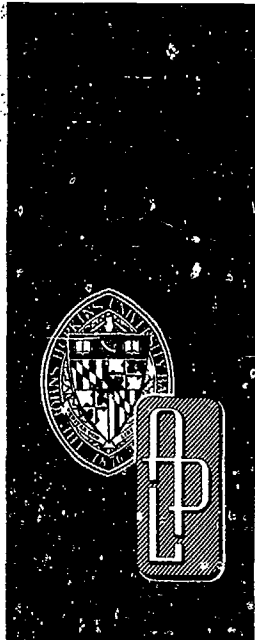


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TG-1373
MARCH 1989



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Technical Memorandum

MODIFICATIONS TO THE AEROTHERM CHARRING MATERIAL THERMAL RESPONSE AND ABLATION PROGRAM (CMA) FOR CARBON ABLATION ANALYSIS

C. C. CHAN

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THE JOHNS HOPKINS UNIVERSITY ■ APPLIED PHYSICS LABORATORY

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Technical Memorandum

**MODIFICATIONS TO THE AEROTHERM
CHARRING MATERIAL THERMAL RESPONSE
AND ABLATION PROGRAM (CMA) FOR
CARBON ABLATION ANALYSIS**

C. C. CHAN

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Operating under Contract N00039-87-C-5301 with the Department of the Navy

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ABSTRACT

Modifications to the Aerotherm Charring Material Thermal Response and Ablation Program (CMA) have been made to resolve deficiencies that were identified during the Aerospace Nuclear Safety Program's Galileo spacecraft reentry/ablation studies for a Venus-Earth-Earth-Gravity-Assist (VEEGA) trajectory. The primary modifications deal with integrating the Hunter carbon oxidation subroutine with the mainstream ablation calculations in CMA. The modified program uses a surface temperature criterion to determine when to switch between the Hunter oxidation subroutine and the sublimation tables in CMA. The user has the option to explicitly define this temperature criterion, indirectly define it via a mass loss parameter, or generate it via a search routine. A related feature uses Hunter's algorithm to compute an "ablation threshold temperature" of the material for switching between ablation and non-ablator routines.

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SUMMARY

Improvements to the Aerotherm Charring Material Thermal Response and Ablation Program (CMA) code have been made to resolve deficiencies that were identified during the Galileo spacecraft reentry/ablation studies for a Venus-Earth-Earth-Gravity-Assist (VEEGA) trajectory. They include several new algorithms to merge the Hunter carbon oxidation subroutine with the mainstream CMA ablation calculations.

A surface-temperature criterion is used for switching from the built-in surface thermochemistry tables to the Hunter subroutine. Three methods are available for the CMA user to define the temperature criterion. The first is a constant transition temperature criterion, the second is a constant mass loss parameter (β') criterion that is used to determine the transition temperature, and the last is a search for a temperature that gives the smoothest transition between the Hunter method and the surface thermochemistry tables in CMA (based on the slope differential between both ablation curves).

The modifications discussed in this report include use of the Hunter algorithm to compute an ablation threshold temperature of the material. The user may then choose either a constant temperature or use the Hunter algorithm to compute the temperature that corresponds to a negligible mass loss (i.e., no ablation).

INTRODUCTION

Problems with the CMA code that were experienced during the Galileo-VEEGA reentry/ ablation studies¹ showed clearly the need for modification to the code. The following modifications were subsequently recommended:

1. Increase the code's capacity for input data; specifically, to double the capacity of (a) the time dependent data table (i.e., the reentry environmental data), (b) the surface thermochemistry subtables (i.e., double the pressure tables and increase the entries per table), and (c) the nodes of the spatial grid (i.e., the structural model);
2. Merge Hunter's carbon oxidation algorithm² with the CMA code's mainstream ablation calculations;
3. Amend the Putz and Bartlett mass transfer correlation for blowing effects on convective heating;
4. Address the numerical characteristics of the surface energy balance in the diffusion-limited oxidation regime.

The code's capacity for input data (item 1 above) was completed previously. It was accomplished by identifying the appropriate arrays in the source code (Appendix A), increasing their dimension declarations, and recompiling the program. There was no descriptive memo generated for these minor modifications; however, the data set containing the source codes is listed in the catalog of IBM mainframe data sets for ANSP.³

More recent modifications to the CMA code will be discussed in this report and we will focus on the algorithms and their implementation. It will be assumed that the reader is familiar with the CMA code and graphite ablation theory. Detailed discussions on these topics can be found in Refs. 4 and 5, respectively.

The primary modifications are algorithms that merge the Hunter carbon oxidation subroutine with the mainstream CMA ablation calculations (item 2). Efficient use of the subroutine in CMA has been hindered by the lack of routines that integrate it with the mainstream CMA ablation calculations. The existing implementation only allows for the Hunter subroutine to be switched ON or OFF, meaning that if the mode of ablation changes from oxidation to sublimation or vice versa, a restart problem would be required.

Items 3 and 4 are future tasks. Work has started on modifying the Putz and Bartlett blowing option, but it is currently "on hold"; a list of the requirements for this task is provided herein for future reference. Some thoughts from the author on item 4 are included in this report.

¹D. W. Conn and C. C. Chan, "Preliminary Galileo-VEEGA Ablation Studies," JHU API BFD-2-87-001, EM-5392, March 12, 1987.

²L. W. Hunter, L. L. Perini, D. W. Conn, and P. T. Brenza, "Calculation of Carbon Ablation on a Re-entry Body During Supersonic/Subsonic Flight," *Journal of Spacecraft Rockets*, Vol. 23, No. 5, Sept.-Oct. 1986.

³C. C. Chan, "Catalog of ANSP Data Sets," JHU API BBE:EAM-7925, October 6, 1987.

⁴"User's Manual: Aerotherm Charring Material Thermal Response and Ablation Program, Version 3," Vol. 1, Aerotherm Report No. UM-70-14, April 1970.

⁵L. L. Perini, "Review of Graphite Ablation Theory and Experimental Data," JHU API ANSP-M-1, December 1971.

DISCUSSION

The new algorithms that have been added to the CMA code will now be discussed, but in order to follow the discussions on merging the Hunter subroutine, a brief background on the CMA ablation calculations is first provided. The CMA code computes values for the surface energy balance equation (Appendix B) using algorithms for either an ablating or a nonablating material. For the ablating material, the chemical and sensible energy components of the surface energy balance are computed using either (a) the Hunter subroutine (or the surface thermochemistry tables if the Hunter subroutine is not evoked) for oxidation ablation or (b) the surface thermochemistry tables for sublimation. For a nonablator, a simple surface energy balance with no mass transfer terms is solved. These stages of the ablation calculations are identified on the typical graphite ablation curve in Fig. 1. The natural logarithm of the material's mass loss parameter (β') is presented as a function of the wall surface temperature. The requirements of a merger routine are to determine the criteria for using ablation or nonablation calculations and oxidation or sublimation ablation calculations. These are illustrated in Fig. 1.

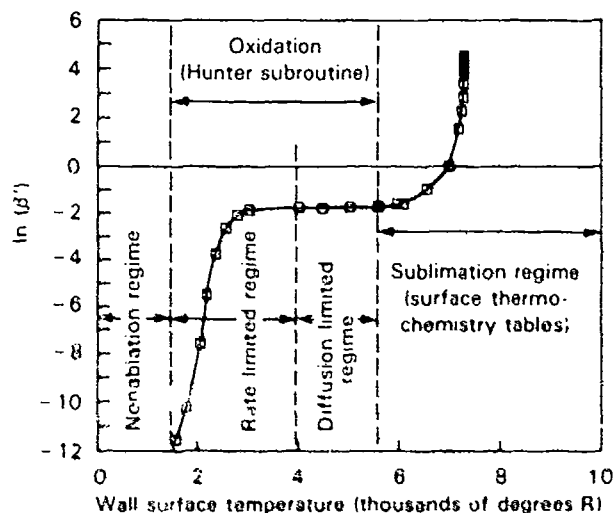


Figure 1 Graphite ablation curve at 1 psi.

Ablation Threshold Temperature

The switch from one to the other of the ablation or nonablation routines is triggered after comparing the surface temperature to a threshold temperature criterion. If the surface temperature is greater than the threshold temperature, then the ablating material routines are used for the surface energy balance; otherwise, the nonablating material routines are used. The previous implementation in CMA used in all cases the lowest temperature value from the ablation part of the surface thermochemistry tables for this criterion, which is inappropriate for the Hunter subroutine. The new implementation refines this process by using a rewritten form of the Hunter algorithm to compute the threshold temperature criterion that yields a negligible value of β' (0.00001). As an option, the user is also allowed to specify a fixed ablation threshold temperature. Implementation of this algorithm is in the partitioned data set 'BBE.CCC1.SOURCE.CMA5.PDS', members INP0UT4, CBM5, and FDTABC. The source code for these can be found in Appendix A.

Merging Hunter Subroutine With Mainstream Ablation Computations

During CMA ablation calculations, the Hunter subroutine or surface thermochemistry tables are used to compute β' and the chemical energy term of the surface energy balance equation, depending on the ablation mechanism. The Hunter subroutine is used for oxidation ablation, and the surface thermochemistry tables for sublimation. A switch from one to the other is based on a comparison of the wall-surface temperature to an "ablation transition temperature" criterion. The Hunter oxidation method is used whenever the material is ablating and the wall-surface temperature is less than the ablation transition temperature; otherwise, the surface thermochemistry tables are used.

The user is given three methods to define the transition temperature criterion for oxidation and sublimation calculations. First, a constant transition temperature may be specified by the user. This is the simplest and, computationally, least expensive implementation. Second, a constant mass loss parameter (β') may be specified by the user. This value of β' is used to interpolate a corresponding wall temperature from the surface thermochemistry tables, which will be used as the transition temperature. This option is slightly more expensive than the first option. Third, a search routine option may be employed. The search routine compares values of β' and its derivative from both the surface thermochemistry table and Hunter subroutine and finds the temperature with smallest differential between these values. This last option is the most expensive.

At the transition temperature, a step in the merged ablation curve may exist because the values of $\ln(\beta')$ computed using the Hunter subroutine and the surface thermochemistry tables do not necessarily agree (Fig. 2). This may prevent convergence of the surface energy balance near the transition temperature. This step is avoided by multiplying the oxidation ablation curve (of β' versus T_w computed

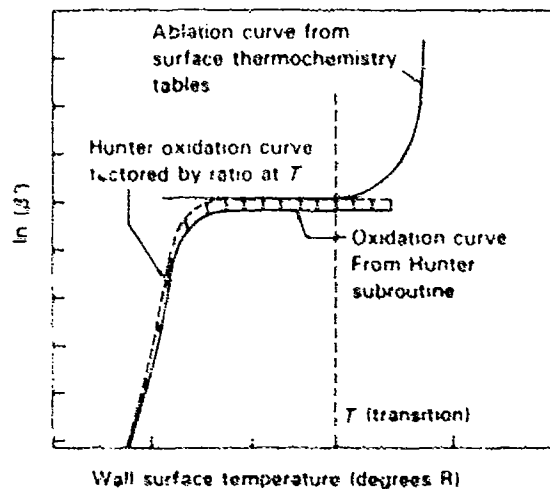


Figure 2 Merged ablation curve in modified CMA using surface thermochemistry tables and Hunter subroutine.

using the Hunter subroutine) by the ratio of the Hunter value and the surface thermochemistry table value at the transition temperature. The magnitude of this merge factor can be minimized by selecting a criterion that puts the transition temperature in the diffusion limited ablation regime.

Implementation of these algorithms is in the partitioned data set 'BBE.CCC1.SOURCE.CMA5.PDS', members INPOUT4, CBMS, MERGER, MERGE1, and MERGE2. The source code listings are in Appendix A.

Economy Feature

An economy feature that was added for use with the Hunter subroutine merger routines allows the user to specify the frequency of iteration steps at which the ablation threshold temperature, the oxidation-to-sublimation transition temperature criterion, and the merge factor are recomputed. For analysis cases using a trajectory with severe transients, the criteria should be recomputed at every iteration step. On the other hand, if the trajectory is long and has mild transients, recomputing every five iteration steps may be sufficient. If the user selects a frequency greater than one iteration per recomputation, a sample problem should be run to verify that the threshold ablation temperature and merge factor do not change drastically between iteration steps. Selecting higher frequencies will of course result in increased computing costs.

Code Validation

Several test problems were run to validate each of these options. Results from these problems were also compared to results from the previous version of the CMA code. The answers were consistent and in good agreement.

Usage

The executable program is stored in the partitioned data set 'BBE.CC1.LOAD.MODULES (CMAV05)' on the mainframe computer. The new features are activated by a new input line at the end of the input file. This line must be present whether the new features are used or not. It follows the existing JTBL input parameter that is used to select the method for computing oxidation (i.e., to use the Hunter subroutine or the EST tables). If the new features are to be bypassed, the new input line should contain zeroes or blanks. A user's guide is provided in Appendix C, and a sample input file listing can be found in Appendix D.

FUTURE EFFORT

Future code improvement efforts will be devoted to amending the Putz and Bartlett mass transfer correlation for blowing effects on convective heating in CMA. They will also address iteration anomalies of the surface energy balance convergence scheme during ablation calculations in the diffusion limited regime.

Putz and Bartlett Blowing Correlation for Graphite

The existing implementation of the Putz and Bartlett blowing correlation for graphite ablation in CMA needs to be replaced with the actual equation from Ref. 4. CMA also needs to be modified to include the ability to calculate ablation when the Putz and Bartlett method predicts a "fully blown" boundary layer (i.e., when there is no convective heating). The following brief guideline is provided for future reference.

1. Install the Putz and Bartlett blowing correlation for range $0 < \beta'_0 < 3$. The equations to be installed are presented in Appendix E. For Eq. (E.7), the molecular weight of gases at the wall (M_w) can be computed using the EST computer code,⁶ and the molecular weight of gases at the edge of the boundary layer (M_e) can be approximated using the tables of gas composition behind a normal shock wave.
2. For the range of $\beta'_0 > 3$ when the boundary layer is fully blown, D. W. Conn suggests* that the code be modified to include algorithms for a surface that is heated solely by shock layer radiation.

Surface Energy Balance Iteration Procedure

During the Galileo-VEEGA reentry analysis, the surface energy balance equation in CMA did not converge in the material's diffusion-limited ablation regime. This is probably caused by the flatness of the ablation curve in this regime. We suggest a slight modification to the iteration scheme in order to achieve convergence.

First, some brief background information on the iteration scheme is needed. The CMA code uses a Newton-Raphson iteration scheme to solve the surface energy balance equation. The following equations summarize this.

$$\beta'_{i+1} = \beta'_i - e / (de/d\beta')$$

or

$$T_{i+1} = T_i - e / (de/dT)$$

where

- β'_i = mass loss parameter at the i th iteration,
- β'_{i+1} = mass loss parameter at the $(i+1)$ th iteration,
- T_i = surface temperature at the i th iteration,
- T_{i+1} = surface temperature at the $(i+1)$ th iteration,
- e = residual from iterating on surface energy balance equation,
- $de/d\beta'$ = derivative of e with respect to β' , and
- de/dT = derivative of e with respect to T .

*K. E. Putz and E. P. Bartlett, "Heat Transfer and Ablation Rate Correlations for Re-entry Heat Shield and Nose-tip Application," AIAA 10th Aerospace Sciences Meeting, San Diego (Jan 17-19, 1972).

*Personal communication with the author.

Iteration terminates when the convergence criterion is satisfied. If convergence has not been satisfied within a given number of iterations, the criterion is doubled. Ultimately, if convergence does not occur within 50 iterations, or if successive iterations yield identical residuals, iteration terminates and the program continues execution using the values computed.

The author suspects that the adjustment term in the Newton-Raphson scheme is overshooting the converged value. Iteration might be improved by employing a relaxation factor (f_r) on the adjustment term:

$$\beta'_{i+1} = \beta'_i - e / (de/d\beta') \cdot f_r ,$$

where

$$0 < f_r < 1.0 .$$

Further investigation of the iteration process during diffusion-limited ablation calculations is needed.

CONCLUSION

Modifications discussed herein have been made to the CMA code that allow the Hunter algorithms to be used when the ablation mechanism is oxidation, and the surface thermochemistry tables to be used when the mechanism is sublimation. This is a dramatic improvement over the existing implementation of this subroutine because it eliminates the need for a restart problem whenever the ablation mechanism changes. These modifications have been installed around the existing code as options, meaning that the previous version of the code can be run by simply not evoking any of the new features.

REFERENCES

- ¹D. W. Conn and C. C. Chan, "Preliminary Galileo-VEEGA Ablation Studies," JHU/APL BFD-2-87-001, EM-5392, March 12, 1987
- ²L. W. Hunter, L. L. Perini, D. W. Conn, and P. T. Brenza, "Calculation of Carbon Ablation on a Re-entry Body During Supersonic/Subsonic Flight," *Journal of Spacecraft Rockets*, Vol. 23, No. 5, Sept.-Oct. 1986.
- ³C. C. Chan, "Catalog of ANSP Data Sets," JHU/APL BBE/EAM-7925, October 6, 1987.
- ⁴"User's Manual: Aerotherm Charring Material Thermal Response and Ablation Program, Version 3," Vol. I, Aerotherm Report No. UM-70-14, April 1970.
- ⁵L. L. Perini, "Review of Graphite Ablation Theory and Experimental Data," JHU/APL ANSP-M-1, December 1971.
- ⁶K. E. Putz and E. P. Bartlett, "Heat Transfer and Ablation Rate Correlations for Re-entry Heat Shield and Nose-tip Application," AIAA 10th Aerospace Sciences Meeting, San Diego (Jan 17-19, 1972).

APPENDIX A
LISTING OF MODIFIED CMA SUBROUTINES

APPENDIX A

Listing of Modified CMA Subroutines

DSNAME = 'BBE.CCC1.SOURCE.CMA6.PDS(ATM)'
 DCB=(RECFM=FB,LRECL=80,BLKSIZE=6160) VOL=SER=D8D080
 01/19/88 019 14:41:11

```

SUBROUTINE ATM(Z1,P1,T1,W1,A1,D1)
C U.S. STANDARD ATMOSPHERE TO 70000 METERS. ATM
C INPUT IS ALTITUDE IN FT (GEOMETRIC). OUTPUT IS, ATM
C P1 PRESSURE (LB/FT**2) ATM
C T1 TEMPERATURE (DEG. RANKINE) ATM
C W1 MOLECULAR WEIGHT (LB/LB-MOLE) ATM
C A1 SPEED OF SOUND (FT/SEC) ATM
C D1 DENSITY (LB-SEC**2)/FT**4
COMMON /ATMOT/ Z(22),TMB(22),R(21), PB(22),C1,C2,C3,
1 C7,C8,ZM,RO,GM,GAM,RST,GO,PO,W0,G01
Z1 = C1*Z1 ATM
DO 1 I = 1, 22 ATM
1 IF (Z1.LT.Z(I)) GO TO 2
I = 23
2 I = I-1
IF (I.EQ.0) I = 1
A1 = RO + Z(I) ATM
A2 = RO + Z1 ATM
A3 = Z(I)**2 - Z1**2 ATM
C WRITE(6,500)I,Z1,Z(I),C1,A1,A2,A3
C 500 FORMAT(' **ATM** I,Z1,Z(I),C1,A1,A2,A3 = ',I3,6E12.5)
IF (I.GE.9) GO TO 50
C ALTITUDE BELOW 90000 METERS ATM
DH = (GM/GO)*((1./A1) - (1./A2)) + C7*A3/(2.*GO) ATM
T1 = TMB(I) + (R(I)*DH/C2) ATM
W1 = W0 ATM
A = GO*W0/RST ATM
DO 11 K = 1,3 ATM
J = -1 + 3*K ATM
11 IF(I.EQ.J) GO TO 12
P1 = PB(I) * ((TMB(I)/(TMB(I) + (R(I)*DH/C2)))**(A/R(I))) ATM
GO TO 200 ATM
12 P1 = PB(I) * EXP(-A*DH/(TMB(I)*C2))
GO TO 200 ATM
C ALTITUDE ABOVE 90000 METERS ATM
50 Z1 = Z1/C2 ATM
IF(Z1.GE.110.0) GO TO 51
W1 = 17.98 + 0.239*Z1 - 0.0013*(Z1**2)
GO TO 53
51 IF (Z1.GT.170.0) GO TO 57
W1 = -.41873644E+02 + .22496378E+01*Z1 - .25825938E-01*(Z1**2)
1 +.12705198E-03*(Z1**3) - .22989608E-06*(Z1**4)
GO TO 53
57 W1 = +.28312068E+02 + .11190901E-01*Z1 - .18061034E-03*(Z1**2)
1 +.31829429E-06*(Z1**3) - .16924926E-09*(Z1**4)
53 Z1 = Z1*C2
TM = TMB(I) + (R(I)*(Z1 - Z(I))/C2)
T1 = (W1/W0)* TM ATM
A4 = -Z(I) + (TMB(I)*C2/R(I)) ATM
A5 = W0*C2/(R(I)*RST) ATM
A6 = Z(I) + A4 ATM
A7 = Z1 + A4 ATM
A8 = RO - A4 ATM
A9 = ((Z(I) - Z1)/(A1*A2)) + (1./A8)*ALOG(A7*A1/(A6*A2)) ATM
A10 = (Z(I) - Z1) + A4*ALOG(A7/A6)
A11 = (-(GM/A8)*A9 - C7*A10)*W0/(R(I)*RST) ATM
P1 = PB(I)*EXP(A11)

```

```
C      WRITE(6,501)W1, TM, T1, P1, G01
C 501  FORMAT(' **ATM** W1, TM, T1, P1, G01 = ', 5E12.5)
C      PRESSURE, TEMPERATURE AND MOLECULAR WEIGHT FOUND.
      Z00 P1 = P0*P1
          Z1 = Z1/C1
          T1 = T1*C3
          A2 = RST*105.86126/W1
          A1 = SQRT (GAM*A2*T1*G0*C8)
          D1 = P1/(A2*T1*G01)
C      WRITE(6,502)P1, Z1, T1, A2, A1, D1
C 502  FORMAT(' **ATM** P1, Z1, T1, A2, A1, D1 = ', 6E12.5)
      RETURN
      END
```

ATM
ATM
ATM
ATM

ATM
ATM

DSNAME = 'BBE.CCC1.SOURCE.CMA5.PDS(CBM5)'
 DCB=(RECFM=FB,LRECL=80,BLKSIZ=6160)

VOL=SER=D8D080
 01/28/88 028 13:10:38

```

SUBROUTINE CBM
C   CHARRING MATERIAL THERMAL RESPONSE AND ABLATION PROGRAM ALLOWING CBM   2
C   FOR UP TO FIVE DECOMPOSING BACK-UP MATERIALS                          CBM   3
C   AEROTHERM CORPORATION      RM KENDALL  C MOYER                          CBM   4
C
C   CHANGES TO PROGRAM:
C   (1/16/87) SIZE OF THH,THE,TQR,TCM,TBRP,TALT,TVEL,TPI
C               EXPANDED TO 120 ELEMENT ARRAYS
C   (1/19/87) SIZE OF ISEN,THSEN,TCPSN,TLMC,ITS,TCHEM,TBPF,
C               TPR,NMG,TIME,NLO,NHI,KHI,ISEN,
C               EXPANDED TO ACCOMMODATE 20 EST TABLES WITH 30
C               ENTRIES EACH
C   (1/29/87) ALL OTHER SUBSCRIPTED VARIABLE DIMENSIONS DOUBLED
C               AS RECOMMENDED BY L.L. PERINI.
C
COMMON KOUT, IEX, DEN, VR                                CBM   5
COMMON TH1(76), ILO(76), IR(76), TT2(60,20), TCP(60,20), TKP(60,20), THZCBM  6
1(60,20), TEP(60,20), THH(120), THE(120), TQR(120), TCM(120), THH(60)  INPOU  4
2, THG(60), DH12(4), RECORD(108), SO(40), RHO(20), TEPBF(60,20)
COMMON MATL(101), DEL(101), TA(101), H(101), RC(101), RA(101),
1AREA(101), EMA(101), RAV(101), LGAP(101), QGEN(101), GAP(101)
COMMON ROA(1000), ROB(1000), ROC(1000)                  CBM   12
COMMON TPR(20), NMG(20),
C   TMG(5,20), NLO(5,20), NHI(5,20), KHI(5,20),
1 TTSEN(30,20), THSEN(30,20), TCPSN(30,20), TLMC(30,5,20), ISEN(20),
2 TPI(120), ITS(30,5,20), TCHEM(30,5,20), VFZ, CMH, TBPF(30,5,20),
3 NPR, NGS
COMMON ICT, NPC, II, NHM, NUMN, NL, DELHG, DELM, RFT, RHORA, RHORB, RHORC, TRACBM  18
1CA, TRACB, TRACC, RHOOA, RHOOB, RHOOC, EA, EB, EC, BA, BB, BC, PSIA, PSIB, PSIC, CBM  19
2TRACM, PETE, PETS, RSV, TTA, DTPR3, DTPR2, DTPRT, TPR3, TPR2, THZRO, THFIN, WT, CBM  20
3TMTW, GAMA, OMG, NO, FJH, FJFS, JF, JFHP, JFH, INPUT, DTHIN, BRP, HCONV, CBM  21
4EPSW, TRES, INCH, DTHB, NN, NI, NOI, CHCRI, PYCRI, TBRP(120), NR,
5 TX(30,6), FI(30,6), FP(30,6), NCON, NBPF, NFIS, BREX, SWELL
COMMON BBB(10,6), FE(10,6), FF(10,6), PSI(10,6), RHOO(10,6), CB
XRHOR(10,6),
1ROCOM(50,3), DHC(10), DHV(10), RHOC(10), RHOV(10), P(10), PP(10),
XTREF(10),
2GA(10), OMGA(10), NLI(10), NLA(10), TT5(60,20), TENT(60,20),
XTKBU(60,20),
3TCBU(30,10), X(101), NDBU, NBM2, TRAC(10,6), NBUFT(10), KNST, IBUG, TBUG,
4 TALT(120), TVEL(120), IRGAP(101), AGAP(101), ICOND, IEROS, ISR,
5 NCC1, NCC2, NCC3, NCC4, ICON1(101), ICON2(101), ICON3(101), ICON4(101),
6 COND1(101), COND2(101), COND3(101), COND4(101),
7 THCONV(101), TEPST(101), TTRES(101), TQ(101), TEPST(101), IBF, TL, THD,
8 JTBL, IDRD, RHOC1(201), DTD(201), RA1, RA2, RA3
COMMON/OTPT/CPE(6), FMO(201), DEP(20,10), CNC(101), CN(101), Y1(4),
1 CNO(101), TO(20), RO(101), NISO(20), BR, CH, GS, SA, TB, TI, ASU, CMD, CMT,
2 ITS, QRP, RAD, RA1(101), RSU, CHDM, CMMT, DCDT, DEDT, DIDD, DPDT, ITER, KSCT,
3 PGPU, PRES, QRP, RADT, SNET, DECOM, DEDT, DSDTB, PGPOT, QCHEM, QCOND,
4 QCONV, QLOSS, SDNET, SUMQI, THPRT, TSAVE, VELFS, DECOMT,
5 PRSATM, QCHEMT, QCOND1, QCONVT, QLOSS, KK, RR(101), DMDC(101),
6 RON(101), ROT(101), DNCP(6), DRO(6), D1(4), FA, FB, FC, DTH, DTHC, DSI,
7 DTA, GSM, COLD, GSMS, GSH, GSM2, DSDT, POLD, TH, AFTFS, DSDTT,
8 TEMP, BF, LL, LU, HL, HW
COMMON/MERGF/VRM, VRP, IMG, IPR, I1, I3
COMMON/OPTION/ICK11, HPCRI1, TABCN, IOPTN, MSG, MITFR, IBL OPT
    
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COMMON/BLOWIN/BLOW,BI OFAC
INTEGER FFLAG,FFLAG1
EQUIVALENCE (DH1,DH12(1)),(DH2,DH12(2)),(TS,TA(1))
DIMENSION VITER(101),EITER(101),EMISF(200),RATG(200),Y2(48),D2(48)
1,Y3(16),D3(16),CPC(101),CPV(101),CP(101),HP(101),HC(101),A(101),
2 B(101),C(101),D(101)
529 FORMAT(17H ITERATION STOP ) CBM 50
542 FORMAT(/33X14H----OUIPUT----) CBM 51
582 FORMAT(6E15.7)
5601 FORMAT(10I5) BUG
5602 FORMAT(7E17.7)
5603 FORMAT(6E17.7)
7043 FORMAT(16,4F10.6)

C CBM 106
C CBM 107
DNC(3)=99999. CBM 108
NMGX=NMG(1)
KSCT=3
SIG=.481E-12 CBM 110
C CHAR AND PYROLYSIS ZONE CRITERIAL DENSITIES CBM 111
DNC(1)=RHO(2)+CHCR1*(RHO(1)-RHO(2)) CBM 112
DNC(2)=RHO(2)+PYCR1*(RHO(1)-RHO(2)) CBM 113
C CBM 114
C INITIAL VALUES FOR TIME LOOP CBM 115
C CBM 116
C ----- INITIAL FACTOR FOR DIKI-TO-TABLES MERGE ROUTINE & BLOWING
FACTOR=-1.0
FFLAG=0
FFLAG1=0
BLOFAC=1.0
C -----
ITER=-1
DTHC=DTHB CBM 118
IAB=0 CBM 119
RSU=ABS(RSV) CBM 127
CMFL=0.0 CBM 129
DSDTM = 0.0
SOEGR=0. CBM 157
GSEGR=0. CBM 158
EGO=0. CBM 161
HW=0. CBM 162
TH=THZRO CBM 165
THDS=THZRO-DTHIN CBM 167
THPRT=TH CBM 168
VRM = 0.0
CMDL = 0.0
IRB = 0
IRD = 0
I2 = 0
I4 = 0
TOLER = 1.0
I1 = 1
DO 4101 I = 1,NUMN
RATG(I) = 0.0
4101 EMISF(I) = 0.0
REWIND KSCT CBM 169
CALL LCOUNT (-2,I CI,NPG)
WRITE (KOUT,542) CBM 171
C ----- TIME INCREMENTI
DTH=DTHIN CBM 173

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C ----- NODE THICKNESS OR MINIMUM ALLOWABLE THICKNESS
  DELCR=AMIN1(DEL(1),D11M)/5.0
C ----- NODAL TEMP. FROM PREVIOUS TIME STEP
  TSAVE=TA(1)+1.0
  FA=(1.-PSIA)*BA*(RHO0A**(1.-PSIA))
  FB=(1.-PSIB)*BB*(RHO0B**(1.-PSIB))
  FC=(1.-PSIC)*BC*(RHO0C**(1.-PSIC))
C ----- EXPONENT TO ADJ. CONVECTION DUE TO ABLATIVE RADIUS CHANGE
  REX = BREX
C
C BEGINNING OF TIME LOOP
C
C NL = LAST ABLATING NODE
C THFIN = TIME AT END OF PROBLEM
C THPRT = OUTPUT TIME
C
  410 IF(NL.GT.1) GO TO 7412
    THFIN = TH
    THPRT = TH
  7412 ITER = ITER + 1
    IF(1BUG.NE.0) WRITE(6,5601) ITER,NL,NDBU,NBM2,NUMN,JFHP ,NCON,
    1 NF IS
C
C CALCULATION OF NODAL PROPERTIES
C
C ISR = 1; NO SURFACE RECESSION OPTION
C ISR = 0; SURFACE RECESSION ALLOWED
C DSI = SURFACE RECESSION DURING TIMESTEP; INITIALIZED
C IN BLOCK COMMON
C
C IF(ISR.NE.0) DSI=0.0
C ----- NODAL LOCATIONS FROM SURFACE
  DO 108 N=2,NL
108  RA(N-1)=RA(N-1)+DSI
    RA(NL)=RA(NL)+DSI/2.
C ----- RR = CROSS-SECTIONAL AREA OF NODE
  CALL OGLE(NL,RA,RR,NUMN,RAV,AREA,EMA)
  ASU=RR(1)
  J=1-JFH-JF
C
C PROCESS ABLATING NODE PROPERTIES
C
C CN(N),CNC(N) = THERMAL CONDUCTIVITY OF PLASTIC AND CHAR
C CPV(N),CPC(N) = SPECIFIC HEAT OF PLASTIC AND CHAR
C HP(N),HC(N) = SENSIBLE ENTHALPY OF PLASTIC AND CHAR
C RO(N),ROT(N) = DENSITY AND TOTAL DENSITY
C X(N) = WEIGHTING FACTOR FOR PARTIALLY PYROLYZED MATERIAL
C RAT(N) = THERMAL RESISTANCE; DL/(K*A)
C GAMA = VOLUME FRACTION
C
  DO 105 N=1,NL
  J=J+JF
  RR(N)=RR(N)/ASU
  CALL LOOK (3,TA(N),112,TCP,TKP,11Z,0,Y2,Y2(4),3)
C ----- VIRGIN PLASTIC MATERIAL
  CN(N)=Y2(2)
  CPV(N)=Y2(1)
  HP(N)=Y2(3)+DH1
  CALL LOOK (4,TA(N),112(1,2),TCP(1,2),TKP(1,2),THZ(1,2),0,Y2,D2,3)
C ----- CHAR MATERIAL

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	CNC(N)=Y2(2)	CBM 201
	CPC(N)=Y2(1)	CBM 202
	HC(N)=Y2(3)+DH2	CBM 203
C	----- SELECT MATERIAL TYPE	
	IF (MATL(N)-1) 103,101,102	CBM 204
C	----- MAIN MATERIAL VIRGIN PLASTIC	
101	X(N)=1.	CBM 205
	CP(N)=CPV(N)	CBM 206
	H(N)=HP(N)	CBM 207
	RO(N)=RHO(1)	CBM 208
	ROT(N)=RHO(1)	CBM 209
	GO TO 105	CBM 210
C	----- MAIN MATERIAL CHAR	
102	X(N)=0.	CBM 211
	CN(N)=Y2(2)	CBM 212
	H(N)=HC(N)	CBM 213
	CP(N)=CPC(N)	CBM 214
	RO(N)=RHOC1(N)	
	ROT(N)=RHOC1(N)	
	GO TO 105	CBM 217
C	----- MAIN MATERIAL PYROLYSIS ZONE	
103	X(N) = RHO(1)*(1.0-RHOC1(N)/RO(N))/(RHO(1)-RHOC1(N))	
	H(N)=X(N)*HP(N)+(1.-X(N))*HC(N)	CBM 219
	CP(N)=X(N)*CPV(N)+(1.-X(N))*CPC(N)	CBM 220
	K = J	
	IF(N.EQ.1) K=1	
C	----- RESIN FILLER DENSITY FROM MATERIAL A, B, C	
	ROT(N)=(ROA(K)+ROB(K))*GAMA+OMG*(ROC(K))	
105	CONTINUE	
	IF (ITER.LE.0)	
	1RAT(NL)=DEL(NL)/(RR(NL)*(CN(NL)*X(NL)+CNC(NL)*(1.0-X(NL)))	
	IF(NDBU.LE.0) GO TO /413	
C		
C	DECOMPOSING BACKUP MATERIAL PROPERTIES	
C		
	DO 740 L=1,NDBU	
	LL=NF1(L)	CBM 231
	LU=NLA(L)	CBM 232
	N=2*L-1	CBM 233
	DO 741 I=LL,LU	CBM 234
	CALL LOOK(20+2*L,1A(I),TT5(1,N),ICBU(1,N),TKBU(1,N),TENT(1,N)	CBM 235
C	, 0,Y2,D2,3)	CBM 236
	CN(I)=Y2(2)	CBM 237
	CPV(I)=Y2(1)	CBM 238
	HP(I)=Y2(3)+DHV(I)	CBM 239
	CALL LOOK(21+2*I, 1A(I), TT5(1,2*L), ICBU(1,2*I), TKBU(1,2*L),	CBM 240
C	TENT(1,2*L), 0,Y2,D2,3)	CBM 241
	CNC(I)=Y2(2)	CBM 242
	CPC(I)=Y2(1)	CBM 243
	HC(I)=Y2(3)+DHC(I)	CBM 244
	H(I)=X(I)*HP(I)+(1.0-X(I))*HC(I)	CBM 245
	RR(I)=AREA(I)/ASU	CBM 246
	IF(ITER.NE.0) GO TO 741	
	RO(I)=X(I)*RHOV(I)+(1.0-X(I))*RHOC(L)	
	RON(I)=RO(I)	CBM 249
	RAT(I)= DEL(I)/(RR(I)*(CN(I)*X(I) + CNC(I)*(1.0 -X(I))))	CBM 250
741	CP(I)=X(I)*CPV(I)+(1.0-X(I))*CPC(I)	CBM 251
740	CONTINUE	CBM 252
7413	IF (NUMN.LT.NBM2) GO TO 112	
	RRGAP(NL) = AGAP(NI)/ASU	

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C
C
C      NON-DECOMPOSING BACKUP MATERIAL PROPERTIES
C
      DO 107 N=NBM2,NUMN
      RR(N)=AREA(N)/ASU
      RRGAP(N) = AGAP(N)/ASU
      KT=MATL(N)
      CALL LOOK(KT+2,TA(N),TT2(1,KT),TCP(1,KT),TKP(1,KT),0,0,Y2,D2,2)
      CP(N)=Y2(1)
      CN(N)=Y2(2)
      ----- THERMAL RESISTANCE
      RAT(N)=DEL(N)/(CN(N)*RR(N))
      RO(N)=RHO(KT)
C
C      GAP RESISTANCES
C
      DO 106 N =NL,NUMN
      RATG(N) = 0.0
      EMISF(N) = 0.0
      KX = NBM2
      IF(N.EQ.NL) GO TO /4/
      KX = N+1
      IF(N.I.T.NBM2) GO TO 106
747 IF(LGAP(N).EQ.0) GO TO 106
      TDUM = (TA(N)+TA(KX))/2.0
      IF (LGAP(N).EQ.1) HA = PIF1(TDUM,TCON1,NGC1,COND1)
      IF (LGAP(N).EQ.2) HA = PIF1(TDUM,TCON2,NGC2,COND2)
      IF (LGAP(N).EQ.3) HA = PIF1(TDUM,TCON3,NGC3,COND3)
      IF (LGAP(N).EQ.4) HA = PIF1(TDUM,TCON4,NGC4,COND4)
C      HELIUM CONDUCTIVITIES P=1ATM
      IF (LGAP(N).EQ.6) HA = 1.0E-6*LXP(5.955-8153.0/(2454.0+TDUM))
      IF (LGAP(N).EQ.7) HA = 0.0
      IF (LGAP(N).NE.5) GO TO 746
C      YOS - P = 1 ATM
      IF(TDUM.GT.3000.0) HA = 1.0E-6*
      1 EXP(10.116-103176.0/(10941.0+TDUM))
C      NBS - P = 1 ATM
      IF(TDUM.LE.3000.0)
      2 HA=3.167E-7*
      SQR(TDUM)/(1.0+441.7*(10.0**(-21.6/TDUM))/TDUM)
746 KT = MATL(N)
      CALL LOOK(KT+2,TDUM,TT2(1,KT),TEPBF(1,KT),0,0,0,Y2,D2,1)
      EM1 = Y2(1)
      KT = MATL(N+1)
      CALL LOOK(KT+2,TDUM,TT2(1,KT),TEP(1,KT),0,0,0,Y2,D2,1)
      EM2 = Y2(1)
      FE = 1.0/(1.0/EM1 + 1.0/EM2 - 1.0)
      RATG(N) = HA*RRGAP(N)/GAP(N)
      EMISF(N) = 1.0/STG/FE/RRGAP(N)
      IF(1BUG.NE.0) WRITE(6,5602) (M1,M2,HA,FE,RR(N),GAP(N),TDUM,
      1 RRGAP(N),AGAP(N)
106 CONTINUE
C
C      BACK WALL HEAT TRANSFER USING TIME TABLES - LIP,SEPT,1975.
C
C      TH = CURRENT TIME
C      TQ = TABLE TIME VALUES
C      INCONV = B.W. CONVECTION COEFFICIENT
C      TEPSPW = B.W. EMISSIVITY TO SPACE
C      TEPSPD = B.W. EMISSIVITY TO RESERVOIR

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CBM 255
 CBM 256
 CBM 257
 CBM 258
 CBM 259
 CBM 260
 CBM 261

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C      TRES = RESERVOIR TEMPERATURE
C      HRES = TOTAL HEAT TRANSFER COEFFICIENT AT BACKWALL
C      DEL = NODE THICKNESS
C      QLOSS = B.W. HEAT FLUX
C      QLOSST = TIME INTEGRATED B.W. HEAT FLUX
C      CMT = AMOUNT OF CHAR ABLATION
C      CMMT = TIME INTEGRATED CHAR ABLATION
C      DTH = TIME INCREMENT
C      DTS = CHANGE IN SURFACE TEMPERATURE
C
112  EPSW = PIF1(TH,TQ,IBF,TEPSW )
      EPSD = PIF1(TH,TQ,IBF,TEPSD)
      TRES = PIF1(TH,TQ,IBF,TTRES )
      HCONV= PIF1(TH,TQ,IBF,THCONV)
      HRES=SIG*EPSW*(TA(NUMN)+TRES)*(TA(NUMN)**2+TRES**2)+HCONV
1    +SIG*EPSD*TA(NUMN)**4/(TA(NUMN)-TRES)
      RAT(NUMN+1)=2./(HRES*RR(NUMN)+.00000001)
      QLOSS = 0.0
      IF (HRES.NE.0.0)
1    QLOSS=(TA(NL)-TA(NBM))/(0.5*(RAT(NL)+RAT(NBM))+RC(NL)/RR(NL))
      QLOSST=QLOSST+QLOSS*DTH/AREA(1)*ASU
      CMT=CMT+RHO(2)*DSDTB*ASU/AREA(1)*DTH
      CMMT = CMMT + RHO(2)*DSDTM*ASU/AREA(1)*DTH
      DEL(NUMN + 1) = CN(NUMN)/(HRES + 0.00000001)
      RR(NUMN+1)=RR(NUMN)
      DTSH=DTH
      DTS=TSAVE-TA(1)
      IF (IBUG.NE.0) WRITE (6,5602) (RAT(1),RO(1) ,RATG(1),
1    EMISF(1),CP(1),CN(1),TA(1),I=1,NUMN)
      IF (ITER.EQ.0) GO TO 606
C
C      OUTPUT
C
C      JJJ = 1; MEANS LAST ITERATION COMPLETED
C
      IF (TH-THPRT.LT.-0.00001) GO TO 4410
3000 JJJ=0
      CALL OUTPT(JJJ)
      IF (JJJ.EQ.1) GO TO 1
C
4410 ----- COMPUTE TIME STEP (DTH) & CURRENT TIME (TH)
      DTH=AMIN1(DTHB,DELCHK/(DSDTB+.00000001),TH-THDS, 50.0/(ABS(TSAVE-TA(CBM
1    11))+.1)*DTH)
      TSAVE=TA(1)
      DTH=(THPRT-TH)/(AINT((THPRT-TH)/DTH+1.0001))
      TH=TH+DTH
      IF (TH.GT.TBUG) IBUG=1
C
----- FUNCTIONS OF TIME
606  I=IR(1)
      VF=VFZ
      IF (TTH(I+1).GE.TH-0.00001) GO TO 604
      IF (I+1.GE.IHI(1)) GO TO 604
      I=I+1
      IF (TTH(I+1).NE.TTH(I)) GO TO 601
      TH=TH-DTH
      THDS=TTH(I)-DTHIN
      DTH=AMAX1(DTHIN,IHI(I)-TH)
      TH=TH+DTH
      GO TO 601
C

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C      TIME DEPENDENT VALUES FROM TABLE
C
C      DEN = INTERPOLATION RATIO
C      CH = HEAT TRANSFER COEFFICIENT (RUCH);
C      QRA = RADIATION FLUX TO SURFACE (OPTION 1 & 3) OR
C            RECESSON (OPTION 2)
C      PRES = NATURAL LOGARITHM OF PRESSURE
C      HE = RECOVERY ENTHALPY
C      BRP = BLOWING REDUCTION PARAMETER, LAMBDA
C      VELFS = VELOCITY
C      AFTFS = ALTITUDE
C
604 DEN=(TH-TTH(1))/(TTH(1+1)-TTH(1)) CBM 452
    IF (TTH(1+1).LE.TTH(1)) DEN=0.0
    CH=TCM(1)+DEN*(TCM(1+1)-TCM(1))
    QRA=TQR(1)+DEN*(TQR(1+1)-TQR(1)) CBM 456
    PRES=TPI(1)+DEN*(TPI(1+1)-TPI(1)) CBM 457
    HE=THE(1)+DEN*(THE(1+1)-THE(1)) CBM 458
    BRP=TBRP(1)+DEN*(TBRP(1+1)-TBRP(1)) CBM 459
    VELFS = TVEL(1) + DEN*(TVEL(1+1)-TVEL(1))
    AFTFS = TALT(1) + DEN*(TALT(1+1)-TALT(1))
C      ----- SELECT PROBLEM OPTION (1,2 OR 3)
    IF (IBUG.NE.0) WRITE(6,5602) TH,CH,QRA,PRES,HE,BRP,ASU,VELFS,AFTFS
    I1=1 CBM 460
    IF (CH.GT.0.0) GO TO 600
    I1=2
    CH=0.0 CBM 463
    IF (HE.GT.2.0) GO TO 600
    I1=3
    VF=HE CBM 466
    HE=0. CBM 467
600 IR(1)=1 CBM 468
    IF (ITER.NE.0) GO TO 610
    DEOT=0.
    ITER=1 CBM 471
    GO TO 3000 CBM 472
C
C      DECOMPOSITION (PYROLYSIS OR CHARRING)
C
610 IF (DTH.ST.0.000001) GO TO 608
    WRITE (KOUT,582) TH,DTH,DTHS,DTHB,THDS,DTS,DELGR,DSDTB
    TH=THFIN CBM 475
    GO TO 3000 CBM 476
C      CBM 477
608 CALL DECOMP
C      CBM 711
C      CALCULATION OF IMPLICIT TEMPERATURE COEFFICIENTS FOR IN-DEPTH
C      ENERGY EQUATION MATRIX AND INTERNAL ENERGY RATE TERMS
C      CBM 712
C      CBM 713
C      CBM 714
C
C      IMIN = INTEGER ZERO
C      NLN = NL - 1
C      NL = LAST ABLATOR NODE
C      GSM = ACCUMULATED PYROLYSIS GAS FLOW RATE ENTERING A NODE
C      DMDG = ACCUMULATED PYROLYSIS GAS GENERATION IN A NODE PER UNIT
C            AREA AND TIMES NO. OF NODELETS PER NODE, FINALLY ADJUSTED
C            TO AMOUNT OF PYROLYSIS GAS GENERATION IN A NODE.
C      DROOTD = TOTAL RATE OF CHANGE OF DENSITY AT CONSTANT Y FOR
C            CURRENT NODE
C      DSDT = SURFACE RECESSON

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C   RR = NORMALIZED CROSS-SECTIONAL AREA OF NODE
C   DEL = NODE THICKNESS
C   DVB = CONDUCTIVITY PARAMETER
C   X1 = WEIGHTING VARIABLE
C   PETE = DENSITY TERM
C   PET = DENSITY FACTOR
C   RAT = CONDUCTION RESISTENCE, DI/KA
C   CP1 = SPECIFIC HEAT AT TOP NODE
C   CP = SPECIFIC HEAT AT A NODE
C   CPGAS = SPECIFIC HEAT OF PYROLYSIS GAS
C   H1 = ENTHALPY AT TOP NODELET IN A NODE
C   HBAR = TEMP. DEPENDENT REACTION ENTHALPY
C   HGAS = ENTHALPY OF PYROLYSIS GAS
C   GSEGR = ENERGY TERM, SUM OF HGAS*DMDG OVER NODES
C   SOEGR = TERM HGAS*DMDG, SUMMED OVER ALL NODES
C   EGO = ENERGY LEAVING SURFACE WITH PYROLYSIS GAS
C   HW = ENTHALPY OF EDGE GASES AT WALL TEMPERATURE (OPTION 1)
C       OR ENTHALPY OF PYROLYSIS GASES AT WALL TEMP (OPTION 3)
C   ROT = DENSITY OF TOP NODELET IN A GIVEN NODE
C   RC = CONTACT RESISTENCE BETWEEN NODE AND NEXT NODE DOWN
C   RON = NEW DENSITY OF A NODE
C   RO = OLD DENSITY OF A NODE
C
DVB=0.                                CBM 715
SOEGR=0.                              CBM 716
GSEGR=0.                              CBM 717
TB=0.                                  CBM 718
RAT(.)=2.*RAT(1)                      CBM 719
CPNL=C*(NL)                            CBM 720
NLM=NL-1                                CBM 721
IMIN=0                                  CBM 722
DSXX = DSDT
IF (ISR.NE.0) DSDT = 0.0
C ----- ABLATING NODE COEFFICIENTS EXCEPT LAST NODE
DO 30 I=IMIN,NLM                        CBM 723
IF (I.LE.0) GO TO 15
GSM=GSM-DMDG(I)
DRODTD=-DMDG(I)/(RR(I)*DEL(I))         CBM 726
FACT1=DTH/(DEL(I)*RR(I))              CBM 727
FACT2=GSM/(DEL(I)*RR(I))              CBM 728
A(I)=-FACT1*DVB                        CBM 729
DVB=1.0/(0.5*(RAT(I)+RAT(I+1))+RC(I)/RR(I)) CBM 730
TERM2=RON(I)*CP(I)-DTH*(CPGAS*(DRODTD-FACT2)
1   -DSDT*RO1*CP1/DEL(I))             CBM 731
TERM1=FACT1*DVB                        CBM 732
B(I)=TERM2-A(I)+TERM1                  CBM 733
C(I)=-TERM1                            CBM 734
D(I)=TA(I)*TERM2+(HGAS*DRODTD-HBAR*(RON(I)
1   -RO(I))/DTH-FACT2*HGAS-DSDT*RO1*H1/DEL(I))*DTH CBM 736
15 RO1=ROT(I+1)                        CBM 737
PETE=0.0                                CBM 738
ZZZ=RHO(I)-RHOC(I(I+1))
IF (ZZZ.NE.0.0) PETE=RHO(I)/ZZZ
PET = PETE*RHOC(I(I+1))
X1=PETE-PET/RO1                        CBM 739
CP1=CPV(I+1)*X1+CP(I+1)*(1.0-X1)     CBM 740
H1=HP(I+1)*X1+HC(I+1)*(1.0-X1)       CBM 741
CP(I+1)=CPV(I+1)*X(I+1)+CP(I+1)*(1.0-X(I+1)) CBM 742
TN=-RO1*HBAR+RO1*H1+1                 CBM 743
HBAR=PCTE*HP(I+1)-PLI/RHO(I)*HC(I+1)  CBM 744

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T=-R01*H1+R01*HBAR
CALL LOOK (2,TA(1+1),111,THG,0,0,0,HGAS,CPGAS,1)
HGAS=HGAS+DELHG
GSEGR=GSEGR+HGAS*DMDG(1+1)
SOEGR=SOEGR+HBAR*DMDG(1+1)
IF(1.GT.0) GO TO 25
EGO=GSMS*HGAS
HW=HGAS
GO TO 30
25 TERM3=(-FACT2*CPGAS-DSDT*R01*CP1/DEL(1))*DTH
C(1)=C(1)+TERM3
D(1)=D(1)+TA(1+1)*TERM3+(FACT2*HGAS+DSDT*R01*H1/DEL(1))*DTH
TB=TB-TN*DSDT*RR(1)
30 CONTINUE
A(1)=DTH/DEL(1)
TI=TT+TB*DTH/AR1A(1)*ASU
----- NOW THE LAST ABLATING NODE REQUIRES DIFFERENT TREATMENT
DRODTD=-DMDG(NL)/(RR(NL)*DEL(NL))
FACT1=DTH/(DEL(NL)*RR(NL))
A(NL)=-FACT1*DVB
IF(LGAP(NL).NE.0)
1 DVB = RATG(NL) + 4.0*TA(NBM)**3/EMISF(NL)
IF(LGAP(NL).EQ.0) DVB = 2.0/(RAT(NL)+RAT(NBM))
C(NL)=-FACT1*DVB
TERM2=RON(NL)*CP(NL)-(CPGAS*DRODTD+(DSDT/DEL(NL))*
1 (RO(NL)*CPNL -R01*CP1))*DTH
B(NL) = TERM2 - A(NL)
IF(LGAP(NL).EQ.0) B(NL) = B(NL) - C(NL)
IF(LGAP(NL).NE.0) B(NL) = B(NL) + FACT1*(RATG(NL)
1 + 4.0*TA(NL)**3/EMISF(NL))
D(NL)=TA(NL)*TERM2+DTH*(HGAS*DRODTD-HBAR*(RON(NL)-
1 RO(NL))/DTH+DSDT*(RO(NL)*H(NL)-R01*H1)/DEL(NL))
2 + QGEN(NL)*DTH
IF(LGAP(NL).NE.0) D(NL)=D(NL)+3.0*FACT1*(TA(NL)**4-TA(NBM)**4)
1 /EMISF(NL)
K = NL
GSM=GSM-DMDG(NL)
IF(NDBU.EQ.0) GO TO 7171
FACT2=GSM/(DEL(NL)*RR(NL))
TERM2=FACT2*CPGAS*DTH
B(NL)=B(NL)+TERM2
D(NL)=D(NL)+TA(NL)*TERM2-FACT2*HGAS*DTH
CALL LOOK(2,TA(NBM),111,THG,0,0,0,HGAS,CPGAS,1)
HGAS=HGAS+DELHG
C(NL)=C(NL)-FACT2*CPGAS*DTH
D(NL)=D(NL)-TA(NBM)*FACT2*CPGAS*DTH+FACT2*HGAS*DTH
7171 CONTINUE
----- NOW FOR DECOMPOSING BACK-UPS IF ANY
IF(NDBU.LE.0) GO TO 720
DO 720 I=1,NDBU
LL=NF1(L)-1
LU=NL A(L)
DO 724 I=LL,IU
IF(1-NF1(L).EQ.-1) GO TO 726
GSM=GSM-DMDG(I)
DVBS=DVB
K=K+1
DRODTD=-DMDG(I)/(RR(I)*DEL(I))
FACT1=DTH/(DEL(I)*RR(I))
FACT2=GSM/(DEL(I)*RR(I))

```

CBM 745
 CBM 747
 CBM 748
 CBM 749
 CBM 752
 CBM 753
 CBM 754
 CBM 755
 CBM 756
 CBM 757
 CBM 758
 CBM 759
 CBM 760
 CBM 761
 CBM 762
 CBM 763
 CBM 766
 CBM 767
 CBM 768
 CBM 770
 CBM 771
 CBM 772
 CBM 773
 CBM 776
 CBM 777
 CBM 778
 CBM 779
 CBM 780
 CBM 781
 CBM 782
 CBM 783
 CBM 784
 CBM 787
 CBM 788
 CBM 789
 CBM 792
 CBM 793
 CBM 794
 CBM 795
 CBM 796

```

A(K)=-FACT1*DVB
DVB=1.0/(0.5*(RAI(1)+RAT(1+1))+RC(1)/RR(1))
TERM2=RON(1)*CP(1)-DIH*(CPGAS*(DRODID-FACT2))
TERM1=FACT1*DVB
B(K)=TERM2-A(K)+IRKM1
C(K)=-TERM1
D(K)=TA(1)*TERM2+(HGAS*DRODID-HBAR*(RON(1)-RO(1))/DTH
C -FACT2*HGAS)*DIH
IF(1-NLA(NDBU)) 726,727,727
726 CP(1+1)=CPV(1+1)*X(1+1)+CPC(1+1)*(1.0-X(1+1))
HBAR=HBAR
HBAR=P(L)*HP(1+1)-PP(L)/RHOV(L)*HC(1+1)
CALL LOOK(2,TA(1+1),TT1,THG,0,0,0,HGAS,CPGAS,1)
HGAS=HGAS+DELHG
IF(1-NF1(L)+1) 7241,7241,727
727 TERM3=(-FACT2*CPGAS)*DTH
C(K)=C(K)+TERM3
D(K)=D(K)+TA(1+1)*TERM3+FACT2*HGAS*DTH
7241 CONTINUE
720 CONTINUE
C ----- NOW FOR BACK UPS IF ANY
7250 IF(NUMN.LT.NBM2) GO TO 60
DO 50 I=NBM2,NUMN
K=K+1
FACT1=DTH/(DEL(1)*RR(1))
D(K)=TA(1)*RO(1)*CP(1)+QGEN(1)*DTH
IF(LGAP(1).EQ.0) GO TO 41
L1=I-1
IF(L.EQ.NBM2) L1=NL
IF(LGAP(L1).EQ.0) GO TO 42
A(K)=-FACT1*(4.0*TA(L1)**3/EMISF(L1)+RATG(L1))
C(K)=-FACT1*(4.0*TA(1+1)**3/EMISF(1)+RATG(1))
B(K)=RO(1)*CP(1)+FACT1*(RATG(1)+RATG(L1)+
1 4.0*TA(1)**3*(1.0/EMISF(1)+1.0/EMISF(L1)))
D(K)=D(K)+3.0*FACT1*((TA(1)**4-TA(L1)**4)/EMISF(L1)
1 +(TA(1)**4-TA(1+1)**4)/EMISF(1))
GO TO 43
41 L1=I-1
IF(L.EQ.NBM2) L1=NL
IF(LGAP(L1).EQ.0) GO TO 44
A(K)=-FACT1*(RATG(L1)+4.0*TA(L1)**3/EMISF(L1))
C(K)=-FACT1*2.0/(RAI(1)+RAT(1+1))
B(K)=RO(1)*CP(1)-C(K)+FACT1*(RATG(L1)
1 +4.0*TA(1)**3/EMISF(L1))
D(K)=D(K)+3.0*FACT1*(TA(1)**4-TA(L1)**4)/EMISF(L1)
GO TO 43
44 A(K)=-FACT1*DVB
DVB=2.0/(RAT(1)+RAI(1+1))
C(K)=-FACT1*DVB
B(K)=RO(1)*CP(1)-C(K)-A(K)
GO TO 50
42 A(K)=-FACT1*DVB
C(K)=-FACT1*(RATG(1)+4.0*TA(1+1)**3/EMISF(1))
B(K)=RO(1)*CP(1)-A(K)+FACT1*(RATG(1)+4.0*TA(1)**3/EMISF(1))
D(K)=D(K)+3.0*FACT1*(TA(1)**4-TA(1+1)**4)/EMISF(1)
43 DVB=2.0/(RAT(1)+RAI(1+1))
50 CONTINUE
C
C ----- NOW IF THE LAST NODE WAS INSULATED WE MUST
C REPAIR CASE B AND C

```

CBM 797
 CBM 798
 CBM 799
 CBM 800
 CBM 801
 CBM 802
 CBM 803
 CBM 804
 CBM 805
 CBM 806
 CBM 807
 CBM 808
 CBM 809
 CBM 810
 CBM 812
 CBM 813
 CBM 814
 CBM 822
 CBM 823
 CBM 824
 CBM 827
 CBM 828
 CBM 831
 CBM 832
 CBM 834

```

C      60 IF (IBUG.NE.0) WRITE(6,5603) (A(I),B(I),C(I),D(I),RR(I),DEL(I),      BUG
      1  I=1,NUMN)
      1  IF (IBUG.NE.0) WRITE(6,5603) (QGEN(I), I=1,NUMN)
      1  IF (HRES.NE.0.0) GO TO 80
      1  B(K)=B(K)+C(K)
      1  C(K)=0.
C      ----- NOW BEFORE GAUSS REDUCTION REWRITE LAST LINE OF MATRIX
      80 D(K)=D(K)-C(K)*TRES
      1  L=K
      1  DO 90 I=2,K
      1  L=L-1
      1  D(L)=D(L)-C(L)/B(L+1)*D(L+1)
      90  B(L)=B(L)-C(L)/B(L+1)*A(L+1)
      1  B(1)=B(1)/A(1)
      1  D(1)=D(1)/A(1)
      1  IF (IBUG.NE.0) WRITE(6,5603) (A(I),B(I),C(I),D(I),RR(I),DEL(I),
      1  I=1,NUMN)
      1  PGPU=EGO-GSEGR
      1  PGPOT=PGPUT+PGPU*DTH/AREA(1)*ASU
      1  DECOM=GSEGR-SOEGR
      1  DECOMT=DECOMT+DECOM*DTH/AREA(1)*ASU
      1  IF (ISR.NE.0) DSDT = DSXX
C      SURFACE BOUNDARY CONDITION PACKAGE
C      CHZ=CH
C      XP1=X(1)
C      ITL=10
C      !TS=1
C      SNET=(1.+SWELL.)*SA-SWELL*CPE(1)
C      IF (I1-2) 2502,1420,2501
      1420 DSDTB=QRA/12000.0
      1  TA(1)=HE
      1  HE=0.
      1  HW=0.0
      1  BR=0.0
      1  CMD=DSDTB*((ROA(1)+ROB(1))*GAMA+ROC(1)*OMG)
      1  RAD=0.
      1  QRA=0.
      1  QCHEM=0.
      1  QCONV=0.
      1  GO TO 1437
      2501 TABC=90000.0
      1  DSDTB=0.
      1  ERFX=D(1)
      1  QCHEM=0.
      1  QCONV=0.
      1  GO TO 2503
      2502 IF (NR.LE.0) GO TO 1424
C      ----- RADIUS CHANGE CORRECTION TO HEATING COEFFICIENT
      1  CH=CH/((1.+SNET/ABS(RSV))*REX)
      1  CHZ=CH
C      1424 BF (CMD-CMFL)/(CH+1.0E-15)
C      ----- FISSURE MODEL
      1  IF (NF'S.EQ.1) BF = III + GS/(CH+1.0E-15)
      1  PH1=2.*BRP*BF
C      ----- BLOWING CORRECTION TO HEATING RATE
      1  IF (BPP.LT.0.0) GO TO 1421
    
```

```

    IF (PHI.GT.0.01) GO TO 1423
    CH=CH*(1.-.5*PHI)
    GO TO 1426
1423 IF (PHI.LT.150.0) CH=CH/(EXP(PHI)-1.0)*PHI
    IF (PHI.GE.150.0) CH=0.05*CH
    GO TO 1426
C ----- PUTZ AND BARTLETTE CORRELATION
1421 IF (BF.LT.0.00001) BF=0.00001
    IF (BF.GT.187.0) PHI=149.0
    IF (BF.LT.187.0) PHI=1.35*BF*EXP(0.14*(BF**1.333))
    IF (PHI.GT.0.01) GO TO 1422
    CH = CH*(1.0-0.5*PHI)
    GO TO 1426
1422 IF (PHI.LT.150.0) CH=CH/(EXP(PHI)-1.0)*PHI
    IF (PHI.GE.150.0) CH=0.05*CH
1426 IF (IBUG.NE.0) WRITE(6,7043) I1ER,TH,CH,BF,PHI
    IF (NF1S.EQ.2) GO TO 14261
    TEMP9 = AMAX1(TMG(1,1),TMG(NMGX,1))
    IF (TEMP9.NE.0.0) CH = AMAX1(CH,GS/TEMP9)
14261 CONTINUE
    IF (IBUG.NE.0) WRITE(6,5602) RSV,PHI,AREA(1),TMG(1,1)
    ERFX=CH*HE+D(1)
    IBOT=+1
    IMG = 1
    IF (NGS.LE.1) GO TO 2511
C ----- INTERPOLATION FRACTION, VMR, USING GAS FLOW
    CALL LOOK (12,GS/(CH*CMH+1.0E-15),TMG,0,0,0,0,Y2,D2,0)
    IMG=IR(12)
    VRM=VR
C ----- INTERPOLATION FRACTION, VRP, USING LN PRESSURE
2511 CALL LOOK (13,PRES,TPR,0,0,0,0,Y2,D2,0)
    IPR=IR(13)
C
C ----- (CCC COMMENT ON 12/87)
C   IHI(14),ILO(14) = HIGH AND LOW ENTRIES IN ABLATION PART OF EST
C                       AT PRESSURE TABLE NUMBER IPR
C                       NHI(IMG,IPR),NLO(IMG,IPR)
C
C   IHI(16),ILO(16) = HIGH AND LOW ENTRIES IN ABLATION PART OF EST
C                       AT PRESSURE TABLE NUMBER IPR+1
C                       NHI(IMG,IPR+1),NLO(IMG,IPR+1)
C
    ILO(16)=NLO(IMG,IPR+1)
    IHI(16)=NHI(IMG,IPR+1)
    ILO(14)=NLO(IMG,IPR)
    IHI(14)=NHI(IMG,IPR)
    VRP=VR
C
    I3=ILO(16)
    I1=ILO(14)
    IF (NGS.LE.1) GO TO 2512
    ILO(17)=NLO(IMG+1,IPR+1)
    IHI(17)=NHI(IMG+1,IPR+1)
    ILO(15)=NLO(IMG+1,IPR)
    IHI(15)=NHI(IMG+1,IPR)
    I4=ILO(17)
    I2=ILO(15)
    IF (IHI(17).LE.I4) GO TO 420
    IF (IHI(15).LE.I2) GO TO 420
2512 IF (IHI(14).LE.I1) GO TO 420
  
```

CBM 888

CBM 892
 BUG
 CBM 893

CBM 895
 CBM 896

CBM 899
 CBM 900

CBM 901
 CBM 902

CBM 909
 CBM 905

CBM 906
 CBM 912

CBM 903
 CBM 904
 CBM 910
 CBM 911
 CBM 907
 CBM 913

IF (IHI(16).LE.13) GO TO 420

```

C ----- COMPUTE NON-ABLATOR TEMPERATURE
C IF (JTBL.LT.0.OR.IOPTN.EQ.0) GO TO 2515
  IF (TABCN.LE.0.0) GO TO 2513
  TABC = TABCN
  GO TO 2503
C ----- SEARCH FOR TABC
2513 IF (MITER.NE.1.AND.MOD(ITER,MITER).NE.1) GO TO 2503
  CALL FDTABC(TABC)
  IF (IMSG.GE.1) WRITE(6,2514)ITER,TABC
2514 FORMAT(' ***** FDIABC SEARCH - ITER., NON-ABLAT. TEMP. = '
  1 ,15,F12.5)
  GO TO 2503
    
```

```

C
2515 TABC = TTS(11,IMG,IPR)+VRP*(TTS(13,IMG,IPR+1)-TTS(11,IMG,IPR))
  IF (NGS.LE.1) GO TO 2503
  TABC = TABC+VRM*(TTS(12,IMG+1,IPR)-TTS(11,IMG,IPR))
  1 +VRP*(VR*(TTS(14,IMG+1,IPR+1)-TTS(13,IMG,IPR+1)))
  2 -VRM*(TTS(12,IMG+1,IPR)-TTS(11,IMG,IPR))
2503 IF (IBUG.NE.0) WRITE(6,5601) I1,I2,I3,I4,IMG,IPR,NGS,NR,ITER
    
```

C IF (TSAVE.LE.TABC) GO TO 420

C ----- ABLATING SURFACE

CBM 924

```

C IF (IAB.GT.0) GO TO 423
  CMDL=TLMC(11,IMG,IPR)-VRP*(TLMC(11,IMG,IPR)-TLMC(13,IMG,IPR+1))
  CMD=EXP(CMDL)*CH
  IAB=1
    
```

CBM 927
 CBM 928

423 JD=0

```

C ----- BYPASS DIKI-TO-TABLES TRANSITION OF IOPTN = 0
  IF (IOPTN.LE.0) GO TO 509
  IF (FACTOR.EQ.-1.0.AND.TSAVE.GT.TABC) GO TO 505
  IF (MOD(ITER,MITER).NE.1) GO TO 508
C ----- SET TRANSITION TEMP. IF IOPTN '1' USED
505 IF (FFLAG1.EQ.ITER) GO TO 508
  IF (IOPTN.EQ.1) XTEMP=TCRIT
C ----- MERGE2 CALLS XTEMP FROM TABLES BASED ON GIVEN BPRIME.
  IF (IOPTN.EQ.2) CALL MERGE2(XTEMP)
C ----- MERGE3 SEARCH FOR TEMP. WITH SMALLEST DIFFERENCE IN SLOPES
  IF (IOPTN.GE.3) CALL MERGE3(XTEMP)
  FFLAG1=ITER
508 IF (TSAVE.GT.XTEMP) GO TO 510
    
```

C 509 IF (JTBL.GE.0) GO TO 4260

C ----- INTERPOLATE LOG B PRIMES

510 FACTOR=-1.0

```

  CALL LOOK(14,CMDL,TLMC(1,IMG,IPR),TTS(1,IMG,IPR),TCHEM(1,IMG,IPR),CBM 929
  1,TBPF(1,IMG,IPR),0,Y2(1),Y2(4),3) CBM 930
  IRA=IR(14) CBM 931
  CALL LOOK(16,CMDL,TLMC(1,IMG,IPR+1),TTS(1,IMG,IPR+1),TCHEM(1,IMG,IPR+1),CBM 937
  1,IPR+1),TBPF(1,IMG,IPR+1),0,Y2(13),Y2(16),3) CBM 938
  IRC=IR(16)
  ITOP = 6
  IF (NGS.LE.1) GO TO 4233
  ITOP = 12
  CALL LOOK(15,CMDL,TLMC(1,IMG+1,IPR),TTS(1,IMG+1,IPR),TCHEM(1,IMG+1,IPR),CBM 932
  1,IPR),TBPF(1,IMG+1,IPR),0,Y2(7),Y2(10),3) CBM 933
  IRB=IR(15) CBM 934
    
```

```

CALL LOOK(17,CMDL,IMG(1,IMG+1,IPR+1),TTS(1,IMG+1,IPR+1),TCHEM(1,ICBM 939
IMG+1,IPR+1),TBPFL(1,IMG+1,IPR+1),0,Y2(19),Y2(22),3) CBM 940
IRD=IR(17) CBM 941
4233 IF(IBUG.NE.0) WRITE(6,5601) IAB,IRA,IRC,IRB,IRD,IMG,IPR,NGS BUG
IF(IBUG.NE.0) WRITE(6,5602) VRP,VRM,CMDL,(Y2(1),1=1,24) BUG
C ----- INTERPOLATE ON LOG PRESSURE
DO 4232 I=1,ITOP
4232 Y2(I)=Y2(I)+VRP*(Y2(I+12)-Y2(I)) CBM 943
IF(NBPF.LE.1) GO TO 4237
IF(VRP.LE.1.0) GO TO 4234
Y2(3)=Y2(15)
IF(NGS.LE.1) GO TO 4231
Y2(9)=Y2(21) CBM 947
GO TO 4237 CBM 948
4234 IF(VRP.GE.0.0) GO TO 4237
Y2(3)=(Y2(3)-Y2(15)*VRP)/(1.-VRP)
IF(NGS.LE.1) GO TO 4231
Y2(9)=(Y2(9)-Y2(21)*VRP)/(1.-VRP) CBM 951
4237 IF(NGS.LE.1) GO TO 4231
DO 426 I=1,6
426 Y2(I)=Y2(I)+VRM*(Y2(I+6)-Y2(I)) CBM 954
4231 IF(Y2(1).GT.0.0) GO TO 4261
ITL=ITS
GO TO 4356 CBM 957

C
4260 CONTINUE
C --- IF IBOT=+1, DIKI RETURNS Y2(4)=-1.0 ONLY
CALL DIKI(PRES,CMDL,CH,Y2,TL,BPLH,IBOT,JTBL)
C --- FFLAG = ITERATION AT WHICH FACTOR IS FIRST COMPUTED (OR UPDATED)
C IF(IMG.EQ.2) WRITE(6,1510) ITER,MITER,FFLAG,FACTOR,IOPTN
C1510 FORMAT(' ***** ITER,MITER,FFLAG,FACTOR,IOPTN, = ',
C 1,/,10X,315,F10.5,15)
IF(IOPTN.LE.0) GO TO 405
IF(FACTOR.EQ.-1.0) FFLAG = ITER
IF(IBOT.GT.0) GO TO 405
IF(MITER.EQ.1.OR.FFLAG.EQ.ITER) GO TO 91
IF(MOD(ITER,MITER).NE.1) GO TO 506
C --- COMPUTE FACTOR TO MERGE CURVES
91 CALL MERGER(FACTOR,XTEMP)
C --- ADJUST BPRIME BY FACTOR
506 CCC=EXP(CMDL)
CMDL=ALOG(AMAX1(FACTOR*CCC,1.0E-5))
CMDLP=EXP(CMDL)
IF(MITER.EQ.1.OR.FFLAG.EQ.ITER) GO TO 92
IF(MOD(ITER,MITER).NE.1) GO TO 405
92 IF(IMG.GE.1) WRITE(6,100)TH,ITER,XTEMP,TS,FACTOR,CCC,CMDLP
100 FORMAT(' ***1*** MERGER - TIME, ITER, XTEMP, TWALL, ',
1' FACTOR, BP, BP*FACTOR = ',/,17X,F9.4,15,2F12.5,3F9.5)

C
405 JD=1
IF (Y2(4).LE.0.0) GO TO 4359
C --- SECOND CALL ON DIKI IF Y2(4).LE.0
GO TO 4261
4359 CMDL=BPLH
IBOT=-1
Y2(1)=TS
CALL DIKI(PRES,CMDL,CH,Y2,TL,BPLH,IBOT,JTBL)
C --- USE FACTOR FROM FIRST CALL TO DIKI TO MERGE CURVES
IF(IOPTN.LE.0) GO TO 4261
C --- ADJUST BPRIME BY FACTOR

```

```

CCC=EXP(CMDL)
CMDL=ALOG(AMAX1(FACTOR*CCC,1.0E-5))
CMDLP=EXP(CMDL)
IF(MITER.EQ.1.OR.FFLAG.EQ.ITER) GO TO 93
IF(MOD(ITER,MITER).NE.1) GO TO 4261
93 IF(IMSG.GE.1) WRITE(6,99)TH,ITER,XTEMP,TS,FACTOR,CCC,CMDLP
99 FORMAT(' ***2*** MERGER - TIME, ITER, XTEMP, TWALL,
1 FACTOR, BP, BP*FACTOR = ',/,'17X,F9.4,15,2F12.5,3F9.5)
4261 CONTINUE
    
```

CBM 958

```

C ----- LOOK UP EMISSIVITY OF SURFACE MATERIAL
CALL LOOK(4,Y2(1),TT2(1,2),TEP(1,2),0,0,0,EMIV,DMIV,1)
IF(MATL(1).EQ.2) GO TO 427
CALL LOOK(3,Y2(1),TT2(1,1),TEP(1,1),0,0,0,Y3,D3,1)
EMIV=EMIV+XP1*(Y3(1)-EMIV)
DMIV=DMIV+XP1*(D3(1)-DMIV)
427 TSSQ=Y2(1)*Y2(1)
TS=Y2(1)
    
```

CBM 959

CBM 962
 CBM 963
 CBM 964
 CBM 965

```

C ----- COMPUTE DEPARTURE FROM ZERO OF SURFACE ENERGY BALANCE
RAD = RADIATION AWAY FROM SURFACE
QRA = INCIDENT RADIATION
ERR = DEPARTURE FROM ZERO OF SURFACE ENERGY BALANCE
DERR = RATE OF ERR PER LN(BPRIME) FOR ABLATING SURFACE OR
RATE OF ERR PER TWALL FOR NON-ABLATING SURFACE.
ERRC = CORRECTION TO LN(BPRIME)
    
```

```

C ----- BLOWING EFFECT ON RADIATIVE HEAT TRANSFER
C DD1 = DENSITY AT ALTITUDE AFTFS
C BLOW = PERCENT BLOWING
C BLOFAC = BLOW FACTOR ON RADIATION H.T., QRA
C
IF(1BLOPT.LE.0) GO TO 5000
CALL ATM(AFTFS,DUMP,DUMT,DUMW,DUMA,DD1)
BLOW=CMD/(VELFS*DD1)*100.0
IF(1BLOPT.EQ.1) GO TO 5100
C ----- USING CARBON ABLATION SPECIES -----
IF(BLOW.GT.20.0) BLOFAC=0.60
IF(BLOW.GT.10.0.AND.BLOW.LE.20.0) BLOFAC=0.70-0.005*BLOW
IF(BLOW.GT.5.0.AND.BLOW.LE.10.0) BLOFAC=0.85-0.020*BLOW
IF(BLOW.GE.0.0.AND.BLOW.LE.5.0) BLOFAC=1.00-0.050*BLOW
GO TO 5150
C ----- USING AIR ABLATION SPECIES -----
5100 IF(BLOW.GT.40.0) BLOFAC=0.83
IF(BLOW.GT.20.0.AND.BLOW.LE.40.0) BLOFAC=0.91-0.002*BLOW
IF(BLOW.GT.10.0.AND.BLOW.LE.20.0) BLOFAC=0.93-0.003*BLOW
IF(BLOW.GE.0.0.AND.BLOW.LE.10.0) BLOFAC=1.00-0.010*BLOW
C -----
5150 IF(1BLOPT.GE.1.AND.1MSG.GE.3)
1 WRITE(6,5200)ITER,CMD,VELFS,DD1,BLOW,BLOFAC
5200 FORMAT(' ***** 11X,CMD,VELFS,DENS,BLOW,BLOFAC = ',
1 /,' ***** ',15,5E14.5)
5000 CONTINUE
    
```

```

C ----- QRA CHANGED TO QRA*BLOFAC BELOW BY CCC 1/88
RAD=SIG*EMIV*TSSQ*TSSQ*VF
ERR=CH*Y2(2)+EMIV*QRA*(BLOFAC-RAD-B(1))*TS+ERFX
DERR=CH*Y2(5)+((QRA*(BLOFAC-RAD)/EMIV)*DMIV-4./TS*RAD-B(1))*Y2(4)
ERRC=ERR/DERR
VITER(ITS)=CMDL
EITER(ITS)=ERR
IF(ERRC.EQ.0.0) GO TO 4355
    
```

CBM 966
 CBM 968
 CBM 969
 CBM 970
 CBM 971

```

        IF (ABS(ERRC).LT.1.0E-6) ERRC = ERRC/ABS(ERRC)*1.0E-6
4355 IF (IBOT.LT.0) GO TO 4357
        CMDL = CMDL - ERRC
        GO TO 4358
4357 TS = TS-ERRC
        Y2(1) = TS
4358 IF (IBUG.NE.0) WRITE(6,5602) (Y2(1),I=1,6)
        IF (JD.EQ.1) GO TO 4367
        CMMI=-1.E+30
        CMMA=+1.E+30
        IF (ILO(14).GE.IRA) GO TO 4363
        IF (ILO(16).GE.IRC) GO TO 4363
        IF (NGS.LE.1) GO TO 4270
        IF (ILO(17).GE.IRD) GO TO 4363
        IF (ILO(15).GE.IRB) GO TO 4363
        CMMI = AMAX1(TLMC(IRD,IMG+1,IPR+1)+TLMC(IRD-1,IMG+1,IPR+1),
1          TLMC(IRB,IMG+1,IPR) + TLMC(IRB-1,IMG+1,IPR))
4270 CMMI = AMAX1(TLMC(IRA,IMG,IPR)+TLMC(IRA-1,IMG,IPR),CMMI,
1          TLMC(IRC,IMG,IPR+1)+TLMC(IRC-1,IMG,IPR+1))/2.0
        CMDL=AMAX1(CMDL,CMMI)
4363 IF (IHI(14).LE.IRA+1) GO TO 4366
        IF (IHI(16).LE.IRC+1) GO TO 4366
        IF (NGS.LE.1) GO TO 4275
        IF (IHI(17).LE.IRD+1) GO TO 4366
        IF (IHI(15).LE.IRB+1) GO TO 4366
        CMMA = AMIN1(TLMC(IRD+1,IMG+1,IPR+1) + TLMC(IRD+2,IMG+1,IPR+1),
1          TLMC(IRB+1,IMG+1,IPR) + TLMC(IRB+2,IMG+1,IPR))
4275 CMMA = AMIN1(CMMA,TLMC(IRC+2,IMG,IPR+1)+TLMC(IRC+1,IMG,IPR+1),
1          TLMC(IRA+1,IMG,IPR)+TLMC(IRA+2,IMG,IPR))/2.0
        CMDL=AMIN1(CMDL,CMMA)
        IF (ITS-ITL-1) 4366,4351,4352
4351 ERRS=ERR
        CMDL=CMMA
        GO TO 4367
4352 IF (ERR*ERRS) 4354,4367,4353
4353 CMDL=CMMA
        GO TO 4367
4354 ITL=55
        IF (ERRC.EQ.0.0) CMDL = CMMI
        GO TO 4367
4366 IF (ITS.NE.ITL) GO TO 4367
4356 CMDL = AMIN1(TLMC(11,IMG,IPR),TLMC(13,IMG,IPR+1))
        IF (NGS.LE.1) GO TO 4367
        CMDL = AMIN1(CMDL,TLMC(12,IMG+1,IPR),TLMC(14,IMG+1,IPR+1))
4367 IF (CMDL.GT.10.0) CMDL=10.0
        CMD=EXP(CMDL)*CH*CMH
        IF (IBUG.NE.0) WRITE(6,5602) TH,DTH,VRM,ERFX,EMIV,DMIV,RAD,B(1),
1 CH,PHI,D(1),HE,XP1,QRA,CMDL,CMMA,ERR,DERR,ERRC
        IF (ITS.EQ.31) TOLER = 2.0*TOLER
        IF (ITS.LE.30) GO TO 415
        IF (IBOT.LT.0) GO TO 415
        DUM=EITER(ITS)-EITER(ITS-1)
C ----- IF SUCCESSIVE SURF. BALANCE ERRORS ARE SAME
        IF (DUM.EQ.0.0) GO TO 4376
        CMDL = VITER(ITS-1) - EITER(ITS-1)*(VITER(ITS)-VITER(ITS-1))
1 /DUM
415 IF (ITS.EQ.40) TOLER = 2.0*TOLER
        IF (ITS.EQ.50) GO TO 4376
        IF (ITS.LT.49) GO TO 4375
        XMIN = 1.0E+6
    
```

BUG

CBM 973
 CBM 974

CBM 985

CBM 996
 CBM 997
 CBM 998
 CBM 999
 CBM 1000
 CBM 1001
 CBM 1002
 CBM 1003
 CBM 1004

CBM 1007

CBM 1013
 BUG
 BUG


```

DO 4374 I5 = 1,49
IF (ABS(EITER(15)).GT.XMIN) GO TO 4374
CMDL = VITER(15)
XMIN = ABS(EITER(15))
4374 CONTINUE
4375 ITS = ITS+1
IF (ABS(ERR)-TOLER) 4372,4372,423
4376 WRITE(6,5604) TH,ERR
5604 FORMAT(37H NO CONV IN SURF BAL, TIME & ERR ARE ,2F14.5 )
GO TO 4372

```

```

C ----- NON-ABLATING SURFACE CBM 1017
C

```

```

C 420 TS=TSAVE CBM 1018

```

```

C ----- FLAG TO INDICATE NEED FOR MERGER SUBR WHEN
C GOING FROM NON-ABLATOR TO ABLATOR USING DIK1
FACTOR=-1.0
BLOW=0.0
BLOWFAC=1.0

```

```

C
C IAB=0 CBM 1019
C CMD=0.0 CBM 1020

```

```

430 IF (I1.EQ.3) GO TO 433
ILO(18)=1
IHI(18)=KHI(IMG,IPR) CBM 1023
ILO(20)=1

```

```

IHI(20)=KHI(IMG,IPR+1) CBM 1032
CALL LOOK (18,TS,TTS(1,IMG,IPR),TCHEM(1,IMG,IPR),0,0,0,Y2(1),Y2(2) CBM 1026
1,1) CBM 1027

```

```

CALL LOOK (20,TS,ITS(1,IMG,IPR+1),TCHEM(1,IMG,IPR+1),0,0,0,Y2(5), CBM 1035
Y2(6),1) CBM 1036

```

```

IF (NGS.LE.1) GO TO 4322
ILO(19)=1 CBM 1024

```

```

IHI(19)=KHI(IMG+1,IPR) CBM 1025
ILO(21)=1 CBM 1033

```

```

IHI(21)=KHI(IMG+1,IPR+1) CBM 1034
CALL LOOK (19,TS,TTS(1,IMG+1,IPR),TCHEM(1,IMG+1,IPR),0,0,0,Y2(3), CBM 1028
Y2(4),1) CBM 1029

```

```

CALL LOOK (21,TS,ITS(1,IMG+1,IPR+1),TCHEM(1,IMG+1,IPR+1),0,0,0, CBM 1037
Y2(7),Y2(8),1) CBM 1038

```

```

DO 4321 I=1,2
4321 Y2(I)=Y2(I)+VRM*(Y2(I+2)-Y2(I))
DO 4423 I=5,6

```

```

4423 Y2(I) = Y2(I) +VRM*(Y2(I+2)-Y2(I))
4322 IF (IBUG.NE.0) WRITE(6,5601) IAB,IMG,IPR CBM 1024

```

```

IF (IBUG.NE.0) WRITE(6,5602) (Y2(I),I=1,8),TS,VRM,VRP CBM 1025
DO 4323 I=1,2

```

```

4323 Y2(I)=Y2(I)+VRP*(Y2(I+4)-Y2(I))

```

```

C ----- Y2(I) = -HW SINCE OLD Y2(I)=TCHEM=-(1+B')*HW+B'C*HC=-HW
C IF (IMSG.GE.3) WRITE(6,4330) ITER,PRES,TS,Y2(I)
4330 FORMAT(' ***** ITR,PRES,TS,Y2(I) = ',15,3F15.5)

```

```

C
C IF (IBUG.NE.0) WRITE(6,5602) (Y2(I),I=1,2) CBM 1026

```

```

433 CALL LOOK (4,TS,IT2(1,2),TEP(1,2),0,0,0,EMIV,DMIV,1) CBM 1043
IF (MATL(1).EQ.2) GO TO 442

```

```

CALL LOOK (3,TS,IT2(1,1),TEP(1,1),0,0,0,Y3,D3,1) C
EMIV=EMIV+XP1*(Y3(1)-EMIV) CBM1046

```

```

DMIV=DMIV+XP1*(D3(1)-DMIV)
442 TSSQ=TS*TS CBM 1048

```

```

IF (I1.NE.3) GO TO 4422

```

```

IF (EMIV.EQ.0.0) EMIV=1.0
4422 RAD=SIG*EMIV*TSSQ*ISSQ*VF CBM 1052
ERR=CH*Y2(1)+EMIV*QRA-RAD-B(1)*TS+ERFX
DERR=CH*Y2(2)+((QRA-RAD/EMIV)*DMIV-4./TS*RAD-B(1)) CBM 1054
ERRC=ERR/DERR CBM 1055
VITER(ITS)=TS CBM 1056
EITER(ITS)=ERR CBM 1057
TS=TS-ERRC CBM 1058
IF (I1.GE.3) GO TO 4507
TSMI=-1.E+30
T SMA=+1.E+30
IRA=IR(18) CBM 1061
IRB=IR(19) CBM 1062
IRC=IR(20) CBM 1063
IRD=IR(21) CBM 1064
IF (ILO(18).GE.IRA) GO TO 4501
IF (ILO(20).GE.IRC) GO TO 4501
IF (NGS.LE.1) GO TO 4503
IF (ILO(21).GE.IRD) GO TO 4501
IF (ILO(19).GE.IRB) GO TO 4501
TSMI = AMAX1(TTS(IRD,IMG+1,IPR+1)+TTS(IRD-1,IMG+1,IPR+1),
1 TTS(IRB,IMG+1,IPR) + TTS(IRB-1,IMG+1,IPR) )
4503 TSMI = AMAX1(TSMI,TTS(IRA,IMG,IPR) + TTS(IRA-1,IMG,IPR),
1 TTS(IRC,IMG,IPR+1)+TTS(IRC-1,IMG,IPR+1) )/2.0
TS=AMAX1(TS,TSMI) CBM 1075
4501 IF (IHI(18).LE.IRA+1) GO TO 4507
IF (IHI(20).LE.IRC+1) GO TO 4507
IF (NGS.LE.1) GO TO 4510
IF (IHI(21).LE.IRD+1) GO TO 4507
IF (IHI(19).LE.IRB+1) GO TO 4507
T SMA = AMIN1(TTS(IRD+1,IMG+1,IPR+1)+TTS(IRD+2,IMG+1,IPR+1),
1 TTS(IRB+1,IMG+1,IPR) + TTS(IRB+2,IMG+1,IPR) )
4510 T SMA = AMIN1(T SMA,TTS(IRA+1,IMG,IPR)+TTS(IRA+2,IMG,IPR),
1 TTS(IRC+1,IMG,IPR+1)+TTS(IRC+2,IMG,IPR+1) )/2.0
TS=AMIN1(TS,T SMA) CBM 1085
4507 CONTINUE CBM 1086
IF (IBUG.EQ.0) GO TO 104
WRITE(6,5601) IRA,IRB,IRC,IRD,IAB
WRITE(6,5602) TSMI,T SMA,TS,ERRC,DERR,ERR,
1 VITER(ITS)
WRITE(6,5602) TH,DTH,VRM,ERFX,EMIV,DMIV,RAD,B(1),
1 CH,PHI,D(1),HE,XP1,QRA,CMDL
104 IF (ITS.GT.50) GO TO 998
ITS = ITS + 1
IF (ABS(ERR).GT.1.0) GO TO 430
C
C ----- POST ITERATION CBM 1096
C
IF (I1.GT.2) GO TO 1437
Y2(2) = Y2(1)
4372 QCHEM=Y2(2) CBM 1099
C IF (ITS.LT.30) GO TO 1438
C WRITE(6,583) TOLER,ERR,TH
IF (ISEN(1).NE.0) GO TO 4373
QCONV = 0.0
GO TO 1439
4373 CALL OGLE(1,TS,QCONV,ISEN(IPR),ITSEN(1,IPR),THSEN(1,IPR),TCPCSEN(1,CBM 1103
1IPR)) CBM 1104
CALL OGLE(1,TS,QQ,ISEN(IPR+1),ITSEN(1,IPR+1),THSEN(1,IPR+1),TCPCBM 1106
ISEN(1,IPR+1)) CBM 1107

```

```

1439 QCONV=QCONV+VRP*(QQ-QCONV)
      QCHEM=(QCHEM+QCONV)*CH
      HW=QCONV
      QCONV=CH*(HE-QCONV)
      DSDTB=CMD/RHO(2)
C ----- EROSION LUNDELL & DICKEY DATA BASED ON JANAF SPECIES
      CMDM = 0.0
      DSDTM = 0.0
      IF (IEROS.EQ.0) GO TO 441
      IF (TS.LT.7245.0.AND.TS.GT.4600.0)
1 CDM = CMD*(564.59/(7521.0-TS)-0.15523)
      IF (TS.GT.7245.0) CDM = 1.89*CMD
      DSDTM = CDM/RHO(2)
441 DSDTT = DSDTB + DSDTM
      IF (NBPF.LE.0) GO TO 1437
      IF (IAB.GT.0) CMFL = EXP(Y2(3))*CH*CMH
1437 RO(1)=RON(1)
      BR=CH/(CHZ+1.0E-15)
      QRP=EMIV*QRA*BLOFAC
      QCOND=-D(1)+B(1)*TA(1)
      TEMP = DTH*ASU/AREA(1)
C ----- TIME INTEGRATED VALUES
      QCONVT = QCONVT + QCONV*TEMP
      QCHEMT = QCHEMT + QCHEM*TEMP
      QCOND1 = QCOND1 + QCOND*TEMP
      QRPT = QRPT + QRP*TEMP
      RADT = RADT + RAD*TEMP
      SUMQE = SUMQE + DTH*(QCONV+QRP-RAD+QCHEM-QCOND)
C ----- RECOMPUTE TOLERANCE
      TOLER =AMAX1(0.25,AMIN1(1.0,ABS(0.01*QCONV)))
C
      DEDT=RON(1)*CP(1)*(TS-TSAVE)*DEL(1)/DTH
      DTD(1) = (TS-TSAVE)/DTH
      DO 95 I=2,NL
      RO(I) = RON(I)
      TEMP =(D(I) -A(I) )*TA(I-1))/B(I)
      DEDT=DEDT+RON(I)*CP(1)*(TEMP-TA(I))*DEL(1)*RR(I)/DTH
      DTD(I) = (TEMP-TA(I))/DTH
95 TA(I)=TEMP
      IF (NUMN.LT.NBM) GO TO 97
      K = NL
      TA(NBM-1) = TA(NL)
      DO 98 I = NBM,NUMN
      K = K+1
98 TA(I) = (D(K)-A(K)*TA(I-1))/B(K)
97 DEDTT=DEDTT+DEDT*DTH/AREA(1)*ASU
      IF (IBUG.NE.0) WRITE(6,5602) (TA(I),I=1,NUMN)
      IF (NDBU.EQ.0) GO TO 756
      LL = NFI(1)
      LU=NLA(NDBU)
      DO 757 I=LL,LU
757 RO(I)=RON(I)
C
C SHRINK (AND DROP) OF LAST ABLATING NODE
C
756 IF (DEL(NL).GT.DELM) GO TO 150
      DRLP=DEL(NL)*RO(NL)*RR(NL)
      DRLCP=DRLP*CP(NL)
      NL=NL-1
      LGAP(NL) =LGAP(NL+1)

```

CBM 1108
 CBM 1110
 CBM 1111
 CBM 1112
 CBM 1116
 CBM 1118
 CBM 1119
 CBM 1125
 CBM 1126
 CBM 1127
 CBM 1128
 CBM 1129
 CBM 1130
 CBM 1131
 CBM 1134
 CBM 1135
 CBM 1136
 CBM 1137
 CBM 1138
 BUG
 CBM 1141
 CBM 1142
 CBM 1143
 CBM 1146
 CBM 1147
 CBM 1148
 CBM 1152
 CBM 1153

```

GAP(NL) = GAP(NL+1)
RC(NL)=RC(NL+1)
DRL=DEL(NL)*RO(NL)*RR(NL)
DRLC=DRL*CP(NL)
HAPHB=DRL*H(NL)+DRLP*H(NL+1)
TOP1=DRL+DRLP
TOP2=DRLC+DRLCP
TOP3=DRLC*TA(NL) +DRLCP*TA(NL+1)
VOL=DEL(NL)*RR(NL)+DEL(NL+1)*RR(NL+1)
DEL(NL)=DEL(NL)+DEL(NL+1)
RA(NL)=RA(NL)+6.*DEL(NL+1)
RO(NL)=TOP1/VOL
CP(NL)=TOP2/TOP1
TA(NL)=TOP3/TOP2
H(NL)=HAPHB/TOP1
DELR=DEL(NL+1)*RR(NL+1)/VOL
CZ=1.0-DELR
DZ=0.0
GZ=CZ
NZ=JF*NL-JFH
N=NZ-JF+1
K=N
FZ=DELR
EZ=GZ
GO TO 179
172 DZ=DZ+1.0
173 FZ=DZ-CZ
    IF(K.EQ.NZ) GZ=DELR
    K=K+1
    CZ=CZ+GZ
    EZ=CZ-DZ
    IF(EZ.LT.0.0) GO TO 178
    ROA(N)=ROA(N)+FZ*ROA(K)
    ROB(N)=ROB(N)+FZ*ROB(K)
    ROC(N)=ROC(N)+FZ*ROC(K)
    IF(N.EQ.NZ) GO TO 150
    N=N+1
179 ROA(N)=ROA(K)*EZ
    ROB(N)=ROB(K)*EZ
    ROC(N)=ROC(K)*EZ
    GO TO 172
178 ROA(N)=ROA(N)+ROA(K)*GZ
    ROB(N)=ROB(N)+ROB(K)*GZ
    ROC(N)=ROC(N)+ROC(K)*GZ
    GO TO 173
C
150 GO TO 410
998 WRITE (KOUT,529)
    WRITE(KOUT,582)(VITER(I),EITER(I),I=1,51)
    WRITE(KOUT,582) TH,DTH,VRM,ERFX,TABC,EMIV,DMIV,RAD,B(1),CH,PHI,
1 D(1),HE,XP1,QRA,Y2(1),Y2(2),Y2(3),Y2(4)
    TH=THF IN
    GO TO 3000
1 RETURN
END

```

CBM 1154
 CBM 1155
 CBM 1156
 CBM 1157
 CBM 1158
 CBM 1159
 CBM 1160
 CBM 1161
 CBM 1162
 CBM 1163
 CBM 1164
 CBM 1165
 CBM 1166
 CBM 1167
 CBM 1168
 CBM 1169
 CBM 1170
 CBM 1171
 CBM 1172
 CBM 1173
 CBM 1174
 CBM 1175
 CBM 1176
 CBM 1177
 CBM 1178
 CBM 1179

 CBM 1183

 CBM 1187
 CBM 1188

 CBM 1191
 CBM 1192
 CBM 1193
 CBM 1194
 CBM 1195
 CBM 1196
 CBM 1197
 CBM 1198
 CBM 1199

 CBM 1090
 CBM 1091
 CBM 1092
 CBM 1093
 CBM 1094
 CBM 1095

 CBM 1202

DSNAME = 'BBE.CCC1.SOURCE.CMA6.PDS(FDTABC)'
 DCB=(RECFM=FB,LRECL=80,BLKSIZE=6160)

VOL=SER=D8D080
 01/13/88 013 14:11:54

SUBROUTINE FDTABC(TABC)

```

C                                     CBM   2
C SUBROUTINE TO COMPUTE THE TEMPERATURE FOR THE MATERIAL TO ABLATE          CBM   3
C USING THE HUNTER FORMULATION REWRITTEN TO GIVE A BPRIME AS A              CBM   4
C FUNCTION OF TEMPERATURE.
C
C INPUT: PRES, RUCH - OUTPUT:TABC
C
COMMON/OTPT/CPE(6),EMO(201),DEP(20,10),CNC(101),CN(101),Y1(4),
1 CNO(101),TO(20),RO(101),NISO(20),BR,CH,GS,SA,TB,TT,ASU,CMD,CMT,
2 ITS,QRP,RAD,RAT(101),RSU,CMDM,CMTT,DCDT,DEDT,DIDT,DPDT,ITER,KSCCT,
3 PGPU,PRES,QRPT,RADT,SNET,DECOM,DEDTT,DSOTB,PGPUT,QCHEM,QCOND,
4 QCONV,QLOSS,SDNET,          SUMQE,THPRT,TSAVE,VELFS,DECOMT,
5 PRSATM,QCHEMT,QCOND, QCONVT,QLOSST,KK,RR(101),DMOG(101),
6 RON(101),ROT(101),DNCP(6),DROT(6),D1(4),FA,FB,FC,DTH,DTHC,DSI,
7 DTA,GSM,COLD,GSMS,GSMT,GSM2T,DSDT,POLD,DUH,AFTFS,DSDTT,
8 TEMP,BF,LL,LU,HE,HW
COMMON/OPTION/TCRIT,BPCRIT,TABCN,IOPTN,IMSG,MITER
COMMON/DIKIBK/E1,KO1,E2,KO2,MWC,MWO,CONO2
DIMENSION TWL(50)
REAL K1,K2,KO1,KO2,MWC,MWO
C ---- R IN ATM-CM**3/GM/K
C ---- PRES IN LN(ATM)
C ---- CH (RUCH) IN LBM/FT**2/S
C ---- GSTAR IN G/CM**2/S
C ---- TW IN K
C ---- E1 IN K
C ---- KO1 IN CM/S
      BP=0.00001
      R = 2.83317
      PW=EXP(PRES)
      GSTAR=0.489*CH
      BE=MWC/MWO*CONO2
      TERM = KO1*PW/R/GSTAR*(ALOG(1.0+BE)/ALOG(1.0+BP)-1.0)
      TW=2000.0/1.8
      TOLER=0.1
C ---- ITERATE TO SOLVE FOR TW
C
      ICOUNT=0
      50 ICOUNT=ICOUNT+1
      TWL(ICOUNT)=TW
      TWLAST=TW
      TW = E1/ALOG(TERM/TW)
      TABC = TW*1.8
      IF(IMG.GE.2) WRITE(6,100)ICOUNT,TABC
      100 FORMAT(' **FDT** FBTABC SUB-ITERATION NO. ',I3,
1 ' ',TABC = ',F12.5)
      IF(ICOUNT.LT.15) GO TO 200
      WRITE(6,150)(TWL(I),I=1,ICOUNT)
      150 FORMAT(' **FDT** WARNING: FDTABC MAX. ITERATIONS EXCEEDED'
1 ' *****' ,/,15E12.5)
      RETURN
      200 IF(ABS(TW-TWLAST).GT.TOLER) GO TO 50
      RETURN
      END

```

CBM 1202


```

538 FORMAT(/27X30H---SURFACE EQUILIBRIUM DATA---)
571 FORMAT(12,F10.5,F10.5,F10.8,F10.5,F10.5)
580 FORMAT(8F10.5)
587 FORMAT(12)
588 FORMAT(2G10.8)
589 FORMAT(35H CONDUCTIVITY TABLE FOR GAP KEY = , 11, /
1 30H TEMP,R K,BTU/(SEC-FT-F) ,/(
2 3X,F12.7,E15.5 ) )
5790 FORMAT(6X,26HNO RADIUS CORRECTION ON CH)
742 FORMAT(615)
28612 FORMAT(6X,36HFISSURE MODEL NOT USED FOR GAS TERMS)
28138 FORMAT(6X,12HCHAR SWELL =F8.4,1X16H* CHAR THICKNESS)
28136 FORMAT(6X,45HNO CHAR SWELL CORRECTION ON SURFACE RECESSION)
28132 FORMAT(6X,66HFISSURE MODEL USED FOR SURFACE ENERGY TERMS AND BLOWING CORRECTION)
7902 FORMAT(/28X,24HDECOMPOSING BACK-UP NO. ,11)
DATA BLANK,ASTER/1H ,1H*/
NPG = 1
NMG(1) = 1
NPR = 1
INPUT=5
KOUT=6
INCH=5

C
C INPUT/OUTPUT
C
1 NPG=1
WRITE (KOUT,551)NPG
551 FORMAT(1H110X65H CHARRING MATERIAL THERMAL RESPONSE AND ABLATION PROGRAM/73X4HPAGE13/1H 67X2A6)
IBUG = 0

C
C ----- TITLE CARDS
C RECORD(1) = ALPHANUMERIC TITLE
READ ( 5, 499) (RECORD(1), I=1,54)
499 FORMAT (18A4,8X/18A4,8X/18A4,8X)
WRITE (KOUT,502)(RECORD(1),I=1,54)
502 FORMAT (6X18A4)

C
C ----- HEADINGS
C WRITE (KOUT,503)
503 FORMAT(/24X31H---REACTION KINETIC EQUATION---/1H )
WRITE (KOUT,504)
504 FORMAT(10X67HDRHO/DTIME = GAMMA ( BA*EXP(-EA/T)RHO0A((RHOA-RHORA)/1RHO0A)**PSIA )/ 21X56H+ GAMMA ( BB*EXP(-EB/T)RHO0B((RHOB-RHORB)/2RHO0B)**PSIB )/ 19X58H+(1-GAMMA)( BC*EXP(-EC/T)RHO0C((RHOC-RHORC)/3RHO0C)**PSIC ))
WRITE (KOUT,505)
505 FORMAT(/24X32H---REACTION KINETIC CONSTANTS---/1H )
WRITE (KOUT,506)

C
C ----- READ PARAMETERS FOR INTERNAL-DECOMPOSITION
C A9,B9,C9 = MATERIAL COMPONENT
C RHO0A,RHO0B,RHO0C = INITIAL DENSITY OF COMPONENT I
C RHORA,RHORB,RHORC = RESIDUAL DENSITY OF COMPONENT I
C BA,BB,BC = PRE-EXPONENTIAL FACTOR
C PSIA,PSIB,PSIC = DENSITY FACTOR EXPONENT
C EA,EB,EC = ACTIVATION ENERGY FACTOR
C TRACA,TRACB,TRACC = MINIMUM TEMPERATURE OF REACTION ZONE
C IDRD = ?
C NOBU = NUMBER OF DECOMPOSING BACKUPS
C
READ (INPUT,564) A9,RHO0A,RHORA,BA,PSIA,EA,TRACA,IDRD,

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1 B9,RHO0B,RHORB,BB,
1 PS1B,EB,TRACB ,C9,RHO0C,RHORC,BC, PS1C,EC,TRACC,NDBU
564 FORMAT(A1,9X,2F10.5,F10.3,F10.5,F10.3,F10.5,I1/A1,9X,2F10.5,E10.3,
1F10.5, E10.3,F10.5/A1,9X,2F10.5,F10.3,F10.5,E10.3,F10.5,9X,I1)
WRITE (KOUT,507)A9,RHO0A,RHORA,BA,PS1A,EA,TRACA,B9,RHO0B,RHORB,BB,INPOU182
1PS1B,EB,TRACB ,C9,RHO0C,RHORC,BC, PS1C,EC,TRACC INPOU183
C ----- READ OUTPUT INTERVALS
C JF = NUMBER OF NODELETS PER NODE
C NUMN = TOTAL NUMBER OF NODES
C NN = SWITCH FOR THERMOCOUPLE AND ISOTHERM OUTPUT
C NO = NUMBER OF THERMOCOUPLES FOR WHICH OUTPUT IS DESIRED
C NI = NUMBER OF ISOTHERMS FOR WHICH OUTPUT IS DESIRED
C THZRO = INITIAL VALUE OF TIME
C THFIN = FINAL VALUE OF TIME
C DTPRT,DTPR2,DTPR3 - OUTPUT TIME INTERVALS
C DTHB = MAXIMUM TIME STEP PERMITTED; DEFAULTS TO 5.0 SECONDS
C BRP = BLOWING PARAMETER; BRP < 0 - PUTZ & BARTLETTE CORRELATION
C BRP > 0 - OVERRIDES ZERO VALUE IN TABLES
C BRP = 0.5 - MICKLEY & SPAULDING CORRELATION
C TPR2,TPR3 = TIME OF TRANSITION FROM INTERVAL TO INTERVAL
C DELM = MINIMUM THICKNESS OF LAST ABLATOR NODE
C DH1,DH2,DELHG = HEAT OF FORMATION OF VIRGIN PLASTIC, CHAR
C AND THE PYROLYSIS ZONE
C GAMA = VOLUME FRACTION OR MASS FRACTION OF THE VIRGIN PLASTIC
C WHICH IS OCCUPIED BY RESIN. NEGATIVE GAMA IS MASS FRACTION
C TZ = DATUM TEMPERATURE OF RHEATS OF FROMATION
C
C READ (INPUT,563) JF,NUMN,NN,NO,NI,THZRO,THFIN,DTPRT,DTPR2,DTPR3, INPOU184
1DTHB,BRP,TPR2,TPR3,DELM,DH1,DH2,DELHG,GAMA,TZ INPOU185
563 FORMAT (12,13,11,12,12,7F10.5/8F10.5) INPOU121
C -----
C IF(1DRD.EQ.0) GO TO 173
C READ(5,580) RA1,RA2,RA3
C WRITE(6,585) RA1,RA2,RA3
585 FORMAT(46H CHAR DENSITY A FUNCTION OF TEMPERATURE RATE ,/
1 46H RHOC/RHOP= RA1+RA2/(RA3-LN(DT/DTIME)) ,/
2 6H RA1=,F12.7, 6H RA2=,F12.7, 6H RA3=,F12.7)
173 IF (JF-1) 171,170,172
170 JF=2 INPOU187
C GO TO 172 INPOU188
171 JF=10 INPOU189
172 JFH=JF/2 INPOU190
C JF=JFH+JFH INPOU191
C JFHP=JFH+1 INPOU192
C FJFS=JF INPOU193
C FJFH=FJFS/2.0 INPOU194
C NO1=NO+NI INPOU195
C IF (NO.GT.0) READ(5,580)(SO(1),I-1,NO)
C IF (NI.LE.0) GO TO 184
C NOP=NO+1
C READ (INPUT,580) (SO(1), I=NOP,NO1) INPOU201
184 IF (GAMA.LT.0.0)
C GAMA=RHOOC/(RHOOC-(RH00A+RH00B)-(RH00A+RH00B)/GAMA)
C ONG=1.0-GAMA
C ----- INSTANTANEOUS DENSITY OF COMPOSITE
C RHO(1)=GAMA*(RH00A+RH00B)+ONG*RHO0C INPOU205
C RHO(2)=GAMA*(RH00A+RH00B)+ONG*RHO0C INPOU206
C GAMA1=GAMA/RHO(1)*(RH00A+RH00B) INPOU207
C WRITE (KOUT,510)GAMA,GAMA1 INPOU208
C IF (NDBU.EQ.0) GO TO 101

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WRITE(6 ,79( ))
7900 FORMAT (/23X,34H---DECOMPOSING BACK-UP KINETICS---/) INPOU211
C
C ----- LOOP FOR DECOMPOSING BACKUP MATERIALS
C
DO 704 I=1,NDBU INPOU212
  READ(INPUT,5640)A9,RH00(1,1),RHOR(1,1),BBB(1,1),PSI(1,1),EE(1,1), INPOU213
  1TRAC(1,1),B9,RH00(1,2),RHOR(1,2),BBB(1,2), PSI(1,2),EE(1,2) INPOU214
  2),TRAC(1,2),C9,RH00(1,3),RHOR(1,3),BBB(1,3),PSI(1,3),EE(1,3),TRAC( INPOU215
  31,3) INPOU216
5640 FORMAT (A1,9X2F10.5,E10.3,F10.5,E10.3,F10.5) INPOU124
  READ(INPUT,7901) DHV(1),DHC(1),GA(1),TREF(1) INPOU217
7901 FORMAT (30X,2F10.5,10X,2F10.5) INPOU218
  WRITE(KOUT,7902) I INPOU219
  WRITE(KOUT,506) INPOU221
  WRITE(KOUT,507) A9,RH00(1,1),RHOR(1,1),BBB(1,1),PSI(1,1),EE(1,1), INPOU222
  1TRAC(1,1),B9,RH00(1,2),RHOR(1,2),BBB(1,2), PSI(1,2),EE(1,2) INPOU223
  2),TRAC(1,2),C9,RH00(1,3),RHOR(1,3),BBB(1,3),PSI(1,3),EE(1,3),TRAC( INPOU224
  31,3) INPOU225
  IF (GA(1).LT.0.0)
  1GA(1)=RH00(1,3)/(RH00(1,3)-(RH00(1,1)+RH00(1,2))-(RH00(1,1)+
  2RH00(1,2))/GA(1))
  OMGA(1)=1.-GA(1)
  RHOV(1)=GA(1)*(RH00(1,1)+RH00(1,2))+OMGA(1)*RH00(1,3) INPOU230
  RHOC(1)=GA(1)*(RHOR(1,1)+RHOR(1,2))+OMGA(1)*RHOR(1,3) INPOU231
  GAMMA=GA(1)/RHOV(1)*(RH00(1,1)+RHOC(1,2)) INPOU232
  WRITE(KOUT,510) GA(1),GAMMA INPOU233
  P(1)=RHOV(1)/(RHOV(1)-RHOC(1)) INPOU234
  PP(1)=P(1)*RHOC(1) INPOU235
  DO 7030 J=1,3 INPOU236
7030 FF(1,J)=(1.-PSI(1,J))*BBB(1,J)*(RH00(1,J)**(1.-PSI(1,J))) INPOU237
704 CONTINUE INPOU238
C
C ----- MAXIMUM TIME STEP DEFAULT TO 5.0 SECONDS
C
701 IF(DTHB.EQ.0.0) DTHB=5.0
  DTHIN=.01
  IF(TPR2.LE.0.0) TPR2=THFIN
  IF(TPR3.GT.0.0) GO TO 417
416 TPR3=THFIN INPOU246
  IF(TPR2.GT.THZRO) GO TO 417
  DTPRT=DTPR2
  DTPR2=DTPR3 INPOU249
  TPR2=TPR3 INPOU250
  GO TO 416 INPOU251
C
C ----- ECHO TIME INTERVAL INFORMATION
417 WRITE (KOUT,511) INPOU252
511 FORMAT (24X32H---TIME INCREMENT INFORMATION---/1H ) INPOU 54
  THFIN=AMAX1(THFIN,TPR2,TPR3) INPOU253
  WRITE (KOUT,512)THZRO,THFIN INPOU254
512 FORMAT (6X18HINITIAL TIME (SEC)F9.2,26X16HFINAL TIME (SEC)F9.2) INPOU 55
  WRITE (KOUT,513)DTPRT,TPR2 INPOU255
513 FORMAT (1H /6X17HOUTPUT INTERVAL =F9.3,1X27HSEC FROM INITIAL TIME INPOU 56
  1UNTIL F9.2,4H SEC)
  WRITE (KOUT,514)DTPR2,TPR2,TPR3 INPOU256
514 FORMAT (6X17HOUTPUT INTERVAL =F9.3,1X8HSEC FROMF9.2,1X9HSEC UNTILF INPOU 58
  19.2,4H SEC)
  WRITE (KOUT,515)DTPR3,TPR3 INPOU257
515 FORMAT (6X17HOUTPUT INTERVAL =F9.3,1X8HSEC FROMF9.2,1X20HSEC UNTIL INPOU 60
  1 FINAL TIME/1H ) INPOU 61
  WRITE (KOUT,516) DTHB INPOU258

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516 FORMAT (6X,19HMAXIMUM TIME STEP =,F9.3,8H SECONDS)
C -----
TRACM=AMIN1(TRACA,IRACB,TRACC) INPOU259
PETE = 0.0
ZZZ = RHO(1) - RHO(2)
IF(ZZZ.NE.0.0) PETE = RHO(1)/ZZZ
PET=PETE*RHO(2) INPOU261
C ----- NODAL PROPERTIES INPOU262
C
N=0 INPOU263
KHS=10 INPOU264
NDBUCH=0 INPOU265
J1=JFH INPOU266
CALL LCOUNT (-NUMN-8,LCT,NPG)
WRITE ( 6,517)
517 FORMAT(/29X16H---NODAL DATA---/1H ) INPOU 63
WRITE ( 6,518)
518 FORMAT(6X74HNODE MATL TEMPERATURE RELATIVE THICKNESS NODAL DEINPOU 64
1PTH GAP QGEN )
WRITE ( 6,519)
519 FORMAT(7X95HNO. NO. (DEG.RANKINE) AREA (INCHES) (INCHES)INPOU 66
1 INCHES BTU/FT3-SEC RRGAP AGAP )
B=ASTER INPOU271
C ----- READ NODAL DATA
C MATL = MATERIAL NUMBER
C TA = INITIAL TEMPERATURE
C AREA = INITIAL CROSS-SECTIONAL AREA; BLANK IF RADIUS RELATED AREA
C DEL = INITIAL THICKNESS OF NODE
C RA = IDENTIFIES GEOMETRY TYPE
C QGEN = HEAT GENERATION
C LGAP = FLAG FOR GAP TYPE
C GAP = GAP SIZE IN INCHES
C
READ( 5,560)(MATL(1),TA(1),AREA(1),DEL(1),RA(1),QGEN(1),
1 LGAP(1),GAP(1),I = 1,NUMN)
560 FORMAT(12,5E10.0,11,E9.0)
C -----
RC(1) = 0.0
AE=RA(2) INPOU273
RSV=RA(1) INPOU274
RA(1)=0.0 INPOU275
RRGAP(1) = DEL(1)
C ----- PROCESS NODAL DATA
C
DO 400 I=1,NUMN INPOU276
IF(I-2) 4541,452,453 INPOU277
453 RA(1)=RA(I-1)+(DEL(I-1)+DEL(I))/2.0 + GAP(I-1)
RRGAP(1) = RA(1) + (GAP(1) + DEL(I))/2.0
GO TO 461 INPOU279
452 RA(2)=DEL(1)+DEL(2)/2. + GAP(1)
RRGAP(2) = RA(2) + (GAP(2) + DEL(2))/2.0
B=BLANK INPOU281
461 DEL(I-1)=DEL(I-1)/12.
GAP(I-1) = GAP(I-1)/12.0 INPOU282
4541 RAV(1)=RA(1) INPOU283
IF(AE.EQ.0.0) GO TO 4543
AREA(1)=(ABS(RSV+RA(1)))**AE INPOU285
AGAP(1) = (ABS(RSV+RRGAP(1)))**AE

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GO TO 454
4543 IF (AREA(1).GT.0.0) GO TO 454
      IF (RSV.EQ.0.0) GO TO 4546
      AREA(1)=ABS(RSV+RA(1))
      AGAP(1) = ABS(RSV+RRGAP(1))
      AE=1.0
GO TO 454
4546 AREA(1)=1.
      AGAP(1) = 1.0
454 QGEN(1) = QGEN(1)*1728.0
      WRITE( 6,520)I,MAIL(1),TA(1),AREA(1),DEL(1),RA(1),GAP(1),
1 LGAP(1),QGEN(1),RRGAP(1),AGAP(1)
520 FORMAT(3X2I6,F12.2,E13.4,F9.5,F12.6,F9.6,1X,I1,F9.3,F9.6,F9.6)
      IF (LGAP(1).EQ.0) GO TO 455
      IF (LGAP(1).LE.4) WRITE(6,546)
546 FORMAT(20H GAP GAS COND BELOW )
      IF (LGAP(1).EQ.5) WRITE(6,547)
547 FORMAT(18H AIR IN GAP )
      IF (LGAP(1).EQ.6) WRITE(6,548)
548 FORMAT(18H HELIUM IN GAP )
      IF (LGAP(1).EQ.7) WRITE(6,549)
549 FORMAT(18H NO GAS IN GAP )
455 IF (MATL(1)-2) 401,405,705
401 NL=1
      DO 404 J=1,J1
      N=N+1
      RHOC(1) = RHO(2)
      ROA(N)=RHOA
      ROB(N)=RHOOB
404 ROC(N)=RHOOC
      J1=JF
      GO TO 400
405 NL=1
      DO 406 J=1,J1
      N=N+1
      ROA(N)=RHORA
      ROB(N)=RHORB
406 ROC(N)=RHORC
      J1=JF
      GO TO 400
705 IF (MATL(1).LE.10) GO TO 400
C ----- PROCESS CHARRING BACKUP MATERIALS
      K=MATL(1)-21
      VKH=FLOAT(K)/2.0
      KH=K/2
      VKH2=KH
      IF (VKH.NE.VKH2) GO TO 708
      ROCOM(1,1)=RHOR(KH,1)
      ROCOM(1,2)=RHOR(KH,2)
      ROCOM(1,3)=RHOR(KH,3)
      X(1)=0.
      GO TO 709
708 KH=KH+1
      ROCOM(1,1)=RHOO(KH,1)
      ROCOM(1,2)=RHOO(KH,2)
      ROCOM(1,3)=RHOO(KH,3)
      X(1)=1.0
709 IF (KH.EQ.KHS) GO TO 7092
      NFI(KH)=I
      KHS=KH

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INPOU286

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INPOU328

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      NDEUCH=NDBUCH+1
7092 NLA,KH)=1
400 CONTINUE
C
C   PROCESS BACKUP MATERIALS
C
      IF (NDBU-NDBUCH) 7095,403 ,7093
7095 WRITE(KOUT,7096)
7096 FORMAT(10X,55HTOO MANY DECOMPOSING BACK-UPS IN NODAL DATA -- QUIT
1JOB)
STOP
7093 WRITE(KOUT,7097)
7097 FORMAT(10X,54HTOO FEW DECOMPOSING BACK-UPS IN NODAL DATA -- QUIT J
10B)
STOP
403 DEL(NUMN)=DEL(NUMN)/12.
GAP(NUMN) = GAP(NUMN)/12.0
CALL SLOPQ(NUMN,RA,AREA,EMA)
NBM=NL+1
IF(NDBU.EQ.0) GO TO 7099
NBM2=NLA(NDBU)+1
GO TO 7091
7099 NBM2=NBM
7091 CONTINUE
      IF(RSV) 4031,4032,4033
4031 RSVN=-RSV
WRITE(KOUT,554)RSVN,AE
554 FORMAT(8X24H*INITIAL EXTERNAL RADIUS,1X,F6.3,4X,21HAREA PROP.TO RA
1DIUS**F4.2)
GO TO 304
4032 WRITE(KOUT,555)
555 FORMAT(8X15H*PLANAR SURFACE)
GO TO 304
4033 WRITE(KOUT,553)RSV,AE
553 FORMAT(8X24H*INITIAL INTERNAL RADIUS,1X,F6.3,4X,21HAREA PROP.TO RA
1DIUS**F4.2)
304 WRITE (KOUT,521) DELM,JF
521 FORMAT ( 14X47HMINIMUM THICKNESS OF LAST ABLATOR NODE (INCHES)F
17.4/14X,10HTHERE ARE ,12,40H NODELETS ASSIGNED TO EACH ABLATING NO
2DE)
DELM=DELM/12.0
C ----- READ BACKWALL HEAT TRANSFER
C IBF = NUMBER OF TABULAR ENTRIES
C HCONV = BACKWALL CONVECTIVE COEFFICIENT
C EPSW = BACKWALL EMMISIVITY; RADIATES TO ZERO DEG R
C TRES = RESERVOIR TEMPERATURE FOR CONVECTION
C CHCRI = CHAR ZONE CRITERIA (RC)
C PYCRI = PYROLYSIS ZONE CRITERIAL (RP)
C NCON = OUTPUT THERMAL CONDUCTIVITY INSTEAD OF ENTHALPY
C
      READ(5,582) IBF,HCONV,EPWS,TRES,CHCRI,PYCRI,NCON
582 FORMAT(12,F8.5,4F10.5,9X,11)
      IF (IBF.EQ.0) GO TO 305
C ----- READ TIME DEPENDENT BACKWALL HEAT TRANSFER TABLE
C TQ = TIME
C THCONV = BACKWALL CONVECTIVE COEFFICIENT
C TEPSW = BACKWALL EMISSIVITY FOR RADIATION TO ZERO DEG R
C TEPDS = BACKWALL EMISSIVITY FOR RADIATION TO TTRES
C TTRES = RESERVOIR TEMPERATURE

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INPOU329
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 INPOU 70
 INPOU 71
 INPOU358

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DO 306 I = 1, IBF
READ(5,590) TQ(1), THCONV(1), TEPSW(1), TEPSD(1), TTRES(1)
590 FORMAT(5F10.5)
306 CONTINUE
GO TO 307

C
305 DO 308 I = 1, 2
    THCONV(I) = HCONV
    TEPSW(I) = EPSW
    TEPSD(I) = 0.0
    TTRES(I) = TRES
308 CONTINUE
    TQ(1) = THZRO
    TQ(2) = THFIN
    IBF = 2
307 IF (CHCRI.LE.0.0) CHCRI = 0.02
    IF (PYCRI.LE.0.0) PYCRI = 0.98
    TA(NUMN+1) = TRES
    CALL LCOUNT(4, LCT, NPG)
    WRITE(KOUT, 581) HCONV, EPSW, TRES
581 FORMAT(/14X20HBACK WALL CONVECTION10X9HBACK WALL10X9HRESERVOIR/
113X23HCOEF BTU/FTSQ-SFC-DEG R8X10HEMISSIVITY8X11HTEMPERATURE/
217XF10.4, 18XF6.3, 10XF10.2)
WRITE(6, 591)
591 FORMAT(20H BACKWALL CONDITIONS /
1 57H TIME(SEC) CH(BTU/S/F2/R) EMSW EMSD TRES(R) )
    DO 309 I = 1, IBF
    WRITE(6, 592) TQ(1), THCONV(1), TEPSW(1), TEPSD(1), TTRES(1)
592 FORMAT( F8.2, F14.4, F13.3, F13.3, F10.1)
309 CONTINUE

C
    CALL LCOUNT(5, LCT, NPG)
    WRITE(KOUT, 522)
522 FORMAT(/18X48H---HEAT OF FORMATION OF MATERIAL CONSTITUENTS---/37X
18H(BTU/LB)/21X7HPLASTIC11X4HCHAR17X3HGAS)
    WRITE(KOUT, 523) DH1, DH2, DELHG
    CALL LCOUNT(2, LCT, NPG)
523 WRITE OUT ENTHALPY DATUM TEMPERATURE
C
    WRITE(KOUT, 524) TZ
524 IF (NDBU.LE.0) GO TO /910
    DO 7908 J = 1, NDBU
    CALL LCOUNT(8, LCT, NPG)
    WRITE(KOUT, 7902) J
7902 FORMAT(/21X7HPLASTIC11X4HCHAR17X3HGAS)
    WRITE(KOUT, 7909)
7909 WRITE(KOUT, 523) DHV(J), DHC(J), DELHG
    WRITE(KOUT, 524) TREF(J)
7908

C
C ----- MATERIAL PROPERTIES
C
7910 CALL LCOUNT(6, LCT, NPG)
    WRITE(KOUT, 525)
525 FORMAT (/22X36H---MATERIAL THERMAL PROPERTY DATA---//6X14HMATERI
11AL NO. 110X14HMATERIAL NO. 210X26HMATERIAL NOS. 3 THROUGH 10/6X14
2HVIRGIN PLASTIC15X4HCHAR23X7HBACK-UP)
    CALL LCOUNT(3, LCT, NPG)
    WRITE(KOUT, 7905)
7905 FORMAT(/3X, 82HDECOMPOSING BACK-UP VIRGIN MATERIALS 22, 24, 26, 28, 30,
1 CHAR MATERIALS 23, 25, 27, 29, 31)
    IT = 0
  
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      ILO(3)=1
      ILO(4)=1
      KT=1
350 IT=IT+1
C ----- READ MATERIAL PROPERTY TABLES
C NC = FLAG TO MARK END OF MATERIAL TABLE
C TT2 = TEMPERATURE
C TCP = SPECIFIC HEAT
C TKP = THERMAL CONDUCTIVITY
C TEP = EMISSIVITY OF FRONT FACE
C TEPBF = EMISSIVITY OF BACK FACE
C
      READ (INPUT,571) NC,TT2(IT,KT),TCP(IT,KT),TKP(IT,KT),TEP(IT,KT),
1 TEPBF(IT,KT)
      IF (NC.EQ.0) GO TO 350
      IHI(KT+2)=ILO(KT+2)+1-1
      IR(KT+2)=ILO(KT+2)
      THZ(1,KT)=0.
C ----- COMPUTE ENTHALPY
C DO 357 I=2,IT
357 THZ(1,KT)=THZ(1-1,KT)+(TCP(1,KT)+TCP(1-1,KT))/2.*(TT2(1,KT)-TT2(1-
1,KT))
      CALL LOOK (KT+2,TZ,TT2(1,KT),THZ(1,KT),0,0,0, HSH,DUM,1)
C ----- REFERENCES ZERO ENTHALPY AT DATUM TEMPERATURE, TZ
C DO 359 I=1,IT
359 THZ(1,KT)=THZ(1,KT)-HSH
      CALL LCOUNT(6+IT,LCI,NPG)
C ----- ECHO MATERIAL PROPERTY INPUT
      WRITE(KOUT,526)KT,RHO(KT), (TT2(1,KT),TCP(1,KT),TKP(1,KT),THZ(1,KT) INPOU405
1,TEP(1,KT),TEPBF(1,KT),I=1,IT)
526 FORMAT(/6X12HMATERIAL NO.12,30X9HDENSITY =F8.3,1X8HLB/CU FT/ INPOU 79
1 7X11HTEMPERATURE5X13HSPECIFIC HEAT5X12HCONDUCTIVITY5X8HSENIPOU 80
2SIBLE4X5HEMISS,5X,5HEMISS /58X,8HENTHALPY,4X,5HFRONT,5X,4HBACK/
3 9X,7H(DEG R),7X,12H(BTU/LB-DEG),4X,16H(BTU/FT-SEC-DEG),
4 3X,8H(BTU/LB)/
5 (8XF8.2,8XF7.4,9XF10.7,7XF9.2,4XF7.4,4X,F7.4))
      KT=KT+1
      IT=0
      IF (NC.GE.0) GO TO 353
      IF (KT.LE.2) GO TO 350
      IF (NDBU.EQ.0) GO TO 4110
      I=1
C ----- PROCESS DECOMPOSING BACKUP MATERIALS
C
C DO 720 K=1,NDBU
      IT=0
712 IT=IT+1
      READ(INPUT,571) NC,IT5(IT,1),TCBU(IT,1),TKBU(IT,1)
      IF (NC) 713,712,713
713 IHI(1+21)=IT
      ILO(1+21)=1
      IR(1+21)=1
      TENT(1,1)=0.
      DO 714 J=2,IT
714 TENT(J,1)=TENT(J-1,1)+(TCBU(J,1)+TCBU(J-1,1))/2.*(TT5(J,1)-TT5(J-1
1,1))
      CALL LOOK(21+1,ITREF(K),IT5(1,1),TENT(1,1),0,0,0, HSH,DUM,1)
      DO 715 J=1,IT
715 TENT(J,1)=TENT(J,1)-HSH

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    IF (2*K-1) 717,716,111
716 RRR=RHO(K)
    GO TO 718
717 RRR=RHOV(K)
718 CALL LCOUNT(6+IT,LCT,NFG)
    L=I+21
    WRITE(KOUT,5260) L,RRR,(TT5(J,I),TCBU(J,I),TKBU(J,I),TENT(J,I),
1J=1,IT)
5260 FORMAT(/6X12HMATERIAL NO.12,30X9HDENSITY =F8.3,1X8HLB/CU FT/
1 7X11HTEMPERATURE5X13HSPECIFIC HEAT5X12HCONDUCTIVITY5X8HSENI
2SIBLE /58X8HENTHALPY/9X7H(DEG R)7X12H(BTU/LB-DEG)4X1
36H(BTU/FT-SEC-DEG)3X8H(BTU/LB)/
4 (8XF8.2,8XF7.4,9XF10.7,7XF9.2 ))
    I=I+1
    IT=0
    IF (NC.GE.0) GO TO 353
    IF (2*K-1.EQ.0) GO TO 712
720 CONTINUE
C
4110 IN=0
    L=0
C
----- F-FUNCTION TABLE LEAD LINE
411 READ(INPUT,561) KT,LEMB,RHO(KT),(KMTL(1),I=1,6)
561 FORMAT(12,11,F7.4,611)
    IF (RHO(KT)) 3550,3550,355
3550 LL=1
    L=L+1
    JBU=0
    IF (KMTL(1).GT.0) GO TO 3559
    WT=FLOAT(L)
    IN=1
    LL=2
3559 DO 3554 I=LL,6
    IF (KMTL(I).LE.0) GO TO 3554
    JBU=JBU+1
    KSV(JBU)=KMTL(I)
    J=KMTL(I)
    NBUFT(J)=L
3554 CONTINUE
    IF (JBU.LE.0) GO TO 3540
    CALL ORDERI(JBU,KSV)
3540 IX=0
3551 IX=IX+1
C
----- F-FUNCTION TABLE
497 READ(INPUT,497) NC,TX(IX,L),F1(IX,L),F2(IX,L)
    IF (NC.EQ.0) GO TO 3551
    ILO(L+31)=1
    IHI(L+31)=IX
    IR(L+31)=1
    CALL LCOUNT(5+IN+JBU+4*(1-(L+2)/4),LCT,IG)
    IF (L.LE.1) WRITE(6,495)
495 FORMAT(/7X,67HTABLES OF OPTIONAL MASS-FRACTION FUNCTIONS FOR THER
1MAL CONDUCTIVITY/25X,23HK = F1(X)*KP + F2(X)*KC)
    WRITE(KOUT,496) L
496 FORMAT(/23X,21HF-FUNCTION TABLE NO. ,11,12H ASSIGNED TO)
    IF (IN.GT.0) WRITE(6,4971)
4971 FORMAT(34X,13HMAIN MATERIAL)
    IF (JBU.GT.0) WRITE(6,4981){KSV(1),I=1,JBU}
4981 FORMAT(28X,24HDECOMPOSING BACK-UP NO. ,11)

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WRITE(KOUT,494) (TX(I,I),F1(I,I),F2(I,L),I=1,IX)
494 FORMAT(/25X,1HX,12X,5HF1(X),10X,5HF2(X)//(13X,3(5X,F10.4))) INPOU478
      IN=0 INPOU477
      IF (NC) 411,411,353 INPOU484
355 IT=IT+1 INPOU485
C ----- READ BACKUP MATERIAL PROPERTIES
  READ (INPUT,571) NC,I12(IT,KT),TCP(IT,KT),TKP(IT,KT),TEP(IT,KT),
1  TEPBF(IT,KT)
  IF (LEMB.EQ.0) TEPBF(IT,KT) = TEP(IT,KT)
  IF (NC.EQ.0) GO TO 355
  ILO(KT+2)=1
  IHI(KT+2)=ILO(KT+2)+IT-1 INPOU489
  IR(KT+2)=ILO(KT+2) INPOU490
  CALL LCOUNT(5+IT,LCT,NPG)
C ----- ECHO BACKUP MATERIAL PROPERTIES
  WRITE (KOUT,527) KT,RHO(KT),(TT2(I,KT),TCP(I,KT),TKP(I,KT),
1  TEP(I,KT),TEPBF(I,KT),I=1,IT)
527 FORMAT(/6X12HMATERIAL NO.12,30X9HDENSITY =F8.3,1X8HLB/CU FT/ INPOU 89
1  7X11HTEMPERATURE5X13HSPECIFIC HEAT5X,7HCONDUCT,5X,
2  5HEMISS,5X,5HEMISS/9X,7H(DEG R),
3  7X12H(BTU/LB-DEG)4X16H(BTU/FT-SEC-DEG),1X,5HFRONT,2X,4HBACK/
4  (8XF8.2,8XF7.4,9XF10.7,4X,F7.4,4X,F7.4))
      IT=0 INPOU493
      IF (NC.LE.0) GO TO 411
C ----- PYROLYSIS GAS ENTHALPY INPOU495
353 NT1=0
361 IN=1+NT1 INPOU497
      NT1=8+NT1 INPOU498
      READ (INPUT,575)NC,(IT1(I),I=IN,NT1),(THG(I),I=IN,NT1) INPOU499
575 FORMAT(11,F9.5,7F10.5/8F10.5) INPOU126
      IF (NC)361,361,362 INPOU500
364 NT1=NT1-1 INPOU501
362 IF (TT1(NT1).LE.0.0) GO TO 364
      ILO(2)=1
      IR(2)=1 INPOU504
      IHI(2)=NT1 INPOU505
      CALL LCOUNT(3*((NT1+9)/5),LCT,NPG)
C ----- DISPLAY RESIN DECOMPOSITION TABLE
  WRITE (KOUT,532)
532 FORMAT (/20X47H---RESIN DECOMPOSITION GAS SENSIBLE ENTHALPY---) INPOU 94
      IFN=0 INPOU508
368 IN=IFN+1 INPOU509
      IFN=MINO(NT1,IFN+5) INPOU510
      WRITE (KOUT,531)(TT1(I),I=IN,IFN) INPOU511
531 FORMAT (1H /6X19HTEMPERATURE (DEG R)5F11.2) INPOU 93
      WRITE (KOUT,533)(THG(I),I=IN,IFN) INPOU512
533 FORMAT (6X19HENTHALPY (BTU/LB)5F11.2) INPOU 95
      IF (NT1.GT.1FN) GO TO 368
C
C ----- FUNCTIONS OF TIME INPOU514
C
      NTH=0
      IS=0 INPOU516
      NOPT=0 INPOU517
      CALL LCOUNT(-3,LCT,NPG)
      WRITE(6,545)
545 FORMAT(26X, 46H--INPUT TIME DEPENDENT BOUNDARY CONDITIONS-- /)
C ----- READ SURFACE BOUNDARY CONDITIONS
C RADUS = NOSE RADIUS USED TO MODIFY CONV. AND RAD. HEAT TRANSFER
C BY (RN)**-0.5

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C   QFC = CONVECTIVE HEAT TRANSFER FACTOR
C   QFR = RADIATIVE HEAT TRANSFER FACTOR
C   QFF = FREE MOLECULAR FLOW HEAT TRANSFER FACTOR
C   QFP = SURFACE PRESSURE FACTOR
C   IEROS = IF NOT ZERO, USES LUNDELL & DICKEY EROSION MODEL
C   IBPRD = NOT USED
C   ISR = IF NOT ZERO, NO SURFACE RECESSON ALLOWED, BUT BLOWING AND
C         ENERGY LOSS TERMS INCLUDED
C   ICOND = NUMBER OF GAS CONDUCTIVITY TABLES FOR GAPS
C   IBUG = DEBUG OUTPUT SWITCH ( 0 = NO DEBUG OUTPUT)
C   TBUG = TIME IN WHICH THE DEBUG OUTPUT STARTS
C
C   READ(5,540) RADUS,QFC,QFR,QFF,QFP,IEROS,IBPRD,ISR,ICOND,IBUG,TBUG
540 FORMAT( 5F10.0,5I2, F10.0)
C   WRITE(6,541) RADUS, QFC, QFR, QFF,QFP
541 FORMAT( 26H --INPUT TIME TABLES----- /
1 18H NOSE RADIUS(IN) = , F10.4 , 5X,15HQCOND FACTOR = , F10.4 /
2 18H QRAD FACTOR = , F10.4 , 5X,15HQFMF FACTOR = , F10.4 /
3 18H PRESS FACTOR = , F10.4 )
C   ----- CONVERSION FOR RADIUS
C   FACT1 = SQRT(RADUS/12.0)
C   WRITE(6,542)
542 FORMAT(
C     41H TIME VEL ALT HT PT
1     38H QRAD QCOND QFMF BP /
2     41H SEC FPS KFT BTU/LB ATM ,
3     38H -----BTU/LB/FT**2----- )
371 NTH=NTH+1
C   ----- SURFACE BOUNDARY CONDITIONS TIME-TABLE
C   NC = FLAG TO INDICATE LAST LINE OF TIME TABLE
C   TTH = TIME
C   THE = OPTION 1: RECOVERY ENTHALPY
C           2: SURFACE TEMPERATURE
C           3: RADIATION VIEW FACTOR
C   XQRAD = OPTION 1: RADIANT ENERGY FLUX TO SURFACE
C           2: SURFACE RECESSON RATE
C           3: RADIANT ENERGY FLUX TO SURFACE
C   XQCO = OPTION 1: CONVECTIVE ENERGY FLUX TO COLD SURFACE
C           2: < 0.0 INVOKES OPTION 2
C           3: = 0.0 INVOKES OPTION 3
C   XQFM = OPTION 1: FREE MOLECULAR ENERGY FLUX TO SURFACE
C           2: BLANK
C           3: BLANK
C   TPI = OPTION 1: SURFACE PRESSURE
C           2: BLANK
C           3: BLANK
C   TALT = ALTITUDE
C   TVEL = VELOCITY
C   TBRP = BLOWING REDUCTION PARAMETER IF TIME DEPENDENT.
C         BLANKS WILL BE FILLED BY CONSTANT VALUES FROM ABOVE
C         OR BY PUTZ AND BARTLETTE CORRELATION.
C
C   READ(5,577) NC,ITH(NTH),THE(NTH),XQRAD,XQCO,XQFM,TPI(NTH),
1     TALT(NTH),TVEL(NTH),TBRP(NTH)
577 FORMAT(11,F9.2,F10.1,3F10.2,F10.5,F6.1,F7.1,F7.2 )
C   WRITE(6,543) TTH(NTH),TVEL(NTH),TALT(NTH),THE(NTH),TPI(NTH),
1     XQRAD,XQCO,XQFM,TBRP(NTH)
543 FORMAT(1X,F7.1,F8.0,F8.2,F11.1,F10.5,F9.1,F8.1,F8.1,F6.1)
C   ----- ADJUST TIME TABLE VALUES USING FACTORS
C   TPI(NTH) = TPI(NTH)*QFP
  
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INPOU518

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XQFM      = XQFM*QFF
TQR(NTH)  = XQRAD*FACT1*QFR
TALT(NTH) = TALT(NTH)*1000.0
TCM(NTH)  = XQCO*QFC/FACT1
IF(XQFM.LE.0.0) GO TO 190
IF (XQFM/XQCO.GT.10.0) GO TO 190
C ----- BRIDGING FREE MOLECULAR TO CONTINUUM CONVECTION
TCM(NTH)  = TCM(NTH)*(1.0 - EXP(-XQFM/TCM(NTH)))
190 IF(THE(NTH).NE.0.0) TCM(NTH)=TCM(NTH)/THE(NTH)
IF (TBRP(NTH).EQ.0.0) TBRP(NTH) = BRP
C ( 11 = PROBLEM OPTION SELECTION BASED ON TIME-TABLE INPUT)
11=1
IF(TCM(NTH).GT.0.0) GO TO 343
11=2
IF (THE(NTH).EQ.0.0) 11=3
343 IOPT(NTH)=11
IF (11.EQ.15) GO TO 346
NOPT=NOPT+1
IS=11
C
C (1/16/87) TIME-TABLE LENGTH CHANGED TO 120
C
IF(NTH.LE.120) GO TO 346
WRITE(6,544)
544 FORMAT( 35H ----TOO MANY TIME TABLE POINTS---- )
STOP
346 IF(NC.LE.0) GO TO 371
ILO(1)=1
IHI(1)=NTH
IR(1)=ILO(1)
CALL LCOUNT(-4,LCT,NPG)
WRITE (KOUT,534)
534 FORMAT (1H //23X40H---TIME DEPENDENT BOUNDARY CONDITIONS---/1H )
IS=0
DO 3476 1=1,NTH
11=IOPT(1)
IF (11.EQ.15) GO TO 349
IS=11
GO TO (3471,3472,3473),11
3471 WRITE(KOUT,535)
535 FORMAT (9X,4HTIME,8X,4HPROB,3X,8HRECOVERY,3X,9HRADIATION,4X,4HHEAT
15X,8HPRESSURE,3X,7HBL OWING/9X,5H(SEC),7X,4HOPTN,3X,8HENTHALPY,3X,
29HHEAT RATE,4X,5HCOLI I ,14X,9HREDUCTION/28X,8H(BTU/LB),2X,11H(BTU/S
3Q FT-,1X,10H(LB/SQ FT-,3X,5H(ATM),3X,9HPARAMETER /40X,7HSECOND),
44X,7HSECOND))
GO TO 3474
3472 WRITE(KOUT,552)
552 FORMAT (9X,4HTIME,8X,4HPROB,3X,7HSURFACE,4X,7HSURFACE/9X,5H(SEC),
17X,4HOPTN,5X,4HTEMP,5X,9HRECESSION/28X,7H( DEG R),6X,4HRATE/38X,
210H(MILS/SEC))
GO TO 3475
3473 WRITE(KOUT,556)
556 FORMAT (5X,4HTIME,8X,4HPROB,5X,4HVIEW,5X,9HRADIATION/9X,5H(SEC),
17X,4HOPTN,4X,6HFACTOR,4X,9HHEAT RATE/38X,11H(BTU/SQ FT-/40X,
27HSECOND))
GO TO 3475
349 GO TO (3474,3475,3475),11
C ----- DISPLAY CONVERTED TIME-TABLE VALUES
3474 WRITE(KOUT,536) 11H(1),11,THE(1),TQR(1),TCM(1),TPI(1),TBRP(1)
GO TO 3476
INPOU531
INPOU534
INPOU535
INPOU537
INPOU96
INPOU538
INPOU539
INPOU540
INPOU543
INPOU544
INPOU97
INPOU98
INPOU99
INPOU100
INPOU101
INPOU545
INPOU546
INPOU108
INPOU109
INPOU110
INPOU547
INPOU548
INPOU116
INPOU117
INPOU118
INPOU549
INPOU550
INPOU551
INPOU552

```

3475 WRITE(KOUT,536) TTH(1),I,THE(1),TQR(1)
 3476 CONTINUE

INPOU553
 INPOU554

C
 C
 C
 C
 C
 C
 C

END TIME-TABLE PROCESSING

----- CONDUCTIVITY TABLES FOR GAPS (UP TO FOUR)
 NNGC1,GC2,NGC3,NGC4, = NUMBER OF TABULAR VALUES
 TCON1 = TEMPERATURE VALUES OF 1TH TABLE
 CONDI = CONDUCTIVITY VALUES OF ITH TABLE CORRESPONDING TO TCON1

IF (ICOND.EQ.0) GO TO 120
 IF (ICOND.GT.4) GO TO 120
 READ (5,587) NGC1
 READ (5,588) (TCON1(1),COND1(1),I=1,NGC1)
 J=1
 WRITE(6,589) J,(TCON1(1),COND1(1),I=1,NGC1)
 IF (ICOND.EQ.1) GO TO 120
 READ (5,587) NGC2
 READ (5,588) (TCON2(1),COND2(1),I=1,NGC2)
 J=2
 WRITE(6,589) J,(TCON2(1),COND2(1),I=1,NGC2)
 IF (ICOND.EQ.2) GO TO 120
 READ (5,587) NGC3
 READ (5,588) (TCON3(1),COND3(1),I=1,NGC3)
 J=3
 WRITE(6,589) J,(TCON3(1),COND3(1),I=1,NGC3)
 IF (ICOND.EQ.3) GO TO 120
 READ (5,587) NGC4
 READ (5,588) (TCON4(1),COND4(1),I=1,NGC4)
 J=4
 WRITE(6,589) J,(TCON4(1),COND4(1),I=1,NGC4)

120 CONTINUE

C

IF (BRP.LT.0.0) WRITE(6,539)
 539 FORMAT(1H /9X,43HCH/CHO FROM PUTZ AND BARTLETTE CORRELATION)
 IF (BRP.GE.0.0) WRITE(6,537)
 537 FORMAT (1H /9X,69HCH/CHO = PHI/(EXP(PHI)-1.) WHERE PHI = 2.*BRP*M INPOU103
 1DOT/CHO. BRP IN TABLE INPOU104
 IF (IEROS.NE.0) WRITE(6,583)
 583 FORMAT(50H LUNDELL & DICKEY MECHANICAL EROSION CORRELATION)
 IF (ISR.NE.0) WRITE(6,584)
 584 FORMAT(50H ZERO SURFACE REGRESSION OPTION IN EFFECT)
 CALL LCOUNT(-1,LCF,NPG)
 IF (NC.GT.1) GO TO 743
 DO 3731 I=1,NTH
 3731 TPI(I)=ALOG(AMAX1(TPI(I),.000001)) INPOU557

C
 C
 C
 C
 C
 C
 C
 C
 C
 C
 C
 C
 C

SURFACE CHEMISTRY DATA LEAD LINE

----- READ DATA FOR SURFACE EQUILIBRIUM TABLE

INPOU560

CMHS = CM/CH RATIO
 VFZ = OPTION 1 VIEW FACTOR
 BREX = EXPONENT USED TO ADJUST INPUT CONVECTIVE TRANSFER
 COEFFICIENT (RUCH) FOR RADIUS CHANGE DUE TO ABLATIVE
 NR = ONE PUNCH CALLS FOR RADIUS RATIO CORRECTION PER ABOVE
 NST = BLANK
 NBPFF = FLAG TO READ B PRIMEF IN "NEW FORMAT" SURFACE CHEM. TABLE
 NFIS = FLAG TO INVOKE "FISSURE MODEL"
 SWELL = CHAR SWELLS PROPORTIONAL TO CONSTANT K IN FOLLOWING
 SWELL = K(ORIG SURF - SWELL)

```

C
5796 READ(INPUT,5796) CMHS,VFZ,BREX,NR,NST,NBPF,NFIS,SWELL          INPOU561
      FORMAT(2F10.0,F9.0,I1,3(9X,I1),F10.0)                          INPOU141
      NFIS=NFIS+1                                                    INPOU562
      IF(NST.GT.0) GO TO 2901
      CMH = CMHS
      GO TO 2902                                                       INPOU565
2901 IF (KNST.NE.777) GO TO 2909
      IF (CMH.NE.CMHS) GO TO 2907
      WRITE(KOUT,2906)
2906 FORMAT(//10X50HSURFACE TABLES ARE THE SAME AS IN PREVIOUS PROBLEM) INPOU570
      CALL LCOUNT(3,LCT,NPG)
      GO TO 2912                                                       INPOU571
2907 WRITE(KOUT,2908)                                                INPOU572
2908 FORMAT(//10X,72HPREVIOUS SURFACE TABLES CALLED FOR BUT CM/CH RATIO INPOU573
      1 HAS CHANGED, QUIT JOB//)                                     INPOU574
      STOP                                                            INPOU575
2909 WRITE(KOUT,2910)                                                INPOU576
2910 FORMAT(//10X,70HPREVIOUS SURFACE TABLES CALLED FOR BUT THIS IS FIR INPOU577
      1ST PROBLEM, QUIT JOB//)                                       INPOU578
      STOP                                                            INPOU579
2902 KNST=777                                                        INPOU580
2912 IF (NR.GT.0) NR=1
      IF (NST.LE.0) GO TO 3285
      IF (NSEN) 2813,2861,2813

C
C      WLS = SAVED TEST VALUE OF WLQ
C      IP,IPN=PRESSURE INDEX
C      I,IN,J=UTILITY INDEX
C      NSEN=NUMBER OF ENTRIES IN CURRENT EDGE TABLE
C
3285 WLS = -1
      NSEN=-1                                                         INPOU590
      IP=1                                                            INPOU591
      IPN=1                                                            INPOU592
      I=1                                                             INPOU593
      IN=1                                                            INPOU594

C
C      PROCESS SURFACE THERMOCHEMISTRY TABLES
C
      J=0
2800 J=J+1                                                           INPOU595
      IF (NBPF.NE.0) GO TO 28001                                       INPOU596
      ----- READ STANDARD SURFACE THERMOCHEMISTRY TABLES
      USE EDGE TABLES WHEN CM/CH.NE.1.0
      EDGE ENTHALPY TABLE          SURFACE THERMOCHEMISTRY
C      PSV = PRESSURE                | PRESSURE
C      DMS = ---                     | B PRIME GAS
C      TLMC = ---                    | B PRIME CHAR
C      TTS = TEMPERATURE              | SURFACE TEMPERATURE
C      WLQ = UNEQUAL DIFFUSION EXPONENT | UNEQU. DIFF. EXP.
C      TCHEM= SUMMATION OF ZIW*HI**TW | SUMMATION OF ZIW*HI**TW
C      TSEN = ENTHALPY OF EDGE GASES  | ENTHALPY OF WALL GASES
C      JNG = FLAG                     | FLAG
C      TSURF= UNUSED ALPHANUMERIC    | SURFACE SPECIES NAME
C
      I = PYROLYSIS GAS RATE
      J = CHAR RATE
      K = PRESSURE
  
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READ(INCH,5791) PSV,DMS,TLMC(J,I,IP),TTS(J,I,IP),WLQ,TCHEM(J,I,IP) INPOU598
1,TSEN(J),JNG,TSURF(J) INPOU599
5791 FORMAT(3F8.5,F9.4,F5.3,2F9.3,12,A6) INPOU130
TDPF(J,I,IP)=0. INPOU600
GO TO 28002 INPOU601
C
----- READ "NEW FORMAT" URFACE THERMOCHEMISTRY TABLES
C
TDPF = B BRIME FAIL
28001 READ(INCH,5788)PSV,DMS,TLMC(J,I,IP),TTS(J,I,IP),WLQ,TCHEM(J,I,IP) INPOU602
1,TSEN(J),JNG,TSURF(J),TDPF(J,I,IP) INPOU603
5788 FORMAT(3F8.5,F9.4,F5.3,2F9.3,12,2X,A4,4X,E10.3) INPOU605
28002 IF (JNG.LE.0) TSURF(J) = BLANK
IF (TTS(J,I,IP)) 2803,2832,2801 INPOU609
C
----- CONVERT TO DEGREES FAHRENHEIT
2801 TTS(J,I,IP)=TTS(J,I,IP)*1.8 INPOU610
TCHEM(J,I,IP)=TCHEM(J,I,IP)*1.8 INPOU611
TSEN(J)=TSEN(J)*1.8 INPOU612
C
GO TO 2805 INPOU613
2803 TTS(J,I,IP)=-TTS(J,I,IP) INPOU614
2805 IF (WLS.LT.0.0) GO TO 2809
IX=4
IF (WLS-WLQ) 2824,2811,2824 INPOU617
2809 WLS=WLQ INPOU618
2811 IF (NSEN.GE.0) GO TO 2828
IF (JNG.LT.0) GO TO 2800
C
( NSEN = NUMBER OF ENTRIES IN CHEMISTRY TABLES )
NSEN=J-1
ISEN(IP)=NSEN INPOU622
IF (NSEN.LE.1) GO TO 2820
DO 2806 L=1,NSEN
TISEN(L,IP)=TTS(L,I,IP) INPOU625
TISEN(L,IP)=TCHEM(L,I,IP) INPOU626
2806 TISEN(L,IP)=TISEN(L) INPOU627
CALL SLOPQ(NSEN,TISEN(1,IP),TISEN(1,IP),TCISEN(1,IP)) INPOU628
CALL SLOPQ(NSEN,TISEN(1,IP),TISEN(1,IP),TCISEN(1,IP)) INPOU629
LLL=(NSEN-1)/3+1 INPOU630
IF (IP.NE.1) GO TO 28137
2813 CALL LCOUNT(11+2*NR,ICT,NPG)
WRITE (KOUT,538) INPOU633
WRITE (KOUT,5797) CMH,WLQ,VFZ INPOU634
5797 FORMAT(/6X,45H RATIO OF MASS TO HEAT TRANSFER COEFFICIENTS =,F6.3/INPOU142
1 6X,28HUNEQUAL DIFFUSION EXPONENT =,F6.3/6X,29H NOMINAL SURFACE VIE INPOU143
2W FACTOR =,F6.3,11H (OPTION 1)) INPOU144
IF (NFIS.EQ.1) GO TO 28130
WRITE(KOUT,28132)
GO TO 28133 INPOU639
C
28130 WRITE(KOUT,28612) INPOU640
28133 CONTINUE INPOU641
IF (NR.LE.0) GO TO 2818
WRITE (KOUT,5799) BRX
5799 FORMAT (6X,66H HEAT TRANSFER COEFFICIENT MULTIPLIED BY (R INITIAL/R INPOU147
1 CURRENT)**EX./8X,10H WHERE EX = ,F8.5 )
GO TO 2815 INPOU644
C
2818 WRITE (KOUT,5790) INPOU645
2815 IF (SWELL.NE.0.0) GO TO 28134
WRITE(KOUT,28136)
GO TO 28137 INPOU649
C

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28134 WRITE(KOUT,28138) SW11 INPOU650
28137 IF (NST.GT.0) GO TO /43
      CALL LCOUNT(LLL+6,LC1,NPG)
      WRITE(KOUT,5792)PSV INPOU654
5792 FORMAT(//6X,3HP =,F9.4,4H ATM//6X,3(25HTEMPERATURE EDGE ENTH )/ INPOU131
      16X,3(25H {DEG R} AT T-WALL )) INPOU132
      DO 2819 LL=1,LLL INPOU655
2819 WRITE(KOUT,5798) (TISEN(L,IP),THSEN(L,IP),L=LL,NSEN,LLL) INPOU656
5798 FORMAT (6X,F9.2,4X,F9.2,3X,F9.2,4X,F9. INPOU145
      12,3X,F9.2,4X,F9.2) INPOU146
      GO TO 2862 INPOU657

C
2820 NSEN=0 INPOU658
      IX=3 INPOU659
      IF (CMH.NE.1.0) GO TO 2824
      IX=2
      IF (WLQ.EQ.0.0) GO TO 2826
2824 WRITE (KOUT,5793) IX
5793 FORMAT (//6X,37HBAD SURFACE EQUILIBRIUM TABLE OF TYPE,12) INPOU133
      STOP INPOU664

C
2826 IF (IP-1) 2862,2861,2862 INPOU665
2828 IF (TTS(J,1,IP).EQ.0.0) GO TO 2832
      IF (PSV.NE.TPR(IP)) GO TO 2832
      IF (DMS-TMG(1,IP)) 2834,2800,2834

2832 IPN=IP+1 INPOU669
      NMG(IP)=1 INPOU670
      NCS = 1
      IN=0 INPOU671
      NSEN=-NSEN INPOU672
2834 IN=IN+1 INPOU673
      NHI(1,IP)=J-1 INPOU674
      NMC=J-1 INPOU675
      CALL ORDERD(NMC,TLMC(1,1,IP),IZ) INPOU676
      IF (NBPF.LE.0) GO TO 3852
      CALL SEQUA5(NMC,IZ,TIS(1,1,IP),TCHEM(1,1,IP),TSEN(1),TSURF(1),TBPF INPOU678
      1(1,1,IP)) INPOU679
      GO TO 4853 INPOU680

C
3852 CONTINUE INPOU681
      CALL SEQUA(NMC,IZ,TIS(1,1,IP),TCHEM(1,1,IP),TSEN(1),TSURF(1)) INPOU682
4853 CONTINUE INPOU683
      IX=0 INPOU684
      IQ=1 INPOU685
      BPG=TMG(1,IP) INPOU686
      NLO(1,IP)=1 INPOU687
      KHI(1,IP)=1 INPOU688

C
C FIRST STEP OF CALCULATING QCHEM/RUCH:
C TCHEM = (B'C*MG + B'C*HC - B'C*HW) - (ZIE - ZIW)HI**TW
C
      DO 2852 K=1,NMC INPOU689
      BP=BPG+TLMC(K,1,IP) INPOU690
      IF (NFIS.EQ.1) GO TO 28340
      HGA=TSEN(K)
      GO TO 28342 INPOU693
28340 CONTINUE INPOU694
      CALL LOOK(2,TIS(K,1,IP),TT1,THG,0.0,0.0,HGA,CT1,1) INPOU695
      HGA=HGA+DELHG INPOU696
28342 CALL LOOK(4,TIS(K,1,IP),TT2(1,2),THZ(1,2),0.0,0.0,HGH,CT2,1)

```

```

HCH=HCH+DHZ
IF (NSEN.NE.0) GO TO 2838
NE=TCHEM(K,I,IP)
C ----- SIMPLIFIED SURFACE ENERGY BALANCE
C USE FOR EQUAL DIFFUSION COEFFICIENT CASES AND WHEN CM/CH=1.0
C TCHEM = B'G*HG + B'C*HC - B'*HW
C
TCHEM(K,I,IP)=BPG*HGA+TLMC(K,I,IP)*HCH-BP*TSEN(K)
GO TO 2840
2838 CALL OGLE(1,TTS(K,I,IP),HZ,ISEN(IP),TSEN(1,IP),TSEN(1,IP),TCZSEN(1,IP))
1(1,IP))
CALL OGLE(1,TTS(K,I,IP),HE,ISEN(IP),TSEN(1,IP),TSEN(1,IP),TCZSEN(1,IP))
1(1,IP))
C ----- COMPLETE SURFACE ENERGY BALANCE
C USE FOR UNEQUAL DIFFUSION COEFFICIENT CASES
C TCHEM = B'G*HG + B'C*HC - B'*NEW + ZIE*HI**TW - ZIW*HI**TW
C
TCHEM(K,I,IP)=BPG*HGA+TLMC(K,I,IP)*HCH-BP*TSEN(K)+HZ-TCHEM(K,I,IP)
2840 TSEN(K)=HE
IF (TSURF(K).NE.BLANK) GO TO 2844
NLO(I,IP)=K+1
IF (IG+IX-1) 2846,2846,2824
2844 IX=1
2846 IF (X.LE.IG) GO TO 2852
IF (TTS(K,I,IP).GT.TTS(K-1,I,IP)) GO TO 2851
IG=NMC
GO TO 2852
2851 KHI(I,IP)=K
2852 CONTINUE
LLL=(NMC-1)/2+1
CALL LCOUNT(LLL+6,LCT,NPG)
C ----- DISPLAY CHEMISTRY TABLES
WRITE(KOUT,5795)TMC(I,IP),TPR(IP),((TTS(L,I,IP),TLMC(L,I,IP),TCHEM(L,I,IP))
1(L,I,IP),TSEN(L),L=LL,NMC,LLL),LL=1,LLL)
C
C (1/30/87) BELOW FORMAT CHANGED TO EXPAND CHEM.PROD. COLUMNS.
C
5795 FORMAT(//6X,14HM-DO1-GAS/CM =,F7.4,8X,10HPRESSURE =,F11.6,4H ATM//
16X,2(5H TEMP,5X,27HM-DO1- CHEM.PROD H WALL ,3X)/5X,
22(38H (DEG R) CHAR/CM (BTU/IB) (BTU/LB),2X)/(5X,F8.2,2X,
3 F7.4,1X,F11.2,1X, F8.1,2X,F8.2,1X,F8.4,1X,F11.2,1X,F8.1))
C
C FINISH QCHEM/RUCH CALCULATION
C (TCHEM' = CM/CH * TCHEM - HW)
C
DO 2856 K=1,NMC
TCHEM(K,I,IP)=CMH*TCHEM(K,I,IP)-TSEN(K)
IF (K.LT.NLO(I,IP)) GO TO 2856
C TAKE NATURAL LOG OF B'C
TLMC(K,I,IP)=ALOG(AMAX1(TLMC(K,I,IP),.00001))
IF (NBPFL.E.0) GO TO 2856
C TAKE NATURAL LOG OF B'FAIL
TBPFL(K,I,IP)=ALOG(AMAX1(TBPFL(K,I,IP),1.E-12))
2856 CONTINUE
IF (TTS(J,I,IP)) 2862,2870,2862
C ----- WRITE OPTIONS
2861 CALL LCOUNT(10+2*NR,LCT,NPG)
WRITE (KOUT,538)
WRITE (KOUT,5794) VHZ
5794 FORMAT (//6X,74HEQUAL MASS AND HEAT TRANSFER COEFFICIENTS AND EQUAINPOU134
    
```

```

1L DIFFUSION COEFFICIENTS/6X,29HNOMINAL SURFACE VIEW FACTOR =,      INPOU135
2F6.3)                                                                INPOU136
  IF (NFIS.EQ.1) GO TO 28610
  WRITE(KOUT,28132)
  GO TO 28613                                                         INPOU747
28610 WRITE(KOUT,28612)                                              INPOU748
28613 IF (NR.LE.0) GO TO 2863
  WRITE(KOUT,5799) BR1X
  GO TO 2715                                                         INPOU753
2863 WRITE (KOUT,5790)                                              INPOU754
2715 IF (SWELL.NE.0.0) GO TO 2734
  WRITE(KOUT,28136)
  GO TO 2737                                                         INPOU757
2734 WRITE(KOUT,28138) SWELL.                                       INPOU758
C ----- OPTION TO REUSE PREVIOUS CHEMISTRY TABLES
2737 IF (NST.GT.0) GO TO 743
2862 TPR(IPN)=PSV
  TMG(IN,IPN)=DMS
  TLMC(1,IN,IPN)=TLMC(J,1,IP)
  TBPF(1,IN,IPN)=TBPF(J,1,IP)
  TTS(1,IN,IPN)=TTS(J,1,IP)
  TCHEM(1,IN,IPN)=TCHEM(J,1,IP)
  TSURF(1)=TSURF(J)
  TSEN(1)=TSEN(J)
  J=1
  I=IN
C (IP = PRESSURE INDEX )
  IP=IPN
  GO TO 2800                                                         INPOU770
C                                                                    INPOU771
C
C END LOOP TO PROCESS SURFACE CHEMISTRY DATA
C
2870 NPR=IP                                                         INPOU772
  IR(12)=1                                                         INPOU773
  ILO(12)=1                                                         INPOU774
  IHI(12)=1                                                         INPOU775
C ----- TAKE NATURAL LOGARITHMS OF TABLE PRESSURES
  DO 2872 I=1,IP
2872 TPR(I)=ALOG(TPR(I))
  IR(13)=1
  IHI(13)=NPR
  ILO(13)=1
  743 CALL DIKI(BA,BB,BC,TSEN,TL,TH,O,JTBL)

```

```

C
C ----- TO ACTIVATE SPECIAL HUNTER SUBROUTINE MERGER PROCEDURE BY CCC.
C (12-28-87)
C ----- JTBL MUST EQUAL 0 OR 1 TO READ IN VALUES BELOW -----
C IBLOPT = 0; NO CORRECTION ON GRAD DUE TO BLOWING EFFECTS
C IBLOPT = 1; CORRECT SURF. RAD'N H.T. USING AIR ABLATION SPECIES
C IBLOPT = 2; CORRECT SURF. RAD'N H.T. USING CARBON ABLATION SPECIES
C IOPTN = 0; NO MERGING EVOKED. JTBL CAN BE 0 OR 1.
C IOPTN = 1; USE A DIKI-TO-TABLES TRANSITION WALL TEMPERATURE;
C   TCRIT REQUIRED.
C IOPTN = 2; USE THE WALL TEMPERATURE AT A SPECIFIED BPRIME;
C   BPCRIT REQUIRED.
C IOPTN = 3; MERGE USING SLOPE SEARCH METHOD.
C TCRIT = TEMPERATURE TRANSITION CRITERIA.
C BPCRIT = FIND TEMPERATURE AT B' CRITERIA FOR TRANSITION.
C IMSG = SWITCH TO PRINT MESSAGES;
C   = 0; DO NOT PRINT MESSAGES;

```



```
C      = 1; PRINT 'MERGER' MESSAGES (TIME, ITERATION, MERGE FACTOR);  
C      = 2; PRINT 'MERGER' MESSAGES & MERGE2 OR MERGE3 MESSAGES.  
C      MITER = NUMBER OF ITERATIONS BETWEEN UPDATES OF MERGE FACTOR.  
C      ----- USE BELOW ONLY IF IOPTN > 0  
C      TABCN = 0.0; USE MODIFIED HUNTER EQN. TO FIND NON-ABLATION TEMP.  
C      > 0.0; NON-ABLATING MATERIAL BELOW TABCN.  
C  
C      READ(5,2000)IBLOPT,IOPTN,TCRIT,BPCRIT,IMSG,TABCN,MITER  
C      IF(IBLOPT.LE.0) WRITE(6,2040)  
C      IF(IBLOPT.EQ.1) WRITE(6,2020)  
C      IF(IBLOPT.GE.2) WRITE(6,2030)  
C      IF(IOPTN.GE.1.AND.JTBL.GE.0) GO TO 2420  
C      IOPTN=0  
C      WRITE(6,2300)  
C      RETURN  
C      2420 IF(IOPTN.EQ.1) WRITE(6,2100) TCRIT  
C      IF(IOPTN.EQ.2) WRITE(6,2200) BPCRIT  
C      IF(IOPTN.GE.3) WRITE(6,2500)  
C      IF(TABCN.LE.0.0) WRITE(6,2550)  
C      IF(TABCN.GT.0.0) WRITE(6,2650)TABCN  
C      WRITE(6,2600)MITER  
C      WRITE(6,2700)IMSG  
C  
C      2000 FORMAT(2I5,2F10.4,15,F10.4,15)  
C      2040 FORMAT('/', 'NO BLOWING EFFECT ON SURFACE RADIATIVE HEAT TRANSFER.'  
C      +',/)  
C      2020 FORMAT('/', 'BLOWING EFFECT ON SURFACE RADIATIVE HEAT TRANSFER '  
C      +', USING AIR ABLATION SPECIES.',/)  
C      2030 FORMAT('/', 'BLOWING EFFECT ON SURFACE RADIATIVE HEAT TRANSFER '  
C      +', USING CARBON ABLATION SPECIES.',/)  
C      2100 FORMAT(' DIKI-TO-TABLES MERGER TEMPERATURE',  
C      1' OF ',F10.5,' DEG R SELECTED.',/)  
C      2200 FORMAT(' SEARCH FOR MERGER TEMPERATURE AT BPRIME OF ',F10.5,  
C      1' SELECTED.',/)  
C      2300 FORMAT(' DIKI-TO-TABLES MERGER OPTION NOT EVOKED.',/)  
C      2500 FORMAT(' SEARCH FOR MERGER TEMPERATURE BASED ON MINIMUM',  
C      1' SLOPE DIFFERENTIAL.',/)  
C      2550 FORMAT(' COMPUTE TEMPERATURE FOR NON-ABLATOR.',/)  
C      2650 FORMAT(' NON-ABLATOR TEMPERATURE OF ',F10.4,' DEG R SELECTED.',/)  
C      2600 FORMAT(' UPDATE MERGE FACTOR & NON-ABLATOR TEMP. EVERY',15,  
C      1' ITERATIONS.',/)  
C      2700 FORMAT(' PRINT MESSAGES CODE = ',13,/)  
C      RETURN  
C      END
```

INPOU791

DSNAME = 'BBE.CCC1.SOURCE.CMA6.PDS(MAIN)'
 DCB=(RECFM=FB,LRECL=80,BLKSIZE=6160)

VOL=SER=D8D080
 01/19/88 019 14:41:17

C MAINLINE DUMMY ROUTINE WHICH DRIVES CBM AND INPOUT SUBROUTINES
 1 CALL INPOUT
 CALL CBM
 GO TO 1
 END

MAIN 1
 MAIN 2
 MAIN 3
 MAIN 4
 MAIN 5

C
 C BLOCK DATA INITIALIZES COMMON VARIABLES TO ZERO. DIMENSION OF X AND
 C Y BELOW MUST BE INCREMENTED BY ABOUT 20 FOR EACH OF THEIR VARIABLES
 C WHOSE DIMENSION HAS BEEN INCREASED.

C
 C (1/20/87) X,Y RANDOMLY DIMENSIONED TO 40000 TO ACCOMMODATE CHANGE
 C TO MULTIPLE SUBSCRIPTED ARRAYS.

C
 C (1/29/87) INCREASE X AND Y TO ACCOMMODATE EXPANDING ALL ARRAYS.

C
 C

BLOCK DATA
 COMMON X(80000)
 COMMON/OTPT/Y(1500)
 DATA X/80000*0.0/,Y/1500*0.0/

C ---- ATMOSPHERE PROPERTY SUBROUTINE DATA
 COMMON /ATMOT/ Z(22),TMB(22),R(21), PB(22),C1,C2,C3,
 1 C7,C8,ZM,RO,GM,GAM,RST,GO,PO,WO,G01

DATA Y/1500*0.0/
 DATA Z/ 0., 11019., 20063., 32162., 47350., 52429.,
 1 61591., 79994., 90000., 100000., 110000., 120000., 150000.,
 2 160000., 170000., 190000., 230000., 300000., 400000., 500000.,
 3 600000., 700000. /
 4 ,TMB/ 288.15, 216.65, 216.65, 228.65, 270.65, 270.65,
 5 252.65, 180.65, 180.65, 210.65, 260.65, 360.65, 960.65,
 6 1110.65, 1210.65, 1350.65, 1550.65, 1830.65, 2160.65, 2420.65,
 7 2590.65, 2700.65 /
 DATA R / -6.5, 0.0, 1.0, 2.8, 0.0, -2.0, -4.0, 0.0, 3.0, 5.0,
 9 10.0, 20.0, 15.0, 10.0, 7.0, 5.0, 4.0, 3.3, 2.6, 1.7, 1.1 /
 DATA PB/ 1.00000E+00, 2.23361E-01, 5.40328E-02, 8.56663E-03,
 21.09455E-03, 5.82289E-04, 1.79718E-04, 1.02410E-05, 1.62230E-06,
 32.96810E-07, 7.25820E-08, 2.48870E-08, 4.99550E-09, 3.64600E-09,
 42.75610E-09, 1.66320E-09, 6.86940E-10, 1.85920E-10, 3.97770E-11,
 51.08140E-11, 3.40513E-12, 1.17620E-12 /, C8/3.28084514/
 6 ,C1/0.3048/, C2/1.00E+03/, C3/1 8/, G01/32.174/, C7/1.00E-08/
 7 ,ZM/9.00E+05/, RO/6.375605E+06/, GM/3.9862216E+14/, GAM/1.4/
 8 ,RST/8.31432/, GO/9.80665/, PO/2.11622E+03/, WO/28.9644/
 END

DSNAME = 'BBE.CCC1.SOURCE.CMA6.PDS(MERGER)'
 DCB=(RECFM=FB,LRECL=80,BLKSIZE=6160)

VOL=SER=D8D080
 01/13/88 013 14:11:55

SUBROUTINE MERGER(FACTOR,XTEMP)

```

C
C SUBROUTINE TO MERGE HUNTER CARBON OXIDATION MODEL WITH          CBM   2
C CMA SURFACE THERMOCHEMISTRY TABLES. CONTINUITY BETWEEN THE    CBM   3
C TWO ABLATION CURVES IS FORCED AT THE INTERFACE TEMPERATURE BY   CBM   4
C APPLYING A MULTIPLIER TO THE HUNTER MASS LOSS PARAMETER.
C THIS IS USED BECAUSE THE MAXIMUM HUNTER MASS LOSS PARAMETER IS
C 0.1741 WHEREAS THE TABLE VALUES THAT WERE CALCULATED BY THE EST
C CODE HAS A MINIMUM VALUE OF ABOUT 0.1750. (THE OXIDATION VALUES
C IN THE TABLES ARE FROM GE DATA.
C
C INPUT IS XTEMP AND OUTPUT IS FACTOR.
C
COMMON KOUT, IEX, DEN, VR
COMMON IHI(76), ILO(76), IR(76), TT2(60,20), TCP(60,20), TKP(60,20), THZCBM  5
1(60,20), TEP(60,20), TTH(120), THE(120), TQR(120), TCM(120), TT1(60)  INPOU  4
2, THG(60), DH12(4), RECORD(108), SO(40), RHO(20), TEPBF(60,20)
COMMON MATL(101), DEL(101), TA(101), H(101), RC(101), RA(101),
1AREA(101), EMA(101), RAV(101), LGAP(101), QGEN(101), GAP(101)
COMMON ROA(1000), ROB(1000), ROC(1000)
COMMON TPR(20), NMG(20)
C
C TMC(5,20), NLO(5,20), NHI(5,20), KHI(5,20),
1 TTS(30,20), THSEN(30,20), TCPSEN(30,20), TLMC(30,5,20), ISEN(20),
2 TPI(120), TTS(30,5,20), TCHEM(30,5,20), VFZ, CMH, TBP(30,5,20),
3 NPR, NGS
COMMON LCT, NPG, I1, NBM, NUMN, NL, DELHG, DELM, RFT, RHORA, RHORB, RHORC, TRACBM  18
1CA, TRACB, TRACC, RHOOA, RHOOB, RHOOC, EA, EB, EC, BA, BB, BC, PSIA, PSIB, PSIC, CBM  19
2TRACM, PET, PETE, RSV, ETA, DTPR3, DTPR2, DTPRT, TPR3, TPR2, THZRO, THFIN, WT, CBM  20
3TMWT, GAMA, OMG, NO, FJFH, FJFS, JF, JFHP, JFH, INPUT, DTHIN, BRP, HCONV, CBM  21
4EPSW, TRES, INCH, DTHB, NN, NI, NO1, CHCRI, PYCRI, TBRP(120), NR,
5 TX(30,6), F1(30,6), F2(30,6), NCON, NBP, NFIS, BREX, SWELL
COMMON BBB(10,6), EE(10,6), FF(10,6), PSI(10,6), RHO(10,6),
XRHOR(10,6),
1ROCOM(50,3), DHC(10), DHV(10), RHOC(10), RHOV(10), P(10), PP(10),
XTREF(10),
2GA(10), OMGA(10), NF1(10), NLA(10), TT5(60,20), TENT(60,20),
XT, BU(60,20),
3TCBU(30,10), X(101), NDBU, NBM2, TRAC(10,6), NBUFT(10), KNST, IBUG, TBUG,
4 TALT(120), TVEL(120), RRGAP(101), AGAP(101), ICOND, IEROS, ISR,
5 NGC1, NGC2, NGC3, NGC4, TCON1(101), TCON2(101), TCON3(101), TCON4(101),
6 COND1(101), COND2(101), COND3(101), COND4(101),
7 THCONV(101), TEP(101), TTRES(101), TQ(101), TEP(101), IBF, TL, THD,
8 JTBL, IDRD, RHOC1(201), DTDT(201), RA1, RA2, RA3
COMMON/OTPT/CPE(6), EMO(201), DEP(20,10), CNC(101), CN(101), Y1(4),
1 CNO(101), TO(20), RO(101), NISO(20), BR, CH, GS, SA, TB, TT, ASU, CMD, CMT,
2 ITS, QRP, RAD, RAT(101), RSU, CDM, CMMT, DCDT, DEDT, DIDT, DPDT, ITER, KSCT,
3 PGPU, PRES, QRPT, RADT, SNET, DECOM, DEDT, DSDB, PGP, QCHEM, QCOND,
4 QCONV, QLOSS, SDNET, SUMQE, THPRT, TSAVE, VELFS, DECOMT,
5 PRSATM, QCHEM, QCOND, QCONVT, QLOSST, KK, RR(101), DMDG(101),
6 RON(101), ROT(101), DNCP(6), DROT(6), D1(4), FA, FB, FC, DTH, DTHC, DSI,
7 DTA, GSM, COLD, GSMS, GSMT, GSM2T, DSDT, POLD, TH, AFTFS, DSDTT,
8 TEMP, BF, LL, LU, HE, HW
C ----- NEW COMMON BLOCKS ADDED BY CCC (12/87) FOR MERGE ROUTINES
COMMON/MERGE/VRM, VRP, IMG, IPR, I1, I3
COMMON/OPTION/TCRIT, BPCRIT, TABCN, IOPTN, IMSG, MITER
C
EQUIVALENCE (DH1, DH12(1)), (DH2, DH12(2)), (TS, TA(1))
DIMENSION Y2(48), D2(48)
    
```

```

C ----- INTERPOLATE ON VMR, GAS FLOW
C IF(NGS.LE.1) GO TO 200
C CALL LOOK(15,XTEMP,TTS(1,IMG+1,IPR),TLMC(1,IMG+1,IPR),0,0,0,Y2(2),
C 1 D2,1)
C CALL LOOK(17,XTEMP,TTS(1,IMG+1,IPR+1),TLMC(1,IMG+1,IPR+1),0,0,0,
C 1 Y2(4),D2,1)
C BPG=Y2(2)+VRP*(Y2(2)-Y2(4))
C WRITE(6,500)IR(13),VRM,VRP
C 500 FORMAT(' ***** IR(13)=',I5,
C 1 ' VRM =',E12.5,' VRP =',E12.5)
C
C IF(NGS.LE.1) GO TO 550
C BP=BP+VRM*(BPG-BP)
C ----- LOOK UP BPRIME & INTERPOLATE ON VRP (LN PRESSURE RATIO)
C IF(IMG.GE.3) WRITE(6,100) BPCRIT
C 100 FORMAT(' **MRG** BPCRIT (INPUT) = ',F12.5)
C IF(IOPTN.EQ.2) GO TO 550
C 200 CALL LOOK(14,XTEMP,TTS(1,IMG,IPR),TLMC(1,IMG,IPR),0,0,0,Y2(3),
C 1 D2,1)
C CALL LOOK(16,XTEMP,TTS(1,IMG,IPR+1),TLMC(1,IMG,IPR+1),0,0,0,Y2(5),
C 1 D2,1)
C BPEST=Y2(3)+VRP*(Y2(5)-Y2(3))
C BPEST=EXP(BPEST)
C 550 Y2(1)=XTEMP
C CALL DIKI(PRES,BPDIKI,CH,Y2,DUM1,DUM2,-1,JTBL)
C BPDIKI=EXP(BPDIKI)
C IF(IOPTN.EQ.2) BPEST=BPCRIT
C FACTOR=BPEST/BPDIKI
C
C IF(IMG.EQ.2) WRITE(6,600)BPEST,BPDIKI,FACTOR
C 600 FORMAT(
C 1 ' **MRG** BPEST =',F12.5,
C 1 ' BPDIKI =',F12.5,' FACTOR =',F12.5)
C
C IF(IMG.EQ.3) WRITE(6,650)IPR,IMG,Y2(3),Y2(5),BPEST,BPDIKI,FACTOR
C 650 FORMAT(' **MRG** IPR =',I3,4X,' IMG =',I3,' Y2(3) =',E12.5,
C 1 ' Y2(5) =',E12.5,
C 1 /,' **MRG** BPEST =',F12.5,' BPDIKI =',F12.5,
C 1 ' FACTOR =',F12.5)
C
C RETURN
C END

```

DSNAME = 'BBE.CCC1.SOURCE.CMA6.PDS(MERGE2)'
 DCB=(RECFM=FB,LRECL=80,BLKSIZE=6160)

VOL=SER=D8D080
 01/25/88 025 10:38:12

SUBROUTINE MERGE2(XTEMP)

C
 C BY C.C.C. (12/87) CBM 2
 C
 C SUBROUTINE TO MERGE HUNTER CARBON OXIDATION MODEL WITH CBM 3
 C CMA SURFACE THERMOCHEMISTRY TABLES. CONTINUITY BETWEEN THE CBM 4
 C TWO ABLATION CURVES IS FORCED AT THE INTERFACE TEMPERATURE BY
 C APPLYING A MULTIPLIER TO THE HUNTER MASS LOSS PARAMETER.
 C SEE MERGER SUBROUTINE.
 C THIS IS USED BECAUSE THE MAXIMUM HUNTER MASS LOSS PARAMETER IS
 C 0.1741 WHEREAS THE TABLE VALUES THAT WERE CALCULATED BY THE EST
 C CODE HAS A MINIMUM VALUE OF ABOUT 0.1750. (THE OXIDATION VALUES
 C IN THE TABLES ARE FROM GE DATA).
 C THE INTERFACE TEMPERATURE IS FOUND FROM THE CHEMISTRY TABLES FOR A
 C GIVEN MASS LOSS PARAMETER, BPRIME.
 C
 C A VALUE OF XTEMP IS COMPUTED FOR A GIVEN BPCRIT (IN COMMON BLOCK).
 C
 COMMON KOUT, IEX, DEN, VR CBM 5
 COMMON IHI(76), ILO(76), IR(76), TT2(60,20), TCP(60,20), TKP(60,20), THZCBM 6
 1(60,20), TEP(60,20), TTH(120), THE(120), TQR(120), TCM(120), TT1(60) INPOU 4
 2, THG(60), DH12(4), RECORD(108), SO(40), RHO(20), TEPBF(60,20)
 COMMON MATL(101), DEL(101), TA(101), H(101), RC(101), RA(101),
 1AREA(101), EMA(101), RAV(101), LGAP(101), QGEN(101), GAP(101)
 COMMON ROA(1000), ROB(1000), ROC(1000) CBM 12
 COMMON TPR(20), NMG(20),
 C TMG(5,20), NLO(5,20), NHI(5,20), KHI(5,20),
 1 TSEN(30,20), THSEN(30,20), TCPSEN(30,20), TLMC(30,5,20), ISEN(20),
 2 TPI(120), TTS(30,5,20), TCHEM(30,5,20), VFZ, CMH, TBP(30,5,20),
 3 NPR, NGS
 COMMON LCT, NPG, I1, NBM, NUMN, NL, DELHG, DELM, RFT, RHORA, RHORB, RHORC, TRACDM 18
 1CA, TRACB, TRACC, RHOA, RHOB, RHOOC, EA, EB, EC, BA, BB, BC, PSIA, PSIB, PSIC, CBM 19
 2TRACM, PET, PETE, RSV, ETA, DTPR3, DTPR2, DTPRT, TPR3, TPR2, THZRO, THFIN, WT, CBM 20
 3TMT, GAMA, OMG, NO, FJFH, FJFS, JF, JFHP, JFH, INPUT, DTHIN, BRP, HCONV, CBM 21
 4EPSW, TRES, INCH, DTHB, NN, NI, NOI, CHCRI, PYCRI, TBRP(120), NR,
 5 TX(30,6), F1(30,6), F2(30,6), NCON, NBPF, NFIS, BREX, SWELL
 COMMON BBB(10,6), EE(10,6), FF(10,6), PSI(10,6), RHO(10,6), CB
 XRHOR(10,6),
 1ROCOM(50,3), DHC(10), DHV(10), RHOC(10), RHOV(10), P(10), PP(10),
 XTREF(10),
 2GA(10), OMGA(10), NFI(10), NLA(10), TT5(60,20), TENT(60,20),
 XTKBU(60,20),
 3TCBU(30,10), X(101), NDBU, NBM2, TRAC(10,6), NBUFT(10), KNST, IBUG, TBUG,
 4 TALT(120), TVEL(120), RRGAP(101), AGAP(101), ICOND, IEROS, ISR,
 5 NGC1, NGC2, NGC3, NGC4, TCON1(101), TCON2(101), TCON3(101), TCON4(101),
 6 COND1(101), COND2(101), COND3(101), COND4(101),
 7 THCONV(101), TEP(101), TTRES(101), TQ(101), TEP(101), IBF, TL, THD,
 8 JTBL, IDRD, RHOC(201), DTD(201), RA1, RA2, RA3
 COMMON/OTPT/CPE(6), EMO(201), DEP(20,10), CNC(101), CN(101), Y1(4),
 1 CNO(101), TO(20), RO(101), NISO(20), BR, CH, CS, SA, TB, TT, ASU, CMD, CMT,
 2 ITS, QRP, RAD, RAT(101), RSU, CMDM, CMMT, DCDT, DEDT, DIDT, DPDT, ITER, KSCT,
 3 PGPU, PRES, QRPT, RADT, SNET, DECOM, DEDTT, DSOTB, PGP(101), QCHEM, QCOND,
 4 QCONV, QLOSS, SDNET, SUMQE, THPRT, TSAVE, VELFS, DECOMT,
 5 PRSATM, QCHEM, QCOND, QCONV, QLOSS, KK, RR(101), DMDG(101),
 6 RON(101), ROT(101), DNCP(6), DROT(6), D1(4), FA, FB, FC, DTH, DTHC, DSI,
 7 DTA, GSM, COLD, GSMS, GSMT, GSM2T, DSDT, POLD, TH, AFTFS, DSDTT,
 8 TEMP, BF, LL, LU, HE, HW

```

C ----- COMMON BLOCKS CREATED BY CCC (12/87) FOR MERGE ROUTINES
COMMON/MERGE/VRM,VRP,IMG,IPR,11,13
COMMON/OPTION/TCRIT,BPCRIT,TABCN,IOPTN,IMSG,MITER
DIMENSION Y2(48),D2(48)

C
C      BPCRITL = ALOG(AMAX1(BPCRIT,1.0E-5))

C
C      ----- INTERPOLATE ON VMR, GAS FLOW
C      IF(NGS.LE.1) GO TO 200
C 200 CALL LOOK(15,BP,TLMC(1,IMG+1,IPR),TTS(1,IMG+1,IPR),0,0,0,
C      1 Y2(2),D2,1)
C      CALL LOOK(17,BP,TLMC(1,IMG+1,IPR+1),TTS(1,IMG+1,IPR+1),0,0,0,
C      1 Y2(4),D2,1)
C      XTG=Y2(2)+VRP*(Y2(4)-Y2(2))
C
C ----- LOOK UP TEMP. CORRESPONDING TO BPCRITL AT TABLE IPR & IPR+1
200 CALL LOOK(14,BPCRITL,TLMC(1,IMG,IPR),TTS(1,IMG,IPR),0,0,0
      1 ,Y2(3),D2,1)
      CALL LOOK(16,BPCRITL,TLMC(1,IMG,IPR+1),TTS(1,IMG,IPR+1),0,0,0
      1 ,Y2(5),D2,1)
C ----- TRANSITION TEMPERATURE IS INTERPOLATED BETWEEN PRESSURE TABLES
      XTEMP=Y2(3)+VRP*(Y2(5)-Y2(3))
C
C      IF(NGS.LE.1) GO TO 550
C      XTEMP=XTEMP+VRM*(STG-XTEMP)
C      WRITE(6,650)IPR,Y2(3),Y2(5),XTEMP
C 650 FORMAT(' ***** IPR =',I4,' Y2(3) =',E12.5,
C      1 ' Y2(5) =',E12.5,
C      1 ' XTEMP =',E12.5)
C
C      IF(TSAVE.GT.XTEMP) RETURN
C
C      IF(IMSG.GE.2) WRITE(6,100)BPCRIT,XTEMP,ITER
100 FORMAT(' **MG2** TRANSITION TEMP. AT BPRIME OF ',F9.5,
      1 ' IS ',F10.4,' DEG R - ITER = ',I5)
      RETURN
      END

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CBM 106

CBM 1202

DSNAME = 'BBE.CCC1.SOURCE.CMA6.PDS(MERGE3)'
 DCB=(RECFM=FB,LRECL=80,BLKSIZE=6160)

VOL=SER=D8D080
 01/25/88 025 10:38:14

SUBROUTINE MERGE3(XTEMP)

```

C
C BY CCC (12/87)
C
C SUBROUTINE TO MERGE HUNTER CARBON OXIDATION MODEL WITH
C CMA SURFACE THERMOCHEMISTRY TABLES. CONTINUITY BETWEEN THE
C TWO ABLATION CURVES IS FORCED AT THE INTERFACE TEMPERATURE BY
C APPLYING A MULTIPLIER TO THE HUNTER MASS LOSS PARAMETER.
C SEE MERGER SUBROUTINE.
C THIS IS USED BECAUSE THE MAXIMUM HUNTER MASS LOSS PARAMETER IS
C 0.1741 WHEREAS THE TABLE VALUES THAT WERE CALCULATED BY THE EST
C CODE HAS A MINIMUM VALUE OF ABOUT 0.1750. (THE OXIDATION VALUES
C IN THE TABLES ARE FROM GE DATA).
C THE INTERFACE TEMPERATURE IS FOUND BY USING A SEARCH PROCEDURE THAT
C COMPARES THE DIFFERENCE IN SLOPES OF THE TABLES AND THE DIKI
C SUBROUTINE. THE LN(BPRIME)'S MUST ALSO BE WITHIN ABS(1.0).
C THE SEARCH STARTS AT THE LOWEST ABLATION TEMPERATURE FROM THE
C TABLES AND MARCHES IN 500 DEG R INCREMENTS. WHEN THE RANGE IS FOUND
C THE INCREMENT IS REDUCED TO 100 DEG R WITHIN THIS RANGE FOR A REFINED
C SEARCH.
C
C A VALUE OF XTEMP IS OUTPUT FOR A GIVEN BPCRIT.
C
C   BP1 = VALUE OF BPRIME FROM DIKI AT (TEMP1 - DDT)
C   BP2 = VALUE OF BPRIME FROM DIKI AT (TEMP1 + DDT)
C   BPDIF = AVERAGE OF BP1 AND BP2
C   BPREST = BPRIME FROM CHEMISTRY TABLES
C   DCDTED = DIFFERENCE IN SLOPES BETWEEN TABLES AND DIKI ROUTINE
C   DCDTD = SLOPE FROM CURVE COMPUTED IN DIKI ROUTINE
C   DCDTL = DIFFERENCE IN SLOPES FROM PRIOR SEARCH ITERATION
C   DCDDT = SLOPE FROM CURVE IN TABLES
C   DDT = TEMPERATURE STEP SIZE FOR DIKI SLOPE COMPUTATION
C   DT1 = FIRST TEMPERATURE SEARCH STEP SIZE
C   DT2 = SECOND TEMPERATURE SEARCH STEP SIZE
C   DTEMP = CURRENT TEMPERATURE STEP SIZE, EITHER DT1 OR DT2
C   ICOUNT = SEARCH ITERATION COUNTER
C   IFIRST = FLAG TO INDICATE FIRST SEARCH POINT
C   LIMIT = MAXIMUM NUMBER OF ITERATIONS
C   TEMP1 = CURRENT TEMPERATURE AT WHICH VALUES ARE EVALUATED
C   TLAST = TEMP1 FROM PRIOR SEARCH ITERATION
C   TMAX = MAXIMUM TEMPERATURE IN ABLATION PART OF TABLES
C   Y2 = DUMMY ARRAY VARIABLE
C
COMMON KOUT, IEX, DEN, VR
COMMON IH1(76), ILO(76), IR(76), TT2(60,20), TCP(60,20), IXP(60,20), THZCBM
1(60,20), TEP(60,20), TTH(120), THE(120), TQR(120), TCM(120), TT1(60)
2, THG(60), DH12(4), RECORD(108), SO(40), RHO(20), TEPBF(60,20)
COMMON MATL(101), DEL(101), TA(101), H(101), RC(101), RA(101),
1AREA(101), EMA(101), RAV(101), LGAP(101), QGEN(101), GAP(101)
COMMON ROA(1000), ROB(1000), ROC(1000)
COMMON TPR(20), NMG(20),
C   TMG(5,20), NLO(5,20), NHI(5,20), KHI(5,20),
1 TTSEN(30,20), THSEN(30,20), TCPSEN(30,20), TLMC(30,5,20), ISEN(20),
2 TPI(120), TTS(30,5,20), TCHEM(30,5,20), VFZ, CMH, TBP(30,5,20),
3 NPR, NGS
COMMON LCT, NPC, II, NBM, NUMN, NL, DLLHG, DELM, RFT, RHORA, RHORB, RHORC, TRACBM

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1CA, TRACB, TRACC, RHO0A, RHO0B, RHO0C, EA, EB, EC, BA, BB, BC, PSIA, PSIB, PSIC, CBM 19
2TRACM, PET, PETE, RSV, ETA, DTPR3, DTPR2, DTPRT, TPR3, TPR2, THZRO, THFIN, WT, CBM 20
3TMWT, GAMA, OMG, NO, FJFH, FJFS, JF, JFHP, JFH, INPUT, DTHIN, BRP, HCONV, CBM 21
4EPSW, TRES, INCH, DTHB, NN, NI, NOI, CHCRI, PYCRI, TBRP(120), NR,
5 TX(30,6), F1(30,6), F2(30,6), NCON, NBPF, NFIS, BREX, SWELL CB
COMMON BBB(10,6), EE(10,6), FF(10,6), PSI(10,6), RHO0(10,6),
XRHOR(10,6),
1ROCOM(50,3), DHC(10), DHV(10), RHOC(10), RHOV(10), P(10), PP(10),
XTREF(10),
2GA(10), OMGA(10), NFI(10), NLA(10), TT5(60,20), TENT(60,20),
XTKBU(60,20),
3TCBU(30,10), X(101), NDBU, NBM2, TRAC(10,6), NBUFT(10), KNST, IBUG, TBUG,
4 TALT(120), TVEL(120), RRGAP(101), AGAP(101), ICOND, IEROS, ISR,
5 NGC1, NGC2, NGC3, NGC4, TCON1(101), TCON2(101), TCON3(101), TCON4(101),
6 COND1(101), COND2(101), CUND3(101), COND4(101),
7 THCONV(101), TEPsw(101), TTRES(101), TQ(101), TEPsd(101), IBF, TL, THD,
8 JTBL, IDRD, RHOC1(201), DTD(201), RA1, RA2, RA3
COMMON/OTPT/CPE(6), EMO(201), DEP(20,10), CNC(101), CN(101), Y1(4),
1 CNO(101), TO(20), RO(101), NISO(20), BR, CH, GS, SA, TB, TT, ASU, CMD, CMT,
2 ITS, QRP, RAD, RAT(101), RSU, CMDM, CMMT, DCDT, DEDT, D1DT, DPDT, ITER, KSCT,
3 PGPU, PRES, QRPT, RADT, SNET, DECOM, DEDTT, DSDB, PGPUR, QCHEM, QCOND,
4 QCONV, QLOSS, SDNET, SUMQE, THPRT, TSAVE, VELFS, DECOMT,
5 PRSATM, QCHEMT, QCOND, QCONVT, QLOSST, KK, RR(101), DMDG(101),
6 RON(101), ROT(101), DNCP(6), DROT(6), D1(4), FA, FB, FC, DTH, DTHC, DSI,
7 DTA, GSM, COLD, GSMS, GSMT, GSM2T, DSDT, POLD, TH, AFTFS, DSDTT,
8 TEMP, BF, LL, LU, HE, HW
C ----- COMMON BLOCKS ADDED BY CCC FOR MERGE ROUTINES.
COMMON/MERGE/VRM, VRP, IMG, IPR, I1, I3
COMMON/OPTION/TCRIT, BPCRIT, TABCN, IOPTN, MSG, MITER
DIMENSION Y2(48), D2(48)
C ----- INITIAL VALUES AND CONSTANTS
C
DT1 = 500.0
DT2 = 100.0
DTEMP = DT1
DDT = 10.0
IFIRST = 1
ICOUNT=0
LIMIT=16
C
C ----- LOCATE LOW & HI TEMP. FROM TABLES TO BOUND SEARCH PROCEDURE
C
TEMP1 = TTS(I1, IMG, IPR)+VRP*(TTS(I3, IMG, IPR+1)-TTS(I1, IMG, IPR))
TMAX = TTS(NHI(IMG, IPR), IMG, IPR)+VRP*(TTS(NHI(IMG, IPR+1), IMG,
1 IPR+1)-TTS(NHI(IMG, IPR), IMG, IPR))
C WRITE(6,801)VRP, IPR, I1, I3, TTS(I1, IMG, IPR), TTS(I1, IMG, IPR+1), TEMP1
C 801 FORMAT(' **MG3** VRP, IPR, I1, I3, TTS(1, IMG, IPR), TTS(1, IMG, IPR+1), '
C 1', TEMP1 = ',/, ' ***** ', E12.5, 3I6, 3E12.5)
GO TO 150
C
100 TLAST = TEMP1
DCDTL = DCDTED
TEMP1 = TEMP1 + DTEMP
IF(TEMP1.GT.TMAX) GO TO 1100
C ----- COMPUTE SLOPE & LN(BPRIME) FROM TABLES AT TEMP1 (AND PRES)
150 ICOUNT=ICOUNT+1
CALL LOOK(14, TEMP1, TTS(1, IMG, IPR), TLMC(1, IMG, IPR), 0, 0, 0, Y2(1),
1 Y2(2), 1)
CALL LOOK(16, TEMP1, TTS(1, IMG, IPR+1), TLMC(1, IMG, IPR+1), 0, 0, 0,
1 Y2(3), Y2(4), 1)

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```

C      WRITE(6,802)TMAX,Y2(1),Y2(3),Y2(2),Y2(4)
C 802  FORMAT(' **MG3** TMAX,Y2(1),Y2(3),Y2(2),Y2(4) = ',5E12.5)
      BPREST=Y2(1)+VRP*(Y2(3)-Y2(1))
      DCDTT=Y2(2)+VRP*(Y2(4)-Y2(2))
C ----- COMPUTE SLOPE & LN(BPRIME) FROM DIKI SUBROUTINE AT TEMP1
      Y2(1) = TEMP1 - DDT
      CALL DIKI (PRES,BP1,CH,Y2,DUM1,DUM2,-1,JTBL)
      Y2(1) = TEMP1 + DDT
      CALL DIKI (PRES,BP2,CH,Y2,DUM1,DUM2,-1,JTBL)
      BPDIKI=(BP1+BP2)/2.0
      DCDTD = (BP2-BP1)/(2.0*DDT)
C ----- COMPUTE DIFFERENCE BETWEEN DIKI & TABLE LN(BPRIME)'S & SLOPES
      BPDIFF=BPREST-BPDIKI
      DCDTED = DCDTT - DCDTD
      IF (IMSG.GE.3) WRITE(6,803)BPREST,BPDIKI,DCDTT,DCDTD
C 803  FORMAT(' **MG3** BPREST,BPDIKI,DCDTT,DCDTD = '
1,/, ' ***** ',5E12.5)
C ----- NEXT TEMPERATURE
      IF (IFIRST.NE.1) GO TO 200
      IFIRST = 0
      GO TO 100
C ----- COMPARE LAST AND CURRENT DIFFERENCE IN SLOPES
C ----- AND TEST FOR DIFFERENCE OF LN(BPRIME)'S LESS THAN 1.0
      200 CONTINUE
      IF (IMSG.GE.3) WRITE(6,800)TEMP1,TLAST,DCDTEd,DCDTL,BPDIFF
C 800  FORMAT(' **MG3** TEMP1,TLAST,DCDTEd,DCDTL,BPDIFF = ',5E12.5)
      IF (ICOUNT.GE.LIMIT) GO TO 600
      IF (BPDIFF.GE.1.0) GO TO 100
      IF (DCDTL.LT.0.AND.DCDTED.LT.0) GO TO 100
      IF (DCDTL.GT.0.AND.DCDTED.GT.0) GO TO 600
      IF (DCDTL.LE.0.AND.DCDTED.GE.0) GO TO 400
C ----- INTERPOLATE XTEMP OR DO SECOND SEARCH WITH SMALLER DTEMP
      400 IF (DTEMP.EQ.DT1) GO TO 500
      XTEMP = TEMP1 - DCDTED/(DCDTEd-DCDTL)*(TEMP1-TLAST)
      IF (TSAVE.GT.XTEMP) RETURN
      IF (IMSG.GE.2) WRITE(6,1000)XTEMP,ITER
      RETURN
C ----- REFINED TEMP. STEP USED WHEN FIRST RANGE IS LOCATED
      500 DTEMP = DT2
      TEMP1=TLAST+DTEMP
      GO TO 150
C --- EXIT IF ITERATIONS EXCEEDED OR IF DCDTEd ALWAYS GREATER THAN ZERO
      600 XTEMP = TLAST
      WRITE(6,700)XTEMP
C 700  FORMAT(' **MG3** WARNING ***** MERGE ROUTINE SEARCH PROCEDURE '
1, ' REACHED ITERATION LIMIT.',/, ' ***** (XTEMP = ',F10.4, ' R). ')
      WRITE(6,1000)XTEMP,ITER
C 1000 FORMAT(' **MG3** TRANSITION TEMPERATURE FROM SEARCH ROUTINE IS '
1, ' F10.5, ' DEG R - ITER = ',15 )
      STOP
C 1100 WRITE(6,1200)TMAX
      WRITE(6,1200)TMAX
      WRITE(6,1200)TMAX
C 1200 FORMAT(' **MG3** LAST TEMPERATURE ENTRY OF TABLE REACHED, NO '
1, ' MERGE POINT FOUND. TMAX = ',F12.5)
      STOP
      END

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CBM 1202

DSNAME = 'BBE.CCC1.SOURCE.CMA6.PDS(OUTPT2)'
 DCB=(RECFM=FB,LRECL=80,BLKSIZE=6160)

VOL=SER=D8D080
 01/19/88 019 14:41:18

SUBROUTINE OUTPT(JJJ)

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C
C   CHANGES TO PROGRAM:
C   (1/16/87) SIZE OF TTH,THE,TQR,TCM,TBRP,TALT,TVEL,TPI
C             EXPANDED TO 120 ELEMENT ARRAYS
C   (1/19/87) SIZE OF TTSEN,THSEN,TCPSN,TLMC,TTS,TCHEM,TBPF,
C             TPR,NMG,IMG,NLO,NHI,KHI,ISEN,
C             EXPANDED TO ACCOMMODATE 20 EST TABLES WITH 30
C             ENTRIES EACH
C
C   (1/29/87) ALL OTHER SUBSCRIPTED VARIABLE DIMENSIONS DOUBLED
C             AS RECOMMENDED BY L.L. PERINI.
C
C   ADDED WRITEOUT OF NODAL DEPTHS & TEMPS TO UNIT 8
COMMON KOUT, IEX, DEN, VR                                CBM    5
COMMON IHI(76), ILO(76), IR(76), TT2(60,20), TCP(60,20), TKP(60,20), THZCBM  6
1(60,20), TEP(60,20), TTH(120), THE(120), TQR(120), TCM(120), TT1(60)    INPOU  4
2, THG(60), DH12(4), RECORD(108), SO(40), RHO(20), TEPBF(60,20)
COMMON MATL(101), DEL(101), TA(101), H(101), RC(101), RA(101),
1AREA(101), EMA(101), RAV(101), LGAP(101), QGEN(101), GAP(101)
COMMON ROA(1000), ROB(1000), ROC(1000)                                CBM   12
COMMON TPR(20), NMG(20),
C             TMG(5,20), NLO(5,20), NHI(5,20), KHI(5,20),
1 TTSEN(30,20), THSEN(30,20), TCPSN(30,20), TLMC(30,5,20), ISEN(20),
2 TPI(120), TTS(30,5,20), TCHEM(30,5,20), VFZ, CMH, TBPF(30,5,20),
3 NPR, NGS
COMMON LCT, NPG, I1, NBM, NUMN, NL, DELHG, DELM, RFT, RHOR, RHORB, RHORC, TRACBM  18
1CA, TRACB, TRACC, RHOA, RHOB, RHOOC, EA, EB, EC, BA, BB, BC, PSIA, PSIB, PSIC, CBM  19
2TRACM, PET, PETE, RSV, ETA, DTPR3, DTPR2, DTPRT, TPR3, TPR2, THZRO, THFIN, WT, CBM  20
3TMWT, GAMA, OMG, NO, FJFH, FJFS, JF, JFHP, JFH, INPUT, DTHIN, BRP, HCONV, CBM  21
4EPSW, TRES, INCH, DTHB, NN, NI, NOI, CHCRI, PYCRI, TBRP(120), NR,
5 TX(30,6), F1(30,6), F2(30,6), NCON, NBPF, NFIS, BREX, SWELL
COMMON BBB(10,6), EE(10,6), FF(10,6), PSI(10,6), RHO(10,6),
XRHOR(10,6),
1ROCOM(50,3), DHC(10), DHV(10), RHOC(10), RHGV(10), P(10), PP(10),
XTREF(10),
2GA(10), OMGA(10), NFI(10), NLA(10), TT5(60,20), TENT(60,20),
XTKBU(60,20),
3TCBU(30,10), X(101), NDBU, NBM2, TRAC(10,6), NBUFT(10), KNST, IBUG, TBUG,
4 TALT(120), TVEL(120), RRGAP(101), AGAP(101), ICOND, IEROS, ISR
COMMON/OTPT/CPE(6), EMO(201), DEP(20,10), CNC(101), CN(101), Y1(4),
1 CNO(101), TO(20), RO(101), NISO(20), BR, CH, GS, SA, TB, TT, ASU, CMD, CMT,
2 ITS, QRP, RAD, RAT(101), RSU, CDM, CMMT, OCDT, DEDT, DIDT, DPDT, ITER, KSCT,
3 PGPU, PRES, QRPT, RADT, SNET, DECOM, DEDTT, DSDTB, PGPOT, QCHEM, QCOND,
4 QCONV, QLOSS, SNET, SUMQE, THPRT, ISAVE, VELFS, DECONT,
5 PRSATM, QCHEMT, QCOND, QCONVT, QLOSST, KK, RR(101), DMDC(101),
6 RON(101), ROT(101), DNCP(6), DROT(6), D1(4), FA, FB, FC, DTH, DTMC, OSI,
7 DTA, GSM, COLD, GSMS, GSMT, GSM2T, DSDT, POLD, TH, AFTFS, DSDTT,
8 TEMP, BF, LL, LV, HE, HW
COMMON/OPTION/TCRIT, BPCRIT, TABEN, IOPTN, IMSC, MITER, IBLOPT
COMMON/BLOWN/BLOW, BLOFAC
EQUIVALENCE (DH1, DH12(1)), (DH2, DH12(2)), (TS, TA(1))
554 FORMAT(1X,8F10.4/(20X,6F10.4))                                CBM   103
4102 FORMAT(72E14.7,10I10)
DIDT = 12.0*OSDTB
NDR=NBM-NL-1                                                    CBM   279
NL!={NUMN-NDR+1}/2                                            CBM   280
    
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K=NL1
BPRM = 0.0
BPRMG=0.0
IF ( ABS(CH).LT.1.0E-15) GO TO 4105
BPRM=(GS +CMD)/(CH*CMH)
BPRMG=GS /(CH*CMH)
CALL LOOK(3,TS,TT2(1,1),THZ(1,1),0,0,0,TEMP,DUM,1)
----- TEMP = INTERPOLATED ENTHALPY OF MATERIAL
HW = (BPRM*TEMP-QCHEM/CH)/(1.0+BPRM)

C
C PRINT OUTPUT AT REQUESTED TIME
C
4105 CALL LCOUNT(33+NL1,LCT,NPG)
C
C WRITE (KOUT,543)TH
543 FORMAT( /6X28H- - - - - F9.4,37H SECONDS - - -
1- - - - - )
C
C WRITE (KOUT,544)
544 FORMAT(6X,4HTIME,2X,4HSURF,2X,4HPROB,2X,7HSURFACE,5X,6HH WALL,
14X,6HH EDGE,6X,10HHEAT COEFF,6X,6HCH/CHO/6X,4HSTEP,2X,4HITER,2X,4HCBM
20PTN,2X,8HRAD (IN),3X,8H(BTU/LB),2X,8H(BTU/LB),3X,14H(LB/SQ FT-SECCBM
3))
C
C WRITE (KOUT,545) ITER,ITS,II ,RSU,HW,HE,CH,BR
545 FORMAT(6X,14,216.F10.4,F11.2,F10.2,F14.6,5X,F8.5/1H )
C
C WRITE (KOUT,546)
546 FORMAT(33X,20H---ABLATION RATES---)
C
IF (IDLOPT.LE.0) GO TO 500
OUTPUT WHEN USING BLOWING OPTION OF GRAB
WRITE (KOUT,570)
570 FORMAT(1 B PRIME B PRIME G M DOT CHAR M DOT ERS
1 M CHAR M ERS PERCENT GRAB1, /26X,
1 (LB/SQ FT SEC) (LB/ORIG SQ FT)
2 BLOWING FRACTION1)
C
WRITE (KOUT,571) BPRM,BPRMG,CMD,CMDM,CMT,CMMT,BLOW,BLOWAC
571 FORMAT(1X,F8.5,2X,F8.5,3X,F10.6,3(2X,F10.6),2X,F9.5,2X,F7.5, /1H )
GO TO 505
C
500 CONTINUE
C
WRITE (KOUT,547)
547 FORMAT(8X,7HB PRIME,3X,9HB PRIME G,3X,10HM DOT CHAR,3X,9HM DOT ERS
16X,6HM CHAR,7X,5HM ERS/34X,14H(LB/SQ FT-SEC),11X,15H(LB/ORIG SQ FT
2))
C
C WRITE (KOUT,548) BPRM,BPRMG,CMD,CMDM,CMT,CMMT
548 FORMAT(8X,F8.5,2X,F8.5,4(3X,F10.6)/1H )
585 CONTINUE
C
C WRITE (KOUT,5480) CHCRI,PYCRI
5480 FORMAT(27X,32H---RECESSIONS/RECESSION RATES---/
133X,19H(IN) / (IN/SEC)/
2 16X,7HSURFACE,16X,6HCHAR (.F4.2,1H),11X,11HPYROLYSIS (.F4.2,1H))
C
C WRITE (KOUT,5481) SA,DIDT,CPE(1),DCDT,CPE(2),DPDT
5481 FORMAT(5X,3(4X,F10.7,1H/,F9.7)/1H )
C

```

```

WRITE (KOUT,5482) CBM 293
5482 FORMAT(27X,31H---SURFACE ENERGY FLUX TERMS---/25X,37HCURRENT RATESCBM 68
1 (BTU/SQ FT SURFACE-SEC)/24X,38HAND INTEGRATED VALUES (BTU/ORIG SQCBM 69
2 FT)/ CBM 70
3 13X,10H CONVECTED ,4X,10H RADIATED ,4X,10H RADIATED ,4X,10H CHECBM 71
4MICAL ,4X,10HCONDUCTION/17X,21HIN,12X,21HIN,11X,3HOUT,8X,10HGENERATICBM 72
5ON,7X,4HAWAY) CBM 73
C
WRITE (KOUT,5483) QCONV,QRP,RAD,QCHEM,QCOND,QCONVT,QRPRT,RADT,QCHEMCBM 294
1T,QCOND) CBM 295
C
----- 5483 EXPANDED FIELD FORMATS
5483 FORMAT (6X,4HRATE,2X,5(E12.5,2X)/6X,5HTOTAL,1X,5(E12.5,2X)/1H ) CBM 74
C
WRITE (KOUT,5484) CBM 296
5484 FORMAT(30X,27H---INTERIOR ENERGY TERMS---/
3 13X,9HPYROL GAS,7X,6HDECOMP,6X,10HCONVECTION,6X,7HSTORAGE, CBM 78
47X,7HLOSS AT/14X,7HPICK UP,6X,10HABSORPTION,3X,11HWITH SOLIDS,5X, CBM 79
58HIN SOLID,6X,9HREAR FACE) CBM 80
C
WRITE (KOUT,5485)PGPU,DECOM, TB,DEDT,QLOSS,PGPUT,DECOMT, TT,DEDTT,CBM 297
1QLOSS) CBM 298
5485 FORMAT (6X,4HRATE,2X,5(E12.5,2X)/6X,5HTOTAL,1X,5(E12.5,2X)/1H ) CBM 81
C
PRSATH = EXP(PRES)
C
WRITE(6,584) SUMQE,PRSATH,VELFS,AFTFS
584 FORMAT( 18H QERR(BTU/FT2) =,F8.2,10H ,PT(ATM)=,F10.6 ,
1 11H ,VEL(FPS)=,F8.1 ,10H ,ALT(FT)=,F9.1)
C
IF(NCON.LE.0) WRITE(6,549)
549 FORMAT (6X8HNODE MAT3X4HTEMP3X7HDENSITY3X8HENTHALPY2X8HNODE MAT3X4CBM 82
1HTEMP3X7HDENSITY3X8HENTHALPY/15X7H(DEG R)11H (LB/CU FT)9H (BTU/LB)CBM 83
211X7H(DEG R)11H (LB/CU FT)9H (BTU/LB)) CBM 84
C
IF(NCON.GT.0) WRITE(6,5490)
5490 FORMAT(6X,8HNODE MAT,3X,4HTEMP,3X,7HDENSITY,2X,9HCOND(BTU/,2X,8HNOCBM 85
1DE MAT,3X,4HTEMP,3X,7HDENSITY,2X,9HCOND(BTU//15X,7H(DEG R),11H (LBCBM 86
2/CU FT),9H FT SC F),11X,7H(DEG R),11H (LB/CU FT),9H FT SC F)) CBM 87
C
WRITE(8,3001);TH,(RAV(1),TA(1)),I=1,NUMN)
3001 FORMAT(F10.5,50(F6.5,F5.0))
C
IF(NOI.LE.0) GO TO 190
CALL SLOPQ (NL,RA(1),TA(1),FMO(1))
IF(NO.LE.0) GO TO 182
CALL CGLE (NO,SO,TO(1),NL,RA(1),TA(1),FMO(1))
182 IF(NI.LE.0) GO TO 189
DO 186 I=1,NI
TO(I) = PIF1(SO(I),RA,NL,TA)
186 CONTINUE
189 IF(NUMN.GE.NBM) CALL THERMS(NISO,TO,DEP,RR,CN,RAT)
WRITE(KSCT,4102) TH,TS,(TO(I),I=1,20),
1 ((DEP(I,J),I=1,10),J=1,5),(NISO(I),I=1,10)
KK=KK+1 CBM 325
190 M = WT
IF(NCON.LE.0) GO TO 3012
DO 3009 I=1,NL
IF(WT.LE.0.0) GO TO 3007
CALL LOOK(31+M,X(1),IX(1,M),F1(1,M),F2(1,M),0.0,Y1,D1,2)
CNO(I)=Y1(1)*CN(I)+Y1(2)*CNC(I) CBM 332

```

```

GO TO 3009
3007 CNO(I)=X(I)*CN(I)+(1.0-X(I))*CNC(I)
3009 CONTINUE
IF(NDBU,LE.0) GO TO 3023
DO 3030 I=1,NDBU
LL=NFI(I)
LU=NLA(I)
L=NBUFT(I)
DO 3025 J=LL,LU
IF(L,LE.0) GO TO 3026
CALL LOOK(31+L,X(J),TX(1,L),F1(1,L),F2(1,L),0,0,Y1,D1,2)
CNO(J)=Y1(1)*CN(J)+Y1(2)*CNC(J)
GO TO 3025
3026 CNO(J)=X(J)*CN(J)+(1.0-X(J))*CNC(J)
3025 CONTINUE
3030 CONTINUE
3023 IF(NUMN,LT,NBM2) GO TO 3012
DO 3029 I=NBM2,NUMN
3029 CNO(I)=CN(I)
3012 DO 3011 J=1,NLI
L=J
IF(L,LE,NL) GO TO 3002
L=L+NDR
K=NLI
GO TO 3003
3002 IF(L+NLI,GT,NL) K = NLI+NDR
3003 N=MINO(NUMN,K+1)
IF(NCON,LE.0)WRITE(6,550)(I,MATL(I),TA(I),RO(I),H(I),I=L,N,K)
550 FORMAT(5X,214,F9.2,F10.3,2XF8.2,1X,214,F9.2,F10.3,F10.2)
IF(NCON,GT.0)WRITE(6,5500)(I,MATL(I),TA(I),RO(I),CNO(I),I=L,N,K)
5500 FORMAT(5X,214,F9.2,F10.3,2X,F8.6,1X,214,F9.2,F10.3,F10.6)
3011 CONTINUE
IF(SWELL,EQ.0.0) GO TO 3101
SDNET=(1.+SWELL)*DIDT-SWELL*DCDT
C
WRITE(6,590) SWET,SDNET
590 FORMAT(/10X,48HSURFACE RECESSION AFTER SWELL (INCHES) = F8CBM 370
1.4/10X,48HSURFACE RECESSION RATE WITH SWELL (INCHES/SEC) =F8.4) CBM 371
C
3101 IF(TH-THFIN,LT,-0.00001) GO TO 1151
IF(NOI,LE.0) GO TO 1
REWIND KSCT
N=0
CALL LCOUNT(-18,LCT,NPG)
C
WRITE(KOUT,552) NO,N1
552 FORMAT(9X,67HOPTIONAL OUTPUT OF THERMOCOUPLE TEMPERATURES AND/OR ISOTHERM DEPTHS/24X,37HDEPTHS MEASURED FROM ORIGINAL SURFACE/24X,231HTEMPERATURES IN DEGREES RANKINE//6X,77HFACH OUTPUT BLOCK SHOWS 3THE TIME IN SECONDS, THE CURRENT SURFACE TEMPERATURE,/6X,20HTHE TEMPERATURES OF ,12,44HTHERMOCOUPLES, AND THE DEPTHS IN INCHES OF ,512,10H ISOTHERMS/6X,34HWITHIN THE MAIN ABLATING MATERIAL./)
C
WRITE(KOUT,5521)
5521 FORMAT(6X,74HTHE FIRST BLOCK SHOWS A SAMPLE TIME AND SURFACE TEMPERATURE, THE SPECIFIED/6X,73HDEPTHS OF THE THERMOCOUPLES (IF ANY) AND THE ISOTHERM TEMPERATURES. THE/6X,76HARRANGEMENT OF THIS BLOCK CORRESPONDS TO THE ARRANGEMENT OF THE OUTPUT DATA./)
WRITE(KOUT,554) TH,TS,(SO(I),I=1,NOI)

```

```

        WRI 2 (KOUT,553)
553 FORMAT (//6X,11HOUTPUT DATA//)
C
        DO 4 K=1,KK
          READ (KSCT,4102) TH,TS,(TO(I),I=1,20),
1 ((DEP(I,J),I=1,10),J=1,5),(NISO(I),I=1,10)
          DO 805 I=1,NI
            IF (N.LT.NISO(I)) N=NISO(I)
805 CONTINUE
          CALL LCOUNT( 1 ,LCT,NPG)
          4 WRITE (KOUT,554) TH,TS, (TO(I), I=1,NC1)
            IF (NUMN.LF.NBM) GO TO 1
            IF (NI*.LE.0) GO TO 1
            REWIND KSCT
            CALL LCOUNT(-7,LCT,NPG)
C
          WRITE(KOUT,560)
560 FORMAT(/6X66HTHF FOLLOWING BLOCK GIVES THE OUTPUT TIME AND UP TO FCBM
1IVE LOCATIONS / 6X,55HOF THE INDICATED ISOTHERMS WITHIN THE BACKUPCBM
2 MATERIALS.)
C
          J=NO+1
          WRITE(KOUT,7041) (SO(I),I=J,NOI)
7041 FORMAT(/12X,9(2X,F10.4))
          WRITE(KOUT,7042)
7042 FORMAT(/)
C
          DO 804 K=1,KK
            READ (KSCT,4102) TH,TS,(TO(I),I=1,20),
1 ((DEP(I,J),I=1,10),J=1,5),(NISO(I),I=1,10)
            DO 804 J=1,N
              CALL LCOUNT( 1,LCT,NPG)
804 WRITE(KOUT,554) TH,(DEP(I,J),I=1,NI)
              GO TO 1
1151 IF (TH.LT.TPR2-C.00001) GO TO 154
              DTPRT=DTPR2
              DTPR2=DTPR3
              TPR2=TPR3
              TPR3=THFIN
              CBM 427
              CBM 428
              CBM 429
154 IF (TH.GE.THPRT-O.00001) THPRT=AMIN1(THPRT+DTPRT,TPR2)
              RETURN
1 JJJ = 1
              RETURN
              END
    
```

APPENDIX B
SURFACE ENERGY BALANCE EQUATION IN CMA

APPENDIX B

Surface Energy Balance Equation in CMA

$$\underbrace{\rho_e u_e C_H (H_r - h_w)}_{\text{Convective heat transfer}} + \underbrace{\rho_e u_e C_H \left[\left(\frac{C_M}{C_H} \right) (\beta'_c h_c + \beta'_g h_g - \beta' h_w) \right]}_{\text{Chemical energy transfer}} +$$

$$\underbrace{\alpha_w q_{\text{rad}}}_{\text{Radiative heating}} - \underbrace{F \sigma \epsilon_w T_w^4}_{\text{Radiation loss}} - \underbrace{q_{\text{cond}}}_{\text{Conduction to wall}} = 0,$$

where

- ρ_e = density at outer edge of boundary layer,
- u_e = velocity of gases at edge of boundary layer,
- C_H = Stanton number,
- H_r = recover enthalpy,
- C_M = mass transfer Stanton number,
- β'_c = mass loss parameter of char (equals $\dot{m}_c / \rho_e u_e C_M$),
- β'_g = mass loss parameter of pyrolysis gases (equals $\dot{m}_g / \rho_e u_e C_M$),
- $\beta' = \beta'_c + \beta'_g$ (equals $(\dot{m}_c + \dot{m}_g) / (\rho_e u_e C_M)$),
- h_c = enthalpy of char,
- h_g = enthalpy of pyrolysis gas,
- h_w = enthalpy of gases at wall (heated surface),
- α_w = absorptance,
- q_{rad} = radiation input to ablating surface,
- F = radiation view factor,
- σ = Stefan-Boltzmann constant,
- ϵ_w = emissivity,
- T_w = wall (surface) temperature, and
- q_{cond} = conduction into ablating material.

APPENDIX C

**USER'S GUIDE FOR CMA CODE WITH ROUTINES
TO MERGE HUNTER GRAPHITE OXIDATION SUBROUTINE
WITH CMA ABLATION CALCULATIONS**

APPENDIX C

User's Guide for CMA Code with Routines to Merge Hunter Graphite Oxidation Subroutines with CMA Ablation Calculations

The new input variables (Table C.1) are listed on a single line, which is the last line in the CMA input file. This line is an addition to the previous format and must be present whether the new features are used or not. It follows the existing JTBL parameter, which is used to select the method for computing graphite oxidation (i.e., values are either read from the surface thermochemistry (ST) tables in CMA or computed by the Hunter subroutine.)

Table C.1
 New Inputs for CMA code.

Variable	Columns	Format	Description
IBLOPT	1-5	I5	Not used
IOPTN	6-10	I5	Merge Hunter subroutine and surface thermochemistry table ablation curves. 0 = This feature not evoked. 1 = Merge curves at constant wall temperature (TCRIT). 2 = Merge curves at wall temperature corresponding to a constant value of β' (BPCRIT). 3 = Search for temperature that produces smoothest curve.
TCRIT	11-20	F10.4	Constant wall temperature at which Hunter and surface thermochemistry table ablation curves are merged. This parameter is only used when IOPTN = 1.
BPCRIT	21-30	F10.4	Value of β' criterion for finding merge temperature. This parameter is only used when IOPTN = 2.
IMSG	31-35	I5	Status messages for new features. 0 = Do not print any messages. 1 = Print 1st level messages. 2 = Print 1st and 2nd level messages. 3 = Print 1st, 2nd and 3rd level messages. IMSG = 2 and 3 are primarily for debugging. They will produce significant output.
TABCN	36-45	F10.4	Computes ablation threshold temperature for ablating material. < = 0.0, Search for threshold temperature. > = 0.0, Material ablates at $T_{w,ab} > TABCN$. This feature is only active when IOPTN \neq 0.
MITER	46-50	I5	Frequency at which merge factor and material ablation threshold temperature is recomputed.

The first input variable, IOPTN, evokes the routines that merge the Hunter oxidation subroutine with the mainstream CMA calculations. The merge routines cause the Hunter subroutine to be used for the oxidation calculations and the ST tables to be used for the sublimation calculations. They also compute and apply a factor (merge factor) on the Hunter ablation curve, which makes it continuous with the ST ablation curve.

The user has three options for specifying the transition temperature criterion (for switching from the Hunter subroutine to the ST tables). The transition can be at a constant wall temperature (TCRIT), at the temperature that corresponds to a constant value of β' (BPCRIT), or found using a procedure that searches for the temperature that gives the smoothest transition between the Hunter and ST ablation curves. As a warning, these methods increase in complexity from the user-specified constant temperature criteria to the search for the smoothest merge temperature, and computation time will also increase. The first two options are relatively inexpensive and the last is most expensive.

The input variable TABCN is used to specify the temperature at which the material begins to ablate (i.e., an ablation threshold temperature). The user can specify a constant ablation threshold temperature or he can activate the FDTABC module, which computes this value using a rewritten form of the Hunter algorithm for a temperature corresponding to a negligible value of β' (0.00001). This feature is only active when the Hunter subroutine and the merge feature are evoked.

The input variable MITER is the frequency of iteration steps at which the merge factor and the ablation threshold temperature are recomputed. For a trajectory with severe transients, these values should be recomputed every iteration step. On the other hand, for a trajectory with small transients, recomputing every five iterations may be sufficient. When MITER is a value other than 1, the user should run a sample problem to verify that the merge factors and ablation temperatures do not change drastically between iterations.

The last input variable, IMSG, is used to print status messages for the merge and ablation temperature operations with the normal CMA output. Four levels of messages are available. Most users will want none or first-level messages only. The other levels are primarily for debugging.

The executable program is called CMAV05. It is saved in the partitioned dataset 'BBE.CCC1.LOAD.MODULES'.

APPENDIX D
SAMPLE INPUT FILE USING NEW CMA CODE

APPENDIX D

Sample Input File Using New CMA Code

```

//CCC1H JOB (11655,C,U,N), 'CCC1',USER=CCC1,NOTIFY=CCC1,MSGCLASS=C
//*MAIN ORG=RM001
//* SAMPLE JCL SET
// EXEC PGM=CMAV05,REGION=2000K,TIME=1
//STEPLIB DD DSN=BBE.CCCT.LOAD.MODULES,DISP=SHR
//FT03F001 DD UNIT=TEMP,
//          DCB=(RECFM=VB,LRECL=1200,BLKSIZE=4804),
//          SPACE=(TRK,(10,5),RLSE)
//FT06F001 DD DSN=BBE.CCCT.CMA.FOR.PTB.OUTPUT01,DISP=(NEW,CATLG),
//          UNIT=SAVE,DCB=(RECFM=VBA,LRECL=137,BLKSIZE=6233,BUFNO=1),
//          SPACE=(CYL,(120,60),RLSE)
//FT08F001 DD DUMMY
//FT05F001 DD *
    
```

Executable program

Write output to dataset

GPHS--BROADSIDE STABLE -- (CMAV05)
 FLIGHT PATH ANGLE = -90
 SAMPLE JCL SET

A		114.7	114.7	0.	0.	0.	15000.
B		114.7	114.7	0.	0.	0.	15000.
C		114.7	114.7	0.	0.	0.	15000.
10	40	0.0	50.00	1.00	5.00	2.00	0.100 0.5
		10.0	40.0	0.0010	0.0	0.0	0.0 536.0

1	1110.	.005	-1.0634
1	1116.	.010	
1	1116.	.010	
1	1121.	.010	
1	1121.	.010	
1	1121.	.010	
1	1126.	.010	
1	1126.	.010	
1	1126.	.010	
1	1131.	.010	
1	1131.	.010	
1	1131.	.010	
1	1136.	.010	
1	1136.	.010	
1	1136.	.010	
1	1141.	.010	
1	1141.	.010	
1	1141.	.010	
1	1149.	.010	
1	1149.	.005	7 0.0008
3	1192.	.020	
3	1222.	.020	
3	1252.	.020	
3	1283.	.010	7 0.014
4	1331.	.010	
4	1336.	.020	
4	1341.	.040	
4	1346.	.040	
4	1351.	.040	
4	1356.	.0165	7 0.0152
5	1532.	.01338	
5	1546.	.01339	7 0.0155
6	1711.	.010	.06267
6	1716.	.020	.06267
6	1726.	.040	.06267
6	1742.	.080	.06267

Nodal data

Up to 100 nodes permitted

6	1774.		.100		.06267
6	1814.		.100		.06267
6	1854.		.100		.06267
6	1894.		.10143		.06267
	0.0	0.0	0.	0.02	0.98
	460.0	0.175	0.02778	0.80	0.80
	710.0	0.225	0.02315	0.80	0.80
	960.0	0.290	0.02014	0.80	0.80
	1210.0	0.330	0.01759	0.80	0.80
	1460.0	0.360	0.01551	0.80	0.80
	1710.0	0.390	0.01377	0.80	0.80
	1960.0	0.410	0.01243	0.80	0.80
	2210.0	0.430	0.01123	0.80	0.80
	2460.0	0.450	0.01076	0.80	0.80
	2960.0	0.480	0.00909	0.80	0.80
	3460.0	0.510	0.00828	0.80	0.80
	3960.0	0.530	0.00741	0.80	0.80
	4460.0	0.550	0.00694	0.80	0.80
	5460.0	0.575	0.00625	0.80	0.80
-1	7960.0	0.575	0.00625	0.80	0.80
	460.0	0.175	0.02778	0.80	0.80
	710.0	0.225	0.02315	0.80	0.80
	960.0	0.290	0.02014	0.80	0.80
	1210.0	0.330	0.01759	0.80	0.80
	1460.0	0.360	0.01551	0.80	0.80
	1710.0	0.390	0.01377	0.80	0.80
	1960.0	0.410	0.01243	0.80	0.80
	2210.0	0.430	0.01123	0.80	0.80
	2460.0	0.450	0.01076	0.80	0.80
	2960.0	0.480	0.00909	0.80	0.80
	3460.0	0.510	0.00828	0.80	0.80
	3960.0	0.530	0.00741	0.80	0.80
	4460.0	0.550	0.00694	0.80	0.80
	5460.0	0.575	0.00625	0.80	0.80
-1	7960.0	0.575	0.00625	0.80	0.80
	3014.40				
	672.0	0.214	0.0000122	0.80	0.80
	852.0	0.265	0.0000144	0.80	0.80
	1032.0	0.312	0.0000169	0.80	0.80
	1212.0	0.351	0.0000197	0.80	0.80
	1392.0	0.380	0.0000225	0.80	0.80
	1572.0	0.406	0.0000239	0.80	0.80
	1752.0	0.424	0.0000253	0.80	0.80
	1932.0	0.440	0.0000267	0.80	0.80
	2112.0	0.450	0.0000281	0.80	0.80
	2292.0	0.461	0.0000297	0.80	0.80
	2472.0	0.470	0.0000311	0.80	0.80
	2652.0	0.478	0.0000325	0.80	0.80
	2832.0	0.482	0.0000339	0.80	0.80
	3012.0	0.487	0.0000356	0.80	0.80
	3460.0	0.500	0.0000392	0.80	0.80
	4460.0	0.520	0.0000475	0.80	0.80
-1	10460.0	0.520	0.0000503	0.80	0.80
	40114.7				
	460.0	0.175	0.02778	0.80	0.80
	710.0	0.225	0.02315	0.80	0.80
	960.0	0.290	0.02014	0.80	0.80
	1210.0	0.330	0.01759	0.80	0.80
	1460.0	0.360	0.01551	0.80	0.80
	1710.0	0.390	0.01377	0.80	0.80

1960.0	0.410	0.01243	0.80	0.80
2210.0	0.430	0.01123	0.80	0.80
2460.0	0.450	0.01076	0.80	0.80
2960.0	0.480	0.00909	0.80	0.80
3460.0	0.510	0.00828	0.80	0.80
3960.0	0.530	0.00741	0.80	0.80
4460.0	0.550	0.00694	0.80	0.80
5460.0	0.575	0.00625	0.80	0.80
-1 7960.0	0.575	0.00625	0.80	0.80
501625.				
460.0	0.0305	0.0239	0.084	0.084
1460.0	0.0347	0.0219	0.137	0.137
2460.0	0.0388	0.0212	0.191	0.191
3460.0	0.0429	0.0182	0.242	0.242
4460.0	0.0470	0.0181	0.298	0.298
4910.0	0.0470	0.0181	0.620	0.620
-1 10460.0	0.0470	0.0181	0.620	0.620
60590.				
460.	.0587	.0000664	.591	.591
560.	.0620	.0000672	.599	.599
1032.	.0780	.0000705	.643	.643
1212.	.0794	.0000739	.659	.659
1392.	.0805	.0000875	.676	.676
1572.	.0811	.0000903	.692	.692
1752.	.0817	.0000931	.709	.709
1932.	.0821	.0001514	.725	.725
2112.	.0825	.0001639	.742	.742
2472.	.0830	.0001892	.775	.775
2652.	.0832	.0002017	.791	.791
2960.	.0835	.0002075	.819	.819
3460.	.0838	.0002167	.865	.865
4460.	.0840	.0002355	.911	.911
5460.	.0840	.0002542	.956	.956
+110460.	.0840	.0002542	.956	.956
1 0.	5000.	10000.		

Time-table

120 entries permitted

	.1	.1	.1	1.000	1.000 0 0 0 0 0	8000.	
	12.0	1,700	0.800	1.000	1.000 0 0 0 0 0	8000.	
0.0	43622.8	0.09	42.628	22.73	0.00034	348.0	46746. 0.0
0.25	43629.4	0.19	57.119	40.78	0.00062	336.3	46753. 0.0
0.50	43636.2	0.37	78.014	76.04	0.00115	324.6	46760. 0.0
0.75	43644.2	0.74	107.316	143.82	0.00218	313.0	46767. 0.0
1.00	43650.8	1.47	150.322	282.07	0.004.8	301.0	46773. 0.0
1.25	43657.4	2.91	211.254	556.89	0.00844	289.6	46778. 0.0
1.50	43661.9	5.78	293.281	1073.13	0.01626	277.9	46780. 0.0
1.75	43657.4	15.38	407.115	2068.20	0.03135	266.2	46779. 0.0
2.00	43640.1	44.94	547.836	3748.09	0.05682	254.5	46766. 0.0
2.25	43598.2	110.79	713.722	6373.13	0.09667	242.8	46741. 0.0
2.50	43514.7	244.76	912.271	10447.53	0.15864	231.2	46593. 0.0
2.75	43367.6	493.88	1145.763	16575.96	0.25214	219.5	46610. 0.0
3.00	43126.7	899.27	1414.083	25487.52	0.38881	207.9	46478. 0.0
3.25	42748.6	1581.84	1727.713	38610.24	0.59.0	195.3	46271. 0.0
3.50	42164.8	2605.77	2093.353	57988.98	0.89477	184.8	45953. 0.0
3.75	41290.5	4191.64	2489.822	0.0	1.30002	173.3	45472. 0.0
3.95	40277.6	6032.64	2847.254	0.0	1.8.072	164.1	44911. 0.0
4.10	39338.6	7685.46	3103.646	0.0	2.25340	157.6	44385. 0.0
4.22	38443.3	9158.19	3310.637	0.0	2.72976	152.5	43877. 0.0
4.32	37530.3	10478.05	3491.145	0.0	3.19620	147.2	43354. 0.0
4.42	36476.7	11885.39	3656.354	0.0	3.72678	143.9	42743. 0.0
4.52	35269.6	13268.12	3798.086	0.0	4.32249	139.6	42031. 0.0
4.62	33899.2	14236.21	3906.083	0.0	4.97773	135.5	41207. 0.0

4.72	32359.8	14945.10	3972.378	0.0	5.68821	131.4	40262.	0.0
4.82	30652.5	14640.01	3986.267	0.0	6.43489	127.4	39187.	0.0
4.92	28786.5	13722.39	3941.544	0.0	7.19944	123.6	37978.	0.0
5.02	26780.8	11248.63	3833.005	0.0	7.95015	119.8	36633.	0.0
5.12	24664.1	8495.31	3660.946	0.0	8.65439	116.2	35158.	0.0
5.22	22475.3	5570.58	3430.057	0.0	9.27424	112.8	33564.	0.0
5.32	20260.3	2822.21	3150.542	0.0	9.77572	109.5	31870.	0.0
5.42	18067.8	1225.46	2836.325	0.0	10.13010	106.4	30100.	0.0
5.52	15950.3	655.31	2498.031	0.0	10.26720	103.5	28285.	0.0
5.62	13958.3	380.10	2159.229	0.0	10.21262	100.8	26464.	0.0
5.72	12123.1	233.62	1836.626	0.0	9.99701	98.2	24667.	0.0
5.82	10462.5	0.0	1541.068	0.0	9.65201	95.9	22920.	0.0
5.92	8984.2	0.0	1278.214	0.0	9.20298	93.6	21245.	0.0
6.02	7686.5	0.0	1050.029	0.0	8.67376	91.6	19657.	0.0
6.12	6560.5	0.0	856.810	0.0	8.10546	89.7	18167.	0.0
6.22	5592.5	0.0	695.483	0.0	7.51296	88.0	16781.	0.0
6.32	4766.5	0.0	562.809	0.0	6.92184	86.4	15500.	0.0
6.42	4065.3	0.0	454.782	0.0	6.34671	84.9	14323.	0.0
6.52	3472.2	0.0	367.437	0.0	5.79764	83.5	13247.	0.0
6.62	2971.6	0.0	297.232	0.0	5.28342	82.2	12265.	0.0
6.72	2549.5	0.0	240.911	0.0	4.80546	81.0	11371.	0.0
6.82	2193.5	0.0	195.823	0.0	4.36690	79.9	10558.	0.0
6.92	1893.0	0.0	159.760	0.0	3.96887	78.9	9821.	0.0
7.02	1638.9	0.0	130.827	0.0	3.60677	78.0	9150.	0.0
7.12	1423.6	0.0	107.592	0.0	3.28012	77.1	8542.	0.0
7.22	1240.6	0.0	88.869	0.0	2.98537	76.3	7988.	0.0
7.32	1084.8	0.0	73.742	0.0	2.72031	75.5	7484.	0.0
7.42	951.6	0.0	61.477	0.0	2.48248	74.8	7025.	0.0
7.52	837.4	0.0	51.489	0.0	2.26866	74.1	6605.	0.0
7.62	739.2	0.0	43.326	0.0	2.07687	73.4	6222.	0.0
7.72	654.4	0.0	36.622	0.0	1.90437	72.8	5872.	0.0
7.82	580.9	0.0	29.762	0.0	1.74954	72.3	5550.	0.0
7.92	517.1	0.0	25.146	0.0	1.60959	71.7	5255.	0.0
8.02	461.4	0.0	21.317	0.0	1.48443	71.2	4983.	0.0
8.12	412.7	0.0	19.111	0.0	1.30149	70.7	4732.	0.0
8.22	370.0	0.0	16.358	0.0	1.20827	70.3	4501.	0.0
8.32	332.4	0.0	14.038	0.0	1.12320	69.8	4287.	0.0
8.42	299.1	0.0	12.082	0.0	1.04621	69.4	4088.	0.0
8.52	269.7	0.0	10.424	0.0	0.97597	69.0	3904.	0.0
8.62	243.5	0.0	9.016	0.0	0.91209	68.6	3733.	0.0
8.72	220.3	0.0	7.817	0.0	0.85384	68.3	3574.	0.0
8.82	199.4	0.0	6.791	0.0	0.80061	67.9	3425.	0.0
8.92	180.8	0.0	5.912	0.0	0.75187	67.6	3287.	0.0
9.02	164.1	0.0	5.156	0.0	0.70713	67.3	3157.	0.0
9.12	149.0	0.0	4.505	0.0	0.66623	67.0	3036.	0.0
9.22	135.4	0.0	3.941	0.0	0.62852	66.7	2922.	0.0
9.32	123.1	0.0	3.452	0.0	0.59369	66.4	2815.	0.0
9.42	112.0	0.0	3.029	0.0	0.56188	66.1	2714.	0.0
9.52	101.9	0.0	2.659	0.0	0.53219	65.8	2620.	0.0
9.62	92.7	0.0	2.336	0.0	0.50467	65.6	2530.	0.0
9.72	84.3	0.0	2.055	0.0	0.47939	65.3	2446.	0.0
9.82	76.7	0.0	1.808	0.0	0.45584	65.1	2367.	0.0
9.92	69.7	0.0	1.591	0.0	0.43416	64.8	2297.	0.0
10.02	63.3	0.0	1.400	0.0	0.41389	64.6	2221.	0.0
10.12	57.4	0.0	1.232	0.0	0.39510	64.4	2153.	0.0
10.22	52.0	0.0	1.083	0.0	0.37778	64.2	2090.	0.0
10.32	47.0	0.0	0.951	0.0	0.36154	64.0	2029.	0.0
10.42	42.4	0.0	0.834	0.0	0.34638	63.8	1971.	0.0
10.52	38.2	0.0	0.730	0.0	0.33219	63.6	1917.	0.0
10.62	34.2	0.0	0.637	0.0	0.31903	63.4	1865.	0.0

10.72	30.6	0.0	0.554	0.0	0.30668	63.2	1815.	0.0
10.82	27.2	0.0	0.480	0.0	0.29520	63.0	1768.	0.0
10.92	24.0	0.0	0.414	0.0	0.28440	62.9	1722.	0.0
11.02	21.1	0.0	0.355	0.0	0.27424	62.7	1679.	0.0
11.22	15.8	0.0	0.254	0.0	0.25582	62.4	1599.	0.0
11.42	11.2	0.0	0.172	0.0	0.23956	62.1	1525.	0.0
11.62	7.1	0.0	0.105	0.0	0.22500	61.8	1456.	0.0
11.84	3.3	0.0	0.047	0.0	0.21729	61.4	1389.	0.0
12.06	-0.1	0.0	-0.002	0.0	0.19895	61.1	1325.	0.0
12.46	-5.0	0.0	-0.064	0.0	0.18129	60.6	1229.	0.0
12.91	-9.4	0.0	-0.112	0.0	0.16557	60.1	1136.	0.0
13.43	-13.4	0.0	-0.149	0.0	0.15199	59.5	1046.	0.0
14.07	-16.8	0.0	-0.176	0.0	0.14087	58.9	959.	0.0
14.86	-19.9	0.0	-0.197	0.0	0.13228	58.2	875.	0.0
19.65	-27.7	0.0	-0.234	0.0	0.12044	54.7	614.	0.0
29.43	-31.1	0.0	-0.249	0.0	0.13572	49.7	452.	0.0
39.43	-32.1	0.0	-0.263	0.0	0.15994	45.5	392.	0.0
49.43	-32.7	0.0	-0.278	0.0	0.18739	41.8	355.	0.0
59.43	-33.1	0.0	-0.292	0.0	0.21725	38.4	326.	0.0
69.43	-32.6	0.0	-0.297	0.0	0.24953	35.2	301.	0.0
79.43	-30.3	0.0	-0.286	0.0	0.28359	32.3	284.	0.0
89.43	-28.1	0.0	-0.275	0.0	0.31953	29.5	269.	0.0
99.43	-26.0	0.0	-0.262	0.0	0.35737	26.9	257.	0.0
109.43	-24.0	0.0	-0.249	0.0	0.39695	24.4	245.	0.0
119.43	-22.0	0.0	-0.236	0.0	0.43827	22.0	235.	0.0
129.43	-20.2	0.0	-0.221	0.0	0.48124	19.7	226.	0.0
139.43	-18.3	0.0	-0.206	0.0	0.52610	17.5	218.	0.0
149.43	-16.6	0.0	-0.191	0.0	0.57253	15.3	210.	0.0
159.43	-14.9	0.0	-0.175	0.0	0.62049	13.3	203.	0.0
169.43	-13.2	0.0	-0.159	0.0	0.67020	11.3	197.	0.0
179.43	-11.6	0.0	-0.143	0.0	0.72130	9.3	191.	0.0
189.43	-10.0	0.0	-0.126	0.0	0.77405	7.5	186.	0.0
199.43	-8.5	0.0	-0.109	0.0	0.82833	5.6	180.	0.0
209.43	-7.0	0.0	-0.091	0.0	0.88426	3.8	176.	0.0
219.43	-5.5	0.0	-0.074	0.0	0.94171	2.1	171.	0.0
229.43	-4.1	0.0	-0.056	0.0	1.00058	0.4	167.	0.0
1 231.97	-3.8	0.0	-0.051	0.0	1.01555	0.0	166.	0.0
1	1.	1.0	0.5	0	0	0	0	0
0.00001	0.0	60.00000	2687.99220.0	6928.273	6928.273	1	C*	C
0.00001	0.0	50.00000	2687.65360.0	6903.277	6903.277	1	C*	C
0.00001	0.0	30.00000	2686.10300.0	6810.352	6810.352	1	C*	C
0.00001	0.0	20.00000	2684.24730.0	6695.957	6695.957	1	C*	C
0.00001	0.0	10.00000	2679.02490.0	6369.059	6369.059	1	C*	C
0.00001	0.0	5.00000	2669.34200.0	5792.414	5792.414	1	C*	C
0.00001	0.0	1.00000	2613.71970.0	3182.023	3182.023	1	C*	C
0.00001	0.0	0.35000	2525.43990.0	1236.478	1236.478	1	C*	C
0.00001	0.0	0.20000	2394.70140.0	433.386	433.386	1	C*	C
0.00001	0.0	0.13000	2359.54710.0	362.322	362.322	1	C*	C
0.00001	0.0	0.18000	2283.43990.0	275.831	275.831	1	C*	C
0.00001	0.0	0.17500	1986.69210.0	150.001	150.001	1	C*	C
0.00001	0.0	0.17491	1728.07060.0	70.276	70.276	1	C*	C
0.00001	0.0	0.1748	1666.67 0.0	51.10	51.10	1	C*	
0.00001	0.0	0.1743	1450.0 0.0	-15.3	-15.3	1	C*	GE
0.00001	0.0	0.1686	1350.0 0.0	-62.9	-62.9	1	C*	GE
0.00001	0.0	0.1252	1250.0 0.0	-238.5	-238.5	1	C*	GE
0.00001	0.0	0.0813	1200.0 0.0	-349.1	-349.1	1	C*	GE
0.00001	0.0	0.0429	1150.0 0.0	-98.4	-98.4	1	C*	GE
0.00001	0.0	0.0193	1100.0 0.0	60.4	60.4	1	C*	GE
0.00001	0.0	0.0027	1000.0 0.0	159.2	159.2	1	C*	GE
0.00001	0.0	0.0	1000.0 0.0	250.0	250.0	0		AIR

Surface thermochemistry tables

20 pressure tables with up to
 30 mass loss parameters (β_c) permitted.

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0.00001	0.0	0.0	500.0	0.0	120.1	120.1	0		AIR
0.00001	0.0	0.0	260.0	0.0	62.2	62.2	0		
0.00001	0.0	0.0	240.0	0.0	57.4	57.4	0		AIR
0.00001	0.0	0.0	200.0	0.0	47.8	47.8	0		AIR
0.00001	0.0	0.0	180.0	0.0	43.0	43.0	0		
0.00001	0.0	0.0	140.0	0.0	33.4	33.4	0		
0.00001	0.0	0.0	100.0	0.0	23.9	23.9	0		
0.00001	0.0	0.0	.0001	0.0	0.0	0.0	0		
0.0001	0.0	60.000002881	.59230.0		6901.996	6901.996	1	C*	C I
0.0001	0.0	50.000002881	.18430.0		6877.484	6877.484	1	C*	C I
0.0001	0.0	30.000002879	.33280.0		6786.594	6786.594	1	C*	C I
0.0001	0.0	20.000002877	.12400.0		6674.496	6674.496	1	C*	C I
0.0001	0.0	10.000002870	.92460.0		6353.332	6353.332	1	C*	C I
0.0001	0.0	5.000002859	.39650.0		5783.715	5783.715	1	C*	C I
0.0001	0.0	1.000002794	.39210.0		3206.576	3206.576	1	C*	C I
0.0001	0.0	0.350002692	.36210.0		1279.992	1279.992	1	C*	C I
0.0001	0.0	0.200002542	.22410.0		478.635	478.635	1	C*	C I
0.0001	0.0	0.190002501	.90990.0		406.375	406.375	1	C*	C I
0.0001	0.0	0.180002414	.66060.0		316.658	316.658	1	C*	C I
0.0001	0.0	0.175002078	.76290.0		178.367	178.367	1	C*	C I
0.0001	0.0	0.174911794	.63940.0		90.524	90.524	1	C*	C I
0.0001	0.0	0.1748	1666.67 0.0		51.10	51.10	1	C*	
0.0001	0.0	0.1743	1450.0 0.0		-15.3	-15.3	1	C*	GE
0.0001	0.0	0.1686	1350.0 0.0		-62.9	-62.9	1	C*	GE
0.0001	0.0	0.1252	1250.0 0.0		-238.5	-238.5	1	C*	GE
0.0001	0.0	0.0813	1200.0 0.0		-349.1	-349.1	1	C*	GE
0.0001	0.0	0.0429	1150.0 0.0		-98.4	-98.4	1	C*	GE
0.0001	0.0	0.0193	1100.0 0.0		60.4	60.4	1	C*	GE
0.0001	0.0	0.0027	1000.0 0.0		159.2	159.2	1	C*	GE
0.0001	0.0	0.0	1000.0 0.0		250.0	250.0	0		AIR
0.0001	0.0	0.0	500.0 0.0		120.1	120.1	0		AIR
0.0001	0.0	0.0	260.0 0.0		62.2	62.2	0		
0.0001	0.0	0.0	240.0 0.0		57.4	57.4	0		AIR
0.0001	0.0	0.0	200.0 0.0		47.8	47.8	0		AIR
0.0001	0.0	0.0	180.0 0.0		43.0	43.0	0		
0.0001	0.0	0.0	140.0 0.0		33.4	33.4	0		
0.0001	0.0	0.0	100.0 0.0		23.9	23.9	0		
0.0001	0.0	0.0	.0001 0.0		0.0	0.0	0		
0.001	0.0	60.000003105	.77390.0		6908.277	6908.277	1	C*	C I
0.001	0.0	50.000003105	.19310.0		6885.961	6885.961	1	C*	C I
0.001	0.0	30.000003102	.95870.0		6796.809	6796.809	1	C*	C I
0.001	0.0	20.000003100	.30180.0		6686.586	6686.586	1	C*	C I
0.001	0.0	10.000003092	.87520.0		6370.063	6370.063	1	C*	C I
0.001	0.0	5.000003079	.07060.0		5806.551	5806.551	1	C*	C I
0.001	0.0	1.000003002	.35550.0		3252.220	3252.220	1	C*	C I
0.001	0.0	0.350002883	.20120.0		1335.477	1335.477	1	C*	C I
0.001	0.0	0.200002708	.93530.0		530.768	530.768	1	C*	C I
0.001	0.0	0.190002662	.21730.0		456.612	456.612	1	C*	C I
0.001	0.0	0.180002561	.16310.0		362.507	362.507	1	C*	C I
0.001	0.0	0.175002178	.06250.0		209.068	209.068	1	C*	C I
0.001	0.0	0.174911863	.28660.0		111.481	111.481	1	C*	C I
0.001	0.0	0.1748	1666.67 0.0		51.10	51.10	1	C*	
0.001	0.0	0.1743	1450.0 0.0		-15.3	-15.3	1	C*	GE
0.001	0.0	0.1686	1350.0 0.0		-62.9	-62.9	1	C*	GE
0.001	0.0	0.1252	1250.0 0.0		-238.5	-238.5	1	C*	GE
0.001	0.0	0.0813	1200.0 0.0		-349.1	-349.1	1	C*	GE
0.001	0.0	0.0429	1150.0 0.0		-98.4	-98.4	1	C*	GE
0.001	0.0	0.0193	1100.0 0.0		60.4	60.4	1	C*	GE
0.001	0.0	0.0027	1000.0 0.0		159.2	159.2	1	C*	GE
0.001	0.0	0.0	1000.0 0.0		250.0	250.0	0		AIR

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0.001	0.0	9.0	500.0	0.0	120.1	120.1	0	AIR
0.001	0.0	0.0	260.0	0.0	62.2	62.2	0	
0.001	0.0	0.0	240.0	0.0	57.4	57.4	0	AIR
0.001	0.0	0.0	200.0	0.0	47.8	47.8	0	AIR
0.001	0.0	0.0	180.0	0.0	43.0	43.0	0	
0.001	0.0	0.0	140.0	0.0	33.4	33.4	0	
0.001	0.0	0.0	100.0	0.0	23.9	23.9	0	
0.001	0.0	0.0	.0001	0.0	0.0	0.0	0	
0.0020	0.0	60.000003180	32350.0	0.0	6917.563	6917.563	1	C*
0.0020	0.0	50.000003179	70170.0	0.0	6895.371	6895.371	1	C*
0.0020	0.0	30.000003177	33230.0	0.0	6806.711	6806.711	1	C*
0.0020	0.0	20.000003174	51440.0	0.0	6697.027	6697.027	1	C*
0.0020	0.0	10.000003166	69920.0	0.0	6381.750	6381.750	1	C*
0.0020	0.0	5.000003152	54980.0	0.0	5819.109	5819.109	1	C*
0.0020	0.0	1.000003071	71800.0	0.0	3270.276	3270.276	1	C*
0.0020	0.0	0.350002943	24220.0	0.0	1363.521	1363.521	1	C*
0.0020	0.0	0.200002757	24390.0	0.0	548.953	548.953	1	C*
0.0020	0.0	0.150002707	18260.0	0.0	472.821	472.821	1	C*
0.0020	0.0	0.180002599	10890.0	0.0	375.333	375.333	1	C*
0.0020	0.0	0.175002249	75170.0	0.0	231.768	231.768	1	C*
0.0020	0.0	0.174902161	85420.0	0.0	203.822	203.822	1	C*
0.0020	0.0	0.1748	1666.67	0.0	51.10	51.10	1	C*
0.0020	0.0	0.1743	1450.0	0.0	-15.3	-15.3	1	C* GE
0.0020	0.0	0.1686	1350.0	0.0	-62.9	-62.9	1	C* GE
0.0020	0.0	0.1252	1250.0	0.0	-238.5	-238.5	1	C* GE
0.0020	0.0	0.0813	1200.0	0.0	-349.1	-349.1	1	C* GE
0.0020	0.0	0.0429	1150.0	0.0	-98.4	-98.4	1	C* GE
0.0020	0.0	0.0193	1100.0	0.0	60.4	60.4	1	C* GE
0.0020	0.0	0.0027	1000.0	0.0	159.2	159.2	1	C* GE
0.0020	0.0	0.0	1000.0	0.0	250.0	250.0	0	AIR
0.0020	0.0	0.0	500.0	0.0	120.1	120.1	0	AIR
0.0020	0.0	0.0	260.0	0.0	62.2	62.2	0	
0.0020	0.0	0.0	240.0	0.0	57.4	57.4	0	AIR
0.0020	0.0	0.0	200.0	0.0	47.8	47.8	0	AIR
0.0020	0.0	0.0	180.0	0.0	43.0	43.0	0	
0.0020	0.0	0.0	140.0	0.0	33.4	33.4	0	
0.0020	0.0	0.0	100.0	0.0	23.9	23.9	0	
0.0020	0.0	0.0	.0001	0.0	0.0	0.0	0	
0.0050	0.0	60.000003284	64090.0	0.0	6934.531	6934.531	1	C*
0.0050	0.0	50.000003283	96440.0	0.0	6912.527	6912.527	1	C*
0.0050	0.0	30.000003281	40110.0	0.0	6824.453	6824.453	1	C*
0.0050	0.0	20.000003278	35570.0	0.0	6715.402	6715.402	1	C*
0.0050	0.0	10.000003269	87330.0	0.0	6401.652	6401.652	1	C*
0.0050	0.0	5.000003254	67040.0	0.0	5841.047	5841.047	1	C*
0.0050	0.0	1.000003167	92940.0	0.0	3297.372	3297.372	1	C*
0.0050	0.0	0.350003074	16850.0	0.0	1382.595	1382.595	1	C*
0.0050	0.0	0.200002831	90840.0	0.0	572.696	572.696	1	C*
0.0050	0.0	0.190002778	49610.0	0.0	495.400	495.400	1	C*
0.0050	0.0	0.180002663	22410.0	0.0	395.472	395.472	1	C*
0.0050	0.0	0.175002293	18600.0	0.0	245.230	245.230	1	C*
0.0050	0.0	0.174902200	8770.0	0.0	215.878	215.878	1	C*
0.0050	0.0	0.1748	1666.67	0.0	51.10	51.10	1	C*
0.0050	0.0	0.1743	1450.0	0.0	-15.3	-15.3	1	C* GE
0.0050	0.0	0.1686	1350.0	0.0	-62.9	-62.9	1	C* GE
0.0050	0.0	0.1252	1250.0	0.0	-238.5	-238.5	1	C* GE
0.0050	0.0	0.0813	1200.0	0.0	-349.1	-349.1	1	C* GE
0.0050	0.0	0.0429	1150.0	0.0	-98.4	-98.4	1	C* GE
0.0050	0.0	0.0193	1100.0	0.0	60.4	60.4	1	C* GE
0.0050	0.0	0.0027	1000.0	0.0	159.2	159.2	1	C* GE
0.0050	0.0	0.0	1000.0	0.0	250.0	250.0	0	AIR

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0.0050	0.0	0.0	500.0	0.0	120.1	120.1	0		AIR
0.0050	0.0	0.0	260.0	0.0	62.2	62.2	0		
0.0050	0.0	0.0	240.0	0.0	57.4	57.4	0		AIR
0.0050	0.0	0.0	200.0	0.0	47.8	47.8	0		AIR
0.0050	0.0	0.0	180.0	0.0	43.0	43.0	0		
0.0050	0.0	0.0	140.0	0.0	33.4	33.4	0		
0.0050	0.0	0.0	100.0	0.0	23.9	23.9	0		
0.0050	0.0	0.0	.0001	0.0	0.0	0.0	0		
0.01	0.0	60.00000	3368.30220.0		6950.918	6950.918	1	C*	C I
0.01	0.0	50.00000	3367.58370.0		6928.996	6928.996	1	C*	C I
0.01	0.0	30.00000	3364.85890.0		6841.363	6841.363	1	C*	C I
0.01	0.0	20.00000	3361.62300.0		6732.754	6732.754	1	C*	C I
0.01	0.0	10.00000	3352.61740.0		6419.977	6419.977	1	C*	C I
0.01	0.0	5.00000	3336.11940.0		5860.250	5860.250	1	C*	C I
0.01	0.0	1.00000	3244.45140.0		3319.316	3319.316	1	C*	C I
0.01	0.0	0.35000	3103.50950.0		1403.857	1403.857	1	C*	C I
0.01	0.0	0.20000	2898.56590.0		590.734	590.734	1	C*	C I
0.01	0.0	0.19000	2843.69560.0		513.877	513.877	1	C*	C I
0.01	0.0	0.18000	2725.08740.0		413.964	413.964	1	C*	C I
0.01	0.0	0.17500	2283.25120.0		241.694	241.694	1	C*	C I
0.01	0.0	0.17491	1930.57130.0		132.089	132.089	1	C*	C I
0.01	0.0	0.1748	1666.67 0.0		51.10	51.10	1	C*	
0.01	0.0	0.1743	1450.0 0.0		-15.3	-15.3	1	C*	GE
0.01	0.0	0.1686	1350.0 0.0		-62.9	-62.9	1	C*	GE
0.01	0.0	0.1252	1250.0 0.0		-238.5	-238.5	1	C*	GE
0.01	0.0	0.0813	1200.0 0.0		-349.1	-349.1	1	C*	GE
0.01	0.0	0.0429	1150.0 0.0		-98.4	-98.4	1	C*	GE
0.01	0.0	0.0193	1100.0 0.0		60.4	60.4	1	C*	GE
0.01	0.0	0.0027	1000.0 0.0		159.2	159.2	1	C*	GE
0.01	0.0	0.0	1000.0 0.0		250.0	250.0	0		AIR
0.01	0.0	0.0	500.0 0.0		120.1	120.1	0		AIR
0.01	0.0	0.0	260.0 0.0		62.2	62.2	0		
0.01	0.0	0.0	240.0 0.0		57.4	57.4	0		AIR
0.01	0.0	0.0	200.0 0.0		47.8	47.8	0		AIR
0.01	0.0	0.0	180.0 0.0		43.0	43.0	0		
0.01	0.0	0.0	140.0 0.0		33.4	33.4	0		
0.01	0.0	0.0	100.0 0.0		23.9	23.9	0		
0.01	0.0	0.0	.0001 0.0		0.0	0.0	0		
0.0220	0.0	60.00000	3468.91410.0		6973.277	6973.277	1	C*	
0.0220	0.0	50.00000	3468.14330.0		6951.520	6951.520	1	C*	
0.0220	0.0	30.00000	3465.21190.0		6864.355	6864.355	1	C*	
0.0220	0.0	20.00000	3461.73680.0		6756.277	6756.277	1	C*	
0.0220	0.0	10.00000	3452.08370.0		6444.684	6444.684	1	C*	
0.0220	0.0	5.00000	3434.84960.0		5886.863	5886.863	1	C*	
0.0220	0.0	1.00000	3337.14650.0		3348.694	3348.694	1	C*	
0.0220	0.0	0.35000	3187.44210.0		1431.739	1431.739	1	C*	
0.0220	0.0	0.20000	2961.05470.0		613.809	613.809	1	C*	
0.0220	0.0	0.19000	2901.37870.0		534.309	534.309	1	C*	
0.0220	0.0	0.18000	2772.66920.0		429.841	429.841	1	C*	
0.0220	0.0	0.17500	2364.37260.0		267.330	267.330	1	C*	
0.0220	0.0	0.17490	2263.93900.0		235.396	235.396	1	C*	
0.0220	0.0	0.1748	1666.67 0.0		51.10	51.10	1	C*	
0.0220	0.0	0.1743	1450.0 0.0		-15.3	-15.3	1	C*	GE
0.0220	0.0	0.1686	1350.0 0.0		-62.9	-62.9	1	C*	GE
0.0220	0.0	0.1252	1250.0 0.0		-238.5	-238.5	1	C*	GE
0.0220	0.0	0.0813	1200.0 0.0		-349.1	-349.1	1	C*	GE
0.0220	0.0	0.0429	1150.0 0.0		-98.4	-98.4	1	C*	GE
0.0220	0.0	0.0193	1100.0 0.0		60.4	60.4	1	C*	GE
0.0220	0.0	0.0027	1000.0 0.0		159.2	159.2	1	C*	GE
0.0220	0.0	0.0	1000.0 0.0		250.0	250.0	0		AIR

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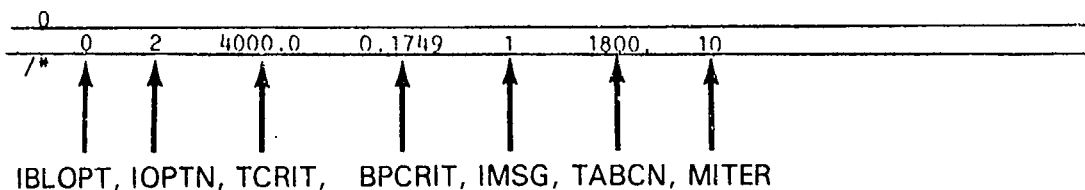
0.0220	0.0	0.0	500.0	0.0	120.1	120.1	0		AIR
0.0220	0.0	0.0	260.0	0.0	62.2	62.2	0		
0.0220	0.0	0.0	240.0	0.0	57.4	57.4	0		AIR
0.0220	0.0	0.0	200.0	0.0	47.8	47.8	0		AIR
0.0220	0.0	0.0	180.0	0.0	43.0	43.0	0		
0.0220	0.0	0.0	140.0	0.0	33.4	33.4	0		
0.0220	0.0	0.0	100.0	0.0	23.9	23.9	0		
0.0220	0.0	0.0	.0001	0.0	0.0	0.0	0		
0.0460	0.0	60.000003568	.74190.0		6997.809	6997.809	1	C*	
0.0460	0.0	50.000003567	.91850.0		6976.176	6976.176	1	C*	
0.0460	0.0	30.000003564	.78050.0		6889.453	6889.453	1	C*	
0.0460	0.0	20.000003561	.05740.0		6781.793	6781.793	1	C*	
0.0460	0.0	10.000003550	.74270.0		6471.188	6471.188	1	C*	
0.0460	0.0	5.000003532	.34520.0		5914.496	5914.496	1	C*	
0.0460	0.0	1.000003428	.41940.0		3377.774	3377.774	1	C*	
0.0460	0.0	0.350003269	.67850.0		1458.450	1458.450	1	C*	
0.0460	0.0	0.200003039	.75490.0		636.239	636.239	1	C*	
0.0460	0.0	0.190002966	.18870.0		554.787	554.787	1	C*	
0.0460	0.0	0.180002829	.75050.0		447.737	447.737	1	C*	
0.0460	0.0	0.175002399	.69800.0		278.312	278.312	1	C*	
0.0460	0.0	0.174902294	.68460.0		244.927	244.927	1	C*	
0.0460	0.0	0.1748	1666.67	0.0	51.10	51.10	1	C*	
0.0460	0.0	0.1743	1450.0	0.0	-15.3	-15.3	1	C*	GE
0.0460	0.0	0.1686	1350.0	0.0	-62.9	-62.9	1	C*	GE
0.0460	0.0	0.1252	1250.0	0.0	-238.5	-238.5	1	C*	GE
0.0460	0.0	0.0813	1200.0	0.0	-349.1	-349.1	1	C*	GE
0.0460	0.0	0.0429	1150.0	0.0	-98.4	-98.4	1	C*	GE
0.0460	0.0	0.0193	1100.0	0.0	60.4	60.4	1	C*	GE
0.0460	0.0	0.0027	1000.0	0.0	159.2	159.2	1	C*	GE
0.0460	0.0	0.0	1000.0	0.0	250.0	250.0	0		AIR
0.0460	0.0	0.0	500.0	0.0	120.1	120.1	0		AIR
0.0460	0.0	0.0	260.0	0.0	62.2	62.2	0		
0.0460	0.0	0.0	240.0	0.0	57.4	57.4	0		AIR
0.0460	0.0	0.0	200.0	0.0	47.8	47.8	0		AIR
0.0460	0.0	0.0	180.0	0.0	43.0	43.0	0		
0.0460	0.0	0.0	140.0	0.0	33.4	33.4	0		
0.0460	0.0	0.0	100.0	0.0	23.9	23.9	0		
0.0460	0.0	0.0	.0001	0.0	0.0	0.0	0		
0.1	0.0	60.000003677	.37650.0		7027.430	7027.430	1	C*	C I
0.1	0.0	50.000003670	.48950.0		7005.883	7005.883	1	C*	C I
0.1	0.0	30.000003676	.10690.0		6919.547	6919.547	1	C*	C I
0.1	0.0	20.000003672	.10210.0		6812.309	6812.309	1	C*	C I
0.1	0.0	10.000003661	.00710.0		6502.574	6502.574	1	C*	C I
0.1	0.0	5.000003641	.20830.0		5945.016	5945.016	1	C*	C I
0.1	0.0	1.000003529	.90870.0		3408.819	3408.819	1	C*	C I
0.1	0.0	0.350003360	.41890.0		1486.246	1486.246	1	C*	C I
0.1	0.0	0.200003115	.15190.0		659.078	659.078	1	C*	C I
0.1	0.0	0.190003049	.50240.0		578.657	578.657	1	C*	C I
0.1	0.0	0.180002907	.61060.0		471.172	471.172	1	C*	C I
0.1	0.0	0.175002389	.57180.0		274.760	274.760	1	C*	C I
0.1	0.0	0.174911994	.11840.0		151.611	151.611	1	C*	C I
0.1	0.0	0.1748	1666.67	0.0	51.10	51.10	1	C*	
0.1	0.0	0.1743	1450.0	0.0	-15.3	-15.3	1	C*	GE
0.1	0.0	0.1686	1350.0	0.0	-62.9	-62.9	1	C*	GE
0.1	0.0	0.1252	1250.0	0.0	-238.5	-238.5	1	C*	GE
0.1	0.0	0.0813	1200.0	0.0	-349.1	-349.1	1	C*	GE
0.1	0.0	0.0429	1150.0	0.0	-98.4	-98.4	1	C*	GE
0.1	0.0	0.0193	1100.0	0.0	60.4	60.4	1	C*	GE
0.1	0.0	0.0027	1000.0	0.0	159.2	159.2	1	C*	GE
0.10	0.0	0.0	1000.0	0.0	250.0	250.0	0		AIR

0.10	0.0	0.0	500.0	0.0	120.1	120.1	0		AIR
0.10	0.0	0.0	260.0	0.0	62.2	62.2	0		
0.10	0.0	0.0	240.0	0.0	57.4	57.4	0		AIR
0.10	0.0	0.0	200.0	0.0	47.8	47.8	0		AIR
0.10	0.0	0.0	180.0	0.0	43.0	43.0	0		
0.10	0.0	0.0	140.0	0.0	33.4	33.4	0		
0.10	0.0	0.0	100.0	0.0	23.8	23.8	0		
0.10	0.0	0.0	.0001	0.0	0.0	0.0	0		
0.2150	0.0	60.000003797	.61740.0		7060.477	7060.477	1	C*	
0.2150	0.0	50.000003796	.66500.0		7039.090	7039.090	1	C*	
0.2150	0.0	30.000003793	.01170.0		6953.199	6953.199	1	C*	
0.2150	0.0	20.000003788	.69700.0		6846.414	6846.414	1	C*	
0.2150	0.0	10.000003776	.76000.0		6537.637	6537.637	1	C*	
0.2150	0.0	5.000003755	.54860.0		5982.898	5982.898	1	C*	
0.2150	0.0	1.000003636	.56670.0		3446.366	3446.366	1	C*	
0.2150	0.0	0.350003455	.95630.0		1519.255	1519.255	1	C*	
0.2150	0.0	0.200003194	.93900.0		685.500	685.500	1	C*	
0.2150	0.0	0.190003125	.17090.0		603.449	603.449	1	C*	
0.2150	0.0	0.180002953	.96360.0		486.518	486.518	1	C*	
0.2150	0.0	0.175002471	.17650.0		300.557	300.557	1	C*	
0.2150	0.0	0.174902355	.32890.0		263.750	263.750	1	C*	
0.2150	0.0	0.1748	1666.67	0.0	51.10	51.10	1	C*	
0.2150	0.0	0.1743	1450.0	0.0	-15.3	-15.3	1	C*	GE
0.2150	0.0	0.1686	1350.0	0.0	-62.9	-62.9	1	C*	GE
0.2150	0.0	0.1252	1250.0	0.0	-238.5	-238.5	1	C*	GE
0.2150	0.0	0.0813	1209.0	0.0	-349.1	-349.1	1	C*	GE
0.2150	0.0	0.0429	1150.0	0.0	-98.4	-98.4	1	C*	GE
0.2150	0.0	0.0193	1100.0	0.0	60.4	60.4	1	C*	GE
0.2150	0.0	0.0027	1000.0	0.0	159.2	159.2	1	C*	GE
0.2150	0.0	0.0	1000.0	0.0	250.0	250.0	0		AIR
0.2150	0.0	0.0	500.0	0.0	120.1	120.1	0		AIR
0.2150	0.0	0.0	260.0	0.0	62.2	62.2	0		
0.2150	0.0	0.0	240.0	0.0	57.4	57.4	0		AIR
0.2150	0.0	0.0	200.0	0.0	47.8	47.8	0		AIR
0.2150	0.0	0.0	180.0	0.0	43.0	43.0	0		
0.2150	0.0	0.0	140.0	0.0	33.3	33.3	0		
0.2150	0.0	0.0	100.0	0.0	23.7	23.7	0		
0.2150	0.0	0.0	.0001	0.0	0.0	0.0	0		
0.4640	0.0	60.000003923	.36870.0		7097.602	7097.602	1	C*	
0.4640	0.0	50.000003922	.34350.0		7076.340	7076.340	1	C*	
0.4640	0.0	30.000003918	.39330.0		6990.828	6990.828	1	C*	
0.4640	0.0	20.000003913	.73240.0		6884.449	6884.449	1	C*	
0.4640	0.0	10.000003900	.84910.0		6576.480	6576.480	1	C*	
0.4640	0.0	5.000003877	.99560.0		6022.477	6022.477	1	C*	
0.4640	0.0	1.000003750	.24930.0		3484.573	3484.573	1	C*	
0.4640	0.0	0.350003556	.89260.0		1552.108	1552.108	1	C*	
0.4640	0.0	0.200003277	.59280.0		711.506	711.506	1	C*	
0.4640	0.0	0.190003202	.85060.0		627.803	627.803	1	C*	
0.4640	0.0	0.180003041	.94780.0		513.834	513.834	1	C*	
0.4640	0.0	0.175002504	.48140.0		310.931	310.931	1	C*	
0.4640	0.0	0.174902382	.65280.0		272.241	272.241	1	C*	
0.4640	0.0	0.1748	1666.67	0.0	51.10	51.10	1	C*	
0.4640	0.0	0.1743	1450.0	0.0	-15.3	-15.3	1	C*	GE
0.4640	0.0	0.1686	1350.0	0.0	-62.9	-62.9	1	C*	GE
0.4640	0.0	0.1252	1250.0	0.0	-238.5	-238.5	1	C*	GE
0.4640	0.0	0.0813	1200.0	0.0	-349.1	-349.1	1	C*	GE
0.4640	0.0	0.0429	1150.0	0.0	-98.4	-98.4	1	C*	GE
0.4640	0.0	0.0193	1100.0	0.0	60.4	60.4	1	C*	GE
0.4640	0.0	0.0027	1000.0	0.0	159.2	159.2	1	C*	GE
0.4640	0.0	0.0	1000.0	0.0	250.0	250.0	0		AIR

0.4640	0.0	0.0	500.0	0.0	120.1	120.1	0	AIR	
0.4640	0.0	0.0	260.0	0.0	62.2	62.2	0		
0.4640	0.0	0.0	240.0	0.0	57.4	57.4	0	AIR	
0.4640	0.0	0.0	200.0	0.0	47.8	47.8	0	AIR	
0.4640	0.0	0.0	180.0	0.0	43.0	43.0	0		
0.4640	0.0	0.0	140.0	0.0	33.3	33.3	0		
0.4640	0.0	0.0	100.0	0.0	23.7	23.7	0		
0.4640	0.0	0.0	.0001	0.0	0.0	0.0	0		
1.0	0.0	60.000004057.66360.0			7138.723	7138.723	1	C*	C I
1.0	0.0	50.000004056.55050.0			7117.508	7117.508	1	C*	C* I
1.0	0.0	30.000004052.27420.0			7032.352	7032.352	1	C*	C* I
1.0	0.0	20.000004047.22220.0			6926.297	6926.297	1	C*	C* I
1.0	0.0	10.000004033.27730.0			6618.926	6618.926	1	C*	C* I
1.0	0.0	5.000004009.40720.0			6061.332	6061.332	1	C*	C* I
1.0	0.0	1.000003871.26760.0			3519.934	3519.934	1	C*	C* I
1.0	0.0	0.350003662.62600.0			1582.190	1582.190	1	C*	C* I
1.0	0.0	0.200003361.40160.0			735.431	735.431	1	C*	C* I
1.0	0.0	0.190003280.58740.0			650.105	650.105	1	C*	C* I
1.0	0.0	0.180003105.82060.0			532.485	532.485	1	C*	C* I
1.0	0.0	0.175002486.32640.0			304.905	304.905	1	C*	C* I
1.0	0.0	0.174912075.06880.0			176.557	176.557	1	C*	C* I
1.0	0.0	0.1748 1666.67 0.0			51.0	51.0	1	C*	
1.0	0.0	0.1743 1450.0 0.0			-15.3	-15.3	1	C*	GE
1.0	0.0	0.1686 1350.0 0.0			-62.9	-62.9	1	C*	GE
1.0	0.0	0.1252 1250.0 0.0			-238.5	-238.5	1	C*	GE
1.0	0.0	0.0813 1200.0 0.0			-349.1	-349.1	1	C*	GE
1.0	0.0	0.0429 1150.0 0.0			-98.4	-98.4	1	C*	GE
1.0	0.0	0.0193 1100.0 0.0			60.4	60.4	1	C*	GE
1.0	0.0	0.0027 1000.0 0.0			159.2	159.2	1	C*	GE
1.00	0.0	0.0 1000.0 0.0			250.0	250.0	0		AIR
1.00	0.0	0.0 500.0 0.0			120.1	120.1	0		AIR
1.00	0.0	0.0 260.0 0.0			62.1	62.1	0		
1.00	0.0	0.0 240.0 0.0			57.3	57.3	0		AIR
1.00	0.0	0.0 200.0 0.0			47.7	47.7	0		AIR
1.00	0.0	0.0 180.0 0.0			42.9	42.9	0		
1.00	0.0	0.0 140.0 0.0			33.2	33.2	0		
1.00	0.0	0.0 100.0 0.0			23.5	23.5	0		
1.00	0.0	0.0 .0001 0.0			0.0	0.0	0		
2.1550	0.0	60.000004201.65630.0			7183.977	7183.977	1	C*	
2.1550	0.0	50.000004200.43360.0			7162.898	7162.898	1	C*	
2.1550	0.0	30.000004195.78910.0			7078.117	7078.117	1	C*	
2.1550	0.0	20.000004190.30470.0			6972.473	6972.473	1	C*	
2.1550	0.0	10.000004175.18360.0			6665.863	6665.863	1	C*	
2.1550	0.0	5.000004148.44530.0			6112.777	6112.777	1	C*	
2.1550	0.0	1.000003999.98240.0			3568.790	3568.790	1	C*	
2.1550	0.0	0.350003776.34940.0			1622.460	1622.460	1	C*	
2.1550	0.0	0.200003452.93730.0			765.805	765.805	1	C*	
2.1550	0.0	0.190003366.03930.0			678.253	678.253	1	C*	
2.1550	0.0	0.180003178.74240.0			556.226	556.226	1	C*	
2.1550	0.0	0.175002563.05590.0			329.181	329.181	1	C*	
2.1550	0.0	0.174902428.73120.0			286.572	286.572	1	C*	
2.1550	0.0	0.1748 1666.67 0.0			51.10	51.10	1	C*	
2.1550	0.0	0.1743 1450.0 0.0			-15.3	-15.3	1	C*	GE
2.1550	0.0	0.1686 1350.0 0.0			-62.9	-62.9	1	C*	GE
2.1550	0.0	0.1252 1250.0 0.0			-238.5	-238.5	1	C*	GE
2.1550	0.0	0.0813 1200.0 0.0			-349.1	-349.1	1	C*	GE
2.1550	0.0	0.0429 1150.0 0.0			-98.4	-98.4	1	C*	GE
2.1550	0.0	0.0193 1100.0 0.0			60.4	60.4	1	C*	GE
2.1550	0.0	0.0027 1000.0 0.0			159.2	159.2	1	C*	GE
2.1550	0.0	0.0 1000.0 0.0			250.0	250.0	0		AIR

2.1550	0.0	0.0	500.0	0.0	120.1	120.1	0		AIR
2.1550	0.0	0.0	260.0	0.0	61.9	61.9	0		
2.1550	0.0	0.0	240.0	0.0	57.1	57.1	0		AIR
2.1550	0.0	0.0	200.0	0.0	47.4	47.4	0		AIR
2.1550	0.0	0.0	180.0	0.0	42.5	42.5	0		
2.1550	0.0	0.0	140.0	0.0	32.5	32.5	0		
2.1550	0.0	0.0	100.0	0.0	22.1	22.1	0		
2.1550	0.0	0.0	.0001	0.0	0.0	0.0	0		
4.6430	0.0	60.000004356	38670.0		7233.516	7233.516	1	C*	
4.6430	0.0	50.000004355	06640.0		7212.535	7212.535	1	C*	
4.6430	0.0	30.000004349	99610.0		7128.082	7128.082	1	C*	
4.6430	0.0	20.000004344	02730.0		7022.750	7022.750	1	C*	
4.6430	0.0	10.000004327	57030.0		6716.680	6716.680	1	C*	
4.6430	0.0	5.000004298	52730.0		6163.723	6163.723	1	C*	
4.6430	0.0	1.000004137	70310.0		3614.779	3614.779	1	C*	
4.6430	0.0	0.350003895	82470.0		1659.755	1659.755	1	C*	
4.6430	0.0	0.200003545	32010.0		793.749	793.749	1	C*	
4.6430	0.0	0.190003450	85520.0		703.942	703.942	1	C*	
4.6430	0.0	0.180003247	23140.0		577.170	577.170	1	C*	
4.6430	0.0	0.175002587	24220.0		336.718	336.718	1	C*	
4.6430	0.0	0.174902446	85180.0		292.211	292.211	1	C*	
4.6430	0.0	0.1748	1666.67	0.0	51.10	51.10	1	C*	
4.6430	0.0	0.1743	1450.0	0.0	-15.3	-15.3	1	C*	GE
4.6430	0.0	0.1686	1350.0	0.0	-62.9	-62.9	1	C*	GE
4.6430	0.0	0.1252	1250.0	0.0	-238.5	-238.5	1	C*	GE
4.6430	0.0	0.0813	1200.0	0.0	-349.1	-349.1	1	C*	GE
4.6430	0.0	0.0429	1150.0	0.0	-98.4	-98.4	1	C*	GE
4.6430	0.0	0.0193	1100.0	0.0	60.4	60.4	1	C*	GE
4.6430	0.0	0.0027	1000.0	0.0	159.2	159.2	1	C*	GE
4.6430	0.0	0.0	1000.0	0.0	250.0	250.0	0		AIR
4.6430	0.0	0.0	500.0	0.0	120.1	120.1	0		AIR
4.6430	0.0	0.0	260.0	0.0	61.6	61.6	0		
4.6430	0.0	0.0	240.0	0.0	56.8	56.8	0		AIR
4.6430	0.0	0.0	200.0	0.0	47.0	47.0	0		AIR
4.6430	0.0	0.0	180.0	0.0	42.0	42.0	0		
4.6430	0.0	0.0	140.0	0.0	31.9	31.9	0		
4.6430	0.0	0.0	100.0	0.0	20.6	20.6	0		
4.6430	0.0	0.0	.0001	0.0	0.0	0.0	0		
10.0	0.0	60.000004523	08590.0		7287.566	7287.566	1	C*	C I
10.0	0.0	50.000004521	64840.0		7266.633	7266.633	1	C*	C I
10.0	0.0	30.000004516	10550.0		7182.422	7182.422	1	C*	C I
10.0	0.0	20.000004509	58200.0		7077.316	7077.316	1	C*	C I
10.0	0.0	10.000004491	61330.0		6771.469	6771.469	1	C*	C I
10.0	0.0	5.000004462	62500.0		6207.809	6207.809	1	C*	C I
10.0	0.0	1.000004285	25780.0		3644.154	3644.154	1	C*	C I
10.0	0.0	0.350004018	12600.0		1683.882	1683.882	1	C*	C I
10.0	0.0	0.200003631	98660.0		814.692	814.692	1	C*	C I
10.0	0.0	0.190003528	03880.0		723.283	723.283	1	C*	C I
10.0	0.0	0.180003304	30910.0		592.285	592.285	1	C*	C I
10.0	0.0	0.175002560	63530.0		328.083	328.083	1	C*	C I
10.0	0.0	0.174881887	29000.0		118.726	118.726	1	C*	C I
10.0	0.0	0.1748	1666.67	0.0	50.80	50.80	1	C*	
10.0	0.0	0.1743	1450.0	0.0	-15.3	-15.3	1	C*	GE
10.0	0.0	0.1686	1350.0	0.0	-62.9	-62.9	1	C*	GE
10.0	0.0	0.1252	1250.0	0.0	-238.5	-238.5	1	C*	GE
10.0	0.0	0.0813	1200.0	0.0	-349.1	-349.1	1	C*	GE
10.0	0.0	0.0429	1150.0	0.0	-98.4	-98.4	1	C*	GE
10.0	0.0	0.0193	1100.0	0.0	60.4	60.4	1	C*	GE
10.0	0.0	0.0027	1000.0	0.0	159.2	159.2	1	C*	GE
10.0	0.0	0.0	1000.0	0.0	250.1	250.1	0		AIR

10.0	0.0	0.0	500.0	0.0	120.1	120.1	0	AIR
10.0	0.0	0.0	260.0	0.0	61.4	61.4	0	
10.0	0.0	0.0	240.0	0.0	56.6	56.6	0	AIR
10.0	0.0	0.0	200.0	0.0	46.7	46.7	0	AIR
10.0	0.0	0.0	180.0	0.0	41.6	41.6	0	
10.0	0.0	0.0	140.0	0.0	31.2	31.2	0	
10.0	0.0	0.0	100.0	0.0	19.2	19.2	0	
10.0	0.0	0.0	.0001	0.0	0.0	0.0	0	
100.	0.0	70.000005112	.92580.0		7495.691	7495.691	1	C* C I
100.	0.0	60.000005111	.53130.0		7480.984	7480.984	1	C* C I
100.	0.0	50.000005109	.60940.0		7460.195	7460.195	1	C* C I
100.	0.0	30.000005102	.23440.0		7376.570	7376.570	1	C* C I
100.	0.0	20.000005093	.54300.0		7271.852	7271.852	1	C* C I
100.	0.0	10.000005069	.67580.0		6965.836	6965.836	1	C* C I
100.	0.0	5.000005027	.73050.0		6409.297	6409.297	1	C* C* I
100.	0.0	1.000004796	.43360.0		3819.462	3819.462	1	C* C* I
100.	0.0	0.350004446	.30470.0		1813.295	1813.295	1	C* C* I
100.	0.0	0.200003926	.84400.0		899.137	899.137	1	C* C* I
100.	0.0	0.190003785	.48900.0		797.616	797.616	1	C* C* I
100.	0.0	0.180003487	.02200.0		646.633	646.633	1	C* C* I
100.	0.0	0.175002627	.85840.0		348.924	348.924	1	C* C* I
100.	0.0	0.174842179	.87450.0		208.590	208.590	1	C* C* I
100.	0.0	0.1743	1450.0	0.0	-15.3	-15.3	1	C* GE
100.	0.0	0.1686	1350.0	0.0	-62.9	-62.9	1	C* GE
100.	0.0	0.1252	1250.0	0.0	-238.5	-238.5	1	C* GE
100.	0.0	0.0813	1200.0	0.0	-349.1	-349.1	1	C* GE
100.	0.0	0.0429	1150.0	0.0	-98.4	-98.4	1	C* GE
100.	0.0	0.0193	1100.0	0.0	60.4	60.4	1	C* GE
100.	0.0	0.0027	1000.0	0.0	159.2	159.2	1	C* GE
100.	0.0	0.0	1000.0	0.0	251.4	251.4	0	AIR
100.	0.0	0.0	500.0	0.0	119.2	119.2	0	AIR
100.	0.0	0.0	260.0	0.0	55.4	55.4	0	
100.	0.0	0.0	240.0	0.0	49.3	49.3	0	AIR
100.	0.0	0.0	200.0	0.0	35.1	35.1	0	AIR
100.	0.0	0.0	180.0	0.0	25.4	25.4	0	
100.	0.0	0.0	140.0	0.0	17.1	17.1	0	
100.	0.0	0.0	100.0	0.0	9.8	9.8	0	
100.	0.0	0.0	.0001	0.0	0.0	0.0	0	



New line of data must be included.

APPENDIX E
PUTZ AND BARTLETT CORRELATION FOR GRAPHITE
ABLATION

APPENDIX E

Putz and Bartlett Correlation for Graphite Ablation

$$q_w = \psi(\rho_e u_e C_{H_o})(H_r - h_w) , \quad (E.1)$$

$$\dot{m} = (\rho_e u_e C_m)\beta' , \quad (E.2)$$

$$\frac{C_M}{C_{H_o}} = \frac{\phi_m}{e^{\phi_m} - 1} , \quad (E.3)$$

$$\phi_m = 2\lambda_m\beta_o' , \quad (E.4)$$

$$\lambda_m = (1.012 + 0.018\beta_o' + 0.0814\beta_o'^2)(1.0 - F_1) , \quad (E.5)$$

$$F_1 = (0.238 + 0.038\beta_o')\left(\frac{F_2 - 0.95}{0.60}\right)^{0.71} , \quad (E.6)$$

$$F_2 = \begin{cases} 0.95, & M_w/M_e \leq 0.95 \\ M_w/M_e, & 0.95 < M_w/M_e < 1.55 \\ 1.55, & M_w/M_e \geq 1.55, \end{cases} \quad (E.7)$$

$$\psi = 1.0 - 0.6563\beta_o' + 0.01794\beta_o'^2 + 0.96365\beta_o'^3 - 0.01125\beta_o'^4; (E.8)$$

where

- q_w = surface convective heat flux,
- $\rho_e u_e C_{H_o}$ = nonablating heat transfer coefficient evaluated at the wall surface temperature,
- H_r = recover enthalpy,
- ψ = heat transfer correlation parameter C_H/C_{H_o} ,
- h_w = static enthalpy evaluated at wall (surface),
- C_M = mass transfer coefficient,
- λ_m = mass transfer correlation parameter,
- β' = $m_w/\rho_e u_e C_M$, mass loss parameter,
- β_o' = $m_w/\rho_e u_e C_{H_o}$,
- M_w = molecular weight of gases at wall (surface),
- M_e = molecular weight of gases at edge of boundary layer,
- m_w = mass loss rate per unit area at wall (surface).

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