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AXAIRQ USER'S MANUAL

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Technical Reviewer

October 1995

Savannah River Technology Center
Westinghouse Savannah River Company
Aiken, SC 29808

SAFETY • RESPONSIBILITY • SECURITY
SRS
SAVANNAH RIVER SITE

PREPARED FOR THE U.S. DEPARTMENT OF ENERGY UNDER CONTRACT NO. DE-AC09-89SR18035

DISCLAIMER

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ABSTRACT

This manual is designed as a tool for novice users of the AXAIRQ dose assessment code. AXAIRQ was developed to predict downwind doses following hypothetical acute atmospheric releases of relatively short duration. AXAIRQ strictly adheres to USNRC Regulatory Guide 1.145. Doses are determined for inhalation, plume shine, and ground shine pathways. This user's manual contains the operating instructions and mathematical models for AXAIRQ.

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AXAIRQ User's Manual

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1.0 INTRODUCTION

AXAIRQ is the primary dose assessment code used at the Savannah River Site to predict downwind doses following a hypothetical atmospheric release of relatively short duration. The primary purpose of the code is to perform calculations for safety-related documentation, and AXAIRQ strictly adheres to the guidance in US Nuclear Regulatory Commission (NRC) Regulatory Guide 1.145 (USNRC 1982) entitled *Atmospheric Dispersion Models for Potential Accident Consequence Assessments at Nuclear Power Plants.* Doses are determined for the plume shine, ground shine, and inhalation pathways. Ingestion is not considered. This report discusses the information needed to execute the program and interpret the results. For a more detailed discussion on the mathematical models within AXAIRQ, refer to Simpkins (1995).

2.0 EXECUTING AXAIRQ

AXAIRQ is maintained on the SRS IBM Mainframe. This manual assumes the user has a base knowledge for executing programs on the IBM. If the user is new to the mainframe, after logging on, from the main menu select 'T', and a tutorial session will offer instructions on the basics.

Two files are needed in order to execute AXAIRQ, the JCL and an input file. The first file is the Job Control Language (JCL) and is under the filename AXAIRQ, located in dataset 'TENVT.TMECA.JCL.' The input file, named AXAIRDQ, is located in dataset 'TENVT.DATA.TMECA.' To copy these files into the user's dataset, from the main menu select '3' (the UTILITIES command) and then choose submenu '3' for MOVE/COPY. The screen will appear as shown in Figure 1. The user only needs to enter the information shown bold type in Figure 1 and then press return.

```
                              Move/Copy Utility
Option ===> C

C  Copy data set or member(s)          CP  Copy and print
M  Move data set or member(s)          MP  Move and print
L  Copy and LMF lock member(s)         LP  Copy, LMF lock, and print
P  LMF Promote data set or member(s)   PP  LMF Promote and print

Specify "From" Data Set below, then press Enter key

From ISPF Library:
Project . . .    TENVT                 (--- Options C, CP, L, and LP only ---)
Group . . . .    TMECA
Type . . . .     JCL
Member . . .     AXAIRQ                (Blank or pattern for member list,
                                        "*" for all members)

From Other Partitioned or Sequential Data Set:
Data Set Name . . .
Volume Serial . . .                    (If not cataloged)

Data Set Password . .                  (If password protected)
```

Figure 1. Copy Screen

The next screen is similar to the first but requests the name of the file to which you are copying. Enter the dataset name that you were assigned (Typically of the form A1234.edit.data) followed by the member name. If the member name is left blank, the previous member name will be used again. If the copy is successful, the upper right hand of the screen will note 'MEMBER AXAIRQ COPIED.' Repeat the same procedure to copy the input file. The user's copy can be duplicated within the user's own dataset in the same manner as discussed above. To conserve space, keep only one copy of the JCL.

The user can ensure use of the most current version of the AXAIRQ JCL, by editing the file TENVT.TMECA.JCL(AXAIRQ) using menu option 2, making necessary modifications, (shown below) and submitting the job. Then type 'CAN' to cancel without making changes (if the user tries to exit without canceling a security message will appear on the screen). This will ensure the user is executing the most current version of the program.

Before AXAIRQ is executed, user-specific information must be entered. In the JCL file (previously called TENVT.TMECA.JCL(AXAIRQ)) the top three lines should be modified. When the JCL is copied it will appear as follows:

```
//AAAAAAAA JOB (BBBBBBBB,CCC,DDDD)'
//              'AXAIRQ   ', TIME=10
// MSGLEVEL=(1,1),MSGCLASS=2,NOTIFY=CCCC
```

The following substitutions should be made:

AAAAAAAA Called "jobname". Identifier for receiving output-shown on the front page of the output. Typically initials followed by the four numerals of computer identification number followed by '#.' Example - abc1234#.

BBBBBBBBB Valid activity code. If this code is not valid the program will terminate with an error. Example - ABCDEF123.

CCCCC Computer identification number used for logging onto mainframe. Example - A1234.

DDDD Box number where printout is delivered. Example - L010. In most areas the printouts are mailed, therefore the box number is irrelevant. If the user specifies 'HOLD' for the box number, the printout can be picked up at the printing destination. (703–A for A Area users)

MSGCLASS= T - Sends output to the terminal. This option is recommended, and then after the user has examined the output, the command 'R' from the outlist menu is used to requeue the output to the printer.
2 - Sends output to the printer. NOTE: The user will be unable to view the output on the terminal if this option is selected.

The user must also modify the last line of the JCL to reflect the name of the data file to be executed. When the JCL is copied, the last line will appear as shown below:

```
//   DSN=TENVT.EDG.######(MEMBER)
```

The user should change this to reflect the name of the input file intended for execution. This is the file previously named TENVT.DATA.TMECA(AXAIRDQ) An example is shown below:

```
//   DSN=A1234.EDIT.DATA(AXAIRDQ)
```

Once these changes are made within the AXAIRQ JCL, the user can submit the job by typing 'SUB' at the command line.

3.0 AXAIRQ INPUT

Next, input parameters are discussed with their validity ranges and default values noted. Hard blanks have been inserted in the input template so the user is unable to enter values in the wrong place. First the input statement is shown as it appears in the input file and then a complete explanation will follow.

TITLE

```
BEGIN TITLE HERE          <== 40& TITLE LINE 1
2ND LINE HERE             <== 40& TITLE LINE 2
```

This input statement allows the user to label the specific run in any manner. All information entered to the left of the '<' on either line is included. The title is echoed in the title box on the first page of the generated output. Identifiers that are helpful include: release area, type of release, date, type of accident, etc.

RELEASE LOCATION

```
<== 6.0&      SRS-GRID EASTING COORDINATE (FT)
<== 6.0&      SRS-GRID EASTING COORDINATE (FT)
<== 1&        OR SRS TOWER LOCATION (A,C,D,F,H,K,L, OR P)
```

The user is to right justify all inputs to the '<' character. The user is required to input either the exact location of the release using the first two statements or the tower location using the third statement. If the user chooses to input the grid location, site coordinates must be used as displayed on the Savannah River Site map. If the user chooses to input the tower location, the release location will be that of the meteorological tower for the area specified. See Table 1 for the site coordinates of the eight onsite towers available for use. The user should enter the coordinates of the release since it is unlikely that the release occurs at the meteorological tower. If the user enters coordinates that are not within the bounds of SRS, the code will terminate with an error. If the user enters both the coordinates and a tower location, the coordinates will be used.

The coordinates shown in Table 1 have been updated for F and H Area and the L Area meteorological database has been added. Since the code selects the tower that is closest for calculational purposes, there is a possibility that a different frequency distribution may be chosen for the same calculation that was performed before. L Area meteorology only exists for the 1987-1991 time period. If the user selects an L Area release and the old database, K Area meteorology from 1982-1986 will be accessed.

Table 1. Meteorological Tower Coordinates

Met Tower Location	East Coordinate	North Coordinate
A	50950	107586
C	47902	66163
D	21329	67168
F	50789	76773
H	66772	68834
K	41286	51712
P	66334	41458
L	53199	46650

RELEASE TYPE

<== 1&	FROM BUILDING VENT (0) OR STACK (1)?
	VENT RELEASE
<== 5.0&	MINIMUM VERTICAL CROSS-SECTION OF ADJACENT SOLID STRUCTURE (VALID RANGE: 0 TO 10000 SQ M)?
	STACK RELEASE
<== 3.0%	HEIGHT OF STACK ABOVE GRADE (VALID RANGE: 0 TO 100M)
<== 3.0&	GRADE ELEVATION IF KNOWN (NORMALLY BLANK) (VALID RANGE: 0 TO 500 FT MSL)

The user first selects the type of release: vent or stack. For a ground level release the option selected should be the vent release as directed in NRC 1.145. Vent release should be selected for release points that are lower than two-and-a-half times the height of adjacent solid structures as specified by USNRC 1.145. This selection is made basically to invoke the correct determination of the relative air concentration. If the user selects the vent release option, the minimum vertical cross-section of the nearest adjacent structure must be entered. If the user selects the stack release option, the two lines under the STACK RELEASE title must be completed (height and grade elevation).

For a vent release, the vertical cross-section of an adjacent solid structure is input if the user has this information. This specifies the size of the building to account for building wake effects. If the user leaves this blank the default is 0 m^2. If the stack option is chosen, the user specifies the height of the stack, in meters, and the elevation. Since this input effects the effective release height, do not enter the elevation unless it is explicitly known. If the user enters a stack height out of the valid range, the default is 62 m. If the user enters nothing, a value of 0 m is assumed.

METEOROLOGICAL PARAMETERS

```
<== 2&          SINGLE SECTOR ANALYSIS OR ALL SECTORS?
                0 FOR ALL; 1 FOR S; 2 FOR SSW; ...; 16 FOR SSE.
```

The user first specifies the sector of interest. A '0' is input if all sectors are considered or a number is entered to specify analysis on a given sector. (See Figure 2 for sector designation.) For calculations in support of USNRC 1.145, the user should select all sectors. Worst-case dose is determined by the code calculating the 99.5% dose for each of the sixteen sectors and then selecting the highest of these. The 95% and 50% doses are always determined on a sector independent basis. If the user selects a specific sector, the 99.5% dose is reported for that sector only and the 95% or 50% dose will be determined using the meteorological data only from that particular sector. If the user enters nothing, all sectors will be considered.

```
<== 3&          METEOROLOGICAL DATA LIBRARY (OLD/NEW)
                OLD - 1982-1986 METEOROLOGICAL DATA
                NEW - 1987-1991 METEOROLOGICAL DATA
```

The user can specify the current or previous site-specific meteorological data file. The new file should be used for all new calculations while the old file is generally used only for duplication of previous runs. The default is the new meteorological data file (Weber, 1992).

DOSIMETRIC PARAMETERS

```
<== 4&  CALENDAR YEAR OF POSTULATED RELEASE
                (VALID RANGE: 1980 to 2020)
```

The user selects the calendar year of the postulated release strictly for the purpose of estimating the population doses. If a value is entered that is not in the valid range, '1990' is the default. A function is contained within the code that estimates the population for the year specified based on the population count from the 1990 census and a growth rate of 14% per decade.

```
<== 1&  GAMMA SHINE METHODOLOGY (0/1/2)
        0 - UPPER-BOUND APPROX. OF NONUNIFORM PLUME MODEL
        1 - NONUNIFORM PLUME MODEL(MAY NEED TO ADD CPU TIME)
        2 - UNIFORM PLUME MODEL
```

The user selects the type of gamma shine methodology based on the above three options. The suggested option is the upper-bound approximation of the nonuniform plume model, which is also the default.

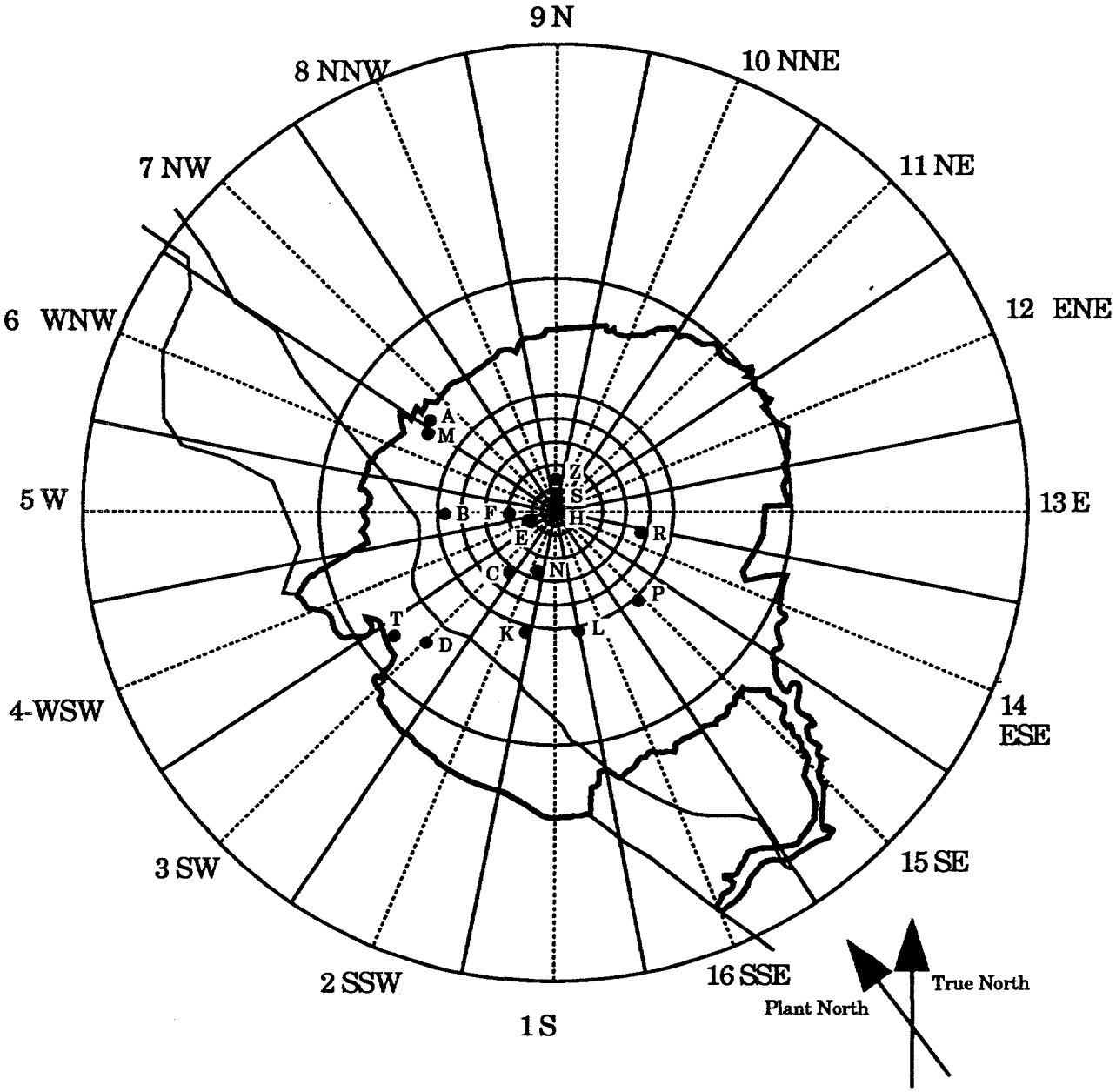

Figure 2. SRS Map

```
<== 4& DO YOU WANT FULL DAUGHTER INGROWTH (YES/NO)?
       ANSWERING 'NO' WILL LIMIT INGROWTH ONLY TO THOSE PARENTS WITH HALF-LIVES
       LESS THAN 24 HOURS. CAUTION MUST BE USED IF ANSWERING 'YES'; DAUGHTER
       NUCLIDES OF SOME PARENTS MAY NOT BE IN DF LIBRARY!
```

Daughter ingrowth is limited based on the user's selection. Typically specifying 'NO' will result in a quicker calculation for some cases with minimal error involved because generally the daughter contributes an insignificant amount in proportion to the parent for longer-lived isotopes. For instance, CEDE from Pm-141 (Half life = 28.4 hr) is on the order of 10^{-3} whereas the CEDE from the daughter, Sm-151, is on the order of 10^{-8}. This comparison is given only as an example and is not indicative of all parent/daughter dose combinations. If the daughter is not in the library, no notice is given to the user. The default is 'NO.'

```
2<== {4} INCLUDE 95% (1),OR 50% (2) (0/1/2)
       0 - 99.5% ONLY (ALWAYS CALCULATED)
```

The user selects whether the 50% or 95% sector-independent doses are to be calculated. Reminder - this dose is determined by ranking all the doses in a sector-independent manner for each of the stability and wind speed combinations. Even though the 50% dose is often referred to as the average dose, it is actually a median dose. The section of this report discussing AXAIRQ's output will give more detail on how the doses are determined. The default calculates only the 99.5% dose. The worst case worst sector 99.5% dose is calculated with all options.

```
YES<== {3} DO YOU WANT TO INCLUDE DEPOSITION (YES/NO)?
       IF NO MUST ANSWER NEXT QUESTION
       IF YES PASQUILL-BRIGGS COEFFICIENT WILL BE USED
```

Next the user selects whether deposition will be allowed to occur. When the user selects deposition, plume depletion is automatically assumed and the ground shine dose pathway is calculated. The default is 'NO'. If the user enters anything other than 'YES', then "NO' is assumed.

```
2<== {1} DIFFUSION COEFFICIENTS (1) PASQUILL-BRIGGS
       (2) PASQUILL GIFFORD (OLD)
```

The user selects the type of diffusion coefficients that will be used. Pasquill-Gifford diffusion coefficients were originally in AXAIR89Q. Pasquill-Briggs coefficients have been added since they are more appropriate for SRS (Simpkins 1994). Another reason for the addition of Pasquill-Briggs coefficients is for comparison with emergency response codes which apply these types of coefficients. The default is Pasquill-Gifford.

```
200<== {4} MIXING HEIGHT (M)
       (VALID RANGE: 200 TO 1000)
```

The user enters the expected mixing height at the time of the release. Valid range is 200 to 1000m. The input should be an integer value. For conservative calculations 200 m should be used. Refer to Garrett (1981) for a complete discussion of a study performed on local mixing heights.

```
<== 2&  DOSE FACTOR LIBRARY (2/30)
                2 - ICRP 2
                30 - ICRP 30
```

The user selects which dose factor library to use for the dose calculations. ICRP 30 is recommended. CAUTION - The ICRP2 methodology is outdated. If the user selects ICRP 2, the data for this library has not been verified. This library was included for comparison and duplication of previous calculations. If the user enters nothing, ICRP 30 values will be used. If ICRP2 is selected, and the user selects the deposition option ground shine doses will be zero since the ICRP2 dose factor file was not updated to include the ground shine dose factors.

```
<== 2&  NUMBER OF USER DISTANCES FOR M.I. DOSE CALCULATION:
                (VALID RANGE:  -4 TO 4)
                NEGATIVE - DEFAULT, BOUNDARY AND USER DISTANCES
                   (DEFAULT DIST: 0.5,1, 2, 3, 4, AND 5 MILES)
                ZERO - ONLY BOUNDARY DISTANCE
                POSITIVE - USER AND BOUNDARY DISTANCES

<== 5.2&        (1) MILES FROM SOURCE (VALID RANGE: 0.06 TO 50 MI)
<== 5.2&        (2) MILES FROM SOURCE
<== 5.2&        (3) MILES FROM SOURCE
<== 5.2&        (4) MILES FROM SOURCE
```

The user selects the downwind distances at which doses will be calculated. The dose at the boundary is always calculated. A positive number allows the user to select up to four distances at which the doses are determined. A negative number allows the user to specify up to four selected distances and also have the code determine the doses at the default distances (0.5, 1, 2, 3, 4, and 5 miles). An input of zero results in the calculation of a dose at the site boundary only. If a non-zero number is specified, then the user must enter receptor distances. The valid range is 0.06 mi to 50 mi. If the user enters a value that is less than 0.06 miles or greater than 50 miles, the range end-point values will be used.

For example, if '2' were input then two user distances must be entered. The doses would be calculated at these distances and also at the site boundary. If the user were to enter '-2', then two user distances must be entered and the doses would be determined at those two distances, the site boundary, and the default distances. If the user enters nothing the dose will be determined at the boundary only.

PRINTOUT TYPE

```
<== 4&  (NORM/SUMM/BOTH)
        NORM - NORMAL PRINTOUT ONLY
        SUMM - SUMM PRINTOUT ONLY
        BOTH - BOTH NORMAL & SUMMARY
```

The user selects the type of display for the output. Specifying 'NORM' will printout all of the results that AXAIRQ produces. The summary option will print out several dose summary tables. Selecting 'BOTH' will allow the user to have access to both the normal and summary printout. The summary printout is very useful as a quick way to locate the doses; however, if any details are needed concerning specific isotopes, the normal printout should be specified. The default printout type is normal.

TABLE OF RELEASES OF RADIOACTIVITY

		1ST PERIOD		2ND PERIOD		3RD PERIOD		4TH PERIOD		5TH
NUCLIDE	I I S I	CURIES	HOURS	CURIES	HOURS	CURIES	HOURS	CURIES	HOURS	....
H-3	T F	0.00E-00	2	0.00E-00	2	0.00E-00	2	0.00E-0.00	2	

In the AXAIRQ input template, all of the nuclides are listed and the user enters the activity released and the release duration. The minimum time period of release is two hours and the maximum is 8760 hrs. If the user enters values outside of this range, the range end-point values are used. Each of the five different release periods start at the same time, therefore, no account for decay up to the release time is taken. In other words, the release periods are not consecutive; they are simultaneous. The T or F that are displayed after the isotope denote whether inhalation and plume shine factors, respectively, are available for that nuclide. Ground shine dose factors exist for all of the nuclides listed (some are zero). The user may select up to 100 isotopes for a given run. The user may also choose to delete those nuclides which are not being considered making input verification easier. Deleting the other nuclides is not necessary for proper code execution.

4.0 AXAIRQ OUTPUT

Sample portions of the output are displayed and information from these portions are discussed. If the user wishes to study this sample run in detail, a hard copy can be generated using the input parameters shown in Table 2. Approximately the first 20 pages of the output are JCL related and are not discussed.

INPUT ECHOED

The input template is echoed as entered by the user, except for the isotope information, which is summarized later. See Figure 3 as an example. The next page of output (not reproduced here) summarizes the run in a more narrative form. At the top, the version number of AXAIRQ is displayed followed by a summary of the input and source term.

METEOROLOGICAL JOINT FREQUENCY

The meteorological joint frequency distribution is shown next. See Figure 4 for an example. This table provides the frequencies as a function of wind speed, stability, and sector (Weber, 1992). If the user enters the coordinates of the release, the data from the closest meteorological tower will be used. The chosen area is shown in the title block of the distribution. Also in the title block is the total number of records or total hours of observed data used to compile the joint frequency distribution. Since the wind speeds and stability classes are based on one hour averages and the frequency distribution is taken over five years, the total number of possible readings is:

(5 yrs* 365 dys/yr * 24 hrs/day) + 24 hrs(leap year)= 43824 hrs.

This number does not always agree with the total number of records within meteorological data file because criteria are used to determine the validity of the data and certain data are discarded based on this criteria. See Laurinat (1987) for details on how this determination is made.

The frequency distribution is determined by taking the number of times that the wind speed and stability class combination occurred for a particular sector divided by the total number of data. This number is then multiplied by 100; therefore, the numbers in the table, when summed, total 100. Referring back to Figure 2 the sectors are shown centered on the dotted lines for the hypothetical release centered on H Area.

TERRAIN HEIGHTS

The next table shows the maximum terrain heights by sector and downwind distance from the source. See Figure 5 for an example. These values are used to adjust the plume heights at the receptor locations. The effective release height (plume height) is determined by taking the actual release height and subtracting the terrain height at the receptor location. Interpolation is performed for intermediate distances to determined the appropriate terrain height for the specified downwind distance. Note that the *maximum* terrain height to that point is displayed for each downwind distance, therefore the numbers are always increasing, or staying the same, as a function of downwind distance.

Table 2. Input for Sample Run

Release Location	East 58000 ft North 62000 ft
Vent or Stack	1 (Stack)
Stack Height	62
Single sector or all sectors	0 (All Sectors)
Meteorological Data (old or new)	NEW
Calendar Year of Release	1995
Gamma Shine Methodology (0,1,2)	0
Full Daughter Ingrowth	YES
Dose- 50%(1),95%(2), only 99.5%(0)	2
Deposition	YES
Diffusion Coefficients	1 (PB)
Mixing Height	1000
Dose Factor Library	30
Number of user distances	2(0.06 and 0.4 miles)
Printout Type	BOTH
Release	1.0 Ci I-131, 2 hr

Figure 3. Input Echoed

```
BEGIN TITLE HERE  AXAIR89Q TEST CASE 1  <==(40) TITLE LINE 1
2ND LINE HERE     AXAIRQ   VERIFICATION <==(40) TITLE LINE 2
```

```
                    RELEASE LOCATION

[[[[ 58000<==(6.0) SRS-GRID EASTING COORDINATE (FT)
[[[[ 62000<==(6.0) SRS-GRID NORTHING COORDINATE (FT)
[[[[[[[[[ <== (1)  OR SRS TOWER LOCATION (A,C,D,F,H,K,L, OR P)
```

```
                    RELEASE TYPE

[[[[[[[[[0<== (1)  FROM BUILDING VENT (0) OR STACK (1)?

                    VENT RELEASE

[[[[[      <==(5.0) MINIMUM VERTICAL CROSS-SECTION OF ADJACENT
                    SOLID STRUCTURE (VALID RANGE: 0 TO 10000 SQ.M)?

                    STACK RELEASE

[[[[[[[    <==(3.0) HEIGHT OF STACK ABOVE GRADE
                    (VALID RANGE: 0 TO 100 M)
[[[[[[[    <==(3.0) GRADE ELEVATION IF KNOWN (NORMALLY BLANK)
                    (VALID RANGE: 0 TO 500 FT MSL)
```

```
                    METEOROLOGICAL PARAMETERS

[[[[[[[[ 0<== (2)  SINGLE SECTOR ANALYSIS OR ALL SECTORS?
                    0 FOR ALL; 1 FOR S; 2 FOR SSW; ... ; 16 FOR SSE.

[[[[[[[NEW<== (3)  METEOROLOGICAL DATA LIBRARY (OLD/NEW)
                    OLD - 1982-1986 METEOROLOGICAL DATA
                    NEW - 1987-1991 METEOROLOGICAL DATA
```

```
                    DOSIMETRIC PARAMETERS

[[[[[[1995<== (4)  CALENDAR YEAR OF POSTULATED RELEASE
                    (VALID RANGE: 1980 TO 2020)

[[[[[[[[[0<== (1)  GAMMA-SHINE DOSE METHODOLOGY (0/1/2)
                    0 - UPPER-BOUND APPROX. OF NONUNIFORM PLUME MODEL
                    1 - NONUNIFORM PLUME MODEL (MAY NEED TO ADD CPU TIME)
                    2 - UNIFORM PLUME MODEL


[[[[[[[YES<== (3)  DO YOU WANT FULL DAUGHTER INGROWTH (YES/NO)?
                    ANSWERING 'NO' WILL LIMIT INGROWTH ONLY TO THOSE
                    PARENTS WITH HALF-LIVES LESS THAN 24 HOURS.
                    CAUTION MUST BE USED IF ANSWERING 'YES'; DAUGHTER
                    NUCLIDES OF SOME PARENTS MAY NOT BE IN DF LIBRARY!

[[[[[[   2<== (4)  INCLUDE 95% (1),OR 50% (2) (0/1/2)
                    0 - 99.5% ONLY (ALWAYS CALCULATED)
```

Figure 3. Input Echoed cont.

```
[[[[[[[YES<== (3)  DO YOU WANT TO INCLUDE DEPOSITION (YES/NO)?
                   IF NO MUST ANSWER NEXT QUESTION
                   IF YES PASQUILL-BRIGGS COEFFICIENT WILL BE USED


[[[[[[   1<== (1)  DISPERSION COEFFICIENTS (1) PASQUILL-BRIGGS
                   (2) PASQUILL GIFFORD (OLD)

[[[[[[1000<== (4)  MIXING HEIGHT (M)
                   (VALID RANGE: 200 TO 1000)

[[[[[[[[30<== (2)  DOSE FACTOR LIBRARY (2/30)
                    2 - ICRP 2
                   30 - ICRP 30


[[[[[[[[ 2<== (2)  NUMBER OF USER DISTANCES FOR M.I. DOSE CALCULATION:
                   (VALID RANGE: -4 TO 4)
                   NEGATIVE - DEFAULT, BOUNDARY AND USER DISTANCES
                     (DEFAULT DIST: 0.5, 1, 2, 3, 4, AND 5 MILES)
                   ZERO - ONLY BOUNDARY DISTANCE
                   POSITIVE - USER AND BOUNDARY DISTANCES

[[[[[ 0.06<==(5.2) (1) MILES FROM SOURCE (VALID RANGE: 0.06 TO 50 MI)
[[[[[  0.4<==(5.2) (2) MILES FROM SOURCE
```

********** METEOROLOGICAL JOINT FREQUENCY DISTRIBUTION *********
* WIND STATS H-AREA 60MIN 62M 87-91 STABILITY FROM SIGMA A *
*   (PERCENT OF TOTAL TIME)   *
*   TOTAL NO. OF RECORDS OF 60-MIN MET DATA= 43824   *
*   (SECTOR 1=S, 2=SSW, ..., 16=SSE)   *

SECTOR NO.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
WIND SPEED(M/SEC) ----- PG STABILITY CLASS A -----																
1 (0-2)	0.37	0.41	0.37	0.42	0.40	0.37	0.40	0.36	0.36	0.35	0.45	0.39	0.45	0.43	0.37	0.41
2 (2-4)	0.87	0.73	0.88	0.99	0.94	0.94	0.65	0.62	0.74	0.72	1.00	1.28	1.29	0.94	0.53	0.60
3 (4-6)	0.57	0.26	0.16	0.19	0.15	0.07	0.07	0.09	0.14	0.14	0.21	0.24	0.27	0.24	0.14	0.24
4 (6-8)	0.09	0.05	0.01	0.01	0.01	0.00	0.00	0.01	0.02	0.02	0.02	0.04	0.03	0.02	0.01	0.05
5 (8-12)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.00	0.01	0.00	0.01
6 (> 12)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
WIND SPEED(M/SEC) ----- PG STABILITY CLASS B -----																
1 (0-2)	0.08	0.08	0.09	0.10	0.05	0.05	0.06	0.05	0.08	0.07	0.05	0.05	0.05	0.08	0.05	0.07
2 (2-4)	0.27	0.41	0.58	0.62	0.43	0.34	0.24	0.22	0.32	0.33	0.48	0.67	0.56	0.37	0.25	0.21
3 (4-6)	0.14	0.39	0.38	0.31	0.16	0.10	0.07	0.08	0.19	0.21	0.32	0.51	0.51	0.36	0.13	0.09
4 (6-8)	0.01	0.08	0.03	0.01	0.00	0.01	0.00	0.01	0.05	0.04	0.05	0.10	0.17	0.21	0.06	0.01
5 (8-12)	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.06	0.06	0.01	0.00
6 (> 12)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
WIND SPEED(M/SEC) ----- PG STABILITY CLASS C -----																
1 (0-2)	0.03	0.06	0.09	0.07	0.06	0.05	0.05	0.05	0.07	0.05	0.05	0.05	0.08	0.05	0.05	0.05
2 (2-4)	0.17	0.57	1.12	1.03	0.60	0.41	0.41	0.37	0.48	0.52	0.59	0.79	0.53	0.44	0.30	0.24
3 (4-6)	0.12	0.54	1.30	0.74	0.35	0.19	0.22	0.25	0.47	0.46	0.56	0.69	0.64	0.56	0.21	0.12
4 (6-8)	0.01	0.10	0.20	0.08	0.02	0.03	0.03	0.06	0.16	0.16	0.21	0.26	0.44	0.43	0.10	0.02
5 (8-12)	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.03	0.04	0.04	0.05	0.06	0.16	0.17	0.02	0.01
6 (> 12)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
WIND SPEED(M/SEC) ----- PG STABILITY CLASS D -----																
1 (0-2)	0.02	0.05	0.05	0.04	0.05	0.03	0.05	0.07	0.05	0.03	0.07	0.05	0.04	0.03	0.05	0.04
2 (2-4)	0.10	0.44	1.07	0.89	0.55	0.50	0.71	0.69	0.92	0.91	0.80	0.81	0.72	0.57	0.43	0.27
3 (4-6)	0.12	0.43	0.85	0.58	0.39	0.44	0.65	1.16	1.45	0.78	0.90	0.77	0.78	0.65	0.32	0.09
4 (6-8)	0.01	0.05	0.10	0.02	0.00	0.01	0.05	0.18	0.22	0.15	0.10	0.09	0.03	0.05	0.03	0.00
5 (8-12)	0.00	0.02	0.02	0.00	0.00	0.00	0.00	0.01	0.02	0.04	0.00	0.00	0.01	0.00	0.00	0.00
6 (> 12)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
WIND SPEED(M/SEC) ----- PG STABILITY CLASS E -----																
1 (0-2)	0.01	0.02	0.04	0.01	0.01	0.03	0.03	0.03	0.02	0.02	0.01	0.01	0.02	0.01	0.02	0.02
2 (2-4)	0.06	0.27	0.69	0.48	0.30	0.33	0.46	0.70	0.67	0.57	0.54	0.47	0.43	0.43	0.33	0.30
3 (4-6)	0.07	0.53	0.69	0.71	0.60	0.45	0.65	1.01	1.18	0.94	0.91	0.89	0.48	0.40	0.19	0.14
4 (6-8)	0.00	0.05	0.03	0.04	0.01	0.01	0.00	0.03	0.04	0.02	0.04	0.01	0.00	0.00	0.00	0.00
5 (8-12)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6 (> 12)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
WIND SPEED(M/SEC) ----- PG STABILITY CLASS F -----																

Figure 4. Meteorological Distribution

Figure 5. Terrain Heights for H Area Release

TABLE OF MAXIMUM RELATIVE TERRAIN HEIGHTS OUT TO LISTED DISTANCES BY COMPASS SECTOR, FEET ABOVE GRADE ELEVATION
(WITH RESPECT TO GRADE ELEVATION = 299 FT. ABOVE MEAN-SEA-LEVEL AT BASE OF STACK)

	MILES	S	SSW	SW	WSW	W	WNW	NW	NNW	N	NNE	NE	ENE	E	ESE	SE	SSE
0	1.0	1	1	1	1	1	1	1	1	1	1	1	1	12	12	1	1
0	2.0	1	1	1	1	1	1	1	1	1	1	2	41	41	37	2	1
0	3.0	1	1	1	1	1	1	1	1	1	1	2	41	41	37	22	1
0	4.0	1	1	1	1	1	1	1	1	1	1	2	41	41	37	22	1
0	5.0	1	1	1	1	1	1	1	1	1	1	2	41	41	37	22	21
0	6.0	1	1	1	1	1	1	1	37	1	1	2	41	41	37	22	21
0	7.0	1	1	1	1	1	51	51	71	16	13	5	41	41	37	22	21
0	8.0	1	1	1	1	1	51	93	92	30	20	14	41	41	37	22	21
0	9.0	1	1	1	1	1	51	101	101	52	22	24	41	41	37	31	21
0	10.0	1	1	1	1	1	51	101	137	52	47	31	41	41	37	31	21
0	12.0	1	1	1	1	1	51	111	161	122	101	55	41	41	37	31	21
0	14.0	1	1	1	1	1	51	111	161	151	111	101	41	41	37	31	21
0	16.0	1	1	1	1	1	51	111	190	155	116	101	48	41	37	31	21
0	18.0	1	1	1	1	1	51	131	201	165	144	101	50	41	37	31	21
0	20.0	1	1	1	11	12	51	161	231	208	144	101	50	41	37	31	21
0	25.0	1	1	35	51	91	101	168	241	221	160	101	50	41	37	31	21
0	30.0	1	41	71	51	161	142	251	261	261	201	116	50	41	37	31	21
0	35.0	1	51	71	111	201	241	261	336	295	231	170	51	41	37	31	21
0	40.0	1	51	101	141	221	241	261	371	345	231	170	51	41	37	31	21
0	45.0	1	51	101	141	221	241	261	371	361	301	201	51	41	37	31	21
0	50.0	1	51	101	141	231	301	261	371	381	351	225	75	41	37	31	21

POPULATION DISTRIBUTION

The population distribution used for both offsite and onsite calculations is displayed in tabular form for radial annuli in each of the sectors. The annuli are centered on the location of interest. A total is also shown for each annuli at the bottom of each table.

The onsite population is determined from an input file based on the report by East (1993). The offsite population is based on 1990 census data and adjusted for the year of the release.

RELATIVE AIR CONCENTRATION

The two-hour 99.5% and average-annual relative air concentrations are displayed as a function of downwind distance for each of the sectors. See Table 3 as an example.

The boundary distances are shown in each of the relative air concentration tables. These values are determined by taking the minimum distance to the boundary for a 45 degree sector, centered on the sector of interest, as specified in USNRC 1.145. Refer back to Figure 2 which shows the radial rings at 1, 2, 3, 4, 5, 10 and 20 miles. As an example look at the WSW, sector 4. Within the WSW sector, the distances appear to be greater than 10 miles or 16 km. However, looking at Table 3 the boundary distance is reported as 13.28 km for the WSW sector. Looking at the 45 degree sector centered on the WSW sector includes distances to the boundary that are less than 16 km, resulting in the listed 13 km boundary distance. This definitely adds conservatism when estimating the maximum dose to the offsite individual.

The downwind distances are calculated according to USNRC 1.145. For this case where the dose was determined at the site boundary, following USNRC 1.145, "for stack releases, χ/Q calculations should be made in each sector at each minimum boundary distance and at various distances beyond the exclusion area boundary distance to determine the maximum relative concentration." For this reason, the boundary distance and the downwind distance could be different. AXAIRQ determines the χ/Q's at 0.5 km increments beyond the minimum boundary distance to determine the maximum χ/Q.

The maximum two-hour relative air concentration is displayed at the bottom of each table. The number reflects the maximum of the 99.5% χ/Q from all of the sectors. This table is generated for each of the user-selected distances and the site boundary.

Table 3. Relative Air Concentrations

SECTOR MAXIMUM OFFSITE TWO-HOUR 99.5 PERCENTILE X/Q AND AVERAGE-ANNUAL X/Q, SEC/CU.METER * 0

SECTOR	99.5 PERCENTILE	AVG.-ANN. X/Q	DOWNWIND DISTANCE (KM)	BOUNDARY DISTANCE (KM)
S	3.300E-07	5.157E-09	14.49	14.49
SSW	7.081E-06	1.605E-08	16.18	16.18
SW	9.642E-06	3.239E-08	13.10	13.10
WSW	6.968E-06	2.451E-08	13.10	13.10
W	5.061E-06	1.783E-08	13.23	13.23
WNW	7.490E-06	2.016E-08	13.37	13.37
NW	7.810E-06	2.113E-08	14.42	14.42
NNW	8.992E-06	2.759E-08	14.42	14.42
N	8.195E-06	3.045E-08	14.95	14.95
NNE	8.971E-06	2.570E-08	15.86	15.86
NE	7.748E-06	2.524E-08	16.32	16.32
ENE	9.172E-06	3.039E-08	12.91	12.91
E	6.252E-06	2.273E-08	12.51	12.51
ESE	5.936E-06	1.963E-08	12.51	12.51
SE	4.731E-06	1.177E-08	14.51	14.51
SSE	4.669E-06	1.047E-08	14.49	14.49

| HIGHEST TWO-HOUR VALUE IS 9.642E-06 IN SW SECTOR |

* TWO-HOUR X/Q THAT IS EXCEEDED ONLY 0.5 PERCENT OF THE TOTAL TIME BASED ON METEOROLOGICAL WORST-CASE PROBABILITY ANALYSIS.

95 PERCENTILE OVERALL TWO-HOUR X/Q AT THE SITE BOUNDARY = 5.489E-06

Table 4 shows a sample ranking of relative air concentrations that would be used to determine the 99.5% value. The first column shows the concentrations ranked started with the highest and then decreasing. The second column shows the corresponding joint frequency associated with that particular combination of stability class and wind speed that resulted in the relative air concentration shown in column one. The third column is the cumulative frequency. When the cumulative frequency is greater than 0.5, an interpolation is performed between the two values bracketing 0.5 to determine the 99.5% relative air concentration. These interpolation values are marked with "*" in the table.

Table 4. Sample Ranking of Relative Air Concentration

	Relative Air Concentration s/m^3	Joint Frequency Distribution	Cumulative Frequency (%)	Stability Class	Wind Speed	
	7.97E-04	0.018	0.018	4	1	
	7.79E-04	0.012	0.030	5	1	
	4.43E-04	0.061	0.091	5	2	
	4.05E-04	0.103	0.194	4	2	
	4.01E-04	0.032	0.226	3	1	
	2.68E-04	0.071	0.297	5	6	
	2.65E-04	0.123	0.420	4	6	
*	2.32E-04	0.018	0.438	6	2	*
*	2.27E-04	0.174	0.612	3	2	*
	2.16E-04	0.075	0.687	2	1	
	1.98E-04	0.011	0.698	4	4	
	1.79E-04	0.374	1.072	1	1	
	1.46E-04	0.003	1.075	7	2	

After the table that displays the boundary relative air concentrations, the 95% overall two-hour χ/Q at the site boundary is displayed. This number is shown as a check to see if the overall 95% χ/Q exceeds the two-hour sector-specific χ/Q as discussed in USNRC 1.145. If the overall 95% χ/Q does indeed exceed the 99.5% χ/Q, the 95% doses should be used.

The next table displays the sector two-hour centerline, two-hour arc and average-annual χ/Qs at fixed distances from the release location. These values are shown for information only and the arc χ/Qs are used to determine the population doses.

DOSES AT USER-SPECIFIED DISTANCES

The 50-yr committed doses are reported broken down by organ, pathway, and nuclide as shown in Figure 6. Above each table the worst sector is listed and the stability and wind speed combinations that were used to determine the 99.5% doses are shown. The 99.5% dose is determined in the same manner as the 99.5% relative air concentration. See Tables 5 and 6 for stability and wind speed category guide, respectively.

Figure 6. Sample Dose Output

```
1       WORST-SECTOR, WORST-CASE DOSES TO THE   ADULT  OFFSITE INDIVIDUAL, MILLIREM
            8.10 MILES (   13.1 km) FROM THE SOURCE
0 WORST-SECTOR IS WSW SECTOR
 WORST-CASE EFFECTIVE DOSE EQUIVALENT EXCEEDED 0.5 PERCENT OF TOTAL TIME IS  3.81E-02
 INTERPOLATION WAS BETWEEN STABILITY-WINDSPEED CLASSES 6-2 AND 5-3 IN THE WSW SECTOR
0DOSE BREAKDOWN BY PATHWAY, BODY ORGAN AND NUCLIDE --
0                     INHALATION                                    PLUME SHINE GROUND SHINE
+    ____________________________________________________________ ___________ ___________

NUCLIDE EFF.D.E. GI-LLI  RED MAR.  LIVER  B. SURF.  THYROID  LUNG   EFF.D.E.    EFF.D.E.
 ------+--------+-------+--------+-------+--------+--------+------+----------+----------+
I-131  |2.90E-02|0.00E+00|0.00E+00|0.00E+00|0.00E+00|9.97E-01|0.00E+00|1.38E-04|8.92E-03|
       | 100.00%| 0.00%  | 0.00%  | 0.00%  | 0.00%  |100.00% | 0.00%  |100.00% |100.00% |
 ------+--------+--------+--------+--------+--------+--------+--------+--------+--------+
XE-131M|0.00E+00|0.00E+00|0.00E+00|0.00E+00|0.00E+00|0.00E+00|0.00E+00|2.55E-09|0.00E+00|
       | 0.00%  | 0.00%  | 0.00%  | 0.00%  | 0.00%  | 0.00%  | 0.00%  | 0.00%  | 0.00%  |
 ------+--------+--------+--------+--------+--------+--------+--------+--------+--------+
*TOTAL*|2.90E-02|0.00E+00|0.00E+00|0.00E+00|0.00E+00|9.97E-01|0.00E+00|1.38E-04|8.92E-03|
 ------+--------+--------+--------+--------+--------+--------+--------+--------+--------+
```

For each nuclide, the first table shows the inhalation organ doses separately from the plume shine and ground shine doses. The organ doses are included as a holdover from the days when ICRP 2 was used and are only shown for convenience. Within the header the distance to the maximally exposed offsite individual has also been added.

The second table of dose output combines the results of cloud shine, ground shine, and inhalation into one table. The doses are listed for each isotope. Both of these tables are displayed for each nuclide and each distance.

Table 5. Stability Categories

Category	Pasquill Stability Class
1	A
2	B
3	C
4	D
5	E
6	F
7	G

Table 6. Wind Speed Categories

Category	Wind speed Range m/sec
1	0-2
2	2-4
3	4-6
4	6-8
5	8-12
6	>12

POPULATION DOSES

The 99.5% dose to a population within 50 miles of the release location is specified for the worst sector. The population dose is also displayed for the worst sector onsite using concentrations not exceeded 99.5% of the time. The worst sector 99.5% dose to population within 1 mile of the release location is specified next. This population dose shows the effects of the postulated accident on nearby workers (within 1 mile). All population doses are determined by using the sector-average relative air concentrations.

SUMMARY OUTPUT

If the user chooses the summary option from the input template, the input is echoed in sentence form and the output is summarized in two tables. The first table contains the results of the maximum individual offsite dose and the population doses. The second table displays the doses at user specified distance. Both tables also show which sector the worst dose occurred in and the organ dose which is the highest. Four tables will appear if the user also chooses the 95% or 50% doses. This is a convenient way for the user to get a quick view of the output. If any information is needed concerning wind speed and stability class combinations or doses from a specific isotope, the user must select the normal output.

5.0 COMMON USER ERRORS

Listed below are common errors that the user may find when executing AXAIRQ. After the job is complete a message will come across the screen. Towards the end of the first line will be the word, 'COND=', followed by a number or number-letter combination. This is called the condition code. If this number comes back '0000' the code has executed correctly. Other codes are representative of the type of error that has occurred during the execution of AXAIRQ. A few of the common errors are listed next.

1. COND = SD722

   This error occurs when the user's dataset has no more space left to allow the execution of the file.

   Solution: Under menu 3 item 1 choose 'C' to compress your dataset. The upper right-hand corner of the screen will state 'COMPRESS SUCCESSFUL' when the job is complete. Resubmit job.

2. COND=0010

   This error can occur when miscellaneous information has been printed as part of the printout and has no effect on the results.

3. COND=0016

   This error can occur when the user has not specified a release location or type of release. These are the only inputs that do not have a default.

   Solution: Specify release location and/or release type and resubmit.

4. COND=0048

   This error occurs when the site coordinates are out of the valid range.

   Solution: Specify release location and resubmit.

5 FAILED BY INTERPRETER

   This error occurs when the user has entered the wrong cost code or otherwise has an error in the JCL.

   Solution: In the top line of the JCL change the cost code to one that is currently valid and check the rest of the JCL for accuracy and resubmit job.

6.0 REFERENCES

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