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ASHMET - A COMPUTER CODE FOR ESTIMATING INSOLATION INCIDENT ON TILTED SURFACES

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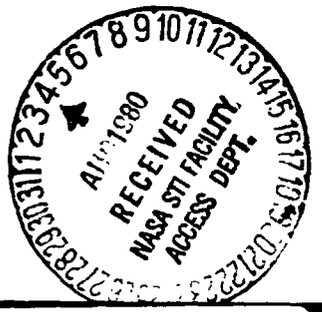
For the U. S. Deparment of Energy



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16. ABSTRACT

A computer code, ASHMET, has been developed by MSFC to estimate the amount of solar insolation incident on the surfaces of solar collectors. Both tracking and fixed-position collectors have been included. Climatological data for 248 U. S. locations are built into the code. This report describes the methodology of the code, and its input and output.

The basic methodology used by ASHMET is the ASHRAE clear-day insolation relationships modified by a clearness index derived from SOLMET-measured solar radiation data to a horizontal surface.

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DOE/NASA Technical Memorandum

ASHMET - A COMPUTER CODE FOR ESTIMATING INSOLATION INCIDENT ON TILTED SURFACES

SUMMARY

A computer code has been developed to estimate the amount of solar insolation indident on the surfaces of several types of collectors. Both tracking and fixed position collectors have been included. Climatological data for 248 U.S. locations are built into the code. This report describes the methodology of the code, its input and output.

I. INTRODUCTION

In designing or analyzing a solar system, the principle question to be answered is how much of the available solar energy can the system deliver to loads. This fraction of available energy is dependent on several parameters: amount of solar energy available, type of collectors used, efficiency of system heat exchangers, system losses, etc. The primary driver is, of course, the solar energy available (energy incident on the surface of the collector array) to the system. This report describes a computer code, ASHMET, developed by MSFC to analytically estimate the solar energy incident on the collector array surface cover.

Two versions of ASHMET exist. Both versions utilize the same basic methodology: ASHRAE relationships [1] are used to obtain clear day total daily insolation incident on the collector surface for a representative day (defined in ASHMET as the 21st day of the month) of each month of the year; the clear day total (direct + diffuse + reflected) daily insolation is then multiplied by a clearness index to obtain the typical or average daily insolation. The clearness index was derived from SOLMET measured insolation [2] and the ASHRAE clear day insolation. In reference 2 average daily total insolation on a horizontal surface for 248 U.S. locations are given for each of the 12 months of the year. These data were divided by the ASHRAE clear day insolation at the same geographical location and the resulting tables built into ASHMET as clearness index. The assumption is made here that the clearness index does not change with collector tilt angle or azimuthal orientation.

Major differences between the two versions are in the procedures for breakout of direct and diffuse insolation. Version I uses the ASHRAE relationships of reference 1; Version II the correlation of Liu and Jordan [3]. Version II resulted when comparisons of incident radiation to tilted surfaces obtained using the ASHRAE relationships for separation of direct and diffuse components to similar data obtained using the Liu and Jordan correlation indicated significant differences in the two sets of data for some geographic locations. Since, at present, insufficient data is available to verify either of the methods, and since the Liu and Jordan procedure is widely used in the solar industry, it was decided to add the Liu and Jordan methodology to ASHMET as an option.

Both versions have the capabilities of calculating incident solar radiation on the collector surface for six types of collectors:

(1) Fixed position flat plate collector - total insolation

(2) Monthly tilt adjusted flat plate collector - total insolation

(3) Beam tracking collector (sun tracker - direct insolation only)

(4) Fixed azimuth tracker - direct insolation only (tracks in plane of tilt, rotating about tilt axis)

(5) Fixed position flat plate collector - direct insolation

(6) Monthly tilt adjusted flat plate collector - direct insolation only.

In type (2) and (6) the monthly tilt angle adjustment is accomplished by setting the tilt equal to latitude minus declination using the declination angle for the 21st day of the month. Additionally, Version II of ASHMET has a type (7), which allows calculation of direct insolation to a collector rotating about its east-west axis. The angle of rotation is chosen such that the angle of incidence between the sun vector and the normal to the collector surface is minimized. (NOTE: Type (4) of both can be used to obtain the same results as type (7) of Version II with some judicious manipulation of input data. However, for the casual user of ASHMET it was felt that a straightforward option for this specific type of collector would be less confusing. Also, the methodology is greatly simplified, reducing computer time.)

The following two sections give the details of methodology used in ASHMET. Input and output for the code are described in Appendix A and computer listings of ASHMET I and ASHMET II in Appendix B.

II. ASHMET I METHODOLOGY

A. Total Insolation to a Fixed Position Collector

Clear day hourly total insolation to a tilted surface are obtained from the ASHRAE relationships [2]:

$$h_{TOTAL,\,CLR\,DAY} = \frac{(A)\cos\theta}{e^{B/\sin\beta}} + \frac{(A)(C)\cos\theta}{e^{B/\sin\beta}}\left(\frac{1+\cos S}{2}\right) + \left(\frac{A}{e^{B/\sin\beta}}\right)(\sin\beta + C)(\rho)\left(\frac{1-\cos S}{2}\right) \quad (1)$$

Where: A, B, and C are monthly varying coefficients taken from Table 1 in chapter 22 of reference 1.

Θ is the angle of incidence the sun's rays form with the collector surface (relative to the surface normal) defined by

$$\cos\theta = \cos S \sin\beta + \sin S \cos\gamma \tan L \sin\beta - \sin S \cos\gamma \sin\delta/\cos L + \sin S \sin\gamma \cos\delta \sin\omega \quad (2)$$

β is the solar altitude (angle between direction of sun and local horizontal) given by

$$\sin\beta = \cos L \cos\delta \cos\omega + \sin L \sin\delta \quad (3)$$

ρ ~ Diffuse Reflectance of Solar Radiation
L ~ Local Latitude
δ ~ Declination Angle
S ~ Slope of Collector Measured from Horizontal
ω ~ Hour Angle, Solar Noon Being Zero
γ ~ Collector Surface Azimuth Angle (0-due south, minus -east, positive -west).

In equation (1) the first term on the right hand side represents the direct insolation received, the second term the diffuse and the third the reflected component. The declination angle, δ, is obtained from a table [1] for the 21st day of each month.

Using equation (1) hourly insolation distribution incident on the tilted surface is calculated for the 21st day of each month of the year and summed for the day:

$$H_{TOTAL,\,CLR\,DAY} = \int_{t=S.R.\,HOUR}^{S.S.\,HOUR} (h_{TOTAL,\,CLR\,DAY})\,dt \approx \sum_{6\,A.M.}^{6\,P.M.} h_{TOTAL,\,CLR\,DAY} \quad (4)$$

The clear day daily total is then multiplied by a clearness index to obtain a typical day's insolation for each month. The clearness index was derived from the SOLMET insolation data (to a horizontal surface) of reference 2: mean SOLMET daily horizontal total insolation for each month of the year was divided by the clear day total horizontal insolation calculated by equation (4) for each of the geographic locations presented in reference 2. These data were incorporated in the ASHMET program. It is assumed that the clearness indexes derived for horizontal data are applicable to tilted surfaces.

B. Total Insolation to a Monthly Tilt Adjusted Collector

On any given day the daily direct insolation incident on a fixed position collector will be maximized if the collector tilt angle is set equal to the latitude minus the declination. ASHMET, therefore, has an option for setting the collector tilt angle equal to the desired site latitude minus the declination angle for the 21st day of each month. Once the tilt angle is calculated the program proceeds as for the total insolation to a fixed position collector option described previously.

C. Beam Tracking Collector

This option provides the direct insolation incident on the surface plane of a sun tracking collector. Clear day direct insolation (for incidence angle $\theta = 0°$) is obtained from the ASHRAE equation:

$$H_{BEAM,\,CLR\,DAY} = \int_{t=\text{SUNRISE HR.}}^{\text{SUNSET HR.}} [A/e^{B/\sin\beta}]\ dt \qquad (5)$$

Typical daily beam insolation (for the 21st day of each month) is calculated by multiplying the clear day value by the average daily percent sunshine (% SS) for that month and the location desired. The percent sunshine was derived as follows.

It is assumed, as suggested by several authors, that the typical daily insolation can be represented by

$$H_{TOTAL} = [F]\ \left[H_{TOTAL,\,CLR\,DAY}\right] \qquad (6)$$

$$F = c\,[a + b\,(\%SS)]$$

The coefficients a, b, and c were determined from the SOLMET insolation data and the annual mean daily percent sunshine data of reference 4. As expected the coefficients varied from location to location within the United States.

However, areas of constant coefficients could be determined from the data. These areas are delineated in Figure 1 along with the values of a, b, and c for each area.

Equation (6) is now solved for the percent sunshine:

$$\%\ SS = \left[\left(\frac{H_{TOTAL}}{H_{TOTAL,\ CLR\ DAY}}\right)/c - a\right]/b \qquad (7)$$

In equation (7) the term $H_{TOTAL}/H_{TOTAL,\ CLRDAY}$ is the previously discussed clearness index derived from the SOLMET data.

The use of equation (7) to calculate the average daily percent sunshine circumvents two problem areas. First, the necessity of adding a second table of data to the program (monthly average daily percent sunshine for 248 geographic locations) is avoided. Secondly, the sunshine data of reference 4 covers only one-fourth of the 248 locations for which insolation data is available. Thus considerable extrapolation of the sunshine data would be necessary if all the SOLMET sites were to be included. It was felt a more accurate approach would be to define areas of constant coefficients a, b, and c of equation (6) from the sunshine data of reference 4 and then use the SOLMET insolation data per equation (7) to define percent sunshine for locations not covered by reference 4.

D. Direct Insolation to a Fixed Azimuth Tracker Rotating About its Axis

With this option direct insolation to the surface of a collector rotating about its axis is calculated. Orientation of axis is determined by specifying its azimuth and tilt angles (input by program user).

Similar to the previously discussed collector systems the daily distribution of clear air hourly direct insolation for the typical day of each month is first calculated from the ASHRAE equation:

$$h_{DIRECT,\ CLR\ DAY} = \frac{A \cos\theta}{e^{B/\sin\beta}} \qquad (8)$$

$$\text{WHERE:} \quad \cos\theta = \sqrt{1.0 - \left[\sin\beta \sin S - \cos\beta \cos S \cos(AZ_s + AZ)\right]^2} \qquad (9)$$

AZ is the collector longitudinal axis azimuth angle measured from due south with east negative and west positive. AZ_s is the solar azimuth angle and is obtained from:

$$AZ_s = \sin^{-1}\left[\frac{\cos\delta \sin\omega}{\cos\beta}\right] \tag{10}$$

The typical daily direct insolation for each month is now obtained by multiplying the clear day insolation by the percent sunshine term described in the previous section on beam trackers.

E. Direct Insolation to Fixed Position and Monthly Tilt Adjusted Flat Plate Collectors

Calculations for these systems proceed the same as for the calculation of the total insolation incident on their surfaces with one exception: typical daily incident insolation is obtained by multiplying the ASHRAE clear day direct radiation by the percent sunshine term of subsection B rather than the clearness index of subsection A.

III. ASHMET II METHODOLOGY

The basic ASHMET II methodology is the same as that of ASHMET I with the exception of the breakout of horizontal diffuse and direct insolation for fixed position collectors (including those with monthly tilt adjustment). For these collector systems the breakout of horizontal diffuse and direct insolation is taken from the correlation of Liu and Jordan [3] instead of the ASHRAE methodology. Calculations of incident insolation for beam tracking and azimuth tracking surfaces remains unchanged.

From the Liu and Jordan correlation clear day diffuse insolation to a horizontal surface is:

$$\left(\frac{h_{DIFF}}{h_{TOTAL}}\right)_{HRLY,\,HORIZ,\,CLR.\,DAY} = 1.39 - 4.027\,(K_T) + 5.531\,(K_T)^2 - 3.108\,(K_T)^3 \tag{11}$$

Where:

$$K_T = \left(\frac{H_{TOTAL}}{H_{EXTRATERRESTRIAL}}\right)_{DAILY,\,HORIZ}$$

The clear day direct insolation component is then:

$$(h_{DIR})_{HRLY,\,HORIZ} = (h_{TOTAL})_{HRLY,\,HORIZ,\,CLR\,DAY} - \left[\left(\frac{h_{DIFF}}{h_{TOTAL}}\right)\left(h_{TOTAL}\right)\right]_{HRLY,\,HORIZ,\,CLR\,DAY} \tag{12}$$

Total clear day hourly to a tilted surface is obtained as in the ASHMET I program:

$$\left(h_{TOTAL}\right)_{HRLY,\,CLR\,DAY} = \left(h_{DIR}\right)_{HRLY,\,HORIZ} \cos\theta + \left(h_{DIR} + h_{DIFF}\right)_{HRLY,\,HORIZ} \left(\frac{1-\cos S}{2}\right) + \left(h_{DIFF}\right)_{HRLY,\,HORIZ} \left(\frac{1+\cos S}{2}\right) \tag{13}$$

Calculation of the typical insolation incident on tilted surface for each month of the year then proceeds as in ASHMET I: typical total insolation by multiplying the clear day daily total to the tilted surface by the appropriate clearness index; typical direct insolation by applying the percent sunshine term to the clear day direct insolation component.

Additionally, ASHMET II has a seventh collector type option: direct insolation incident on a horizontal surface rotating about an east-west axis in a north-south direction. For this case the clear day daily direct component is (for the 21st day of the month):

$$H_{DIR,\,CLR\,DAY} = \int_{t=\text{SUNRISE HR.}}^{\text{SUNSET HR.}} \left[A/e^{\,B/\sin\beta}\right]\left[1-(\cos\delta\cos\omega)^2\right]^{1/2} dt \qquad (14)$$

(NOTE: The previously discussed option of a fixed azimuth tracker rotating about its axis may also be used to obtain incident insolation for the case. However, the casual user of ASHMET may not be sufficiently knowledgable of the program methodology to use the fixed azimuth tracker option in this manner; also, computer time will be saved by using equation (14).)

REFERENCES

1. ASHRAE Handbook of Fundamentals, 1972, Chapter 22.

2. Cinquemani, V., Owenby, J. R. and Baldwin, R. G., Input Data for Solar Systems, U.S. Department of Commerce, November 1978.

3. Liu, B. Y. H. and Jordan, R. C., The Interrelationship and Characteristic Distribution of Direct, Diffuse and Total Solar Radiation, Solar Energy IV (3), July 1960.

4. Solar Heating Systems Design Manual, International Telephone and Telegraph Corporation Bulletin TESE-576.

NOMENCLATURE

A, B, C,	~	Monthly varying coefficients of equation (1); A-apparent solar irradiation at air mass = 0, B-atmospheric extinction coefficient, C-diffuse radiation factor
a, b, c,	~	Coefficients defining the percent sunshine function of equation (6)
A_Z	~	Collector azimuth
A_{Z_s}	~	Solar azimuth
H	~	Monthly insolation per unit surface area
h	~	Hourly insolation per unit surface area
L	~	Local latitude
S.R.	~	Sunrise
S.S.	~	Sunset
S	~	Collector slope, measured from local horizontal
t	~	Solar time, hours
β	~	Solar altitude
γ	~	Collector surface angle, 0°-south, -90°-east, +90°-west
δ	~	Declination angle
θ	~	Angle of incidence formed sun and collector surface normals
ρ	~	Diffuse reflectance of solar radiation
ω	~	Hour angle, solar noon being zero

APPENDIX A

ASHMET INPUT

ASHMET is programmed for interactive use with a computer and a remote terminal. Once the program is started the user will find ASHMET self-explanatory. Questions concerning program options are asked and input parameters are called for with explanations of the parameters. A sample input case is shown in Figure 2.

The input data consists of

1. Latitude of desired location (format - F9.4)
2. Slope of collector measured from the horizontal (format - F9.4)
3. Azimuth of collector surface (0° south, minus-easterly facing, plus-westerly facing) (format - F9.4)
4. Type of collector-beam tracker, fixed position flat plate, etc. (Program informs the user of code number to be used for each type.)
5. Ground reflectance (if desired)
6. City location number from Table 1.

If city location desired is not listed in the table the user has the option of inputing twelve monthly values of clearness indexes (ratio of monthly typical day's total insolation to clear day insolation in percent) in the format 12F4.0.

ASHMET OUTPUT

A sample output is shown in Figure 3 and should be self-explanatory. The type of collector system called for is output along with the other required input data (latitude, slope, etc.). Monthly clearness indexes will be output only if they are input by the user. Insolation output includes the hourly clear day incident insolation, clear day and typical daily insolation for each month.

APPENDIX B

ASHRAE I

```
      DIMENSION      A(12),B(12),C(12),DEC(12),REFLY(12),DLYSUM(12),
     *DAYS(12),TIME(13),BTA(13),SLRAZ(13),HRLYRD(13,12),DIFRAD(13)
      DIMENSION BRAD(13),DIRRAD(13),HORZRD(13),REFRD(13)
      DIMENSION DECL(12),TTILT(12)
      DIMENSION PCTSS(12),DLPRSM(12)
      REAL LAT
C     ASHRAE CONSTANT DATA
      DATA A/390.,385.,376.,360.,350.,345.,344.,351.,365.,373.,387.,391/
      DATA B/.142,.144,.156,.18,.196,.205,.207,.201,.177,.16,.149,.142/
      DATA C/.058,.06,.071,.097,.121,.134,.136,.122,.092,.073,.063,.057/
      DATA DEC/-20.,-10.8,0.,11.6,20.,23.45,20.6,12.3,0.,-10.5,-19.8,
     *-23.45/
      DATA TIME/' 6AM',' 7AM',' 8AM',' 9AM','10AM','11AM','12PM',' 1PM'
     *,' 2PM',' 3PM',' 4PM',' 5PM',' 6PM'/
      DATA REFLT/0.,0.,0.,0.,0.,0.,0.,0.,0.,0.,0.,0./
      DATA DAYS/31.,28.,31.,30.,31.,30.,31.,31.,30.,31.,30.,31./
      DATA N /'N'/
      DTR=57.29578
      WRITE(1,999)
  999 FORMAT(1X,'DEFINE OUTPUT DEVICE'/' INPUT 1 FOR TERMINAL OR'/
     *' INPUT 6 FOR LINE PRINTER')
      OPEN(UNIT=6,NAME='PRINT.LST',TYPE='NEW')
      READ(1,404) NOUT
C
C      READ DATA FOR SITE
C
    1 WRITE(1,2)
    2 FORMAT(1X,'INPUT LATITUDE DEG')
      READ(1,3)LAT
    3 FORMAT(F9.4)
      WRITE(1,4)
    4 FORMAT(1X,'INPUT TILT ANGLE FROM HORIZONTAL DEG')
      READ(1,3)TILT
      WRITE(1,5)
    5 FORMAT(1X,'INPUT AZIMUTH ANGLE DEG  0 DUE SOUTH + WEST - EAST')
      READ(1,3)AZI
      WRITE(1,555)
  555 FORMAT(1X,'IS GROUND REFLECTANCE DESIRED? (Y OR N)')
      READ (1,9)IR
      IF (IR.EQ.N)GO TO 80
      WRITE(1,6)
    6 FORMAT(1X,'PRELOADED VALUES OF GROUND REFLECTANCE ARE')
      WRITE(1,7)(REFLT(I),I=1,12)
    7 FORMAT(1X,12F3.2)
      WRITE(1,8)
    8 FORMAT(1X,'IS CHANGE DESIRED? (Y OR N)')
      READ(1,9)IA
    9 FORMAT(1A1)
      IF(IA.EQ.N) GO TO 84
      WRITE(1,19)
```

```
 19  FORMAT(1X,'INPUT 12 MONTHLY VALUES OF REFLECTANCE')
     READ(1,71)(REFLT(I),I=1,12)
 71  FORMAT(12F3.2)
     GO TO 84
 80  DO 83 I=1,12
 83  REFLT(I)=0.0

 84  WRITE(1,81)
 81  FORMAT(1X,'DO YOU DESIRE CLOUD COVER CALCULATIONS? (Y OR N)')
     READ(1,9)IC
     IF(IC.EQ.N)GO TO 10
     WRITE(1,400)
 400 FORMAT(1X,'IS CITY LOCATION NUMBER KNOWN? (Y OR N)')
     READ(1,9)IL
     IF(IL.EQ.N)GO TO 90
 401 WRITE(1,402)
 402 FORMAT(1X,'INPUT CITY LOCATION NUMBER')
 403 READ(1,404)LOC
 404 FORMAT(I4)
 405 CALL SUNSHN(LOC,PCTSS,KSSM)
     GO TO 10
C
  90 WRITE(1,91)
  91 FORMAT(1X,'PRELOADED VALUES OF PERCENT SUNSHINE ARE')
  92 FORMAT(1X,12F4.0)
     WRITE(1,92)(PCTSS(I),I=1,12)
     WRITE(1,8)
     READ(1,9)IA
     IF(IA.EQ.N)GO TO 10
  95 WRITE(1,93)
  93 FORMAT(1X,'INPUT 12 MONTHLY VALUES OF PERCENT SUNSHINE IN WHOLE NU
    &MBERS')
     READ(1,921)(PCTSS(I),I=1,12)
 921 FORMAT(12F4.0)
     KSSM=1
C 94 WRITE(1,82)
C 82 FORMAT(1X,'INPUT LOCATION CLOUD COVER MODIFIER FLAG FROM MAP')
C    &' 1 PERCENT SUNSHINE MULTIPLIER'/
C    &' 2 F TERM WITH .65 MULTIPLIER'/
C    &' 3 F PRIME WITH .70 MULTIPLIER'/
C    &' 4 F PRIME TIMES 1.1'
C    &' 5 CLEAR AIR INSOLATION')
C    &' 6 F PRIME TIMES 1.05')
C     READ(1,12)KSSM
  10 WRITE(1,11)
  11 FORMAT(1X,'SELECT TYPE OF COLLECTOR:'/' 1 BEAM TRACKER'/
    &' 2  FIXED POSITION FLAT PLATE WITH TOTAL INSOLATION'/
    &' 3  AZIMUTH TRACKER - DIRECT INSOLATION ONLY'/
    &' 4  MONTHLY TILT ADJUSTED FLAT PLATE WITH TOTAL INSOLATION'/
    &' 5  FIXED POSITION FLAT PLATE - DIRECT INSOLATION ONLY'/
    &' 6  MONTHLY TILT ADJUSTED FLAT PLATE - DIRECT INSOLATION ONLY')
     READ(1,12)KIND
  12 FORMAT(I2)
     CALL ERASE
C    START RUN
     DO 22 I=1,12
     DO 21 J=1,13
  21 MRLYRD(J,I)=0.
```

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```
   22 DLYSUR(I)=0.
      YRMXSM=0.
      YRFRSM=0.
C      SET UP TRIG CONSTANTS FOR INPUT NUMBERS
      LAT=LAT/DTR
      CLAT=COS(LAT)
      SLAT=SIN(LAT)
      TLAT=SLAT/CLAT
      TILT=TILT/DTR
      CTLT=COS(TILT)
      STLT=SIN(TILT)
      AZI=AZI/DTR
      CAZ=COS(AZI)
      SAZ=SIN(AZI)
      XXX=.5*(1.-CTL )
      DIFMPY=1.-XXX
C
      DO 1000 M=1,12
      ITIM=0
      REFMPY=XXX*REFLT(M)
      DECL(M)=DEC(M)/DTR
      SDECL=SIN(DECL(M))
      CDECL=COS(DECL(M))
C
C     DAILY LOOP FOR 6 AM TO 6PM
C
      DO 500 ITM=-6,6,1
      ITIM=ITIM+1
      BRAD(ITIM)=0.
      HRANGL=15.*FLOAT(ITM)
      HRNGL=HRNGL/DTR
      CHRNGL=COS(HRNGL)
      SHRNGL=SIN(HRNGL)
      SBTA=CLAT*CDECL*CHRNGL+SLAT*SDECL
C       CHEC IF SUN IS UP
      IF(SBTA-.01)51,51,20
   20 BTA(ITIM)=ASIN(SBTA)
      CBTA=COS(BTA(ITIM))
      SLRAD(ITIM)=ASIN(CDECL*SHRNGL/CBTA)
      BRAD(ITIM)=A(M)*EXP(-B(M)/SBTA)
      GO TO (25,50,75,100,125,100)KIND
C     BEAM TRACKER
C
   25 HRLYRD(ITIM,M)=BRAD(ITIM)
      GO TO 499
C
C     FLAT PLATE
   50 TALMPY=CTLT*SBTA+STLT*(CAZ*((TLAT*SBTA)-(SDECL/CLAT))+SAZ*CDECL*
     1SHRNGL)
      IF(TALMPY)51,51,52
   51 DIRRAD(ITIM)=0.
      DIFRAD(ITIM)=0.
      REFRD(ITIM)=0.
      GO TO 53
   52 DIRRAD(ITIM)=BRAD(ITIM)*TALMPY
   54 DIFRAD(ITIM)=BRAD(ITIM)*C(M)*DIFMPY
      HORZRD(ITIM)=BRAD(ITIM)*(C(M)+SBTA)
      REFRD(ITIM)=HORZRD(ITIM)*REFMPY
```

```
  53  HRLYRD(ITIM,M)=DIRRAD(ITIM)+DIFRAD(ITIM)+REFRD(ITIM)
      GO TO 499
C
C     ROTATING AZIMUTH TRACKING COLLECTOR
C
  75  TALMPY=CTLT*SBTA+STLT*(CAZ*((TLAT*SBTA)-(SDECL/CLAT))+SAZ*CDECL*
     1SHRNGL)
      IF(TALMPY)51,51,76
  76  SSLRAZ=SIN(SLRAZ(ITIM))
      CSLRAZ=COS(SLRAZ(ITIM))
      S2=CBTA*SSLRAZ
      S3=CBTA*CSLRAZ
      P=STLT*SBTA+CTLT*SAZ*S2-CTLT*CAZ*S3
      U1=SBTA-P*STLT
      U2=S2-P*CTLT*SAZ
      U3=-(S3+P*CTLT*CAZ)
      CTH=(SBTA*U1+S2*U2-S3*U3)/SQRT(U1*U1+U2*U2+U3*U3)
      HRLYRD(ITIM,M)=BRAD(ITIM)*CTH
      GO TO 499
C     MONTHLY TILT ADJUSTED
C      CALCULATE TILT FROM LAT-DECL
 100  TILT=LAT-DECL(M)
      TTILT(M)=TILT
      CTLT=COS(TILT)
      STLT=SIN(TILT)
      IF(KIND.EQ.6)GO TO 125
 110  XXX=.5*(1.-CTLT)
      DIFMPY=1.-XXX
      REFMPY=XXX*REFLT(M)
      GO TO 50
C
C     SET DIFFUSE AND REFLECTED TO ZERO FOR FLAT PLATE DIRECT ONLY
 125  REFMPY=0.
      DIFMPY=0.
      GO TO 50
C
C     SUM FOR DAY
 499  DLYSUM(M)=DLYSUM(M)+HRLYRD(ITIM,M)
 500  CONTINUE
      YRDXSM=YRDXSM+DLYSUM(M)*DAYS(M)
      IF(KIND.EQ.2.OR.KIND.EQ.4)GO TO 581
      GO TO (581,582,583,584,585,586,587)KSSM
C       USES SOLMET DERIVED % SUNSHINE
 581  DLPRSM(M)=DLYSUM(M)*PCTSS(M)/100.
      GO TO 590
C      MODIFIED SOLMET %SS FOR VARIOUS LOCATIONS FOR TRACKING COLL
 582  DLPRSM(M)=DLYSUM(M)*(PCTSS(M)-30.)/65.
      GO TO 590
 583  DLPRSM(M)=DLYSUM(M)*(PCTSS(M)-30.)/70.
      GO TO 590
 584  DLPRSM(M)=DLYSUM(M)*(.909*PCTSS(M)-30.)/70.
      GO TO 590
 585  DLPRSM(M)=DLYSUM(M)*(1.052*PCTSS(M)-30.)/65.
      GO TO 590
 586  DLPRSM(M)=DLYSUM(M)*(.952*PCTSS(M)-30.)/70.
      GO TO 590
 587  DLPRSM(M)=DLYSUM(M)*(.800*PCTSS(M)-30.)/70.
 590  YRPRSM=YRPRSM+DLPRSM(M)*DAYS(M)
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ORIGINAL PAGE IS
OF POOR QUALITY

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1000 CONTINUE
     LAT=LAT*DTR
     TILT=TILT*DTR
     AZI=AZI*DTR
     DO 1002 I=1,12
1002 TTILT(I)=TTILT(I)*DTR
C    SET UP OUTPUT HEADERS
C
     GO TO (501,502,503,504,505,506)KIND
 501 WRITE(NOUT,511)
     WRITE(NOUT,998)
 998 FORMAT(//55X,'***ASHRAE DATA***')
 511 FORMAT(//23X,'DIRECT INSOLATION FOR BEAM TRACKING COLLECTORS
    * - BTUH/SQFT -')
 521 WRITE(NOUT,531) LAT
 531 FORMAT(//5X,'LATITUDE=' F9.4)
     GO TO 600
 502 WRITE(NOUT,512)
     WRITE(NOUT,998)
 512 FORMAT(//23X,'TOTAL SOLAR INSOLATION FOR FIXED POSITION COLLECTORS
    * - BTUH/SQFT -')
 542 WRITE(NOUT,552) LAT,TILT,AZI
 552 FORMAT(/5X,'LATITUDE=' F9.4,5X,'TILT=' F9.4,5X,'AZIMUTH=' F9.4)
 522 IF(IR.EQ.N)GO TO 600
     WRITE(NOUT,532)(REFLT(J),J=1,12)
 532 FORMAT(/5X,'MONTHLY REFLECTANCE VALUES ARE   '(12F3.2))
     GO TO 600
 503 WRITE(NOUT,513)
     WRITE(NOUT,998)
 513 FORMAT(//18X,'DIRECT SOLAR INSOLATION FOR ROTATING AZIMUTH TRACKIN
    *G COLLECTORS - BTUH/SQFT -')
 523 WRITE(NOUT,552) LAT,TILT,AZI
     GO TO 600
 504 WRITE(NOUT,514)
     WRITE(NOUT,998)
 514 FORMAT(//13X,'TOTAL SOLAR INSOLATION FOR MONTHLY TILT ADJUSTED COL
    *LECTORS (TILT=LAT-DECL) - BTUH/SQFT -')
 524 WRITE(NOUT,534) LAT,AZI
 534 FORMAT(/5X,'LATITUDE=' F9.4,5X,'AZIMUTH=' F9.4)
 544 WRITE(NOUT,554)(TTILT(K),K=1,12)
 554 FORMAT(/5X,'TILT'3X,F5.1,3X,F5.1,3X,F5.1,3X,F5.1,3X,F5.1,
    *3X,F5.1,3X,F5.1,3X,F5.1,3X,F5.1,3X,F5.1,3X,F5.1,3X,F5.1)
     GO TO 522
 505 WRITE(NOUT,515)
     WRITE(NOUT,998)
 515 FORMAT(//23X,'DIRECT SOLAR INSOLATION FOR FIXED POSITION COLLECTOR
    *S - BTUH/SQFT -')
     GO TO 542
 506 WRITE(NOUT,516)
     WRITE(NOUT,998)
 516 FORMAT(//13X,'DIRECT SOLAR INSOLATION FOR MONTHLY TILT ADJUSTED CO
    *LLECTORS (TILT=LAT-DECL) - BTUH/SQFT -')
     GO TO 524
 600 IF(IC.EQ.N)GO TO 611
     WRITE(NOUT,601)LOC
 601 FORMAT(/,15X,'MONTHLY CLOUD COVER ADJUSTMENT VALUES ARE FOR CITY NO.
    * '(I3))
 611 WRITE(NOUT,610)
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 610 FORMAT( //5X,'TIME    JAN     FEB     MAR     APR     MAY     JUNE
    1    JULY    AUG     SEPT    OCT     NOU     DEC'//)
     DO 602 I=1,13
 602 WRITE(NOUT,603) TIME(I) ,(HRLYRD(I,K),K=1,12)
 603 FORMAT(  5X,A4,3X,F5.0,3X,F6.0,3X,F6.0,3X,F5.0,3X,F5.0,3X,F5.0,3X,
    1F5.0,3X,F5.0,3X,F5.0,3X,F5.0,3X,F5.0,3X,F5.0)
     WRITE(NOUT,613)
 613 FORMAT(/4X,'MAXIMUM CLEAR AIR DAILY INSOLATION - BTU/SQFT')
C
 604 WRITE(NOUT,605)(DLYSUM(I),I=1,12)
 605 FORMAT( 4X,'DLYSM',2X,F6.0,2X,F6.0,2X,F6.0,2X,F6.0,2X,F6.0,2X,F6.0
    1,2X,F6.0,2X,F6.0,2X,F6.0,2X,F6.0,2X,F6.0,2X,F6.0)
     WRITE(NOUT,606)YRMXSM
 606 FORMAT(4X,'MAXIMUM YEARLY INSOLATION - BTU/SQFT - ='F10.0)
     IF(IC.EQ.N)GO TO 699
     WRITE(NOUT,607)
 607 FORMAT(/4X,'PROBABLE DAILY INSOLATION DUE TO CLOUD COVER')
     WRITE(NOUT,605)(DLPRSM(I),I=1,12)
     WRITE(NOUT,608)YRPRSM
 608 FORMAT(4X,'PROBABLE YEARLY INSOLATION - BTU/SQFT - ='F10.0)
C
 699 CALL TPAUSE
     WRITE(1,700)
 700 FORMAT(1X,'IS ANOTHER RUN DESIRED? (Y OR N)')
     READ(1,701)IB
 701 FORMAT(1A1)
     IF(IB.EQ.N) CLOSE(UNIT=6,DISPOSE='PRINT')
     IF(IB.EQ.N) STOP
     IF (NOUT.EQ.6) WRITE(6,800)
 800 FORMAT(1H1)
     CALL ERASE
     GO TO 1
     END
     SUBROUTINE SUNSHN(LOC,PCTSS,KSSM)
     DIMENSION PCTS(14,248)
     DIMENSION PCTSS(12),PCTX(14,90),PCTY(14,68)
     EQUIVALENCE(PCTS(1,91),PCTX(1,1))
     EQUIVALENCE(PCTS(1,181),PCTY(1,1))
     DATA PCTS/
    A58.,59.,63.,71.,72.,73.,71.,74.,74.,76.,71.,62.,33.57,2.,
    B62.,63.,66.,72.,72.,71.,67.,69.,71.,76.,72.,64.,30.68,2.,
    C59.,60.,65.,72.,73.,75.,72.,74.,73.,77.,73.,64.,32.30,2.,
    D65.,64.,66.,69.,74.,79.,81.,81.,78.,78.,74.,69.,35.33,3.,
    E62.,63.,65.,68.,75.,80.,79.,80.,78.,79.,73.,66.,34.73,3.,
    F83.,84.,89.,99.,104.,104.,97.,98.,102.,98.,94.,87.,33.43,6.,
    G86.,84.,88.,96.,102.,104.,90.,90.,101.,99.,97.,91.,34.65,6.,
    H86.,85.,90.,99.,103.,104.,91.,93.,98.,97.,95.,88.,32.12,6.,
    I85.,84.,89.,97.,101.,103.,92.,92.,100.,98.,97.,89.,35.02,6.,
    J87.,87.,93.,101.,106.,107.,96.,99.,103.,100.,97.,90.,32.67,6.,
    K59.,59.,62.,70.,72.,74.,71.,71.,76.,72.,66.,64.,40.98,6.,
    L67.,71.,80.,89.,97.,106.,105.,105.,104.,95.,83.,69.,35.42,6.,
    M80.,80.,87.,96.,99.,104.,102.,113.,103.,97.,92.,86.,35.68,6.,
    N82.,80.,88.,97.,100.,105.,102.,103.,104.,98.,93.,87.,34.87,6.,
    O78.,78.,79.,81.,80.,83.,92.,92.,88.,85.,85.,82.,33.67,6.,
    P61.,64.,68.,70.,71.,73.,69.,65.,70.,67.,62.,60.,40.80,6.,
    P60.,67.,70.,90.,97.,103.,105.,106.,105.,97.,82.,62.,36.77,6.,
    Q77.,75.,79.,82.,80.,81.,90.,89.,86.,83.,83.,80.,33.82,6.,
    R77.,75.,80.,82.,80.,90.,90.,89.,86.,83.,84.,81.,33.93,6.,
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S63.,65.,69.,78.,86.,92.,102.,100.,99.,89.,74.,70.,41.32,6.,
T84.,85.,91.,98.,103.,106.,99.,98.,104.,99.,96.,90.,34.77,6.,
U68.,70.,76.,83.,86.,90.,91.,90.,92.,84.,79.,73.,37.73,6.,
V77.,76.,81.,82.,78.,78.,82.,83.,82.,82.,84.,82.,34.12,6.,
W61.,65.,73.,84.,93.,99.,105.,103.,103.,91.,75.,66.,40.15,6.,
X59.,65.,77.,87.,95.,102.,106.,104.,104.,93.,78.,63.,38.52,6.,
Y78.,76.,79.,81.,78.,78.,85.,83.,86.,84.,85.,82.,32.73,6.,
A67.,69.,75.,83.,87.,90.,94.,93.,94.,85.,79.,72.,37.62,6.,
B73.,72.,79.,82.,83.,89.,92.,91.,89.,88.,84.,80.,34.90,6.,
C70.,70.,77.,84.,89.,93.,96.,95.,94.,86.,80.,74.,37.42,6.,
D89.,83.,82.,84.,83.,90.,87.,90.,96.,97.,95.,94.,38.82,7.,
E88.,81.,82.,83.,84.,89.,90.,91.,96.,96.,93.,92.,39.75,7.,
F78.,78.,81.,85.,88.,95.,94.,93.,98.,96.,91.,87.,39.65,7.,
G80.,79.,83.,87.,93.,98.,97.,97.,102.,97.,94.,89.,39.12,7.,
H37.,81.,82.,85.,84.,92.,91.,92.,97.,96.,94.,91.,38.28,7.,
I55.,55.,55.,59.,62.,64.,65.,64.,67.,67.,58.,55.,41.93,5.,
J57.,57.,60.,64.,67.,72.,71.,71.,73.,72.,66.,58.,38.85,2.,
K59.,60.,62.,65.,67.,71.,72.,72.,73.,72.,67.,61.,39.67,5.,
L62.,64.,69.,78.,81.,76.,71.,71.,74.,79.,76.,66.,29.75,2.,
M68.,68.,72.,78.,76.,70.,70.,71.,71.,71.,74.,69.,29.18,2.,
N67.,67.,72.,77.,76.,72.,70.,72.,70.,72.,74.,68.,30 50,2.,
O74.,79.,81.,81.,79.,76.,75.,76.,72.,72.,75.,73.,24.55,2.,
P68.,69.,72.,76.,72.,66.,70.,68.,67.,70.,73.,73.,25.80,2.,
Q70.,69.,73.,78.,77.,70.,71.,70.,71.,73.,77.,72.,28.55,2.,
R65.,65.,70.,76.,75.,72.,68.,71.,73.,77.,75.,68.,30.38,2.
S69.,69.,73.,79.,78.,71.,69.,69.,71.,75.,77.,72.,27.97,2.,
T66.,66.,70.,74.,72.,66.,70.,70.,66.,66.,71.,70.,26.68,2.,
U59.,60.,64.,71.,72.,72.,71.,73.,72.,75.,73.,63.,33.65,2.,
V61.,62.,65.,73.,72.,72.,70.,71.,71.,76.,75.,67.,33.37,2.,
W61.,61.,66.,73.,73.,73.,70.,73.,72.,77.,75.,66.,32.70,2.,
X62.,62.,67.,74.,72.,70.,70.,69.,68.,74.,74.,67.,32.13,2.,
Y63.,64.,64.,68.,74.,80.,82.,82.,80.,81.,73.,64.,40.78,3.,
A66.,66.,65.,51.,73.,80.,83.,82.,82.,83.,75.,68.,41.53,3.,
B64.,66.,65.,71.,72.,74.,81.,77.,73.,69.,61.,59.,42.50,3.,
C68.,67.,67.,69.,75.,81.,83.,84.,83.,83.,74.,69.,43.15,3.,
D68.,66.,66.,71.,75.,81.,84.,84.,83.,83.,77.,69.,42.40,3.,
E61.,69.,75.,83.,90.,94.,104.,101.,104.,94.,80.,70.,43.57,7.,
F51.,55.,62.,67.,74.,77.,84.,91.,91.,79.,62.,56.,46.38,7.,
G66.,70.,78.,82.,93.,94.,104.,102.,104.,93.,84.,73.,42.92,7.,
H62.,67.,71.,78.,80.,84.,87.,85.,83.,81.,69.,62.,37.97,3.,
I58.,58.,62.,65.,70.,76.,77.,78.,78.,75.,65.,57.,41.78,3.,
J60.,62.,62.,65.,69.,75.,77.,77.,78.,77.,68.,60.,41.45,3.,
K61.,62.,62.,66.,73.,80.,81.,80.,81.,79.,71.,62.,39.83,3.,
L55.,57.,60.,65.,70.,75.,75.,76.,75.,76.,66.,57.,38.00,5.,
M50.,52.,54.,60.,66.,70.,71.,72.,73.,71.,57.,50.,41.00,5.,
N52.,54.,56.,61.,66.,71.,71.,73.,74.,72.,61.,52.,39.73,5.,
O48.,51.,55.,62.,68.,73.,73.,75.,74.,71.,57.,48.,41.70,5.,
P72.,72.,73.,74.,76.,81.,85.,83.,80.,79.,75.,71.,39.57,3.,
Q79.,77.,77.,82.,81.,89.,93.,90.,91.,90.,86.,83.,37.77,4.,
R81.,75.,76.,80.,81.,85.,92.,91.,91.,92.,83.,86.,39.37,4.,
S69.,67.,67.,72.,75.,80.,84.,84.,83.,83.,78.,71.,30.07,3.,
T75.,72.,73.,77.,79.,86.,88.,89.,87.,87.,83.,79.,37.65,3.,
U53.,54.,57.,64.,68.,72.,73.,74.,74.,73.,64.,56.,38.03,2.,
V53.,54.,58.,64.,67.,72.,72.,74.,74.,73.,64.,57.,38.18,2.,
W58.,60.,65.,70.,72.,73.,68.,71.,71.,76.,69.,61.,30.53,2.,
X53.,57.,62.,65.,72.,75.,70.,70.,72.,80.,68.,58.,30.17,2.,
Y61.,63.,66.,74.,76.,76.,71.,72.,74.,77.,71.,64.,29.98,2.,
A60.,62.,65.,68.,73.,78.,79.,80.,78.,80.,74.,65.,32.47,2.,
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B56.,56.,57.,60.,64.,69.,70.,67.,74.,71.,66.,59.,42.37,5.,
C60.,60.,62.,65.,67.,71.,72.,71.,73.,72.,67.,61.,39.18,2.,
D60.,60.,62.,67.,69.,72.,71.,72.,74.,72.,70.,62.,38.28,2.,
E62.,62.,65.,66.,69.,71.,75.,76.,77.,73.,64.,66.,44.80,2.,
F65.,67.,70.,66.,64.,68.,71.,71.,71.,64.,57.,63.,46.87,2.,
G62.,66.,66.,66.,66.,67.,69.,70.,68.,65.,56.,59.,44.90,2.,
H57.,56.,56.,59.,62.,65.,66.,67.,69.,68.,58.,58.,43.65,5.,
I50.,53.,61.,65.,69.,72.,76.,74.,71.,65.,53.,48.,45.07,3.,
J50.,53.,56.,63.,68.,71.,73.,71.,73.,70.,57.,51.,42.42,3.,
K47.,51.,54.,60.,66.,65.,72.,71.,71.,67.,53.,47.,42.97,3.,
L45.,52.,58.,64.,69.,74.,68.,76.,74.,70.,57.,47.,42.88,3.,
M38.,45.,58.,64.,67.,71.,75.,72.,65.,63.,46.,40.,47.17,3.,
X52.,58.,63.,66.,67.,69.,74.,70.,63.,57.,47.,47.,46.57,3.,
X221210./
 DATA PCTX/
N49.,55.,63.,64.,68.,70.,74.,72.,67.,62.,50.,50.,46.47,3.,
O42.,48.,51.,64.,69.,73.,77.,75.,71.,65.,51.,45.,44.73,3.,
P60.,62.,64.,64.,66.,68.,75.,73.,70.,68.,59.,60.,46.83,3.,
Q62.,65.,67.,69.,70.,72.,78.,78.,75.,70.,60.,64.,48.57,3.,
R63.,65.,65.,66.,69.,74.,79.,78.,77.,75.,66.,62.,44.88,3.,
S61.,62.,63.,64.,67.,73.,76.,76.,75.,73.,64.,61.,43.92,3.,
T61.,62.,62.,66.,73.,79.,83.,83.,80.,79.,71.,63.,38.82,3.,
U66.,64.,64.,69.,73.,79.,83.,82.,80.,79.,76.,69.,39.30,3.,
V64.,62.,64.,69.,73.,78.,81.,82.,79.,78.,73.,67.,37.23,3.,
W63.,62.,64.,68.,73.,79.,81.,80.,80.,79.,72.,63.,38.75,3.,
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Y58.,60.,64.,70.,72.,74.,71.,74.,72.,77.,71.,62.,32.33,2.,
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C73.,73.,76.,75.,80.,82.,96.,94.,94.,90.,84.,81.,45.25,4.,
D66.,65.,70.,71.,74.,79.,90.,90.,89.,87.,82.,76.,48.22,4.,
E68.,68.,73.,70.,75.,81.,95.,92.,89.,89.,81.,72.,47.48,4.,
Z71.,78.,80.,82.,82.,83.,93.,91.,82.,77.,70.,68.,48.55,4.,
F64.,65.,70.,70.,75.,78.,94.,91.,90.,86.,79.,73.,46.60,4.,
Z55.,64.,71.,77.,78.,79.,92.,89.,80.,72.,55.,48.,48.20,4.,
G66.,64.,70.,68.,73.,79.,93.,90.,88.,85.,80.,75.,47.05,4.,
H69.,67.,72.,72.,76.,83.,93.,93.,92.,88.,83.,79.,46.43,4.,
148.,53.,61.,65.,72.,74.,94.,89.,87.,76.,64.,55.,46.92,4.,
J63.,62.,66.,71.,70.,70.,70.,70.,71.,75.,75.,67.,35.43,2.,
K60.,61.,66.,75.,76.,77.,75.,74.,76.,74.,76.,66.,35.27,2.,
L62.,62.,66.,72.,72.,73.,72.,73.,73.,76.,75.,67.,35.22,2.,
M65.,65.,69.,76.,75.,73.,72.,70.,74.,76.,78.,71.,34.90,2.,
N64.,63.,67.,72.,73.,74.,73.,74.,74.,76.,76.,69.,36.68,2.,
O62.,61.,64.,70.,70.,70.,70.,70.,72.,73.,73.,66.,35.87,2.,
P72.,71.,72.,68.,74.,79.,88.,89.,87.,85.,78.,75.,46.77,4.,
Z74.,79.,78.,79.,78.,81.,88.,85.,78.,76.,67.,68.,48.12,4.,
Q64.,65.,68.,69.,74.,77.,86.,86.,84.,82.,71.,69.,46.90,4.,
R65.,64.,67.,70.,75.,76.,85.,86.,85.,84.,75.,71.,48.27,4.,
Z72.,78.,79.,82.,84.,84.,93.,91.,83.,79.,70.,70.,48.17,4.,
S73.,69.,70.,75.,77.,85.,88.,87.,86.,87.,82.,77.,40.97,3.,
T70.,71.,72.,72.,74.,78.,83.,80.,77.,76.,71.,69.,40.85,3.,
U71.,68.,68.,69.,74.,81.,83.,84.,79.,81.,73.,71.,41.37,3.,
V77.,78.,73.,76.,78.,86.,90.,89.,89.,90.,85.,83.,41.13,4.,
W78.,73.,73.,74.,76.,85.,91.,90.,92.,90.,84.,82.,41.87,4.,
X57.,55.,56.,60.,63.,65.,67.,66.,68.,67.,58.,56.,43.20,5.,
Z80.,64.,64.,65.,67.,69.,70.,69.,69.,62.,64.,61.,39.45,5.,
Y58.,58.,60.,64.,65.,67.,67.,68.,71.,71.,66.,61.,40.03,5.,
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A60.,59.,61.,64.,66.,68.,70.,70.,72.,72.,65.,60.,40.70,5.,
B88.,85.,88.,95.,98.,101.,97.,99.,102.,100.,98.,93.,35.05,4.,
C87.,82.,84.,87.,86.,91.,90.,91.,95.,96.,94.,92.,36.45,4.,
D87.,85.,86.,92.,95.,101.,97.,98.,102.,100.,97.,90.,36.75,4.,
E85.,84.,88.,93.,95.,99.,95.,96.,97.,95.,93.,89.,33.40,4.,
F90.,88.,92.,98.,99.,100.,92.,95.,98.,98.,99.,93.,33.23,4.,
G87.,83.,86.,89.,90.,94.,92.,93.,95.,94.,93.,91.,35.18,4.,
H85.,83.,84.,92.,96.,98.,89.,90.,98.,97.,94.,89.,35.10,4.,
I76.,77.,80.,84.,90.,96.,104.,104.,107.,101.,90.,83.,40.83,7.,
J84.,81.,86.,88.,90.,95.,96.,99.,107.,102.,95.,89.,39.28,7.,
K88.,88.,92.,99.,103.,105.,101.,102.,107.,102.,98.,92.,36.08,6.,
L85.,85.,90.,95.,100.,104.,110.,111.,113.,108.,99.,92.,40.07,7.,
M83.,83.,88.,95.,99.,102.,106.,107.,111.,105.,95.,88.,39.50,7.,
N89.,88.,93.,98.,100.,105.,106.,107.,111.,107.,100.,95.,38.07,7.,
O76.,77.,81.,87.,93.,97.,106.,105.,108.,101.,90.,83.,40.90,7.,
P88.,85.,91.,97.,100.,103.,104.,104.,108.,103.,97.,93.,36.95,7.,
Q55.,55.,56.,60.,62.,66.,69.,68.,69.,66.,55.,54.,42.75,5.,
R45.,45.,48.,56.,59.,64.,66.,65.,66.,62.,49.,43.,42.22,5.,
S43.,44.,51.,59.,63.,69.,71.,69.,68.,63.,49.,43.,42.93,5.,
T54.,61.,63.,61.,65.,70.,71.,70.,65.,59.,50.,50.,44.60,5.,
U53.,53.,58.,62.,64.,68.,70.,69.,69.,64.,53.,52.,44.93,2.,
V55.,54.,57.,69.,64.,65.,67.,67.,69.,68.,59.,54.,40.78,5.,
W60.,59.,61.,64.,66.,68.,70.,71.,73.,72.,65.,61.,40.77,5.,
X45.,45.,52.,60.,64.,69.,71.,69.,69.,64.,50.,44.,43.12,5.,
Y47.,46.,51.,60.,62.,68.,70.,69.,69.,63.,49.,44.,43.12,5.,
A47.,49.,53.,60.,65.,70.,71.,72.,73.,69.,56.,48.,40.92,5.,
B51.,52.,55.,61.,65.,70.,70.,72.,72.,71.,60.,52.,36.07,5.,
C44.,46.,51.,60.,62.,70.,72.,71.,71.,67.,53.,44.,41.40,5.,
D48.,49.,53.,59.,64.,72.,69.,73.,72.,70.,57.,49.,40.00,5.,
E51.,53.,55.,62.,66.,71.,71.,73.,74.,72.,60.,52.,39.90,5.,
F50.,52.,55.,62.,68.,71.,73.,73.,73.,71.,57.,50.,41.60,5.,
G43.,44.,49.,57.,62.,67.,69.,68.,68.,66.,51.,43.,41.27,5.,
H70.,68.,70.,73.,74.,81.,83.,84.,81.,81.,79.,73.,35.40,3.,
I66.,64.,66.,69.,71.,76.,80.,81.,77.,78.,75.,69.,36.20,3.,
J46.,43.,53.,53.,65.,62.,70.,70.,75.,65.,57.,50.,46.15,6.,
K62.,58.,73.,76.,78.,81.,93.,91.,86.,77.,65.,59.,44.83,6.,
L62.,65.,68.,75.,81.,87.,98.,96.,97.,87.,75.,69.,43.58,6.,
M48.,58.,64.,73.,80.,87.,98.,96.,93.,78.,60.,50.,42.37,6.,
N55.,76.,61.,68.,74.,76.,84.,82.,82.,74.,66.,60.,43.42,6.,
O50.,54.,63.,70.,77.,82.,96.,93.,94.,81.,63.,55.,45.68,6.,
P44.,49.,54.,60.,67.,68.,82.,78.,76.,65.,55.,48.,45.60,6.,
Q65.,65.,70.,77.,83.,87.,98.,95.,96.,85.,76.,71.,44.27,6.,
R49.,55.,61.,69.,73.,75.,90.,88.,81.,62.,52.,45.,43.22,6.,
S45.,50.,56.,63.,69.,71.,86.,82.,82.,67.,56.,49.,44.92,6.,
T57.,57.,59.,62.,64.,67.,70.,69.,70.,70.,62.,57.,49.65,5.,
U40.,45.,52.,61.,65.,70.,73.,66.,70.,65.,49.,40.,42.08,5.,
V57.,57.,59.,62.,65.,68.,70.,69.,71.,70.,62.,58.,40.22,5./
 DATA PCTY/
W58.,58.,60.,63.,65.,69.,69.,70.,71.,71.,65.,60.,39.88,5.,
X46.,46.,51.,58.,63.,62.,62.,62.,68.,62.,55.,46.,40.50,5.,
Y51.,52.,55.,59.,63.,67.,69.,68.,69.,69.,55.,51.,41.33,5.,
A72.,72.,75.,77.,72.,73.,76.,76.,73.,72.,75.,72.,18.43,3.,
B59.,65.,61.,66.,68.,69.,70.,70.,69.,68.,63.,59.,41.17,5.,
C58.,57.,57.,61.,65.,67.,67.,68.,70.,71.,62.,59.,41.73,5.,
D59.,60.,65.,73.,72.,70.,70.,68.,70.,74.,75.,66.,32.90,2.,
E63.,63.,67.,74.,73.,74.,72.,73.,73.,76.,77.,69.,33.95,2.,
F63.,62.,66.,72.,71.,73.,72.,88.,73.,76.,76.,66.,34.90,2.,
G65.,63.,65.,70.,75.,88.,87.,87.,83.,84.,77.,85.,44.38,4.,
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H70.,67.,71.,74.,78.,84.,91.,92.,91.,88.,83.,75.,44.38,4.,
I70.,69.,71.,72.,75.,81.,89.,90.,92.,90.,84.,79.,44.05,4.,
J67.,65.,66.,70.,75.,80.,86.,85.,84.,84.,77.,70.,43.57,4.,
K54.,55.,59.,66.,67.,69.,68.,70.,69.,72.,67.,58.,35.03,2.,
L55.,56.,60.,68.,70.,72.,71.,72.,72.,74.,68.,59.,35.82,2.,
M59.,60.,64.,70.,73.,77.,77.,79.,76.,78.,71.,63.,35.05,2.,
N50.,52.,56.,66.,71.,74.,74.,75.,72.,72.,62.,52.,35.12,2.,
O73.,71.,76.,77.,79.,84.,84.,83.,80.,80.,80.,77.,32.43,3.,
P77.,78.,82.,86.,86.,90.,89.,91.,91.,91.,90.,88.,35.23,3.,
Q64.,64.,67.,67.,71.,79.,82.,81.,78.,78.,73.,68.,30.30,3.,
R59.,60.,65.,71.,75.,82.,87.,84.,79.,77.,69.,62.,25.90,3.,
S61.,62.,65.,67.,72.,80.,86.,50.,80.,76.,72.,64.,27.77,3.,
T65.,65.,69.,68.,73.,81.,83.,83.,80.,79.,75.,71.,32.85,3.,
U68.,68.,73.,70.,71.,77.,80.,81.,76.,78.,76.,72.,29.37,3.,
V87.,87.,91.,99.,101.,102.,96.,97.,98.,99.,97.,90.,31.80,4.,
W64.,65.,68.,68.,73.,82.,84.,85.,81.,80.,75.,70.,32.83,3.,
X65.,65.,69.,73.,78.,83.,80.,80.,79.,82.,73.,64.,29.30,3.,
Y56.,59.,61.,63.,69.,72.,71.,71.,71.,74.,63.,60.,29.98,3.,
A62.,63.,65.,68.,72.,78.,83.,80.,77.,77.,71.,64.,27.52,3.,
B65.,65.,69.,71.,76.,80.,84.,84.,80.,78.,71.,67.,27.53,3.,
C85.,82.,86.,92.,93.,96.,94.,95.,92.,92.,92.,88.,33.65,3.,
D56.,62.,65.,68.,72.,78.,78.,79.,75.,80.,73.,66.,31.23,3.,
E84.,82.,88.,92.,94.,97.,93.,94.,91.,92.,92.,88.,31.93,3.,
F58.,61.,63.,67.,72.,77.,72.,73.,74.,76.,70.,62.,29.95,3.,
G73.,71.,76.,77.,79.,83.,83.,83.,79.,80.,80.,77.,31.37,3.,
H64.,65.,68.,67.,73.,79.,83.,82.,79.,77.,73.,68.,29.53,3.,
I65.,64.,67.,68.,72.,80.,81.,83.,80.,80.,76.,70.,33.72,3.,
J64.,64.,68.,67.,69.,80.,83.,83.,79.,78.,74.,70.,31.62,3.,
K71.,70.,72.,74.,78.,84.,85.,84.,82.,82.,80.,76.,33.97,3.,
L87.,84.,88.,92.,96.,100.,95.,95.,103.,102.,101.,92.,37.70,7.,
M84.,80.,85.,90.,96.,102.,98.,98.,106.,102.,105.,89.,37.70,7.,
N70.,74.,80.,84.,93.,97.,102.,101.,104.,98.,87.,76.,40.77,7.,
O63.,62.,66.,72.,73.,76.,73.,73.,74.,74.,75.,68.,36.90,2.,
P60.,59.,63.,68.,69.,71.,70.,70.,72.,71.,70.,63.,37.50,2.,
Q62.,61.,64.,68.,69.,71.,70.,71.,73.,74.,72.,65.,37.32,2.,
R51.,51.,55.,59.,63.,66.,69.,69.,68.,63.,50.,48.,44.47,2.,
S42.,46.,52.,59.,66.,65.,77.,73.,74.,60.,53.,46.,46.97,6.,
T42.,47.,53.,61.,69.,70.,91.,77.,74.,63.,54.,45.,47.45,6.,
U51.,57.,65.,71.,78.,80.,96.,93.,93.,81.,65.,55.,47.58,6.,
V51.,58.,60.,65.,66.,65.,67.,64.,66.,59.,51.,48.,48.38,6.,
W49.,57.,69.,78.,81.,84.,95.,93.,84.,75.,56.,46.,46.08,6.,
X49.,52.,56.,64.,72.,70.,81.,77.,78.,65.,61.,54.,48.35,6.,
Y55.,60.,69.,75.,81.,83.,95.,93.,94.,82.,67.,59.,46.57,6.,
A52.,64.,64.,55.,67.,72.,76.,75.,73.,72.,62.,60.,44.37,3.,
B60.,61.,65.,66.,68.,73.,76.,75.,74.,70.,62.,60.,44.48,3.,
C62.,63.,64.,65.,68.,73.,76.,77.,75.,72.,64.,60.,43.87,3.,
D64.,65.,65.,63.,69.,74.,77.,78.,77.,74.,62.,60.,43.13,3.,
E59.,59.,62.,65.,70.,75.,78.,78.,77.,74.,64.,58.,42.95,3.,
F49.,49.,53.,59.,64.,67.,66.,67.,69.,69.,60.,51.,38.37,2.,
G52.,54.,57.,61.,66.,66.,66.,64.,66.,63.,57.,52.,38.92,2.,
H52.,53.,56.,63.,67.,70.,70.,70.,71.,71.,63.,55.,38.37,2.,
I50.,53.,57.,62.,66.,69.,71.,69.,69.,64.,54.,49.,39.27,2.,
J83.,81.,82.,83.,87.,95.,101.,101.,103.,99.,94.,91.,42.92,4.,
K85.,80.,79.,78.,78.,86.,88.,88.,96.,95.,91.,91.,41.01,4.,
L84.,87.,88.,84.,83.,90.,92.,91.,88.,85.,80.,81.,42.80,4.,
M84.,83.,85.,87.,92.,98.,101.,101.,106.,102.,96.,91.,41.60,4.,
N70.,67.,71.,70.,75.,82.,93.,93.,92.,87.,80.,77.,44.77,4.,
O63.,72.,75.,77.,76.,82.,89.,88.,83.,77.,68.,62.,44.42,4./
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C
      DO 500 I=1,12
  500 PCTSS(I)=PCTS(I,LOC)
      KSSM=PCTS(14,LOC)
C
      RETURN
      END

PIP>
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      DIMENSION A(12),B(12),C(12),DEC(12),REFLT(12),DLYSUM(12),
     &DAYS(12),TIME(13),BTA(13),SLRAZ(13),HRLYRD(13,12),DIFRAD(13),
     &CLRDIR(13),CLRDIF(13),CLRSUM(12),CLRMON(12),CLRTOT(13,12)
      DIMENSION BRAD(13),DIARAD(13),HORZRD(13),REFRD(13)
      DIMENSION DECL(12),TTILT(12)
      DIMENSION PCTSS(12),DLPRSM(12)
      DIMENSION DAY(12),SC(12)
      DIMENSION HRTHMX(12),HRMTH(12)
      DIMENSION SINPHI(13,12)
      REAL LAT
C     ASHRAE CONSTANT DATA
      DATA A/390.,385.,376.,360.,350.,345.,344.,351.,365.,378.,387.,
     &391./
      DATA B/.142,.144,.156,.18,.196,.205,.207,.201,.177,.16,.149,.142/
      DATA C/.058,.06,.071,.097,.121,.134,.136,.122,.092,.073,.063,.057/
      DATA DEC/-20.,-10.8,0.,11.6,20.,23.45,20.6,12.3,0.,-10.5,-19.8,
     1-23.45/
      DATA TIME/' 6AM',' 7AM',' 8AM',' 9AM','10AM','11AM','12PM',' 1PM'
     &,' 2PM',' 3PM',' 4PM',' 5PM',' 6PM'/
      DATA REFL  0.,0.,0.,0.,0.,0.,0.,0.,0.,0.,0.,0./
      DATA DAYS/31.,28.,31.,30.,31.,30.,31.,31.,30.,31.,30.,31./
      DATA DAY/17.,47.,75.,105.,135.,162.,198.,228.,258.,288.,318.,348./
      DATA SC/443.,439.,432.,425.,419.,416.,416.,420.,426.,434.,440.,
     1444./
      DATA N /'N'/
      DTR=57.29578
      WRITE(1,999)
  999 FORMAT(1X,'DEFINE OUTPUT DEVICE'/' INPUT 1 FOR TERMINAL OR'/
     &' INPUT 6 FOR LINE PRINTER')
      OPEN(UNIT=6,NAME='PRINT.LST',TYPE='NEW')
      READ(1,404) NOUT
C
C      READ DATA FOR SITE
C
    1 WRITE(1,2)
    2 FORMAT(1X,'INPUT LATITUDE DEG')
      READ(1,3)LAT
    3 FORMAT(F9.4)
      WRITE(1,4)
    4 FORMAT(1X,'INPUT TILT ANGLE FROM HORIZONTAL DEG')
      READ(1,3)TILT
      WRITE(1,5)
    5 FORMAT(1X,'INPUT AZIMUTH ANGLE DEG  0 DUE SOUTH + WEST - EAST')
      READ(1,3)AZI
      WRITE(1,555)
  555 FORMAT(1X,'IS GROUND REFLECTANCE DESIRED? (Y OR N)')
      READ (1,9)IR
      IF (IR.EQ.N)GO TO 88
      WRITE(1,6)
    6 FORMAT(1X,'PRELOADED VALUES OF GROUND REFLECTANCE ARE')
      WRITE(1,7)(REFLT(I),I=1,12)
    7 FORMAT(1X,12F3.2)
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      WRITE 1,8)
    8 FORMAT(1X,'IS CHANGE DESIRED? (Y OR N)')
      READ(1,9)IA
    9 FORMAT(1A1)
      IF'IA.EQ.N) GO TO 84
      WRITE(1,19)
   19 FORMAT(1X,'INPUT 12 MONTHLY VALUES OF REFLECTANCE')
      READ(1,71)(REFLT(I),I=1,12)
   71 FORMAT(12F3.2)
      GO TO 84
   88 DO 83 I=1,12
   83 REFLT(I)=0.0
   84 WRITE(1,81)
   81 FORMAT(1X,'DO YOU DESIRE CLOUD COVER CALCULATIONS? (Y OR N)')
      READ(1,9)IC
      IF(IC.EQ.N)GO TO 888
      WRITE(1,400)
  400 FORMAT(1X,'IS CITY LOCATION NUMBER KNOWN? (Y OR N)')
      READ(1,9)IL
      IF(IL.EQ.N)GO TO 90
  401 WRITE(1 402)
  402 FORMAT(1X,'INPUT CITY LOCATION NUMBER')
  403 READ(1,404)LOC
  404 FORMAT(I4)
  405 CALL SUNSHN(LOC,PCTSS,KSSM)
      GO TO 10
C
   90 WRITE(1,91)
   91 FORMAT(1X,'PRELOADED VALUES OF PERCENT SUNSHINE ARE')
   92 FORMAT(1X,12F4.0)
      WRITE(1,92)(PCTSS(I),I=1,12)
      WRITE(1,8)
      READ(1,9)IA
      IF(IA.EQ.N)GO TO 10
   95 WRITE(1,93)
   93 FORMAT(1X,'INPUT 12 MONTHLY VALUES OF PERCENT SUNSHINE IN WHOLE NU
     &MBERS')
      READ(1,921)(PCTSS(I),I=1,12)
  921 FORMAT(12F4.0)
      KSSM=1
C 94 WRITE(1,82)
C 82 FORMAT(1X,'INPUT LOCATION CLOUD COVER MODIFIER FLAG FROM MAP')
C     &' 1 PERCENT SUNSHINE MULTIPLIER'/
C     &' 2 F TERM WITH .65 MULTIPLIER'/
C     &' 3 F PRIME WITH .70 MULTIPLIER'/
C     &' 4 F PRIME TIMES 1.1'
C     &' 5 CLEAR AIR INSOLATION')
C     &' 6 F PRIME TIMES 1.05')
C     READ(1,12)KSSM
      GO TO 10
  888 DO 889 M=1,12
      PCTSS(M)=100.
  889 CONTINUE
   10 WRITE(1,11)
   11 FORMAT(1X,'SELECT TYPE OF COLLECTOR:'/' 1 BEAM TRACKER'/
     &' 2  FIXED POSITION FLAT PLATE WITH TOTAL INSOLATION'/
     &' 3  AZIMUTH TRACKER - DIRECT INSOLATION ONLY'/
     &' 4  MONTHLY TILT ADJUSTED FLAT PLATE WITH TOTAL INSOLATION'/
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     $' 5  FIXED POSITION FLAT PLATE - DIRECT INSOLATION ONLY'/
     $' 6  MONTHLY TILT ADJUSTED FLAT PLATE - DIRECT INSOLATION ONLY'/
     $' 7  TILT TRACKING CONCENTRATOR-E/W AXIS ALIGNMENT-DIRECT
     $INSOLATION ONLY')
      READ(1,12)KIND
   12 FORMAT(I2)
      CALL ERASE
C     START RUN
      DO 22 I=1,12
      DO 21 J=1,13
   21 HRLYRD(J,I)=0.
      CLRSUM(I)=0.
   22 DLYSUM(I)=0.
      YRDXSM=0.
      YRPRSM=0.
      CLRYR=0.
C      SET UP TRIG CONSTANTS FOR INPUT NUMBERS
      LAT=LAT/DTR
      CLAT=COS(LAT)
      SLAT=SIN(LAT)
      TLAT=SLAT/CLAT
      TILT=TILT/DTR
      CTLT=COS(TILT)
      STLT=SIN(TILT)
      AZI=AZI/DTR
      CAZ=COS(AZI)
      SAZ=SIN(AZI)
      XXX=.5*(1.-CTLT)
      DIFMPY=1.-XXX
C
      DO 1000 M=1,12
      ITIM=0
      REFMPY=XXX*REFLT(M)
      DECL(M)=DEC(M)/DTR
      SDECL=SIN(DECL(M))
      CDECL=COS(DECL(M))
C
C      TOTAL DAILY HORIZONTAL RADIATION CALC.
C
       HDLYHZ=0.0
      DO 900 IHR=-6,6
      HRANGL=15.*FLOAT(IHR)/DTR
      CHRANGL=COS(HRANGL)
      SBTA=CLAT*CDECL*CHRANGL+SLAT*SDECL
      IF(SBTA .GT. 1.0)SBTA=1.0
      IF(ABS(SBTA) .GT. 1.0)SBTA=-1.0
      IF(SBTA-.01)900,900,910
  910 DH=(A(M)/EXP(B(M)/SBTA))*(C(M)+SBTA)*(PCTSS(M)/100.)
      HDLYHZ=HDLYHZ+DH
      CLRDAY=HDLYHZ/(PCTSS(M)/100.)
  900 CONTINUE
C
C    DAILY LOOP FOR 6 AM TO 6PM
C
      DO 500 ITM=-6,6,1
      ITIM=ITIM+1
      ERAD(ITIM)=0.
      HRANGL=15.*FLOAT(ITM)
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      HRANGL=HANGL/DTR
      CHRNGL=COS(HRNGL)
      SHRNGL=SIN(HRNGL)
      SBTA=CLAT*CDECL*CHRNGL+SLAT*SDECL
      IF(SBTA .GT. 1.0)SBTA=1.0
      IF(ABS(SBTA) .GT. 1.)SBTA=-1.0
C      CHEC IF SUN IS UP
      IF(SBTA-.01)51,51,20
   20 BTA(ITIM)=ASIN(SBTA)
      CBTA=COS(BTA(ITIM))
      TEST=CDECL*SHRNGL/CBTA
      IF(TEST .GT. 1.0)TEST=1.0
      IF(ABS(TEST) .GT. 1.0)TEST=-1.0
      SLRAZ(ITIM)=ASIN(TEST)
      BRAD(ITIM)=A(M)/EXP(B(M)/SBTA)
      GO TO (25,50,75,100,125,100,77)KIND
C     BEAM TRACKER
C
   25 HRLYRD(ITIM,M)=BRAD(ITIM)
      GO TO 499
C
C     FLAT PLATE
   50 TALMPY=CTLT*SBTA+STLT*(CAZ*((TLAT*SBTA)-(SDECL/CLAT))+SAZ*CDECL*
     1SHRNGL)
      ECC=1.0+.033*COS(6.28318*DAY(M)/365.)
      CHRSR=-TLAT*SDECL/CDECL
      HRSR=ACOS(CHRSR)
      SHRSR=SIN(HRSR)
      RSUBD=(3.1415926/24.)*(CHRNGL-CHRSR)
     1/(SHRSR-HRSR*CHRSR)
      HEX=(24./3.1415926)*SC(M)*ECC*(CLAT*CDECL*SHRSR
     1+HRSR*SLAT*SDECL)
      XKT=HDLYHZ/HEX
      HORZRD(ITIM)=DRAD(ITIM)*(C(M)+SBTA)
      HD=HORZRD(ITIM)*(1.39-4.027*XKT+5.531*XKT*XKT-
     13.168*XKT*XKT*XKT)
      HB=HORZRD(ITIM)-HD
      CLRKT=CLRDAY/HEX
      CLRHD=HORZRD(ITIM)*(1.39-4.027*CLRKT+5.531*CLRKT*CLRKT
     1-3.108*CLRKT*CLRKT*CLRKT)
      CLRHD=CLRHD*RSUBD
      ECCHOR=ECC*SC(M)*SBTA
      CLRHD=.384*ECCHOR-.416*HORZRD(ITIM)
      IF(CLRHD.GT.HORZRD(ITIM))CLRHD=HORZRD(ITIM)
      CLRHB=HORZRD(ITIM)-CLRHD
      IF(TALMPY)51,51,52
   51 DIRRAD(ITIM)=0.
      DIFRAD(ITIM)=0.
      REFRD(ITIM)=0.
      CLRDIR(ITIM)=0.
      CLRDIF(ITIM)=0.
      GO TO 53
   52 DIRRAD(ITIM)=HB*TALMPY/SBTA
      CLRDIR(ITIM)=CLRHB*TALMPY/SBTA
   54 DIFRAD(ITIM)=HD*DIFMPY
      CLRDIF(ITIM)=CLRHD*DIFMPY
   55 REFRD(ITIM)=HORZRD(ITIM)*REFMPY
   53 HRLYRD(ITIM,M)=DIRRAD(ITIM)+DIFRAD(ITIM)+REFRD(ITIM)
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      CLRTOT(ITIM,M)=CLRDIR(ITIM)+CLRDIF(ITIM)+REFRD(ITIM)
      GO TO 499
C
C     ROTATING AZIMUTH TRACKING COLLECTOR
C
   75 TALMPY=CTLT*SBTA+STLT*(CAZ*((TLAT*SBTA)-(SDECL/CLAT))+SAZ*CDECL*
     1SHRNGL)
      IF(TALMPY)51,51,76
   76 SSLRAZ=SIN(SLRAZ(ITIM))
      CSLRAZ=COS(SLRAZ(ITIM))
      S2=CBTA*SSLRAZ
      S3=CBTA*CSLRAZ
      P=STLT*SBTA+CTLT*SAZ*S2-CTLT*CAZ*S3
      U1=SBTA-P*STLT
      U2=S2-P*CTLT*SAZ
      U3=-(S3+P*CTLT*CAZ)
      CTH=(SBTA*U1+S2*U2-S3*U3)/SQRT(U1*U1+U2*U2+U3*U3)
      HRLYRD(ITIM,M)=BRAD(ITIM)*CTH
      GO TO 499
C     N-S TILT TRACKER
   77 CTHETA=SQRT(1.0-CDECL*CDECL*SHRNGL*SHRNGL)
      BRAD(ITIM)=A(M)/EXP(B(M)/SBTA)
      HRLYRD(ITIM,M)=BRAD(ITIM)*CTHETA
      GO TO 499
C     MONTHLY TILT ADJUSTED
C      CALCULATE TILT FROM LAT-DECL
  100 TILT=LAT-DECL(M)
      TTILT(M)=TILT
      CTLT=COS(TILT)
      STLT=SIN(TILT)
      IF(KIND.EQ.6)GO TO 125
  110 XXX=.5*(1.-CTLT)
      DIFMPY=1.-XXX
      REFMPY=XXX*REFLT(M)
      GO TO 50
C
C     SET DIFFUSE AND REFLECTED TO ZERO FOR FLAT PLATE DIRECT ONLY
  125 REFMPY=0.
      DIFMPY=0.
      GO TO 50
C
C     SUM FOR DAY
  499 DLYSUM(M)=DLYSUM(M)+HRLYRD(ITIM,M)
      CLRSUM(M)=CLRSUM(M)+CLRTOT(ITIM,M)
  500 CONTINUE
      YRMXSM=YRMXSM+DLYSUM(M)*DAYS(M)
      MNTHDX(M)=DLYSUM(M)*DAYS(M)
      CLRYR=CLRYR+CLRSUM(M)*DAYS(M)
      CLRMON(M)=CLRSUM(M)*DAYS(M)
      IF(KIND.EQ.2.OR.KIND.EQ.4)GO TO 501
      GO TO (581,582,583,584,585,586,587)KSSM
C       USES SOLMET DERIVED % SUNSHINE
  581 DLPRSM(M)=DLYSUM(M)*PCTSS(M)/100.
      GO TO 590
C      MODIFIED SOLMET %SS FOR VARIOUS LOCATIONS FOR TRACKING COLL
  582 DLPRSM(M)=DLYSUM(M)*(PCTSS(M)-30.)/65.
      GO TO 590
  583 DLPRSM(M)=DLYSUM(M)*(PCTSS(M)-30.)/70.
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      GO TO 590
  584 DLPRSM(M)=DLYSUM(M)*(.909*PCTSS(M)-30.)/70.
      GO TO 590
  585 DLPRSM(M)=DLYSUM(M)*(1.0526*PCTSS(M)-30.)/65.
      GO TO 590
  586 DLPRSM(M)=DLYSUM(M)*(.9524*PCTSS(M)-30.)/70.
      GO TO 590
  587 DLPRSM(M)=DLYSUM(M)*(.8696*PCTSS(M)-30.)/70.
  590 YRPRSM=YRPRSM+DLPRSM(M)*DAYS(M)
      MONTH(M)=DLPRSM(M)*DAYS(M)
 1000 CONTINUE
      LAT=LAT*DTR
      TILT=TILT*DTR
      AZI=AZI*DTR
      DO 1002 I=1,12
 1002 TTILT(I)=TTILT(I)*DTR
C     SET UP OUTPUT HEADERS
C
      GO TO (501,502,503,504,505,506,507)KIND
  501 WRITE(NOUT,511)
      WRITE(NOUT,998)
  998 FORMAT(//35X,'***SOLRAD DATA***')
  511 FORMAT(//23X,'DIRECT INSOLATION FOR BEAM TRACKING COLLECTORS
     * - BTUH/SQFT -')
  521 WRITE(NOUT,531) LAT
  531 FORMAT(//5X,'LATITUDE=' F9.4)
      GO TO 600
  502 WRITE(NOUT,512)
      WRITE(NOUT,998)
  512 FORMAT(//23X,'TOTAL SOLAR INSOLATION FOR FIXED POSITION COLLECTORS
     * - BTUH/SQFT -')
  542 WRITE(NOUT,552) LAT,TILT,AZI
  552 FORMAT(/5X,'LATITUDE=' F9.4,5X,'TILT=' F9.4,5X,'AZIMUTH=' F9.4)
  522 IF(IR.EQ.N)GO TO 600
      WRITE(NOUT,532)(REFLT(J),J=1,12)
  532 FORMAT(/5X,'MONTHLY REFLECTANCE VALUES ARE   '(12F3.2))
      GO TO 600
  503 WRITE(NOUT,513)
      WRITE(NOUT,998)
  513 FORMAT(//18X,'DIRECT SOLAR INSOLATION FOR ROTATING AZIMUTH TRACKIN
     *G COLLECTORS - BTUH/SQFT -')
  523 WRITE(NOUT,552) LAT,TILT,AZI
      GO TO 600
  504 WRITE(NOUT,514)
      WRITE(NOUT,998)
  514 FORMAT(//13X,'TOTAL SOLAR INSOLATION FOR MONTHLY TILT ADJUSTED COL
     *LECTORS (TILT=LAT-DECL) - BTUH/SQFT -')
  524 WRITE(NOUT,534) LAT,AZI
  534 FORMAT(/5X,'LATITUDE=' F9.4,5X,'AZIMUTH=' F9.4)
  544 WRITE(NOUT,554)(TTILT(K),K=1,12)
  554 FORMAT(/5X,'TILT'3X,F5.1,3X,F5.1,3X,F5.1,3X,F5.1,3X,F5.1,3X,F5.1,
     *3X,F5.1,3X,F5.1,3X,F5.1,3X,F5.1,3X,F5.1,3X,F5.1,3X,F5.1,3X,F5.1)
      GO TO 522
  505 WRITE(NOUT,515)
      WRITE(NOUT,998)
  515 FORMAT(//23X,'DIRECT SOLAR INSOLATION FOR FIXED POSITION COLLECTOR
     *S - BTUH/SQFT -')
      GO TO 542
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505 WRITE(NOUT,516)
    WRITE(NOUT,998)
516 FORMAT(//13X,'DIRECT SOLAR INSOLATION FOR MONTHLY TILT ADJUSTED CO
   1LLECTORS (TILT=LAT-DECL) - BTUH/SQFT -')
    GO TO 524
507 WRITE(NOUT,508)
508 FORMAT(//10X,'DIRECT INSOLATION FOR SOLAR ALTITUDE TRACKING COLLEC
   1TORS FACING SOUTH- BTU/SQFT')
    WRITE(NOUT,998)
    WRITE(NOUT,970)LAT
970 FORMAT(/15X,'LATITUDE=',F9.4)
600 IF(IC.EQ.N)GO TO 611
    WRITE(NOUT,601)LOC
601 FORMAT(/,15X,'MONTHLY CLOUD COVER ADJUSTMENT VALUES ARE FOR CITY NO
   1 '(I3))
611 WRITE(NOUT,610)
610 FORMAT( //5X,'TIME    JAN     FEB     MAR     APR     MAY     JUNE
   1    JULY    AUG     SEPT    OCT     NOV     DEC'//)
    DO 950 I=1,13
    IF(KIND.EQ.1.OR.KIND.EQ.3.OR.KIND.EQ.7)GO TO 602
    WRITE(NOUT,603) TIME(I), (CLRTOT(I,K),K=1,12)
    GO TO 950
602 WRITE(NOUT,600) TIME(I) ,(HRLYRD(I,K),K=1,12)
950 CONTINUE
603 FORMAT(  5X,A4,3X,F5.0,3X,F5.0,3X,F5.0,3X,F5.0,3X,F5.0,3X,F5.0,3X,F5.0,3X,
   2F5.0,3X,F5.0,3X,F5.0,3X,F5.0,3X,F5.0,3X,F5.0,3X,F5.0)
    WRITE(NOUT,613)
613 FORMAT(/4X,'MAXIMUM CLEAR AIR DAILY INSOLATION - BTU/SQFT')
    IF(KIND.EQ.1.OR.KIND.EQ.3.OR.KIND.EQ.7)GO TO 604
    DO 951 I=1,12
    HMTHMX(I)=CLRMON(I)
951 DLYSUM(I)=CLRSUM(I)
604 WRITE(NOUT,605)(DLYSUM(I),I=1,12)
605 FORMAT( 4X,'DLYSM',2X,F6.0,2X,F6.0,2X,F6.0,2X,F6.0,2X,F6.0,2X,F6.0,2X,F6.0
   2,2X,F6.0,2X,F6.0,2X,F6.0,2X,F6.0,2X,F6.0,2X,F6.0,2X,F6.0)
    WRITE(NOUT,697)
697 FORMAT(4X,'MAXIMUM CLEAR AIR MONTHLY INSOLATION-BTU/SQFT')
    WRITE(NOUT,696)(HMTHMX(I),I=1,12)
    IF'KIND.EQ.1.OR.KIND.EQ.3.OR,KIND.EQ.7)GO TO 777
    YRMXSM=CLRYR
777 WRITE(NOUT,606)YRMXSM
606 FORMAT(4X,'MAXIMUM YEARLY INSOLATION - BTU/SQFT - *'F10.0)
    IF(IC.NE.N)GO TO 698
696 FORMAT(11X,F6.0,2X,F6.0,2X,F6.0,2X,F6.0,2X,F6.0,2X,F6.0,2X,
   1F6.0,2X,F6.0,2X,F6.0,2X,F6.0,2X,F6.0,2X,F6.0,2X,F6.0)
    GO TO 699
698 WRITE(NOUT,697)
697 FORMAT(/4X,'PROBABLE DAILY INSOLATION DUE TO CLOUD COVER')
    WRITE(NOUT,695)(DLPRSM(I),I=1,12)
    WRITE(NOUT,695)
695  FORMAT(4X,'PROBABLE MONTHLY INSOLATION DUE TO CLOUD COVER
   1-BTU/SQFT')
    WRITE(NOUT,696)(MNNTH(I),I=1,12)
    WRITE(NOUT,698)YRPRSM
698 FORMAT(4X,'PROBABLE YEARLY INSOLATION - BTU/SQFT - *'F10.0)
C
699 CALL TPAUSE
    WRITE(1,700)
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700 FORMAT(1X,'IS ANOTHER RUN DESIRED? (Y OR N)')
    READ(1,701)IB
701 FORMAT(1A1)
    IF(IB.EQ.N) CLOSE(UNIT=6,DISPOSE='PRINT')
    IF(IB.EQ.N) STOP
    IF (NOUT.EQ.6) WRITE(6,800)
800 FORMAT(1H1)
    CALL ERASE
    GO TO 1
    END
    SUBROUTINE SUNSHN(LOC,PCTSS,KSSN)
    DIMENSION PCTS(14,248)
    DIMENSION PCTSS(12),PCTX(14,90),PCTY(14,68)
    EQUIVALENCE(PCTS(1,91),PCTX(1,1))
    EQUIVALENCE(PCTS(1,181),PCTY(1,1))
    DATA PCTS/
   A58.,59.,63.,71.,72.,73.,71.,74.,74.,76.,71.,62.,33.57,2.,
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   C59.,60.,65.,72.,73.,75.,72.,74.,73.,77.,73.,64.,32.30,2.,
   D65.,64.,66.,69.,74.,79.,81.,81.,78.,78.,74.,69.,35.33,3.,
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   G86.,84.,88.,96.,102.,104.,90.,99.,101.,99.,97.,91.,34.65,6.,
   H86.,85.,89.,99.,103.,104.,91.,93.,98.,97.,95.,88.,32.12,6.,
   I85.,84.,89.,97.,101.,103.,92.,92.,100.,98.,97.,89.,35.02,6.,
   J87.,87.,93.,101.,106.,107.,96.,99.,103.,100.,97.,90.,32.67,6.,
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   N82.,80.,88.,97.,100.,105.,102.,103.,104.,98.,93.,87.,34.87,6.,
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   R77.,75.,80.,82.,80.,82.,80.,83.,83.,84.,81.,33.93,6.,
   S63.,65.,69.,78.,88.,92.,102.,108.,93.,93.,74.,70.,41.32,6.,
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   B73.,72.,79.,82.,83.,89.,92.,91.,89.,88.,84.,80.,34.90,6.,
   C70.,70.,77.,84.,89.,93.,96.,95.,94.,86.,80.,74.,37.42,6.,
   D89.,83.,82.,84.,83.,90.,87.,90.,96.,97.,95.,94.,33.82,7.,
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J84.,81.,86.,88.,89.,95.,96.,99.,107.,102.,95.,89.,39.28,7.,
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N89.,88.,93.,88.,100.,105.,106.,107.,111.,107.,100.,95 ,38.87,7.,
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Q64.,64.,67.,67.,71.,79.,82.,81.,78.,78.,73.,68.,30.30,3.,
R59.,60.,65.,71.,75.,82.,87.,84.,79.,77.,69.,62.,25.90,3.,
S61.,62.,65.,67.,72.,80.,86.,90.,80.,78.,72.,64.,27.77,3.,
T65.,65.,69.,68.,73.,81.,83.,83.,80.,79.,75.,71.,32.85,3.,
U68.,68.,73.,70.,71.,77.,80.,81.,76.,78.,76.,72.,29.37,3.,
V87.,87.,91.,99.,101.,102.,105.,97.,98.,99.,97.,90.,31.80,4.
W54.,65.,68.,68.,73.,82.,84.,85.,81.,80.,75.,70.,32.83,3.,
X65.,65.,69.,73.,78.,83.,89.,89.,79.,82.,73.,64.,29.30,3.,
Y56.,59.,61.,63.,69.,72.,71.,71.,71.,74.,63.,60.,29.88,3.,
A62.,63.,66.,68.,72.,78.,83.,80.,77.,77.,71.,64.,27.52,3.,
B65.,65.,69.,71.,76.,80.,84.,84.,80.,78.,71.,67.,27.53,3.,
C85.,82.,86.,92.,93.,96.,94.,95.,92.,92.,92.,88.,33.65,3.,
D56.,62.,65.,68.,72.,72.,78.,79.,75.,80.,73.,66.,31.23,3.,
E84.,82.,88.,92.,94.,97.,93.,94.,91.,92.,92.,88.,31.93,3.,
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ORIGINAL PAGE IS
OF POOR QUALITY

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      F58.,61.,63.,67.,72.,77.,72.,73.,74.,76.,70.,62.,29.95,3.,
      G73.,71.,76.,77.,79.,83.,83.,83.,79.,80.,80.,77.,31.37,3.,
      H64.,65.,68.,67.,73.,79.,83.,82.,79.,77.,73.,68.,29.53,3.,
      I65.,64.,67.,68.,72.,89.,81.,83.,80.,80.,76.,70.,33.72,3.,
      J64.,64.,68.,67.,69.,88.,83.,83.,79.,78.,74.,70.,31.62,3.,
      K71.,70.,72.,74.,78.,84.,85.,84.,82.,82.,80.,76.,33.97,3.,
      L87.,84.,88.,92.,96.,100.,95.,96.,103.,102.,101.,92.,37.70,7.,
      M84.,80.,85.,90.,96.,102.,98.,98.,106.,102.,105.,89.,37.70,7.,
      N70.,74.,80.,84.,93.,97.,102.,101.,104.,98.,87.,76.,40.77,7.,
      O63.,62.,66.,72.,73.,76.,73.,73.,74.,74.,75.,68.,36.90,2.,
      P60.,59.,63.,68.,69.,71.,70.,70.,72.,71.,70.,63.,37.50,2.,
      Q62.,61.,64.,68.,69.,71.,70.,71.,73.,74.,72.,65.,37.32,2.,
      R51.,51.,55.,59.,63.,66.,69.,68.,68.,63.,58.,48.,44.47,2.,
      S42.,46.,52.,59.,66.,65.,77.,73.,74.,60.,53.,46.,46.97,6.,
      T42.,47.,53.,61.,69.,79.,91.,77.,74.,63.,54.,45.,47.45,6.,
      U51.,57.,65.,71.,78.,89.,98.,93.,93.,81.,65.,55.,47.58,6.,
      V51.,58.,60.,65.,66.,65.,67.,64.,66.,59.,51.,48.,48.38,6.,
      W49.,57.,69.,78.,81.,84.,95.,93.,84.,75.,56.,46.,46.63,6.,
      X49.,52.,59.,64.,72.,70.,81.,77.,78.,65.,61.,54.,48.35,6.,
      Y55.,60.,69.,75.,81.,83.,95.,93.,94.,82.,67.,59.,46.57,6.,
      A62.,64.,64.,65.,67.,72.,76.,75.,73.,72.,62.,60.,44.87,3.,
      B60.,61.,65.,66.,68.,73.,76.,75.,74.,70.,62.,60.,44.48,3.,
      C62.,63.,64.,65.,68.,73.,76.,77.,75.,72.,64.,60.,43.87,3.,
      D64.,65.,65.,63.,69.,74.,77.,78.,77.,74.,62.,60.,43.13,3.,
      E59.,59.,62.,65.,70.,75.,78.,78.,77.,74.,64.,58.,42.95,3.,
      F49.,49.,53.,59.,64.,67.,66.,67.,69.,69.,60.,51.,38.37,2.,
      G52.,54.,57.,61.,66.,66.,66.,64.,66.,63.,57.,52.,38.92,2.,
      H52.,53.,56.,63.,67.,70.,70.,70.,71.,71.,63.,55.,38.37,2.,
      I50.,53.,57.,62.,66.,69.,71.,69.,69.,64.,54.,49.,39.27,2.,
      J83.,81.,82.,83.,87.,95.,101.,101.,103.,99.,94.,91.,42.92,4.,
      K85.,80.,79.,78.,78.,86.,88.,88.,95.,95.,91.,91.,41.01,4.,
      L84.,87.,88.,84.,83.,90.,92.,91.,88.,85.,80.,81.,42.80,4.,
      M84.,83.,85.,87.,92.,98.,101.,101.,105.,102.,95.,91.,41.60,4.,
      N70.,67.,71.,70.,75.,82.,93.,93.,92.,87.,80.,77.,44.77,4.,
      O63.,72.,75.,77.,76.,82.,89.,88.,83.,77.,68.,62.,44.42,4./
C
      DO 500 I=1,12
  500 PCTSS(I)=PCTS(I,LOC)
      KSSM=PCTS(14,LOC)
C
      RETURN
      END

PIP>
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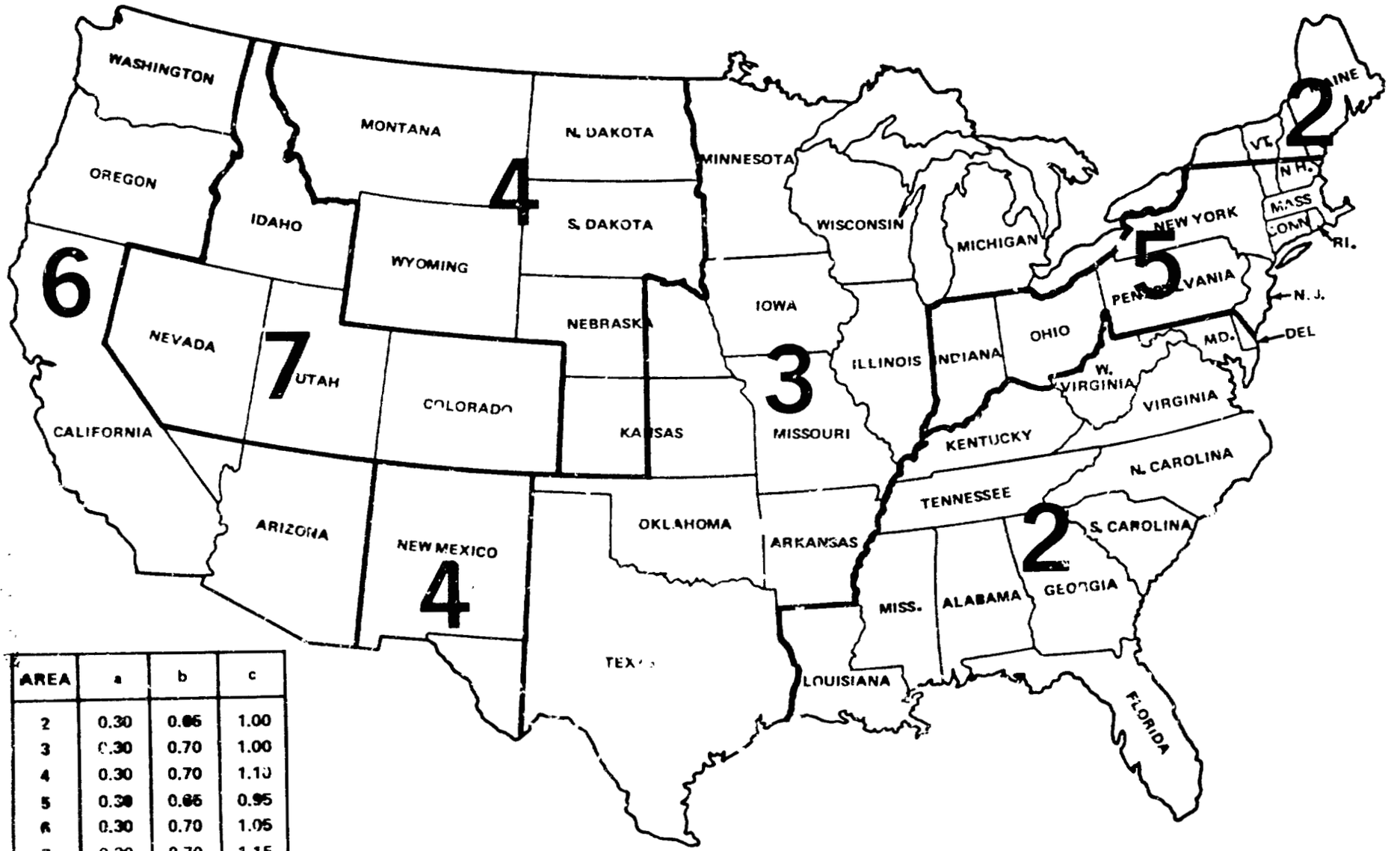
TABLE 1. ASHMET PROGRAM CITY LIST

NO.	STATION AND STATE	LAT.°N	NO.	STATION AND STATE	LAT.°N	NO.	STATION AND STATE	LAT.°N
1	BIRMINGHAM, AL	33.57	46	W. PALM BEACH, FL	26.68	91	SAULT STE. MARIE, MI	46.47
2	MOBILE, AL	30.68	47	ATLANTA, GA	33.65	92	TRAVERSE CITY, MI	44.73
3	MONTGOMERY, AL	32.30	48	AUGUSTA, GA	33.37	93	DULUTH, MN	46.83
4	FT. SMITH, AR	35.33	49	MACON, GA	32.70	94	INTERNATIONAL FALLS, MN	48.57
5	LITTLE ROCK, AR	34.73	50	SAVANNAH, GA	32.13	95	MINNEAPOLIS–ST.PAUL, MN	44.88
6	PHOENIX, AZ	33.43	51	BURLINGTON, IA	40.78	96	ROCHESTER, MN	43.92
7	PRESCOTT, AZ	34.65	52	DES MOINES, IA	41.53	97	COLUMBIA, MO	38.82
8	TUCSON, AZ	32.12	53	DUBUQUE, IA	42.50	98	KANSAS CITY, MO	39.30
9	WINSLOW, AZ	35.02	54	MASON CITY, IA	43.15	99	SPRINGFIELD, MO	37.23
10	YUMA, AZ	32.67	55	SOUIX, CITY IA	42.40	100	ST. LOUIS, MO	38.75
11	ARCATA, CA	40.98	56	BOISE, ID	43.57	101	JACKSON, MS	32.32
12	BAKERSFIELD, CA	35.42	57	LEWISTON, ID	46.38	102	MERIDIAN, MS	32.33
13	CHINA LAKE, CA	35.68	58	POCATELLO, ID	42.92	103	VICKSBURG, MS	32.33
14	DAGGETT, CA	34.87	59	CAIRO, IL	37.07	104	BILLINGS, MT	45.80
15	EL TORO, CA	33.67	60	CHICAGO, IL	41.78	105	CUT BANK, MT	48.60
16	EUREKA, CA	40.80	61	MOLINE, IL	41.45	106	DILLON, MT	45.25
17	FRESNO, CA	36.77	62	SPRINGFIELD, IL	39.83	107	GLASGOW, MT	48.22
18	LONG BEACH, CA	33.82	63	EVANSVILLE, IN	38.00	108	GREAT FALLS, MT	47.48
19	LOS ANGELES, CA	33.93	64	FORT WAYNE, IN	41.00	109	HAVRE, MT	48.55
20	MT. SHASTA, CA	41.32	65	INDIANAPOLIS, IN	39.73	110	HELENA, MT	46.60
21	NEEDLES, CA	34.77	66	SOUTH BEND, IN	41.70	111	KALISPELL, MT	48.20
22	OAKLAND, CA	37.73	67	CONCORDIA, KS	39.57	112	LEWISTON, MT	47.05
23	PT. MUGU, CA	34.12	68	DODGE CITY, KS	37.77	113	MILES CITY, MT	46.43
24	RED BLUFF, CA	40.15	69	GOODLAND, KS	39.37	114	MISSOULA, MT	46.92
25	SACRAMENTO, CA	38.52	70	TOPEKA, KS	39.17	115	ASHVILLE, NC	35.43
26	SAN DIEGO, CA	32.73	71	WICHITA, KS	37.65	116	CAPE HATTERAS, NC	35.27
27	SAN FRANCISCO, CA	37.62	72	LEXINGTON, KY	38.03	117	CHARLOTTE, NC	35.22
28	SANTA MARIA, CA	34.90	73	LOUISVILLE, KY	38.18	118	CHERRY POINT, NC	34.90
29	SUNNYVALE, CA	37.42	74	BATON ROUGE, LA	30.53	119	GREENSBORO, NC	36.08
30	COLORADO SPRINGS, CO	38.82	75	LAKE CHARLES, LA	30.17	120	RALEIGH–DURHAM, NC	35.87
31	DENVER, CO	39.75	76	NEW ORLEANS, LA	29.98	121	BISMARK, ND	46.77
32	EAGLE, CO	39.65	77	SHREVEPORT, LA	32.47	122	DEVILS LAKE, ND	48.12
33	GRAND JUNCTION, CO	39.12	78	BOSTON, MA	42.37	123	FARGO, ND	46.90
34	PUEBLO, CO	38.28	79	BALTIMORE, MD	39.18	124	MINOT, ND	48.27
35	HARTFORD, CT	41.93	80	PATUXENT RIVER, MD	38.28	125	WILLISTON, ND	48.17
36	WASHINGTON, DC	38.85	81	BANGOR, ME	44.80	126	GRAND ISLAND, NE	40.97
37	WILMINGTON, DE	39.67	82	CARIBOU, ME	46.87	127	LINCOLN, NE	40.85
38	APALACHICOLA, FL	29.75	83	EASTPORT, ME	44.90	128	NORTH OMAHA, NE	41.37
39	DAYTONA BEACH FL	29.18	84	PORTLAND ME	43.65	129	NORTH PLATT, NE	41.13
40	JACKSONVILLE, FL	30.50	85	ALPENA, MI	45.07	130	SCOTTSBLUFF, NE	41.87
41	KEY WEST, FL	24.55	86	DETROIT, MI	42.42	131	CONCORD, NH	43.20
42	MIAMI, FL	25.80	87	FLINT, MI	42.97	132	ATLANTIC CITY, NJ	39.45
43	ORLANDO, FL	28.55	88	GRAND RAPIDS, MI	42.88	133	LAKEHURST, NJ	40.03
44	TALLAHASSEE, FL	30.38	89	HOUGHTON, MI	47.17	134	NEWARK, NJ	40.70
45	TAMPA, FL	27.97	90	MARQUETTE, MI	46.57	135	ALBUQUERQUE, NM	35.05

TABLE 1. CONCLUDED

NO.	STATION AND STATE	LAT.$^{\circ}$	NO.	STATION AND STATE	LAT.$^{\circ}$	NO.	STATION AND STATE	LAT.$^{\circ}$
136	CLAYTON, NM	36.45	180	HARRISBURG, PA	40.22	223	NORFOLK, VA	36.90
137	FARMINGTON, NM	36.75	181	PHILADELPHIA, PA	39.88	224	RICHMOND, VA	37.50
138	ROSWELL, NM	33.40	182	PITTSBURG, PA	40.50	225	ROANOKE, VA	37.32
139	TRUTH OR CONSEQUENCES, NM	33.23	183	WILKES–BARRE–SCRANTON, PA	41.33	226	BURLINGTON, VT	44.47
140	TUCUMCARI, NM	35.18	184	SAN JUAN, PR	18.43	227	OLYMPIA, WA	46.97
141	ZUNI, NM	35.10	185	BLOCK ISLAND, RI	41.17	228	SEATTLE–TACOMA, WA	47.45
142	ELKO, NV	40.83	186	PROVIDENCE, RI	41.73	229	SPOKANE, WA	47.58
143	ELY, NV	39.28	187	CHARLESTON, SC	32.90	230	TATOOSH ISLAND, WA	48.38
144	LAS VEGAS, NV	36.08	188	COLUMBIA, SC	33.95	231	WALLA WALLA, WA	46.08
145	LOVELOCK, NV	40.07	189	GREENVILLE–SPARTANBURG, SC	34.90	232	WHIDBEY ISLAND, WA	48.35
146	RENO, NV	39.50				233	YAKIMA, WA	46.57
147	TONOPAH, NV	38.07	190	HURON, SD	44.38	234	EAU CLAIRE, WI	44.87
148	WINNEMUCCA, NV	40.90	191	PIERRE, SD	44.38	235	GREENBAY, WI	44.48
149	YUCCA FLATS, NV	36.95	192	RAPID CITY, SD	44.05	236	LA CROSSE, WI	43.87
150	ALBANY, NY	42.75	193	SOUIX FALLS, SD	43.57	237	MADISON, WI	43.13
151	BINGHAMTON, NY	42.22	194	CHATTANOOGA, TN	35.03	238	MILWAUKEE, WI	42.95
152	BUFFALO, NY	42.93	195	KNOXVILLE, TN	35.82	239	CHARLESTON, WV	38.37
153	CANTON, NY	44.60	196	MEMPHIS, TN	35.05	240	ELKINS, WV	38.92
154	MASSENA, NY	44.93	197	NASHVILLE, TN	35.12	241	HUNTINGTON, WV	38.37
155	NYC (CENTRAL PARK), NY	40.78	198	ABILENE, TX	32.43	242	PARKERSBURG, WV	39.27
156	NYC (LA GUARDIA), NY	40.77	199	AMARILLO, TX	35.23	243	CASPER, WY	42.92
157	ROCHESTER, NY	43.12	200	AUSTIN, TX	30.30	244	CHEYENNE, WY	41.01
158	SYRACUSE, NY	43.12	201	BROWNSVILLE, TX	25.90	245	LANDER, WY	42.80
159	AKRON–CANTON, OH	40.92	202	CORPUS CHRISTI, TX	27.77	246	ROCK SPRINGS, WY	41.60
160	CINCINNATI, OH	36.07	203	DALLAS, TX	32.85	247	SHERIDAN, WY	44.77
161	CLEVELAND, OH	41.40	204	DEL RIO, TX	29.37	248	YELLOWSTONE PARK, WY	44.42
162	COLUMBUS, OH	40.00	205	EL PASO, TX	31.80			
163	DAYTON, OH	39.90	206	FORT WORTH, TX	32.83			
164	TOLEDO, OH	41.60	207	GALVESTON, TX	29.30			
165	YOUNGSTOWN, OH	41.27	208	HOUSTON, TX	29.98			
166	OKLAHOMA CITY, OK	35.40	209	KINGSVILLE, TX	27.52			
167	TULSA, OK	36.20	210	LAREDO, TX	27.53			
168	ASTORIA, OR	46.15	211	LUBBOCK, TX	33.65			
169	BAKER, OR	44.83	212	LUFKIN, TX	31.23			
170	BURNS, OR	43.58	213	MIDLAND–ODESSA, TX	31.93			
171	MEDFORD, OR	42.37	214	PORT AUTHUR, TX	29.95			
172	NORTH BEND, OR	43.42	215	SAN ANGELO, TX	31.37			
173	PENDLETON, OR	45.68	216	SAN ANTONIA, TX	29.53			
174	PORTLAND, OR	45.60	217	SHERMAN, TX	33.72			
175	REDMOND, OR	44.27	218	WACO, TX	31.62			
176	ROSEBURG, OR	43.22	219	WICHITA FALLS, TX	33.97			
177	SALEM, OR	49.44	220	BRYCE CANYON, UT	37.70			
178	ALLENTOWN, PA	40.65	221	CEDAR CITY, UT	37.70			
179	ERIE, PA	42.08	222	SALT LAKE CITY, UT	40.77			



AREA	a	b	c
2	0.30	0.86	1.00
3	0.30	0.70	1.00
4	0.30	0.70	1.10
5	0.30	0.86	0.95
6	0.30	0.70	1.05
7	0.30	0.70	1.15

FIGURE 1. AREAS OF CONSTANT COEFFICIENTS IN EQUATION (6).

```
DEFINE OUTPUT DEVICE
INPUT 1 FOR TERMINAL OR
INPUT 6 FOR LINE PRINTER
1
INPUT LATITUDE DEG
38.85
INPUT TILT ANGLE FROM HORIZONTAL DEG
50.
INPUT AZIMUTH ANGLE DEG  0 DUE SOUTH + WEST - EAST
-10.
IS GROUND REFLECTANCE DESIRED? (Y OR N)
N
DO YOU DESIRE CLOUD COVER CALCULATIONS? (Y OR N)
Y
IS CITY LOCATION NUMBER KNOWN? (Y OR N)
Y
INPUT CITY LOCATION NUMBER
36
SELECT TYPE OF COLLECTOR:
1 BEAM TRACKER
2  FIXED POSITION FLAT PLATE WITH TOTAL INSOLATION
3  AZIMUTH TRACKER - DIRECT INSOLATION ONLY
4  MONTHLY TILT ADJUSTED FLAT PLATE WITH TOTAL INSOLATION
5  FIXED POSITION FLAT PLATE - DIRECT INSOLATION ONLY
6  MONTHLY TILT ADJUSTED FLAT PLATE - DIRECT INSOLATION ONLY
2
```

FIGURE 2. SAMPLE INPUT FOR ASHMET (FROM REMOTE TERMINAL)

TOTAL SOLAR INSOLATION FOR FIXED POSITION COLLECTORS - BTUH/SQFT -

###ASHMET DATA###

LATITUDE= 38.8500 TILT= 50.0000 AZIMUTH= -10.0000

MONTHLY CLOUD COVER ADJUSTMENT VALUES ARE FOR CITY N 36

TIME	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
6AM	0.	0.	0.	15.	23.	24.	23.	15.	0.	0.	0.	0.
7AM	0.	29.	76.	86.	85.	83.	84.	83.	69.	26.	0.	0.
8AM	103.	151.	166.	160.	150.	145.	147.	154.	157.	143.	100.	70.
9AM	207.	234.	238.	222.	207.	198.	202.	215.	227.	224.	202.	180.
10AM	262.	289.	289.	267.	248.	237.	242.	259.	277.	279.	264.	254.
11AM	300.	318.	316.	292.	270.	258.	264.	282.	303.	308.	296.	287.
12PM	304	321.	318.	293.	271.	259.	265.	284.	305.	311.	299.	292.
1PM	281.	297.	295.	272.	251.	241.	246.	264.	283.	288.	277.	270.
2PM	234.	250.	249.	230.	213.	204.	209.	223.	239.	242.	230.	222.
3PM	163.	183.	185	172.	159.	153.	157.	167.	177.	176.	160.	149.
4PM	76.	100.	108.	103.	96.	93.	95.	101.	104.	96.	68.	48.
5PM	0.	13.	32.	34.	33.	32.	34.	35.	30.	12.	0.	0.
6PM	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

MAXIMUM CLEAR AIR DAILY INSOLATION - BTU/SQFT

DLYSM	1931.	2186.	2272.	2145.	2005.	1929.	1969.	2081.	2172.	2105.	1896.	1781.

MAXIMUM YEARLY INSOLATION - BTU/SQFT - = 743899.

PROBABLE DAILY INSOLATION DUE TO CLOUD COVER

DLYSM	1101.	1246.	1363.	1373.	1343.	1389.	1398.	1477.	1586.	1516.	1251.	1033.

PROBABLE YEARLY INSOLATION - BTU/SQFT - = 488997.

FIGURE 3. SAMPLE OUTPUT FOR ASHMET (FROM REMOTE TERMINAL)

AP OVAL

ASHMET - A COMPUTER CODE FOR ESTIMATING INSOLATION INCIDENT ON TILTED SURFACES

BY Robert F. Elkin and Ronald G. Toelle

The information in this report has been reviewed for technical content. Review of any information concerning Department of Defense or nuclear energy activities or programs has been made by the MSFC Security Classification Officer. This report, in its entirety, has been determined to be unclassified.

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