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# RADCAL: A Narrow-Band Model for Radiation Calculations in a Combustion Environment

William L. Grosshandler

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# *RADCAL: A Narrow-Band Model for Radiation Calculations in a Combustion Environment*

William L. Grosshandler

Fire Science Division
Building and Fire Research Laboratory
National Institute of Standards and Technology
Gaithersburg, MD 20899

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## ABSTRACT

Radiation within a medium containing products of combustion is dependent upon the temperature and concentrations throughout the entire field. The energy is distributed across the infrared spectrum in a highly nonlinear fashion, which greatly complicates modeling of the heat transfer within a burning environment. This report describes a numerical program, RADCAL, which predicts the radiant intensity leaving a nonisothermal volume containing nonuniform levels of carbon dioxide, water vapor, methane, carbon monoxide, nitrogen, oxygen, and soot. The absorption coefficient of the combined gases is calculated from a narrow-band model and a combination of tabulated spectral properties and theoretical approximations to the vibrational-rotational molecular bands. Soot is treated as a purely absorbing substance in the Rayleigh limit. Background on the development of the model, example calculations, and an explanation of input procedures are presented.



Key Words: models, radiation, radiative heat transfer, spectra, spectral absorptivity, spectral emissivity

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# RADCAL: A NARROW-BAND MODEL FOR RADIATION CALCULATIONS IN A COMBUSTION ENVIRONMENT

## I. INTRODUCTION

The transfer of energy from and within a burning environment is controlled by diffusive, convective, and radiative processes. Because the temperatures associated with combustion are high, a proper physical description needs to account for radiation unless the characteristic radiation-to-convection ratio of the system is small. Bhattacharjee and Grosshandler (1989) define the following radiation/convection parameter, $\Psi$, in terms of the flame, surrounding wall and inlet temperatures ($T_f$, $T_w$ and $T_i$), the mass flux of material brought into the flame times its heat capacity, $\rho_i u_i c_p$, and the optical thickness of the system based upon the absorption coefficient, $a$, and a stream-wise dimension, L:

$$\Psi = \frac{\sigma a L}{\rho_i u_i c_p} \frac{(T_f^4 - T_w^4)}{(T_f - T_i)} \tag{1}$$

$\sigma$ is the Stefan-Boltzmann constant. For $\Psi$ less than unity, radiation has little effect on the energy transfer.

The radiation/convection parameter can be recast in terms relevant to fires by using a typical flame temperature of 1500 K and by replacing the convective energy with the thermal input, Q, per unit area of burning surface, A. Equation (1) becomes

$$\Psi \sim 300 \frac{aV}{Q} \tag{2}$$

where V is the volume, LA, in cubic meters and Q is in kilowatts. Hence, highly absorbing fires in large volumes can be strongly influenced by radiation; conversely, a large thermal input can diminish the importance of radiation if the absorption properties, temperature and volume of interest remain about constant.

While $\Psi$ is a useful global parameter, one must be able to estimate the absorption properties of the system and must recognize that the value of $a$ can change substantially within the flow field. The absorption coefficient of the cool gases surrounding a fire can influence the transfer of energy from a burning object to a distant object. The absorption coefficient can also be used to analyze remotely the contents of the plume from a fire or an exhaust stack; and the absorption spectra of the pyrolysis and product gases formed during smoldering or shortly following ignition can be used for early detection of a fire.

For the above applications, a model which can predict the spectral structure of various combustion products over a wide range of temperatures, pressures and pathlengths is required. The purpose of this report is to describe the development of one such model, RADCAL, to demonstrate its application, and to instruct others so that they can adapt it to their own needs.

## II. DEVELOPMENT OF RADCAL

RADCAL computes the spectral intensity, $i_\lambda'$, from a non-isothermal mixture of combustion gases and soot incident upon a volume element within or external to the environment. The program solves the equation of transfer for an absorbing and emitting medium (no scattering) by breaking the line-of-sight into a number of uniform elements and by using molecular models and tabulated data for the spectral absorption coefficient, $a_\lambda$. Under these conditions the equation of transfer can be written as

$$i_\lambda'(l) = i_{\lambda,w}' e^{-\kappa_\lambda(l)} + \int_0^{\kappa_\lambda(l)} i_{b,\lambda}(l*) \exp[-(\kappa_\lambda(l) - \kappa_\lambda(l*))] d\kappa_\lambda(l*) \tag{3}$$

$i_{b,\lambda}$ is the Planck blackbody function, $\kappa_\lambda$ is the optical thickness defined by $\kappa_\lambda \equiv {}_0{}^l\int \, a_\lambda(l^*)\, dl^*$, $\lambda$ is the wavelength, and the subscript w refers to a bounding wall condition.

The average spectral intensity incident on a differential volume from all directions is found by integrating eq (3) over solid angle, $\omega$:

$$\overline{i_\lambda(l)} = \frac{1}{4\pi} \int i_\lambda'(l) d\omega \tag{4}$$

Two different spectrally averaged absorption coefficients are useful to define: the incident-mean, $a_i$,

$$a_i(l) \equiv \int_0^\infty \overline{i_\lambda(l)} a_\lambda(l) d\lambda / i_i(l) \ , \tag{5}$$

and the Planck-mean, $a_P$,

$$a_P(l) \equiv \int_o^\infty i_{b,\lambda}(l)\, a_\lambda(l) d\lambda / i_b(l) \, . \tag{6}$$

The denominators in eqs (5) and (6) are, respectively, the average incident intensity (integral of eq (4) over wavelength) and the blackbody intensity, $\sigma T^4/\pi$. The $l$ functionality persists because the medium is generally nonhomogeneous.

The divergence of the radiative flux vector, $\mathbf{q}_r$, (which is equal to the source term in the generalized energy equation) can then be written in terms of the mean coefficients (Siegel and Howell, 1981) as

$$-\nabla \cdot q_r(l) = 4\pi a_i(l) i_i(l) - 4\pi a_p(l) i_b(l) \,. \tag{7}$$

The first version of RADCAL was developed to predict the enhancement in radiation caused by the addition of pulverized coal to a 60 kW methanol-fired furnace (Grosshandler, 1976). The program solved the equations for the single-line group model (SLG) as listed in Table 5-18 of the **Handbook of Infrared Radiation from Combustion Gases** (Ludwig, *et al.*, 1973). A combination of molecular models and data tables were used for the spectral properties of carbon dioxide, water vapor, and carbon monoxide, and contributions to the radiant intensity from the soot, ash and coal particles were handled with scattering neglected.

Validation of RADCAL was documented in a Factory Mutual Research Technical Report (Grosshandler, 1979), in which published experimental data were compared to the predictions of the numerical code for $CO_2$, $H_2O$, and CO individually and in mixtures. Spectral and total intensity experiments were examined, and the fidelity of the program for both isothermal and nonisothermal conditions was investigated. The spectrum between 1.25 and 12.5 $\mu$m was satisfactorily reproduced, although some of the data at particular wavelengths differed from the prediction by as much as 17%. Considerable disagreement occurred between the integrated emittance of $CO_2$ as predicted from RADCAL and that computed from the charts of Hottel (1954). No one source for this disagreement was identified, but it was thought to be a combination of the difficulty in obtaining high accuracy spectral measurements under the full range of conditions investigated, the uncertainty associated with extrapolating total transmittance results beyond the measured temperature and pressure-pathlengths, and the approximations associated with the narrow-band models.

RADCAL was used as the benchmark for a simplified, non-spectral model, TTNH, which was designed to estimate the radiant intensity from combustion gas mixtures (Grosshandler, 1980). The total transmittance nonhomogeneous gas model (TTNH) was able to reproduce the narrow-band results from RADCAL within an error band of about 10% for a range of pathlengths between 0.2 and 2 m, temperatures between 800 and 1800 K, $CO_2/H_2O$ ratios between 1/2 and 2, and for a total pressure of 101 kPa. The advantage of TTNH over RADCAL is its two orders-of-magnitude faster computational time.

Methane was added to the data base of RADCAL (Grosshandler and Nguyen, 1985) and the spectral region over which the calculations could be made was extended to 200 $\mu$m. The current version of the program accounts for a radiating boundary, computes various absorption coefficients, has eliminated errors which were promulgated by the NASA report (Ludwig, *et al.*, 1973), and has a more convenient data input. Table 1 summarizes the species currently in RADCAL, which molecular bands are modeled, and how they are modeled. The accuracy of the calculations are limited to those of the individual models at temperatures, pressures, and

Table 1. Molecular bands included in RADCAL

| Species | Band | Method | Reference |
|---|---|---|---|
| $CO_2$ | 2.0 $\mu$m | modeled | 9 |
| $CO_2$ | 2.7 $\mu$m | modeled | 1 |
| $CO_2$ | 4.3 $\mu$m | modeled | 2 |
| $CO_2$ | 10 $\mu$m | modeled | 9 |
| $CO_2$ | 15 $\mu$m | tabulated | 3 |
| $H_2O$ | 1.38 $\mu$m | tabulated | 3 |
| $H_2O$ | 1.88 $\mu$m | tabulated | 3 |
| $H_2O$ | 2.7 $\mu$m | tabulated | 3 |
| $H_2O$ | 6.3 $\mu$m | tabulated | 3 |
| $H_2O$ | 20-200 $\mu$m | tabulated | 3 |
| CO | 4.6 $\mu$m | modeled | 4 |
| $CH_4$ | 2.4 $\mu$m | modeled | 5,6 |
| $CH_4$ | 3.3 $\mu$m | tabulated | 7,8 |
| $CH_4$ | 7.7 $\mu$m | tabulated | 7,8 |
| soot | 0.4-2000 $\mu$m | modeled | 10 |

1. Malkmus, 1963a
2. Malkmus, 1963b
3. Ludwig, *et al.*, 1973
4. Malkmus and Thomson, 1961
5. Vincent-Geisse, 1955
6. Gray and Penner, 1965
7. Brosmer and Tien, 1985
8. Lee and Happel, 1984
9. Leckner, 1971
10. Dalzell and Sarofim, 1969

pathlengths for which the models were originally developed. In general, RADCAL is likely to be less accurate at temperatures below 295 or greater than 2500 K, at pressures over 1.0 MPa, and at distances greater than 50 m.

Applications of the program are demonstrated in the next section, and details of data input and parameter definition are given in the last section. A full listing of the fortran code is included in the appendix.

## III. SAMPLE APPLICATIONS OF RADCAL

Computational results from earlier versions of RADCAL have been presented in several references (e.g., Grosshandler, 1979; Grosshandler, 1980; Grosshandler and Modak, 1981; Grosshandler and Thurlow, 1992). Several of these calculations have been verified with the latest version of RADCAL and are included here as baseline cases.

Hottel's charts (1954) are often referenced as the source of total emittance data for carbon dioxide and water vapor. Estimates of $CO_2$ emittance from the current version of RADCAL as a function of pressure-pathlength are compared to what one calculates from Hottel (1954) in Figure 1. The results are in better agreement than indicated in an earlier study (Grosshandler, 1979) because the 15 $\mu$m band is now included and an error in the tabulated data of Ludwig *et al.* (1973) has been corrected. From Figure 2, it can be seen that the two techniques diverge somewhat at the highest and lowest temperatures for a pressure-pathlength of 18.5 kPa-m. Discrepancies seen previously in the $H_2O$ data remain, with RADCAL predicting greater emittance for all pressure-pathlengths at 1500 K, as shown in Figure 3. The open circles are data taken from Ludwig, *et al.* (1973), and indicate that, not surprisingly, RADCAL is in full agreement with the reference upon which it is based. Hottel and RADCAL are more consistent with each other at intermediate temperatures, as can be seen in Figure 4 for the case of a PL = 15.4 kPa-m. Ludwig (1973) pointed out that the earlier work by Hottel covered a more limited range of conditions and attempted to minimize the number of parameters for engineering estimates, and, thus, should not be expected to be as accurate as the narrow-band calculations.

Figure 5 is a spectral radiance calculation from a simulated 1.0 m diameter fire containing $CO_2$, $H_2O$ and soot at the levels indicated in Table 2 (Grosshandler, 1979; Grosshandler and Modak, 1981). The total intensity integrates to 33.77 kW/m$^2$/sr. The spectral transmittance is also plotted in the figure. The major water and carbon dioxide bands are easily identifiable within the continuous soot spectrum.

Figure 6 represents the spectral intensity radiated upstream in a premixed methane/$N_2$/$O_2$ flame at 606 kPa. Temperature and concentration profiles are listed in Table 3. In addition to carbon dioxide and water vapor, the molecular bands of CO and $CH_4$ are observable in this soot-free simulation. The program computes a total radiant intensity of 15.71 kW/m$^2$/sr.

The spectral transmittance one might measure through a 320 K plume rising above material slowly pyrolyzing in atmospheric pressure air is shown in Figure 7. The concentrations of $CO_2$, $H_2O$, $CH_4$, and CO are uniform and equal 10 ppm (vol.) across the 0.5 m plume diameter, and it is assumed that smoke is present with a volume fraction of $10^{-8}$. Even at these low concentrations the spectral character is evident, but the transmittance is close to 1.0 everywhere but in 4.3 and 15 $\mu$m $CO_2$ bands.

## IV. PROGRAM STRUCTURE

Figure 8 is a diagram of the structure of the program. The numerical code consists of a short main program which reads the temperature and concentration information from the data file, RC.DAT. SUBROUTINE RADCAL is called from the main program to perform all of the calculations listed in Table 5-18 of Ludwig, *et al.* (1973), and contains the instructions for printing the results into a file called RCOUT.DAT.

RADCAL relies upon four subroutines to compute the narrow-band parameters for the

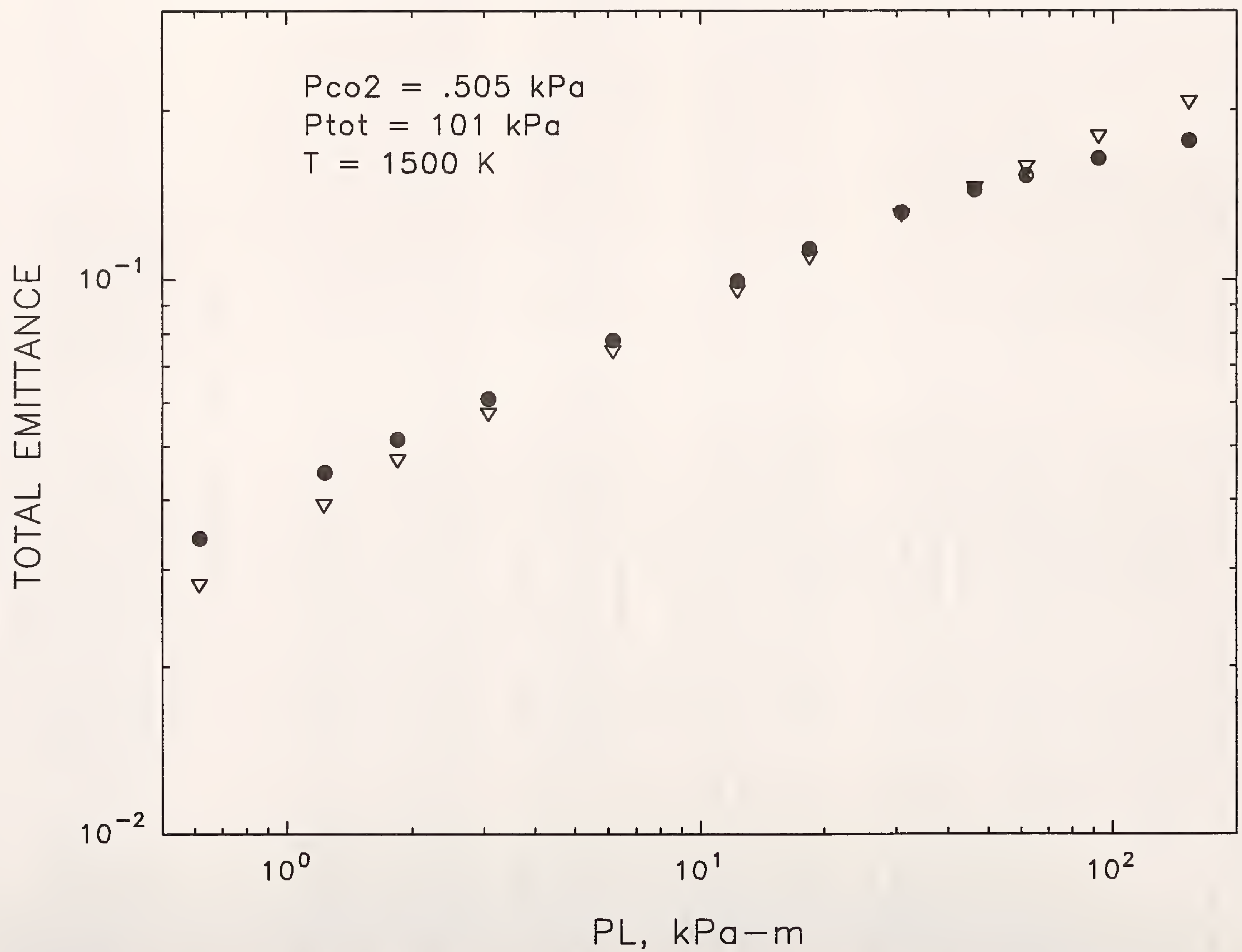


Figure 1. Total emittance of carbon dioxide/air mixtures as a function of pressure-pathlength, comparing RADCAL (filled circles) to the measurements of Hottel (1954) (triangles).

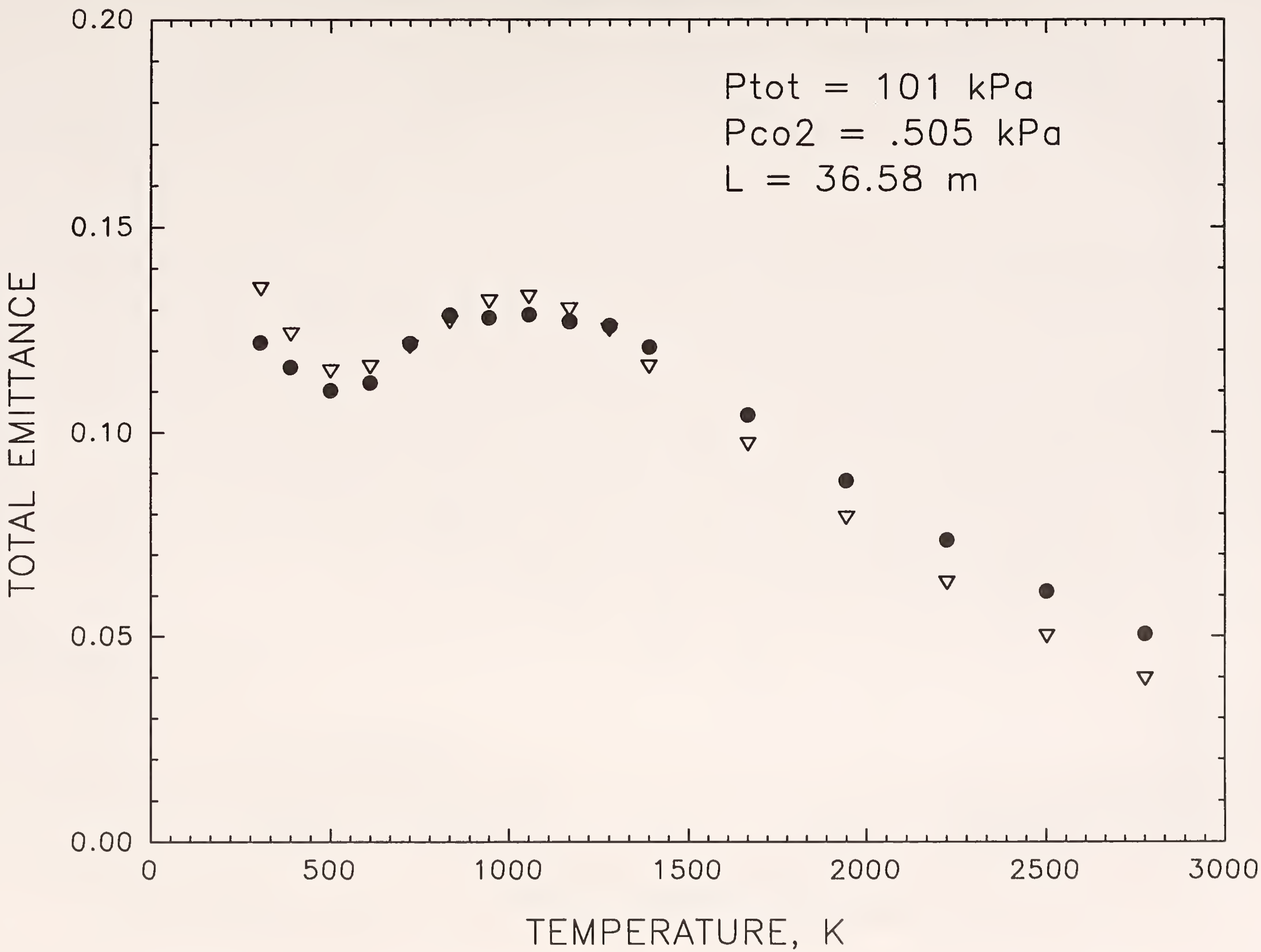


Figure 2. Total emittance of carbon dioxide/air mixtures as a function of temperature, comparing RADCAL (filled circles) to the measurements of Hottel (1954) (triangles).

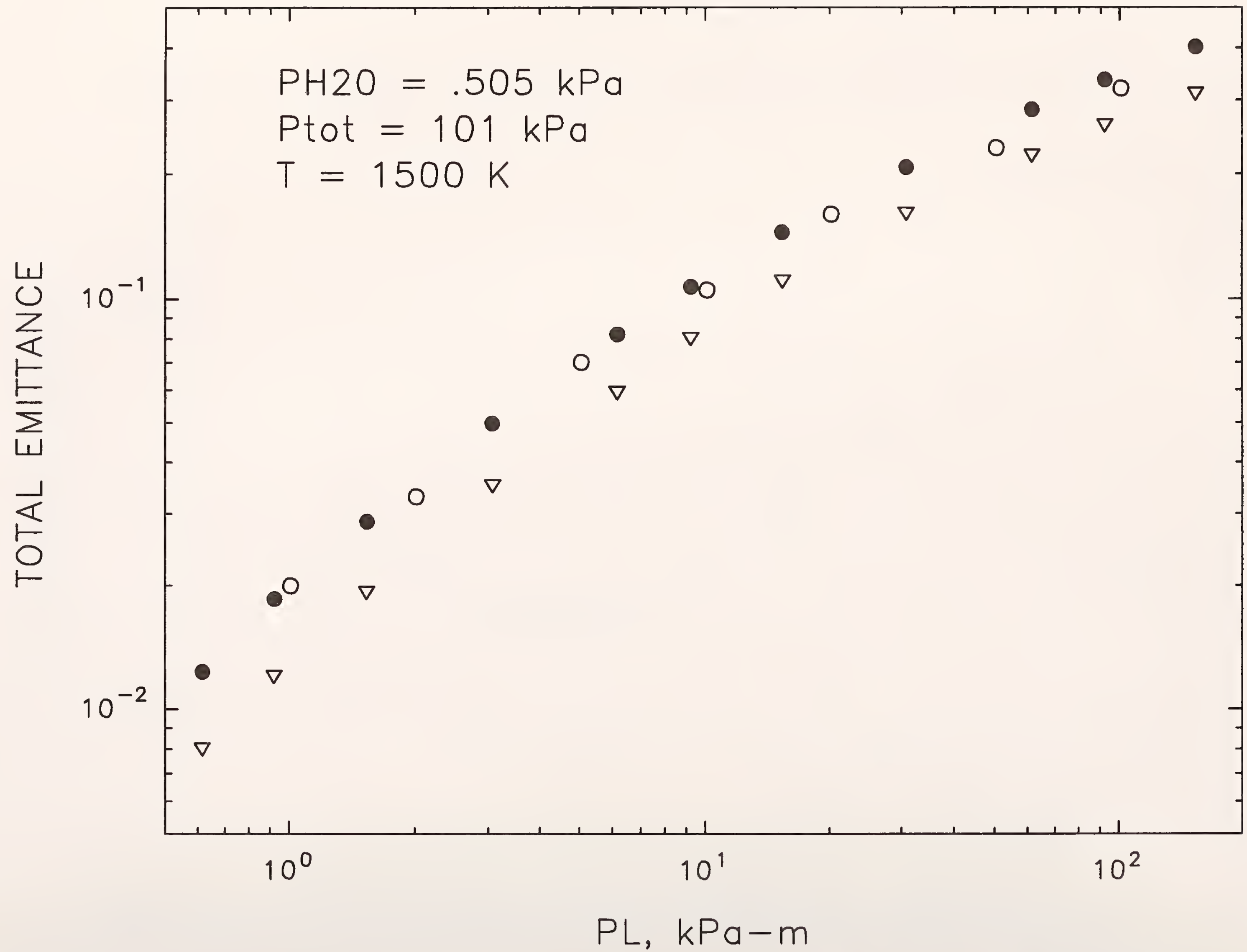


Figure 3. Total emittance of water vapor/air mixtures as a function of pressure-pathlength, comparing RADCAL (filled circles) to the measurements of Hottel (1954) (triangles). The open circles are taken from Fig. 6-33 of Ludwig, *et al.*(1973).

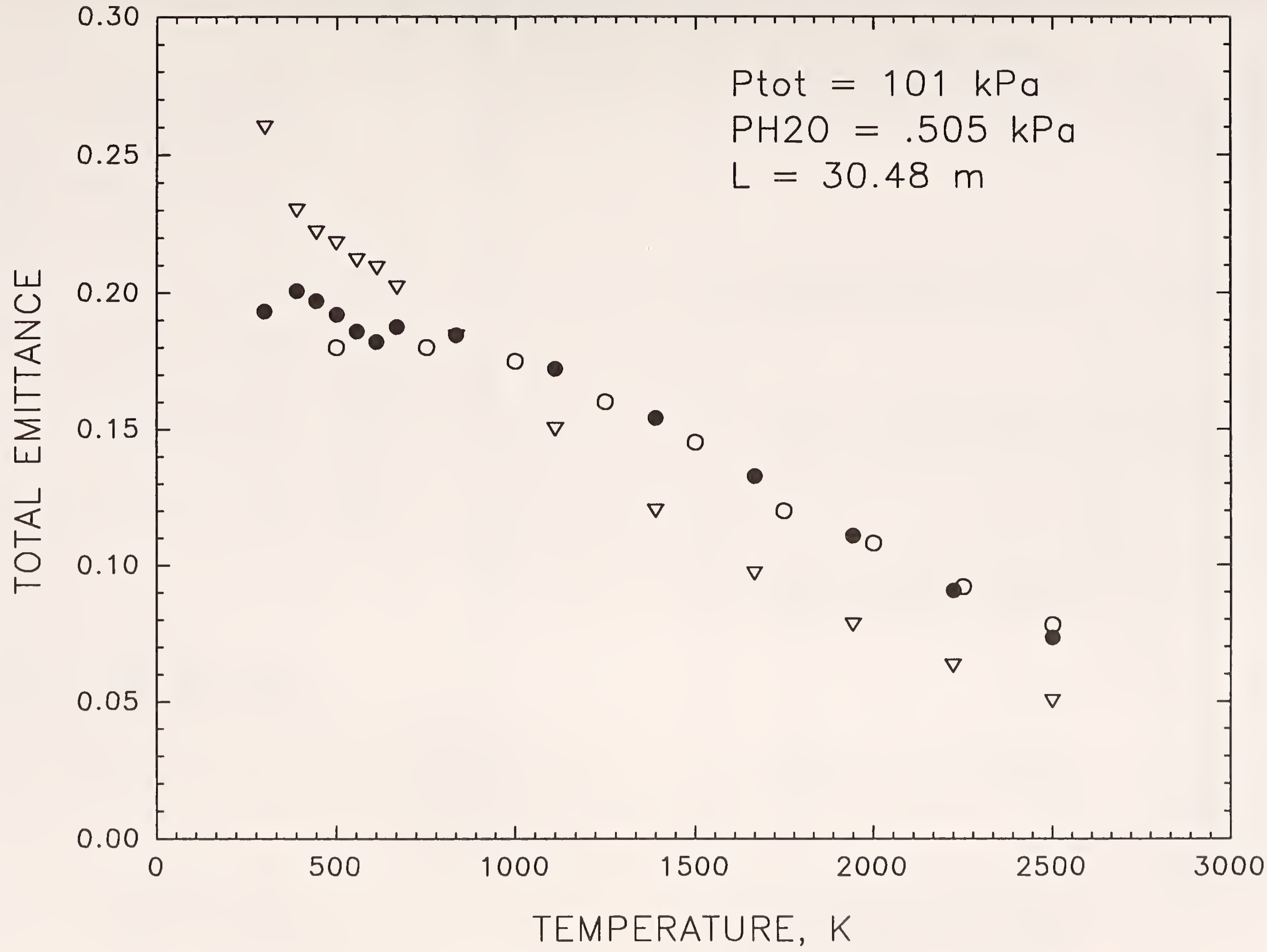


Figure 4. Total emittance of water vapor/air mixtures as a function of temperature, comparing RADCAL (filled circles) to the measurements of Hottel (1954) (triangles). The open circles are taken from Fig. 6-33 of Ludwig, *et al.*(1973).

Table 2. Radial profiles through simulated one meter diameter pool fire

| | | Partial Pressures, kPa | | | |
|---|---|---|---|---|---|
| Dist., m | Temp., K | $CO_2$ | $H_2O$ | $N_2$ | Soot, $f_v$ |
| 0.05 | 899 | 7.07 | 7.07 | 86.8 | $5.55 \times 10^{-8}$ |
| 0.10 | 1158 | 10.0 | 10.0 | 81.0 | $5.55 \times 10^{-8}$ |
| 0.20 | 1438 | 13.1 | 13.1 | 74.7 | $5.55 \times 10^{-8}$ |
| 0.30 | 1637 | 15.4 | 15.4 | 70.3 | $5.55 \times 10^{-8}$ |
| 0.50 | 1770 | 16.9 | 16.9 | 67.3 | $5.55 \times 10^{-8}$ |
| 0.70 | 1637 | 15.4 | 15.4 | 70.3 | $5.55 \times 10^{-8}$ |
| 0.80 | 1438 | 13.1 | 13.1 | 74.7 | $5.55 \times 10^{-8}$ |
| 0.90 | 1158 | 10.0 | 10.0 | 81.0 | $5.55 \times 10^{-8}$ |
| 0.95 | 899 | 7.07 | 7.07 | 86.8 | $5.55 \times 10^{-8}$ |

Table 3. Line-of-sight profiles through 20 mm thick, simulated, fuel-rich premixed methane/$O_2$/$N_2$ flame

| | | Partial Pressures, kPa | | | | | |
|---|---|---|---|---|---|---|---|
| Dist., m | Temp., K | $CO_2$ | $H_2O$ | $CH_4$ | CO | $O_2$ | $N_2$ |
| 0.001 | 300 | 0.0 | 0.0 | 122.2 | 0.0 | 185.8 | 298.0 |
| 0.003 | 725 | 0.0 | 58.6 | 92.9 | 29.3 | 139.4 | 285.8 |
| 0.005 | 1150 | 0.0 | 117.2 | 62.6 | 59.6 | 97.5 | 274.7 |
| 0.007 | 1575 | 0.0 | 181.8 | 31.3 | 98.0 | 49.5 | 264.6 |
| 0.009 | 2000 | 5.0 | 224.2 | 10.1 | 107.1 | 15.2 | 256.5 |
| 0.015 | 2525 | 5.0 | 244.4 | 0.0 | 117.2 | 0.0 | 254.5 |

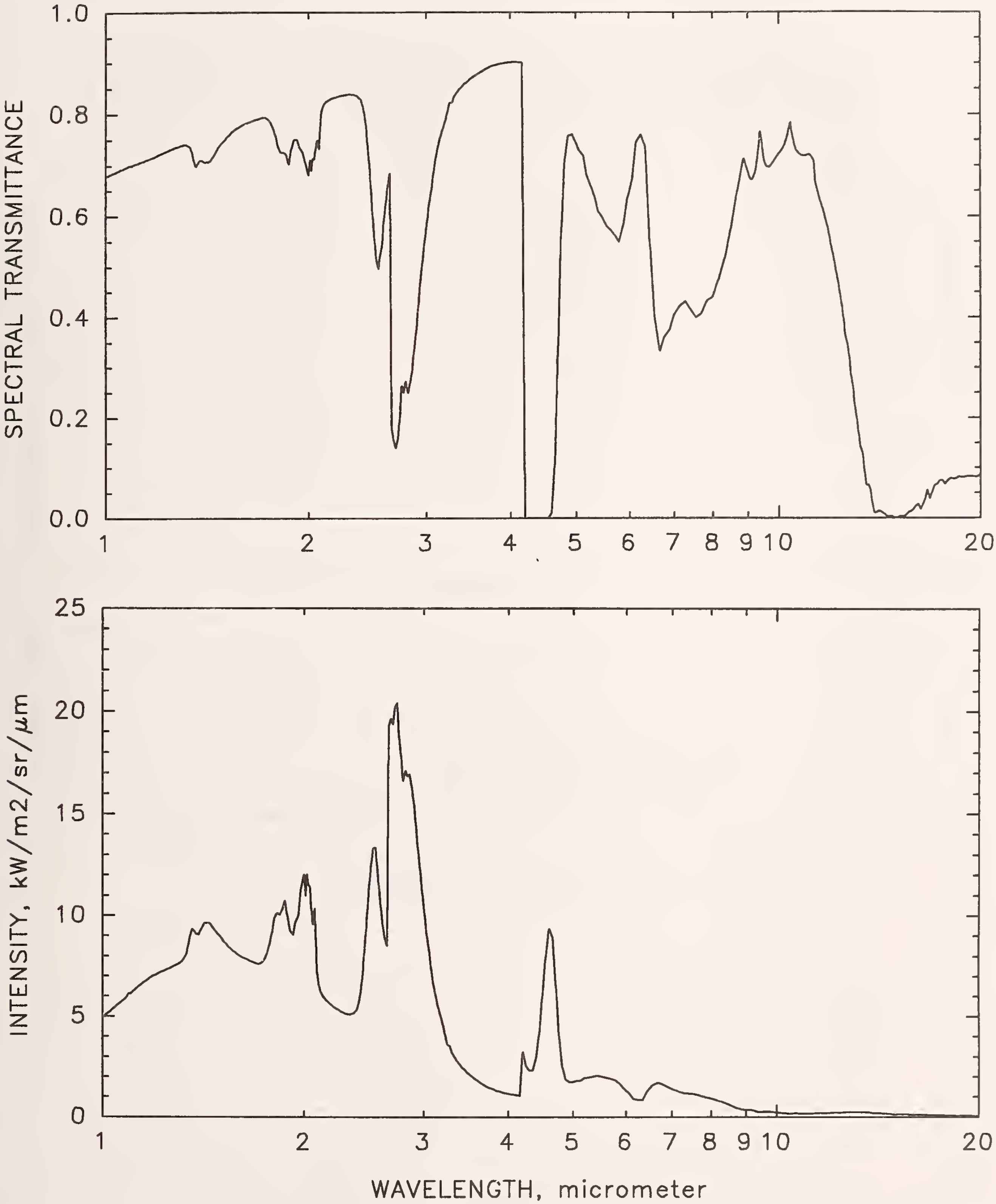


Figure 5. Spectral intensity and transmittance in simulated pool fire with profile as given in Table 2.

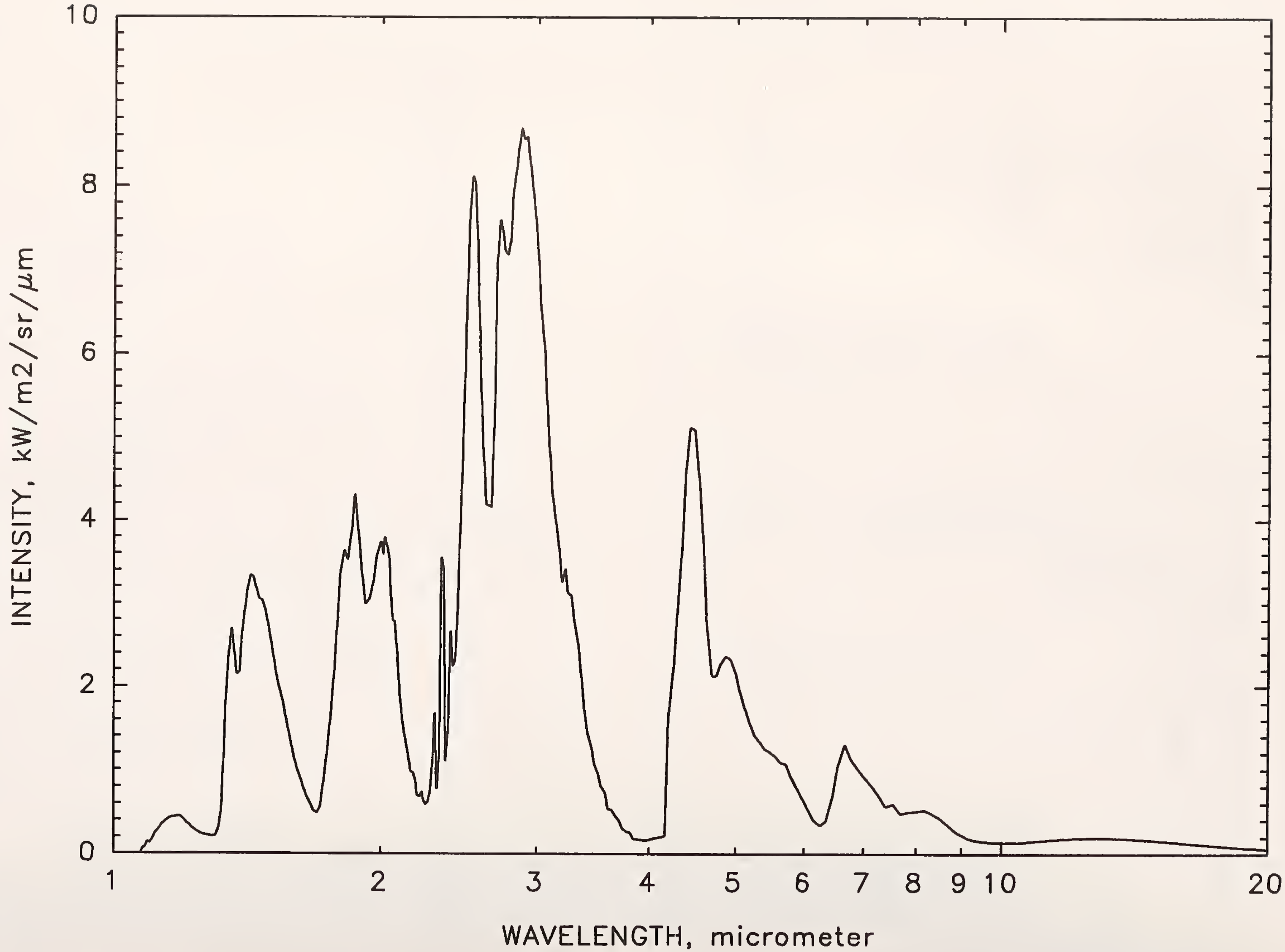


Figure 6. Spectral intensity from simulated premixed methane/oxygen/nitrogen flame with profile as given in Table 3.

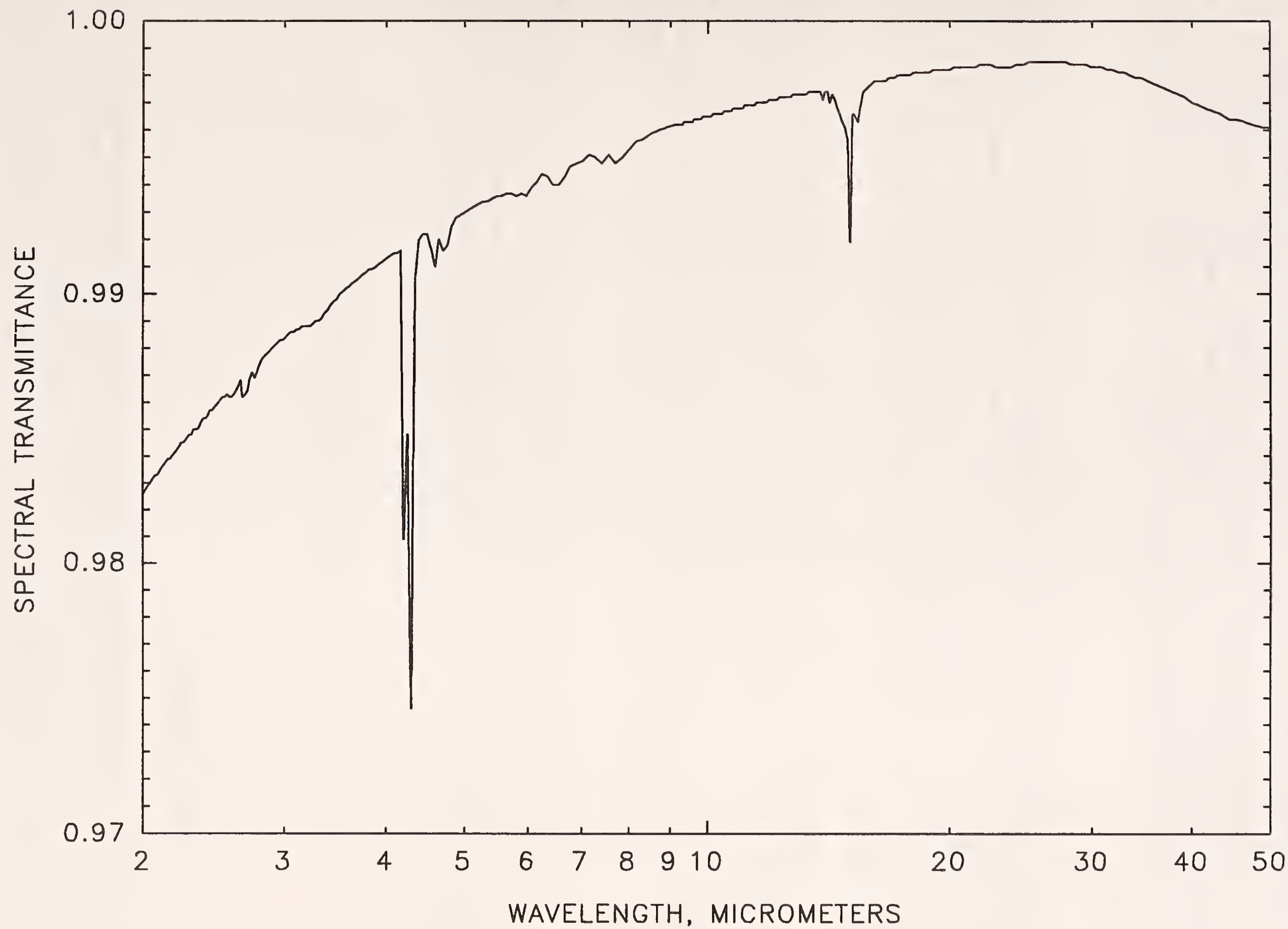


Figure 7. Spectral transmittance through simulated 1/2 meter diameter plume of pyrolysis gases consisting of 10 ppm (vol.) each of $CO_2$, $H_2O$, $CH_4$, and CO and .01 ppm soot in atmospheric pressure air. T = 320 K.

carbon dioxide (SUBROUTINE CO2), water vapor (SUBROUTINE H2O), carbon monoxide (SUBROUTINE CO), and methane (SUBROUTINE FUEL). Two large block data files (BLOCK DATA BD1 and BLOCK DATA BD2) contain the absorption coefficient of water vapor as a function of temperature and wave number (Table A2-35 of Ludwig, *et al.* (1973)). A third data file, BLOCK DATA BD3, contains similar information for the 15.0 $\mu$m band of $CO_2$ (Table A2-28 of Ludwig, *et al.*, 1973), and the 3.3 and 7.4 $\mu$m bands of $CH_4$ (Brosmer and Tien, 1985). Line broadening parameters of Ludwig, *et al.* (1973) are listed at the beginning of BD3.

The spectral optical depth is calculated in SUBROUTINE RADCAL from the band-averaged absorption and line-width-to-line-spacing parameters (computed in the species subroutines), with a curve-of-growth based upon the particular species pressure-pathlength and with nonisothermal effects accounted for by the Curtis-Godson method. The particle optical depth is calculated in SUBROUTINE POD assuming the soot is in the Rayleigh limit with an albedo of zero. This value is added, in SUBROUTINE RADCAL, to the contributions from the gaseous species to determine the combined spectral optical depth.

SUBROUTINE RADCAL uses the optical depth to determine the spectral transmittance and intensity (calling FUNCTION PLANCK to evaluate the Planck blackbody intensity) as each new spatial element is added to the radiating path. Radiation from the far wall is counted after being attenuated by the calculated transmittance along the total length of the path. The spectral intensity is integrated across the spectrum to determine the total directional radiated energy flux. SUBROUTINE RADCAL separately computes the radiation from the soot for regions of the spectrum above and below the limits for the gas bands.

When the path contains only one element (i.e., it is isothermal and of uniform composition) three different absorption coefficients are calculated: the Planck-mean based upon the gas temperature (eq (6)), the incident-mean based upon the wall temperature (eq (5)), and the effective absorption coefficient, $a_e$. The effective absorption coefficient is used to calculate the total radiant intensity, $i$, leaving a uniform gas bounded by a black wall; *i.e.*,

$$i = \frac{\sigma}{\pi}[(1 - e^{-a_e L})T^4 + e^{-a_e L} T_w^4] \qquad \textbf{(8)}$$

A. input parameters

The input data file, RC.DAT, is in free format, with the first line containing the number of elements (maximum of 50) into which the path is divided, NPT. The second line lists the size of the first element in meters, DD(1), its temperature in Kelvin, T(1), and the partial pressures in kilopascals of carbon dioxide, P(1,1), water vapor, P(1,2), methane, P(1,3), carbon monoxide, P(1,4), oxygen, P(1,5) and nitrogen, P(1,6). The last entry on the second line is the

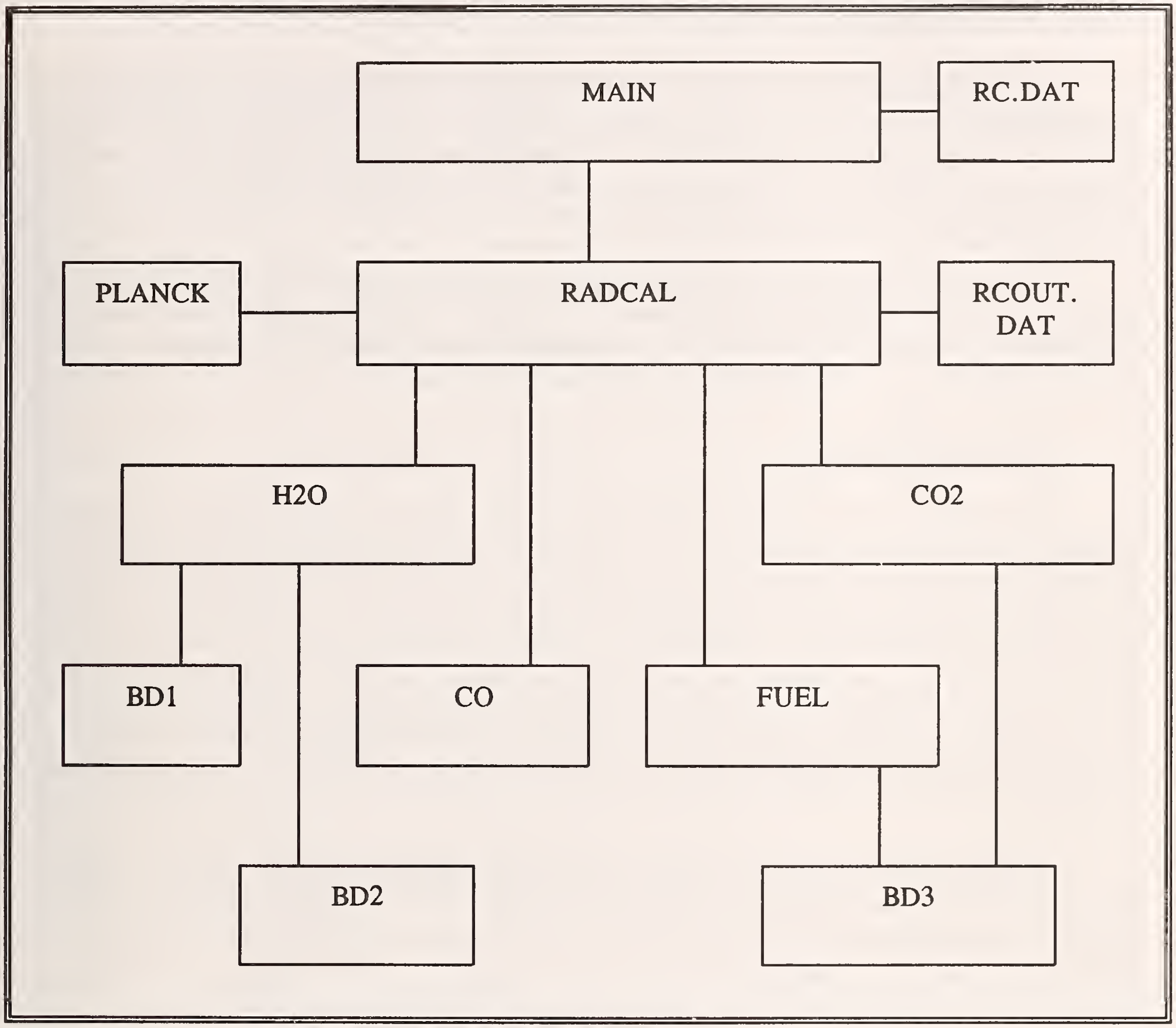


Figure 8. Structure of radiation calculation program RADCAL.

volume fraction of soot in the first element, W(1). It is important to remember that the first element is located at the point in space for which the intensity is desired, and not at the far boundary of the computational volume.

The third line contains the size, temperature, species partial pressures, and soot volume fraction for the second element. Similar data is entered for the remainder of the NPT elements. Following this information is a line containing the wall temperature in Kelvin, TWALL, and the minimum and maximum wavenumbers in $cm^{-1}$, OMMIN and OMMAX. Normally, there is no need to go below 50 $cm^{-1}$ or above 10,000 $cm^{-1}$.

Additional cases can be stacked one upon another, but no data are carried over from the previous case even if they remain unchanged. The program terminates when it reads 0 for the value of NPT. Table 4 summarizes the input parameters and gives their limiting values.

B. output parameters

The results of the calculations can be found in the output file, RCOUT.DAT. The input conditions are summarized in tabular form, followed by the total directional radiated energy flux emanating outward from element one, Q. The spectral intensity, QW(K), and transmittance, TTAU(K), are listed for each wavelength, AMBDA(K). The number of wavelengths computed is limited to 600, and the wavelength intervals vary between 0.005 $\mu$m (50 $cm^{-1}$) at 1.0 $\mu$m and 18.2 $\mu$m (5 $cm^{-1}$) at 200 $\mu$m. For the special case of a uniform pathlength with only one element, the program also calculates the effective absorption coefficient, AMEAN, the Planck-mean absorption coefficient, APO, and the wall-incident-mean absorption coefficient, AIWALL. Additional parameters which are used within the different subroutines are defined in the Glossary.

Table 5 lists the output of the single uniform element case plotted in Figure 7. Only a few spectral entries are included for the sake of brevity. The output for the non-isothermal condition described in Table 2, and plotted over the full spectral range in Figure 5, is given in Table 6.

Table 4. Input data for RC.DAT

| parameter | definition | units | range* | line numbers |
|---|---|---|---|---|
| NPT | number of spatial elements | none | 1 to 50 | 1 |
| DD(J) | length of Jth element | meters | $10^{-4}$ to $10^{3}$ m | 2 to (NPT+1) |
| T(J) | temperature | Kelvin | 270 to 2500 K | 2 to (NPT+1) |
| P(1,J) | partial pressure of $CO_2$ | kilopascals | 0 to 10 MPa | 2 to (NPT+1) |
| P(2,J) | partial pressure of $H_2O$ | kilopascals | 0 to 10 MPa | 2 to (NPT+1) |
| P(3,J) | partial pressure of $CH_4$ | kilopascals | 0 to 10 MPa | 2 to (NPT+1) |
| P(4,J) | partial pressure of CO | kilopascals | 0 to 10 MPa | 2 to (NPT+1) |
| P(5,J) | partial pressure of $O_2$ | kilopascals | 0 to 10 MPa | 2 to (NPT+1) |
| P(6,J) | partial pressure of $N_2$ | kilopascals | 0 to 10 MPa | 2 to (NPT+1) |
| W(J) | volume fraction of soot | $m^3/m^3$ | 0 to $10^{-3}$ | 2 to (NPT+1) |
| TWALL | far wall temperature | K | 0 to 5000 K | (NPT+2) |
| OMMIN | minimum wavenumber | $cm^{-1}$ | 50 $cm^{-1}$ | (NPT+2) |
| OMMAX | maximum wavenumber | $cm^{-1}$ | 10,000 $cm^{-1}$ | (NPT+2) |

*The accuracy of the program outside of the range where experimental data are available is limited to the accuracy of the original references.

Table 5. Sample output from RCOUT.DAT with isothermal, uniform path

Radial Profiles

---------------

| | | | Partial Pressures, kPa | | | | | |
|---|---|---|---|---|---|---|---|---|
| J dist,m | temp,K | CO2 | H2O | CH4 | CO | O2 | N2 | FV |
| 1 .5000 | 320. | .001 | .001 | .001 | .001 | 20.200 | 80.800 | .1000E-07 |
| wall | 295. | | | | | | | |

Total directional radiated energy flux = .136910E+03 Watts/m-2/strad

Spectral Intensity Distribution, Watts/m-2/$\mu$m/strad

------------------------------------------------------

| wavelength | intensity | tau | wavelength | intensity | tau |
|---|---|---|---|---|---|
| 3.125 | .6838E-01 | .9887 | 28.169 | .1445E+01 | .9984 |
| 3.175 | .8059E-01 | .9888 | 28.986 | .1329E+01 | .9984 |
| 3.200 | .8745E-01 | .9888 | 29.412 | .1273E+01 | .9984 |
| 3.252 | .1029E+00 | .9889 | 30.303 | .1165E+01 | .9983 |
| 3.361 | .1417E+00 | .9893 | 32.258 | .9646E+00 | .9981 |
| 3.419 | .1660E+00 | .9896 | 33.333 | .8720E+00 | .9980 |
| 3.448 | .1795E+00 | .9897 | 33.898 | .8277E+00 | .9979 |
| 3.509 | .2098E+00 | .9900 | 35.088 | .7430E+00 | .9978 |
| 3.540 | .2266E+00 | .9901 | 35.714 | .7026E+00 | .9977 |
| 3.636 | .2852E+00 | .9904 | 37.736 | .5893E+00 | .9974 |
| 3.704 | .3318E+00 | .9906 | 39.216 | .5204E+00 | .9972 |
| 3.738 | .3577E+00 | .9907 | 40.000 | .4879E+00 | .9970 |
| 3.846 | .4468E+00 | .9909 | 42.553 | .3979E+00 | .9967 |
| 3.922 | .5170E+00 | .9911 | 44.444 | .3442E+00 | .9964 |
| 3.960 | .5558E+00 | .9912 | 45.455 | .3191E+00 | .9964 |
| 4.040 | .6413E+00 | .9914 | 47.619 | .2726E+00 | .9962 |
| 4.082 | .6884E+00 | .9915 | 48.780 | .2511E+00 | .9961 |
| 4.167 | .7919E+00 | .9916 | 51.282 | .2115E+00 | .9960 |
| 4.211 | .8621E+00 | .9809 | 52.632 | .1933E+00 | .9960 |
| 4.301 | .9969E+00 | .9746 | 55.556 | .1601E+00 | .9960 |
| 4.348 | .1043E+01 | .9907 | 57.143 | .1451E+00 | .9960 |
| 4.444 | .1190E+01 | .9922 | 60.606 | .1179E+00 | .9961 |
| 4.494 | .1271E+01 | .9922 | 62.500 | .1057E+00 | .9961 |
| 4.598 | .1449E+01 | .9910 | 66.667 | .8390E-01 | .9963 |
| 4.651 | .1543E+01 | .9920 | 68.966 | .7426E-01 | .9964 |
| 4.819 | .1861E+01 | .9925 | 76.923 | .4997E-01 | .9969 |
| 4.878 | .1977E+01 | .9928 | 80.000 | .4329E-01 | .9970 |
| 5.000 | .2229E+01 | .9930 | 86.957 | .3185E-01 | .9975 |

The effective absorption coef. is .894161E-02/m

The Planck-mean absorption coef. is .673106E-02/m

The wall-incident mean is .632162E-02/m

Table 6. Sample output from RCOUT.OUT with nonhomogeneous input conditions

Radial Profiles

---------------

| | | | Partial Pressures, kPa | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| J | dist,m | temp,K | CO2 | H2O | CH4 | CO | O2 | N2 | FV |
| 1 | .0500 | 899. | 7.070 | 7.070 | .000 | .000 | .000 | 86.800 | .5550E-07 |
| 2 | .1000 | 1158. | 10.000 | 10.000 | .000 | .000 | .000 | 81.000 | .5550E-07 |
| 3 | .1000 | 1438. | 13.100 | 13.100 | .000 | .000 | .000 | 74.700 | .5550E-07 |
| 4 | .1000 | 1637. | 15.400 | 15.400 | .000 | .000 | .000 | 70.300 | .5550E-07 |
| 5 | .3000 | 1770. | 16.900 | 16.900 | .000 | .000 | .000 | 67.300 | .5550E-07 |
| 6 | .1000 | 1637. | 15.400 | 15.400 | .000 | .000 | .000 | 70.300 | .5550E-07 |
| 7 | .1000 | 1438. | 13.100 | 13.100 | .000 | .000 | .000 | 74.700 | .5550E-07 |
| 8 | .1000 | 1158. | 10.000 | 10.000 | .000 | .000 | .000 | 81.000 | .5550E-07 |
| 9 | .0500 | 899. | 7.070 | 7.070 | .000 | .000 | .000 | 86.800 | .5550E-07 |
| wall | | 0. | | | | | | | |

Total directional radiated energy flux = .337731E+05 Watts/m-2/strad

Spectral Intensity Distribution, Watts/m-2/$\mu$m/strad

----------------------------------------------------

| w.l. | intensity | tau | w.l. | intensity | tau | w.l. | intensity | tau | w.l. | intensity | tau |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1.005 | .4981E+04 | .6794 | 6.061 | .1187E+04 | .6708 | 2.198 | .5553E+04 | .8340 | 16.000 | .1248E+03 | .0244 |
| 1.010 | .5046E+04 | .6807 | 6.154 | .9046E+03 | .7455 | 2.210 | .5493E+04 | .8349 | 16.129 | .1220E+03 | .0276 |
| 1.015 | .5111E+04 | .6820 | 6.250 | .8433E+03 | .7598 | 2.222 | .5441E+04 | .8355 | 16.260 | .1151E+03 | .0172 |
| 1.020 | .5177E+04 | .6834 | 6.349 | .8481E+03 | .7371 | 2.235 | .5373E+04 | .8366 | 16.393 | .1132E+03 | .0247 |
| 1.026 | .5242E+04 | .6847 | 6.452 | .1305E+04 | .5433 | 2.247 | .5336E+04 | .8369 | 16.529 | .1118E+03 | .0369 |
| 1.031 | .5307E+04 | .6860 | 6.557 | .1582E+04 | .3942 | 2.260 | .5277E+04 | .8378 | 16.667 | .1082E+03 | .0557 |
| 1.036 | .5373E+04 | .6874 | 6.667 | .1717E+04 | .3330 | 2.273 | .5228E+04 | .8384 | 16.807 | .1047E+03 | .0385 |
| 1.042 | .5438E+04 | .6887 | 6.780 | .1607E+04 | .3618 | 2.286 | .5181E+04 | .8389 | 16.949 | .1014E+03 | .0514 |
| 1.047 | .5503E+04 | .6900 | 6.897 | .1499E+04 | .3751 | 2.299 | .5138E+04 | .8393 | 17.094 | .9767E+02 | .0659 |
| 1.053 | .5569E+04 | .6914 | 7.018 | .1368E+04 | .4061 | 2.312 | .5124E+04 | .8391 | 17.241 | .9467E+02 | .0686 |
| 1.058 | .5634E+04 | .6927 | 7.143 | .1272E+04 | .4224 | 2.326 | .5098E+04 | .8390 | 17.391 | .9110E+02 | .0754 |
| 1.064 | .5699E+04 | .6941 | 7.273 | .1184E+04 | .4316 | 2.339 | .5101E+04 | .8384 | 17.544 | .8796E+02 | .0754 |
| 1.070 | .5764E+04 | .6954 | 7.407 | .1155E+04 | .4151 | 2.353 | .5147E+04 | .8366 | 17.699 | .8539E+02 | .0671 |
| 1.075 | .5829E+04 | .6968 | 7.547 | .1120E+04 | .3994 | 2.367 | .5143E+04 | .8359 | 17.857 | .8187E+02 | .0756 |
| 1.081 | .5899E+04 | .6980 | 7.692 | .1058E+04 | .4079 | 2.381 | .5246E+04 | .8322 | 18.018 | .7857E+02 | .0791 |
| 1.087 | .5965E+04 | .6993 | 7.843 | .9627E+03 | .4337 | 2.395 | .5340E+04 | .8289 | 18.182 | .7570E+02 | .0785 |
| 1.093 | .6139E+04 | .6980 | 8.000 | .9147E+03 | .4411 | 2.410 | .5704E+04 | .8177 | 18.349 | .7289E+02 | .0783 |
| 1.099 | .6105E+04 | .7016 | 8.163 | .8186E+03 | .4747 | 2.424 | .6139E+04 | .8042 | 18.519 | .6994E+02 | .0819 |
| 1.105 | .6174E+04 | .7028 | 8.333 | .7143E+03 | .5182 | 2.439 | .6892E+04 | .7804 | 18.692 | .6737E+02 | .0812 |
| 1.111 | .6249E+04 | .7038 | 8.511 | .5970E+03 | .5749 | 2.454 | .8025E+04 | .7452 | 18.868 | .6491E+02 | .0814 |
| 1.117 | .6324E+04 | .7048 | 8.696 | .4628E+03 | .6495 | 2.469 | .9151E+04 | .7037 | 19.048 | .6230E+02 | .0832 |
| 1.124 | .6395E+04 | .7059 | 8.889 | .3522E+03 | .7129 | 2.484 | .1021E+05 | .6586 | 19.231 | .5993E+02 | .0828 |
| 1.130 | .6465E+04 | .7070 | 9.091 | .3632E+03 | .6725 | 2.500 | .1159E+05 | .5996 | 19.417 | .5753E+02 | .0831 |
| 1.136 | .6533E+04 | .7082 | 9.132 | .3553E+03 | .6729 | 2.516 | .1263E+05 | .5503 | 19.608 | .5531E+02 | .0821 |
| 1.143 | .6599E+04 | .7095 | 9.174 | .3451E+03 | .6762 | 2.532 | .1333E+05 | .5110 | 19.802 | .5310E+02 | .0820 |
| 1.149 | .6663E+04 | .7107 | 9.217 | .3322E+03 | .6828 | 2.548 | .1334E+05 | .4961 | 20.000 | .5065E+02 | .0871 |
| 1.156 | .6728E+04 | .7120 | 9.259 | .3162E+03 | .6937 | 2.564 | .1254E+05 | .5222 | 20.202 | .4863E+02 | .0863 |
| 1.163 | .6788E+04 | .7133 | 9.302 | .2961E+03 | .7100 | 2.581 | .1141E+05 | .5399 | 20.408 | .4667E+02 | .0855 |
| 1.170 | .6850E+04 | .7146 | 9.346 | .2720E+03 | .7318 | 2.597 | .1034E+05 | .5943 | 20.619 | .4478E+02 | .0848 |
| 1.176 | .6907E+04 | .7160 | 9.390 | .2363E+03 | .7667 | 2.614 | .9393E+04 | .6261 | 20.833 | .4296E+02 | .0842 |
| 1.183 | .6966E+04 | .7173 | 9.434 | .2460E+03 | .7515 | 2.632 | .8849E+04 | .6607 | 21.053 | .4120E+02 | .0836 |
| 1.190 | .7018E+04 | .7189 | 9.479 | .2626E+03 | .7272 | 2.649 | .8499E+04 | .6840 | 21.277 | .3946E+02 | .0833 |

Table 6. (continued)

| w.l. | intensity | tau | w.l. | intensity | tau |
|---|---|---|---|---|---|
| 1.198 | .7058E+04 | .7207 | 9.524 | .2703E+03 | .7124 |
| 1.205 | .7102E+04 | .7224 | 9.569 | .2737E+03 | .7028 |
| 1.212 | .7146E+04 | .7240 | 9.615 | .2737E+03 | .6977 |
| 1.220 | .7193E+04 | .7255 | 9.662 | .2711E+03 | .6963 |
| 1.227 | .7230E+04 | .7273 | 9.709 | .2666E+03 | .6977 |
| 1.235 | .7278E+04 | .7288 | 9.756 | .2606E+03 | .7011 |
| 1.242 | .7321E+04 | .7303 | 9.804 | .2541E+03 | .7051 |
| 1.250 | .7354E+04 | .7321 | 9.852 | .2470E+03 | .7097 |
| 1.258 | .7400E+04 | .7335 | 9.901 | .2397E+03 | .7145 |
| 1.266 | .7443E+04 | .7349 | 9.950 | .2322E+03 | .7190 |
| 1.274 | .7486E+04 | .7363 | 10.000 | .2248E+03 | .7231 |
| 1.282 | .7532E+04 | .7376 | 10.050 | .2182E+03 | .7263 |
| 1.290 | .7571E+04 | .7390 | 10.101 | .2114E+03 | .7297 |
| 1.299 | .7639E+04 | .7395 | 10.152 | .2043E+03 | .7339 |
| 1.307 | .7687E+04 | .7407 | 10.204 | .1964E+03 | .7396 |
| 1.316 | .7770E+04 | .7405 | 10.256 | .1873E+03 | .7476 |
| 1.325 | .7909E+04 | .7386 | 10.309 | .1777E+03 | .7572 |
| 1.333 | .8095E+04 | .7366 | 10.363 | .1658E+03 | .7709 |
| 1.342 | .8524E+04 | .7261 | 10.417 | .1550E+03 | .7833 |
| 1.351 | .9011E+04 | .7089 | 10.471 | .1643E+03 | .7642 |
| 1.361 | .9320E+04 | .6979 | 10.526 | .1701E+03 | .7500 |
| 1.370 | .9217E+04 | .7029 | 10.582 | .1744E+03 | .7383 |
| 1.379 | .9073E+04 | .7100 | 10.638 | .1766E+03 | .7299 |
| 1.389 | .9044E+04 | .7091 | 10.695 | .1771E+03 | .7244 |
| 1.399 | .9281E+04 | .7063 | 10.753 | .1762E+03 | .7213 |
| 1.408 | .9447E+04 | .7073 | 10.811 | .1742E+03 | .7201 |
| 1.418 | .9644E+04 | .7063 | 10.870 | .1723E+03 | .7190 |
| 1.429 | .9643E+04 | .7106 | 10.929 | .1697E+03 | .7190 |
| 1.439 | .9622E+04 | .7161 | 10.989 | .1666E+03 | .7197 |
| 1.449 | .9534E+04 | .7218 | 11.050 | .1633E+03 | .7207 |
| 1.460 | .9385E+04 | .7291 | 11.111 | .1600E+03 | .7216 |
| 1.471 | .9231E+04 | .7369 | 11.173 | .1593E+03 | .7181 |
| 1.481 | .9111E+04 | .7416 | 11.236 | .1587E+03 | .7140 |
| 1.493 | .8975E+04 | .7468 | 11.299 | .1584E+03 | .7093 |
| 1.504 | .8866E+04 | .7511 | 11.364 | .1802E+03 | .6634 |
| 1.515 | .8706E+04 | .7563 | 11.429 | .1820E+03 | .6534 |
| 1.527 | .8591E+04 | .7606 | 11.494 | .1866E+03 | .6376 |
| 1.538 | .8457E+04 | .7649 | 11.561 | .1876E+03 | .6283 |
| 1.550 | .8350E+04 | .7687 | 11.628 | .1898E+03 | .6162 |
| 1.563 | .8224E+04 | .7726 | 11.696 | .1908E+03 | .6063 |
| 1.575 | .8150E+04 | .7752 | 11.765 | .1925E+03 | .5947 |
| 1.587 | .8063E+04 | .7780 | 11.834 | .1955E+03 | .5794 |
| 1.600 | .8000E+04 | .7802 | 11.905 | .1996E+03 | .5612 |
| 1.613 | .7927E+04 | .7826 | 11.976 | .2032E+03 | .5434 |
| 1.626 | .7870E+04 | .7846 | 12.048 | .2060E+03 | .5255 |
| 1.639 | .7814E+04 | .7865 | 12.121 | .2076E+03 | .5107 |
| 1.653 | .7758E+04 | .7884 | 12.195 | .2098E+03 | .4889 |
| 1.667 | .7706E+04 | .7901 | 12.270 | .2144E+03 | .4692 |
| 1.681 | .7657E+04 | .7917 | 12.346 | .2164E+03 | .4505 |
| 1.695 | .7615E+04 | .7932 | 12.422 | .2205E+03 | .4251 |
| 1.709 | .7593E+04 | .7943 | 12.500 | .2258E+03 | .3964 |
| 1.724 | .7678E+04 | .7932 | 12.579 | .2317E+03 | .3644 |
| 1.739 | .7830E+04 | .7905 | 12.658 | .2313E+03 | .3483 |
| 1.754 | .8075E+04 | .7849 | 12.739 | .2336E+03 | .3228 |
| 1.770 | .8506E+04 | .7743 | 12.821 | .2405E+03 | .2819 |
| 1.786 | .9149E+04 | .7574 | 12.903 | .2411E+03 | .2608 |
| 1.802 | .9882E+04 | .7363 | 12.987 | .2452E+03 | .2261 |
| 1.818 | .1012E+05 | .7257 | 13.072 | .2454E+03 | .2012 |
| 1.835 | .1005E+05 | .7260 | 13.158 | .2471E+03 | .1690 |
| 1.852 | .1026E+05 | .7215 | 13.245 | .2469E+03 | .1407 |
| 1.869 | .1073E+05 | .7024 | 13.333 | .2444E+03 | .1299 |
| 1.887 | .1003E+05 | .7319 | 13.423 | .2432E+03 | .0938 |
| 1.905 | .9225E+04 | .7506 | 13.514 | .2388E+03 | .0659 |

| w.l. | intensity | tau | w.l. | intensity | tau |
|---|---|---|---|---|---|
| 2.667 | .1935E+05 | .1753 | 21.505 | .3778E+02 | .0831 |
| 2.685 | .1964E+05 | .1533 | 21.739 | .3616E+02 | .0828 |
| 2.703 | .1936E+05 | .1395 | 21.978 | .3460E+02 | .0826 |
| 2.721 | .2019E+05 | .1566 | 22.222 | .3310E+02 | .0825 |
| 2.740 | .2039E+05 | .1936 | 22.472 | .3163E+02 | .0828 |
| 2.759 | .1874E+05 | .2632 | 22.727 | .3022E+02 | .0831 |
| 2.778 | .1785E+05 | .2504 | 22.989 | .2886E+02 | .0834 |
| 2.797 | .1662E+05 | .2721 | 23.256 | .2755E+02 | .0838 |
| 2.817 | .1709E+05 | .2502 | 23.529 | .2628E+02 | .0841 |
| 2.837 | .1683E+05 | .2693 | 23.810 | .2505E+02 | .0850 |
| 2.857 | .1693E+05 | .2894 | 24.096 | .2387E+02 | .0859 |
| 2.878 | .1642E+05 | .3301 | 24.390 | .2273E+02 | .0867 |
| 2.899 | .1557E+05 | .3713 | 24.691 | .2163E+02 | .0876 |
| 2.920 | .1452E+05 | .4191 | 25.000 | .2058E+02 | .0884 |
| 2.941 | .1332E+05 | .4673 | 25.316 | .1956E+02 | .0899 |
| 2.963 | .1220E+05 | .5105 | 25.641 | .1858E+02 | .0913 |
| 2.985 | .1111E+05 | .5500 | 25.974 | .1763E+02 | .0927 |
| 3.008 | .1001E+05 | .5905 | 26.316 | .1673E+02 | .0941 |
| 3.030 | .9034E+04 | .6246 | 26.667 | .1586E+02 | .0956 |
| 3.053 | .8281E+04 | .6515 | 27.027 | .1502E+02 | .0977 |
| 3.077 | .7399E+04 | .6840 | 27.397 | .1422E+02 | .0998 |
| 3.101 | .6549E+04 | .7158 | 27.778 | .1345E+02 | .1019 |
| 3.125 | .6023E+04 | .7352 | 28.169 | .1271E+02 | .1040 |
| 3.150 | .5463E+04 | .7546 | 28.571 | .1200E+02 | .1062 |
| 3.175 | .5021E+04 | .7703 | 28.986 | .1132E+02 | .1091 |
| 3.200 | .4556E+04 | .7861 | 29.412 | .1066E+02 | .1120 |
| 3.226 | .4112E+04 | .8023 | 29.851 | .1004E+02 | .1150 |
| 3.252 | .3598E+04 | .8217 | 30.303 | .9439E+01 | .1180 |
| 3.279 | .3519E+04 | .8229 | 30.769 | .8867E+01 | .1211 |
| 3.306 | .3149E+04 | .8365 | 31.250 | .8320E+01 | .1249 |
| 3.333 | .2972E+04 | .8423 | 31.746 | .7798E+01 | .1288 |
| 3.361 | .2764E+04 | .8494 | 32.258 | .7300E+01 | .1328 |
| 3.390 | .2625E+04 | .8539 | 32.787 | .6825E+01 | .1369 |
| 3.419 | .2462E+04 | .8597 | 33.333 | .6373E+01 | .1411 |
| 3.448 | .2357E+04 | .8631 | 33.898 | .5938E+01 | .1465 |
| 3.478 | .2232E+04 | .8674 | 34.483 | .5525E+01 | .1521 |
| 3.509 | .2101E+04 | .8722 | 35.088 | .5133E+01 | .1579 |
| 3.540 | .2002E+04 | .8753 | 35.714 | .4760E+01 | .1639 |
| 3.571 | .1912E+04 | .8781 | 36.364 | .4407E+01 | .1701 |
| 3.604 | .1799E+04 | .8825 | 37.037 | .4075E+01 | .1771 |
| 3.636 | .1721E+04 | .8851 | 37.736 | .3761E+01 | .1843 |
| 3.670 | .1639E+04 | .8877 | 38.462 | .3464E+01 | .1919 |
| 3.704 | .1551E+04 | .8910 | 39.216 | .3184E+01 | .1999 |
| 3.738 | .1481E+04 | .8934 | 40.000 | .2920E+01 | .2081 |
| 3.774 | .1413E+04 | .8956 | 40.816 | .2673E+01 | .2171 |
| 3.810 | .1368E+04 | .8968 | 41.667 | .2441E+01 | .2266 |
| 3.846 | .1313E+04 | .8984 | 42.553 | .2224E+01 | .2365 |
| 3.883 | .1270E+04 | .8993 | 43.478 | .2020E+01 | .2470 |
| 3.922 | .1229E+04 | .9003 | 44.444 | .1829E+01 | .2581 |
| 3.960 | .1190E+04 | .9011 | 45.455 | .1651E+01 | .2702 |
| 4.000 | .1153E+04 | .9019 | 46.512 | .1485E+01 | .2830 |
| 4.040 | .1125E+04 | .9022 | 47.619 | .1331E+01 | .2967 |
| 4.082 | .1103E+04 | .9019 | 48.780 | .1187E+01 | .3114 |
| 4.124 | .1081E+04 | .9017 | 50.000 | .1054E+01 | .3272 |
| 4.167 | .1069E+04 | .9007 | 51.282 | .9335E+00 | .3428 |
| 4.211 | .3232E+04 | .0002 | 52.632 | .8224E+00 | .3595 |
| 4.255 | .2517E+04 | .0000 | 54.054 | .7201E+00 | .3777 |
| 4.301 | .2324E+04 | .0000 | 55.556 | .6262E+00 | .3974 |
| 4.348 | .2347E+04 | .0000 | 57.143 | .5402E+00 | .4189 |
| 4.396 | .2874E+04 | .0000 | 58.824 | .4672E+00 | .4375 |
| 4.444 | .4123E+04 | .0000 | 60.606 | .4009E+00 | .4576 |
| 4.494 | .5932E+04 | .0000 | 62.500 | .3410E+00 | .4795 |
| 4.545 | .7919E+04 | .0002 | 64.516 | .2868E+00 | .5037 |

Table 6. (continued)

| w.l. | intensity | tau | w.l. | intensity | tau | w.l. | intensity | tau | w.l. | intensity | tau |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1.923 | .9061E+04 | .7501 | 13.605 | .2328E+03 | .0669 | 4.598 | .9343E+04 | .0099 | 66.667 | .2381E+00 | .5305 |
| 1.942 | .9682E+04 | .7339 | 13.699 | .2282E+03 | .0571 | 4.651 | .8932E+04 | .1075 | 68.966 | .1997E+00 | .5506 |
| 1.961 | .9963E+04 | .7259 | 13.793 | .2209E+03 | .0302 | 4.706 | .6495E+04 | .3408 | 71.429 | .1656E+00 | .5725 |
| 1.980 | .1139E+05 | .7044 | 13.889 | .2030E+03 | .0107 | 4.762 | .3933E+04 | .5764 | 74.074 | .1355E+00 | .5965 |
| 2.000 | .1204E+05 | .6812 | 13.986 | .1979E+03 | .0115 | 4.819 | .2442E+04 | .7117 | 76.923 | .1091E+00 | .6231 |
| 2.010 | .1100E+05 | .7105 | 14.085 | .1952E+03 | .0140 | 4.878 | .1865E+04 | .7577 | 80.000 | .8594E-01 | .6530 |
| 2.020 | .1202E+05 | .6897 | 14.184 | .1895E+03 | .0130 | 4.938 | .1728E+04 | .7601 | 83.333 | .6909E-01 | .6727 |
| 2.030 | .1149E+05 | .7135 | 14.286 | .1819E+03 | .0099 | 5.000 | .1763E+04 | .7443 | 86.957 | .5464E-01 | .6941 |
| 2.041 | .1143E+05 | .7123 | 14.388 | .1721E+03 | .0062 | 5.063 | .1802E+04 | .7279 | 90.909 | .4235E-01 | .7177 |
| 2.051 | .1033E+05 | .7317 | 14.493 | .1603E+03 | .0033 | 5.128 | .1800E+04 | .7186 | 95.238 | .3199E-01 | .7439 |
| 2.062 | .9567E+04 | .7486 | 14.599 | .1542E+03 | .0033 | 5.195 | .1942E+04 | .6779 | 100.000 | .2334E-01 | .7735 |
| 2.073 | .1035E+05 | .7321 | 14.706 | .1537E+03 | .0036 | 5.263 | .1975E+04 | .6584 | 105.263 | .1746E-01 | .7924 |
| 2.083 | .8910E+04 | .7692 | 14.815 | .1351E+03 | .0010 | 5.333 | .1997E+04 | .6395 | 111.111 | .1270E-01 | .8129 |
| 2.094 | .7131E+04 | .8055 | 14.925 | .1142E+03 | .0000 | 5.405 | .2040E+04 | .6082 | 117.647 | .8894E-02 | .8355 |
| 2.105 | .6487E+04 | .8176 | 15.038 | .1234E+03 | .0009 | 5.479 | .2020E+04 | .5972 | 125.000 | .5920E-02 | .8605 |
| 2.116 | .6219E+04 | .8225 | 15.152 | .1391E+03 | .0039 | 5.556 | .1971E+04 | .5800 | 133.333 | .3649E-02 | .8886 |
| 2.128 | .6085E+04 | .8249 | 15.267 | .1331E+03 | .0029 | 5.634 | .1925E+04 | .5718 | 142.857 | .2470E-02 | .9007 |
| 2.139 | .5974E+04 | .8269 | 15.385 | .1296E+03 | .0042 | 5.714 | .1875E+04 | .5617 | 153.846 | .1600E-02 | .9135 |
| 2.151 | .5854E+04 | .8291 | 15.504 | .1320E+03 | .0081 | 5.797 | .1814E+04 | .5491 | 166.667 | .9796E-03 | .9270 |
| 2.162 | .5769E+04 | .8305 | 15.625 | .1320E+03 | .0123 | 5.882 | .1628E+04 | .5807 | 181.818 | .5543E-03 | .9414 |
| 2.174 | .5685E+04 | .8319 | 15.748 | .1290E+03 | .0134 | 5.970 | .1368E+04 | .6365 | 200.000 | .2782E-03 | .9568 |
| 2.186 | .5630E+04 | .8327 | 15.873 | .1267E+03 | .0174 | | | | | | |

## V. GLOSSARY

The glossary lists the major program parameters in alphabetical order, and gives the subroutine where they are first introduced. Parameters which are common to several subroutines are so indicated.

| | |
|---|---|
| AB(J) | spectral absorption coefficient through element J (RADCAL) |
| AC(J) | collision-broadened fine structure parameter in element J (RADCAL) |
| AD(J) | doppler-broadened fine structure parameter in element J (RADCAL) |
| AIWALL | wall temperature weighted mean absorption coefficient in uniform medium (RADCAL) |
| ALPHA | integrated band intensity (CO2, CO) |
| AMBDA(KK) | wavelength (RADCAL) |
| AMEAN | effective absorption coefficient in uniform medium (RADCAL) |
| AP0 | Planck-mean absorption coefficient in uniform medium (RADCAL) |
| DD(J) | length of Jth element (COMMON) |
| DINV | inverse line spacing parameter (CO2, H2O, CO, FUEL) |
| GAMMA(I,7) | line-broadening parameter of species I by individual gases (RADCAL, BD3) |
| GDDINV | line-width to line-spacing ratio for Doppler broadening (RADCAL) |
| GDINV | line-width to line-spacing ratio (RADCAL) |
| I | species index (COMMON) |
| J | element index (COMMON) |
| KK | spectral index (COMMON) |
| NOM | number of wavenumber intervals (600 maximum) (COMMON) |
| NPT | number of spatial elements (50 maximum) (COMMON) |
| NPRINT | controls output (COMMON) |
| OMEGA | wavenumber (COMMON) |
| OMMAX | maximum wavenumber (COMMON) |
| OMMIN | minimum wavenumber (COMMON) |
| P(1,J) | partial pressure of $CO_2$ (COMMON) |
| P(2,J) | partial pressure of $H_2O$ (COMMON) |
| P(3,J) | partial pressure of $CH_4$ (COMMON) |
| P(4,J) | partial pressure of CO (COMMON) |
| P(5,J) | partial pressure of $O_2$ (COMMON) |
| P(6,J) | partial pressure of $N_2$ (COMMON) |
| PLANCK(A,B) | Planck blackbody distribution function at temperature A and wavelength B |
| Q | total radiant intensity leaving path (RADCAL) |
| QW(KK) | spectral intensity leaving path (RADCAL) |
| RIK | imaginary part of the index of refraction for soot (POD) |
| RIN | real part of the index of refraction for soot (POD) |
| RSL | long wavelength soot radiance (RADCAL) |
| RSS | short wavelength soot radiance (RADCAL) |
| SDWEAK | spectral absorption coefficient (COMMON) |

| | |
|---|---|
| SD(L,K) | tabulated values of the absorption coefficient for the L th temperature of the K th wavenumber of water vapor (BD1, BD2) |
| SD7(L,K) | tabulated values of the absorption coefficient for the L th temperature of the K th wavenumber of the 7.7 $\mu$m band of $CH_4$ (BD3) |
| SD15(L,K) | tabulated values of the absorption coefficient for the L th temperature of the K th wavenumber of the 15 $\mu$m band of $CO_2$ (BD3) |
| SPECIE(I) | if zero, particular species is absent (COMMON) |
| T(J) | temperature of gas (COMMON) |
| TAU(J) | spectral transmittance through element J (RADCAL) |
| TAUS(J) | spectral transmittance through soot particles up to element J (RADCAL) |
| TTAU(K) | spectral transmittance through entire path (RADCAL) |
| TWALL | far wall temperature (COMMON) |
| U(I,J) | pressure-pathlength of species I in element J (RADCAL) |
| UK | pressure-pathlength times absorption coefficient (RADCAL) |
| W(J) | volume fraction of soot (RADCAL) |
| X(I,J) | optical depth of species I in element J (RADCAL) |
| XC | optical depth for pure collision curve-of-growth (RADCAL) |
| XD | optical depth for pure doppler curve-of-growth (RADCAL) |
| XPART(J) | particle optical depth in element J (COMMON) |
| XSTAR(J) | optical depth of species in the weak-line limit |
| XTOT(J) | combined optical depth in element J of all gases and soot (RADCAL) |

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# VII. APPENDIX

## A. Typical data input file, RC.DAT

```
1
36.58  306. .005 .0 .0 .0 .2 .795 .0
0. 400. 8000.
5
.30 1770. .1667 .1667 .0 .0 .0 .666 0.
.10 1637. .1520 .1520 .0 .0 .0 .696 0.
.10 1438. .1300 .1300 .0 .0 .0 .740 0.
.10 1158. .0992 .0992 .0 .0 .0 .802 0.
.05  899. .0705 .0705 .0 .0 .0 .859 0.
0. 50. 10000.
0
```

Data input file for RADCAL

line 1: number of homogeneous elements, n
line 2: pathlength (m), temperature (K), CO2 (atm), H2O, CH4, CO, O2, N2, fv
lines 3 through n+1: same as line 2 for the rest of the elements
line n+2: wall temperature (K), minimum wavenumber (cm-1), maximum wavenumber
line n+3: 0, or the number of homogeneous elements in the next case

## B. Listing of RADCAL

### RCPART1.FOR

```
C     PROGRAM RADCAL (11/92)
C     **************
C
C     CONTROLLING PROGRAM FOR SUBROUTINE "RADCAL", A NARROW-BAND
C     MODEL FOR CALCULATING SPECTRAL INTENSITY (W/M-2/SR/MICRON) AND
C     SPECTRAL TRANSMITTANCE VERSUS WAVELENGTH (MICRONS) IN A NONISO-
C     THERMAL, VARIABLE COMPOSITION  MIXTURE OF CO2, H2O, CO, N2, O2,
C     CH4, AND SOOT.   FOR A HOMOGENEOUS PATH, THE PROGRAM ALSO COMPUTES
C     THE PLANCK-MEAN ABSORPTION COEF., AP0, THE INCIDENT-MEAN ABSORPTION
C     COEFFICIENT, AIWALL, AND THE EFFECTIVE-MEAN ABSORPTION COEFFICIENT,
C     AMEAN, ALL IN UNITS OF INVERSE METERS.
C
C     INPUT PARAMETERS:
C         NPT=NUMBER OF HOMOGENEOUS ELEMENTS
C         DD(J)=THICKNESS OF J TH ELEMENT, M
C         T(J)=TEMPERATURE OF J TH ELEMENT, K.
C              P(I,J)=PARTIAL PRESSURE OF GASEOUS COMPONENTS, kPa:
C               I   GASEOUS SPECIES
C               1        CO2
C               2        H2O
C               3        CH4
C               4        CO
```

```
C              5       O2
C              6       N2
C        W(J)=SOOT VOLUME FRACTION OF J TH ELEMENT
C        OMMIN=MINIMUM WAVE NUMBER IN SPECTRUM, CM-1.
C        OMMAX=MAXIMUM WAVE NUMBER IN SPECTRUM, CM-1.
C
C
      COMMON/CPART/W(50),XPART(50),T(50),DD(50),NPT
      COMMON/CMAIN/OMMIN,OMMAX,NOM,TWALL,P(6,50),SPECIE(5),NPRINT
C
C     DATA ARE READ INTO UNIT 5 FROM DATA FILE "RC.DAT".
      OPEN (5,FILE='RC.DAT')
      OPEN (1,FILE='RCOUT.DAT')
C
40    CONTINUE
      READ(5,*)NPT
      IF(NPT.EQ.0)GO TO 3000
      SPECIE(1)=0.
      SPECIE(2)=0.
      SPECIE(3)=0.
      SPECIE(4)=0.
      SPECIE(5)=0.
      DO 50 J=1,NPT
      READ(5,*)DD(J),T(J),(P(I,J),1=1,6),W(J)
      DO 48 I=1,6
48    P(I,J)=P(I,J)/101.
      SPECIE(1)=P(1,J)+SPECIE(1)
      SPECIE(2)=P(2,J)+SPECIE(2)
      SPECIE(3)=P(3,J)+SPECIE(3)
      SPECIE(4)=P(4,J)+SPECIE(4)
      SPECIE(5)=W(J)+SPECIE(5)
50    CONTINUE
      READ(5,*)TWALL,OMMIN,OMMAX
      IF(OMMAX.LT.1100.)GO TO 101
      IF(OMMIN.GT.5000.)GO TO 102
      IF(OMMIN.LT.1100..AND.OMMAX.GT.5000.)GOTO 103
      IF(OMMIN.LT.1100.)GO TO 104
      IF(OMMAX.GT.5000.)GO TO 105
      NOM=IFIX((OMMAX-OMMIN)/25.)
      GO TO 106
101   NOM=IFIX((OMMAX-OMMIN)/5.)
      GO TO 106
102   NOM=IFIX((OMMAX-OMMIN)/50.)
      GO TO 106
103   NOM=IFIX((1100.-OMMIN)/5.)+IFIX((5000.-1100.)/25.)
     2         +IFIX((OMMAX-5000.)/50.)
      GO TO 106
104   NOM=IFIX((1100.-OMMIN)/5.)+IFIX((OMMAX-1100.)/25.)
      GO TO 106
105   NOM=IFIX((5000.-OMMIN)/25.)+IFIX((OMMAX-5000.)/50.)
106   NPRINT=1
      CALL RADCAL
      GO TO 40
3000  CONTINUE
      STOP
      END
C
C***************************************************************************
C
      SUBROUTINE RADCAL
      DOUBLE PRECISION SDWEAK,GDINV,GDDINV,XC,AOM,Q,QW(600),TTAU(600),
     2                 XTOT(50),XT(600),XSTAR(50),X(4,50),UK,TAU(50)
      COMMON/CMAIN/OMMIN,OMMAX,NOM,TWALL,P(6,50),SPECIE(5),NPRINT
      COMMON/CPARAM/GAMMA(4,7)
      COMMON/CPART/W(50),XPART(50),T(50),DD(50),NPT
      DIMENSION U(4,50),AC(50),AD(50),GC(4,50),AMBDA(600),TAUS(50),
     2             AB(600),PKPA(6)
```

```
C
C [NOTE: THE TOTAL INTENSITY CALCULATED IS THAT WHICH LEAVES INTERVAL J=1.
C P(I,J) IS PARTIAL PRESSURE, ATM, OF SPECIES 1 IN  INTERVAL J.
C 1=1,2,3,4,5, OR 6 IMPLIES SPECIES IS CO2, H2O, CH4, CO, O2, OR N2, RESP.]
C
      DOM=5.0
      OMEGA=OMMIN-DOM
      NM=NOM-1
C
C      LOOP 1000 COMPUTES EACH SPECTRAL CONTRIBUTION
C      ***********************************************
      DO 1000 KK=1,NOM
      OMEGA=OMEGA+DOM
      IF(OMEGA.LE.1100.)GO TO 109
      OMEGA=OMEGA+20.
      IF(OMEGA.LE.5000.)GO TO 109
      OMEGA=OMEGA+25.
109   AMBDA(KK)=10000./OMEGA
      ABGAS=0.
C
C         LOOP 200 COMPUTES THE CONTRIBUTION OF EACH SPECIES TO TAU
C            **********************************************************
      DO 200 1=1,4
C      IF SPECIE(I) IS SET TO 0., THAT PARTICULAR RADIATING SPECIES IS
C      NOT PRESENT.  THE SPECIES CONSIDERED ARE
C         I   SPECIES
C         1     CO2
C         2     H2O
C         3     CH4
C         4     CO
C         5     PARTICULATES
      IF(SPECIE(I).EQ.0.) GO TO 200
C
C             LOOP 100 IS FOR EACH ELEMENT ALONG PATH
C             ****************************************
      DO 100 J=1,NPT
C      (CALCULATION PROCEEDS IN ACCORDANCE WITH THE SLG MODEL, TABLE 5-18
C      IN NASA SP-3080.)
      IF(KK.GT.1) GO TO 107
      U(I,J)=273./T(J)*P(I,J)*100.*DD(J)
      GC(I,J)=0.
      PTOT=0.
      DO 105 II=1,6
      PTOT=P(II,J)+PTOT
105   GC(I,J)=GC(I,J)+GAMMA(I,II)*P(II,J)*(273./T(J))**.5
      GC(I,J)=GC(I,J)+GAMMA(I,7)*P(I,J)*273./T(J)
107   IF(P(I,J).EQ.0.) GO TO 121
      TEMP=T(J)
      GO TO(101,102,103,104),I
101   CALL CO2(OMEGA,TEMP,GC(1,J),SDWEAK,GDINV,GDDINV)
      GO TO 108
102   CALL H2O(OMEGA,TEMP,GC(2,J),SDWEAK,GDINV,GDDINV)
      GO TO 108
103   CONTINUE
      CALL FUEL(OMEGA,TEMP,P(3,J),PTOT,GC(3,J),SDWEAK,GDINV,GDDINV)
      GO TO 108
104   CONTINUE
      CALL CO(OMEGA,TEMP,GC(4,J),SDWEAK,GDINV,GDDINV)
108   UK=SDWEAK*U(I,J)
      IF(J.EQ.1) GO TO 110
      GKD=UK*GDINV
      GKDD=UK*GDDINV
      XSTAR(J)=XSTAR(J-1)+UK
      AD(J)=(XSTAR(J-1)*AD(J-1)+GKDD)/XSTAR(J)
      AC(J)=(XSTAR(J-1)*AC(J-1)+GKD)/XSTAR(J)
      GO TO 115
110   XSTAR(1)=UK+1.D-34
```

```
      ABGAS=UK/DD(1)+ABGAS
      AD(1)=GDDINV
      AC(1)=GDINV
115   IF(XSTAR(J).LT.1.E-6) GO TO 125
      XD=1.7*AD(J)*(DLOG(1.+(XSTAR(J)/1.7/AD(J))**2))**.5
      YD=1.-(XD/XSTAR(J))**2
      XC=XSTAR(J)/(1.+XSTAR(J)/4./AC(J))**.5
C
C   THE FOLLOWING LOOP COMPUTES THE OPTICAL THICKNESS, XC, FOR METHANE USING
C   THE GODSON EQUATION AND AN APPROXIMATION TO THE LADENBERG-REICHE
C   FUNCTION AS RECOMMENDED BY BROSMER AND TIEN (JQSRT 33,P 521).  THE
C   ERROR FUNCTION IS FOUND FROM ITS SERIES EXPANSION.
C
      IF(I.NE.3.) GO TO 118
      IF(XC.GT.10.)GO TO 118
      AOM=XC
      XX=.5*3.141593**.5*XC
      IF(XX.LE.3.)GO TO 111
      AOM=1.-EXP(-XX**2)/(3.141593**.5*XX)
      GO TO 117
111   ENN=1.
      DO 116 N=1,30
      ENN=ENN*N
      MM=2*N+1
      ARG=1.128379*(-1.)**N*((.88622693*XC)**MM)/(MM*ENN)
      ARGNEW=ARG+AOM
C     IF(ABS(ARG/ARGNEW).LT..000001)N=30
116   AOM=ARGNEW
117   IF(AOM.GE.1.)AOM=.9999999
      XC=-DLOG(1.-AOM)
C
C
118   YC=1.-(XC/XSTAR(J))**2
      Y=1./YC**2+1./YD**2-1.
      X(I,J)=XSTAR(J)*((1.-(Y**(-.5)))**.5)
      GO TO 100
121   IF(J.GT.1) GO TO 123
      XSTAR(1)=1.D-34
      AC(1)=1.
      AD(1)=1.
      GO TO 125
123   XSTAR(J)=XSTAR(J-1)
      AC(J)=AC(J-1)
      AD(J)=AD(J-1)
125   X(I,J)=XSTAR(J)
100   CONTINUE
C
C
200   CONTINUE
C
C  DETERMINE OPTICAL DEPTH OF SOOT
C
      IF(SPECIE(5).EQ.0.) GO TO 250
      CALL POD(OMEGA)
      GO TO 260
250   DO 255 J=1,NPT
255   XPART(J)=0.
260   CONTINUE
      AB(KK)=ABGAS+XPART(1)/DD(1)
C
C     EVALUATE THE COMBINED SPECTRAL TRANSMITTANCE AND RADIANCE
C     ************************************************************
      DO 500 J=1,NPT
      XTOT(J)=0.
      DO 300 I=1,4
      IF(SPECIE(I).EQ.0.) X(I,J)=0.
300   XTOT(J)=X(I,J)+XTOT(J)
```

```
      XTOT(J)=XTOT(J)+XPART(J)
      IF(XTOT(J).GE.99.) GO TO 305
      TAU(J)=DEXP(-XTOT(J))
      GO TO 310
305   TAU(J)=0.
310   IF(J.EQ.1) GO TO 510
      QW(KK)=QW(KK)-(TAU(J)-TAU(J-1))*PLANCK(T(J),AMBDA(KK))
      GO TO 500
510   QW(KK)=-(TAU(1)-1.)*PLANCK(T(1),AMBDA(KK))
500   CONTINUE
      XT(KK)=XTOT(NPT)
      TTAU(KK)=TAU(NPT)
      QW(KK)=QW(KK)+TTAU(KK)*PLANCK(TWALL,AMBDA(KK))
1000  CONTINUE
C
C  INTEGRATE THE RADIANCE OVER THE SPECTRUM
C
      Q=QW(1)*(AMBDA(1)-AMBDA(2))
      DO 1100 KK=2,NM
1100  Q=Q+QW(KK)*(AMBDA(KK-1)-AMBDA(KK+1))/2.
      Q=Q+QW(NOM)*(AMBDA(NOM-1)-AMBDA(NOM))
C
C  DETERMINE SOOT RADIANCE FOR SHORT AND LONG WAVELENGTHS.
C
      RSL=0.
      RSS=0.
      ABLONG=0.
      ABSHRT=0.
      ABIL=0.
      ABIS=0.
      IF(SPECIE(5).EQ.0..AND.TWALL.EQ.0.)GOTO 1090
      KMAX=OMMIN/5*5
      DO 1040 KK=5,KMAX,5
      OMEGA=FLOAT(KK)
      WL=10000./OMEGA
      DAMBDA=10000./(OMEGA-2.5)-10000./(OMEGA+2.5)
      CALL POD(OMEGA)
      DO 1020 J=1,NPT
      IF(XPART(J).GE.33.) GO TO 1010
      TAUS(J)=EXP(-XPART(J))
      GO TO 1012
1010  TAUS(J)=0.
1012  IF(J.EQ.1)GO TO 1021
      RSL=RSL-(TAUS(J)-TAUS(J-1))*PLANCK(T(J),WL)*DAMBDA
      GO TO 1020
1021  RSL=RSL-(TAUS(1)-1.)*PLANCK(T(1),WL)*DAMBDA
      ABLONG=ABLONG+XPART(1)/DD(1)*PLANCK(T(1),WL)*DAMBDA*5.5411E7
     2          /(T(1))**4
      ABIL=ABIL+XPART(1)/DD(1)*PLANCK(TWALL,WL)*DAMBDA*5.5411E7
     2          /(TWALL+.000001)**4
1020  CONTINUE
      RSL=RSL+TAUS(NPT)*PLANCK(TWALL,WL)*DAMBDA
1040  CONTINUE
      KMIN=OMMAX/100*100
      DO 1080 KK=KMIN,25000,100
      OMEGA=FLOAT(KK)
      WL=10000./OMEGA
      DAMBDA=10000./(OMEGA-50.)-10000./(OMEGA+50.)
      CALL POD(OMEGA)
      DO 1070 J=1,NPT
      IF(XPART(J).GE.33.) GO TO 1050
      TAUS(J)=EXP(-XPART(J))
      GO TO 1060
1050  TAUS(J)=0.
1060  IF(J.EQ.1)GO TO 1071
      RSS=RSS-(TAUS(J)-TAUS(J-1))*PLANCK(T(J),WL)*DAMBDA
      GO TO 1070
```

```
1071  RSS=RSS-(TAUS(1)-1.)*PLANCK(T(1),WL)*DAMBDA
      ABSHRT=ABSHRT+XPART(1)/DD(1)*PLANCK(T(1),WL)*DAMBDA*5.5411E7
     2            /(T(1))**4
      ABIS=ABIS+XPART(1)/DD(1)*PLANCK(TWALL,WL)*DAMBDA*5.5411E7
     2          /(TWALL+.000001)**4
1070  CONTINUE
      RSS=RSS+TAUS(NPT)*PLANCK(TWALL,WL)*DAMBDA
1080  CONTINUE
1090  CONTINUE
      Q=Q+RSS+RSL
C
C
      IF(NPRINT.EQ.1) GO TO 2300
      IF(NPRINT.EQ.0)GO TO 3000
      GO TO 2400
2300  WRITE(1,4)
      NPRINT=2
      DO 2000 J=1,NPT
      DO 2001 I=1,6
2001  PKPA(I)=P(I,J)*101.
2000  WRITE(1,6)J,DD(J),T(J),(PKPA(I),I=1,6),W(J)
      WRITE(1,7)TWALL
2400  WRITE(1,8) Q
2401  WRITE(1,10)
      LMAX=NOM/2
      IF(LMAX*2.LT.NOM) LMAX=LMAX+1
      DO 2100 L=1,LMAX
      K=NOM-LMAX+1-L
      J=K+LMAX
      IF(K.LT.1) K=1
2100  WRITE(1,12)AMBDA(J),QW(J),TTAU(J),AMBDA(K),QW(K),TTAU(K)
3000  CONTINUE
C
C           THE FOLLOWING SECTION COMPUTES THE MEAN ABSORPTION COEFFICIENTS
C           IF THE SYSTEM IS HOMOGENEOUS (IE., NPT=1).
C
      IF(NPT.NE.1)GO TO 6109
      NM=NOM-1
      AIWALL=AB(1)*(AMBDA(1)-AMBDA(2))/2.*PLANCK(TWALL,AMBDA(1))
      AP0=AB(1)*(AMBDA(1)-AMBDA(2))/2.*PLANCK(T(1),AMBDA(1))
      DO 6100 KK=2,NM
      AIWALL=AIWALL+AB(KK)*(AMBDA(KK-1)-AMBDA(KK+1))/2.
     2            *PLANCK(TWALL,AMBDA(KK))
      AP0=AP0+AB(KK)*(AMBDA(KK-1)-AMBDA(KK+1))/2.
     2          *PLANCK(T(1),AMBDA(KK))
6100  CONTINUE
      AP0=(AP0+AB(NOM)*(AMBDA(NM)-AMBDA(NOM))/2.
     2          *PLANCK(T(1),AMBDA(NOM)))*5.5411E7/T(1)**4+ABSHRT+ABLONG
      IF(TWALL.EQ.T(1).OR.TWALL.EQ.0.) GO TO 6105
      AIWALL=(AIWALL+AB(NOM)*(AMBDA(NM)-AMBDA(NOM))/2.*
     2            PLANCK(TWALL,AMBDA(NOM)))*5.5411E7/TWALL**4
      AMEAN=-1./DD(1)*DLOG((5.5411E7*Q-T(1)**4)/(TWALL**4-T(1)**4))
      GO TO 6107
6105  AIWALL=AP0
      AMEAN=-1./DD(1)*DLOG((5.5411E7*Q-T(1)**4)/(-T(1)**4))
6107  WRITE(1,14) AMEAN,AP0,AIWALL
C
C
4     FORMAT(/,'                         Radial Profiles'/
     1'                          ---------------'//
     2'                   Partial Pressures, kPa'/
     3' J  dist,m   temp,K   CO2    H2O    CH4    CO     O2     N2
     4       FV')
6     FORMAT(1X,I2,F9.4,F7.0,6(F8.3),1X,E10.4)
7     FORMAT('wall',9X,F6.0)
8     FORMAT(/,' Total directional radiated energy flux =',E12.6,
     1' Watts/m-2/strad'//' ')
```

```
10    FORMAT(8X,'Spectral Intensity Distribution, Watts/m-2/micron/strad
     1',/    8X,'-----------------------------------------------------------
     2',//,2X,'micron',4X,'intensity',6X,'tau',8X,'micron',4X,'intensity
     3',6X,'tau')
12    FORMAT(2(F8.3,3X,E10.4,2X,F8.4,5X))
14    FORMAT(///'The effective absorption coef. is ', E12.6,'/m',/
     2         'The Planck-mean absorption coef. is ', E12.6,'/m',/
     3         'The wall-incident mean is ', E12.6,'/m',/////)
C
C
6109  CONTINUE
      RETURN
      END
C
C*******************************************************************************
C
      SUBROUTINE CO2(OMEGA,TEMP,GC1,SDWEAK,GDINV,GDDINV)
      COMMON/CCO2/SD15(6,80)
      DOUBLE PRECISION AA,BB,CC,DD,EE,FF,GG,SMINUS,SPLUS,SDWEAK,SDSTRG
     1,DINV,GDINV,GDDINV
      DIMENSION ATOT(3),BCNT(3)
      IF(OMEGA.GT.5725.)GO TO 300
      WM=44.
      GD=5.94E-6*OMEGA*(TEMP/(273.*WM))**.5
      IF(OMEGA.GT.4550.)GO TO 500
      IF(OMEGA.GT.3800.)GO TO 300
      IF(OMEGA.GT.3050.)GO TO 100
      IF(OMEGA.GT.2474.)GO TO 300
      IF(OMEGA.GT.1975.)GO TO 100
      IF(OMEGA.GT.1100.)GO TO 300
      IF(OMEGA.GT.880.)GO TO 600
      IF(OMEGA.GT.500.)GO TO 400
      GO TO 300
CONTRIBUTION TO 2.0 MICRON BAND FROM (000)-(041),(000)-(121),AND (000)
C     -(201) TRANS.
500   OM1=1354.91
      OM2=673.0
      OM3=2396.49
      BCNT(1)=4860.5
      BCNT(2)=4983.5
      BCNT(3)=5109.0
      TO=300.
      C2=1.4388
      BE=0.391635
      COM1=4.*OM2+OM3
      COM2=OM1+2.*OM2+OM3
      COM3=2.*OM1+OM3
      ATOT(3)=0.426*TO/TEMP*(1.-EXP(-C2*COM3/TEMP/(1.-EXP(-C2*OM1/TEMP))
     1))**2/(1.-EXP(-C2*OM3/TEMP))
      ATOT(2)=1.01*TO/TEMP*(1.-EXP(-C2*COM2/TEMP))/(1.-EXP(-C2*OM1/TEMP)
     1)/(1.-EXP(-C2*OM2/TEMP))**2/(1.-EXP(-C2*OM3/TEMP))
      ATOT(1)=0.272*TO/TEMP*(1.-EXP(-C2*COM1/TEMP))/(1.-EXP(-C2*OM2/TEMP
     1))**4/(1.-EXP(-C2*OM3/TEMP))
      SDWEAK=0.0
      DO 510 K=1,3
      SDWEAK=SDWEAK+ATOT(K)*C2/(4.*BE*TEMP)*ABS(OMEGA-BCNT(K))
     1*EXP(-C2/(4.*BE*TEMP)*(OMEGA-BCNT(K))**2)
510   CONTINUE
      DINV=1./(4.*BE)
      GDINV=GC1*DINV
      GDDINV=GD*DINV
C***EXPRESS S/D AT STP, AS IS IN NASA SP-3080
      SDWEAK=SDWEAK*TEMP/273.
      RETURN
100   CONTINUE
      B=.391635
      A=.0030875
```

```
      X13=-19.37
      X23=-12.53
      X33=-12.63
      OM1=1354.91
      OM2=673.
      OM3=2396.49
      T0=300.
      C2=1.4388
      XBAR=.5*(.5*X13+X23)
      OM12=.5*(.5*OM1+OM2)
      SDWEAK=0.
      SDSTRG=0.
      IF(OMEGA.LE.2395.)GO TO 200
C     CALCULATE ABSORPTION COEF. AND LINE SPACING PARAMETER FOR 2.7 MICRON BAND
      L=1
C     CONTRIBUTION TO 2.7 MICRON BAND FROM (000)-(021) AND (010)-(031) TRANS.
      ALPHA=28.5
      OMPRIM=2.*OM2+OM3
120   AA=ALPHA*B*C2/(A*(1.-EXP(-OM3*C2/T0))*(1.-EXP(-OM12*C2/T0))**3
     1*(1.+EXP(-OM12*C2/T0))*(1.-EXP(-OMPRIM*C2/T0)))
      BB=(1.-EXP(-C2*OMEGA/TEMP))*(1.-EXP(-C2*OM3/TEMP))*
     1(1.-EXP(-OM12*C2/TEMP))**3*(1.+EXP(-OM12*C2/TEMP))
     2 *(1.-EXP(-C2*OMPRIM/TEMP))
      CC=AA*BB*OMEGA/TEMP*T0/TEMP
      DO 102 J=1,20
      V=FLOAT(J-1)
      IF(J/2*2.EQ.J)G=(V+1.)*(V+3.)/4.
      IF(J/2*2.NE.J)G=(V+2.)*(V+2.)/4.
      VBAR1=-1.+(V+3.)*(V+4.)/(V+2.)/6.
      IF(J/2*2.EQ.J)VBAR1=-1.+(V+5.)/6.
      DO 101 K=1,10
      V3=FLOAT(K-1)
      DD=(V3+1)*G*EXP(-(V3*OM3+V*OM12)*C2/TEMP)*(VBAR1+1.)
      GAM=B-A*(V3+1.)
      IF(L.EQ.2)GO TO 125
      OMVV3=3598.-18.*V-47.*V3
      IF(V.EQ.0.)OMVV3=3613.-47.*V3
      GO TO 130
125   OMVV3=3728.-5.*V-47.*V3
      IF(V.EQ.0.)OMVV3=3715.-47.*V3
130   DELTA=A*(OMEGA-OMVV3)
      IF(GAM*GAM.LE.DELTA)GO TO 102
      D=2.*(GAM*GAM-DELTA)**.5
      OMVBAR=OMVV3*(1.-EXP(-OMVV3*C2/TEMP))
      F1=GAM-D/2
      F2=GAM+D/2.
      EE=C2*GAM/(A*A*TEMP)
      UNFLO1=EE*DELTA*(1.+.5*A/GAM)
      IF(UNFLO1.LE.-78.)GO TO 102
      UNFLO2=EE*2.*GAM*F1
      IF(UNFLO2.GE.78.)GO TO 102
      FF=DEXP(EE*DELTA*(1.+.5*A/GAM))
      SMINUS=CC*DD/OMVBAR*ABS(F1)*FF*DEXP(-EE*2.*GAM*F1)
      UNFLO3=EE*2.*GAM*F2
      IF(UNFLO3.GE.78.)GO TO 160
      SPLUS=CC*DD/OMVBAR*ABS(F2)*FF*DEXP(-EE*2.*GAM*F2)
      GO TO 170
160   SPLUS=0.
170   GG=SDWEAK
      SDWEAK=(SMINUS+SPLUS)/D+SDWEAK
      TEST=(SDWEAK-GG)/SDWEAK
      IF(TEST.LT..0001)GO TO 102
      SDSTRG=(.5*G)**.5*(SMINUS**.5+SPLUS**.5)/D+SDSTRG
101   CONTINUE
102   CONTINUE
      IF(L.EQ.2)GO TO 250
C     CONTRIBUTION TO 2.7 MICRON BAND FROM (000)-(101) AND (010)-(111) TRANS.
```

```
      ALPHA=42.3
      OMPRIM=OM1+OM3
      L=2
      GO TO 120
C     CALCULATE ABSORPTION COEF AND LINE SPACING PARAMETER FOR 4.3 MICRON BAND
200   ALPHA=2700.
      OMPRIM=OM3
      AA=ALPHA*B*C2/(A*(1.-EXP(-OM3*C2/T0))*(1.-EXP(-OM12*C2/T0))**3
     1*(1.+EXP(-OM12*C2/T0))*(1.-EXP(-OMPRIM*C2/T0)))
      BB=(1.-EXP(-C2*OMEGA/TEMP))*(1.-EXP(-C2*OM3/TEMP))*
     1(1.-EXP(-OM12*C2/TEMP))**3*(1.+EXP(-OM12*C2/TEMP))
     2 *(1.-EXP(-C2*OMPRIM/TEMP))
      CC=AA*BB*OMEGA/TEMP*T0/TEMP
      DO 202 J=1,20
      V=FLOAT(J-1)
      IF(J/2*2.EQ.J)G=(V+1.)*(V+3.)/4.
      IF(J/2*2.NE.J)G=(V+2.)*(V+2.)/4.
      DO 201 K=1,10
      V3=FLOAT(K-1)
      DD=(V3+1.)*G*EXP(-(V3*OM3+V*OM12)*C2/TEMP)
      GAM=B-A*(V3+1.)
      OMVV3=OM3+.5*X13+X23+2.*X33+XBAR*V+2.*X33*V3
      DELTA=A*(OMEGA-OMVV3)
      IF(GAM*GAM.LE.DELTA)GO TO 202
      D=2.*(GAM*GAM-DELTA)**.5
      OMVBAR=OMVV3*(1.-EXP(-OMVV3*C2/TEMP))
      F1=GAM-D/2
      F2=GAM+D/2.
      EE=C2*GAM/(A*A*TEMP)
      UNFLO1=EE*DELTA*(1.+.5*A/GAM)
      IF(UNFLO1.LE.-78.)GO TO 202
      UNFLO2=EE*2.*GAM*F1
      IF(UNFLO2.GE.78.)GO TO 202
      FF=DEXP(EE*DELTA*(1.+.5*A/GAM))
      SMINUS=CC*DD/OMVBAR*ABS(F1)*FF*DEXP(-EE*2.*GAM*F1)
      UNFLO3=EE*2.*GAM*F2
      IF(UNFLO3.GE.78.)GO TO 246
      SPLUS=CC*DD/OMVBAR*ABS(F2)*FF*DEXP(-EE*2.*GAM*F2)
      GO TO 247
246   SPLUS=0.
247   GG=SDWEAK
      SDWEAK=(SMINUS+SPLUS)/D+SDWEAK
      TEST=(SDWEAK-GG)/SDWEAK
      IF(TEST.LT..0001)GO TO 202
      SDSTRG=(.5*G)**.5*(SMINUS**.5+SPLUS**.5)/D+SDSTRG
201   CONTINUE
202   CONTINUE
250   CONTINUE
      IF(SDWEAK.EQ.0.)GO TO 300
      DINV=SDSTRG*SDSTRG/SDWEAK
      GDINV=GC1*DINV
      GDDINV=GD*DINV
C***EXPRESS S/D AT STP, AS IS K IN NASA SP-3080
      SDWEAK=SDWEAK*TEMP/273.
      RETURN
C     CONTRIBUTION TO 10.0 MICRON BAND FROM (100)-(001) AND (020)-(001) TRANS.
600   OM1=1354.91
      OM2=673.
      OM3=2396.49
      C2=1.4388
      BCNT(1)=960.8
      BCNT(2)=1063.6
      OMA=OM3
      OMB=(OM1+2.*OM2)/2.
      TO=300.
      ATOT(1)=0.0219
      ATOT(2)=0.0532
```

```
      BE=0.391635
      DO 610 K=1,2
      ATOT(K)=TO/TEMP*ATOT(K)*EXP(C2*OMB*(1./TO-1./TEMP))
     1*(1.-EXP(-C2*(OMA-OMB)/TEMP))/(1.-EXP(-C2*OMA/TEMP))
     2/(1.-EXP(-OMB*C2/TEMP))
610   CONTINUE
      SDWEAK=0.
      DO 620 I=1,2
      SDWEAK=SDWEAK+ATOT(I)*C2/(4.*BE*TEMP)*ABS(OMEGA-BCNT(I))
     1*EXP(-C2/(4.*BE*TEMP)*(OMEGA-BCNT(I))**2)
620   CONTINUE
      DINV=1./4./BE
      GDINV=GC1*DINV
      GDDINV=GD*DINV
C***EXPRESS S/D AT STP, AS IS IN NASA SP-3080
      SDWEAK=SDWEAK*TEMP/273.
      RETURN
CONTRIBUTION TO 15.0 MICRON BAND FROM (000)-(010) TRANS.
400   TTEMP=TEMP
      J=(OMEGA-495.)/5.
      W1=495.+5.*FLOAT(J)
      WW=(OMEGA-W1)/5
      IF(TEMP.GT.2400.)TEMP=2399.99
      IF(TEMP.LT.300.)TEMP=300.
      I=TEMP/300.
      IF((I.GT.2).AND.(TEMP.LT.1200.))GOTO 410
      IF((I.GT.5).AND.(TEMP.LT.2400.))GOTO 420
      T1=FLOAT(I)*300.
      TT=(TEMP-T1)/300.
      IF(I.GT.4)I=I-1
      GO TO 430
410   I=2
      TT=(TEMP-600.)/600.
      GO TO 430
420   I=5
      TT=(TEMP-1800.)/600.
430   TW=TT*WW
      SDWEAK=SD15(I,J)*(1.-TT-WW+TW)+SD15(I+1,J)*(TT-TW)
     1+SD15(I,J+1)*(WW-TW)+SD15(I+1,J+1)*TW
      IF(SDWEAK.EQ.0.)GO TO 300
CALCULATE LINE SPACING PARAMETER FOR 15.0 MICRON BAND
      DINV1=1.2
      DINV2=8.0
      DINV3=30.0
      TEMP1=300.0
      TEMP2=550.0
      TEMP3=830.0
      DINV=DINV1*(TEMP-TEMP2)*(TEMP-TEMP3)/(TEMP1-TEMP2)/
     1(TEMP1-TEMP3)+DINV2*(TEMP-TEMP1)*(TEMP-TEMP3)/(TEMP2-TEMP1)
     2/(TEMP2-TEMP3)+DINV3*(TEMP-TEMP1)*(TEMP-TEMP2)/(TEMP3-TEMP1)
     3/(TEMP3-TEMP2)
      GDINV=GC1*DINV
      GDDINV=GD*DINV
      RETURN
300   SDWEAK=0.
      GDINV=1.
      GDDINV=1.
      RETURN
      END
C
C******************************************************************************
C
      SUBROUTINE H2O(OMEGA,TEMP,GC2,SDWEAK,GDINV,GDDINV)
      DOUBLE PRECISION SDWEAK,GDINV,GDDINV
      COMMON/CH2O/SD(6,376)
      IF (OMEGA.GE.9300..OR.OMEGA.LT.50.)GOTO 200
      WM=18.
```

```
      GD=5.94E-6*OMEGA*(TEMP/(273.*WM))**.5
      J=(OMEGA-25.)/25.
      TTEMP=TEMP
      IF(TEMP.GE.2500.) TEMP=2499.99
      IF(TEMP.LT.300.) TEMP=300.
      I=TEMP/500. +1
      IF(I.EQ.2.AND.TEMP.LT.600.) I=1
      W1=25.+25.*FLOAT(J)
      WW=(OMEGA-W1)/25.
      IF(I.GT.2) GO TO 75
      IF(I.EQ.1) TT=(TEMP-300.)/300.
      IF(I.EQ.2) TT=(TEMP-600.)/400.
      GO TO 100
75    T1=FLOAT(I-1)*500.
      TT=(TEMP-T1)/500.
100   TW=TT*WW
      SDWEAK=SD(I,J)*(1.-TT-WW+TW)+SD(I+1,J)*(TT-TW)+SD(I,J+1)*(WW-TW)
     1 +SD(I+1,J+1)*TW
      D=-2.294+.3004E-02*TEMP-.366E-06*TEMP**2
      B=SIN(.0036*OMEGA-8.043)
      DINV=EXP(.7941*B+D)
C     DINV=EXP(0.00106*TEMP-1.21)
      GDINV=GC2*DINV
      GDDINV=GD*DINV
      TEMP=TTEMP
      RETURN
200   CONTINUE
      SDWEAK=0.
      GDINV=1.
      GDDINV=1.
      RETURN
      END
C
C***********************************************************************
C
      SUBROUTINE CO(OMEGA,TEMP,GC4,SDWEAK,GDINV,GDDINV)
      DOUBLE PRECISION AA,BB,CC,DD,EE,FF,GG,SMINUS,SPLUS,SDWEAK,SDSTRG
     2,GDINV,GDDINV
      IF(OMEGA.LT.1600..OR.OMEGA.GT.2400.)GO TO 300
      B=1.93139
      ALPHA=260.
      A=.017485
      OME=2170.21
      WX=13.461
      WY=.0308
      OMPRIM=OME-2.*WX+3.25*WY
      T0=300.
      C2=1.4388
      WM=28.
      GD=5.94E-6*OMEGA*(TEMP/(273.*WM))**.5
      SDWEAK=1.D-99
      SDSTRG=1.D-99
      AA=ALPHA*B*C2/(A*(1.-EXP(-OMPRIM*C2/T0))**2)
      BB=(1.-EXP(-OMEGA*C2/TEMP))*(1.-EXP(-OMPRIM*C2/TEMP))**2
      CC=AA*BB*OMEGA/TEMP*T0/TEMP
      DO 101 J=1,20
      V=FLOAT(J-1)
      DD=(V+1.)*EXP(-V*OME*C2/TEMP)
      GAM=B-A*(V+1.)
      OMV=OME-2.*(V+1.)*WX+(3.*(V+1.)*(V+1.)+.25)*WY
      DELTA=A*(OMEGA-OMV)
      IF(GAM*GAM.LE.DELTA) GO TO 102
      D=2.*(GAM*GAM-DELTA)**.5
      OMVBAR=OMV*(1.-EXP(-OMV*C2/TEMP))
      F1=GAM-D/2.
      F2=GAM+D/2.
      EE=C2*GAM/(A*A*TEMP)
```

```
      FF=DEXP(EE*DELTA*(I.+.5*A/GAM))
      SMINUS=CC*DD/OMVBAR*ABS(F1)*FF*DEXP(-EE*2.*GAM*F1)
      SPLUS=CC*DD/OMVBAR*ABS(F2)*FF*DEXP(-EE*2.*GAM*F2)
      GG=SDWEAK
      SDWEAK=(SMINUS+SPLUS)/D+SDWEAK
      TEST=(SDWEAK-GG)/SDWEAK
      IF(TEST.LT..000I) GO TO 102
      SDSTRG=(SMINUS**.5+SPLUS**.5)/D+SDSTRG
101   CONTINUE
102   DINV=SDSTRG*SDSTRG/SDWEAK
      GDINV=GC4*DINV
      GDDINV=GD*DINV
C***EXPRESS S/D AT STP, AS IS K IN NASA SP-3080
      SDWEAK=SDWEAK*TEMP/273.
      RETURN
300   SDWEAK=0.
      GDINV=1.
      GDDINV=I.
      RETURN
      END
C
C*****************************************************************************
C
      SUBROUTINE POD(OMEGA)
C***POD CALCULATES PARTICLE OPTICAL DEPTH, XPART, OF THE VOLUME
C   FRACTION OF SOOT PARTICLES IN GAS CLOUD.  RIN AND RIK ARE
C   THE REAL AND IMAGINARY PARTS OF THE INDEX OF REFRACTION.  THE
C   PARTICLES ARE ASSUMED TO BE IN THE RAYLEIGH LIMIT.
C
      COMMON/CPART/W(50),XPART(50),T(50),DD(50),NPT
      AMBDA=10000./OMEGA
      RIN=1.6
      RIK=.5
C     FF=36.*3.1416*RIN*RIK/AMBDA/((RIN*RIN-RIK*RIK+2.)**2+(2.*RIN*RIK)
C     2**2)
C
C     ABSORPTION COEF. IS BASED UPON MEASUREMENTS OF DALZELL AND
C     SAROFIM.
      FF=7./AMBDA
      DO 300 J=1,NPT
      ABCO=FF*W(J)*1.E06
      IF(J.EQ.1)GO TO 290
      XPART(J)=XPART(J-1)+ABCO*DD(J)
      GO TO 300
290   XPART(1)=ABCO*DD(1)
300   CONTINUE
      RETURN
      END
C
C*****************************************************************************
C
      SUBROUTINE FUEL(OMEGA,TEMP,PCH4,PTOT,GC3,SDWEAK,GDINV,GDDINV)
      COMMON/CCH4/SD7(3,16),SD3(3,32)
      DOUBLE PRECISION SDWEAK,GDINV,GDDINV
      DIMENSION BCNT(4),ATOT(4)
      IF(OMEGA.GT.5000..OR.OMEGA.LT.I125.)GOTO 100
      PI=3.14159
      BE=5.2412
      C2=1.4388
      WM=16.
      GD=5.94E-6*OMEGA*(TEMP/(273.*WM))**.5
      IF(OMEGA.GT.3400.)GO TO 50
      PE=PTOT+.3*PCH4
      IF(OMEGA.GE.2625.)GO TO 200
      IF(OMEGA.GT.I450.)GO TO I00
      GO TO 300
C
```

```
C  CONTRIBUTION TO 2.4 MICRON BAND FROM (0000)-(0110), (0000)-(0011),
C  (0000)-(1001), AND (0000)-(0102) TRANS.  THE INTEGRATED BAND INTENSITIES
C  OF VINCENT-GEISSE (ANNALES DE PHYSIQUE SER.12, V. 10, 1955) HAVE
C  BEEN MULTIPLIED BY A FACTOR OF 4 AND THE LINE SPACING IS THAT
C  OF V4 FROM GRAY AND PENNER (JQSRT V. 5, 1965).
C
50    OM1=2914.2
      OM2=1526.0
      OM3=3020.3
      OM4=1306.2
      BCNT(1)=4123.0
      BCNT(2)=4216.3
      BCNT(3)=4313.2
      BCNT(4)=4546.0
      COM1=OM2+2.*OM4
      COM2=OM1+OM4
      COM3=OM3+OM4
      COM4=OM2+OM3
      ATOT(1)=.64*273./TEMP**(1.-EXP(-C2*COM1/TEMP))/
     2(1.-EXP(-C2*OM2/TEMP))/(1.-EXP(-C2*OM4/TEMP))**2
      ATOT(2)=17.6*273./TEMP*(1.-EXP(-C2*COM2/TEMP))/
     2(1.-EXP(-C2*OM1/TEMP))/(1.-EXP(-C2*OM4/TEMP))
      ATOT(3)=14.8*273./TEMP*(1.-EXP(-C2*COM3/TEMP))/
     2(1.-EXP(-C2*OM3/TEMP))/(1.-EXP(-C2*OM4/TEMP))
      ATOT(4)=5.04*273./TEMP*(1.-EXP(-C2*COM4/TEMP))/
     2(1.-EXP(-C2*OM2/TEMP))/(1.-EXP(-C2*OM3/TEMP))
      DINV=1./5.74
      GDINV=GC3*DINV
      GDDINV=GD*DINV
      SDWEAK=0.0
      DO 51 I=1,4
      SDWEAK=SDWEAK+2.*(OMEGA-BCNT(I))**2*(C2*BE/TEMP)**1.5*ATOT(I)
     2/PI**0.5*DINV**3*EXP(-C2*BE*DINV**2/TEMP*(OMEGA-BCNT(I))**2)
51    CONTINUE
      SDWEAK=SDWEAK*(TEMP/273.)
      RETURN
C
CONTRIBUTION TO 3.3 MICRON BAND FROM (0000)-(0010) TRANS.
C  REFER TO BROSMER AND TIEN, JQSRT V. 33, P. 521
200   CONTINUE
      GDINV=.00734*PE*(273./TEMP)**.5*EXP(1.02*(TEMP-273.)/273.)
      GDDINV=GD/9.4
      J=(OMEGA-2600.)/25.
      W1=2600.+25.*FLOAT(J)
      SDB=SD3(2,J)+(OMEGA-W1)/25.*(SD3(2,J+1)-SD3(2,J))
      IF(TEMP.GT.600.)GO TO 260
      SDA=SD3(1,J)+(OMEGA-W1)/25.*(SD3(1,J+1)-SD3(1,J))
      SDWEAK=SDA+(TEMP-290.)/310.*(SDB-SDA)
      IF(SDWEAK.LT.0.)SDWEAK=0.
      RETURN
260   SDC=SD3(3,J)+(OMEGA-W1)/25.*(SD3(3,J+1)-SD3(3,J))
      SDWEAK=SDB+(TEMP-600.)/250.*(SDC-SDB)
      IF(SDWEAK.LT.0.)SDWEAK=0.
      RETURN
C
CONTRIBUTION TO 7.7 MICRON BAND FROM (0000)-(0001) TRANS.
C   REFER TO BROSMER AND TIEN, JQSRT V. 33, P. 521.
300   CONTINUE
      GDINV=.0243*PE*(TEMP/273.)**.8
      GDDINV=GD/5.1
      J=(OMEGA-1100.)/25.
      W1=1100.+25.*FLOAT(J)
      SDB=SD7(2,J)+(OMEGA-W1)/25.*(SD7(2,J+1)-SD7(2,J))
      IF(TEMP.GT.600.)GO TO 360
      SDA=SD7(1,J)+(OMEGA-W1)/25.*(SD7(1,J+1)-SD7(1,J))
      SDWEAK=SDA+(TEMP-290.)/310.*(SDB-SDA)
      IF(SDWEAK.LT.0.)SDWEAK=0.
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      RETURN
360   SDC=SD7(3,J)+(OMEGA-W1)/25.*(SD7(3,J+1)-SD7(3,J))
      SDWEAK=SDB+(TEMP-600.)/250.*(SDC-SDB)
      IF(SDWEAK.LT.0.)SDWEAK=0.
      RETURN
100   SDWEAK=0.0
      GDINV=1.
      GDDINV=1.
      RETURN
      END
C
C******************************************************************************
C
      FUNCTION PLANCK(A,B)
C     COMPUTES BLACKBODY FUNCTION IN UNITS OF W/M-2/MICRON/SR
      C1=.59544E08
      C2=14388.
      IF(A.EQ.0.)GO TO 100
      OVRFLO=C2/A/B
      IF(OVRFLO.GT.38.)GO TO 100
      PLANCK=2.*C1*(B**(-5))/(EXP(C2/A/B)-1.)
      GO TO 101
100   PLANCK=0.
101   CONTINUE
      RETURN
      END
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## RCPART2.FOR

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      BLOCK DATA BD1
      COMMON/CH2O/SD(6,376)
      DIMENSION A1(6,8),A2(6,8),A3(6,8),A4(6,8),A5(6,8),A6(6,8),A7(6,8),
     2A8(6,8),A9(6,8),A10(6,8),A11(6,8),A12(6,8),A13(6,8),A14(6,8),
     3A15(6,8),A16(6,8),A17(6,8),A18(6,8),A19(6,8),A20(6,8),A21(6,8)
      EQUIVALENCE(A1(1,1),SD(1,1)),(A2(1,1),SD(1,9)),(A3(1,1),SD(1,17))
     1,(A4(1,1),SD(1,25)),(A5(1,1),SD(1,33)),(A6(1,1),SD(1,41))
     2,(A7(1,1),SD(1,49)),(A8(1,1),SD(1,57)),(A9(1,1),SD(1,65))
     3,(A10(1,1),SD(1,73)),(A11(1,1),SD(1,81)),(A12(1,1),SD(1,89))
     4,(A13(1,1),SD(1,97)),(A14(1,1),SD(1,105)),(A15(1,1),SD(1,113))
     5,(A16(1,1),SD(1,121)),(A17(1,1),SD(1,129)),(A18(1,1),SD(1,137))
     6,(A19(1,1),SD(1,145)),(A20(1,1),SD(1,153)),(A21(1,1),SD(1,161))
C  TEMP,K= 300     600      1000      1500      2000      2500           WAVE NO.
      DATA A1/
     1 .950E+00, .103E+00, .420E-01, .114E-01, .450E-02, .300E-02,        50
     1 .208E+01, .365E+00, .113E+00, .375E-01, .195E-01, .134E-01,        75
     1 .368E+01, .990E+00, .300E+00, .104E+00, .577E-01, .365E-01,       100
     1 .650E+01, .201E+01, .650E+00, .214E+00, .128E+00, .845E-01,       125
     1 .825E+01, .325E+01, .121E+01, .415E+00, .260E+00, .168E+00,       150
     1 .870E+01, .452E+01, .189E+01, .765E+00, .450E+00, .289E+00,       175
     1 .810E+01, .540E+01, .261E+01, .126E+01, .695E+00, .460E+00,       200
     1 .682E+01, .600E+01, .337E+01, .179E+01, .101E+01, .679E+00/       225
      DATA A2/
     1 .493E+01, .622E+01, .407E+01, .230E+01, .135E+01, .935E+00,       250
     1 .316E+01, .592E+01, .456E+01, .281E+01, .172E+01, .122E+01,       275
     1 .199E+01, .528E+01, .479E+01, .328E+01, .213E+01, .149E+01,       300
     1 .113E+01, .450E+01, .484E+01, .361E+01, .249E+01, .179E+01,       325
     1 .585E+00, .370E+01, .471E+01, .383E+01, .284E+01, .208E+01,       350
     1 .293E+00, .289E+01, .443E+01, .394E+01, .312E+01, .237E+01,       375
     1 .138E+00, .205E+01, .400E+01, .396E+01, .330E+01, .260E+01,       400
     1 .620E-01, .143E+01, .347E+01, .388E+01, .341E+01, .280E+01/       425
      DATA A3/
     1 .255E-01, .950E+00, .292E+01, .370E+01, .345E+01, .295E+01,       450
     1 .940E-02, .610E+00, .236E+01, .343E+01, .342E+01, .304E+01,       475
     1 .340E-02, .386E+00, .188E+01, .310E+01, .334E+01, .309E+01,       500
     1 .105E-02, .236E+00, .145E+01, .274E+01, .319E+01, .307E+01,       525
     1 .350E-03, .144E+00, .110E+01, .238E+01, .300E+01, .301E+01,       550
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1 .126E-03, .820E-01, .818E+00, .204E+01, .276E+01, .289E+01,
1 .430E-04, .445E-01, .598E+00, .174E+01, .248E+01, .275E+01,
1 .150E-04, .242E-01, .427E+00, .145E+01, .222E+01, .260E+01/
 DATA A4/
1 .510E-05, .127E-01, .294E+00, .118E+01, .195E+01, .241E+01,
1 .170E-05, .630E-02, .200E+00, .950E+00, .169E+01, .221E+01,
1 .570E-06, .300E-02, .134E+00, .748E+00, .146E+01, .200E+01,
1 .195E-06, .140E-02, .902E-01, .580E+00, .124E+01, .178E+01,
1 .680E-07, .620E-03, .590E-01, .443E+00, .103E+01, .156E+01,
1 .385E-07, .275E-03, .450E-01, .330E+00, .845E+00, .136E+01,
1 .670E-07, .113E-03, .355E-01, .242E+00, .695E+00, .117E+01,
1 .113E-06, .500E-04, .289E-01, .174E+00, .560E+00, .100E+01/
 DATA A5/
1 .195E-06, .230E-04, .245E-01, .123E+00, .450E+00, .855E+00,
1 .328E-06, .103E-04, .214E-01, .100E+00, .357E+00, .718E+00,
1 .560E-06, .460E-05, .189E-01, .830E-01, .278E+00, .595E+00,
1 .950E-06, .205E-05, .174E-01, .730E-01, .239E+00, .492E+00,
1 .160E-05, .140E-05, .166E-01, .665E-01, .211E+00, .405E+00,
1 .275E-05, .350E-05, .165E-01, .630E-01, .195E+00, .352E+00,
1 .470E-05, .850E-05, .167E-01, .620E-01, .190E+00, .312E+00,
1 .810E-05, .215E-04, .175E-01, .630E-01, .191E+00, .289E+00/
 DATA A6/
1 .136E-04, .570E-04, .188E-01, .675E-01, .194E+00, .281E+00,
1 .235E-04, .150E-03, .208E-01, .745E-01, .202E+00, .283E+00,
1 .400E-04, .380E-03, .233E-01, .865E-01, .223E+00, .314E+00,
1 .680E-04, .950E-03, .268E-01, .122E+00, .260E+00, .380E+00,
1 .120E-03, .245E-02, .343E-01, .176E+00, .328E+00, .461E+00,
1 .200E-03, .620E-02, .638E-01, .251E+00, .411E+00, .511E+00,
1 .365E-03, .140E-01, .107E+00, .330E+00, .458E+00, .542E+00,
1 .680E-03, .330E-01, .166E+00, .405E+00, .487E+00, .571E+00/
 DATA A7/
1 .130E-02, .635E-01, .244E+00, .459E+00, .535E+00, .557E+00,
1 .250E-02, .123E+00, .341E+00, .477E+00, .502E+00, .562E+00,
1 .500E-02, .212E+00, .407E+00, .547E+00, .531E+00, .514E+00,
1 .103E-01, .285E+00, .489E+00, .592E+00, .497E+00, .486E+00,
1 .219E-01, .328E+00, .491E+00, .558E+00, .489E+00, .485E+00,
1 .485E-01, .345E+00, .505E+00, .521E+00, .477E+00, .484E+00,
1 .114E+00, .361E+00, .538E+00, .563E+00, .503E+00, .502E+00,
1 .249E+00, .460E+00, .621E+00, .624E+00, .538E+00, .538E+00/
 DATA A8/
1 .397E+00, .569E+00, .749E+00, .768E+00, .581E+00, .565E+00,
1 .418E+00, .627E+00, .824E+00, .849E+00, .640E+00, .594E+00,
1 .108E+01, .125E+01, .113E+01, .940E+00, .807E+00, .663E+00,
1 .165E+01, .155E+01, .118E+01, .670E+00, .562E+00, .483E+00,
1 .142E+01, .675E+00, .557E+00, .349E+00, .276E+00, .263E+00,
1 .451E+00, .202E+00, .132E+00, .118E+00, .134E+00, .156E+00,
1 .603E-01, .538E-01, .863E-01, .112E+00, .120E+00, .125E+00,
1 .501E+00, .252E+00, .118E+00, .112E+00, .131E+00, .140E+00/
 DATA A9/
1 .730E+00, .430E+00, .237E+00, .191E+00, .171E+00, .170E+00,
1 .149E+01, .506E+00, .294E+00, .238E+00, .210E+00, .201E+00,
1 .100E+01, .553E+00, .434E+00, .340E+00, .260E+00, .220E+00,
1 .802E+00, .658E+00, .528E+00, .411E+00, .300E+00, .240E+00,
1 .580E+00, .527E+00, .460E+00, .378E+00, .322E+00, .283E+00,
1 .330E+00, .403E+00, .430E+00, .356E+00, .318E+00, .270E+00,
1 .250E+00, .393E+00, .405E+00, .342E+00, .301E+00, .275E+00,
1 .147E+00, .249E+00, .313E+00, .318E+00, .291E+00, .268E+00/
 DATA A10/
1 .910E-01, .252E+00, .298E+00, .295E+00, .269E+00, .253E+00,
1 .580E-01, .158E+00, .214E+00, .244E+00, .244E+00, .245E+00,
1 .370E-01, .113E+00, .184E+00, .218E+00, .214E+00, .218E+00,
1 .244E-01, .118E+00, .156E+00, .188E+00, .195E+00, .200E+00,
1 .162E-01, .606E-01, .976E-01, .141E+00, .166E+00, .179E+00,
1 .112E-01, .425E-01, .903E-01, .133E+00, .148E+00, .156E+00,
1 .780E-02, .400E-01, .765E-01, .112E+00, .129E+00, .137E+00,
1 .540E-02, .352E-01, .647E-01, .876E-01, .110E+00, .118E+00/
 DATA A11/
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1 .380E-02, .252E-01, .507E-01, .705E-01, .888E-01, .100E+00,          2050
1 .260E-02, .179E-01, .377E-01, .546E-01, .724E-01, .828E-01,          2075
1 .180E-02, .123E-01, .294E-01, .443E-01, .608E-01, .686E-01,          2100
1 .127E-02, .850E-02, .212E-01, .378E-01, .579E-01, .640E-01,          2125
1 .880E-03, .680E-02, .152E-01, .275E-01, .449E-01, .521E-01,          2150
1 .620E-02, .400E-02, .107E-01, .214E-01, .374E-01, .453E-01,          2175
1 .480E-03, .298E-02, .931E-02, .189E-01, .329E-01, .403E-01,          2200
1 .405E-03, .175E-02, .696E-02, .152E-01, .295E-01, .365E-01/          2225
 DATA A12/
1 .321E-03, .120E-02, .452E-02, .101E-01, .252E-01, .331E-01,          2250
1 .229E-03, .721E-03, .364E-02, .930E-02, .225E-01, .305E-01,          2275
1 .195E-03, .544E-03, .318E-02, .750E-02, .202E-01, .284E-01,          2300
1 .154E-03, .375E-03, .185E-02, .603E-02, .175E-01, .269E-01,          2325
1 .101E-03, .263E-03, .119E-02, .480E-02, .156E-01, .253E-01,          2350
1 .852E-04, .185E-03, .909E-03, .360E-02, .133E-01, .241E-01,          2375
1 .763E-04, .137E-03, .711E-03, .316E-02, .122E-01, .237E-01,          2400
1 .615E-04, .126E-03, .610E-03, .257E-02, .101E-01, .218E-01/          2425
 DATA A13/
1 .480E-04, .113E-03, .518E-03, .201E-02, .920E-02, .200E-01,          2450
1 .372E-04, .106E-03, .435E-03, .168E-02, .785E-02, .183E-01,          2475
1 .355E-04, .101E-03, .376E-03, .168E-02, .669E-02, .166E-01,          2500
1 .358E-04, .990E-04, .366E-03, .167E-02, .651E-02, .156E-01,          2525
1 .389E-04, .102E-03, .376E-03, .167E-02, .641E-02, .152E-01,          2550
1 .422E-04, .106E-03, .373E-03, .168E-02, .656E-02, .150E-01,          2575
1 .521E-04, .111E-03, .371E-03, .170E-02, .673E-02, .152E-01,          2600
1 .646E-04, .121E-03, .384E-03, .179E-02, .798E-02, .179E-01/          2625
 DATA A14/
1 .742E-04, .129E-03, .479E-03, .201E-02, .788E-02, .175E-01,          2650
1 .953E-04, .165E-03, .544E-03, .249E-02, .945E-02, .204E-01,          2675
1 .101E-03, .190E-03, .761E-03, .324E-02, .106E-01, .231E-01,          2700
1 .147E-03, .272E-03, .892E-03, .441E-02, .125E-01, .257E-01,          2725
1 .195E-03, .326E-03, .100E-02, .499E-02, .147E-01, .295E-01,          2750
1 .261E-03, .421E-03, .145E-02, .568E-02, .161E-01, .306E-01,          2775
1 .305E-03, .515E-03, .195E-02, .754E-02, .185E-01, .363E-01,          2800
1 .362E-03, .645E-03, .237E-02, .830E-02, .205E-01, .373E-01/          2825
 DATA A15/
1 .507E-03, .850E-03, .274E-02, .888E-02, .234E-01, .431E-01,          2850
1 .799E-03, .118E-02, .322E-02, .110E-01, .262E-01, .451E-01,          2875
1 .935E-03, .160E-02, .386E-02, .126E-01, .292E-01, .530E-01,          2900
1 .108E-02, .231E-02, .451E-02, .140E-01, .306E-01, .536E-01,          2925
1 .192E-02, .271E-02, .563E-02, .159E-01, .357E-01, .629E-01,          2950
1 .263E-02, .300E-02, .625E-02, .179E-01, .385E-01, .666E-01,          2975
1 .295E-02, .330E-02, .701E-02, .203E-01, .460E-01, .782E-01,          3000
1 .310E-02, .370E-02, .846E-02, .220E-01, .519E-01, .889E-01/          3025
 DATA A16/
1 .340E-02, .400E-02, .969E-02, .279E-01, .662E-01, .109E+00,          3050
1 .730E-02, .450E-02, .111E-01, .272E-01, .676E-01, .109E+00,          3075
1 .900E-02, .480E-02, .137E-01, .372E-01, .864E-01, .133E+00,          3100
1 .100E-02, .510E-02, .162E-01, .471E-01, .100E+00, .142E+00,          3125
1 .640E-03, .550E-02, .205E-01, .530E-01, .122E+00, .168E+00,          3150
1 .160E-02, .600E-02, .247E-01, .633E-01, .135E+00, .177E+00,          3175
1 .330E-02, .700E-02, .283E-01, .770E-01, .153E+00, .185E+00,          3200
1 .410E-02, .860E-02, .376E-01, .914E-01, .166E+00, .206E+00/          3225
 DATA A17/
1 .410E-02, .103E-01, .514E-01, .117E+00, .194E+00, .228E+00,          3250
1 .290E-02, .129E-01, .664E-01, .147E+00, .220E+00, .254E+00,          3275
1 .220E-02, .161E-01, .834E-01, .171E+00, .237E+00, .263E+00,          3300
1 .220E-02, .212E-01, .103E+00, .201E+00, .268E+00, .283E+00,          3325
1 .250E-02, .285E-01, .135E+00, .240E+00, .295E+00, .295E+00,          3350
1 .310E-02, .385E-01, .169E+00, .272E+00, .312E+00, .301E+00,          3375
1 .420E-02, .540E-01, .214E+00, .309E+00, .329E+00, .307E+00,          3400
1 .600E-02, .770E-01, .267E+00, .343E+00, .332E+00, .314E+00/          3425
 DATA A18/
1 .940E-02, .117E+00, .333E+00, .372E+00, .344E+00, .303E+00,          3450
1 .165E-01, .173E+00, .365E+00, .385E+00, .353E+00, .300E+00,          3475
1 .360E-01, .258E+00, .438E+00, .393E+00, .315E+00, .288E+00,          3500
1 .720E-01, .375E+00, .510E+00, .409E+00, .294E+00, .271E+00,          3525
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     1 .133E+00, .401E+00, .499E+00, .390E+00, .281E+00, .257E+00,          3550
     1 .215E+00, .500E+00, .443E+00, .341E+00, .254E+00, .230E+00,          3575
     1 .318E+00, .450E+00, .346E+00, .286E+00, .245E+00, .219E+00,          3600
     1 .442E+00, .400E+00, .354E+00, .279E+00, .233E+00, .216E+00/          3625
      DATA A19/
     1 .473E+00, .405E+00, .347E+00, .281E+00, .238E+00, .219E+00,          3650
     1 .568E+00, .501E+00, .423E+00, .315E+00, .243E+00, .218E+00,          3675
     1 .690E+00, .708E+00, .673E+00, .432E+00, .268E+00, .189E+00,          3700
     1 .617E+00, .831E+00, .566E+00, .320E+00, .194E+00, .123E+00,          3725
     1 .181E+01, .520E+00, .200E+00, .131E+00, .124E+00, .107E+00,          3750
     1 .136E+00, .124E+00, .120E+00, .119E+00, .115E+00, .115E+00,          3775
     1 .455E+00, .298E+00, .167E+00, .129E+00, .123E+00, .112E+00,          3800
     1 .760E+00, .503E+00, .242E+00, .154E+00, .129E+00, .127E+00/          3825
      DATA A20/
     1 .836E+00, .584E+00, .277E+00, .184E+00, .161E+00, .145E+00,          3850
     1 .840E+00, .728E+00, .422E+00, .236E+00, .197E+00, .167E+00,          3875
     1 .505E+00, .500E+00, .379E+00, .276E+00, .227E+00, .192E+00,          3900
     1 .117E+00, .400E+00, .423E+00, .315E+00, .243E+00, .202E+00,          3925
     1 .460E-01, .300E+00, .358E+00, .290E+00, .230E+00, .202E+00,          3950
     1 .183E-01, .205E+00, .269E+00, .235E+00, .195E+00, .192E+00,          3975
     1 .730E-02, .135E+00, .186E+00, .179E+00, .159E+00, .168E+00,          4000
     1 .557E-02, .790E-01, .113E+00, .124E+00, .124E+00, .134E+00/          4025
      DATA A21/
     1 .283E-02, .415E-01, .662E-01, .886E-01, .103E+00, .106E+00,          4050
     1 .226E-02, .197E-01, .367E-01, .594E-01, .801E-01, .879E-01,          4075
     1 .155E-02, .860E-02, .211E-01, .395E-01, .503E-01, .610E-01,          4100
     1 .103E-02, .521E-02, .119E-01, .246E-01, .354E-01, .480E-01,          4125
     1 .821E-03, .365E-02, .759E-02, .166E-01, .258E-01, .370E-01,          4150
     1 .752E-03, .183E-02, .445E-02, .100E-01, .179E-01, .268E-01,          4175
     1 .429E-03, .141E-02, .354E-02, .821E-02, .142E-01, .212E-01,          4200
     1 .327E-03, .902E-03, .209E-02, .588E-02, .112E-01, .172E-01/          4225
      END
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## RCPART3.FOR

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      BLOCK DATA BD2
      COMMON/CH2O/SD(6,376)
      DIMENSION A22(6,8),A23(6,8),A24(6,8),A25(6,8),A26(6,8),A27(6,8),
     4A28(6,8),
     5A29(6,8),A30(6,8),A31(6,8),A32(6,8),A33(6,8),A34(6,8),A35(6,8),
     6A36(6,8),A37(6,8),A38(6,8),A39(6,8),A40(6,8),A41(6,8),A42(6,8),
     7A43(6,8),A44(6,8),A45(6,8),A46(6,8),A47(6,8)
      EQUIVALENCE(A22(1,1),SD(1,169)),(A23(1,1),SD(1,177)),(A24(1,1)
     1,SD(1,185)),(A25(1,1),SD(1,193)),(A26(1,1),SD(1,201)),(A27(1,1)
     2,SD(1,209)),(A28(1,1),SD(1,217)),(A29(1,1),SD(1,225)),(A30(1,1)
     3,SD(1,233)),(A31(1,1),SD(1,241)),(A32(1,1),SD(1,249)),(A33(1,1)
     4,SD(1,257)),(A34(1,1),SD(1,265)),(A35(1,1),SD(1,273)),(A36(1,1)
     5,SD(1,281)),(A37(1,1),SD(1,289)),(A38(1,1),SD(1,297))
      EQUIVALENCE(A39(1,1),SD(1,305)),(A40(1,1),SD(1,313)),(A41(1,1)
     1,SD(1,321)),(A42(1,1),SD(1,329)),(A43(1,1),SD(1,337)),(A44(1,1)
     2,SD(1,345)),(A45(1,1),SD(1,353)),(A46(1,1),SD(1,361)),(A47(1,1)
     3,SD(1,369))
C  TEMP,K= 300    600    1000    1500    2000    2500       WAVE NO.
      DATA A22/
     1 .225E-03, .685E-03, .189E-02, .512E-02, .101E-01, .164E-01,    4250
     1 .186E-03, .551E-03, .156E-02, .366E-02, .812E-02, .136E-01,    4275
     1 .173E-03, .472E-03, .139E-02, .306E-02, .661E-02, .115E-01,    4300
     1 .138E-03, .395E-03, .110E-02, .272E-02, .587E-02, .104E-01,    4325
     1 .900E-04, .270E-03, .968E-03, .222E-02, .497E-02, .921E-02,    4350
     1 .752E-04, .233E-03, .744E-03, .208E-02, .466E-02, .876E-02,    4375
     1 .618E-04, .175E-03, .638E-03, .185E-02, .465E-02, .914E-02,    4400
     1 .504E-04, .134E-03, .499E-03, .174E-02, .455E-02, .935E-02/    4425
      DATA A23/
     1 .375E-04, .123E-03, .485E-03, .182E-02, .456E-02, .971E-02,    4450
     1 .305E-04, .892E-04, .338E-03, .134E-02, .460E-02, .104E-01,    4475
     1 .257E-04, .790E-04, .329E-03, .154E-02, .477E-02, .112E-01,    4500
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1 .242E-04, .740E-04, .308E-03, .135E-02, .497E-02, .122E-01,      4525
1 .215E-04, .653E-04, .282E-03, .131E-02, .521E-02, .133E-01,      4550
1 .218E-04, .660E-04, .272E-03, .152E-02, .573E-02, .148E-01,      4575
1 .215E-04, .671E-04, .268E-03, .134E-02, .607E-02, .159E-01,      4600
1 .217E-04, .695E-04, .285E-03, .161E-02, .677E-02, .173E-01/      4625
 DATA A24/
1 .219E-04, .722E-04, .297E-03, .169E-02, .783E-02, .197E-01,      4650
1 .226E-04, .771E-04, .341E-03, .236E-02, .925E-02, .226E-01,      4675
1 .250E-04, .815E-04, .387E-03, .286E-02, .106E-01, .250E-01,      4700
1 .280E-04, .845E-04, .420E-03, .357E-02, .124E-01, .276E-01,      4725
1 .351E-04, .192E-03, .470E-03, .467E-02, .166E-01, .313E-01,      4750
1 .435E-04, .200E-03, .105E-02, .566E-02, .185E-01, .341E-01,      4775
1 .522E-04, .233E-03, .129E-02, .736E-02, .229E-01, .378E-01,      4800
1 .673E-04, .306E-03, .183E-02, .982E-02, .258E-01, .404E-01/      4825
 DATA A25/
1 .886E-04, .399E-03, .246E-02, .128E-01, .302E-01, .430E-01,      4850
1 .113E-03, .618E-03, .346E-02, .161E-01, .358E-01, .459E-01,      4875
1 .174E-03, .825E-03, .441E-02, .200E-01, .417E-01, .493E-01,      4900
1 .265E-03, .163E-02, .777E-02, .245E-01, .450E-01, .507E-01,      4925
1 .355E-03, .200E-02, .978E-02, .317E-01, .492E-01, .527E-01,      4950
1 .538E-03, .271E-02, .167E-01, .401E-01, .503E-01, .523E-01,      4975
1 .651E-03, .301E-02, .264E-01, .467E-01, .520E-01, .526E-01,      5000
1 .987E-03, .530E-02, .321E-01, .499E-01, .523E-01, .510E-01/      5025
 DATA A26/
1 .135E-02, .860E-02, .389E-01, .528E-01, .513E-01, .492E-01,      5050
1 .226E-02, .130E-01, .472E-01, .559E-01, .500E-01, .469E-01,      5075
1 .431E-02, .198E-01, .526E-01, .557E-01, .480E-01, .452E-01,      5100
1 .628E-02, .282E-01, .488E-01, .495E-01, .451E-01, .430E-01,      5125
1 .900E-02, .390E-01, .471E-01, .449E-01, .430E-01, .423E-01,      5150
1 .180E-01, .462E-01, .412E-01, .391E-01, .403E-01, .415E-01,      5175
1 .348E-01, .710E-01, .402E-01, .360E-01, .384E-01, .414E-01,      5200
1 .718E-01, .590E-01, .399E-01, .360E-01, .376E-01, .420E-01/      5225
 DATA A27/
1 .111E+00, .368E-01, .340E-01, .369E-01, .409E-01, .454E-01,      5250
1 .329E-01, .285E-01, .365E-01, .423E-01, .461E-01, .482E-01,      5275
1 .281E-01, .270E-01, .432E-01, .505E-01, .529E-01, .511E-01,      5300
1 .121E+00, .422E-01, .589E-01, .598E-01, .572E-01, .544E-01,      5325
1 .139E+00, .105E+00, .844E-01, .687E-01, .593E-01, .560E-01,      5350
1 .774E-01, .710E-01, .683E-01, .618E-01, .556E-01, .534E-01,      5375
1 .858E-01, .483E-01, .579E-01, .547E-01, .503E-01, .495E-01,      5400
1 .985E-01, .575E-01, .589E-01, .510E-01, .451E-01, .449E-01/      5425
 DATA A28/
1 .996E-01, .682E-01, .539E-01, .489E-01, .454E-01, .446E-01,      5450
1 .680E-01, .680E-01, .548E-01, .495E-01, .460E-01, .458E-01,      5475
1 .325E-01, .520E-01, .515E-01, .483E-01, .449E-01, .454E-01,      5500
1 .150E-01, .350E-01, .451E-01, .464E-01, .452E-01, .449E-01,      5525
1 .620E-02, .238E-01, .369E-01, .408E-01, .414E-01, .417E-01,      5550
1 .270E-02, .158E-01, .282E-01, .339E-01, .366E-01, .384E-01,      5575
1 .113E-02, .101E-01, .203E-01, .263E-01, .303E-01, .333E-01,      5600
1 .829E-03, .590E-02, .148E-01, .206E-01, .247E-01, .295E-01/      5625
 DATA A29/
1 .365E-03, .310E-02, .969E-02, .154E-01, .203E-01, .258E-01,      5650
1 .240E-03, .130E-02, .589E-02, .112E-01, .164E-01, .222E-01,      5675
1 .158E-03, .400E-03, .417E-02, .850E-02, .134E-01, .190E-01,      5700
1 .103E-03, .262E-03, .208E-02, .594E-02, .109E-01, .162E-01,      5725
1 .741E-04, .181E-03, .142E-02, .455E-02, .907E-02, .141E-01,      5750
1 .625E-04, .135E-03, .816E-03, .316E-02, .698E-02, .121E-01,      5775
1 .499E-04, .111E-03, .624E-03, .230E-02, .551E-02, .102E-01,      5800
1 .325E-04, .677E-04, .425E-03, .124E-02, .385E-02, .818E-02/      5825
 DATA A30/
1 .231E-04, .563E-04, .278E-03, .986E-03, .290E-02, .672E-02,      5850
1 .165E-04, .481E-04, .247E-03, .944E-03, .253E-02, .612E-02,      5875
1 .126E-04, .432E-04, .241E-03, .886E-03, .220E-02, .582E-02,      5900
1 .118E-04, .420E-04, .235E-03, .847E-03, .209E-02, .571E-02,      5925
1 .110E-04, .408E-04, .226E-03, .812E-03, .221E-02, .604E-02,      5950
1 .101E-04, .400E-04, .213E-03, .805E-03, .239E-02, .641E-02,      5975
1 .983E-05, .395E-04, .186E-03, .801E-03, .247E-02, .691E-02,      6000
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1 .979E-05, .401E-04, .193E-03, .805E-03, .260E-02, .732E-02/      6025
 DATA A31/
1 .976E-05, .410E-04, .201E-03, .814E-03, .285E-02, .776E-02,      6050
1 .988E-05, .420E-04, .210E-03, .832E-03, .317E-02, .842E-02,      6075
1 .991E-05, .425E-04, .219E-03, .877E-03, .340E-02, .888E-02,      6100
1 .102E-04, .435E-04, .231E-03, .937E-03, .361E-02, .929E-02,      6125
1 .110E-04, .486E-04, .244E-03, .971E-03, .402E-02, .994E-02,      6150
1 .127E-04, .579E-04, .257E-03, .111E-02, .437E-02, .104E-01,      6175
1 .131E-04, .612E-04, .277E-03, .113E-02, .465E-02, .110E-01,      6200
1 .150E-04, .783E-04, .353E-03, .116E-02, .510E-02, .116E-01/      6225
 DATA A32/
1 .178E-04, .922E-04, .394E-03, .157E-02, .555E-02, .123E-01,      6250
1 .203E-04, .115E-03, .481E-03, .188E-02, .601E-02, .131E-01,      6275
1 .230E-04, .145E-03, .617E-03, .183E-02, .644E-02, .139E-01,      6300
1 .280E-04, .187E-03, .723E-03, .202E-02, .686E-02, .146E-01,      6325
1 .305E-04, .209E-03, .811E-03, .243E-02, .779E-02, .157E-01,      6350
1 .455E-04, .244E-03, .935E-03, .243E-02, .844E-02, .166E-01,      6375
1 .661E-04, .320E-03, .989E-03, .288E-02, .902E-02, .173E-01,      6400
1 .723E-04, .397E-03, .122E-02, .359E-02, .100E-01, .184E-01/      6425
 DATA A33/
1 .847E-04, .481E-03, .143E-02, .429E-02, .108E-01, .192E-01,      6450
1 .103E-03, .591E-03, .174E-02, .488E-02, .116E-01, .200E-01,      6475
1 .131E-03, .703E-03, .247E-02, .549E-02, .124E-01, .205E-01,      6500
1 .165E-03, .872E-03, .265E-02, .641E-02, .131E-01, .211E-01,      6525
1 .205E-03, .110E-02, .298E-02, .749E-02, .140E-01, .218E-01,      6550
1 .253E-03, .130E-02, .346E-02, .811E-02, .150E-01, .230E-01,      6575
1 .338E-03, .150E-02, .445E-02, .890E-02, .159E-01, .237E-01,      6600
1 .437E-03, .170E-02, .491E-02, .107E-01, .170E-01, .245E-01/      6625
 DATA A34/
1 .581E-03, .190E-02, .537E-02, .116E-01, .179E-01, .254E-01,      6650
1 .685E-03, .220E-02, .578E-02, .128E-01, .189E-01, .263E-01,      6675
1 .900E-03, .250E-02, .649E-02, .134E-01, .195E-01, .275E-01,      6700
1 .121E-02, .280E-02, .722E-02, .142E-01, .202E-01, .281E-01,      6725
1 .152E-02, .330E-02, .813E-02, .161E-01, .212E-01, .288E-01,      6750
1 .185E-02, .370E-02, .907E-02, .168E-01, .222E-01, .292E-01,      6775
1 .220E-02, .430E-02, .929E-02, .183E-01, .233E-01, .294E-01,      6800
1 .255E-02, .500E-02, .114E-01, .195E-01, .245E-01, .289E-01/      6825
 DATA A35/
1 .290E-02, .580E-02, .167E-01, .215E-01, .260E-01, .291E-01,      6850
1 .320E-02, .670E-02, .208E-01, .237E-01, .274E-01, .293E-01,      6875
1 .360E-02, .880E-02, .220E-01, .253E-01, .282E-01, .300E-01,      6900
1 .400E-02, .920E-02, .238E-01, .273E-01, .290E-01, .304E-01,      6925
1 .460E-02, .108E-01, .272E-01, .279E-01, .298E-01, .310E-01,      6950
1 .530E-02, .128E-01, .304E-01, .292E-01, .297E-01, .312E-01,      6975
1 .620E-02, .152E-01, .344E-01, .303E-01, .293E-01, .310E-01,      7000
1 .760E-02, .182E-01, .341E-01, .297E-01, .290E-01, .300E-01/      7025
 DATA A36/
1 .980E-02, .222E-01, .398E-01, .318E-01, .291E-01, .294E-01,      7050
1 .132E-01, .271E-01, .402E-01, .294E-01, .274E-01, .282E-01,      7075
1 .190E-01, .335E-01, .421E-01, .286E-01, .262E-01, .269E-01,      7100
1 .240E-01, .432E-01, .431E-01, .276E-01, .245E-01, .257E-01,      7125
1 .288E-01, .570E-01, .458E-01, .270E-01, .228E-01, .243E-01,      7150
1 .323E-01, .740E-01, .449E-01, .261E-01, .214E-01, .221E-01,      7175
1 .570E-01, .890E-01, .435E-01, .225E-01, .199E-01, .196E-01,      7200
1 .216E-01, .680E-01, .378E-01, .239E-01, .195E-01, .192E-01/      7225
 DATA A37/
1 .126E-01, .475E-01, .364E-01, .238E-01, .197E-01, .192E-01,      7250
1 .117E-01, .369E-01, .385E-01, .249E-01, .212E-01, .204E-01,      7275
1 .140E-01, .370E-01, .419E-01, .272E-01, .228E-01, .213E-01,      7300
1 .425E-01, .418E-01, .440E-01, .280E-01, .248E-01, .229E-01,      7325
1 .640E-01, .460E-01, .427E-01, .290E-01, .263E-01, .238E-01,      7350
1 .385E-01, .385E-01, .374E-01, .259E-01, .235E-01, .224E-01,      7375
1 .182E-01, .179E-01, .282E-01, .231E-01, .211E-01, .214E-01,      7400
1 .170E-01, .810E-02, .191E-01, .175E-01, .181E-01, .194E-01/      7425
 DATA A38/
1 .161E-01, .370E-02, .105E-01, .127E-01, .152E-01, .171E-01,      7450
1 .145E-01, .170E-02, .554E-02, .855E-02, .113E-01, .131E-01,      7475
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1 .175E-02, .140E-02, .385E-02, .595E-02, .803E-02, .945E-02,        7500
1 .772E-03, .751E-03, .384E-02, .575E-02, .537E-02, .594E-02,        7525
1 .491E-03, .600E-03, .301E-02, .453E-02, .380E-02, .434E-02,        7550
1 .275E-03, .410E-03, .193E-02, .366E-02, .319E-02, .332E-02,        7575
1 .185E-01, .280E-03, .131E-02, .232E-02, .247E-02, .256E-02,        7600
1 .101E-03, .160E-03, .915E-03, .150E-02, .186E-02, .197E-02/        7625
 DATA A39/
1 .691E-04, .110E-03, .565E-03, .114E-02, .205E-02, .192E-02,        7650
1 .476E-04, .750E-04, .114E-02, .124E-02, .175E-02, .187E-02,        7675
1 .305E-04, .590E-04, .529E-03, .114E-02, .160E-02, .185E-02,        7700
1 .240E-04, .480E-04, .293E-03, .842E-03, .141E-02, .184E-02,        7725
1 .170E-04, .360E-04, .122E-03, .435E-03, .124E-02, .182E-02,        7750
1 .120E-04, .240E-04, .121E-03, .435E-03, .118E-02, .187E-02,        7775
1 .810E-05, .170E-04, .103E-03, .439E-03, .126E-02, .192E-02,        7800
1 .550E-05, .120E-04, .866E-04, .367E-03, .119E-02, .193E-02/        7825
 DATA A40/
1 .390E-05, .900E-05, .716E-04, .351E-03, .116E-02, .194E-02,        7850
1 .295E-05, .830E-05, .373E-04, .254E-03, .114E-02, .196E-02,        7875
1 .230E-05, .800E-05, .465E-04, .298E-03, .117E-02, .201E-02,        7900
1 .225E-05, .820E-05, .367E-04, .252E-03, .116E-02, .205E-02,        7925
1 .220E-05, .840E-05, .371E-04, .268E-03, .127E-02, .211E-02,        7950
1 .223E-05, .920E-05, .396E-04, .273E-03, .128E-02, .216E-02,        7975
1 .235E-05, .103E-04, .415E-04, .263E-03, .121E-02, .221E-02,        8000
1 .280E-05, .125E-04, .633E-04, .363E-03, .136E-02, .231E-02/        8025
 DATA A41/
1 .310E-05, .150E-04, .979E-04, .492E-03, .150E-02, .241E-02,        8050
1 .370E-05, .180E-04, .120E-03, .580E-03, .167E-02, .251E-02,        8075
1 .420E-05, .200E-04, .987E-04, .509E-03, .171E-02, .257E-02,        8100
1 .510E-05, .240E-04, .134E-03, .547E-03, .173E-02, .267E-02,        8125
1 .600E-05, .270E-04, .121E-03, .534E-03, .172E-02, .274E-02,        8150
1 .720E-05, .300E-04, .204E-03, .684E-03, .184E-02, .285E-02,        8175
1 .820E-05, .330E-04, .276E-03, .819E-03, .199E-02, .297E-02,        8200
1 .100E-04, .380E-04, .317E-03, .859E-03, .214E-02, .308E-02/        8225
 DATA A42/
1 .125E-04, .420E-04, .240E-03, .818E-03, .220E-02, .317E-02,        8250
1 .145E-04, .500E-04, .452E-03, .109E-02, .238E-02, .293E-02,        8275
1 .175E-04, .560E-04, .301E-03, .941E-03, .243E-02, .342E-02,        8300
1 .198E-04, .630E-04, .280E-03, .107E-02, .260E-02, .353E-02,        8325
1 .230E-04, .710E-04, .276E-03, .109E-02, .272E-02, .365E-02,        8350
1 .280E-04, .830E-04, .369E-03, .127E-02, .295E-02, .377E-02,        8375
1 .330E-04, .890E-04, .430E-03, .139E-02, .306E-02, .385E-02,        8400
1 .360E-04, .950E-04, .371E-03, .135E-02, .306E-02, .384E-02/        8425
 DATA A43/
1 .390E-04, .980E-04, .434E-03, .147E-02, .316E-02, .385E-02,        8450
1 .400E-04, .990E-04, .397E-03, .143E-02, .318E-02, .384E-02,        8475
1 .400E-04, .980E-04, .364E-03, .141E-02, .317E-02, .381E-02,        8500
1 .390E-04, .940E-04, .390E-03, .142E-02, .314E-02, .376E-02,        8525
1 .380E-04, .900E-04, .380E-03, .145E-02, .318E-02, .375E-02,        8550
1 .380E-04, .900E-04, .380E-03, .145E-02, .318E-02, .375E-02,        8575
1 .330E-04, .750E-04, .358E-03, .138E-02, .310E-02, .372E-02,        8600
1 .270E-04, .580E-04, .382E-03, .143E-02, .315E-02, .369E-02/        8625
 DATA A44/
1 .240E-04, .500E-04, .343E-03, .136E-02, .306E-02, .363E-02,        8650
1 .200E-04, .450E-04, .309E-03, .134E-02, .306E-02, .359E-02,        8675
1 .180E-04, .400E-04, .281E-03, .127E-02, .294E-02, .341E-02,        8700
1 .170E-04, .360E-04, .276E-03, .124E-02, .290E-02, .336E-02,        8725
1 .160E-04, .310E-04, .272E-03, .122E-02, .283E-02, .323E-02,        8750
1 .140E-04, .280E-04, .241E-03, .117E-02, .273E-02, .309E-02,        8775
1 .120E-04, .250E-04, .237E-03, .115E-02, .269E-02, .297E-02,        8800
1 .100E-04, .220E-04, .218E-03, .111E-02, .259E-02, .284E-02/        8825
 DATA A45/
1 .920E-05, .198E-04, .206E-03, .105E-02, .246E-02, .269E-02,        8850
1 .810E-05, .170E-04, .205E-03, .100E-02, .235E-02, .257E-02,        8875
1 .720E-05, .160E-04, .177E-03, .921E-03, .220E-02, .245E-02,        8900
1 .650E-05, .150E-04, .172E-03, .834E-03, .205E-02, .232E-02,        8925
1 .590E-05, .130E-04, .147E-03, .735E-03, .194E-02, .218E-02,        8950
1 .510E-05, .110E-04, .120E-03, .629E-03, .177E-02, .203E-02,        8975
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 1 .460E-05, .950E-05, .960E-04, .513E-03, .154E-02, .180E-02,       9000
 1 .420E-05, .800E-05, .578E-04, .314E-03, .123E-02, .154E-02/       9025
  DATA A46/
 1 .380E-05, .720E-05, .529E-04, .292E-03, .114E-02, .137E-02,       9050
 1 .330E-05, .660E-05, .485E-04, .269E-03, .102E-02, .122E-02,       9075
 1 .290E-05, .580E-05, .430E-04, .239E-03, .896E-03, .107E-02,       9100
 1 .270E-05, .520E-05, .259E-04, .193E-03, .748E-03, .944E-03,       9125
 1 .240E-05, .450E-05, .316E-04, .207E-03, .671E-02, .848E-03,       9150
 1 .220E-05, .400E-05, .444E-05, .602E-04, .516E-03, .750E-03,       9175
 1 .190E-05, .360E-05, .324E-05, .460E-04, .439E-03, .688E-03,       9200
 1 .170E-05, .320E-05, .180E-05, .321E-04, .384E-03, .653E-03/       9225
  DATA A47/
 1 .140E-05, .280E-05, .171E-05, .344E-04, .340E-03, .616E-03,       9250
 1 .130E-05, .250E-05, .299E-05, .600E-04, .343E-03, .619E-03,       9275
 1 .120E-05, .220E-05, .299E-05, .600E-04, .343E-03, .619E-03,       9300
 1 1., 1., 1., 1., 1., 1., 1., 1., 1., 1., 1., 1., 1., 1., 1.,
 1 1., 1., 1., 1., 1., 1., 1., 1., 1., 1., 1., 1., 1., 1., 1./
  END
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## RCPART4.FOR

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      BLOCK DATA BD3
      COMMON/CCO2/SD15(6,80)
      COMMON/CCH4/SD7(3,16),SD3(3,32)
      COMMON/CPARAM/GAMMA(4,7)
      DIMENSION B1(6,8),B2(6,8),B3(6,8),B4(6,8),B5(6,8),
     1B6(6,8),B7(6,8),B8(6,8),B9(6,8),B10(6,8)
      DIMENSION C1(3,8),C2(3,8),C3(3,8),C4(3,8),C5(3,8),C6(3,8)
      EQUIVALENCE(B1(1,1),SD15(1,1)),(B2(1,1),SD15(1,9)),(B3(1,1),
     1SD15(1,17)),(B4(1,1),SD15(1,25)),(B5(1,1),SD15(1,33)),
     2(B6(1,1),SD15(1,41)),(B7(1,1),SD15(1,49)),(B8(1,1),SD15(1,57))
     3,(B9(1,1),SD15(1,65)),(B10(1,1),SD15(1,73))
      EQUIVALENCE(C1(1,1),SD7(1,1)),(C2(1,1),SD7(1,9)),
     1(C3(1,1),SD3(1,1)),(C4(1,1),SD3(1,9)),(C5(1,1),SD3(1,17)),
     2(C6(1,1),SD3(1,25))
      DATA GAMMA/
C    LINE BROADENING PARAMETERS,GAMMA(I,J),
C    J=CO2,H2O,CH4,CO,O2,N2,SELFRESONANT.
C    I=        CO2  H2O  CH4   CO
C    J
     1     .09 , .12, .0 , .07,
     2     .07 , .09, .0 , .06,
     3     .0  , .0 , .16, .0 ,
     4     .06 , .10, .0 , .06,
     5     .055, .04, .0 , .05,
     6     .07 , .09, .0 , .06,
     7     .01 , .44, .0 , .0 /
C  THE FOLLOWING ARE DATA FOR THE 15.0 MICRON BAND OF CO2
C  TEMP, K=300        600        1200      1500      1800       2400      WAVE NO.
      DATA B1/
     1 .000E+00, .000E+00, .000E+00, .105E-01, .300E-01, .880E-01,        500
     1 .000E+00, .000E+00, .000E+00, .180E-01, .490E-01, .880E-01,        505
     1 .000E+00, .000E+00, .000E+00, .300E-01, .540E-01, .740E-01,        510
     1 .000E+00, .000E+00, .000E+00, .300E-01, .560E-01, .890E-01,        515
     1 .000E+00, .000E+00, .000E+00, .330E-01, .690E-01, .990E-01,        520
     1 .000E+00, .000E+00, .880E-02, .380E-01, .720E-01, .970E-01,        525
     1 .000E+00, .000E+00, .110E-01, .530E-01, .950E-01, .124E+00,        530
     1 .000E+00, .000E+00, .285E-01, .630E-01, .990E-01, .140E+00/        535
      DATA B2/
     1 .000E+00, .000E+00, .330E-01, .680E-01, .103E+00, .134E+00,        540
     1 .000E+00, .000E+00, .450E-01, .920E-01, .138E+00, .176E+00,        545
     1 .000E+00, .000E+00, .490E-01, .970E-01, .148E+00, .191E+00,        550
     1 .000E+00, .000E+00, .490E-01, .120E-01, .188E+00, .247E+00,        555
     1 .000E+00, .000E+00, .480E-01, .126E+00, .201E+00, .241E+00,        560
     1 .000E+00, .000E+00, .820E-01, .198E+00, .270E+00, .265E+00,        565
     1 .000E+00, .750E-02, .690E-01, .140E+00, .225E+00, .340E+00,        570
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1 .000E+00, .205E-01, .820E-01, .145E+00, .236E+00, .530E+00/     575
 DATA B3/
1 .000E+00, .355E-01, .117E+00, .193E+00, .295E+00, .550E+00,     580
1 .157E-01, .520E-01, .170E+00, .235E+00, .305E+00, .410E+00,     585
1 .150E-01, .880E-01, .270E+00, .330E+00, .440E+00, .520E+00,     590
1 .510E-01, .130E+00, .400E+00, .530E+00, .560E+00, .540E+00,     595
1 .120E+00, .165E+00, .275E+00, .320E+00, .420E+00, .560E+00,     600
1 .880E-01, .190E+00, .430E+00, .540E+00, .620E+00, .680E+00,     605
1 .110E+00, .350E+00, .710E+00, .760E+00, .760E+00, .690E+00,     610
1 .180E+00, .470E+00, .920E+00, .970E+00, .910E+00, .670E+00/     615
 DATA B4/
1 .970E-01, .265E+00, .610E+00, .720E+00, .780E+00, .730E+00,     620
1 .175E+00, .380E+00, .720E+00, .790E+00, .830E+00, .840E+00,     625
1 .370E+00, .640E+00, .920E+00, .960E+00, .980E+00, .940E+00,     630
1 .590E+00, .840E+00, .107E+01, .110E+01, .111E+01, .106E+01,     635
1 .940E+00, .103E+01, .115E+01, .115E+01, .115E+01, .118E+01,     640
1 .196E+01, .177E+01, .146E+01, .136E+01, .132E+01, .139E+01,     645
1 .345E+01, .282E+01, .198E+01, .172E+01, .156E+01, .148E+01,     650
1 .282E+01, .248E+01, .200E+01, .190E+01, .186E+01, .205E+01/     655
 DATA B5/
1 .254E+01, .234E+01, .184E+01, .176E+01, .174E+01, .203E+01,     660
1 .142E+02, .860E+01, .370E+01, .260E+01, .196E+01, .142E+01,     665
1 .450E+01, .570E+01, .580E+01, .520E+01, .350E+01, .420E+01,     670
1 .360E+01, .310E+01, .330E+01, .290E+01, .205E+01, .200E+01,     675
1 .310E+01, .260E+01, .200E+01, .196E+01, .180E+01, .210E+01,     680
1 .240E+01, .250E+01, .230E+01, .220E+01, .170E+01, .194E+01,     685
1 .182E+01, .200E+01, .218E+01, .205E+01, .184E+01, .130E+01,     690
1 .104E+01, .135E+01, .172E+01, .172E+01, .165E+01, .130E+01/     695
 DATA B6/
1 .550E+00, .120E+01, .143E+01, .147E+01, .148E+01, .125E+01,     700
1 .136E+01, .128E+01, .128E+01, .135E+01, .138E+01, .134E+01,     705
1 .210E+00, .780E+00, .127E+01, .133E+01, .137E+01, .132E+01,     710
1 .190E+00, .780E+00, .140E+01, .146E+01, .147E+01, .142E+01,     715
1 .900E+00, .106E+01, .140E+01, .150E+01, .155E+01, .134E+01,     720
1 .720E-01, .300E+00, .800E+00, .100E+01, .115E+01, .126E+01,     725
1 .640E-01, .210E+00, .560E+00, .720E+00, .860E+00, .102E+01,     730
1 .680E-01, .210E+00, .530E+00, .670E+00, .790E+00, .101E+01/     735
 DATA B7/
1 .690E-01, .210E+00, .540E+00, .690E+00, .820E+00, .910E+00,     740
1 .330E-01, .140E+00, .390E+00, .530E+00, .690E+00, .770E+00,     745
1 .230E-01, .780E-01, .270E+00, .410E+00, .560E+00, .890E+00,     750
1 .300E-01, .860E-01, .280E+00, .400E+00, .520E+00, .710E+00,     755
1 .175E-01, .620E-01, .225E+00, .335E+00, .450E+00, .660E+00,     760
1 .105E-01, .450E-01, .180E+00, .280E+00, .380E+00, .600E+00,     765
1 .450E-02, .300E-01, .148E+00, .240E+00, .345E+00, .570E+00,     770
1 .000E+00, .140E-01, .124E+00, .205E+00, .285E+00, .430E+00/     775
 DATA B8/
1 .000E+00, .115E-01, .110E+00, .185E+00, .260E+00, .375E+00,     780
1 .000E+00, .135E-01, .840E-01, .140E+00, .205E+00, .335E+00,     785
1 .000E+00, .430E-02, .650E-01, .120E+00, .185E+00, .325E+00,     790
1 .000E+00, .000E+00, .540E-01, .115E+00, .180E+00, .315E+00,     795
1 .000E+00, .000E+00, .440E-01, .950E-01, .150E+00, .270E+00,     800
1 .000E+00, .000E+00, .360E-01, .790E-01, .125E+00, .205E+00,     805
1 .000E+00, .000E+00, .250E-01, .650E-01, .110E+00, .178E+00,     810
1 .000E+00, .000E+00, .180E-01, .620E-01, .103E+00, .153E+00/     815
 DATA B9/
1 .000E+00, .000E+00, .320E-01, .580E-01, .860E-01, .147E+00,     820
1 .000E+00, .000E+00, .800E-02, .510E-01, .870E-01, .134E+00,     825
1 .000E+00, .000E+00, .600E-02, .480E-01, .830E-01, .133E+00,     830
1 .000E+00, .000E+00, .000E+00, .430E-01, .780E-01, .118E+00,     835
1 .000E+00, .000E+00, .000E+00, .420E-01, .700E-01, .108E+00,     840
1 .000E+00, .000E+00, .000E+00, .360E-01, .640E-01, .980E-01,     845
1 .000E+00, .000E+00, .000E+00, .350E-01, .610E-01, .870E-01,     850
1 .000E+00, .000E+00, .000E+00, .320E-01, .580E-01, .860E-01/     855
 DATA B10/
1 .000E+00, .000E+00, .000E+00, .330E-01, .560E-01, .750E-01,     860
1 .000E+00, .000E+00, .000E+00, .300E-01, .530E-01, .750E-01,     865
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     1 .000E+00, .000E+00, .000E+00, .290E-01, .530E-01, .850E-01,        870
     1 .000E+00, .000E+00, .000E+00, .240E-01, .470E-01, .900E-01,        875
     1 .000E+00, .000E+00, .000E+00, .220E-01, .450E-01, .860E-01,        880
     1 .000E+00, .000E+00, .000E+00, .000E+00, .000E+00, .000E+00,
     1 .000E+00, .000E+00, .000E+00, .000E+00, .000E+00, .000E+00,
     1 .000E+00, .000E+00, .000E+00, .000E+00, .000E+00, .000E+00/
C  THE FOLLOWING DATA ARE FOR THE 7.7 MICRON BAND OF CH4
C TEMP,K= 290      600   850                                             WAVE NO.
      DATA C1/
     1 0., 0., 0.,
     1 0., 0., 0.03,
     1 0., 0., 0.22,
     1 0.16, 0.20, 0.47,
     1 0.34, 0.34, 0.62,
     1 0.69, 0.53, 0.65,
     1 1.27, 0.88, 1.09,
     1 1.68, 1.38, 0.87/
      DATA C2/
     1 0.55, 0.28, 0.40,
     1 1.25, 0.86, 0.93,
     1 0.34, 0.59, 0.75,
     1 0., 0.13, 0.25,
     1 0., 0., 0.06,
     1 0., 0., 0.,
     1 0., 0., 0.,
     1 0., 0., 0./
C  THE FOLLOWING DATA ARE FOR THE 3.3 MICRON BAND OF CH4
C TEMP, K= 290      600   850
      DATA C3/
     1 0., 0., 0.03,
     1 0., 0., 0.03,
     1 0., 0., 0.03,
     1 0., 0., 0.06,
     1 0.03, 0.03, 0.09,
     1 0.07, 0.07, 0.12,
     1 0.09, 0.09, 0.12,
     1 0.14, 0.15, 0.22/
      DATA C4/
     1 0.18, 0.22, 0.28,
     1 0.24, 0.31, 0.37,
     1 0.33, 0.44, 0.47,
     1 0.45, 0.50, 0.53,
     1 0.59, 0.62, 0.62,
     1 0.74, 0.70, 0.68,
     1 0.91, 0.77, 0.72,
     1 1.00, 0.81, 0.75/
      DATA C5/
     1 1.03, 0.84, 0.78,
     1 1.03, 0.84, 0.78,
     1 1.00, 0.81, 0.75,
     1 0.94, 0.77, 0.72,
     1 0.72, 0.68, 0.68,
     1 0.52, 0.63, 0.63,
     1 0.33, 0.50, 0.56,
     1 0.25, 0.42, 0.50/
      DATA C6/
     1 0.17, 0.26, 0.37,
     1 0.08, 0.18, 0.31,
     1 0.04, 0.11, 0.22,
     1 0., 0.06, 0.16,
     1 0., 0.02, 0.12,
     1 0., 0., 0.06,
     1 0., 0., 0.03,
     1 0., 0., 0./
      END
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