500+017  9.2500-002  8.0658+000  4.0000+001  4.3034+000
13   3.5695+001  2.7021+000  2.3578-005  9.4481-001  1.3352+018  3.5500+017  9.2500-002  6.9357+000  4.0000+001  3.7611+000
14   3.8571+001  2.8758+000  2.3578-005  1.1755+000  1.1779+018  3.5500+017  9.2500-002  6.0282+000  4.0000+001  3.3180+000
15   4.1638+001  3.0673+000  2.3578-005  1.4625+000  1.0361+018  3.5500+017  9.2500-002  5.1376+000  4.0000+001  2.9185+000
16   4.4916+001  3.2773+000  2.3578-005  1.8195+000  9.0559+017  3.5500+017  9.2500-002  4.2353+000  4.0000+001  2.5509+000
17   4.8422+001  3.5063+000  2.3578-005  2.2637+000  7.9054+017  3.5500+017  9.2500-002  3.5954+000  4.0000+001  2.2269+000
18   5.2177+001  3.7553+000  2.3578-005  2.8164+000  6.7786+017  3.5500+017  9.2500-002  3.1204+000  4.0000+001  1.9095+000
19   5.6203+001  4.0254+000  2.3578-005  3.5040+000  5.8218+017  3.5500+017  9.2500-002  2.7122+000  4.0000+001  1.6399+000
20   6.0520+001  4.3178+000  2.3578-005  4.3595+000  4.8620+017  3.5500+017  9.2500-002  2.4130+000  4.0000+001  1.3696+000
21   6.5154+001  4.6339+000  2.3578-005  5.4238+000  4.0546+017  3.5500+017  9.2500-002  2.1760+000  4.0000+001  1.1421+000
22   7.0130+001  4.9753+000  2.3578-005  6.7479+000  3.3744+017  3.5500+017  9.2500-002  1.9600+000  4.0000+001  9.5054-001
23   7.5473+001  5.3437+000  2.3578-005  8.3954+000  2.7643+017  3.5500+017  9.2500-002  1.7580+000  4.0000+001  7.7868-001
24   8.1214+001  5.7410+000  2.3578-005  1.0445+001  2.1337+017  3.5500+017  9.2500-002  1.5592+000  4.0000+001  6.0104-001
25   8.7383+001  6.1691+000  2.3578-005  1.2995+001  1.6558+017  3.5500+017  9.2500-002  1.3864+000  4.0000+001  4.6641-001
26   9.4014+001  6.6303+000  2.3578-005  1.6168+001  1.2753+017  3.5500+017  9.2500-002  1.2297+000  4.0000+001  3.5924-001
27   1.0114+002  7.1270+000  2.3578-005  2.0115+001  9.4600+016  3.5500+017  9.2500-002  1.1105+000  4.0000+001  2.6648-001
28   1.0880+002  7.6618+000  2.3578-005  2.5026+001  6.9816+016  3.5500+017  9.2500-002  1.0011+000  4.0000+001  1.9666-001
29   1.1704+002  8.2375+000  2.3578-005  3.1136+001  5.1311+016  3.5500+017  9.2500-002  9.0113-001  4.0000+001  1.4454-001
30   1.2590+002  8.8570+000  2.3578-005  3.8737+001  3.1346+016  3.5500+017  9.2500-002  8.2435-001  4.0000+001  8.8299-002
31   1.3542+002  9.5237+000  2.3578-005  4.8194+001  1.4164+016  3.5500+017  9.2500-002  7.6871-001  4.0000+001  3.9899-002
32   1.4566+002  1.0241+001  2.3578-005  5.9961+001  6.3742+015  3.5500+017  9.2500-002  7.1657-001  4.0000+001  1.7956-002
33   1.5667+002  1.1013+001  2.3578-005  7.4599+001  2.8719+015  3.5500+017  9.2500-002  6.6803-001  4.0000+001  8.0900-003
34   1.6852+002  1.1843+001  2.3578-005  9.2812+001  1.3416+015  3.5500+017  9.2500-002  6.2477-001  4.0000+001  3.7791-003
35   1.8125+002  1.2737+001  2.3578-005  1.1547+002  6.2723+014  3.5500+017  9.2500-002  5.8435-001  4.0000+001  1.7669-003
36   1.9415+002  1.2891+001  2.3578-005  1.3462+002  1.7391+010  3.5500+017  9.2500-002  4.8447-001  4.0000+001  4.8988-008
```

```
37  2.0586+002  1.1712+001  2.3578-005  1.3885+002  1.2433+006  3.5500+017  9.2500-002  4.0963-001  4.0000+001  3.5022-012
38  2.1637+002  1.0512+001  2.3578-005  1.3885+002  2.8599+005  3.5500+017  9.2500-002  3.5621-001  4.0000+001  8.0560-013
39  2.2595+002  9.5795+000  2.3578-005  1.3885+002  2.5365+005  3.5500+017  9.2500-002  3.1593-001  4.0000+001  7.1449-013
40  2.3478+002  8.8296+000  2.3578-005  1.3885+002  2.3175+005  3.5500+017  9.2500-002  2.8865-001  4.0000+001  6.5280-013
41  2.4299+002  8.2111+000  2.3578-005  1.3885+002  2.1350+005  3.5500+017  9.2500-002  2.6593-001  4.0000+001  6.0142-013
42  2.5068+002  7.6908+000  2.3578-005  1.3885+002  1.9892+005  3.5500+017  9.2500-002  2.4776-001  4.0000+001  5.6033-013
43  2.5793+002  7.2458+000  2.3578-005  1.3885+002  1.8701+005  3.5500+017  9.2500-002  2.3293-001  4.0000+001  5.2678-013
44  2.6479+002  6.8601+000  2.3578-005  1.3885+002  1.7677+005  3.5500+017  9.2500-002  2.2017-001  4.0000+001  4.9794-013
45  2.7131+002  6.5219+000  2.3578-005  1.3885+002  1.6743+005  3.5500+017  9.2500-002  2.0854-001  4.0000+001  4.7163-013
46  2.7753+002  6.2226+000  2.3578-005  1.3885+002  1.6186+005  3.5500+017  9.2500-002  2.0161-001  4.0000+001  4.5595-013
47  2.8349+002  5.9554+000  2.3578-005  1.3885+002  1.5575+005  3.5500+017  9.2500-002  1.9400-001  4.0000+001  4.3873-013
48  2.8920+002  5.7152+000  2.3578-005  1.3885+002  1.5043+005  3.5500+017  9.2500-002  1.8737-001  4.0000+001  4.2376-013
49  2.9470+002  5.4978+000  2.3578-005  1.3885+002  1.4577+005  3.5500+017  9.2500-002  1.8156-001  4.0000+001  4.1062-013
50  3.0000+002  5.3000+000  2.3578-005  1.3885+002  1.4165+005  3.5500+017  9.2500-002  1.7643-001  4.0000+001  3.9901-013
                                        2.6667+003

 #    R PRESS     ION PRESS    R INT ENE   ION INT ENE VELOCITY
     (J/CM3)      (J/CM3)      (J/    )    (J/    )    (CM/S)

 0                                                     0.0000-001
 1  3.3581-010  3.2367+003  2.7007-007  2.5014+006  0.0000-001
 2  3.3581-010  1.7038+002  4.5431-006  2.2488+006  0.0000-001
 3  3.3581-010  1.2714+002  4.5431-006  1.7310+006  0.0000-001
 4  3.3581-010  5.4043+001  5.6523-006  9.0195+005  0.0000-001
 5  3.3581-010  3.5199+001  7.0322-006  7.1222+005  0.0000-001
 6  3.3581-010  2.3310+001  8.7491-006  6.0751+005  0.0000-001
 7  3.3581-010  1.3041+001  1.0885-005  5.5136+005  0.0000-001
 8  3.3581-010  8.3395+000  1.3543-005  5.0584+005  0.0000-001
 9  3.3581-010  5.8797+000  1.6849-005  4.7321+005  0.0000-001
10  3.3581-010  4.2905+000  2.0962-005  4.4964+005  0.0000-001
11  3.3581-010  3.1808+000  2.6080-005  4.2968+005  0.0000-001
12  3.3581-010  2.4327+000  3.2447-005  4.2124+005  0.0000-001
13  3.3581-010  1.8780+000  4.0369-005  4.0646+005  0.0000-001
14  3.3581-010  1.4803+000  5.0225-005  3.9918+005  0.0000-001
15  3.3581-010  1.1449+000  6.2487-005  3.9276+005  0.0000-001
16  3.3581-010  8.5530-001  7.7742-005  3.8638+005  0.0000-001
17  3.3581-010  6.5981-001  9.6722-005  3.8446+005  0.0000-001
18  3.3581-010  5.1632-001  1.2034-004  3.7859+005  0.0000-001
19  3.3581 010  4.0720-001  1.4971-004  3.7372+005  0.0000-001
20  3.3581-010  3.2517-001  1.8627-004  3.6483+005  0.0000-001
21  3.3581-010  2.6509-001  2.3174-004  3.5877+005  0.0000-001
22  3.3581-010  2.1742-001  2.8832-004  3.5187+005  0.0000-001
23  3.3581-010  1.7783-001  3.5871-004  3.4346+005  0.0000-001
24  3.3581-010  1.4197-001  4.4628-004  3.3442+005  0.0000-001
25  3.3581-010  1.1562-001  5.5524-004  3.2727+005  0.0000-001
26  3.3581-010  9.5059-002  6.9080-004  3.1835+005  0.0000-001
27  3.3581-010  7.9983-002  8.5945-004  3.0982+005  0.0000-001
28  3.3581-010  6.8127-002  1.0693-003  3.0026+005  0.0000-001
29  3.3581-010  5.8656-002  1.3303-003  2.9000+005  0.0000-001
30  3.3581-010  5.1021-002  1.6551-003  2.8263+005  0.0000-001
31  3.3581-010  4.5461-002  2.0592-003  2.7554+005  0.0000-001
32  3.3581-010  4.1484-002  2.5619-003  2.6830+005  0.0000-001
33  3.3581-010  3.8299-002  3.1874-003  2.6134+005  0.0000-001
34  3.3581-010  3.5665-002  3.9656-003  2.5740+005  0.0000-001
35  3.3581-010  3.3291-002  4.9337-003  2.5358+005  0.0000-001
36  3.3581-010  2.7553-002  5.7519-003  2.3903+005  0.0000-001
37  3.3581-010  2.3296-002  5.9326-003  2.0545+005  0.0000-001
```

```
38  3.3581-010  2.0258-002  5.9326-003  1.7895+005  0.0000-001
39  3.3581-010  1.7967-002  5.9326-003  1.5871+005  0.0000-001
40  3.3581-010  1.6416-002  5.9326-003  1.4501+005  0.0000-001
41  3.3581-010  1.5124-002  5.9326-003  1.3359+005  0.0000-001
42  3.3581-010  1.4090-002  5.9326-003  1.2446+005  0.0000-001
43  3.3581-010  1.3247-002  5.9326-003  1.1701+005  0.0000-001
44  3.3581-010  1.2521-002  5.9326-003  1.1061+005  0.0000-001
45  3.3581-010  1.1860-002  5.9326-003  1.0476+005  0.0000-001
46  3.3581-010  1.1466-002  5.9326-003  1.0128+005  0.0000-001
47  3.3581-010  1.1033-002  5.9326-003  9.7455+004  0.0000-001
48  3.3581-010  1.0656-002  5.9326-003  9.4129+004  0.0000-001
49  3.3581-010  1.0326-002  5.9326-003  9.1211+004  0.0000-001
50  3.3581-010  1.0034-002  5.9326-003  8.8632+004  0.0000-001
                            1.1394-001  2.1144+007  0.0000-001
```

```
                 COEFFICIENTS USED IN FIRE - CON

ION THERMAL COND.........( 1)  1.2175+002          R THERMAL COND...........( 2)  1.0000+010
RAD. EQ. COND............( 3)  1.0000-001          FLUX LIMIT EPSILON TERM..( 4)  1.0000-030
CONST LOG LAMBDA.........( 5)  0.0000-001          4*SIGMA/C................( 6)  1.3713-005
PLASMA EMISS. COEF.......( 7)  4.1138+005          PLASMA ABSORP. COEF......( 8)  3.0000+010
ION PRESS(I.GAS).........( 9)  1.6020-019                                   (10)  3.0000+010
                         (11)  0.0000-001          ION PRESS DERIV(I.GAS)...(12)  1.6020-019
                         (13)  0.0000-001          ION SP HEAT(I.GAS).......(14)  2.4030-019
ION INT ENERGY(I.GAS)....(15)  2.4030-019          RAD SP. ENERGY COEF......(16)  1.3713-005
UP-STREAM AVE PARAMETER..(17)  0.0000-001          ION SHOCK HEATING........(18)  1.0000+000
                         (19)  0.0000-001                                   (20)  0.0000-001
ARTIFICIAL VISCOSITY.....(21)  1.4140+000          MULTI-FREQ RAD ABSORPTION(22)  3.0000+010
MULTI-FREQ RAD EMISSION..(23)  6.3349+004          MULTI-FREQ RAD CONDUCT...(24)  1.0000+010
MULTI-FREQ RAD FLUX LIM..(25)  3.0000+010          MIN INIT M-F RAD ENERGY..(26)  1.0000-020
                         (27)  0.0000-001                                   (28)  0.0000-001
                         (29)  0.0000-001                                   (30)  0.0000-001
                         (31)  0.0000-001


                 CALCULATION OPTIONS USED IN FIRE - ISW

     RADIATION TEMPERATURE OP.( 1)   0                NO. OF CONST TIME STEPS..( 2)  10
                              ( 3)   0                AUTOMATIC ZONING.........( 4)   1
     FREQ OF WALL OUTPUT......( 5)  20                HYDRODYNAMIC MOTION......( 6)   0
                              ( 7)   0                ION DEPOSITION SOURCE....( 8)   1
                              ( 9)   0                FREQ. OF DTB CALCULATION.(10)   1
     AUTOMATIC XRAY DEPOSITION(11)   0                EQN OF STATE OPTION......(12)   0
     NO. FREQ. GR. SUB-DIVNS..(13)   1                ARBITRARY RADIATION OPC..(14)   0
     ARBITRARY ROSSELAND OPC..(15)   0                                         (16)   0
                              (17)   0                                         (18)   0
                              (19)   0


                 EQUATION OF STATE TABLE INDICES


                 DENSITY SLOPE.......    5.0000-001
                 DENSITY BASE........    1.5431+001
                 TEMPERATURE SLOPE...    1.6299-001
                 TEMPERATURE BASE....   -3.9794-001
                 MIN DENSITY(1/CM3)..    2.7002+015
                 MAX DENSITY(1/CM3)..    8.5389+019
                 MIN TEMPERATURE(EV)     4.0000-001
                 MAX TEMPERATURE(EV)     4.9999+002

                 ARGON
```

```
  THE BLACKBODY TEMPERATURE WAS 0.0000-001 KEV FOR THE X-RAYS
  THE X-RAY SPECTRA CONTAINED 2.1814+007 JOULES
  THE X-RAY ENERGY DEPOSITED WAS 2.0227+007 JOULES



************ XRAY FLUX TO WALL ************

ENERGY  ENERGY         EXITING       ATTENUATION
GROUP                  ENERGY        COEFFICIENT
         (KEV)         (J/KEV)         (/CM)

   1    2.5000-001    3.5364-150    5.2430+004
   2    7.5000-001    6.2392-013    6.3279+003
   3    1.2500+000    3.5904+001    1.7468+003
   4    1.7500+000    3.2292+004    7.2999+002
   5    2.2500+000    2.4989+005    3.7467+002
   6    2.7500+000    7.5998+005    2.1659+002
   7    3.2500+000    3.5253+002    1.3003+003
   8    3.7500+000    5.5689+003    9.0637+002
   9    4.2500+000    1.7530+004    6.5454+002
  10    4.7500+000    1.7936+004    4.8715+002
  11    5.2500+000    4.0693+004    3.7194+002
  12    5.7500+000    7.2908+004    2.9022+002
  13    6.2500+000    1.1161+005    2.3072+002
  14    6.7500+000    1.5336+005    1.8640+002
  15    7.2500+000    1.9534+005    1.5273+002
  16    7.7500+000    2.3557+005    1.2669+002
  17    8.2500+000    2.7292+005    1.0625+002
  18    8.7500+000    3.0688+005    8.9980+001
  19    9.2500+000    3.3732+005    7.6869+001
  20    9.7500+000    3.6435+005    6.6187+001

              INITIAL CONDITIONS FOR PROJECTILES

    INITIAL  INITIAL     FINAL     FINAL   NUMBER
 #   ENERGY    SPEED     RANGE  STD.DEV. PARTICLES
      (KEV)   CM/SEC      (CM)     (CM)

 1 1.76+002 4.05+007 4.05-002 1.08-002 1.77+020

   4.98+000 MJ TOTAL                    1.77+020 PARTICLES TOTAL

 #  LOWER BD     UPPER BD     AVE
    (EV)         (EV)         (EV)

 1  3.0000-003   1.0000+000   5.0150-001
 2  1.0000+000   3.0000+000   2.0000+000
 3  3.0000+000   5.0000+000   4.0000+000
 4  5.0000+000   7.5000+000   6.2500+000
 5  7.5000+000   1.0000+001   8.7500+000
 6  1.0000+001   1.3000+001   1.1500+001
 7  1.3000+001   1.5700+001   1.4350+001
 8  1.5700+001   2.5000+001   2.0350+001
```

```
 9   2.5000+001   3.2300+001   2.8650+001
10   3.2300+001   4.8700+001   4.0500+001
11   4.8700+001   7.5000+001   6.1850+001
12   7.5000+001   1.0000+002   8.7500+001
13   1.0000+002   1.2500+002   1.1250+002
14   1.2500+002   1.5000+002   1.3750+002
15   1.5000+002   2.0000+002   1.7500+002
16   2.0000+002   3.0000+002   2.5000+002
17   3.0000+002   4.0000+002   3.5000+002
18   4.0000+002   5.0000+002   4.5000+002
19   5.0000+002   1.0000+003   7.5000+002
20   1.0000+003   2.0000+004   1.0500+004


 #  RAD TEMP     RAD ENERGY   RAD PRESS
    (EV)         (J/G)        (J/CM3)
 1  9.2500-002   1.0074-009   3.3581-010
 2  9.2500-002   1.0074-009   3.3581-010
 3  9.2500-002   1.0074-009   3.3581-010
 4  9.2500-002   1.0074-009   3.3581-010
 5  9.2500-002   1.0074-009   3.3581-010
 6  9.2500-002   1.0074-009   3.3581-010
 7  9.2500-002   1.0074-009   3.3581-010
 8  9.2500-002   1.0074-009   3.3581-010
 9  9.2500-002   1.0074-009   3.3581-010
10  9.2500-002   1.0074-009   3.3581-010
11  9.2500-002   1.0074-009   3.3581-010
12  9.2500-002   1.0074-009   3.3581-010
13  9.2500-002   1.0074-009   3.3581-010
14  9.2500-002   1.0074-009   3.3581-010
15  9.2500-002   1.0074-009   3.3581-010
16  9.2500-002   1.0074-009   3.3581-010
17  9.2500-002   1.0074-009   3.3581-010
18  9.2500-002   1.0074-009   3.3581-010
19  9.2500-002   1.0074-009   3.3581-010
20  9.2500-002   1.0074-009   3.3581-010
21  9.2500-002   1.0074-009   3.3581-010
22  9.2500-002   1.0074-009   3.3581-010
23  9.2500-002   1.0074-009   3.3581-010
24  9.2500-002   1.0074-009   3.3581-010
25  9.2500-002   1.0074-009   3.3581-010
26  9.2500-002   1.0074-009   3.3581-010
27  9.2500-002   1.0074-009   3.3581-010
28  9.2500-002   1.0074-009   3.3581-010
29  9.2500-002   1.0074-009   3.3581-010
30  9.2500-002   1.0074-009   3.3581-010
31  9.2500-002   1.0074-009   3.3581-010
32  9.2500-002   1.0074-009   3.3581-010
33  9.2500-002   1.0074-009   3.3581-010
34  9.2500-002   1.0074-009   3.3581-010
35  9.2500-002   1.0074-009   3.3581-010
36  9.2500-002   1.0074-009   3.3581-010
37  9.2500-002   1.0074-009   3.3581-010
38  9.2500-002   1.0074-009   3.3581-010
39  9.2500-002   1.0074-009   3.3581-010
40  9.2500-002   1.0074-009   3.3581-010
41  9.2500-002   1.0074-009   3.3581-010
```

```
42  9.2500-002  1.0074-009  3.3581-010
43  9.2500-002  1.0074-009  3.3581-010
44  9.2500-002  1.0074-009  3.3581-010
45  9.2500-002  1.0074-009  3.3581-010
46  9.2500-002  1.0074-009  3.3581-010
47  9.2500-002  1.0074-009  3.3581-010
48  9.2500-002  1.0074-009  3.3581-010
49  9.2500-002  1.0074-009  3.3581-010
50  9.2500-002  1.0074-009  3.3581-010
SLOW DEBRIS TURNED OFF AT CYCLE 125
```

```
   CYCLE        TIME(S)       DELTA T(S)       CRITERION( V/V) IN ZONE (45) OTHERWISE ( V/V) IN ZONE (45)
     600        7.7894-004    2.9907-006

 #  RADIUS      ZONE WIDTH  MASS DENS   COMPRESSION VELOCITY    R TEMP      ION TEMP    R PRESS     ION PRESS   ART VISC
    (CM)        (CM)        (G/CM3)     (V0/V)      (CM/S)      (EV)        (EV)        (J/CM3)     (J/CM3)     (J/CM3)

 0  0.0000-001                                      0.0000-001
 1  1.7591+001  1.7591+001  4.6636-006  1.1758-002  3.5934+004  3.5889-001  9.2753-001  7.5829-008  1.1458-002  0.0000-001
 2  2.2045+001  4.4547+000  4.8160-006  2.0426-001  4.0270+004  3.5890-001  9.2882-001  7.5839-008  1.1956-002  0.0000-001
 3  2.5126+001  3.0804+000  4.9309-006  2.0913-001  4.3376+004  3.5944-001  9.3096-001  7.6298-008  1.2365-002  0.0000-001
 4  2.8074+001  2.9481+000  5.0415-006  2.1382-001  4.4262+004  3.6063-001  9.3549-001  7.7310-008  1.2819-002  0.0000-001
 5  3.0996+001  2.9219+000  5.1345-006  2.1776-001  4.5259+004  3.6272-001  9.4214-001  7.9123-008  1.3273-002  0.0000-001
 6  3.3934+001  2.9385+000  5.2577-006  2.2299-001  4.8092+004  3.6502-001  9.4879-001  8.1147-008  1.3847-002  0.0000-001
 7  3.6911+001  2.9770+000  5.4240-006  2.3004-001  4.9487+004  3.6647-001  9.5340-001  8.2442-008  1.4549-002  0.0000-001
 8  3.9966+001  3.0552+000  5.5844-006  2.3684-001  5.0107+004  3.6737-001  9.5636-001  8.3259-008  1.5214-002  0.0000-001
 9  4.3133+001  3.1668+000  5.7370-006  2.4332-001  4.7967+004  3.6755-001  9.5777-001  8.3420-008  1.5759-002  0.0000-001
10  4.6472+001  3.3390+000  5.8224-006  2.4694-001  4.4395+004  3.6756-001  9.5828-001  8.3426-008  1.6007-002  0.0000-001
11  4.9997+001  3.5248+000  5.9204-006  2.5110-001  3.8713+004  3.6756-001  9.5902-001  8.3426-008  1.6295-002  0.0000-001
12  5.3738+001  3.7409+000  6.0022-006  2.5457-001  3.2469+004  3.6756-001  9.5939-001  8.3426-008  1.6530-002  4.6764-005
13  5.7717+001  3.9793+000  6.0814-006  2.5792-001  2.7002+004  3.6756-001  9.5950-001  8.3426-008  1.6750-002  3.6325-005
14  6.2036+001  4.3184+000  6.0392-006  2.5613-001  2.3797+004  3.6756-001  9.5909-001  8.3426-008  1.6623-002  0.0000-001
15  6.6754+001  4.7181+000  5.9458-006  2.5217-001  2.2177+004  3.6756-001  9.5879-001  8.3426-008  1.6359-002  0.0000-001
16  7.1839+001  5.0854+000  5.9266-006  2.5136-001  2.1986+004  3.6756-001  9.5865-001  8.3426-008  1.6302-002  0.0000-001
17  7.7355+001  5.5155+000  5.8666-006  2.4882-001  2.7051+004  3.6756-001  9.5785-001  8.3426-008  1.6116-002  0.0000-001
18  8.3367+001  6.0119+000  5.7701-006  2.4472-001  3.0406+004  3.6756-001  9.5809-001  8.3425-008  1.5858-002  0.0000-001
19  8.9972+001  6.6053+000  5.6172-006  2.3824-001  3.6531+004  3.6756-001  9.5774-001  8.3425-008  1.5373-002  0.0000-001
20  9.7246+001  7.2745+000  5.4396-006  2.3071-001  4.4773+004  3.6755-001  9.5740-001  8.3424-008  1.4702-002  0.0000-001
21  1.0502+002  7.7745+000  5.4252-006  2.3009-001  4.6799+004  3.6755-001  9.5812-001  8.3424-008  1.4666-002  0.0000-001
22  1.1315+002  8.1297+000  5.5482-006  2.3531-001  4.7059+004  3.6755-001  9.5837-001  8.3424-008  1.5128-002  0.0000-001
23  1.2145+002  8.3044+000  5.8442-006  2.4787-001  4.2700+004  3.6755-001  9.5894-001  8.3423-008  1.6084-002  0.0000-001
24  1.2997+002  8.5109+000  6.1775-006  2.6200-001  4.1567+004  3.6755-001  9.5872-001  8.3423-008  1.6993-002  0.0000-001
25  1.3894+002  8.9751+000  6.3713-006  2.7022-001  3.7469+004  3.6755-001  9.5900-001  8.3421-008  1.7533-002  0.0000-001
26  1.4832+002  9.3819+000  6.6450-006  2.8183-001  4.2900+004  3.6755-001  9.5816-001  8.3420-008  1.8260-002  0.0000-001
27  1.5799+002  9.6663+000  7.0572-006  2.9931-001  3.7389+004  3.6755-001  9.5916-001  8.3418-008  1.9422-002  4.2854-005
28  1.6829+002  1.0297+001  7.2643-006  3.0810-001  2.5509+004  3.6754-001  9.5980-001  8.3415-008  2.0011-002  2.0474-004
29  1.8011+002  1.1827+001  6.9008-006  2.9268-001  2.3646+004  3.6738-001  9.5845-001  8.3269-008  1.8971-002  0.0000-001
30  1.9252+002  1.2410+001  7.1530-006  3.0337-001  2.2215+004  3.6698-001  9.5730-001  8.2901-008  1.9626-002  0.0000-001
31  2.0601+002  1.3482+001  7.1615-006  3.0373-001  2.5903+004  3.6271-001  9.4489-001  7.9114-008  1.9264-002  0.0000-001
32  2.1956+002  1.3556+001  7.7717-006  3.2961-001  4.4244+004  3.6269-001  9.4389-001  7.9093-008  2.0871-002  0.0000-001
33  2.3419+002  1.4634+001  7.8783-006  3.3414-001  5.3667+004  3.6266-001  9.4439-001  7.9068-008  2.1174-002  0.0000-001
34  2.4491+002  1.0716+001  1.2008-005  5.0929-001  6.6017+004  3.2943-001  7.2549-001  5.3835-008  2.1425-002  0.0000-001
35  2.5360+002  8.6894+000  1.7019-005  7.2183-001  7.7663+004  3.2529-001  5.9373-001  5.1177-008  2.4430-002  0.0000-001
36  2.6142+002  7.8241+000  2.0646-005  8.7565-001  7.6153+004  3.2027-001  5.3428-001  4.8093-008  2.6609-002  0.0000-001
37  2.6769+002  6.2654+000  2.5196-005  1.0686+000  7.8219+004  3.1709-001  4.8104-001  4.6212-008  2.9237-002  0.0000-001
38  2.7275+002  5.0645+000  2.9877-005  1.2672+000  8.0128+004  3.1040-001  4.5704-001  4.2431-008  3.2939-002  0.0000-001
39  2.7707+002  4.3179+000  3.3858-005  1.4360+000  7.9068+004  3.0637-001  4.3594-001  4.0272-008  3.5604-002  0.0000-001
40  2.8095+002  3.8773+000  3.6606-005  1.5526+000  7.7327+004  3.0516-001  4.2168-001  3.9640-008  3.7236-002  0.0000-001
41  2.8446+002  3.5107+000  3.9380-005  1.6702+000  7.6462+004  3.0263-001  4.1095-001  3.8338-008  3.9037-002  0.0000-001
42  2.8763+002  3.1662+000  4.2650-005  1.8089+000  7.4350+004  3.0168-001  4.0687-001  3.7863-008  4.1859-002  3.8033-005
43  2.9033+002  2.7010+000  4.8987-005  2.0776+000  5.4357+004  3.0116-001  4.2364-001  3.7598-008  5.0060-002  3.8745-003
44  2.9234+002  2.0161+000  6.4571-005  2.7386+000  1.9474+004  3.0049-001  4.9083-001  3.7266-008  7.6451-002  1.5320-002
45  2.9383+002  1.4864+000  8.6540-005  3.6704+000 -3.3059+003  3.0038-001  5.6921-001  3.7214-008  1.1885-001  8.7780-003
46  2.9511+002  1.2836+000  9.9268-005  4.2102+000 -6.5041+003  2.9963-001  5.9378-001  3.6844-008  1.4232-001  2.0226-004
47  2.9636+002  1.2482+000  1.0121-004  4.2927+000 -2.7530+003  2.9855-001  5.8433-001  3.6313-008  1.4278-001  0.0000-001
```

```
48  2.9756+002  1.2026+000  1.0419-004  4.4187+000 -1.6549+003  2.9848-001  5.6580-001  3.6280-008  1.4222-001  0.0000-001
49  2.9876+002  1.1952+000  1.0399-004  4.4104+000 -6.0658+002  2.9757-001  5.6693-001  3.5839-008  1.4224-001  0.0000-001
50  3.0000+002  1.2405+000  9.9381-005  4.2149+000  0.0000-001  2.9515-001  5.9644-001  3.4689-008  1.4313-001  0.0000-001
                                                                2.5000-002  2.5000-002


 #  R ENERGY    ION ENERGY  KIN ENERGY  R SOURCE    ION SOURCE  ION->R EX   FLUX LIM    HEAT FLUX
    (J/     )   (J/     )   (J/     )   (J/     )   (J/     )   (J/     )   (J/CM2-S)   (J/CM2-S)
 0                          0.0000-001
 1  5.1867-003  9.8920+002  6.8649+000  0.0000-001  0.0000-001 -4.2553+000  7.5000-011  0.0000-001
 2  5.0232-003  1.0139+003  8.6215+000  0.0000-001  0.0000-001 -2.8647+000  7.5000-011  0.0000-001
 3  4.9358-003  1.0364+003  1.1224+001  0.0000-001  0.0000-001 -2.5575+000  7.5000-011  0.0000-001
 4  6.0858-003  1.3271+003  1.4541+001  0.0000-001  0.0000-001 -2.6005+000  7.5000-011  0.0000-001
 5  7.6088-003  1.7063+003  1.8915+001  0.0000-001  0.0000-001 -3.4967+000  7.5000-011  0.0000-001
 6  9.4811-003  2.1992+003  2.6571+001  0.0000-001  0.0000-001 -4.8051+000  7.5000-011  0.0000-001
 7  1.1617-002  2.8258+003  3.5003+001  0.0000-001  0.0000-001 -4.8362+000  7.5000-011  0.0000-001
 8  1.4177-002  3.6061+003  4.4646+001  0.0000-001  0.0000-001 -4.7215+000  7.5000-011  0.0000-001
 9  1.7202-002  4.5434+003  5.0902+001  0.0000-001  0.0000-001 -1.0285+000  7.5000-011  0.0000-001
10  2.1089-002  5.6601+003  5.4250+001  0.0000-001  0.0000-001  1.7796+000  7.5000-011  0.0000-001
11  2.5804-002  7.0554+003  5.1322+001  0.0000-001  0.0000-001  8.7668+000  7.5000-011  0.0000-001
12  3.1666-002  8.7857+003  4.4916+001  0.0000-001  0.0000-001  1.5421+001  7.5000-011  0.0000-001
13  3.8884-002  1.0932+004  3.8648+001  0.0000-001  0.0000-001  2.1985+001  7.5000-011  0.0000-001
14  4.8715-002  1.3586+004  3.7347+001  0.0000-001  0.0000-001  1.9142+001  7.5000-011  0.0000-001
15  6.1560-002  1.6892+004  4.0354+001  0.0000-001  0.0000-001  1.5942+001  7.5000-011  0.0000-001
16  7.6837-002  2.1008+004  4.9344+001  0.0000-001  0.0000-001  1.7226+001  7.5000-011  0.0000-001
17  9.6573-002  2.6079+004  9.2938+001  0.0000-001  0.0000-001 -4.8367+000  7.5000-011  0.0000-001
18  1.2216-001  3.2478+004  1.4609+002  0.0000-001  0.0000-001  3.4314+000  7.5000-011  0.0000-001
19  1.5612-001  4.0163+004  2.6235+002  0.0000-001  0.0000-001 -1.3498+001  7.5000-011  0.0000-001
20  2.0058-001  4.9034+004  4.9028+002  0.0000-001  0.0000-001 -4.2557+001  7.5000-011  0.0000-001
21  2.5021-001  6.1051+004  6.6645+002  0.0000-001  0.0000-001  3.7553+000  7.5000-011  0.0000-001
22  3.0439-001  7.6963+004  8.3838+002  0.0000-001  0.0000-001  3.0541+001  7.5000-011  0.0000-001
23  3.5952-001  9.7040+004  8.5878+002  0.0000-001  0.0000-001  1.1299+002  7.5000-011  0.0000-001
24  4.2316-001  1.2055+005  1.0125+003  0.0000-001  0.0000-001  1.1138+002  7.5000-011  0.0000-001
25  5.1045-001  1.5003+005  1.0236+003  0.0000-001  0.0000-001  1.8625+002  7.5000-011  0.0000-001
26  6.0890-001  1.8608+005  1.6694+003  0.0000-001  0.0000-001  2.8625+001  7.5000-011  0.0000-001
27  7.1329-001  2.3196+005  1.5776+003  0.0000-001  0.0000-001  3.4818+002  7.5000-011  0.0000-001
28  8.6210-001  2.8898+005  9.1363+002  0.0000-001  0.0000-001  6.9724+002  7.5000-011  0.0000-001
29  1.1271+000  3.5844+005  9.7668+002  0.0000-001  0.0000-001  3.5382+002  7.5000-011  0.0000-001
30  1.3468+000  4.4423+005  1.0725+003  0.0000-001  0.0000-001  3.9381+002  7.5000-011  0.0000-001
31  1.5972+000  5.3316+005  1.8142+003  0.0000-001  0.0000-001  5.3698+002  7.5000-011  0.0000-001
32  1.8307+000  6.6089+005  6.5851+003  0.0000-001  0.0000-001 -4.8862+001  7.5000-011  0.0000-001
33  2.2461+000  8.2333+005  1.2054+004  0.0000-001  0.0000-001  4.1004+002  7.5000-011  0.0000-001
34  1.2483+000  4.4277+005  2.2694+004  0.0000-001  0.0000-001 -5.1743+002  7.5000-011  0.0000-001
35  1.0417+000  2.6933+005  3.7711+004  0.0000-001  0.0000-001 -2.0510+001  7.5000-011  0.0000-001
36  9.4076-001  2.6615+005  3.9649+004  0.0000-001  0.0000-001 -8.2524-001  7.5000-011  0.0000-001
37  7.6401-001  2.4455+005  4.2476+004  0.0000-001  0.0000-001 -1.0079-001  7.5000-011  0.0000-001
38  5.9157-001  2.3119+005  4.4574+004  0.0000-001  0.0000-001 -1.1581-002  7.5000-011  0.0000-001
39  4.9546-001  2.1962+005  4.3403+004  0.0000-001  0.0000-001 -3.3043-003  7.5000-011  0.0000-001
40  4.5107-001  2.1188+005  4.1513+004  0.0000-001  0.0000-001 -9.1263-004  7.5000-011  0.0000-001
41  4.0553-001  2.0609+005  4.0589+004  0.0000-001  0.0000-001 -5.0835-004  7.5000-011  0.0000-001
42  3.6979-001  2.0389+005  3.8377+004  0.0000-001  0.0000-001 -3.4361-003  7.5000-011  0.0000-001
43  3.1971-001  2.1283+005  2.0513+004  0.0000-001  0.0000-001 -1.0985-002  7.5000-011  0.0000-001
44  2.4041-001  2.4849+005  2.6327+003  0.0000-001  0.0000-001 -2.3222-001  7.5000-011  0.0000-001
45  1.7912-001  2.8964+005  7.5872+001  0.0000-001  0.0000-001 -5.6533-001  7.5000-011  0.0000-001
46  1.5460-001  3.1270+005  2.9369+002  0.0000-001  0.0000-001  3.3307+000  7.5000-011  0.0000-001
47  1.4945-001  2.9906+005  5.2617+001  0.0000-001  0.0000-001 -1.1362+000  7.5000-011  0.0000-001
48  1.4505-001  2.8727+005  1.9014+001  0.0000-001  0.0000-001 -1.9276+000  7.5000-011  0.0000-001
```

```
49   1.4356-001  2.8787+005  2.5544+000  0.0000-001  0.0000-001 -6.1137-001  7.5000-011  0.0000-001
50   1.4540 001  3.1658+005  0.0000-001  0.0000-001  0.0000-001  3.5076+000  7.5000-011  0.0000-001

                             ENERGY CONSERVATION CHECK -- UNITS ARE (J/     )

     INT ENE     T KE        INT ENE(0)  T BDFLUX    T I->R EX   T SOURCE    BDFLUX      I->R EX     SOURCE

R    2.0927+001              1.1394-001  1.4494+007  1.4496+007  0.0000-001  2.6400+003  2.6399+003  0.0000-001
I    8.8335+006  4.0716+005  2.1144+007  1.0605-001              2.8523+006  5.2819-003              0.0000-001

                             RADIATION    2.0927+001    -6.1283+002
                             ION          9.2407+006     9.5023+006
                             TOTAL        9.2407+006     9.5017+006

 #   E DENSITY   ION DENSITY CHARGE      ROSS OPC    PLK OPC     EQM T OPC   EPSILON
     (1/CM3)     (1/CM3)     (ESU)       (CM2/G)     (CM2/G)   (CM2/G)

 1   7.2870+015  7.0222+016  9.8123-002  0.0000-001  0.0000-001  0.0000-001  0.0000-001
 2   8.1921+015  7.2517+016  1.0807-001  0.0000-001  0.0000-001  0.0000-001  0.0000-001
 3   9.0307+015  7.4247+016  1.1665-001  0.0000-001  0.0000-001  0.0000-001  0.0000-001
 4   9.9414+015  7.5913+016  1.2680-001  0.0000-001  0.0000-001  0.0000-001  0.0000-001
 5   1.0942+016  7.7312+016  1.3746-001  0.0000-001  0.0000-001  0.0000-001  0.0000-001
 6   1.2325+016  7.9167+016  1.5070-001  0.0000-001  0.0000-001  0.0000-001  0.0000-001
 7   1.3954+016  8.1672+016  1.6634-001  0.0000-001  0.0000-001  0.0000-001  0.0000-001
 8   1.5573+016  8.4086+016  1.8098-001  0.0000-001  0.0000-001  0.0000-001  0.0000-001
 9   1.6355+016  8.6385+016  1.8896-001  0.0000-001  0.0000-001  0.0000-001  0.0000-001
10   1.6623+016  8.7671+016  1.8928-001  0.0000-001  0.0000-001  0.0000-001  0.0000-001
11   1.6943+016  8.9146+016  1.8975-001  0.0000-001  0.0000-001  0.0000-001  0.0000-001
12   1.7199+016  9.0379+016  1.8997-001  0.0000-001  0.0000-001  0.0000-001  0.0000-001
13   1.7436+016  9.1570+016  1.9002-001  0.0000-001  0.0000-001  0.0000-001  0.0000-001
14   1.7287+016  9.0935+016  1.8975-001  0.0000-001  0.0000-001  0.0000-001  0.0000-001
15   1.7001+016  8.9529+016  1.8959-001  0.0000-001  0.0000-001  0.0000-001  0.0000-001
16   1.6941+016  8.9239+016  1.8950-001  0.0000-001  0.0000-001  0.0000-001  0.0000-001
17   1.6724+016  8.8337+016  1.8897-001  0.0000-001  0.0000-001  0.0000-001  0.0000-001
18   1.6465+016  8.6883+016  1.8917-001  0.0000-001  0.0000-001  0.0000-001  0.0000-001
19   1.5840+016  8.4582+016  1.8459-001  0.0000-001  0.0000-001  0.0000-001  0.0000-001
20   1.4181+016  8.1907+016  1.7028-001  0.0000-001  0.0000-001  0.0000-001  0.0000-001
21   1.4004+016  8.1690+016  1.6966-001  0.0000-001  0.0000-001  0.0000-001  0.0000-001
22   1.5119+016  8.3542+016  1.7947-001  0.0000-001  0.0000-001  0.0000-001  0.0000-001
23   1.6725+016  8.7999+016  1.8973-001  0.0000-001  0.0000-001  0.0000-001  0.0000-001
24   1.7655+016  9.3018+016  1.8945-001  0.0000-001  0.0000-001  0.0000-001  0.0000-001
25   1.8217+016  9.5935+016  1.8958-001  0.0000-001  0.0000-001  0.0000-001  0.0000-001
26   1.8934+016  1.0006+017  1.8892-001  0.0000-001  0.0000-001  0.0000-001  0.0000-001
27   2.0167+016  1.0626+017  1.8945-001  0.0000-001  0.0000-001  0.0000-001  0.0000-001
28   2.0802+016  1.0938+017  1.8981-001  0.0000-001  0.0000-001  0.0000-001  0.0000-001
29   1.9669+016  1.0391+017  1.8903-001  0.0000-001  0.0000-001  0.0000-001  0.0000-001
30   2.0296+016  1.0771+017  1.8820-001  0.0000-001  0.0000-001  0.0000-001  0.0000-001
31   1.9467+016  1.0783+017  1.8018-001  0.0000-001  0.0000-001  0.0000-001  0.0000-001
32   2.1050+016  1.1702+017  1.7950-001  0.0000-001  0.0000-001  0.0000-001  0.0000-001
33   2.1373+016  1.1863+017  1.7981-001  0.0000-001  0.0000-001  0.0000-001  0.0000-001
34   3.5479+015  1.8081+017  1.9510-002  0.0000-001  0.0000-001  0.0000-001  0.0000-001
35   5.8951+014  2.5627+017  2.2641-003  0.0000-001  0.0000-001  0.0000-001  0.0000-001
36   4.3277+012  3.1088+017  1.3365-005  0.0000-001  0.0000-001  0.0000-001  0.0000-001
37   1.3446+010  3.7938+017  3.2269-008  0.0000-001  0.0000-001  0.0000-001  0.0000-001
```

```
 38  8.5448+008  4.4987+017  1.7191-009  0.0000-001  0.0000-001  0.0000-001  0.0000-001
 39  6.1662+007  5.0982+017  1.1681-010  0.0000-001  0.0000-001  0.0000-001  0.0000-001
 40  9.9153+006  5.5120+017  1.7779-011  0.0000-001  0.0000-001  0.0000-001  0.0000-001
 41  2.5343+006  5.9296+017  4.1424-012  0.0000-001  0.0000-001  0.0000-001  0.0000-001
 42  1.4912+006  6.4221+017  2.3562-012  0.0000-001  0.0000-001  0.0000-001  0.0000-001
 43  7.6924+006  7.3762+017  2.2669-011  0.0000-001  0.0000-001  0.0000-001  0.0000-001
 44  9.8355+009  9.7228+017  8.0138-008  0.0000-001  0.0000-001  0.0000-001  0.0000-001
 45  6.3175+013  1.3031+018  2.4670-004  0.0000-001  0.0000-001  0.0000-001  0.0000-001
 46  1.4315+015  1.4947+018  9.7250-004  0.0000-001  0.0000-001  0.0000-001  0.0000-001
 47  1.2260+015  1.5240+018  7.8926-004  0.0000-001  0.0000-001  0.0000-001  0.0000-001
 48  2.6668+014  1.5688+018  1.5508-004  0.0000-001  0.0000-001  0.0000-001  0.0000-001
 49  2.9638+014  1.5658+018  1.7313-004  0.0000-001  0.0000-001  0.0000-001  0.0000-001
 50  1.5393+015  1.4964+018  1.0255-003  0.0000-001  0.0000-001  0.0000-001  0.0000-001


SHORT EDIT
TOTAL ENERGY RADIATED TO THE WALL(J)..........  1.4+007
ENERGY RADIATED TO THE WALL ON THIS TIME STEP.  2.6+003
PRESSURE AT THE WALL(J/CM3)...................  1.4-001
HEAT FLUX AT THE WALL(J/CM2-S)................  0.0-001


                  1       8      15      22      29      36      43      50
 RADIUS   1.8+001 4.0+001 6.7+001 1.1+002 1.8+002 2.6+002 2.9+002 3.0+002
VELOCITY 3.6+004 5.0+004 2.2+004 4.7+004 2.4+004 7.6+004 5.4+004 0.0-001
 I TEMP   9.3-001 9.6-001 9.6-001 9.6-001 9.6-001 5.3-001 4.2-001 6.0-001
 R TEMP   3.6-001 3.7-001 3.7-001 3.7-001 3.7-001 3.2-001 3.0-001 3.0-001
 P  MFP   0.0-001 0.0-001 0.0-001 0.0-001 0.0-001 0.0-001 0.0-001 0.0-001
 R  MFP   0.0-001 0.0-001 0.0-001 0.0-001 0.0-001 0.0-001 0.0-001 0.0-001


ENERGY CONSERVATION

      INT ENE + KIN ENE = RHS =      INT ENE 0-T BDFLUX +T SOURCE+-T I->R EX

   R    2.1+001              -6.1+002   1.1-001   1.4+007   0.0-001  -1.4+007
   I    8.8+006   4.1+005    9.5+006   2.1+007   1.1-001   2.9+006   1.4+007
   T    9.2+006              9.5+006


  #  RAD TEMP    RAD ENERGY  PLANCK OPC  ROSS OPC    EMISSION    ABSORPTION
     (EV)        (J/CM3)     (CM2/G)     (CM2/G)     (J/G*S)     (J/G*S)

  1  3.5889-001  2.2749-007  4.2639+004  2.5542-001  2.7803+008  2.9141+008
  2  3.5890-001  2.2752-007  4.2768+004  2.6198-001  2.8323+008  2.9223+008
  3  3.5944-001  2.2889-007  4.3584+004  2.7108-001  2.9155+008  2.9960+008
  4  3.6063-001  2.3193-007  4.5189+004  2.9038-001  3.0814+008  3.1471+008
  5  3.6272-001  2.3737-007  4.7890+004  3.1972-001  3.3425+008  3.4136+008
  6  3.6502-001  2.4344-007  5.0811+004  3.5129-001  3.6368+008  3.7153+008
  7  3.6647-001  2.4733-007  5.2729+004  3.7570-001  3.8531+008  3.9166+008
  8  3.6737-001  2.4978-007  5.4045+004  3.9249-001  4.0039+008  4.0537+008
  9  3.6755-001  2.5026-007  5.4437+004  3.9970-001  4.0798+008  4.0886+008
 10  3.6756-001  2.5028-007  5.4526+004  4.0070-001  4.1069+008  4.0947+008
 11  3.6756-001  2.5028-007  5.4614+004  4.0273-001  4.1483+008  4.1002+008
 12  3.6756-001  2.5028-007  5.4692+004  4.0287-001  4.1734+008  4.1055+008
 13  3.6756-001  2.5028-007  5.4770+004  4.0137-001  4.1890+008  4.1112+008
 14  3.6756-001  2.5028-007  5.4734+004  3.9987-001  4.1636+008  4.1092+008
```

```
15  3.6756-001  2.5028-007  5.4645+004  4.0057-001  4.1393+008  4.1028+008
16  3.6756-001  2.5028-007  5.4627+004  4.0016-001  4.1335+008  4.1018+008
17  3.6756-001  2.5028-007  5.4580+004  3.9662-001  4.0923+008  4.0995+008
18  3.6756-001  2.5028-007  5.4477+004  4.0106-001  4.0954+008  4.0913+008
19  3.6756-001  2.5027-007  5.4308+004  4.0156-001  4.0669+008  4.0797+008
20  3.6755-001  2.5027-007  5.4070+004  3.9856-001  4.0298+008  4.0624+008
21  3.6755-001  2.5027-007  5.4035+004  4.0328-001  4.0607+008  4.0584+008
22  3.6755-001  2.5027-007  5.4203+004  4.0554-001  4.0856+008  4.0705+008
23  3.6755-001  2.5027-007  5.4542+004  4.0456-001  4.1398+008  4.0948+008
24  3.6755-001  2.5027-007  5.4881+004  3.9357-001  4.1563+008  4.1207+008
25  3.6755-001  2.5026-007  5.5065+004  3.9030-001  4.1819+008  4.1340+008
26  3.6755-001  2.5026-007  5.5332+004  3.7839-001  4.1613+008  4.1553+008
27  3.6755 001  2.5025-007  5.5692+004  3.7566-001  4.2386+008  4.1808+008
28  3.6754-001  2.5024-007  5.5868+004  3.7542-001  4.2860+008  4.1929+008
29  3.6738-001  2.4981-007  5.5367+004  3.7490-001  4.1872+008  4.1492+008
30  3.6698-001  2.4870-007  5.5096+004  3.6364-001  4.1447+008  4.1107+008
31  3.6271-001  2.3734-007  4.9665+004  3.0594-001  3.5738+008  3.5365+008
32  3.6269-001  2.3728-007  5.0059+004  2.9194-001  3.5623+008  3.5650+008
33  3.6266-001  2.3720-007  5.0138+004  2.9269-001  3.5873+008  3.5689+008
34  3.2943-001  1.6151-007  2.1276+003  2.9547-003  8.4494+006  1.0314+007
35  3.2529-001  1.5353-007  6.2991+001  5.4650-005  2.3120+005  2.9059+005
36  3.2027-001  1.4428-007  5.9668+000  2.7238-006  2.3829+004  2.5879+004
37  3.1709-001  1.3864-007  5.4363-001  1.2781-007  2.0289+003  2.2716+003
38  3.1040-001  1.2729-007  1.5283-001  3.1242-008  5.5866+002  5.8655+002
39  3.0637-001  1.2082-007  4.5176-002  9.8470-009  1.5607+002  1.6403+002
40  3.0516-001  1.1892-007  1.8082-002  5.1580-009  6.2351+001  6.4549+001
41  3.0263-001  1.1501-007  9.2139-003  3.6636-009  3.0617+001  3.1842+001
42  3.0168-001  1.1359-007  9.0457-003  3.3059-009  2.2528+001  3.0802+001
43  3.0116-001  1.1280-007  2.2871-002  5.6532-009  4.7975+001  7.4428+001
44  3.0049-001  1.1180-007  6.0392-001  2.1371-007  1.2635+003  1.8227+003
45  3.0038-001  1.1164-007  1.6466+001  1.5920-005  4.9309+004  5.0671+004
46  2.9963-001  1.1053-007  6.3970+001  4.5170-005  2.1955+005  2.1153+005
47  2.9855-001  1.0894-007  5.3516+001  3.3464-005  1.7276+005  1.7550+005
48  2.9848-001  1.0884-007  2.7831+001  1.3335-005  8.6673+004  9.1315+004
49  2.9757-001  1.0752-007  2.8345+001  1.4117-005  9.0383+004  9.1855+004
50  2.9515-001  1.0407-007  7.7210+001  4.9180-005  2.4963+005  2.4118+005

FREQUENCY DEPENDENT RADIATION ENERGY DENSITY(J/CM3)

 #        GR1        GR2        GR3        GR4        GR5        GR6        GR7        GR8        GR9       GR10       GR11

 1  1.749-008  1.306-007  1.862-008  2.532-009  1.848-010  5.310-008  4.466-009  4.821-010  7.496-014  6.810-017  1.000-020
 2  1.749-008  1.306-007  1.862-008  2.532-009  1.848-010  5.313-008  4.467-009  4.823-010  8.433-014  7.977-017  1.000-020
 3  1.749-008  1.306-007  1.862-008  2.532-009  1.848-010  5.440-008  4.561-009  4.930-010  9.228-014  8.881-017  1.000-020
 4  1.749-008  1.306-007  1.862-008  2.532-009  1.848-010  5.711-008  4.849-009  5.317-010  1.028-013  1.005-016  1.000-020
 5  1.749-008  1.306-007  1.862-008  2.532-009  1.848-010  6.195-008  5.381-009  6.048-010  1.172-013  1.165-016  1.000-020
 6  1.749-008  1.306-007  1.862-008  2.532-009  1.848-010  6.734-008  5.982-009  6.838-010  1.328-013  1.344-016  1.000-020
 7  1.749-008  1.306-007  1.862-008  2.532-009  1.848-010  7.080-008  6.362-009  7.225-010  1.459-013  1.501-016  1.000-020
 8  1.749-008  1.306-007  1.862-008  2.532-009  1.848-010  7.312-008  6.490-009  7.307-010  1.559-013  1.623-016  1.000-020
 9  1.749-008  1.306-007  1.862-008  2.532-009  1.848-010  7.359-008  6.497-009  7.312-010  1.625-013  1.707-016  1.000-020
10  1.749-008  1.306-007  1.862-008  2.532-009  1.848-010  7.361-008  6.497-009  7.312-010  1.668-013  1.763-016  1.000-020
11  1.749-008  1.306-007  1.862-008  2.532-009  1.848-010  7.361-008  6.497-009  7.313-010  1.700-013  1.804-016  1.000-020
12  1.749-008  1.306-007  1.862-008  2.532-009  1.848-010  7.361-008  6.497-009  7.313-010  1.719-013  1.830-016  1.000-020
13  1.749-008  1.306-007  1.862-008  2.532-009  1.848-010  7.361-008  6.497-009  7.313-010  1.726-013  1.840-016  1.000-020
14  1.749-008  1.306-007  1.862-008  2.532-009  1.848-010  7.361-008  6.497-009  7.313-010  1.719-013  1.832-016  1.000-020
15  1.749 008  1.306-007  1.862-008  2.532-009  1.848-010  7.361-008  6.497-009  7.313-010  1.708-013  1.819-016  1.000-020
```

```
16  1.749-008  1.306-007  1.862-008  2.532-009  1.848-010  7.361-008  6.497-009  7.313-010  1.696-013  1.804-016  1.000-020
17  1.749-008  1.306-007  1.862-008  2.532-009  1.848-010  7.361-008  6.497-009  7.313-010  1.678-013  1.781-016  1.000-020
18  1.749-008  1.306-007  1.862-008  2.532-009  1.848-010  7.361-008  6.497-009  7.313-010  1.673-013  1.774-016  1.000-020
19  1.749-008  1.306-007  1.862-008  2.532-009  1.848-010  7.361-008  6.497-009  7.313-010  1.663-013  1.762-016  1.000-020
20  1.749-008  1.306-007  1.862-008  2.532-009  1.848-010  7.361-008  6.497-009  7.313-010  1.657-013  1.755-016  1.000-020
21  1.749-008  1.306-007  1.862-008  2.532-009  1.848-010  7.362-008  6.497-009  7.313-010  1.675-013  1.777-016  1.000-020
22  1.749-008  1.306-007  1.862-008  2.532-009  1.848-010  7.362-008  6.497-009  7.313-010  1.691-013  1.798-016  1.000-020
23  1.749-008  1.306-007  1.862-008  2.532-009  1.848-010  7.362-008  6.497-009  7.313-010  1.710-013  1.822-016  1.000-020
24  1.748-008  1.306-007  1.862-008  2.532-009  1.848-010  7.362-008  6.497-009  7.313-010  1.709-013  1.823-016  1.000-020
25  1.748-008  1.306-007  1.862-008  2.532-009  1.848-010  7.362-008  6.497-009  7.313-010  1.713-013  1.826-016  1.000-020
26  1.748-008  1.306-007  1.862-008  2.532-009  1.848-010  7.362-008  6.497-009  7.313-010  1.693-013  1.805-016  1.000-020
27  1.748-008  1.306-007  1.862-008  2.532-009  1.848-010  7.362-008  6.497-009  7.313-010  1.726-013  1.845-016  1.000-020
28  1.748-008  1.306-007  1.862-008  2.531-009  1.848-010  7.362-008  6.497-009  7.313-010  1.748-013  1.868-016  1.000-020
29  1.747-008  1.306-007  1.862-008  2.531-009  1.848-010  7.323-008  6.463-009  7.276-010  1.685-013  1.786-016  1.000-020
30  1.746-008  1.306-007  1.862-008  2.531-009  1.848-010  7.227-008  6.356-009  7.134-010  1.600-013  1.664-016  1.000-020
31  1.745-008  1.306-007  1.862-008  2.530-009  1.847-010  6.217-008  5.268-009  5.700-010  1.178-013  1.149-016  1.000-020
32  1.744-008  1.305-007  1.862-008  2.530-009  1.847-010  6.214-008  5.265-009  5.690-010  1.121-013  1.066-016  1.000-020
33  1.742-008  1.305-007  1.861-008  2.529-009  1.847-010  6.214-008  5.264-009  5.690-010  1.099-013  1.026-016  1.000-020
34  1.640-008  1.230-007  1.714-008  2.328-009  1.701-010  2.322-009  1.223-010  1.114-011  3.252-015  6.722-018  1.000-020
35  1.599-008  1.185-007  1.657-008  2.251-009  1.644-010  9.128-011  2.380-012  1.606-013  7.685-017  4.058-019  1.000-020
36  1.462-008  1.115-007  1.580-008  2.147-009  1.567-010  1.080-011  1.052-013  2.753-015  1.557-018  2.464-020  1.000-020
37  1.422-008  1.074-007  1.483-008  2.008-009  1.467-010  1.276-012  6.267-015  6.471-017  3.161-020  1.000-020  1.000-020
38  1.333-008  9.789-008  1.403-008  1.906-009  1.393-010  3.810-013  1.195-015  6.284-018  1.000-020  1.000-020  1.000-020
39  1.221-008  9.358-008  1.311-008  1.788-009  1.304-010  1.222-013  2.742-016  1.034-018  1.000-020  1.000-020  1.000-020
40  1.216-008  9.211-008  1.279-008  1.729-009  1.264-010  5.291-014  9.259-017  2.831-019  1.000-020  1.000-020  1.000-020
41  1.208-008  8.856-008  1.254-008  1.708-009  1.248-010  2.804-014  4.338-017  1.051-019  1.000-020  1.000-020  1.000-020
42  1.158-008  8.792-008  1.230-008  1.671-009  1.220-010  2.796-014  4.810-017  8.728-020  1.000-020  1.000-020  1.000-020
43  1.156-008  8.718-008  1.227-008  1.663-009  1.215-010  6.257-014  1.814-016  9.958-019  1.000-020  1.000-020  1.000-020
44  1.156-008  8.635-008  1.212-008  1.653-009  1.207-010  1.079-012  6.154-015  5.454-017  1.000-020  1.000-020  1.000-020
45  1.149-008  8.633-008  1.205-008  1.628-009  1.190-010  1.931-011  1.830-013  2.527-015  1.000-020  1.000-020  1.000-020
46  1.132-008  8.534-008  1.205-008  1.628-009  1.189-010  6.738-011  8.817-013  1.641-014  1.000-020  1.000-020  1.000-020
47  1.132-008  8.403-008  1.179-008  1.615-009  1.179-010  5.701-011  7.183-013  1.279-014  1.000-020  1.000-020  1.000-020
48  1.132-008  8.403-008  1.174-008  1.594-009  1.164-010  3.233-011  3.503-013  5.413-015  1.000-020  1.000-020  1.000-020
49  1.071-008  8.336-008  1.171-008  1.590-009  1.161-010  3.234-011  3.503-013  5.414-015  1.000-020  1.000-020  1.000-020
50  1.070-008  8.037-008  1.128-008  1.532-009  1.119-010  7.600-011  1.028-012  1.974-014  1.215-020  1.000-020  1.000-020

 #       GR12       GR13       GR14       GR15       GR16       GR17       GR18       GR19       GR20

 1  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020
 2  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020
 3  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020
 4  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020
 5  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020
 6  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020
 7  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020
 8  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020
 9  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020
10  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020
11  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020
12  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020
13  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020
14  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020
15  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020
16  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020
17  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020
18  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020
19  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020
```

```
20   1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020
21   1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020
22   1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020
23   1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020
24   1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020
25   1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020
26   1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020
27   1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020
28   1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020
29   1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020
30   1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020
31   1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020
32   1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020
33   1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020
34   1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020
35   1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020
36   1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020
37   1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020
38   1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020
39   1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020
40   1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020
41   1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020
42   1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020
43   1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020
44   1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020
45   1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020
46   1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020
47   1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020
48   1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020
49   1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020
50   1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020

FREQUENCY DEPENDENT PLANCK OPACITY(CM2/G)

 #         GR1        GR2        GR3        GR4        GR5        GR6        GR7        GR8        GR9       GR10       GR11

 1   1.269+001  1.017+001  1.507+000  4.271-001  1.484-001  1.750+005  8.506+004  5.388+004  2.018+004  1.416+004  4.131+003
 2   1.298+001  1.035+001  1.533+000  4.347-001  1.511-001  1.755+005  8.523+004  5.394+004  2.019+004  1.421+004  4.145+003
 3   1.344+001  1.064+001  1.574+000  4.462-001  1.551-001  1.757+005  8.525+004  5.389+004  2.024+004  1.433+004  4.182+003
 4   1.446+001  1.123+001  1.659+000  4.704-001  1.636-001  1.758+005  8.508+004  5.364+004  2.039+004  1.465+004  4.274+003
 5   1.607+001  1.215+001  1.790+000  5.074-001  1.765-001  1.756+005  8.471+004  5.321+004  2.062+004  1.514+004  4.417+003
 6   1.786+001  1.315+001  1.932+000  5.476-001  1.906-001  1.756+005  8.443+004  5.283+004  2.083+004  1.562+004  4.559+003
 7   1.923+001  1.391+001  2.041+000  5.783-001  2.013-001  1.760+005  8.443+004  5.269+004  2.096+004  1.593+004  4.649+003
 8   2.017+001  1.444+001  2.116+000  5.996-001  2.088-001  1.766+005  8.455+004  5.268+004  2.101+004  1.611+004  4.700+003
 9   2.061+001  1.472+001  2.156+000  6.109-001  2.127-001  1.771+005  8.474+004  5.276+004  2.100+004  1.612+004  4.703+003
10   2.075+001  1.483+001  2.171+000  6.152-001  2.142-001  1.773+005  8.485+004  5.280+004  2.097+004  1.607+004  4.688+003
11   2.096+001  1.498+001  2.192+000  6.212-001  2.163-001  1.776+005  8.495+004  5.285+004  2.094+004  1.602+004  4.675+003
12   2.106+001  1.506+001  2.204+000  6.246-001  2.175-001  1.779+005  8.506+004  5.290+004  2.090+004  1.597+004  4.659+003
13   2.107+001  1.510+001  2.210+000  6.262-001  2.181-001  1.781+005  8.517+004  5.297+004  2.086+004  1.590+004  4.638+003
14   2.095+001  1.502+001  2.198+000  6.229-001  2.169-001  1.780+005  8.513+004  5.296+004  2.087+004  1.591+004  4.641+003
15   2.088+001  1.495+001  2.188+000  6.199-001  2.159-001  1.777+005  8.501+004  5.289+004  2.092+004  1.598+004  4.662+003
16   2.084+001  1.492+001  2.184+000  6.188-001  2.155-001  1.777+005  8.499+004  5.288+004  2.092+004  1.599+004  4.665+003
17   2.060+001  1.477+001  2.162+000  6.127-001  2.134-001  1.775+005  8.495+004  5.288+004  2.093+004  1.599+004  4.665+003
18   2.071+001  1.478+001  2.165+000  6.134-001  2.136-001  1.772+005  8.478+004  5.277+004  2.099+004  1.611+004  4.700+003
19   2.061+001  1.468+001  2.150+000  6.092-001  2.122-001  1.766+005  8.453+004  5.262+004  2.106+004  1.621+004  4.729+003
20   2.047+001  1.456+001  2.133+000  6.044-001  2.105-001  1.758+005  8.417+004  5.241+004  2.110+004  1.626+004  4.743+003
```

```
 21  2.069+001  1.468+001  2.149+000  6.090-001  2.121-001  1.757+005  8.408+004  5.234+004  2.113+004  1.632+004  4.762+003
 22  2.080+001  1.476+001  2.161+000  6.125-001  2.133-001  1.763+005  8.433+004  5.248+004  2.110+004  1.629+004  4.753+003
 23  2.096+001  1.495+001  2.188+000  6.199-001  2.159-001  1.774+005  8.484+004  5.278+004  2.098+004  1.610+004  4.697+003
 24  2.078+001  1.499+001  2.194+000  6.217-001  2.165-001  1.785+005  8.537+004  5.312+004  2.078+004  1.574+004  4.593+003
 25  2.082+001  1.508+001  2.207+000  6.255-001  2.178-001  1.791+005  8.564+004  5.328+004  2.069+004  1.558+004  4.545+003
 26  2.047+001  1.499+001  2.196+000  6.222-001  2.166-001  1.799+005  8.609+004  5.358+004  2.052+004  1.527+004  4.454+003
 27  2.068+001  1.525+001  2.233+000  6.328-001  2.203-001  1.811+005  8.661+004  5.387+004  2.035+004  1.499+004  4.372+003
 28  2.083+001  1.541+001  2.255+000  6.392-001  2.225-001  1.817+005  8.685+004  5.401+004  2.028+004  1.486+004  4.336+003
 29  2.050+001  1.510+001  2.211+000  6.265-001  2.181-001  1.807+005  8.643+004  5.379+004  2.041+004  1.507+004  4.396+003
 30  2.007+001  1.495+001  2.190+000  6.207-001  2.161-001  1.814+005  8.684+004  5.407+004  2.026+004  1.479+004  4.315+003
 31  1.657+001  1.294+001  1.904+000  5.398-001  1.877-001  1.817+005  8.751+004  5.488+004  1.989+004  1.401+004  4.086+003
 32  1.621+001  1.287+001  1.896+000  5.374-001  1.869-001  1.831+005  8.826+004  5.538+004  1.963+004  1.356+004  3.958+003
 33  1.631+001  1.296+001  1.909+000  5.411-001  1.881-001  1.834+005  8.835+004  5.542+004  1.961+004  1.353+004  3.948+003
 34  1.401-001  2.588-001  4.375-002  1.245-002  4.248-003  1.433+005  8.296+004  6.287+004  1.737+004  8.851+003  2.143+003
 35  2.337-003  7.891-003  1.513-003  4.315-004  1.452-004  1.040+005  7.129+004  6.395+004  1.773+004  8.827+003  1.679+003
 36  1.230-004  6.224-004  1.323-004  3.801-005  1.270-005  7.908+004  6.219+004  6.415+004  1.788+004  7.987+003  1.640+003
 37  5.484-006  4.235-005  1.007-005  2.915-006  9.669-007  5.881+004  5.360+004  6.427+004  1.803+004  7.068+003  1.640+003
 38  1.204-006  1.142-005  2.868-006  8.333-007  2.754-007  5.091+004  4.985+004  6.432+004  1.810+004  6.659+003  1.640+003
 39  2.965-007  3.405-006  8.988-007  2.621-007  8.633-008  4.455+004  4.661+004  6.438+004  1.817+004  6.302+003  1.640+003
 40  1.107-007  1.454-006  3.975-007  1.162-007  3.819-008  4.056+004  4.447+004  6.441+004  1.821+004  6.063+003  1.640+003
 41  5.157-008  7.513-007  2.111-007  6.184-008  2.028-008  3.772+004  4.287+004  6.444+004  1.825+004  5.883+003  1.640+003
 42  3.836-008  5.818-007  1.652-007  4.843-008  1.587-008  3.667+004  4.227+004  6.445+004  1.826+004  5.815+003  1.640+003
 43  1.270-007  1.637-006  4.453-007  1.301-007  4.274-008  4.110+004  4.476+004  6.441+004  1.821+004  6.095+003  1.640+003
 44  9.954-006  7.092-005  1.650-005  4.768-006  1.583-006  6.225+004  5.515+004  6.424+004  1.800+004  7.235+003  1.640+003
 45  8.026-004  3.148-003  6.257-004  1.788-004  5.999-005  9.454+004  6.803+004  6.408+004  1.779+004  8.598+003  1.640+003
 46  2.342-003  7.904-003  1.515-003  4.322-004  1.454-004  1.040+005  7.130+004  6.395+004  1.773+004  8.827+003  1.680+003
 47  1.688-003  5.978-003  1.157-003  3.303-004  1.110-004  1.013+005  7.044+004  6.403+004  1.775+004  8.827+003  1.647+003
 48  6.719-004  2.700-003  5.401-004  1.544-004  5.178-005  9.295+004  6.746+004  6.408+004  1.780+004  8.538+003  1.640+003
 49  7.127-004  2.841-003  5.671-004  1.621-004  5.437-005  9.348+004  6.765+004  6.408+004  1.780+004  8.558+003  1.640+003
 50  2.565-003  8.544-003  1.633-003  4.658-004  1.568-004  1.047+005  7.154+004  6.392+004  1.772+004  8.827+003  1.689+003

  #       GR12       GR13       GR14       GR15       GR16       GR17       GR18       GR19       GR20

  1  8.729+002  3.607+002  1.928+002  1.005+002  3.866+001  1.256+001  5.636+000  1.889+000  1.378-002
  2  8.771+002  3.620+002  1.935+002  1.009+002  3.879+001  1.261+001  5.656+000  1.895+000  1.383-002
  3  8.867+002  3.652+002  1.952+002  1.018+002  3.914+001  1.272+001  5.706+000  1.912+000  1.396-002
  4  9.101+002  3.732+002  1.995+002  1.040+002  3.999+001  1.300+001  5.831+000  1.954+000  1.426-002
  5  9.466+002  3.856+002  2.062+002  1.075+002  4.133+001  1.343+001  6.026+000  2.019+000  1.474-002
  6  9.834+002  3.981+002  2.128+002  1.109+002  4.266+001  1.386+001  6.220+000  2.084+000  1.521-002
  7  1.007+003  4.059+002  2.170+002  1.131+002  4.350+001  1.414+001  6.342+000  2.125+000  1.551-002
  8  1.021+003  4.104+002  2.194+002  1.144+002  4.398+001  1.429+001  6.413+000  2.149+000  1.568-002
  9  1.023+003  4.106+002  2.195+002  1.144+002  4.401+001  1.430+001  6.416+000  2.150+000  1.569-002
 10  1.021+003  4.094+002  2.188+002  1.141+002  4.387+001  1.426+001  6.396+000  2.143+000  1.564-002
 11  1.018+003  4.082+002  2.182+002  1.137+002  4.375+001  1.422+001  6.379+000  2.138+000  1.560-002
 12  1.015+003  4.068+002  2.175+002  1.134+002  4.360+001  1.417+001  6.357+000  2.130+000  1.555-002
 13  1.011+003  4.050+002  2.165+002  1.128+002  4.340+001  1.411+001  6.328+000  2.121+000  1.548-002
 14  1.011+003  4.053+002  2.167+002  1.129+002  4.343+001  1.412+001  6.332+000  2.122+000  1.549-002
 15  1.015+003  4.071+002  2.176+002  1.134+002  4.363+001  1.418+001  6.361+000  2.132+000  1.556-002
 16  1.016+003  4.073+002  2.178+002  1.135+002  4.365+001  1.419+001  6.365+000  2.133+000  1.557-002
 17  1.015+003  4.073+002  2.177+002  1.135+002  4.365+001  1.419+001  6.364+000  2.133+000  1.557-002
 18  1.023+003  4.104+002  2.194+002  1.144+002  4.398+001  1.429+001  6.412+000  2.149+000  1.568-002
 19  1.029+003  4.129+002  2.208+002  1.151+002  4.425+001  1.438+001  6.452+000  2.162+000  1.578-002
 20  1.032+003  4.141+002  2.214+002  1.154+002  4.438+001  1.442+001  6.471+000  2.168+000  1.583-002
 21  1.036+003  4.158+002  2.223+002  1.159+002  4.456+001  1.448+001  6.497+000  2.177+000  1.589-002
 22  1.035+003  4.150+002  2.219+002  1.156+002  4.447+001  1.445+001  6.484+000  2.173+000  1.586-002
 23  1.023+003  4.101+002  2.192+002  1.143+002  4.395+001  1.428+001  6.408+000  2.147+000  1.567-002
 24  1.000+003  4.010+002  2.144+002  1.117+002  4.298+001  1.397+001  6.266+000  2.100+000  1.533-002
```

```
25  9.900+002  3.968+002  2.121+002  1.106+002  4.253+001  1.382+001  6.201+000  2.078+000  1.517-002
26  9.695+002  3.890+002  2.079+002  1.084+002  4.168+001  1.355+001  6.078+000  2.037+000  1.486-002
27  9.525+002  3.818+002  2.041+002  1.064+002  4.091+001  1.330+001  5.965+000  1.999+000  1.459-002
28  9.451+002  3.786+002  2.024+002  1.055+002  4.057+001  1.319+001  5.915+000  1.982+000  1.447-002
29  9.572+002  3.839+002  2.052+002  1.070+002  4.114+001  1.337+001  5.998+000  2.010+000  1.467-002
30  9.384+002  3.768+002  2.014+002  1.050+002  4.038+001  1.312+001  5.887+000  1.973+000  1.440-002
31  8.782+002  3.568+002  1.907+002  9.942+001  3.824+001  1.243+001  5.575+000  1.868+000  1.364-002
32  8.497+002  3.456+002  1.847+002  9.629+001  3.703+001  1.204+001  5.400+000  1.809+000  1.321-002
33  8.480+002  3.447+002  1.843+002  9.605+001  3.694+001  1.201+001  5.386+000  1.805+000  1.317-002
34  5.026+002  2.255+002  1.205+002  6.283+001  2.417+001  7.854+000  3.523+000  1.181+000  8.617-003
35  5.013+002  2.249+002  1.202+002  6.266+001  2.410+001  7.832+000  3.514+000  1.177+000  8.594-003
36  5.013+002  2.249+002  1.202+002  6.266+001  2.410+001  7.832+000  3.514+000  1.177+000  8.594-003
37  5.013+002  2.249+002  1.202+002  6.266+001  2.410+001  7.832+000  3.514+000  1.177+000  8.594-003
38  5.013+002  2.249+002  1.202+002  6.266+001  2.410+001  7.832+000  3.514+000  1.177+000  8.594-003
39  5.013+002  2.249+002  1.202+002  6.266+001  2.410+001  7.832+000  3.514+000  1.177+000  8.594-003
40  5.013+002  2.249+002  1.202+002  6.266+001  2.410+001  7.832+000  3.514+000  1.177+000  8.594-003
41  5.013+002  2.249+002  1.202+002  6.266+001  2.410+001  7.832+000  3.514+000  1.177+000  8.594-003
42  5.013+002  2.249+002  1.202+002  6.266+001  2.410+001  7.832+000  3.514+000  1.177+000  8.594-003
43  5.013+002  2.249+002  1.202+002  6.266+001  2.410+001  7.832+000  3.514+000  1.177+000  8.594-003
44  5.013+002  2.249+002  1.202+002  6.266+001  2.410+001  7.832+000  3.514+000  1.177+000  8.594-003
45  5.013+002  2.249+002  1.202+002  6.266+001  2.410+001  7.832+000  3.514+000  1.177+000  8.594-003
46  5.013+002  2.249+002  1.202+002  6.266+001  2.410+001  7.832+000  3.514+000  1.177+000  8.594-003
47  5.013+002  2.249+002  1.202+002  6.266+001  2.410+001  7.832+000  3.514+000  1.177+000  8.594-003
48  5.013+002  2.249+002  1.202+002  6.266+001  2.410+001  7.832+000  3.514+000  1.177+000  8.594-003
49  5.013+002  2.249+002  1.202+002  6.266+001  2.410+001  7.832+000  3.514+000  1.177+000  8.594-003
50  5.013+002  2.249+002  1.202+002  6.266+001  2.410+001  7.832+000  3.514+000  1.177+000  8.594-003
```

```
FREQUENCY DEPENDENT ROSSELAND OPACITY(CM2/G)

 #        GR1        GR2        GR3        GR4        GR5        GR6        GR7        GR8        GR9       GR10       GR11

 1  1.121+000  2.318-001  1.261-001  3.681-001  1.375-001  6.249-002  3.118-002  5.296-001  1.607+004  1.416+004  4.131+003
 2  1.151+000  2.370-001  1.289-001  3.746-001  1.399-001  6.360-002  3.173-002  5.400-001  1.611+004  1.421+004  4.145+003
 3  1.203+000  2.455-001  1.334-001  3.845-001  1.437-001  6.529-002  3.258-002  5.561-001  1.612+004  1.433+004  4.182+003
 4  1.320+000  2.640-001  1.431-001  4.053-001  1.515-001  6.884-002  3.436-002  5.904-001  1.612+004  1.465+004  4.274+003
 5  1.510+000  2.933-001  1.585-001  4.371-001  1.634-001  7.428-002  3.710-002  6.436-001  1.611+004  1.514+004  4.417+003
 6  1.727+000  3.259-001  1.755-001  4.717-001  1.764-001  8.019-002  4.006-002  7.018-001  1.610+004  1.562+004  4.559+003
 7  1.895+000  3.508-001  1.886-001  4.981-001  1.864-001  8.470-002  4.233-002  7.464-001  1.613+004  1.593+004  4.649+003
 8  2.010+000  3.679-001  1.976-001  5.165-001  1.933-001  8.783-002  4.390-002  7.774-001  1.617+004  1.611+004  4.700+003
 9  2.040+000  3.761-001  2.020-001  5.261-001  1.969-001  8.948-002  4.473-002  7.936-001  1.621+004  1.612+004  4.703+003
10  2.026+000  3.787-001  2.035-001  5.299-001  1.983-001  9.012-002  4.505-002  7.999-001  1.622+004  1.607+004  4.688+003
11  2.016+000  3.826-001  2.057-001  5.350-001  2.002-001  9.100-002  4.549-002  8.085-001  1.623+004  1.602+004  4.675+003
12  1.999+000  3.844-001  2.067-001  5.379-001  2.013-001  9.149-002  4.574-002  8.133-001  1.624+004  1.597+004  4.659+003
13  1.973+000  3.847-001  2.070-001  5.393-001  2.018-001  9.172-002  4.585-002  8.155-001  1.625+004  1.590+004  4.638+003
14  1.972+000  3.825-001  2.058-001  5.365-001  2.008-001  9.124-002  4.561-002  8.107-001  1.624+004  1.591+004  4.641+003
15  1.997+000  3.811-001  2.049-001  5.339-001  1.998-001  9.081-002  4.539-002  8.065-001  1.623+004  1.598+004  4.662+003
16  1.999+000  3.804-001  2.045-001  5.329-001  1.994-001  9.064-002  4.531-002  8.049-001  1.623+004  1.599+004  4.665+003
17  1.991+000  3.760-001  2.021-001  5.277-001  1.975-001  8.975-002  4.486-002  7.960-001  1.622+004  1.599+004  4.665+003
18  2.040+000  3.778-001  2.029-001  5.283-001  1.977-001  8.985-002  4.491-002  7.972-001  1.621+004  1.611+004  4.700+003
19  2.067+000  3.760-001  2.018-001  5.247-001  1.964-001  8.925-002  4.461-002  7.915-001  1.618+004  1.621+004  4.729+003
20  2.051+000  3.732-001  2.002-001  5.206-001  1.948-001  8.855-002  4.427-002  7.850-001  1.611+004  1.626+004  4.743+003
21  2.081+000  3.773-001  2.023-001  5.245-001  1.963-001  8.922-002  4.461-002  7.918-001  1.610+004  1.632+004  4.762+003
22  2.092+000  3.793-001  2.035-001  5.275-001  1.974-001  8.973-002  4.486-002  7.965-001  1.615+004  1.629+004  4.753+003
23  2.044+000  3.825-001  2.055-001  5.339-001  1.998-001  9.081-002  4.540-002  8.068-001  1.622+004  1.610+004  4.697+003
24  1.907+000  3.797-001  2.045-001  5.355-001  2.004-001  9.106-002  4.552-002  8.086-001  1.626+004  1.574+004  4.593+003
25  1.850+000  3.805-001  2.053-001  5.387-001  2.016-001  9.161-002  4.579-002  8.139-001  1.629+004  1.558+004  4.545+003
```

```
26  1.731+000  3.745-001  2.025-001  5.359-001  2.005-001  9.111-002  4.554-002  8.083-001  1.632+004  1.527+004  4.454+003
27  1.646+000  3.786-001  2.052-001  5.450-001  2.039-001  9.266-002  4.631-002  8.232-001  1.637+004  1.499+004  4.372+003
28  1.612+000  3.815-001  2.071-001  5.504-001  2.059-001  9.358-002  4.678-002  8.322-001  1.639+004  1.486+004  4.336+003
29  1.666+000  3.752-001  2.032-001  5.396-001  2.019-001  9.174-002  4.585-002  8.142-001  1.635+004  1.507+004  4.396+003
30  1.562+000  3.677-001  1.996-001  5.345-001  2.000-001  9.086-002  4.541-002  8.050-001  1.639+004  1.479+004  4.315+003
31  1.216+000  3.036-001  1.657-001  4.650-001  1.738-001  7.898-002  3.943-002  6.867-001  1.644+004  1.401+004  4.086+003
32  1.083+000  2.974-001  1.629-001  4.629-001  1.730-001  7.860-002  3.924-002  6.823-001  1.650+004  1.356+004  3.958+003
33  1.077+000  2.995-001  1.641-001  4.661-001  1.742-001  7.914-002  3.951-002  6.876-001  1.651+004  1.353+004  3.948+003
34  3.801-003  2.475-003  1.411-003  1.086-002  3.967-003  1.797-003  8.814-004  1.090-002  1.716+004  8.851+003  1.821+003
35  7.117-005  3.919-005  2.231-005  3.817-004  1.368-004  6.174-005  2.987-005  2.876-004  1.756+004  8.827+003  1.157+003
36  3.329-006  1.993-006  1.222-006  3.399-005  1.203-005  5.416-006  2.613-006  2.240-005  1.774+004  7.360+003  1.107+003
37  1.211-007  8.453-008  5.669-008  2.637-006  9.220-007  4.135-007  1.989-007  1.524-006  1.791+004  5.893+003  1.107+003
38  2.378-008  1.789-008  1.250-008  7.582-007  2.634-007  1.179-007  5.659-008  4.100-007  1.799+004  5.288+003  1.107+003
39  5.273-009  4.251-009  3.084-009  2.397-007  8.280-008  3.698-008  1.772-008  1.219-007  1.807+004  4.784+003  1.107+003
40  1.825-009  1.545-009  1.151-009  1.067-007  3.669-008  1.636-008  7.828-009  5.193-008  1.813+004  4.459+003  1.107+003
41  7.993-010  7.028-010  5.339-010  5.693-008  1.952-008  8.693-009  4.153-009  2.678-008  1.817+004  4.222+003  1.107+003
42  5.766-010  5.142-010  3.930-010  4.463-008  1.528-008  6.801-009  3.246-009  2.069-008  1.819+004  4.134+003  1.107+003
43  2.049-009  1.716-009  1.265-009  1.194-007  4.106-008  1.830-008  8.736-009  5.811-008  1.812+004  4.503+003  1.107+003
44  2.187-007  1.465-007  9.559-008  4.304-006  1.507-006  6.753-007  3.240-007  2.527-006  1.788+004  6.150+003  1.107+003
45  2.467-005  1.316-005  7.625-006  1.588-004  5.664-005  2.553-005  1.232-005  1.130-004  1.764+004  8.416+003  1.107+003
46  6.442-005  3.926-005  2.235-005  3.823-004  1.370-004  6.183-005  2.992-005  2.881-004  1.756+004  8.827+003  1.157+003
47  5.306-005  2.818-005  1.604-005  2.925-004  1.046-004  4.721-005  2.282-005  2.154-004  1.759+004  8.827+003  1.116+003
48  2.036-005  1.096-005  6.378-006  1.372-004  4.891-005  2.204-005  1.064-005  9.686-005  1.765+004  8.309+003  1.107+003
49  2.170-005  1.164-005  6.766-006  1.440-004  5.135-005  2.314-005  1.117-005  1.019-004  1.764+004  8.344+003  1.107+003
50  6.800-005  4.307-005  2.452-005  4.120-004  1.477-004  6.666-005  3.226-005  3.124-004  1.755+004  8.827+003  1.169+003

 #       GR12       GR13       GR14       GR15       GR16       GR17       GR18       GR19       GR20

 1  7.610+002  3.231+002  1.791+002  8.389+001  2.726+001  1.049+001  5.049+000  8.776-001  4.033-004
 2  7.652+002  3.243+002  1.797+002  8.418+001  2.736+001  1.052+001  5.067+000  8.807-001  4.064-004
 3  7.745+002  3.271+002  1.813+002  8.493+001  2.760+001  1.062+001  5.112+000  8.886-001  4.138-004
 4  7.968+002  3.343+002  1.853+002  8.679+001  2.821+001  1.085+001  5.224+000  9.080-001  4.321-004
 5  8.315+002  3.455+002  1.915+002  8.969+001  2.915+001  1.121+001  5.398+000  9.384-001  4.614-004
 6  8.667+002  3.566+002  1.976+002  9.258+001  3.009+001  1.157+001  5.572+000  9.686-001  4.918-004
 7  8.899+002  3.636+002  2.015+002  9.441+001  3.068+001  1.180+001  5.682+000  9.878-001  5.121-004
 8  9.036+002  3.677+002  2.038+002  9.545+001  3.102+001  1.193+001  5.745+000  9.987-001  5.244-004
 9  9.059+002  3.679+002  2.039+002  9.550+001  3.104+001  1.194+001  5.748+000  9.993-001  5.265-004
10  9.038+002  3.667+002  2.033+002  9.521+001  3.094+001  1.190+001  5.731+000  9.962-001  5.245-004
11  9.023+002  3.657+002  2.027+002  9.495+001  3.086+001  1.187+001  5.715+000  9.934-001  5.231-004
12  8.996+002  3.644+002  2.020+002  9.462+001  3.075+001  1.183+001  5.695+000  9.900-001  5.206-004
13  8.957+002  3.628+002  2.011+002  9.419+001  3.061+001  1.177+001  5.669+000  9.855-001  5.171-004
14  8.958+002  3.631+002  2.012+002  9.425+001  3.063+001  1.178+001  5.673+000  9.862-001  5.172-004
15  8.995+002  3.647+002  2.021+002  9.468+001  3.077+001  1.184+001  5.699+000  9.907-001  5.206-004
16  8.998+002  3.649+002  2.023+002  9.474+001  3.079+001  1.184+001  5.702+000  9.913-001  5.209-004
17  8.987+002  3.649+002  2.022+002  9.473+001  3.079+001  1.184+001  5.702+000  9.912-001  5.199-004
18  9.058+002  3.676+002  2.038+002  9.545+001  3.102+001  1.193+001  5.745+000  9.987-001  5.264-004
19  9.110+002  3.699+002  2.050+002  9.604+001  3.121+001  1.201+001  5.781+000  1.005+000  5.311-004
20  9.131+002  3.710+002  2.056+002  9.632+001  3.130+001  1.204+001  5.797+000  1.008+000  5.330-004
21  9.178+002  3.725+002  2.065+002  9.671+001  3.143+001  1.209+001  5.821+000  1.012+000  5.372-004
22  9.164+002  3.718+002  2.061+002  9.652+001  3.137+001  1.207+001  5.809+000  1.010+000  5.360-004
23  9.063+002  3.674+002  2.036+002  9.538+001  3.100+001  1.192+001  5.741+000  9.980-001  5.268-004
24  8.860+002  3.593+002  1.991+002  9.327+001  3.031+001  1.166+001  5.614+000  9.759-001  5.083-004
25  8.771+002  3.555+002  1.970+002  9.229+001  3.000+001  1.154+001  5.555+000  9.657-001  5.002-004
26  8.586+002  3.484+002  1.931+002  9.046+001  2.940+001  1.131+001  5.445+000  9.465-001  4.838-004
27  8.440+002  3.420+002  1.896+002  8.879+001  2.886+001  1.110+001  5.344+000  9.290-001  4.708-004
28  8.377+002  3.391+002  1.880+002  8.805+001  2.862+001  1.101+001  5.299+000  9.212-001  4.653-004
29  8.478+002  3.439+002  1.906+002  8.928+001  2.902+001  1.116+001  5.374+000  9.342-001  4.742-004
```

```
30  8.306+002  3.375+002  1.871+002  8.763+001  2.848+001  1.095+001  5.274+000  9.168-001  4.591-004
31  7.725+002  3.196+002  1.772+002  8.298+001  2.697+001  1.037+001  4.995+000  8.682-001  4.093-004
32  7.471+002  3.096+002  1.716+002  8.037+001  2.612+001  1.005+001  4.837+000  8.408-001  3.879-004
33  7.457+002  3.088+002  1.711+002  8.017+001  2.605+001  1.002+001  4.825+000  8.387-001  3.867-004
34  4.195+002  2.020+002  1.120+002  5.244+001  1.704+001  6.555+000  3.156+000  5.484-001  1.453-004
35  4.184+002  2.015+002  1.117+002  5.230+001  1.700+001  6.538+000  3.148+000  5.469-001  1.412-004
36  4.184+002  2.014+002  1.117+002  5.230+001  1.700+001  6.537+000  3.148+000  5.469-001  1.412-004
37  4.184+002  2.014+002  1.117+002  5.230+001  1.700+001  6.537+000  3.148+000  5.469-001  1.412-004
38  4.184+002  2.014+002  1.117+002  5.230+001  1.700+001  6.537+000  3.148+000  5.469-001  1.412-004
39  4.184+002  2.014+002  1.117+002  5.230+001  1.700+001  6.537+000  3.148+000  5.469-001  1.412-004
40  4.184+002  2.014+002  1.117+002  5.230+001  1.700+001  6.537+000  3.148+000  5.469-001  1.412-004
41  4.184+002  2.014+002  1.117+002  5.230+001  1.700+001  6.537+000  3.148+000  5.469-001  1.412-004
42  4.184+002  2.014+002  1.117+002  5.230+001  1.700+001  6.537+000  3.148+000  5.469-001  1.412-004
43  4.184+002  2.014+002  1.117+002  5.230+001  1.700+001  6.537+000  3.148+000  5.469-001  1.412-004
44  4.184+002  2.014+002  1.117+002  5.230+001  1.700+001  6.537+000  3.148+000  5.469-001  1.412-004
45  4.184+002  2.014+002  1.117+002  5.230+001  1.700+001  6.537+000  3.148+000  5.469-001  1.412-004
46  4.184+002  2.014+002  1.117+002  5.230+001  1.700+001  6.537+000  3.148+000  5.469-001  1.412-004
47  4.184+002  2.014+002  1.117+002  5.230+001  1.700+001  6.537+000  3.148+000  5.469-001  1.412-004
48  4.184+002  2.014+002  1.117+002  5.230+001  1.700+001  6.537+000  3.148+000  5.469-001  1.412-004
49  4.184+002  2.014+002  1.117+002  5.230+001  1.700+001  6.537+000  3.148+000  5.469-001  1.412-004
50  4.184+002  2.014+002  1.117+002  5.230+001  1.700+001  6.537+000  3.148+000  5.469-001  1.412-004

 FREQUENCY DEPENDENT TIME INTEGRATED RADIATION SPECTRUM(J/GROUP)

4.8758+005  5.3197+006  3.4207+006  2.6851+006  2.4923+006  3.5973+001  4.8729-001  9.4039-003  3.6703-008  5.4988-008
6.2811-008  6.4805-008  1.3321-007  1.0577-005  6.8074-004  2.5313-001  3.0361+002  7.3884+003  6.0306+002  8.0463+004
```

```
    CYCLE        TIME(S)       DELTA T(S)       CRITERION( V/V) IN ZONE (24) OTHERWISE ( V/V) IN ZONE (24)
      735        1.5001-003    4.3422-006

 #   RADIUS       ZONE WIDTH   MASS DENS    COMPRESSION  VELOCITY      R TEMP       ION TEMP     R PRESS      ION PRESS    ART VISC
     (CM)         (CM)         (G/CM3)      (VO/V)       (CM/S)        (EV)         (EV)         (J/CM3)      (J/CM3)      (J/CM3)

 0   0.0000-001                                           0.0000-001
 1   1.6194+001   1.6194+001   5.9771-006   1.5070-002  -5.5943+004   4.2452-001   9.6213-001   1.4846-007   1.6533-002   3.6565-003
 2   2.0086+001   3.8918+000   6.5819-006   2.7915-001  -6.0303+004   4.2258-001   9.4981-001   1.4576-007   1.7846-002   2.4611-005
 3   2.2972+001   2.8863+000   6.3154-006   2.6785-001  -6.1901+004   4.2162-001   9.4449-001   1.4444-007   1.6978-002   3.1840-006
 4   2.5828+001   2.8560+000   6.1839-006   2.6227-001  -6.4392+004   4.2088-001   9.4092-001   1.4343-007   1.6530-002   7.5673-006
 5   2.8750+001   2.9217+000   6.0138-006   2.5506-001  -6.7516+004   4.2017-001   9.3715-001   1.4246-007   1.5977-002   1.1589-005
 6   3.1788+001   3.0377+000   5.8500-006   2.4811-001  -6.8108+004   4.1968-001   9.3354-001   1.4181-007   1.5452-002   4.0609-007
 7   3.4942+001   3.1544+000   5.7690-006   2.4468-001  -6.6312+004   4.1944-001   9.3128-001   1.4148-007   1.5182-002   3.6950-006
 8   3.8225+001   3.2832+000   5.7362-006   2.4328-001  -6.3886+004   4.1933-001   9.3014-001   1.4133-007   1.5068-002   6.7090-006
 9   4.1665+001   3.4399+000   5.7136-006   2.4233-001  -6.0986+004   4.1929-001   9.2937-001   1.4127-007   1.4990-002   9.5562-006
10   4.5291+001   3.6259+000   5.6927-006   2.4144-001  -5.7120+004   4.1928-001   9.2868-001   1.4126-007   1.4919-002   1.6951-005
11   4.9139+001   3.8476+000   5.6599-006   2.4005-001  -5.2097+004   4.1927-001   9.2801-001   1.4125-007   1.4805-002   2.8495-005
12   5.3250+001   4.1114+000   5.6053-006   2.3773-001  -4.6096+004   4.1927-001   9.2740-001   1.4125-007   1.4591-002   4.0323-005
13   5.7656+001   4.4063+000   5.5460-006   2.3522-001  -4.0238+004   4.1927-001   9.2709-001   1.4125-007   1.4370-002   3.8032-005
14   6.2370+001   4.7133+000   5.5077-006   2.3359-001  -3.4482+004   4.1927-001   9.2688-001   1.4125-007   1.4229-002   3.6485-005
15   6.7415+001   5.0450+000   5.4753-006   2.3222-001  -2.9697+004   4.1927-001   9.2687-001   1.4125-007   1.4114-002   2.5065-005
16   7.2801+001   5.3859+000   5.4669-006   2.3186-001  -2.5654+004   4.1927-001   9.2688-001   1.4125-007   1.4085-002   1.7863-005
17   7.8533+001   5.7320+000   5.4864-006   2.3269-001  -2.2687+004   4.1927-001   9.2700-001   1.4125-007   1.4156-002   9.6567-006
18   8.4639+001   6.1060+000   5.5118-006   2.3377-001  -2.0681+004   4.1927-001   9.2713-001   1.4125-007   1.4250-002   4.4318-006
19   9.1209+001   6.5701+000   5.4874-006   2.3273-001  -1.8931+004   4.1927-001   9.2715-001   1.4125-007   1.4163-002   3.3566-006
20   9.8403+001   7.1944+000   5.3623-006   2.2742-001  -1.6874+004   4.1928-001   9.2701-001   1.4126-007   1.3722-002   4.5382-006
21   1.0630+002   7.9011+000   5.2117-006   2.2104-001  -2.0605+004   4.1928-001   9.2753-001   1.4126-007   1.3220-002   1.4484-005
22   1.1433+002   8.0279+000   5.4938-006   2.3300-001  -5.2776+004   4.1958-001   9.3228-001   1.4166-007   1.4305-002   1.1254-003
23   1.2140+002   7.0658+000   6.8041-006   2.8858-001  -1.1060+005   4.2484-001   9.6075-001   1.4891-007   1.8774-002   4.4559-003
24   1.2702+002   5.6243+000   9.5774-006   4.0620-001  -1.6503+005   4.3667-001   1.0060+000   1.6620-007   2.8347-002   5.5288-003
25   1.3166+002   4.6363+000   1.3332-005   5.6542-001  -1.9508+005   4.4320-001   1.0221+000   1.7636-007   4.0342-002   2.3595-003
26   1.3616+002   4.5004+000   1.5942-005   6.7612-001  -1.9621+005   4.4285-001   1.0181+000   1.7581-007   4.7876-002   3.9998-006
27   1.4153+002   5.3744+000   1.5447-005   6.5516-001  -1.7190+005   4.3998-001   1.0070+000   1.7129-007   4.5640-002   0.0000-001
28   1.4803+002   6.5003+000   1.4613-005   6.1976-001  -1.5566+005   4.3565-001   9.9503-001   1.6465-007   4.2412-002   0.0000-001
29   1.5541+002   7.3715+000   1.4599-005   6.1918-001  -1.4646+005   4.3404-001   9.9047-001   1.6222-007   4.2081-002   2.4678-004
30   1.6350+002   8.0938+000   1.4976-005   6.3518-001  -1.3785+005   4.3213-001   9.8409-001   1.5940-007   4.2748-002   2.2161-004
31   1.7262+002   9.1177+000   1.4889-005   6.3149-001  -1.2272+005   4.2888-001   9.7188-001   1.5465-007   4.1719-002   0.0000-001
32   1.8317+002   1.0556+001   1.4279-005   6.0561-001  -1.0854+005   4.2675-001   9.6365-001   1.5160-007   3.9515-002   0.0000-001
33   1.9511+002   1.1938+001   1.3895-005   5.8932-001  -1.0235+005   4.2669-001   9.6411-001   1.5151-007   3.8482-002   1.0631-004
34   2.0570+002   1.0586+001   1.7367-005   7.3659-001  -8.0827+004   4.0052-001   8.1868-001   1.1762-007   3.7354-002   0.0000-001
35   2.1502+002   9.3221+000   2.2272-005   9.4460-001  -7.6735+004   3.9381-001   6.5031-001   1.0994-007   3.5150-002   7.4512-005
36   2.2457+002   9.5472+000   2.3224-005   9.8497-001  -6.1777+004   3.8522-001   6.0269-001   1.0065-007   3.3848-002   0.0000-001
37   2.3315+002   8.5883+000   2.4560-005   1.0416+000  -5.5021+004   3.7688-001   5.5356-001   9.2220-008   3.2798-002   0.0000-001
38   2.4070+002   7.5464+000   2.6081-005   1.1062+000  -5.0313+004   3.6912-001   4.8837-001   8.4856-008   3.0725-002   0.0000-001
39   2.4737+002   6.6730+000   2.7802-005   1.1791+000  -4.6096+004   3.5952-001   4.3158-001   7.6364-008   2.8943-002   0.0000-001
40   2.5366+002   6.2819+000   2.8025-005   1.1886+000  -4.2719+004   3.5759-001   3.9904-001   7.4741-008   2.6976-002   0.0000-001
41   2.5964+002   5.9833+000   2.8035-005   1.1890+000  -3.8306+004   3.5446-001   3.7096-001   7.2154-008   2.5086-002   0.0000-001
42   2.6517+002   5.5335+000   2.8998-005   1.2299+000  -3.1610+004   3.5203-001   3.4861-001   7.0200-008   2.4385-002   0.0000-001
43   2.7031+002   5.1351+000   3.0016-005   1.2730+000  -2.5040+004   3.4977-001   3.3173-001   6.8410-008   2.4019-002   0.0000-001
44   2.7516+002   4.8477+000   3.0642-005   1.2996+000  -2.3376+004   3.4372-001   3.2218-001   6.3803-008   2.3814-002   0.0000-001
45   2.7976+002   4.6038+000   3.1175-005   1.3222+000  -1.8537+004   3.4255-001   2.9636-001   6.2939-008   2.2287-002   0.0000-001
46   2.8426+002   4.4990+000   3.0880-005   1.3097+000  -1.5366+004   3.3986-001   2.8873-001   6.0985-008   2.1507-002   0.0000-001
47   2.8838+002   4.1253+000   3.2671-005   1.3857+000  -1.0865+004   3.3298-001   2.8247-001   5.6190-008   2.2262-002   0.0000-001
```

```
48  2.9217+002  3.7825+000  3.4668-005  1.4703+000 -5.7639+003  3.3273-001  2.7650-001  5.6023-008  2.3123-002  0.0000-001
49  2.9593+002  3.7658+000  3.3934-005  1.4392+000 -1.8557+003  3.3168-001  2.7351-001  5.5320-008  2.2389-002  0.0000-001
50  3.0000+002  4.0679+000  3.0593-005  1.2975+000  0.0000-001  3.2861-001  2.9093-001  5.3301-008  2.1470-002  0.0000-001
                                                                2.5000-002  2.5000-002

 #  R ENERGY    ION ENERGY  KIN ENERGY  R SOURCE    ION SOURCE  ION->R EX   FLUX LIM    HEAT FLUX
    (J/     )   (J/     )   (J/     )   (J/     )   (J/     )   (J/     )   (J/CM2-S)   (J/CM2-S)
 0                          0.0000-001
 1  7.9230-003  1.2402+003  1.6638+001  0.0000-001  0.0000-001  1.0485+001  7.5000-011  0.0000-001
 2  7.0641-003  1.1944+003  1.9333+001  0.0000-001  0.0000-001  3.9262+000  7.5000-011  0.0000-001
 3  7.2958-003  1.1763+003  2.2858+001  0.0000-001  0.0000-001  3.5340+000  7.5000-011  0.0000-001
 4  9.2050-003  1.4482+003  3.0773+001  0.0000-001  0.0000-001  5.6747+000  7.5000-011  0.0000-001
 5  1.1697-002  1.7819+003  4.2092+001  0.0000-001  0.0000-001  7.6818+000  7.5000-011  0.0000-001
 6  1.4891-002  2.1931+003  5.3291+001  0.0000-001  0.0000-001  7.7371+000  7.5000-011  0.0000-001
 7  1.8743-002  2.7099+003  6.2850+001  0.0000-001  0.0000-001  7.6823+000  7.5000-011  0.0000-001
 8  2.3428-002  3.3599+003  7.2577+001  0.0000-001  0.0000-001  7.9086+000  7.5000-011  0.0000-001
 9  2.9251-002  4.1704+003  8.2286+001  0.0000-001  0.0000-001  6.9571+000  7.5000-011  0.0000-001
10  3.6521-002  5.1775+003  8.9807+001  0.0000-001  0.0000-001  4.2504+000  7.5000-011  0.0000-001
11  4.5700-002  6.4206+003  9.2944+001  0.0000-001  0.0000-001 -7.2117-001  7.5000-011  0.0000-001
12  5.7411-002  7.9248+003  9.0529+001  0.0000-001  0.0000-001 -8.2032+000  7.5000-011  0.0000-001
13  7.2192-002  9.7846+003  8.5824+001  0.0000-001  0.0000-001 -1.5392+001  7.5000-011  0.0000-001
14  9.0441-002  1.2113+004  7.8412+001  0.0000-001  0.0000-001 -2.2741+001  7.5000-011  0.0000-001
15  1.1319-001  1.5013+004  7.2358+001  0.0000-001  0.0000-001 -2.9271+001  7.5000-011  0.0000-001
16  1.4104-001  1.8662+004  6.7182+001  0.0000-001  0.0000-001 -3.5689+001  7.5000-011  0.0000-001
17  1.7484-001  2.3278+004  6.5366+001  0.0000-001  0.0000-001 -3.9596+001  7.5000-011  0.0000-001
18  2.1653-001  2.9058+004  6.7579+001  0.0000-001  0.0000-001 -4.1518+001  7.5000-011  0.0000-001
19  2.7059-001  3.6054+004  7.0455+001  0.0000-001  0.0000-001 -4.8977+001  7.5000-011  0.0000-001
20  3.4452-001  4.4191+004  6.9637+001  0.0000-001  0.0000-001 -7.2996+001  7.5000-011  0.0000-001
21  4.4103-001  5.4098+004  1.2920+002  0.0000-001  0.0000-001 -7.3401+001  7.5000-011  0.0000-001
22  5.2201-001  7.0613+004  1.0545+003  0.0000-001  0.0000-001  1.1951+002  7.5000-011  0.0000-001
23  5.5119-001  9.7314+004  5.7618+003  0.0000-001  0.0000-001 -1.2662+002  7.5000-011  0.0000-001
24  5.4378-001  1.3591+005  1.5960+004  0.0000-001  0.0000-001  1.2669+002  7.5000-011  0.0000-001
25  5.1572-001  1.7382+005  2.7747+004  0.0000-001  0.0000-001  2.2528+003  7.5000-011  0.0000-001
26  5.3490-001  2.1259+005  3.4920+004  0.0000-001  0.0000-001  8.2628+002  7.5000-011  0.0000-001
27  6.6912-001  2.5791+005  3.3347+004  0.0000-001  0.0000-001  5.6236+000  7.5000-011  0.0000-001
28  8.4592-001  3.1219+005  3.4022+004  0.0000-001  0.0000-001  3.8863+002  7.5000-011  0.0000-001
29  1.0379+000  3.8407+005  3.7471+004  0.0000-001  0.0000-001  6.7556+002  7.5000-011  0.0000-001
30  1.2368+000  4.7000+005  4.1300+004  0.0000-001  0.0000-001  7.0289+002  7.5000-011  0.0000-001
31  1.5017+000  5.6723+005  4.0721+004  0.0000-001  0.0000-001  5.8210+002  7.5000-011  0.0000-001
32  1.9098+000  6.9169+005  3.9633+004  0.0000-001  0.0000-001  1.8917+002  7.5000-011  0.0000-001
33  2.4403+000  8.6200+005  4.3846+004  0.0000-001  0.0000-001  1.1465+003  7.5000-011  0.0000-001
34  1.8857+000  6.9331+005  3.4018+004  0.0000-001  0.0000-001 -5.7490+002  7.5000-011  0.0000-001
35  1.7099+000  3.6967+005  3.6815+004  0.0000-001  0.0000-001 -9.7283+001  7.5000-011  0.0000-001
36  1.7504+000  3.2944+005  2.6092+004  0.0000-001  0.0000-001 -3.4019+000  7.5000-011  0.0000-001
37  1.5641+000  2.8484+005  2.1017+004  0.0000-001  0.0000-001 -9.6175-001  7.5000-011  0.0000-001
38  1.3553+000  2.4854+005  1.7574+004  0.0000-001  0.0000-001 -2.2711-001  7.5000-011  0.0000-001
39  1.1441+000  2.1736+005  1.4752+004  0.0000-001  0.0000-001 -2.0557-002  7.5000-011  0.0000-001
40  1.1109+000  2.0048+005  1.2670+004  0.0000-001  0.0000-001 -1.4356-003  7.5000-011  0.0000-001
41  1.0721+000  1.8637+005  1.0187+004  0.0000-001  0.0000-001 -1.9111-004  7.5000-011  0.0000-001
42  1.0084+000  1.7514+005  6.9370+003  0.0000-001  0.0000-001 -2.8229-005  7.5000-011  0.0000-001
43  9.4937-001  1.6666+005  4.3528+003  0.0000-001  0.0000-001 -5.2547-006  7.5000-011  0.0000-001
44  8.6734-001  1.6186+005  3.7935+003  0.0000-001  0.0000-001 -1.4701-006  7.5000-011  0.0000-001
45  8.4095-001  1.4889+005  2.3857+003  0.0000-001  0.0000-001 -1.0789-006  7.5000-011  0.0000-001
46  8.2263-001  1.4506+005  1.6391+003  0.0000-001  0.0000-001 -7.2239-007  7.5000-011  0.0000-001
47  7.1640-001  1.4191+005  8.1958+002  0.0000-001  0.0000-001 -6.4722-007  7.5000-011  0.0000-001
48  6.7314-001  1.3892+005  2.3065+002  0.0000-001  0.0000-001 -6.7110-007  7.5000-011  0.0000-001
```

```
49  6.7907-001  1.3741+005  2.3907+001  0.0000-001  0.0000-001 -7.0161-007  7.5000-011  0.0000-001
50  7.2574-001  1.4616+005  0.0000-001  0.0000-001  0.0000-001 -5.0122-007  7.5000-011  0.0000-001

                            ENERGY CONSERVATION CHECK -- UNITS ARE (J/     )

    INT ENE     T KE        INT ENE(0)  T BDFLUX    T I->R EX   T SOURCE    BDFLUX      I->R EX     SOURCE

R   3.3318+001              1.1394-001  1.5166+007  1.5168+007  0.0000-001  5.8895+003  5.8896+003  0.0000-001
I   8.4084+006  5.5047+005  2.1144+007  3.2831-001              2.8523+006  3.3282-006              0.0000-001

                            RADIATION   3.3318+001    -6.0058+002
                            ION         8.9589+006     8.8308+006
                            TOTAL       8.9589+006     8.8302+006

 #  E DENSITY   ION DENSITY CHARGE      ROSS OPC    PLK OPC     EQM T OPC   EPSILON
    (1/CM3)     (1/CM3)     (ESU)       (CM2/G)     (CM2/G)  (CM2/G)

 1  1.7067+016  9.0000+016  1.9185-001  0.0000-001  0.0000-001  0.0000-001  0.0000-001
 2  1.7997+016  9.9108+016  1.8343-001  0.0000-001  0.0000-001  0.0000-001  0.0000-001
 3  1.6978+016  9.5094+016  1.8000-001  0.0000-001  0.0000-001  0.0000-001  0.0000-001
 4  1.6434+016  9.3115+016  1.7770-001  0.0000-001  0.0000-001  0.0000-001  0.0000-001
 5  1.5773+016  9.0552+016  1.7527-001  0.0000-001  0.0000-001  0.0000-001  0.0000-001
 6  1.5161+016  8.8086+016  1.7294-001  0.0000-001  0.0000-001  0.0000-001  0.0000-001
 7  1.4848+016  8.6867+016  1.7149-001  0.0000-001  0.0000-001  0.0000-001  0.0000-001
 8  1.4681+016  8.6372+016  1.7076-001  0.0000-001  0.0000-001  0.0000-001  0.0000-001
 9  1.4519+016  8.6032+016  1.7027-001  0.0000-001  0.0000-001  0.0000-001  0.0000-001
10  1.4394+016  8.5718+016  1.6983-001  0.0000-001  0.0000-001  0.0000-001  0.0000-001
11  1.4159+016  8.5225+016  1.6850-001  0.0000-001  0.0000-001  0.0000-001  0.0000-001
12  1.3706+016  8.4401+016  1.6363-001  0.0000-001  0.0000-001  0.0000-001  0.0000-001
13  1.3182+016  8.3508+016  1.5866-001  0.0000-001  0.0000-001  0.0000-001  0.0000-001
14  1.2861+016  8.2932+016  1.5549-001  0.0000-001  0.0000-001  0.0000-001  0.0000-001
15  1.2571+016  8.2444+016  1.5295-001  0.0000-001  0.0000-001  0.0000-001  0.0000-001
16  1.2500+016  8.2318+016  1.5230-001  0.0000-001  0.0000-001  0.0000-001  0.0000-001
17  1.2664+016  8.2612+016  1.5390-001  0.0000-001  0.0000-001  0.0000-001  0.0000-001
18  1.2885+016  8.2995+016  1.5598-001  0.0000-001  0.0000-001  0.0000-001  0.0000-001
19  1.2675+016  8.2627+016  1.5408-001  0.0000-001  0.0000-001  0.0000-001  0.0000-001
20  1.1617+016  8.0742+016  1.4439-001  0.0000-001  0.0000-001  0.0000-001  0.0000-001
21  1.0345+016  7.8476+016  1.3369-001  0.0000-001  0.0000-001  0.0000-001  0.0000-001
22  1.2254+016  8.2723+016  1.5783-001  0.0000-001  0.0000-001  0.0000-001  0.0000-001
23  1.9103+016  1.0245+017  1.9059-001  0.0000-001  0.0000-001  0.0000-001  0.0000-001
24  3.1008+016  1.4421+017  2.1964-001  0.0000-001  0.0000-001  0.0000-001  0.0000-001
25  4.5656+016  2.0074+017  2.2737-001  0.0000-001  0.0000-001  0.0000-001  0.0000-001
26  5.3486+016  2.4004+017  2.2291-001  0.0000-001  0.0000-001  0.0000-001  0.0000-001
27  5.0465+016  2.3260+017  2.1627-001  0.0000-001  0.0000-001  0.0000-001  0.0000-001
28  4.6126+016  2.2003+017  2.0923-001  0.0000-001  0.0000-001  0.0000-001  0.0000-001
29  4.5418+016  2.1983+017  2.0643-001  0.0000-001  0.0000-001  0.0000-001  0.0000-001
30  4.5672+016  2.2551+017  2.0242-001  0.0000-001  0.0000-001  0.0000-001  0.0000-001
31  4.3821+016  2.2420+017  1.9518-001  0.0000-001  0.0000-001  0.0000-001  0.0000-001
32  4.0974+016  2.1501+017  1.9049-001  0.0000-001  0.0000-001  0.0000-001  0.0000-001
33  3.9950+016  2.0923+017  1.9084-001  0.0000-001  0.0000-001  0.0000-001  0.0000-001
34  2.3456+016  2.6151+017  8.9102-002  0.0000-001  0.0000-001  0.0000-001  0.0000-001
35  2.0372+015  3.3536+017  6.0905-003  0.0000-001  0.0000-001  0.0000-001  0.0000-001
36  8.8898+014  3.4969+017  2.5257-003  0.0000-001  0.0000-001  0.0000-001  0.0000-001
37  3.6553+013  3.6981+017  9.4887-005  0.0000-001  0.0000-001  0.0000-001  0.0000-001
```

```
38   3.0493+010   3.9272+017   7.5591-008   0.0000-001   0.0000-001   0.0000-001   0.0000-001
39   2.9212+007   4.1862+017   6.7315-011   0.0000-001   0.0000-001   0.0000-001   0.0000-001
40   3.8103+005   4.2199+017   9.0246-013   0.0000-001   0.0000-001   0.0000-001   0.0000-001
41   3.5458+005   4.2213+017   8.3896-013   0.0000-001   0.0000-001   0.0000-001   0.0000-001
42   3.4520+005   4.3664+017   7.8841-013   0.0000-001   0.0000-001   0.0000-001   0.0000-001
43   3.4013+005   4.5196+017   7.5024-013   0.0000-001   0.0000-001   0.0000-001   0.0000-001
44   3.3634+005   4.6139+017   7.2863-013   0.0000-001   0.0000-001   0.0000-001   0.0000-001
45   3.1545+005   4.6942+017   6.7023-013   0.0000-001   0.0000-001   0.0000-001   0.0000-001
46   3.0414+005   4.6498+017   6.5298-013   0.0000-001   0.0000-001   0.0000-001   0.0000-001
47   3.1519+005   4.9195+017   6.3883-013   0.0000-001   0.0000-001   0.0000-001   0.0000-001
48   3.2766+005   5.2202+017   6.2534-013   0.0000-001   0.0000-001   0.0000-001   0.0000-001
49   3.1699+005   5.1096+017   6.1857-013   0.0000-001   0.0000-001   0.0000-001   0.0000-001
50   3.0348+005   4.6065+017   6.5796-013   0.0000-001   0.0000-001   0.0000-001   0.0000-001


SHORT EDIT
TOTAL ENERGY RADIATED TO THE WALL(J)..........  1.5+007
ENERGY RADIATED TO THE WALL ON THIS TIME STEP.  5.9+003
PRESSURE AT THE WALL(J/CM3)..................  2.1-002
HEAT FLUX AT THE WALL(J/CM2-S)...............  0.0-001


                1        8        15       22       29       36       43       50
 RADIUS   1.6+001 3.8+001 6.7+001 1.1+002 1.6+002 2.2+002 2.7+002 3.0+002
VELOCITY-5.6+004-6.4+004-3.0+004-5.3+004-1.5+005-6.2+004-2.5+004 0.0-001
 I TEMP   9.6-001 9.3-001 9.3-001 9.3-001 9.9-001 6.0-001 3.3-001 2.9-001
 R TEMP   4.2-001 4.2-001 4.2-001 4.2-001 4.3-001 3.9-001 3.5-001 3.3-001
 P  MFP   0.0-001 0.0-001 0.0-001 0.0-001 0.0-001 0.0-001 0.0-001 0.0-001
 R  MFP   0.0-001 0.0-001 0.0-001 0.0-001 0.0-001 0.0-001 0.0-001 0.0-001


ENERGY CONSERVATION

       INT ENE + KIN ENE = RHS =     INT ENE 0-T BDFLUX +T SOURCE+-T I->R EX

  R     3.3+001              -6.0+002   1.1-001    1.5+007    0.0-001   -1.5+007
  I     8.4+006    5.5+005    8.8+006   2.1+007    3.3-001    2.9+006    1.5+007
  T     9.0+006               8.8+006


  #  RAD TEMP     RAD ENERGY   PLANCK OPC   ROSS OPC     EMISSION     ABSORPTION
     (EV)         (J/CM3)      (CM2/G)      (CM2/G)      (J/G*S)      (J/G*S)

  1  4.2452-001   4.4538-007   2.9072+004   4.7750-001   4.0962+008   3.8691+008
  2  4.2258-001   4.3728-007   2.6851+004   3.7779-001   3.5981+008   3.5131+008
  3  4.2162-001   4.3333-007   2.5500+004   3.5384-001   3.3850+008   3.3084+008
  4  4.2088-001   4.3030-007   2.4458+004   3.3779-001   3.2500+008   3.1512+008
  5  4.2017-001   4.2739-007   2.3402+004   3.2217-001   3.1027+008   2.9953+008
  6  4.1968-001   4.2542-007   2.2661+004   3.0753-001   2.9754+008   2.8884+008
  7  4.1944-001   4.2444-007   2.2294+004   2.9809-001   2.9054+008   2.8360+008
  8  4.1933-001   4.2399-007   2.2128+004   2.9320-001   2.8699+008   2.8124+008
  9  4.1929-001   4.2382-007   2.2063+004   2.8989-001   2.8440+008   2.8034+008
 10  4.1928-001   4.2377-007   2.2044+004   2.8689-001   2.8211+008   2.8012+008
 11  4.1927-001   4.2376-007   2.2034+004   2.8401-001   2.7978+008   2.8005+008
 12  4.1927-001   4.2376-007   2.2016+004   2.8091-001   2.7740+008   2.7989+008
 13  4.1927-001   4.2376-007   2.1995+004   2.7929-001   2.7590+008   2.7965+008
 14  4.1927-001   4.2376-007   2.1981+004   2.7819-001   2.7504+008   2.7950+008
```

```
15  4.1927-001  4.2376-007  2.1967+004  2.7805-001  2.7472+008  2.7933+008
16  4.1927-001  4.2376-007  2.1964+004  2.7810-001  2.7477+008  2.7928+008
17  4.1927-001  4.2376-007  2.1971+004  2.7870-001  2.7533+008  2.7936+008
18  4.1927-001  4.2376-007  2.1981+004  2.7942-001  2.7607+008  2.7947+008
19  4.1927-001  4.2376-007  2.1971+004  2.7948-001  2.7613+008  2.7935+008
20  4.1928-001  4.2377-007  2.1922+004  2.7859-001  2.7489+008  2.7874+008
21  4.1928-001  4.2379-007  2.1861+004  2.8090-001  2.7482+008  2.7793+008
22  4.1958-001  4.2499-007  2.2345+004  3.0534-001  2.8857+008  2.8449+008
23  4.2484-001  4.4672-007  2.9808+004  4.4152-001  3.9469+008  3.9816+008
24  4.3667-001  4.9860-007  4.6282+004  7.3513-001  6.8927+008  6.8647+008
25  4.4320-001  5.2907-007  5.6965+004  8.0657-001  9.3790+008  8.9798+008
26  4.4285-001  5.2742-007  5.8120+004  7.2427-001  9.2913+008  9.1736+008
27  4.3998-001  5.1386-007  5.3902+004  6.3152-001  8.3265+008  8.3258+008
28  4.3565-001  4.9394-007  4.7820+004  5.4870-001  7.1253+008  7.0895+008
29  4.3404-001  4.8667-007  4.5661+004  5.1656-001  6.7144+008  6.6644+008
30  4.3213-001  4.7819-007  4.3196+004  4.7079-001  6.2366+008  6.1948+008
31  4.2888-001  4.6394-007  3.8543+004  3.9858-001  5.3941+008  5.3663+008
32  4.2675-001  4.5480-007  3.5316+004  3.5882-001  4.8262+008  4.8190+008
33  4.2669-001  4.5454-007  3.5233+004  3.6361-001  4.8388+008  4.8035+008
34  4.0052-001  3.5286-007  5.4974+003  2.9033-002  5.6816+007  5.8242+007
35  3.9381-001  3.2981-007  1.4664+002  2.8265-004  1.2562+006  1.4502+006
36  3.8522-001  3.0196-007  3.4588+001  6.1989-005  3.0787+005  3.1369+005
37  3.7688-001  2.7666-007  6.5184+000  7.1572-006  5.2617+004  5.4212+004
38  3.6912-001  2.5457-007  4.2286-001  1.9708-007  2.8570+003  3.2337+003
39  3.5952-001  2.2909-007  2.2247-002  7.5165-009  1.1907+002  1.5317+002
40  3.5759-001  2.2422-007  2.3245-003  1.8913-009  1.3255+001  1.5636+001
41  3.5446-001  2.1646-007  3.3721-004  1.9398-009  1.8728+000  2.1898+000
42  3.5203-001  2.1060-007  5.9116-005  1.9624-009  3.2667-001  3.7350-001
43  3.4977-001  2.0523-007  1.3407-005  1.9915-009  7.3832-002  8.2548-002
44  3.4372-001  1.9141-007  5.2200-006  2.1058-009  2.7536-002  2.9974-002
45  3.4255-001  1.8882-007  7.4207-007  2.0748-009  2.4140-003  4.2034-003
46  3.3986-001  1.8295-007  4.4703-007  2.1264-009  1.2554-003  2.4536-003
47  3.3298-001  1.6857-007  3.7851-007  2.2601-009  8.4067-004  1.9142-003
48  3.3273-001  1.6807-007  3.4327-007  2.2450-009  6.1771-004  1.7308-003
49  3.3168-001  1.6596-007  3.4143-007  2.2690-009  5.3622-004  1.6999-003
50  3.2861-001  1.5990-007  4.8065-007  2.3272-009  1.4744-003  2.3057-003


FREQUENCY DEPENDENT RADIATION ENERGY DENSITY(J/CM3)

 #        GR1        GR2        GR3        GR4        GR5        GR6        GR7        GR8        GR9        GR10        GR11

 1  3.597-008  2.836-007  4.275-008  6.302-009  5.033-010  6.993-008  5.745-009  5.951-010  1.538-013  1.566-016  1.000-020
 2  3.597-008  2.836-007  4.275-008  6.302-009  5.033-010  6.262-008  5.042-009  5.044-010  1.147-013  1.080-016  1.000-020
 3  3.597-008  2.836-007  4.275-008  6.302-009  5.033-010  5.922-008  4.550-009  4.622-010  1.019-013  9.347-017  1.000-020
 4  3.597-008  2.836-007  4.275-008  6.302-009  5.033-010  5.650-008  4.256-009  4.375-010  9.307-014  8.350-017  1.000-020
 5  3.597-008  2.836-007  4.275-008  6.302-009  5.033-010  5.374-008  4.123-009  4.251-010  8.544-014  7.520-017  1.000-020
 6  3.597-008  2.836-007  4.275-008  6.302-009  5.033-010  5.182-008  4.075-009  4.200-010  7.943-014  6.882-017  1.000-020
 7  3.597-008  2.836-007  4.275-008  6.302-009  5.033-010  5.085-008  4.059-009  4.181-010  7.527-014  6.438-017  1.000-020
 8  3.597-008  2.836-007  4.275-008  6.302-009  5.033-010  5.041-008  4.054-009  4.174-010  7.247-014  6.132-017  1.000-020
 9  3.597-008  2.836-007  4.275-008  6.302-009  5.033-010  5.024-008  4.053-009  4.172-010  7.045-014  5.910-017  1.000-020
10  3.597-008  2.836-007  4.275-008  6.302-009  5.033-010  5.019-008  4.052-009  4.171-010  6.887-014  5.738-017  1.000-020
11  3.597-008  2.836-007  4.275-008  6.302-009  5.033-010  5.018-008  4.052-009  4.171-010  6.757-014  5.599-017  1.000-020
12  3.597-008  2.836-007  4.275-008  6.302-009  5.033-010  5.018-008  4.052-009  4.170-010  6.651-014  5.490-017  1.000-020
13  3.597-008  2.836-007  4.275-008  6.302-009  5.033-010  5.018-008  4.052-009  4.170-010  6.578-014  5.414-017  1.000-020
14  3.597-008  2.836-007  4.275-008  6.302-009  5.033-010  5.018-008  4.052-009  4.170-010  6.535-014  5.369-017  1.000-020
15  3.597-008  2.836-007  4.275-008  6.302-009  5.033-010  5.018-008  4.052-009  4.170-010  6.518-014  5.352-017  1.000-020
```

```
16   3.597-008  2.836-007  4.275-008  6.302-009  5.033-010  5.018-008  4.052-009  4.170-010  6.520-014  5.359-017  1.000-020
17   3.597-008  2.836-007  4.275-008  6.302-009  5.033-010  5.018-008  4.052-009  4.170-010  6.542-014  5.391-017  1.000-020
18   3.597-008  2.836-007  4.275-008  6.302-009  5.033-010  5.018-008  4.052-009  4.171-010  6.578-014  5.454-017  1.000-020
19   3.597-008  2.836-007  4.275-008  6.302-009  5.033-010  5.019-008  4.052-009  4.171-010  6.630-014  5.569-017  1.000-020
20   3.597-008  2.836-007  4.275-008  6.302-009  5.033-010  5.019-008  4.052-009  4.173-010  6.755-014  5.828-017  1.000-020
21   3.597-008  2.836-007  4.275-008  6.302-009  5.033-010  5.021-008  4.055-009  4.185-010  7.215-014  6.599-017  1.000-020
22   3.597-008  2.836-007  4.274-008  6.302-009  5.033-010  5.126-008  4.188-009  4.415-010  9.117-014  9.503-017  1.000-020
23   3.597-008  2.836-007  4.274-008  6.302-009  5.033-010  7.058-008  6.302-009  7.283-010  1.863-013  2.353-016  1.000-020
24   3.597-008  2.836-007  4.274-008  6.302-009  5.033-010  1.163-007  1.167-008  1.500-009  5.135-013  7.648-016  1.000-020
25   3.597-008  2.836-007  4.274-008  6.302-009  5.033-010  1.433-007  1.476-008  1.936-009  8.378-013  1.354-015  1.000-020
26   3.596-008  2.836-007  4.274-008  6.301-009  5.033-010  1.417-007  1.466-008  1.929-009  7.972-013  1.276-015  1.000-020
27   3.596-008  2.836-007  4.274-008  6.301-009  5.033-010  1.295-007  1.352-008  1.813-009  6.417-013  9.905-016  1.000-020
28   3.595-008  2.836-007  4.274-008  6.300-009  5.033-010  1.123-007  1.115-008  1.420-009  4.716-013  6.783-016  1.000-020
29   3.595-008  2.835-007  4.274-008  6.300-009  5.033-010  1.060-007  1.033-008  1.288-009  4.055-013  5.508-016  1.000-020
30   3.594-008  2.835-007  4.274-008  6.298-009  5.032-010  9.864-008  9.438-009  1.154-009  3.396-013  4.375-016  1.000-020
31   3.592-008  2.834-007  4.273-008  6.296-009  5.031-010  8.617-008  7.964-009  9.405-010  2.483-013  2.967-016  1.000-020
32   3.589-008  2.833-007  4.272-008  6.292-009  5.030-010  7.821-008  7.045-009  8.103-010  1.962-013  2.202-016  1.000-020
33   3.585-008  2.831-007  4.271-008  6.285-009  5.028-010  7.821-008  7.045-009  8.101-010  1.930-013  2.104-016  1.000-020
34   3.253-008  2.631-007  3.958-008  5.751-009  4.557-010  1.082-008  6.032-010  4.575-011  5.013-015  9.331-018  1.000-020
35   3.173-008  2.543-007  3.753-008  5.433-009  4.309-010  3.943-010  1.161-011  6.131-013  7.220-017  3.577-019  1.000-020
36   2.889-008  2.320-007  3.542-008  5.142-009  4.077-010  9.705-011  1.462-012  3.301-014  9.241-019  1.265-020  1.000-020
37   2.515-008  2.148-007  3.174-008  4.615-009  3.655-010  2.048-011  1.983-013  2.823-015  1.261-020  1.000-020  1.000-020
38   2.435-008  1.964-007  2.926-008  4.217-009  3.349-010  1.745-012  9.253-015  7.743-017  1.000-020  1.000-020  1.000-020
39   2.158-008  1.764-007  2.681-008  3.945-009  3.124-010  1.173-013  3.181-016  1.447-018  1.000-020  1.000-020  1.000-020
40   2.119-008  1.734-007  2.565-008. 3.705-009  2.938-010  1.489-014  1.998-017  4.709-020  1.000-020  1.000-020  1.000-020
41   2.116-008  1.662-007  2.520-008  3.649-009  2.894-010  2.085-015  1.533-018  1.000-020  1.000-020  1.000-020  1.000-020
42   2.046-008  1.624-007  2.396-008  3.501-009  2.772-010  3.542-016  1.526-019  1.000-020  1.000-020  1.000-020  1.000-020
43   1.852-008  1.593-007  2.373-008  3.418-009  2.713-010  7.687-017  2.088-020  1.000-020  1.000-020  1.000-020  1.000-020
44   1.843-008  1.466-007  2.272-008  3.383-009  2.680-010  2.688-017  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020
45   1.798-008  1.463-007  2.126-008  3.035-009  2.405-010  2.315-018  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020
46   1.652-008  1.420-007  2.124-008  3.005-009  2.387-010  6.939-019  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020
47   1.651-008  1.293-007  1.967-008  2.902-009  2.300-010  3.212-019  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020
48   1.651-008  1.292-007  1.929-008  2.799-009  2.219-010  1.477-019  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020
49   1.530-008  1.284-007  1.923-008  2.791-009  2.213-010  1.281-019  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020
50   1.516-008  1.234-007  1.847-008  2.681-009  2.126-010  7.628-019  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020

 #        GR12       GR13       GR14       GR15       GR16       GR17       GR18       GR19       GR20

 1   1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020
 2   1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020
 3   1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020
 4   1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020
 5   1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020
 6   1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020
 7   1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020
 8   1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020
 9   1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020
10   1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020
11   1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020
12   1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020
13   1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020
14   1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020
15   1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020
16   1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020
17   1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020
18   1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020
19   1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020
```

```
20  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020
21  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020
22  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020
23  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020
24  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020
25  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020
26  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020
27  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020
28  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020
29  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020
30  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020
31  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020
32  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020
33  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020
34  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020
35  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020
36  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020
37  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020
38  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020
39  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020
40  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020
41  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020
42  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020
43  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020
44  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020
45  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020
46  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020
47  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020
48  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020
49  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020
50  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020  1.000-020

FREQUENCY DEPENDENT PLANCK OPACITY(CM2/G)

 #        GR1        GR2        GR3        GR4        GR5        GR6        GR7        GR8        GR9       GR10       GR11

 1  2.197+001  1.553+001  2.271+000  6.435-001  2.241-001  1.777+005  8.484+004  5.268+004  2.102+004  1.621+004  4.729+003
 2  1.801+001  1.360+001  1.998+000  5.664-001  1.971-001  1.800+005  8.650+004  5.409+004  2.029+004  1.475+004  4.302+003
 3  1.663+001  1.274+001  1.876+000  5.317-001  1.849-001  1.795+005  8.647+004  5.424+004  2.024+004  1.459+004  4.257+003
 4  1.575+001  1.220+001  1.799+000  5.099-001  1.773-001  1.793+005  8.653+004  5.439+004  2.018+004  1.444+004  4.213+003
 5  1.487+001  1.165+001  1.720+000  4.876-001  1.695-001  1.790+005  8.656+004  5.452+004  2.012+004  1.430+004  4.173+003
 6  1.407+001  1.114+001  1.648+000  4.671-001  1.623-001  1.787+005  8.660+004  5.466+004  2.007+004  1.417+004  4.133+003
 7  1.358+001  1.084+001  1.604+000  4.548-001  1.581-001  1.786+005  8.666+004  5.477+004  2.002+004  1.406+004  4.103+003
 8  1.334+001  1.069+001  1.583+000  4.488-001  1.560-001  1.786+005  8.670+004  5.483+004  1.999+004  1.400+004  4.086+003
 9  1.319+001  1.059+001  1.569+000  4.448-001  1.546-001  1.786+005  8.673+004  5.487+004  1.998+004  1.396+004  4.074+003
10  1.304+001  1.051+001  1.556+000  4.412-001  1.533-001  1.786+005  8.675+004  5.491+004  1.996+004  1.393+004  4.064+003
11  1.291+001  1.042+001  1.544+000  4.377-001  1.521-001  1.785+005  8.675+004  5.494+004  1.995+004  1.390+004  4.055+003
12  1.277+001  1.033+001  1.532+000  4.342-001  1.509-001  1.784+005  8.671+004  5.493+004  1.994+004  1.387+004  4.046+003
13  1.271+001  1.029+001  1.525+000  4.323-001  1.502-001  1.782+005  8.664+004  5.489+004  1.994+004  1.386+004  4.045+003
14  1.266+001  1.025+001  1.520+000  4.310-001  1.497-001  1.781+005  8.659+004  5.487+004  1.994+004  1.386+004  4.043+003
15  1.265+001  1.025+001  1.519+000  4.306-001  1.496-001  1.780+005  8.654+004  5.484+004  1.995+004  1.387+004  4.045+003
16  1.265+001  1.025+001  1.519+000  4.306-001  1.496-001  1.780+005  8.653+004  5.483+004  1.995+004  1.387+004  4.046+003
17  1.268+001  1.026+001  1.522+000  4.314-001  1.499-001  1.780+005  8.655+004  5.484+004  1.995+004  1.387+004  4.047+003
18  1.271+001  1.029+001  1.525+000  4.322-001  1.502-001  1.781+005  8.658+004  5.486+004  1.995+004  1.388+004  4.048+003
19  1.271+001  1.028+001  1.524+000  4.321-001  1.501-001  1.780+005  8.654+004  5.483+004  1.996+004  1.388+004  4.050+003
20  1.267+001  1.024+001  1.519+000  4.305-001  1.496-001  1.776+005  8.634+004  5.471+004  1.998+004  1.391+004  4.058+003
```

```
21  1.276+001  1.028+001  1.523+000  4.318-001  1.500-001  1.770+005  8.605+004  5.450+004  2.004+004  1.399+004  4.081+003
22  1.380+001  1.092+001  1.615+000  4.579-001  1.592-001  1.777+005  8.616+004  5.442+004  2.014+004  1.426+004  4.160+003
23  2.126+001  1.548+001  2.265+000  6.418-001  2.235-001  1.803+005  8.617+004  5.355+004  2.052+004  1.531+004  4.466+003
24  4.017+001  2.694+001  3.875+000  1.098+000  3.833-001  1.888+005  8.820+004  5.347+004  2.032+004  1.556+004  4.541+003
25  4.831+001  3.378+001  4.833+000  1.370+000  4.783-001  2.000+005  9.273+004  5.573+004  1.904+004  1.354+004  3.951+003
26  4.461+001  3.309+001  4.743+000  1.345+000  4.692-001  2.055+005  9.549+004  5.751+004  1.820+004  1.213+004  3.539+003
27  3.839+001  2.901+001  4.175+000  1.183+000  4.128-001  2.032+005  9.490+004  5.750+004  1.826+004  1.211+004  3.532+003
28  3.261+001  2.505+001  3.621+000  1.026+000  3.577-001  2.002+005  9.403+004  5.734+004  1.839+004  1.218+004  3.552+003
29  3.056+001  2.375+001  3.438+000  9.745-001  3.396-001  1.996+005  9.400+004  5.747+004  1.836+004  1.207+004  3.522+003
30  2.781+001  2.209+001  3.206+000  9.089-001  3.166-001  1.996+005  9.429+004  5.785+004  1.821+004  1.178+004  3.436+003
31  2.331+001  1.909+001  2.783+000  7.890-001  2.746-001  1.981+005  9.414+004  5.814+004  1.813+004  1.153+004  3.363+003
32  2.074+001  1.722+001  2.518+000  7.139-001  2.484-001  1.962+005  9.364+004  5.810+004  1.819+004  1.153+004  3.364+003
33  2.094+001  1.727+001  2.525+000  7.158-001  2.490-001  1.957+005  9.335+004  5.790+004  1.828+004  1.167+004  3.405+003
34  1.652+000  2.123+000  3.327-001  9.448-002  3.253-002  1.739+005  9.092+004  6.225+004  1.715+004  8.830+003  2.472+003
35  1.500-002  3.851-002  6.973-003  1.987-003  6.728-004  1.203+005  7.638+004  6.346+004  1.756+004  8.827+003  1.874+003
36  3.174-003  1.024-002  1.945-003  5.548-004  1.869-004  1.065+005  7.211+004  6.387+004  1.770+004  8.827+003  1.710+003
37  3.514-004  1.542-003  3.157-004  9.044-005  3.028-005  8.739+004  6.540+004  6.411+004  1.783+004  8.324+003  1.640+003
38  8.582-006  6.236-005  1.459-005  4.219-006  1.401-006  6.137+004  5.476+004  6.425+004  1.801+004  7.193+003  1.640+003
39  2.203-007  2.633-006  7.025-007  2.050-007  6.751-008  4.331+004  4.596+004  6.439+004  1.818+004  6.229+003  1.640+003
40  2.318-008  3.763-007  1.088-007  3.195-008  1.047-008  3.495+004  4.126+004  6.447+004  1.829+004  5.701+003  1.640+003
41  2.318-008  3.763-007  1.088-007  3.195-008  1.047-008  3.495+004  4.126+004  6.447+004  1.829+004  5.701+003  1.640+003
42  2.318-008  3.763-007  1.088-007  3.195-008  1.046-008  3.495+004  4.126+004  6.447+004  1.829+004  5.701+003  1.640+003
43  2.318-008  3.763-007  1.088-007  3.195-008  1.046-008  3.495+004  4.126+004  6.447+004  1.829+004  5.701+003  1.640+003
44  2.318-008  3.763-007  1.088-007  3.194-008  1.046-008  3.495+004  4.126+004  6.447+004  1.829+004  5.701+003  1.640+003
45  2.318-008  3.763-007  1.088-007  3.194-008  1.046-008  3.495+004  4.126+004  6.447+004  1.829+004  5.701+003  1.640+003
46  2.318-008  3.763-007  1.088-007  3.194-008  1.046-008  3.495+004  4.126+004  6.447+004  1.829+004  5.701+003  1.640+003
47  2.317-008  3.763-007  1.088-007  3.194-008  1.046-008  3.495+004  4.126+004  6.447+004  1.829+004  5.701+003  1.640+003
48  2.317-008  3.763-007  1.088-007  3.194-008  1.046-008  3.495+004  4.126+004  6.447+004  1.829+004  5.701+003  1.640+003
49  2.317-008  3.763-007  1.088-007  3.194-008  1.046-008  3.495+004  4.126+004  6.447+004  1.829+004  5.701+003  1.640+003
50  2.318-008  3.763-007  1.088-007  3.194-008  1.046-008  3.495+004  4.126+004  6.447+004  1.829+004  5.701+003  1.640+003

 #     GR12       GR13       GR14       GR15       GR16       GR17       GR18       GR19       GR20

 1  1.033+003  4.130+002  2.208+002  1.151+002  4.426+001  1.438+001  6.453+000  2.162+000  1.578-002
 2  9.290+002  3.757+002  2.008+002  1.047+002  4.026+001  1.308+001  5.870+000  1.967+000  1.436-002
 3  9.145+002  3.717+002  1.987+002  1.036+002  3.983+001  1.295+001  5.808+000  1.946+000  1.420-002
 4  9.021+002  3.679+002  1.967+002  1.025+002  3.943+001  1.281+001  5.749+000  1.926+000  1.406-002
 5  8.902+002  3.644+002  1.948+002  1.015+002  3.905+001  1.269+001  5.694+000  1.908+000  1.393-002
 6  8.786+002  3.609+002  1.929+002  1.006+002  3.868+001  1.257+001  5.639+000  1.890+000  1.379-002
 7  8.702+002  3.583+002  1.915+002  9.983+001  3.839+001  1.248+001  5.598+000  1.876+000  1.369-002
 8  8.656+002  3.568+002  1.907+002  9.941+001  3.823+001  1.243+001  5.574+000  1.868+000  1.363-002
 9  8.625+002  3.558+002  1.902+002  9.913+001  3.813+001  1.239+001  5.559+000  1.863+000  1.360-002
10  8.598+002  3.549+002  1.897+002  9.888+001  3.803+001  1.236+001  5.545+000  1.858+000  1.356-002
11  8.573+002  3.541+002  1.893+002  9.866+001  3.795+001  1.233+001  5.533+000  1.854+000  1.353-002
12  8.550+002  3.533+002  1.889+002  9.845+001  3.786+001  1.231+001  5.521+000  1.850+000  1.350-002
13  8.543+002  3.532+002  1.888+002  9.840+001  3.785+001  1.230+001  5.518+000  1.849+000  1.350-002
14  8.538+002  3.530+002  1.887+002  9.837+001  3.783+001  1.230+001  5.516+000  1.849+000  1.349-002
15  8.543+002  3.532+002  1.888+002  9.842+001  3.786+001  1.230+001  5.519+000  1.850+000  1.350-002
16  8.545+002  3.533+002  1.889+002  9.845+001  3.786+001  1.231+001  5.521+000  1.850+000  1.350-002
17  8.548+002  3.534+002  1.889+002  9.847+001  3.787+001  1.231+001  5.522+000  1.850+000  1.351-002
18  8.551+002  3.535+002  1.890+002  9.849+001  3.788+001  1.231+001  5.523+000  1.851+000  1.351-002
19  8.556+002  3.537+002  1.891+002  9.855+001  3.790+001  1.232+001  5.526+000  1.852+000  1.352-002
20  8.570+002  3.543+002  1.894+002  9.872+001  3.797+001  1.234+001  5.536+000  1.855+000  1.354-002
21  8.625+002  3.564+002  1.905+002  9.930+001  3.819+001  1.241+001  5.568+000  1.866+000  1.362-002
22  8.833+002  3.633+002  1.942+002  1.012+002  3.893+001  1.265+001  5.676+000  1.902+000  1.388-002
23  9.744+002  3.899+002  2.085+002  1.087+002  4.179+001  1.358+001  6.093+000  2.042+000  1.490-002
24  1.033+003  3.965+002  2.120+002  1.105+002  4.249+001  1.381+001  6.195+000  2.076+000  1.515-002
```

```
25  9.119+002  3.450+002  1.844+002  9.612+001  3.697+001  1.202+001  5.390+000  1.806+000  1.318-002
26  8.140+002  3.091+002  1.652+002  8.611+001  3.312+001  1.076+001  4.829+000  1.618+000  1.181-002
27  8.043+002  3.084+002  1.649+002  8.594+001  3.305+001  1.074+001  4.819+000  1.615+000  1.179-002
28  8.002+002  3.102+002  1.658+002  8.643+001  3.324+001  1.080+001  4.847+000  1.624+000  1.185-002
29  7.900+002  3.075+002  1.644+002  8.569+001  3.296+001  1.071+001  4.805+000  1.610+000  1.175-002
30  7.662+002  3.000+002  1.604+002  8.360+001  3.215+001  1.045+001  4.688+000  1.571+000  1.147-002
31  7.415+002  2.937+002  1.570+002  8.183+001  3.147+001  1.023+001  4.589+000  1.538+000  1.122-002
32  7.361+002  2.938+002  1.570+002  8.185+001  3.148+001  1.023+001  4.590+000  1.538+000  1.123-002
33  7.452+002  2.973+002  1.589+002  8.283+001  3.186+001  1.035+001  4.645+000  1.557+000  1.136-002
34  5.014+002  2.249+002  1.203+002  6.268+001  2.411+001  7.835+000  3.515+000  1.178+000  8.597-003
35  5.013+002  2.249+002  1.202+002  6.266+001  2.410+001  7.832+000  3.514+000  1.177+000  8.594-003
36  5.013+002  2.249+002  1.202+002  6.266+001  2.410+001  7.832+000  3.514+000  1.177+000  8.594-003
37  5.013+002  2.249+002  1.202+002  6.266+001  2.410+001  7.832+000  3.514+000  1.177+000  8.594-003
38  5.013+002  2.249+002  1.202+002  6.266+001  2.410+001  7.832+000  3.514+000  1.177+000  8.594-003
39  5.013+002  2.249+002  1.202+002  6.266+001  2.410+001  7.832+000  3.514+000  1.177+000  8.594-003
40  5.013+002  2.249+002  1.202+002  6.266+001  2.410+001  7.832+000  3.514+000  1.177+000  8.594-003
41  5.013+002  2.249+002  1.202+002  6.266+001  2.410+001  7.832+000  3.514+000  1.177+000  8.594-003
42  5.013+002  2.249+002  1.202+002  6.266+001  2.410+001  7.832+000  3.514+000  1.177+000  8.594-003
43  5.013+002  2.249+002  1.202+002  6.266+001  2.410+001  7.832+000  3.514+000  1.177+000  8.594-003
44  5.013+002  2.249+002  1.202+002  6.266+001  2.410+001  7.832+000  3.514+000  1.177+000  8.594-003
45  5.013+002  2.249+002  1.202+002  6.266+001  2.410+001  7.832+000  3.514+000  1.177+000  8.594-003
46  5.013+002  2.249+002  1.202+002  6.266+001  2.410+001  7.832+000  3.514+000  1.177+000  8.594-003
47  5.013+002  2.249+002  1.202+002  6.266+001  2.410+001  7.832+000  3.514+000  1.177+000  8.594-003
48  5.013+002  2.249+002  1.202+002  6.266+001  2.410+001  7.832+000  3.514+000  1.177+000  8.594-003
49  5.013+002  2.249+002  1.202+002  6.266+001  2.410+001  7.832+000  3.514+000  1.177+000  8.594-003
50  5.013+002  2.249+002  1.202+002  6.266+001  2.410+001  7.832+000  3.514+000  1.177+000  8.594-003

FREQUENCY DEPENDENT ROSSELAND OPACITY(CM2/G)

 #        GR1        GR2        GR3        GR4        GR5        GR6        GR7        GR8        GR9       GR10       GR11

 1  2.120+000  4.011-001  2.154-001  5.542-001  2.074-001  9.427-002  4.714-002  8.415-001  1.622+004  1.621+004  4.729+003
 2  1.482+000  3.295-001  1.788-001  4.879-001  1.824-001  8.290-002  4.141-002  7.264-001  1.636+004  1.475+004  4.302+003
 3  1.398+000  3.041-001  1.651-001  4.580-001  1.712-001  7.780-002  3.885-002  6.763-001  1.635+004  1.459+004  4.257+003
 4  1.333+000  2.880-001  1.565-001  4.392-001  1.642-001  7.460-002  3.724-002  6.449-001  1.635+004  1.444+004  4.213+003
 5  1.277+000  2.719-001  1.479-001  4.201-001  1.569-001  7.132-002  3.560-002  6.131-001  1.635+004  1.430+004  4.173+003
 6  1.225+000  2.572-001  1.400-001  4.024-001  1.503-001  6.832-002  3.409-002  5.841-001  1.636+004  1.417+004  4.133+003
 7  1.189+000  2.483-001  1.353-001  3.919-001  1.464-001  6.652-002  3.319-002  5.667-001  1.636+004  1.406+004  4.103+003
 8  1.170+000  2.440-001  1.329-001  3.867-001  1.444-001  6.563-002  3.274-002  5.582-001  1.636+004  1.400+004  4.086+003
 9  1.157+000  2.411-001  1.314-001  3.833-001  1.431-001  6.505-002  3.245-002  5.525-001  1.636+004  1.396+004  4.074+003
10  1.146+000  2.385-001  1.300-001  3.802-001  1.420-001  6.452-002  3.218-002  5.475-001  1.637+004  1.393+004  4.064+003
11  1.135+000  2.359-001  1.286-001  3.771-001  1.408-001  6.400-002  3.192-002  5.425-001  1.637+004  1.390+004  4.055+003
12  1.121+000  2.335-001  1.274-001  3.742-001  1.397-001  6.349-002  3.167-002  5.377-001  1.635+004  1.387+004  4.046+003
13  1.114+000  2.323-001  1.267-001  3.725-001  1.391-001  6.321-002  3.153-002  5.351-001  1.634+004  1.386+004  4.045+003
14  1.109+000  2.314-001  1.262-001  3.714-001  1.387-001  6.302-002  3.143-002  5.333-001  1.633+004  1.386+004  4.043+003
15  1.108+000  2.313-001  1.261-001  3.711-001  1.386-001  6.297-002  3.141-002  5.329-001  1.632+004  1.387+004  4.045+003
16  1.109+000  2.313-001  1.261-001  3.711-001  1.386-001  6.297-002  3.141-002  5.329-001  1.632+004  1.387+004  4.046+003
17  1.111+000  2.318-001  1.264-001  3.717-001  1.388-001  6.308-002  3.146-002  5.339-001  1.632+004  1.387+004  4.047+003
18  1.114+000  2.324-001  1.267-001  3.725-001  1.391-001  6.320-002  3.153-002  5.351-001  1.633+004  1.387+004  4.048+003
19  1.115+000  2.324-001  1.267-001  3.724-001  1.390-001  6.319-002  3.152-002  5.350-001  1.632+004  1.388+004  4.050+003
20  1.111+000  2.316-001  1.263-001  3.710-001  1.385-001  6.295-002  3.140-002  5.329-001  1.629+004  1.391+004  4.058+003
21  1.123+000  2.332-001  1.270-001  3.721-001  1.390-001  6.316-002  3.150-002  5.351-001  1.624+004  1.399+004  4.081+003
22  1.238+000  2.521-001  1.371-001  3.946-001  1.474-001  6.699-002  3.342-002  5.716-001  1.629+004  1.426+004  4.160+003
23  1.773+000  3.890-001  2.103-001  5.527-001  2.068-001  9.399-002  4.699-002  8.371-001  1.633+004  1.531+004  4.466+003
24  2.863+000  7.398-001  4.013-001  9.446-001  3.543-001  1.610-001  8.070-002  1.530+000  1.654+004  1.556+004  4.541+003
25  2.639+000  8.982-001  4.967-001  1.178+000  4.420-001  2.008-001  1.007-001  1.951+000  1.694+004  1.354+004  3.951+003
```

```
26  1.989+000  8.332-001  4.669-001  1.156+000  4.336-001  1.969-001  9.873-002  1.902+000  1.717+004  1.213+004  3.539+003
27  1.674+000  7.159-001  4.008-001  1.018+000  3.815-001  1.733-001  8.681-002  1.648+000  1.711+004  1.211+004  3.532+003
28  1.419+000  6.067-001  3.389-001  8.830-001  3.307-001  1.502-001  7.522-002  1.405+000  1.703+004  1.218+004  3.552+003
29  1.301+000  5.683-001  3.177-001  8.385-001  3.140-001  1.426-001  7.138-002  1.325+000  1.702+004  1.207+004  3.522+003
30  1.116+000  5.172-001  2.898-001  7.821-001  2.928-001  1.330-001  6.653-002  1.224+000  1.704+004  1.178+004  3.436+003
31  8.846-001  4.331-001  2.429-001  6.791-001  2.540-001  1.154-001  5.768-002  1.043+000  1.702+004  1.153+004  3.363+003
32  7.893-001  3.849-001  2.157-001  6.146-001  2.298-001  1.044-001  5.215-002  9.325-001  1.697+004  1.153+004  3.364+003
33  8.224-001  3.883-001  2.173-001  6.162-001  2.304-001  1.047-001  5.230-002  9.357-001  1.695+004  1.167+004  3.405+003
34  2.807-002  3.013-002  1.719-002  8.171-002  3.021-002  1.372-002  6.782-003  9.750-002  1.691+004  8.830+003  2.384+003
35  3.501-004  2.575-004  1.467-004  1.746-003  6.313-004  2.854-004  1.389-004  1.499-003  1.737+004  8.827+003  1.420+003
36  9.104-005  5.342-005  3.042-005  4.903-004  1.759-004  7.943-005  3.847-005  3.774-004  1.753+004  8.827+003  1.197+003
37  1.015-005  5.744-006  3.415-006  8.056-005  2.864-005  1.290-005  6.227-006  5.543-005  1.768+004  7.933+003  1.107+003
38  1.947-007  1.328-007  8.787-008  3.810-006  1.335-006  5.987-007  2.881-007  2.242-006  1.789+004  6.085+003  1.107+003
39  3.912-009  3.211-009  2.358-009  1.877-007  6.479-008  2.894-008  1.388-008  9.460-008  1.809+004  4.683+003  1.107+003
40  3.545-010  3.261-010  2.555-010  2.950-008  1.009-008  4.495-009  2.151-009  1.351-008  1.821+004  3.987+003  1.107+003
41  3.545-010  3.261-010  2.555-010  2.950-008  1.009-008  4.495-009  2.151-009  1.351-008  1.821+004  3.987+003  1.107+003
42  3.530-010  3.245-010  2.541-010  2.950-008  1.009-008  4.494-009  2.150-009  1.350-008  1.821+004  3.987+003  1.107+003
43  3.514-010  3.229-010  2.526-010  2.950-008  1.009-008  4.493-009  2.149-009  1.349-008  1.821+004  3.987+003  1.107+003
44  3.505-010  3.220-010  2.517-010  2.950-008  1.008-008  4.492-009  2.148-009  1.349-008  1.821+004  3.987+003  1.107+003
45  3.497-010  3.212-010  2.510-010  2.950-008  1.008-008  4.492-009  2.148-009  1.348-008  1.821+004  3.987+003  1.107+003
46  3.501-010  3.217-010  2.514-010  2.950-008  1.008-008  4.492-009  2.148-009  1.348-008  1.821+004  3.987+003  1.107+003
47  3.476-010  3.191-010  2.491-010  2.949-008  1.008-008  4.490-009  2.146-009  1.346-008  1.821+004  3.987+003  1.107+003
48  3.450-010  3.164-010  2.466-010  2.949-008  1.008-008  4.488-009  2.144-009  1.344-008  1.821+004  3.987+003  1.107+003
49  3.459-010  3.174-010  2.475-010  2.949-008  1.008-008  4.489-009  2.145-009  1.345-008  1.821+004  3.987+003  1.107+003
50  3.506-010  3.221-010  2.518-010  2.950-008  1.008-008  4.492-009  2.149-009  1.349-008  1.821+004  3.987+003  1.107+003

 #       GR12       GR13       GR14       GR15       GR16       GR17       GR18       GR19       GR20

 1  9.168+002  3.699+002  2.050+002  9.604+001  3.121+001  1.201+001  5.781+000  1.005+000  5.363-004
 2  8.192+002  3.365+002  1.865+002  8.737+001  2.840+001  1.092+001  5.259+000  9.141-001  4.494-004
 3  8.042+002  3.330+002  1.845+002  8.644+001  2.809+001  1.081+001  5.203+000  9.044-001  4.368-004
 4  7.919+002  3.296+002  1.827+002  8.557+001  2.781+001  1.070+001  5.150+000  8.952-001  4.265-004
 5  7.800+002  3.264+002  1.809+002  8.475+001  2.754+001  1.059+001  5.101+000  8.867-001  4.168-004
 6  7.684+002  3.233+002  1.792+002  8.394+001  2.728+001  1.049+001  5.052+000  8.782-001  4.075-004
 7  7.602+002  3.209+002  1.779+002  8.332+001  2.708+001  1.042+001  5.015+000  8.717-001  4.009-004
 8  7.557+002  3.196+002  1.771+002  8.297+001  2.697+001  1.037+001  4.994+000  8.681-001  3.973-004
 9  7.527+002  3.187+002  1.766+002  8.274+001  2.689+001  1.034+001  4.980+000  8.656-001  3.949-004
10  7.500+002  3.179+002  1.762+002  8.253+001  2.682+001  1.032+001  4.967+000  8.634-001  3.928-004
11  7.476+002  3.172+002  1.758+002  8.235+001  2.676+001  1.029+001  4.956+000  8.615-001  3.909-004
12  7.453+002  3.165+002  1.754+002  8.217+001  2.671+001  1.027+001  4.946+000  8.597-001  3.891-004
13  7.447+002  3.164+002  1.754+002  8.214+001  2.669+001  1.027+001  4.944+000  8.593-001  3.887-004
14  7.442+002  3.163+002  1.753+002  8.211+001  2.669+001  1.026+001  4.942+000  8.590-001  3.883-004
15  7.446+002  3.164+002  1.754+002  8.215+001  2.670+001  1.027+001  4.945+000  8.595-001  3.887-004
16  7.447+002  3.165+002  1.754+002  8.217+001  2.671+001  1.027+001  4.946+000  8.597-001  3.889-004
17  7.450+002  3.166+002  1.755+002  8.219+001  2.671+001  1.027+001  4.947+000  8.599-001  3.891-004
18  7.454+002  3.167+002  1.755+002  8.221+001  2.672+001  1.028+001  4.948+000  8.601-001  3.893-004
19  7.458+002  3.168+002  1.756+002  8.226+001  2.673+001  1.028+001  4.951+000  8.606-001  3.897-004
20  7.470+002  3.174+002  1.759+002  8.240+001  2.678+001  1.030+001  4.960+000  8.621-001  3.908-004
21  7.519+002  3.193+002  1.769+002  8.288+001  2.694+001  1.036+001  4.989+000  8.671-001  3.950-004
22  7.720+002  3.254+002  1.804+002  8.449+001  2.746+001  1.056+001  5.085+000  8.840-001  4.110-004
23  8.640+002  3.493+002  1.936+002  9.069+001  2.947+001  1.134+001  5.459+000  9.489-001  4.886-004
24  9.367+002  3.552+002  1.969+002  9.222+001  2.997+001  1.153+001  5.550+000  9.649-001  5.623-004
25  8.330+002  3.090+002  1.713+002  8.023+001  2.608+001  1.003+001  4.829+000  8.395-001  4.778-004
26  7.422+002  2.769+002  1.534+002  7.188+001  2.336+001  8.985+000  4.326+000  7.520-001  4.010-004
27  7.296+002  2.763+002  1.531+002  7.173+001  2.331+001  8.967+000  4.317+000  7.504-001  3.868-004
28  7.217+002  2.779+002  1.540+002  7.214+001  2.345+001  9.018+000  4.342+000  7.548-001  3.765-004
29  7.109+002  2.755+002  1.527+002  7.152+001  2.324+001  8.940+000  4.305+000  7.482-001  3.666-004
```

```
30  6.873+002  2.688+002  1.490+002  6.978+001  2.268+001  8.723+000  4.200+000  7.300-001  3.465-004
31  6.612+002  2.631+002  1.458+002  6.830+001  2.220+001  8.538+000  4.111+000  7.145-001  3.233-004
32  6.536+002  2.632+002  1.459+002  6.832+001  2.220+001  8.540+000  4.112+000  7.147-001  3.157-004
33  6.619+002  2.663+002  1.476+002  6.914+001  2.247+001  8.643+000  4.161+000  7.233-001  3.221-004
34  4.185+002  2.015+002  1.117+002  5.232+001  1.700+001  6.540+000  3.149+000  5.471-001  1.417-004
35  4.184+002  2.014+002  1.117+002  5.230+001  1.700+001  6.537+000  3.148+000  5.469-001  1.412-004
36  4.184+002  2.014+002  1.117+002  5.230+001  1.700+001  6.537+000  3.148+000  5.469-001  1.412-004
37  4.184+002  2.014+002  1.117+002  5.230+001  1.700+001  6.537+000  3.148+000  5.469-001  1.412-004
38  4.184+002  2.014+002  1.117+002  5.230+001  1.700+001  6.537+000  3.148+000  5.469-001  1.412-004
39  4.184+002  2.014+002  1.117+002  5.230+001  1.700+001  6.537+000  3.148+000  5.469-001  1.412-004
40  4.184+002  2.014+002  1.117+002  5.230+001  1.700+001  6.537+000  3.148+000  5.469-001  1.412-004
41  4.184+002  2.014+002  1.117+002  5.230+001  1.700+001  6.537+000  3.148+000  5.469-001  1.412-004
42  4.184+002  2.014+002  1.117+002  5.230+001  1.700+001  6.537+000  3.148+000  5.469-001  1.412-004
43  4.184+002  2.014+002  1.117+002  5.230+001  1.700+001  6.537+000  3.148+000  5.469-001  1.412-004
44  4.184+002  2.014+002  1.117+002  5.230+001  1.700+001  6.537+000  3.148+000  5.469-001  1.412-004
45  4.184+002  2.014+002  1.117+002  5.230+001  1.700+001  6.537+000  3.148+000  5.469-001  1.412-004
46  4.184+002  2.014+002  1.117+002  5.230+001  1.700+001  6.537+000  3.148+000  5.469-001  1.412-004
47  4.184+002  2.014+002  1.117+002  5.230+001  1.700+001  6.537+000  3.148+000  5.469-001  1.412-004
48  4.184+002  2.014+002  1.117+002  5.230+001  1.700+001  6.537+000  3.148+000  5.469-001  1.412-004
49  4.184+002  2.014+002  1.117+002  5.230+001  1.700+001  6.537+000  3.148+000  5.469-001  1.412-004
50  4.184+002  2.014+002  1.117+002  5.230+001  1.700+001  6.537+000  3.148+000  5.469-001  1.412-004

 FREQUENCY DEPENDENT TIME INTEGRATED RADIATION SPECTRUM(J/GROUP)

5.5284+005  5.8403+006  3.4952+006  2.6955+006  2.4931+006  7.9165+001  9.9632-001  1.8300-002  7.0090-008  1.0446-007
1.2098-007  1.2481-007  1.9381-007  1.0638-005  6.8080-004  2.5313-001  3.0361+002  7.3884+003  6.0306+002  8.0463+004
```

```
MAX OVER-PRESSURE=  1.4997-001 (J/CM3)  TIME=  7.4042-004 (S)  CYCLE= 587


MAX HEAT FLUX=  2.4419+006 (J/CM2*S)   TIME=  4.8744-008 (S)   CYCLE= 133


PRESSURE AND HEAT FLUX AT THE FIRST WALL


TIME(S)
  1.0976-10   1.6708-09   3.3981-09   5.7320-09   9.7349-09   2.3022-08   7.2383-08   1.9667-07   3.9752-07   7.4352-07
  1.1038-06   1.4803-06   1.9539-06   2.6373-06   3.6862-06   5.3633-06   8.1625-06   1.3631-05   2.5038-05   4.5374-05
  7.0360-05   1.2081-04   2.0583-04   2.6872-04   3.3191-04   4.3058-04   5.5256-04   6.5814-04   7.1919-04   7.7894-04
  8.3952-04   9.1953-04   1.0317-03   1.1690-03   1.3160-03   1.4345-03   0.0000

PRESSURE(J/CM3)
  1.0035-02   1.0035-02   1.0035-02   1.0035-02   1.0035-02   1.0035-02   1.0036-02   1.0036-02   1.0036-02   1.0036-02
  1.0036-02   1.0036-02   1.0036-02   1.0037-02   1.0037-02   1.0037-02   1.0039-02   1.0043-02   1.0058-02   1.0107-02
  1.0198-02   1.0447-02   1.0915-02   1.1286-02   1.1701-02   1.2491-02   1.3911-02   1.6841-02   1.0407-01   1.4313-01
  1.2063-01   9.0020-02   6.5542-02   4.4510-02   2.9287-02   2.4276-02   0.0000

HEAT FLUX(J/CM2*S)
  8.9290+00   7.0734+00   6.4418+00   5.8419+00   6.1818+00   1.1866+04   1.2526+06   4.3425+05   4.3545+05   4.1445+05
  3.8426+05   3.5866+05   3.2348+05   2.8125+05   2.2789+05   1.8174+05   1.5526+05   1.2840+05   9.5920+04   5.8939+04
  3.7343+04   2.5699+04   1.8387+04   1.4581+04   7.4393+03   3.4195+03   1.7301+03   1.1103+03   9.1053+02   7.8051+02
  6.7445+02   5.6933+02   4.7570+02   8.2133+02   1.0971+03   1.1692+03   0.0000


         DEBRIS SPECTRA
     NO. OF    ENERGY POSITION TIME OF
       IONS   PER ION          ARRIVAL
               (KEV)             (SEC)

  1 1.77+020 7.53+001 2.38-002 0.00-001

  TOTAL PROJECTILES =  1.77+020     TOTAL ENERGY LEFT =  2.13+000 MJ
@COPY 8.,EXAMMFBF.
FURPUR 28R3A U01 SLIB27 04/11/84 21:30:48
    77 BLOCKS COPIED.
@BRKPT PRINT$




***EOF***       55 PAGES COST     $1.65    PROJ BALANCE   $1208.94 USER BALANCE    $300.70
```

Figure 15. Positions of the Lagrangian zone boundaries as functions of time for the example problem with 20 group radiative transfer.

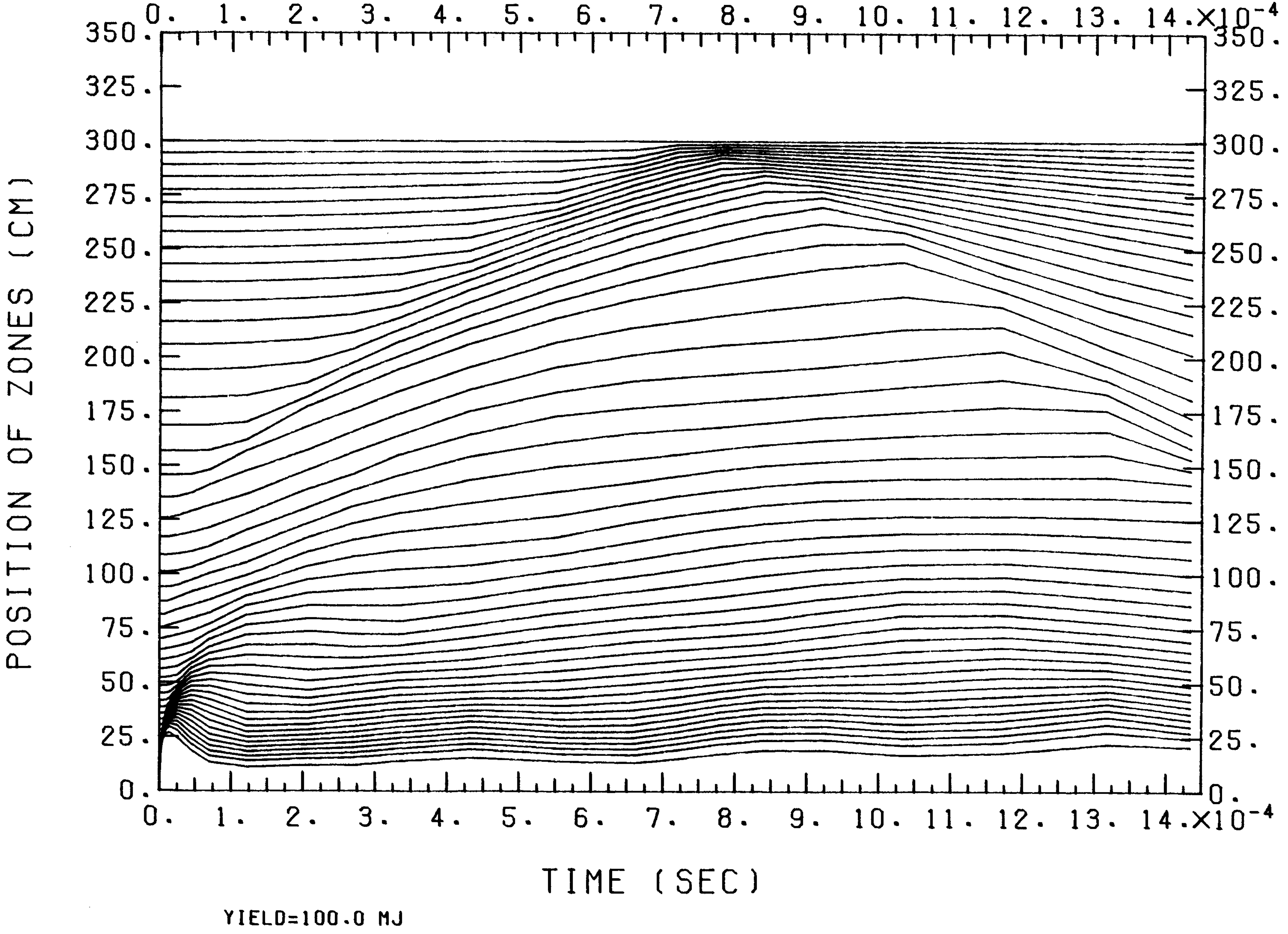


Figure 16. Gas pressure and heat flux versus time on the wall at the outer boundary of the gas for the example problem with 20 group radiative transfer.

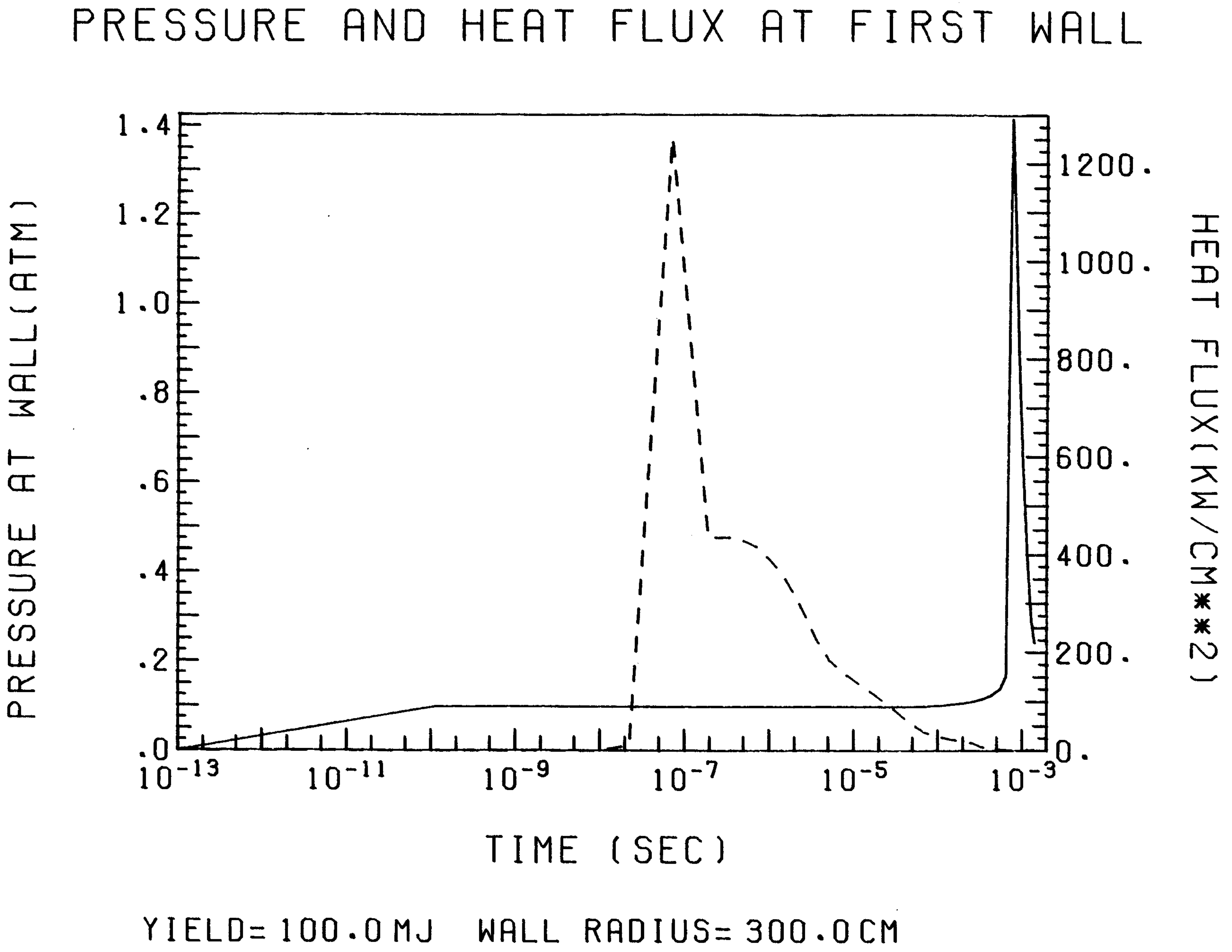


Figure 17. The gas pressure profiles at various times for the example problem with 20 group radiative transfer.

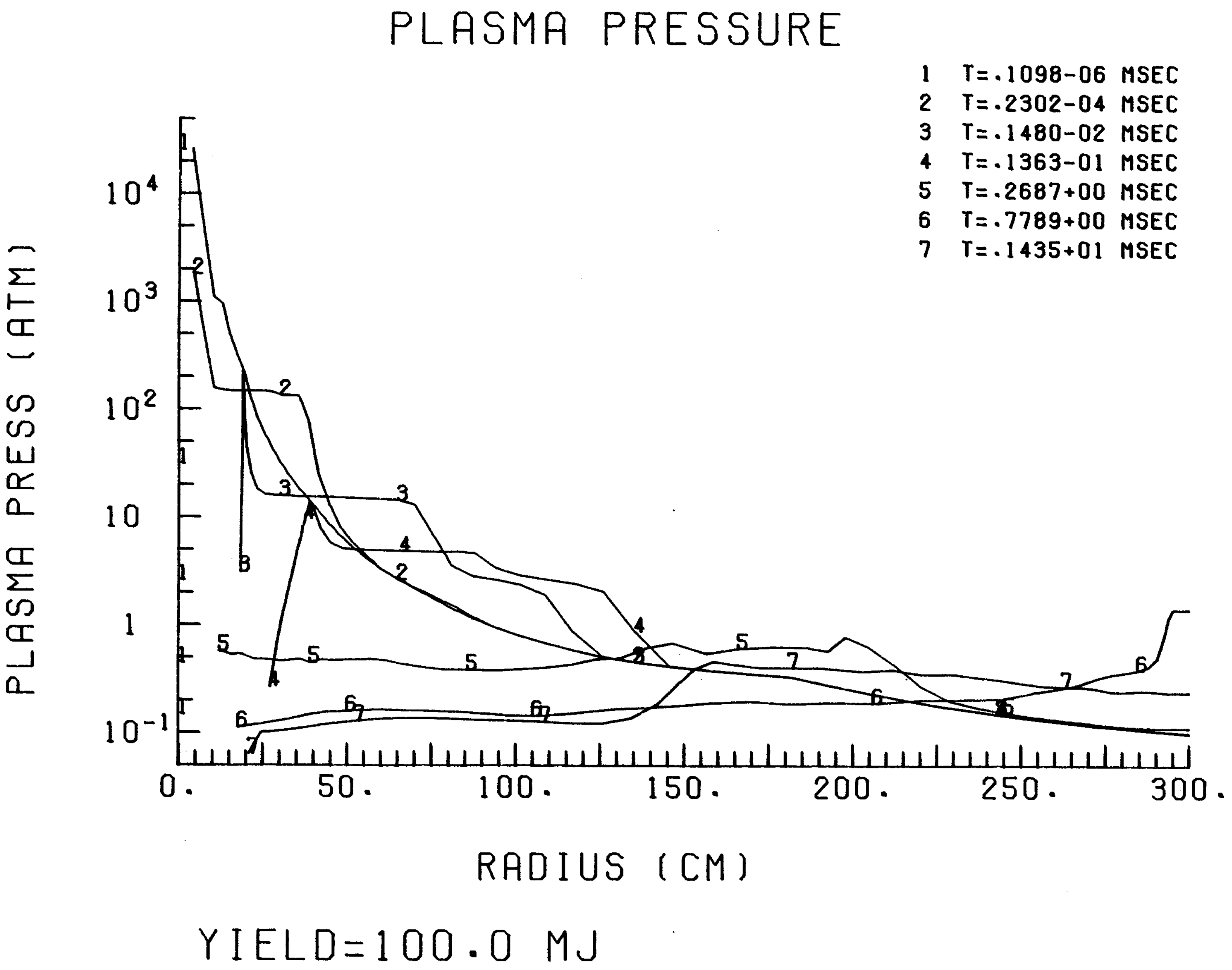


Figure 18. The gas temperature profiles at various times for the example problem with 20 group radiative transfer.

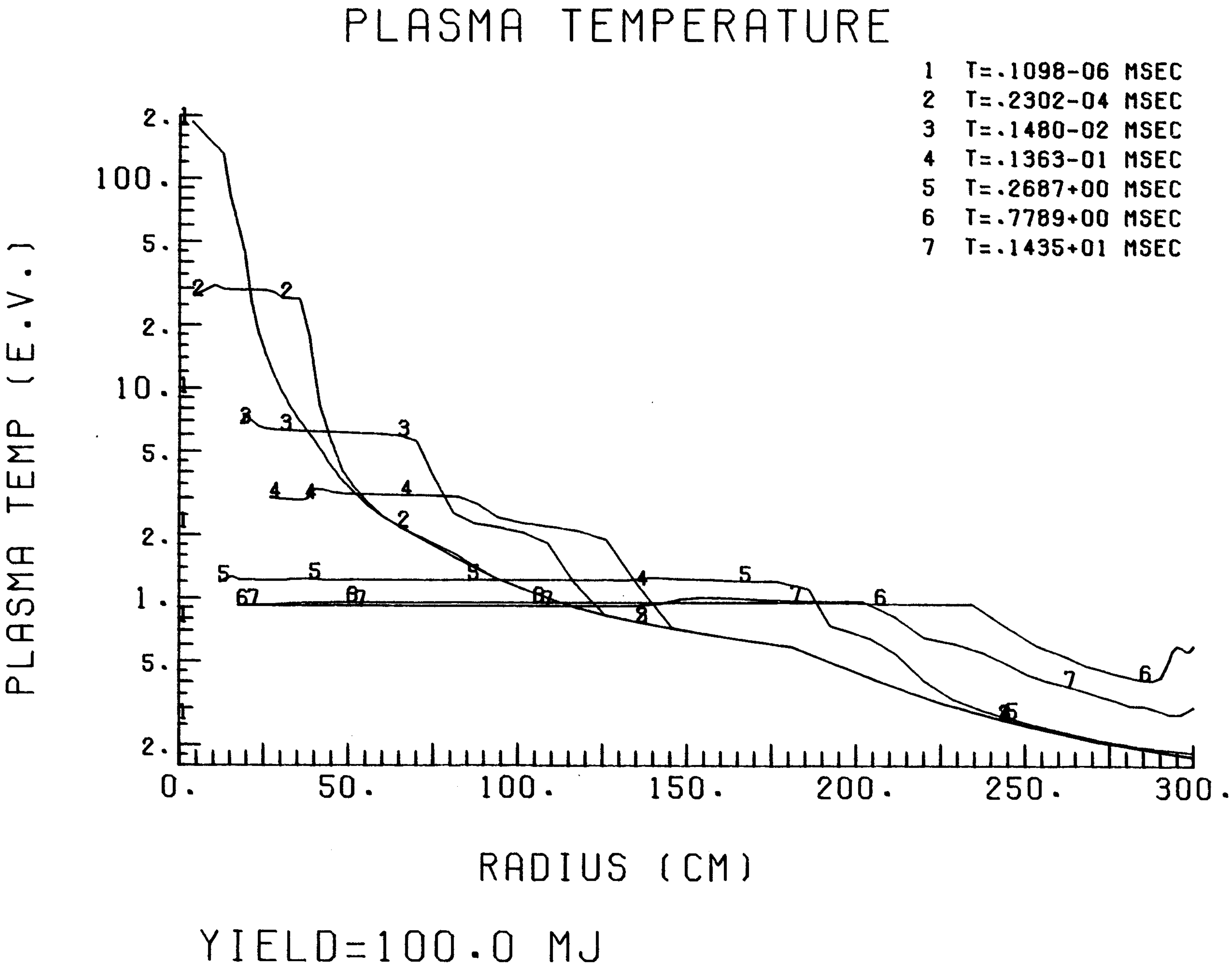


Figure 19. The radiation temperature profiles at various times for the example problem with 20 group radiative transfer.

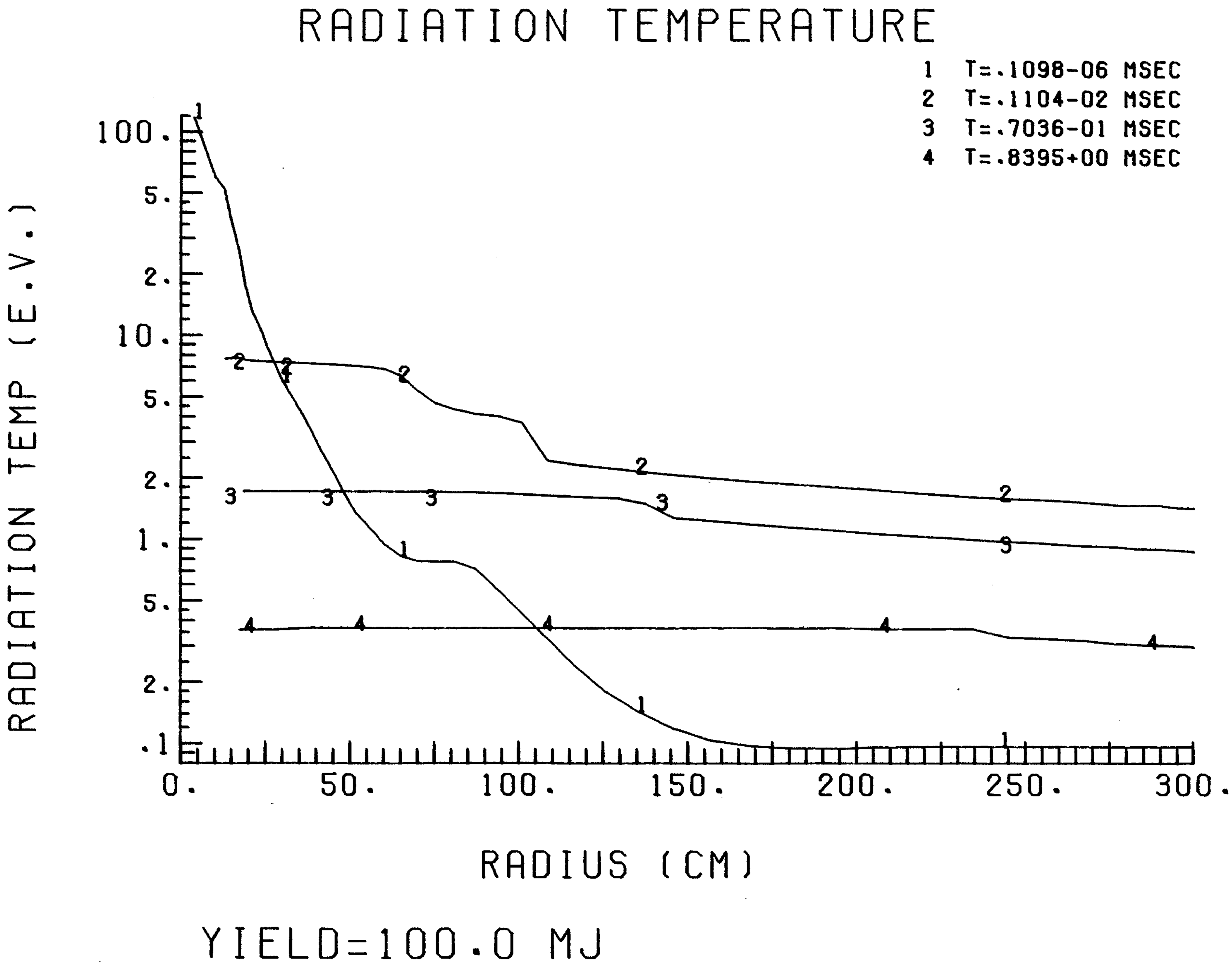


Figure 20. The mass density profiles at various times for the example problem with 20 group radiative transfer.

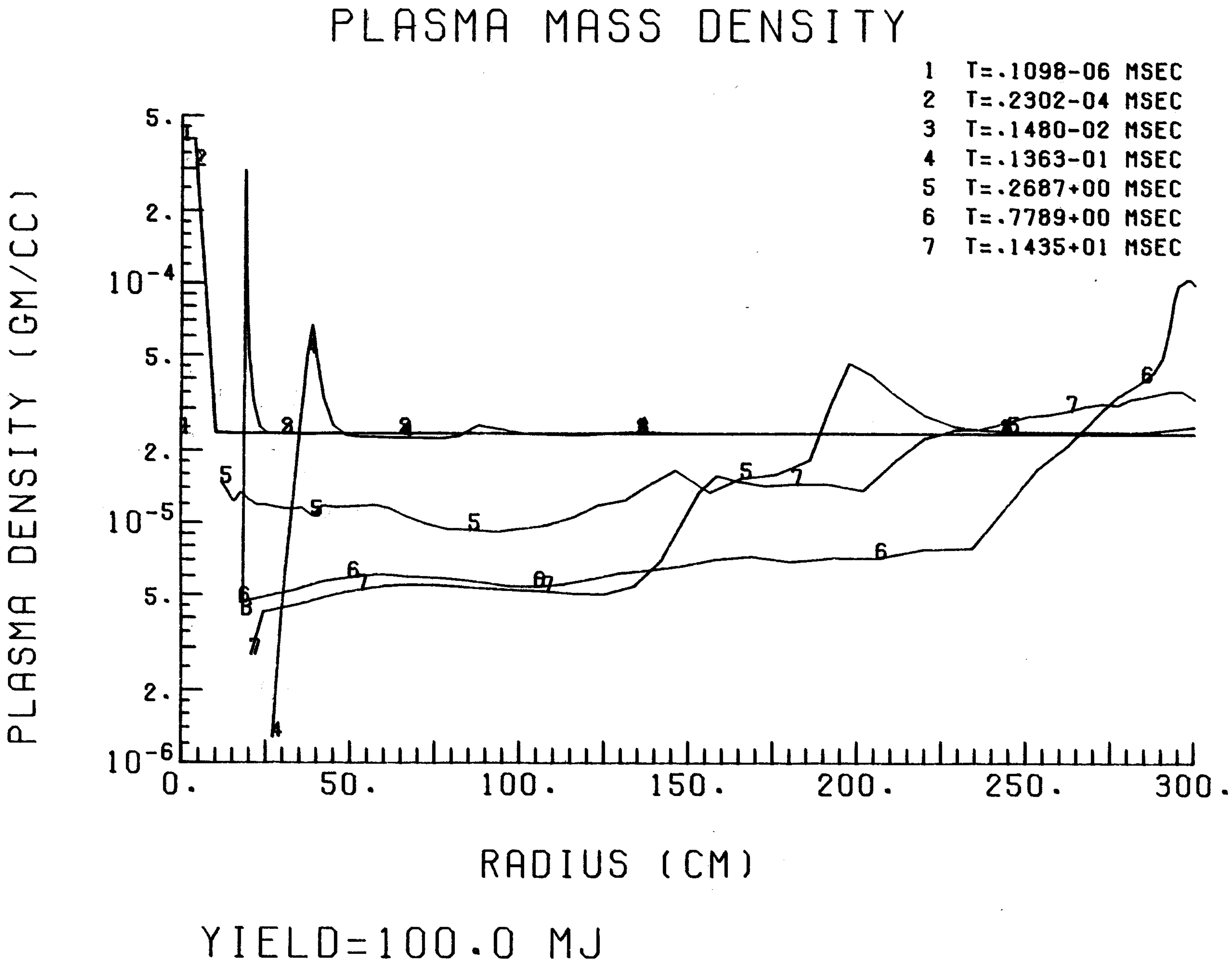


Figure 21. Time integrated x-ray spectrum incident on the first wall as a result of gas re-radiation for the example problem with 20 group radiative transfer.