

WASHINGTON STATE UNIVERSITY
Pullman, Washington

SHOCK DYNAMICS LABORATORY
Department of Physics

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COMPUTER CODE SERVICE PROGRAMS

by

D. B. Hayes

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SERVICE PROGRAMS

D. B. Hayes

The following pages briefly describe six computer codes. These descriptions are not complete and will not in general allow for immediate useage of the program. What these pages provide is a statement of the function of the code, a description of key variables and a few comments. Thus a cursory inspection will allow the reader to judge whether the code will be of any use. To implement the code, the user will probably need to rewrite parts which have been written for some special case. The codes described are all duplicated on paper tape stored in the office. The codes described have the following functions:

- Q Evaluate the fraction of guard ring gap area necessary to minimize scatter in quartz calibration data.
- CHAR Solve for wave velocities, pressures, times of arrival, etc., for the special case of aluminum impacting KCl backed by quartz using the jump condition.
- ANALYT Evaluate an analytic form for the phase-1 Hugoniot of KCl.
- LSQ Perform a linear least squares fit.
- QUART Reduce quartz gage records.
- IMPACT Map stress-projectile velocity data to p-u and p-v space.

Program Q

Function: To evaluate the sum of the square of the deviation for quartz gage calibration data if the calibration is of the form

$$\min \sum_n \left(\frac{i_n l_n}{\sigma_n \frac{\pi}{4} [d_1 + \alpha(d_2 - d_1)]^2 C} - k_0 - a\sigma_n \right)^2$$

a = 10^{-10}

i_n = quartz current

l_n = quartz thickness

σ_n = quartz stress

d_1, d_2 = inner and outer guard ring electrode diameters

C = sound speed in quartz

where the quartz calibration is of the form

$$k = k_0 + a\sigma$$

For a fixed value of α , the above function is minimized by adjusting k_0 . This is repeated for a variety of α 's. Thus by finding the absolute minimum of the above function with respect to k_0 and α , one can determine the effective fraction of the guard ring gap area, characterized by α , which minimizes scatter in the data.

Key Variables:

EI current (amps)

EL quartz thickness (cm)

D1, D2 inner and outer electrode diameters (cm)

P stress in quartz

AL α

CAY k_0

Comments: Program indicates $\alpha \neq 0$

```
Q      12:35 16 THU 05/18/72
100    DIMENSION EI(10),EL(10),D1(10),D2(10),P(10),Y(10)
110    A=0.01
120    PI=3.14159265
130    C=5.72E5
140    N=5
150    READ,(EI(I),EL(I),D1(I),D2(I),P(I),I=1,N)
160 DØ 70 K=1.6
161    AL=(K-1.)*0.3
170    CAY=2
180    DC=-0.025
190    DØ 10 I=1,N
200    DEN=(D1(I)+AL*(D2(I)-D1(I)))*2*P(I)*PI*C
201 10 Y(I)=4.E8*EI(I)*EL(I)/DEN
205    S1=0
206    S2=0
207    DØ 15 I=1,N
208    S1=S1+Y(I)
209    S2=S2+P(I)
210 15 CØNTINUE
211    CAY=S1-A*S2
212    CAY=CAY/N
240    SUM=0.
250    DØ 30 I=1,N
260 30 SUM=SUM+(Y(I)-CAY-A*P(I))**2
270    PRINT 900,AL,CAY,SUM
272 900 FØRMAT(3F15.8)
280    DØ 40 I=1,N
290 40 PRINT,P(I),Y(I)
291 70 CØNTINUE
300    END
1000 $DATA
1001    .186,.2885,.4390,.4548,26.45
1002    .177,.2885,.4315,.4455,26.45
1003    .105,.3223,.3608,.3729,25.70
1004    .0809,.3194,.3551,.3632,20.70
1005    .1078,.3193,.3626,.3707,26.40
```

Program CHAR

Function: To calculate wave velocities, pressures, particle velocities, specific volumes and times of arrival for the special case of aluminum impacting KCl backed by quartz. All materials are assumed to be in thermodynamic equilibrium with known constitutive relations $V = V(p)$. All velocities are in lab coordinates.

Key Variables: units(cm, gm, μ sec, mbar)

EL KCl thickness
UU Aluminum impact velocity
Z Quartz or aluminum shock impedance
DXX Shock velocity where XX is a two letter post script denoting the states which the shock carries the material from and to. For instances, DAC denotes the velocity of the shock which carries the material from state A to state C.
UX Particle velocity where X is a one letter post script denoting which state the material is in. For instance, UA is the particle velocity of material in state A.
VX Specific volume with same labeling convention as UX
PX Pressure or stress with same labeling convention as UX

Comments:

Definitions of states and a description of wave interactions are identical to those in Fig. 4.4 and described on pages 83-85 in thesis.

For materials in equilibrium, specifications of impact velocity, KCl thickness and p-V locus for each material completely define all shock states, wave velocities and times of arrival. Calculation of these quantities requires only mathematical statements of conservation of mass and momentum as expressed in the Rankine-Hugoniot jump conditions, coupled with a knowledge of the constitutive relation for each material. Since all waves are compressive, continuity of normal stress and particle velocity at material interfaces provide the necessary boundary conditions. With the jump conditions and constitutive relation

$$p - p_0 = \rho_0(D - u_0)(u - u_0)$$
$$\rho_0(D - u_0) = \rho(D - u)$$
$$\rho = \rho(p)$$

or, re-expressed

$$u = \sqrt{(p-p_0)(V_0-V)} + u_0$$
$$D = V_0 \sqrt{(p-p_0)/(V_0-V)} + u_0$$
$$V = V(p)$$

a complete solution necessitates only bookkeeping, that is keeping track of wave velocities, wave interactions, boundary velocities, etc.

Caution: This program was written explicitly for a description of KCl. Not only is the constitutive relation $V = V(p)$ specialized to that case but also statements 110, 115, 120, 150, 155, 220, 225, 315 and 380 do not apply to an arbitrary material. The first three of these statements define special material

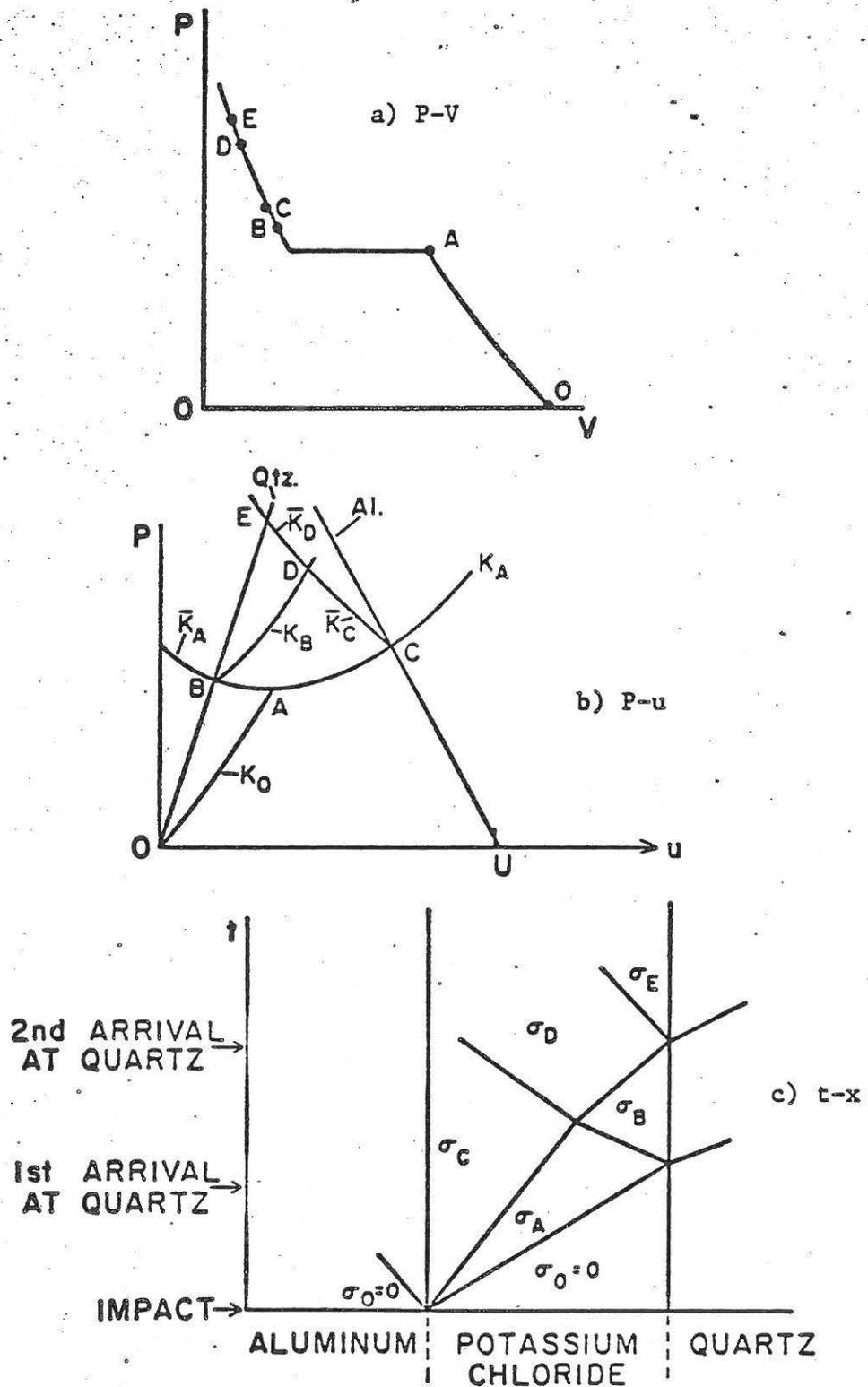


Fig. 4.4.--Shock diagrams for time independent transmission calculation.

properties for KCl; the remaining seven statements define pressure ranges over which searches are made while simultaneously solving the transcendental equations resulting from continuity of pressure, continuity of particle velocity and constitutive relations.

```

CHAR      12:30  16 THU 05/18/72

50      COMMON PT,VT
95      D0 80 ILK=1,10
96      Y=(ILK-1)*0.0005
97      PRINT,Y
100     EL=0.1
105     X1=EL
110     PT=0.0209
115     VT=0.4605
120     V0=0.503
125     UU=0.0585
130     Z=1.516
135     PA=PT
136     VA=VT
140     UA=SQRT((V0-VT)*PA)
145     D0A=V0*PA/UA
150     PC=0.03
155     DP=0.01
160     5 U=UU-PC/Z
165     VC=V(PC)
170     DU=SQRT((PC-PA)*(VA-VC))
175     UC=UA+DU-U
180     DP=DP/2.
185     IF(UC) 1,2,3
190     3 PC=PC-DP
195     G0 T0 10
200     1 PC=PC+DP
205     10 IF(ABS(DP/PC)-1.E-6) 2,2,5
210     2 UC=UA+DU
215     T1=EL/D0A
220     PB=0.03
225     DP=0.01
230     14 U=PB/Z
235     VB=V(PB)
240     DU=SQRT((PB-PA)*(VA-VB))
245     DP=DP/2.
250     IF(U-UA+DU) 15,16,17
255     17 PB=PB-DP
260     G0 T0 18
265     15 PB=PB+DP
270     18 IF(ABS(DP/PB)-1.E-6) 16,16,14
280     16 UB=UA-DU
285     DBAR=SQRT((PB-PA)/(VA-VB))
286     DBAR=DBAR*VA
290     DBA=UA-DBAR
295     DAC=SQRT((PC-PA)/(VA-VC))
296     DAC=DAC*VA
300     DAC=DAC+UA
305     T2=(EL-DBA*T1)/(DAC-DBA)
310     X2=DAC*T2
315     PD=0.04

```

```

316 DP=PD-PB
320 28 VD=V(PD)
325 UD=UB+SQRT((PD-PB)*(VB-VD))
330 UDP=UC-SQRT((PD-PC)*(VC-VD))
335 DP=DP/2.
340 IF(UD-UDP) 21,27,23
345 23 PD=PD-DP
350 GO TO 25
355 21 PD=PD+DP
360 25 IF(ABS(DP/PD)-1.E-6) 27,27,28
365 27 CONTINUE
370 DBDR=SQRT((PD-PB)/(VB-VD))*VB
375 DBD=UB+DBDR
380 PE=0.05
385 DP=PE-PD
390 26 U=PE/Z
395 VE=V(PE)
400 UP=SQRT((PE-PD)*(VD-VE))
405 UP=UD-UP
410 DP=DP/2.
415 IF(U-UP) 37,35,29
420 29 PE=PE-DP
425 UE=U
426 GO TO 30
430 37 PE=PE+DP
435 UE=U
440 30 IF(ABS(DP/PE)-1.E-6) 35,35,26
445 35 CONTINUE
446 DBC=DBD
450 T3=(X2-DBC*T2+UB*T1-EL)/(UB-DBC)
455 X3=EL+UB*(T3-T1)
488 PRINT 60,EL,PT,UU
489 PRINT 60,D0A,DBA,DAC,DBC
490 PRINT 60,PA,PB,PC,PD,PE
491 PRINT 60,UA,UB,UC,UD,UE
492 PRINT 60,VA,VB,VC,VD,VE
493 PRINT 60,X1,X2,X3
494 PRINT 60,T1,T2,T3
495 80 CONTINUE
499 60 FORMAT(5F14.6)
500 END
600 FUNCTION V(P)
602 COMMON PT,VT
605 V0=0.503
610 VA=VT
615 PA=PT
620 PB=PA
625 VB=0.39
630 VC=0.374
635 PC=0.05
640 IF(P-0.032) 1,1,2
645 1 V=VA
647 T=(.389-.4605)/(0.032-.0205)
648 V=V+T*(P-0.0205)
650 RETURN
655 2 V=0.4025-(.4025-.39)*(P-0.0197)/(0.031-0.0197)
660 RETURN
665 END

```

Program ANALYT

Function: Evaluate the analytic approximation to the single phase Hugoniot described in Appendix C of thesis.

Comments: FORTRAN notation duplicates that in text of thesis.

ANALYT 12:38 16 THU 05/18/72

```
100 CV=6.62E-6
110 A=0.346
120 B=2.64
130 T0=300.
140 GV=3.3
150 V0=0.503
160 ALPHA=A+GV**2*CV*T0
170 BETA=2.*B+GV**3*CV*T0
180 PSI=GV/2.
190 AA=BETA/PSI**2
200 BB=-AA-ALPHA/PSI
210 DV=-0.003
220 V=V0-DV
230 10 V=V+DV
240 EP=1.-PSI*(V0-V)
250 EL=ALOG(EP)
260 P=EP*(AA*EL+BB*(1.-1./EP))
261 U=SQRT(P*(V0-V))
270 PRINT 50,P,V,U
271 50 FORMAT(3F11.6)
280 GO TO 10
290 END
```

Program LSQ

Function: To perform linear least squares fit evaluating a and b in the function $y = ax + b$.

Key Variables: Self explanatory

Comments: Besides calculating a and b, this routine calculates the standard deviation.

```
LSQ      12:26 16 THU 05/18/72
100      DIMENSION X(100),Y(100)
110      N=7
120      READ,(X(I),Y(I),I=1,N)
130      SX=0.
140      SY=0.
150      SX2=0.
160      SY2=0.
170      SXY=0.
180      DO 10 I=1,N
190      SX=SX+X(I)
200      SY=SY+Y(I)
210      SXY=SXY+X(I)*Y(I)
220      SX2=SX2+X(I)**2
230      SY2=SY2+Y(I)**2
240 10 CONTINUE
250      DEN=N*SX2-SX**2
260      A=N*SXY-SX*SY
270      B=SY*SX2-SX*SXY
280      A=A/DEN
290      B=B/DEN
300      DEV=SY2+B**2*N+A**2*SX2+2.*A*B*SX-2.*A*SXY-2.*B*SY
310      DEV=SQRT(DEV/(N-1.))
320      PRINT 50,A,B,DEV
330 50 FORMAT(3E15.5)
1000 $DATA
1001      .4321,25.14,.3865,23.40,.3439,21.68,.4287,24.89
1002      .5582,29.88,.3049,20.24,.3108,20.4
```

Program QUART

Function: To perform linear interpolation between calibration marks read from oscilloscope traces thus converting vertical and horizontal deflections into currents and times; to calculate stress from current according to calibration in Appendix F of thesis; to remove ramping from quartz gage records according to procedure described in Chapter 2 in thesis.

Key Variables:

NT number of time calibration marks
NCAL number of current calibration marks
NP number of pairs of (x,y) points to be converted to (t,i) points
YY, CUR vertical deflection, calibrated current pairs
XX, TT horizontal deflection, calibrated time pairs
ALFA ramping coefficient described in Chapter 2
TH quartz gage thickness (cm)
AR Guard ring area (cm)

Comments: This routine is used by Gupta and Dandekar who are very familiar with its operation. The data shown in the following listing are for a quartz record obtained by Dandekar. This routine is stored in data bank as of 5/18/72.

QUART 12:19 16 THU 05/18/72

```

3 PRINT,"72-028,BARIUM FLUORIDE,<111>,TRANSMISSION SHOT."
4 PRINT,"SCOPE #3,GAUGE #29 OLD LOT."
60   ELL=2.623
98   DIMENSION TSA(100),ASA(100),ASB(100)
99   DIMENSION XX(50),YY(50),CUR(50),TT(50),X(100),Y(100)
105  ALFA=0.41
106  ASA(I)=0.
108  TSA(I)=0.
109  ASB(I)=0.
110  READ,NT,NCAL,NP
120  READ,(YY(I),CUR(I),I=1,NCAL)
130  READ,(XX(I),TT(I),I=1,NT)
140  READ,(X(I),Y(I),I=1,NP)
141  C0N=X(1)-XX(1)
142  D0 9 I=1,NT
143  9 XX(I)=XX(I)+C0N
144  C0N=Y(1)-YY(1)
145  D0 8 I=1,NCAL
146  8 YY(I)=YY(I)+C0N
150  READ,TH,AR
151  PRINT,"GAGE THICKNESS AND AREA"
152  PRINT,TH,AR
155  PRINT,"PROGRAM MODIFIED WITH NEW DATA 9/71"
156  PRINT," USE INNER ELECTRODE AREA"
160  PRINT 10,NT
170  10 FORMAT(I5,12HTIMING MARKS)
180  PRINT"DEFLECTION          TIME"
190  PRINT"      (MM)          (MICROSEC)"
210  PRINT 11,(XX(I),TT(I),I=1,NT)
220  11 FORMAT(4X,F5.2,10X,F6.3)
230  PRINT 12,NCAL
240  12 FORMAT(I5,17HCALIBRATION MARKS)
250  PRINT" DEFLECTION          CURRENT"
260  PRINT"      (MM)          AMPS"
269  NKAL=NCAL-1
270  PRINT 13,(YY(I),CUR(I),I=1,NCAL)
271  SUM=0.
272  D0 90 I=1,NKAL
273  90 SUM=SUM+YY(I+1)-YY(I)
274  SUM=SUM/NKAL
275  SAM=0.
276  D0 91 I=1,NKAL
277  91 SAM=SAM+(YY(I+1)-YY(I)-SUM)**2
278  STP=100.*SQRT(SAM/NCAL)/SUM
279  PRINT,"STD DEVIATION =",STP,"PERCENT"
280  13 FORMAT(4X,F5.2,10X,F8.5)
290  PRINT"      X          Y          TIME          CURRENT          PRESSURE"
300  PRINT"      (MM)      (MM) (MICROSEC) (AMPS)      (KBAR)"
301  CAY=TH/(AR*5.72E5)
310  NCAL=NCAL-1

```

```

320     NT=NT-1
330     DØ 30 I=1,NP
340     DØ 31 J=1,NT
350     K=J
360     IF (XX(J+1)-X(I)) 31,33,33
370 33  GØ TØ,*34
380 31  CØNTINUE
390 34  TIM=TI(K)+(TT(K+1)-TT(K))/(XX(K+1)-XX(K))*(X(I)-XX(K))
400     DØ 41 J=1,NCAL
410     K=J
420     IF (YY(J+1)-Y(I)) 41,43,43
430 43  GØ,*TØ 44
440 41  CØNTINUE
450 44  TA=(CUR(K+1)-CUR(K))/(YY(K+1)-YY(K))
460     AMP=CUR(K)+TA*(Y(I)-YY(K))
470     IF (I-1) 49,50,49
480 50  AS=AMP
490     TS=TIM
500 49  AMP=AMP-AS
510     TIM=TIM-TS
520     A=2.0089E-8
521     B=9.852E-11
522     AØB=-A/(2.*B)
523     PRESS=AØB*(AØB**2+AMP*TH/(AR*5.72E5*B))**.5
540     PRINT,X(I),Y(I),TIM,AMP,PRESS
541     TSA(I+1)=TIM
542     ASA(I+1)=AMP
550 51  FØRMAT(3X,F5.2,5X,F5.2,5X,F6.3,5X,F8.5,5X,F10.5)
560 30  CØNTINUE
570     ENT=0.
572,27,162,30,212
580     PRINT,"ADJUSTEDFØR RAMPING"
590
600     DØ 60 I=2,NP
610     DTT=(TSA(I)-TSA(I-1))/2.
615     TT=(ASA(I)-ALFA*ENT-ALFA*DTT*ASB(I-1))
620     SCT=TSA(I)/ELL
630     ASB(I)=TT/(1.+ALFA*DTT)
640     ENT=ENT+(ASB(I)+ASB(I-1))*DTT
650     PRESS=AØB*(AØB**2+ASB(I)*TH/(AR*5.72E5*B))**.5
660 60  PRINT 61,TSA(I),ASB(I),ASA(I),PRESS,SCT
661 61  FØRMAT(5F12.6)
670     END
1000  SDATA
1001  6,4,7
1002  3.921,.0,10.215,.026,16.44,.052,22.761,.078
1003  6.317,.0,14.095,.1,21.879,.2,29.787,.3,37.649,.4
1004  44.633,.5
1005  5.336,2.958,9.629,19.275,24.641,20.188,24.879,20.226
1006  26.667,20.619,36.238,21.249,40.384,21.465
1007  .3216,.105481

```

Program IMPACT

Function: To map pressure-projectile velocity data from front surface impact shots to p-u and p-v space.

Key Variables:

P3 Measured quartz stress (mbar)
U Impact velocity (cm/ μ sec)
U3 Particle velocity (cm/ μ sec)
V Specific volume (cm³/gm)
C3 Shock speed behind p₂ wave (cm/ μ sec)

Comments: The elastic precursor amplitude and phase transformation point are specialized to the case for KCl.

IMPACT 12:41 16 THU 05/18/72

```
99 10 CONTINUE
100 P1=0.000445
110 P2=.0209
111 V0=0.503
120 U1=0.000497
130 U2=.0297
140 Z0=1.515
150 READ,SHOT,U
151 I=SHOT
153 IF(I-20) 1,1,2
154 2 CONTINUE
156 1 CONTINUE
157 READ,P3
160 U3=U-P3/Z0
170 DV1=U1**2/P1
180 DV2=(U2-U1)**2/(P2-P1)
182 IF(P3-P2) 20,21,21
183 20 DV2=(U3-U1)**2/(P3-P1)
184 DV3=0.
185 C3=(P3-P1)*(V0-DV1)/(U3-U1)
186 GO TO 25
187 21 CONTINUE
190 DV3=(U3-U2)**2/(P3-P2)
191 C3=(P3-P2)*(V0-DV1-DV2)/(U3-U2)
195 25 CONTINUE
200 V=V0-DV1-DV2-DV3
205 C2=(P2-P1)*(V0-DV1)/(U2-U1)
210 PRINT 50,I,U,P3,U3,V,C2,C3
211 50 FORMAT("KC",I3,6F9.5)
212 40 CONTINUE
220 GO TO 10
230 END
250 $DATA
1010 10.,.0598,.02614
1011 11.,.0541,.02437
1012 12.,.0487,.02256
1013 13.,.0422,.02030
1014 14.,.0366,.01734
1015 15.,.0593,.02583
1016
1017 17.,.0755,.03099
1018 18.,.0438,.02105
1019 19.,.0445,.02113
1020 20.,.0403,.01923
1021 21.,.0600,.02533
1022 22.,.0544,.02394
1023 23.,.0453,.02180
1027 27.,.0613,.02754
1028 28.,.0363,.01726
1029 29.,.0404,.01938
1030 30.,.0480,.02148
1031 31.,.0591,.02328
1032 32.,.0590,.02408
1033 33.,.0557,.02291
1034 34.,.0518,.02205
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