```
      PROGRAM R2RRAD
      IMPLICIT REAL*8 (A-H,O-Z)
      REAL*8 L
      DIMENSION F(26,26),FV(5),A(26,26),B(26),TW(26),HRAD(26),S(26)
C
C                     FLECHT  Test 31805
C               FLECHT SEASET RUN WITH 3 THIMBLES in a 5x5 array
C                      -hot rod at 2250 F
C                      -surrounding rods 25 F below hot rod (2225 F)
C                      -thimbles at 1800 F
C
C
C
C  NROD X NROD SQUARE ARRAY ROD-TO-ROD RADIATION COMPUTATION
C
C          ONLY SURFACE-TO-SURFACE RADIATION IS MODELED
C
C  THE NET RADIATION OR RADIOSITY METHOD IS USED TO COMPUTE THE
C  THERMAL RADIATION IN THE ENCLOSURE.  THIS METHOD IS DESCRIBED IN
C  ORNL-5239,"RADIATIVE HEAT TRANSFER IN ARRAYS OF PARRALLEL CYLINDERS
"
C  BY R. L. COX, JUNE 1977.  THE VIEW FACTORS CALCULATION IS BASED ON
C  D. A. MANDELL, "GEOMETRIC VIEW FACTORS FOR RADIATIVE HEAT TRANSFER
C  WITHIN BOILING WATER REACTOR FUEL BUNDLES," NUCL. TECH., VOL. 52,
C  MARCH 1981.
C
C  THE METHOD CONSISTS OF SUPPLYING VIEW FACTORS AND STRUCTURE TEMPERA
TURES
C  INTO THE FOLLOWING EQUATION WHICH IS SOLVED FOR THE NET HEAT TRANSF
ERED
C  PER UNIT TIME, Q(I), BETWEEN THE EMITTED RADIATION AND THE ABSORBED
 PORTION
C  OF THE INCIDENT RADIATION.  THE EQUATION BELOW IS SOLVED FOR Q(I):
C
C    N                                    N
C   SUM[F(I,J)-DEL(I,J)]*SIGMA*TW(J)**4=SUM[F(I,J)*(1-E)/E-DEL(I,J)/E]
*Q(J)/A(J)
C   J=1                                  J=1
C
C   WHERE TW IS THE WALL TEMPERATURE, DEL(I,J) IS THE KRONECKER DELTA
FUNCTION,
C   SIGMA IS THE STEPHAN-BOLTZMAN CONSTANT, E IS THE EMISSIVITY,
C   F(I,J) IS THE VIEW FACTOR, AND A(J) IS THE SURFACE AREA
C
C                    BY L. W. WARD
C
      OPEN(6,FILE='R2RRAD31805.OUT',STATUS='UNKNOWN')
      TSAT=270.0
```

```
C
C    geometry is set for 5x5 array with nrod = 5
C
      NROD=5
      NRODS=NROD*NROD
      NVF=5
      R=0.374/12.0/2.0
C      R=0.422/12.0/2.0
      D=2.0*R
      P=0.496/12.0
C      P=0.563/12.0
      PI=3.14159
      SIGMA=0.1712D-08
      L=12.5
      AA=PI*D*L
      AB=8.0*(P+R)*L
C
C   note thimbles have larger dia than rods in FLECHT
C
C  MULTIPLY BOUNDARY AREA BY 5.0 SO BOUNDARY VIEW FACTOR F(NMAX,NMAX)
C  IS NON-NEGATIVE.  SEE LINE 158
C
      WRITE(6,7001)
 7001 FORMAT(1X,'EVALUATION OF Test 31805, FLECHT-SEASET ROD 11K')
      WRITE(6,7000)R,P
 7000 FORMAT(/,1X,'ROD RADIUS (FT)=',F7.4,/,1X,'PITCH (FT)     =',F7.4
)
C
C  CALCULATE VIEW FACTORS
C
      X=P/D
C
C    ADJACENT ROD VIEW FACTOR
C
      FV(1)=(DSQRT(X**2-1.0D0)-X+PI/2.0-DACOS(1.0D0/X))/PI
C
C    SECOND NEAREST NEIGHBOR ROD VIEW FACTOR
C
      X1=DSQRT(P**2-D**2)
      X2=DSQRT(2.0*P**2-D**2)
      A1=(DATAN(X1/D)+0.7854-DATAN(X2/D))*D/2.0
      A2=(PI/2.0-2.0*DATAN(X1/D))*D/2.0
      FV(2)=(X2-2.0*X1-A2+2.0*A1)/(PI*D)
C
C    THIRD AND GREATER NEAREST NEIGHBOR ROD VIEW FACTOR
C
      DO 10 I=3,NROD
      DI=DFLOAT(I-1)
```

```
      Y1=DSQRT(((DI-1.0)**2+1.0)*P**2-D**2)
      Y2=DSQRT((DI**2+1.0)*P**2-D**2)
      Y3=DSQRT(((DI-2.0)**2+1.0)*P**2-D**2)
      B1=(DATAN(Y3/D)-DATAN(DI-2.0)-DATAN(Y1/D)+DATAN(DI-1.0D0))*D/2.0
      B2=(DATAN(Y1/D)-DATAN(DI-1.0)-DATAN(Y2/D)+DATAN(DI))*D/2.0
      FV(I)=(Y2+Y3-2.0*(Y1+B1-B2))/(2.0*PI*D)
   10 CONTINUE
C
C  COMPUTE VIEW FACTORS FOR THE NROD X NROD ARRAY
C
      DO 20 I=1,NROD
      DO 30 J=1,NROD
      L1=NROD*(J-1)+I
      DO 40 II=1,NROD
      DO 50 JJ=1,NROD
      L2=NROD*(JJ-1)+II
      IF(IABS(I-II).NE.0)GO TO 45
C
C  CONSIDER RODS IN THE SAME ROW
C
      IF(IABS(J-JJ).EQ.1)F(L1,L2)=FV(1)
      GO TO 60
   45 CONTINUE
      IF(IABS(I-II).NE.1)GO TO 70
C
C  RODS IN ADJACENT ROWS
C
      DO 80 K=1,NVF
      KK=K-1
      IF(IABS(J-JJ).NE.KK)GO TO 80
      F(L1,L2)=FV(K)
      GO TO 60
   80 CONTINUE
C
   70 CONTINUE
C
C  CONSIDER RODS TWO OR MORE ROWS AWAY FROM EACH OTHER
C
      IF(IABS(J-JJ).NE.0)GO TO 75
      F(L1,L2)=0.0
      GO TO 60
   75 CONTINUE
      IF(IABS(J-JJ).GT.1) GO TO 60
      DO 90 K=1,NVF
      KK=K-1
      IF(IABS(I-II).NE.KK) GO TO 90
      F(L1,L2)=FV(K)
      GO TO 60
```

```
   90 CONTINUE
C
   60 CONTINUE
   50 CONTINUE
   40 CONTINUE
   30 CONTINUE
   20 CONTINUE
C
C  CALCULATE VIEW FACTOR FOR BOUNDARY
C  FOR EACH ROD
C
      NMAX=NRODS+1
      DO 600 I=1,NRODS
      SUM=0.0
      DO 700 J=1,NRODS
      SUM=SUM+F(I,J)
  700 CONTINUE
      F(I,NMAX)=1.0-SUM
  600 CONTINUE
C
C  CALCULATE VIEW FACTORS FOR BOUNDARY (NMAX)
C  AA IS ROD SURFACE AREA, AB IS BOUNDARY SURFACE AREA
C
      SUM=0.0
      DO 900 J=1,NRODS
      F(NMAX,J)=F(J,NMAX)*AA/AB
      SUM=SUM+F(NMAX,J)
  900 CONTINUE
      F(NMAX,NMAX)=1.0D0-SUM
C     WRITE(6,6000)
C6000 FORMAT(//,1X,'FROM ROD I',3X,'TO ROD J',5X,'VIEW FACTOR')
      DO 100 I=1,NMAX
      S(I)=0.0
      DO 200 J=1,NMAX
      S(I)=S(I)+F(I,J)
C     WRITE(6,300)I,J,F(I,J)
C 300 FORMAT(6X,I2,9X,I2,6X,F12.6)
  200 CONTINUE
  100 CONTINUE
C     WRITE(6,6001)
C6001 FORMAT(/,1X,'SURFACE I',4X,'SUM OF F(I,J)')
C     DO 302 I=1,NMAX
C     WRITE(6,301)I,S(I)
C 301 FORMAT(5X,I2,6X,D12.6)
  302 CONTINUE
      WRITE(6,4000)
 4000 FORMAT(//,2X,'I',3X,'HEAT LOAD',7X,'H.T. COEFF.')
      WRITE(6,5000)
```

```
 5000 FORMAT(6X,'(BTU/HR)',5X,'(BTU/HR-FT2-F)',/)
C
C    SOLVE FOR THE NET HEAT FLUXES LEAVING EACH SURFACE I.E. Q(I)
C    WHICH IS RETURNED AS THE B VECTOR IN  CALL TO GAUSS
C
      CALL TWALL(TW,RPF1,RPFA,RPFTH,TTH,TAF,T1F)
      E=0.8
      DO 500 I=1,NMAX
      RHS=0.0
      DO 400 J=1,NMAX
      IF(I.EQ.J)DELTIJ=1.0
      IF(I.NE.J)DELTIJ=0.0
      RHS=RHS+(F(I,J)-DELTIJ)*SIGMA*(TW(J)**4)
      A(I,J)=(F(I,J)*(1.0-E)/E-DELTIJ/E)/AA
      IF(J.EQ.NMAX)A(I,J)=(F(I,J)*(1.0-E)/E-DELTIJ/E)/AB
  400 CONTINUE
      B(I)=RHS
  500 CONTINUE
      CALL GAUSS(NMAX,A,B)
C
C  compute equivalent H. T. Coef.
C
      DO 1000 I=1,NMAX
      HRAD(I)=B(I)/(AA*(TW(I)-460.0-TSAT))
      IF(I.EQ.NMAX)HRAD(I)=B(I)/(AB*(TW(I)-460.0-TSAT))
      WRITE(6,3000)I,B(I),HRAD(I)
 3000 FORMAT(1X,I2,2X,D12.6,3X,D12.6)
 1000 CONTINUE
      T1F=T1F-460.0
      TAF=TAF-460.0
      TTH=TTH-460.0
      RPFTH=10000.0
      RPF1=10000.0
      RPFA=10000.0
      WRITE(6,8008)
 8008 FORMAT(/)
      WRITE(6,8000)T1F,RPF1,TAF,RPFA,TTH,RPFTH,TAF
 8000 FORMAT(1X,'HOT ROD TEMP=',F7.2,3X,'HOT ROD RADIAL PEAKING FACTOR
='
     &,F5.3,/,1X,'AVE ROD TEMP=',F7.2,3X,'AVE ROD RADIAL PEAKING FACTO
R=
     &',F5.3,/,1X,'THIMBLE TEMP=',F7.2,3X,'THIMBLE PEAKING RADIAL FACT
OR
     &=',F5.3,/,1X,'BOUNDARY TEMP=',F7.2)
      IHOT=13
      WRITE(6,9001)IHOT
 9001 FORMAT(/,'HOT ROD SURFACE (I) =',I2)
      WRITE(6,9002)HRAD(IHOT)
```

```
 9002 FORMAT(/,'HOT ROD EQUIV. THERMAL RADIATION H. T. COEFF =',D12.6)
      STOP
      END
      SUBROUTINE TWALL(TW,RPF1,RPFA,RPFTH,TTH,TAF,T1F)
      IMPLICIT REAL*8 (A-H,O-Z)
      REAL*8 M
      DIMENSION TW(26)
C
C  T1F - HOT ROD TEMPERATURE WITH RPF OF 1.1
C  TAF - AVE FUEL TEMPERATURE WITH RPF OF 1.0
C  T2  - OTHER POWERED ROD TEMPERATURE WITH RPF OF 0.95
C  TTH - THIMBLE WITH RPF OF 0.9 (THIMBLES IN FLECHT ARE
C        AT A TEMP. OF ABOUT 1750 F AT THE TIME OF PCT)
C
C  KNOWING THE HOT AND AVE ROD TEMPERATURES AND RPFS, THE TEMPERATURE
C  OF OTHER ROD AT DIFFERENT POWER LEVELS CAN BE READILY DETERMINED
C  THROUGH A SIMPLE INTERPOLATION
C
C    THE HOT ROD AND AVE ROD TEMPS BASED ON DATA FROM L. HOCHREITER
C    "DATA VARIABILITY VERSUS DATA UNCERTAINTY."
C    THE AVE AND HOT ROD TEMP SCATTER OF +51 F BASED ON FLECHT SKEWED
C    POWER DATA FOR TEST # 13404
C
C     TAF=2010.0+460.0
C     T1F=2061.0+460.0
C     RPFTH=0.90
C     RPF1=1.10
C     RPFA=1.0
C     RPF2=1.045
C     M=(T1F-TAF)/(RPF1-RPFA)
C
C     INPUT RPFTH TO DETERMINE THE THIMBLE TEMP RELATIVE TO THE HOT
C     AND AVERAGE ROD OR INPUT TTH
C
C     TTH=T1F+(RPFTH-RPF1)*M
C     TTH=1750.0+460.0
      RPF1=1.10
      RPF2=1.075
      RPFA=1.0
C
C  READ IN TEMPS,  FENCE is surface 26
C  hot rod is 13, THIMBLES at 6, 9, 21, & 24
C
C
C    1  2  3  4  5
C
C    6  7  8  9  10
C
```

```
C     11 12 13 14 15
C
C     16 17 18 19 20
C
C     21 22 23 24 25
C
      TTH=1800.0+460.0
      T1F=2225.0+460.0
      TAF=2225.0+460.0
        thot=2250.0+460.0
CC    TAF=T1F
cc    tth=1500.0+460.0
cc    t1f=1811.0+460.0
cc    taf=1760.0+460.0
cc     m not used since temps read in
      M=(T1F-TAF)/(RPF1-RPFA)
C     T2=T1F+(RPF2-RPF1)*M
C     T2=TAF
C
C  DO NOT COMPUTE THIMBLE TEMP FROM 0.9 RPF, USE ACTUAL TEMP OF 1750 F
C  AT TIME OF PCT FOR RADIATION EVALUATION
C     SEE NUREG/CR-2256, FIG. 2-5, ROD 8G IS
C     HOT ROD.  ALL RODS AT PCT, THIMBLE AT 1750
C
      TW(1)=T1F
      TW(2)=T1F
      TW(3)=T1F
      TW(4)=T1F
      TW(5)=T1F
      TW(6)=Tth
      TW(7)=T1F
      TW(8)=T1F
      TW(9)=Tth
      TW(10)=T1F
      TW(11)=T1F
      TW(12)=T1F
      TW(13)=Thot
      TW(14)=T1F
      TW(15)=T1F
      TW(16)=T1F
      TW(17)=T1F
      TW(18)=T1F
      TW(19)=T1F
      TW(20)=T1F
      TW(21)=TTH
      TW(22)=T1F
      TW(23)=T1F
      TW(24)=TTH
```

```
      TW(25)=T1F
      TW(26)=TAF
      RETURN
      END
      SUBROUTINE GAUSS(N,A,B)
      IMPLICIT REAL*8 (A-H,O-Z)
      DIMENSION A(26,26),B(26)
      N1=N-1
      DO 100 K=1,N1
      C=A(K,K)
      K1=K+1
      IF(DABS(C)-0.000001D0)1,1,3
    3 DO 4 J=K1,N
    4 A(K,J)=A(K,J)/C
      B(K)=B(K)/C
      DO 10 I=K1,N
      C=A(I,K)
      DO 5 J=K1,N
    5 A(I,J)=A(I,J)-C*A(K,J)
   10 B(I)=B(I)-C*B(K)
  100 CONTINUE
      IF(DABS(A(N,N))-0.000001D0)1,1,101
  101 B(N)=B(N)/A(N,N)
      DO 200 L=1,N1
      K=N-L
      K1=K+1
      DO 200 J=K1,N
  200 B(K)=B(K)-A(K,J)*B(J)
      D=1.0
      DO 250 I=1,N
  250 D=D*A(I,I)
      RETURN
    1 WRITE(6,2) K
    2 FORMAT('**** SINGULARITY IN ROW',I5)
      D=0.0
      RETURN
      END
```

R2RRAD3x3.FOR

```
      PROGRAM R2RRAD
      IMPLICIT REAL*8 (A-H,O-Z)
      REAL*8 L
      DIMENSION F(26,26),FV(5),A(26,26),B(26),TW(26),HRAD(26),S(26)
C
C                    3x3  test of model
C
C       hot rod at 2100 F, all surrounding rods at 2000 F
C
C  NROD X NROD SQUARE ARRAY ROD-TO-ROD RADIATION COMPUTATION
C
C          ONLY SURFACE-TO-SURFACE RADIATION IS MODELED
C
C  THE NET RADIATION OR RADIOSITY METHOD IS USED TO COMPUTE THE
C  THERMAL RADIATION IN THE ENCLOSURE.  THIS METHOD IS DESCRIBED IN
C  ORNL-5239,"RADIATIVE HEAT TRANSFER IN ARRAYS OF PARRALLEL CYLINDERS
"
C  BY R. L. COX, JUNE 1977.  THE VIEW FACTORS CALCULATION IS BASED ON
C  D. A. MANDELL, "GEOMETRIC VIEW FACTORS FOR RADIATIVE HEAT TRANSFER
C  WITHIN BOILING WATER REACTOR FUEL BUNDLES," NUCL. TECH., VOL. 52,
C  MARCH 1981.
C
C  THE METHOD CONSISTS OF SUPPLYING VIEW FACTORS AND STRUCTURE TEMPERA
TURES
C  INTO THE FOLLOWING EQUATION WHICH IS SOLVED FOR THE NET HEAT TRANSF
ERED
C  PER UNIT TIME, Q(I), BETWEEN THE EMITTED RADIATION AND THE ABSORBED
 PORTION
C  OF THE INCIDENT RADIATION.  THE EQUATION BELOW IS SOLVED FOR Q(I):
C
C    N                                   N
C   SUM[F(I,J)-DEL(I,J)]*SIGMA*TW(J)**4=SUM[F(I,J)*(1-E)/E-DEL(I,J)/E]
*Q(J)/A(J)
C   J=1                                 J=1
C
C   WHERE TW IS THE WALL TEMPERATURE, DEL(I,J) IS THE KRONECKER DELTA
FUNCTION,
C   SIGMA IS THE STEPHAN-BOLTZMAN CONSTANT, E IS THE EMISSIVITY,
C   F(I,J) IS THE VIEW FACTOR, AND A(J) IS THE SURFACE AREA
C
C                    BY L. W. WARD
C
      OPEN(6,FILE='R2RRADtest3x3.OUT',STATUS='UNKNOWN')
      TSAT=270.0
      NROD=3
      NRODS=NROD*NROD
      NVF=3
      R=0.374/12.0/2.0
```

```
C      R=0.422/12.0/2.0
      D=2.0*R
      P=0.496/12.0
C      P=0.563/12.0
      PI=3.14159
      SIGMA=0.1712D-08
      L=12.5
c      AA=PI*D*L/12.0
c      AB=5.0D0*8.0*(P+R)*L/12.0
       AA=PI*D*L
      AB=8.0*(P+2.0*R)*L
C
C   note thimbles have larger dia than rods in FLECHT
C
C  MULTIPLY BOUNDARY AREA BY 5.0 SO BOUNDARY VIEW FACTOR F(NMAX,NMAX)
C  IS NON-NEGATIVE.  SEE LINE 158
C
      WRITE(6,7001)
 7001 FORMAT(1X,'TEST EVALUATION 3x3 ARRAY')
      WRITE(6,7000)R,P
 7000 FORMAT(/,1X,'ROD RADIUS (FT)=',F7.4,/,1X,'PITCH (FT)      =',F7.4
)
C
C  CALCULATE VIEW FACTORS
C
      X=P/D
C
C    ADJACENT ROD VIEW FACTOR
C
      FV(1)=(DSQRT(X**2-1.0D0)-X+PI/2.0-DACOS(1.0D0/X))/PI
C
C    SECOND NEAREST NEIGHBOR ROD VIEW FACTOR
C
      X1=DSQRT(P**2-D**2)
      X2=DSQRT(2.0*P**2-D**2)
      A1=(DATAN(X1/D)+0.7854-DATAN(X2/D))*D/2.0
      A2=(PI/2.0-2.0*DATAN(X1/D))*D/2.0
      FV(2)=(X2-2.0*X1-A2+2.0*A1)/(PI*D)
C
C    THIRD AND GREATER NEAREST NEIGHBOR ROD VIEW FACTOR
C
      DO 10 I=3,NROD
      DI=DFLOAT(I-1)
      Y1=DSQRT(((DI-1.0)**2+1.0)*P**2-D**2)
      Y2=DSQRT((DI**2+1.0)*P**2-D**2)
      Y3=DSQRT(((DI-2.0)**2+1.0)*P**2-D**2)
      B1=(DATAN(Y3/D)-DATAN(DI-2.0)-DATAN(Y1/D)+DATAN(DI-1.0D0))*D/2.0
      B2=(DATAN(Y1/D)-DATAN(DI-1.0)-DATAN(Y2/D)+DATAN(DI))*D/2.0
```

```
      FV(I)=(Y2+Y3-2.0*(Y1+B1-B2))/(2.0*PI*D)
   10 CONTINUE
C
C  COMPUTE VIEW FACTORS FOR THE NROD X NROD ARRAY
C
      DO 20 I=1,NROD
      DO 30 J=1,NROD
      L1=NROD*(J-1)+I
      DO 40 II=1,NROD
      DO 50 JJ=1,NROD
      L2=NROD*(JJ-1)+II
      IF(IABS(I-II).NE.0)GO TO 45
C
C  CONSIDER RODS IN THE SAME ROW
C
      IF(IABS(J-JJ).EQ.1)F(L1,L2)=FV(1)
      GO TO 60
   45 CONTINUE
      IF(IABS(I-II).NE.1)GO TO 70
C
C  RODS IN ADJACENT ROWS
C
      DO 80 K=1,NVF
      KK=K-1
      IF(IABS(J-JJ).NE.KK)GO TO 80
      F(L1,L2)=FV(K)
      GO TO 60
   80 CONTINUE
C
   70 CONTINUE
C
C  CONSIDER RODS TWO OR MORE ROWS AWAY FROM EACH OTHER
C
      IF(IABS(J-JJ).NE.0)GO TO 75
      F(L1,L2)=0.0
      GO TO 60
   75 CONTINUE
      IF(IABS(J-JJ).GT.1) GO TO 60
      DO 90 K=1,NVF
      KK=K-1
      IF(IABS(I-II).NE.KK) GO TO 90
      F(L1,L2)=FV(K)
      GO TO 60
   90 CONTINUE
C
   60 CONTINUE
   50 CONTINUE
   40 CONTINUE
```

```
   30 CONTINUE
   20 CONTINUE
C
C  CALCULATE VIEW FACTOR FOR BOUNDARY
C  FOR EACH ROD
C
      NMAX=NRODS+1
      DO 600 I=1,NRODS
      SUM=0.0
      DO 700 J=1,NRODS
      SUM=SUM+F(I,J)
  700 CONTINUE
      F(I,NMAX)=1.0-SUM
  600 CONTINUE
C
C  CALCULATE VIEW FACTORS FOR BOUNDARY (NMAX)
C  AA IS ROD SURFACE AREA, AB IS BOUNDARY SURFACE AREA
C
      SUM=0.0
      DO 900 J=1,NRODS
      F(NMAX,J)=F(J,NMAX)*AA/AB
      SUM=SUM+F(NMAX,J)
  900 CONTINUE
      F(NMAX,NMAX)=1.0D0-SUM
C     WRITE(6,6000)
C6000 FORMAT(//,1X,'FROM ROD I',3X,'TO ROD J',5X,'VIEW FACTOR')
      DO 100 I=1,NMAX
      S(I)=0.0
      DO 200 J=1,NMAX
      S(I)=S(I)+F(I,J)
C     WRITE(6,300)I,J,F(I,J)
C 300 FORMAT(6X,I2,9X,I2,6X,F12.6)
  200 CONTINUE
  100 CONTINUE
C     WRITE(6,6001)
C6001 FORMAT(/,1X,'SURFACE I',4X,'SUM OF F(I,J)')
C     DO 302 I=1,NMAX
C     WRITE(6,301)I,S(I)
C 301 FORMAT(5X,I2,6X,D12.6)
  302 CONTINUE
      WRITE(6,4000)
 4000 FORMAT(//,2X,'I',3X,'HEAT LOAD',7X,'H.T. COEFF.')
      WRITE(6,5000)
 5000 FORMAT(7X,'(BTU/HR)',5X,'(BTU/HR-FT2-F)',/)
C
C   SOLVE FOR THE NET HEAT FLUXES LEAVING EACH SURFACE I.E. Q(I)
C   WHICH IS RETURNED AS THE B VECTOR IN  CALL TO GAUSS
C
```

```
      CALL TWALL(TW,RPF1,RPFA,RPFTH,TTH,TAF,T1F)
      E=0.8
      DO 500 I=1,NMAX
      RHS=0.0
      DO 400 J=1,NMAX
      IF(I.EQ.J)DELTIJ=1.0
      IF(I.NE.J)DELTIJ=0.0
      RHS=RHS+(F(I,J)-DELTIJ)*SIGMA*(TW(J)**4)
      A(I,J)=(F(I,J)*(1.0-E)/E-DELTIJ/E)/AA
      IF(J.EQ.NMAX)A(I,J)=(F(I,J)*(1.0-E)/E-DELTIJ/E)/AB
  400 CONTINUE
      B(I)=RHS
  500 CONTINUE
      CALL GAUSS(NMAX,A,B)
      DO 1000 I=1,NMAX
      HRAD(I)=B(I)/(AA*(TW(I)-460.0-TSAT))
      IF(I.EQ.NMAX)HRAD(I)=B(I)/(AB*(TW(I)-460.0-TSAT))
      WRITE(6,3000)I,B(I),HRAD(I)
 3000 FORMAT(1X,I2,2X,D12.6,3X,D12.6)
 1000 CONTINUE
      T1F=T1F-460.0
      TAF=TAF-460.0
      TTH=TTH-460.0
      RPFTH=10000.0
      RPF1=10000.0
      RPFA=10000.0
      WRITE(6,8008)
 8008 FORMAT(/)
      WRITE(6,8000)T1F,RPF1,TAF,RPFA,TTH,RPFTH,TAF
 8000 FORMAT(1X,'HOT ROD TEMP=',F7.2,3X,'HOT ROD RADIAL PEAKING FACTOR
='
     &,F5.3,/,1X,'AVE ROD TEMP=',F7.2,3X,'AVE ROD RADIAL PEAKING FACTO
R=
     &',F5.3,/,1X,'THIMBLE TEMP=',F7.2,3X,'THIMBLE PEAKING RADIAL FACT
OR
     &=',F5.3,/,1X,'BOUNDARY TEMP=',F7.2)
      IHOT=5
      WRITE(6,9001)IHOT
 9001 FORMAT(/,'HOT ROD SURFACE (I) =',I2)
      WRITE(6,9002)HRAD(IHOT)
 9002 FORMAT(/,'HOT ROD EQUIV. THERMAL RADIATION H. T. COEFF =',D12.6)
      T1=2100.0+460.0
        T2=2000.0+460.0
        A1=pi*D*L
        A2=3.0*pi*D*L+(8.0*P)*L+AB
        E1=E
        E2=E
        qa=A1*sigma*(T1**4-T2**4)/(1.0/E1+(1/E2-1.0)*A1/A2)
```

```
        htc=qa/(A1*(TW(IHOT)-460.0-TSAT))
        write(6,4009)qa,htc
 4009 format(//,'Test 3x3 with two-surface model',/,1x,'Q=',d12.6,2x,
     &'BTU/HR',3x,'HTC=',d12.6,1x,'BTU/HR-FT2-F')

      STOP
      END
      SUBROUTINE TWALL(TW,RPF1,RPFA,RPFTH,TTH,TAF,T1F)
      IMPLICIT REAL*8 (A-H,O-Z)
      REAL*8 M
      DIMENSION TW(26)
C
C  T1F - HOT ROD TEMPERATURE WITH RPF OF 1.1
C  TAF - AVE FUEL TEMPERATURE WITH RPF OF 1.0
C  T2  - OTHER POWERED ROD TEMPERATURE WITH RPF OF 0.95
C  TTH - THIMBLE WITH RPF OF 0.9 (THIMBLES IN FLECHT ARE
C        AT A TEMP. OF ABOUT 1750 F AT THE TIME OF PCT)
C
C  KNOWING THE HOT AND AVE ROD TEMPERATURES AND RPFS, THE TEMPERATURE
C  OF OTHER ROD AT DIFFERENT POWER LEVELS CAN BE READILY DETERMINED
C  THROUGH A SIMPLE INTERPOLATION
C
C    THE HOT ROD AND AVE ROD TEMPS BASED ON DATA FROM L. HOCHREITER
C    "DATA VARIABILITY VERSUS DATA UNCERTAINTY."
C    THE AVE AND HOT ROD TEMP SCATTER OF +51 F BASED ON FLECHT SKEWED
C    POWER DATA FOR TEST # 13404
C
C     TAF=2010.0+460.0
C     T1F=2061.0+460.0
C     RPFTH=0.90
C     RPF1=1.10
C     RPFA=1.0
C     RPF2=1.045
C     M=(T1F-TAF)/(RPF1-RPFA)
C
C     INPUT RPFTH TO DETERMINE THE THIMBLE TEMP RELATIVE TO THE HOT
C     AND AVERAGE ROD OR INPUT TTH
C
C     TTH=T1F+(RPFTH-RPF1)*M
C     TTH=1750.0+460.0
      RPF1=1.10
      RPF2=1.075
      RPFA=1.0
C
C  READ IN TEMPS,  FENCE is surface 10
C  hot rod is 5
C
C
```

```
C     1  2  3
C
C     4  5  6
C
C     7  8  9
C
C     hot rod is 2100, allremaining rods at 2000
C
      TTH=2000.0+460.0
      T1F=2000.0+460.0
      TAF=2000.0+460.0
        thot=2100.0+460.0
CC    TAF=T1F
cc    tth=1500.0+460.0
cc    t1f=1811.0+460.0
cc    taf=1760.0+460.0
cc     m not used since temps read in
      M=(T1F-TAF)/(RPF1-RPFA)
C     T2=T1F+(RPF2-RPF1)*M
C     T2=TAF
C
C   DO NOT COMPUTE THIMBLE TEMP FROM 0.9 RPF, USE ACTUAL TEMP OF 1750 F
C   AT TIME OF PCT FOR RADIATION EVALUATION
C      SEE NUREG/CR-2256, FIG. 2-5, ROD 8G IS
C      HOT ROD.  ALL RODS AT PCT, THIMBLE AT 1750
C
      TW(1)=T1F
      TW(2)=T1F
      TW(3)=T1F
      TW(4)=T1F
      TW(5)=Thot
      TW(6)=Tth
      TW(7)=T1F
      TW(8)=T1F
      TW(9)=Tth
      TW(10)=T1F
      TW(11)=T1F
      TW(12)=T1F
      TW(13)=Thot
      TW(14)=T1F
      TW(15)=T1F
      TW(16)=T1F
      TW(17)=T1F
      TW(18)=T1F
      TW(19)=T1F
      TW(20)=T1F
      TW(21)=TTH
      TW(22)=T1F
```

```
      TW(23)=T1F
      TW(24)=TTH
      TW(25)=T1F
      TW(26)=TAF
      RETURN
      END
      SUBROUTINE GAUSS(N,A,B)
      IMPLICIT REAL*8 (A-H,O-Z)
      DIMENSION A(26,26),B(26)
      N1=N-1
      DO 100 K=1,N1
      C=A(K,K)
      K1=K+1
      IF(DABS(C)-0.000001D0)1,1,3
    3 DO 4 J=K1,N
    4 A(K,J)=A(K,J)/C
      B(K)=B(K)/C
      DO 10 I=K1,N
      C=A(I,K)
      DO 5 J=K1,N
    5 A(I,J)=A(I,J)-C*A(K,J)
   10 B(I)=B(I)-C*B(K)
  100 CONTINUE
      IF(DABS(A(N,N))-0.000001D0)1,1,101
  101 B(N)=B(N)/A(N,N)
      DO 200 L=1,N1
      K=N-L
      K1=K+1
      DO 200 J=K1,N
  200 B(K)=B(K)-A(K,J)*B(J)
      D=1.0
      DO 250 I=1,N
  250 D=D*A(I,I)
      RETURN
    1 WRITE(6,2) K
    2 FORMAT('**** SINGULARITY IN ROW',I5)
      D=0.0
      RETURN
      END
```