UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

APR 9 1990

OFFICE OF
AIR AND RADIATION

MEMORANDUM

SUBJECT: COMPLY-R Computer Program for Determining Compliance with 40 CFR 61, Subpart B

FROM: Albert Colli, Environmental Engineer *Albert Colli*
Environmental Standards Branch

TO: Milton W. Lammering
Radiation Program Manager, Region 8

Enclosed is an updated version (1.2) of COMPLY-R and its user's guide to be used to determine compliance with 40 CFR Part 61, Subpart B. We have included a sufficient number of copies to distribute to owners or operators of underground uranium mines in your region to replace version 1.0 of COMPLY-R. The first version does not completely account for the in-growth of daughters from the point of release to the receptor. This has been revised in version 1.2.

In addition, the instructions for entering a stack distance file are unclear in the first version. We have modified version 1.2 of COMPLY-R and its user's guide to make the program and instructions as clear as possible.

Several changes have been made to the User's Guide for COMPLY-R. On page 3-6, line 11 of paragraph 3, the words "TO" and "FROM" have been reversed and the sample problem has changed slightly. Also, we have added "exit" before "diameter" on page 3-5, paragraph 2, line 1, because of comments pointing out that the vent diameter should be more properly taken at the exit of the vent. We have also updated the names and addresses of some of the regional program managers.

We have enclosed sufficient numbers of COMPLY-R and its user's guide for you to distribute to owners or operators of underground uranium mines in your region. The revised version of the User's Guide to COMPLY-R has been entered into the docket. Please call me at 475-9610 if you need any additional information.

cc: Terrence A. McLaughlin
Barbara Durso

EPA 520/1-89-029

USER'S GUIDE FOR THE COMPLY-R CODE

(Revision 1)

U.S. ENVIRONMENTAL PROTECTION AGENCY
Office of Radiation Programs
401 M Street, S.W.
Washington, DC 20460

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1.0 INTRODUCTION

The COMPLY-R computer program may be used to demonstrate compliance with the National Emission Standards for Hazardous Air Pollutants (NESHAPS) in 40 CFR 61, Subpart B. The program can be used by owner or operators of underground uranium mines to determine the dose to the maximally exposed individual from Radon-222 emissions.

At all levels, the program will determine whether you are in compliance or whether you exceed the standard. The program is designed to be easy to run and requires only minimum input. At the end, the program will create a report containing all the input values and the results of its calculations. This report, along with the supporting documentation described in EPA89, is all that you need to send to the EPA if you are required to report.

2.0 HOW TO SET UP YOUR SYSTEM

COMPLY requires an IBM PC or PC-compatible computer having at least 512 kilobytes of memory, at least one floppy disk drive and a printer. A hard disk makes the system easier to run. The operating system must be DOS.

The following instructions are written for the novice PC user. We ask the expert user to be patient with some of the long explanations.

2.1 MAKING A WORKING COPY

In the following explanation, we assume that the hard disk (if one exists on your system) is named "C", the first floppy disk drive is named "A", and the second floppy disk drive (if one exists) is named "B". This configuration is fairly standard. If your system is not set up this way, you will have to adapt these instructions accordingly.

The program is on one 360 kilobyte diskette marked COMPLY-R. If you have a hard disk, put the COMPLY-R diskette in drive A, type copy A:*.* C: and press Enter. This will result in the program and all the data being copied onto the hard disk.

If you have two floppy disk drives but do not have a hard disk, put the COMPLY-R diskette in drive A and a blank diskette in drive B. Use the DOS DISKCOPY command to copy all the information on the original diskette to the blank diskette:

```
DISKCOPY A: B:
```

2.2 RUNNING THE COMPLY PROGRAM

If you are not using the hard disk, place your copy of the COMPLY-R diskette in drive A.

You start the program by typing COMPLY-R and pressing Enter. After a short delay (while the program is transferred from the disk into memory), a message will appear on the screen telling you how to proceed.

2.3 OUTPUT

The first page of the output is a cover sheet containing the facility name and other identifying information. Succeeding pages reproduce the information you gave the program and the results of its calculations.

3.0 DETAILED INPUT GUIDANCE

3.1 OVERVIEW

The following instructions may seem complicated at first; this is because we have tried to cover every contingency. It may be wise to start running the program using the sample problem (Appendix B) as a guide and read the explanation as you proceed. This will make the explanation more concrete, not just an abstract set of instructions.

The program will ask you for input as it is needed. It will begin by asking whether you want the output to go to a file or to the printer. It will then ask for information regarding your company and facility.

Each of the input parameters is described below. They are presented in the order in which the program most commonly asks for them. Once a value has been requested and supplied, the program will not ask for it again.

While you are running the program, if you decide to stop, simply hold down the Ctrl key and press the Break key (on IBM keyboards, this is also the Scroll Lock key), and the program will stop. The Ctrl and C keys will also stop the program. If you do stop, you lose all of the data entered up to that point and must start over from the beginning.

3.2 FORMAT FOR ENTERING NUMERICAL VALUES

The program allows you to enter numerical values in different ways. For example, to enter 1400, you may type either 1400, 1400., 1.4e3, 1.4E3, 1.4e+3, 1.4E+3, or 1.4+3. To enter

0.012 you may type 0.012, .012, 1.2e-2, 1.2E-2, or 1.2-2.

NOTE: The lower case L is not a numeral 1 as it is on typewriter keyboards. You must use the "1" key.

The following formats are NOT correct: 1,400, 1.4x10+3, 012, and 1.2x10-2. If you type 1,400, the program will not recognize this as 1400, but it will not give you an error message. It will ignore everything after the comma and treat the value as 1. The program will read 012 as 12, not .012. The other two incorrect forms will result in an error message.

NOTE: If you recognize an error before you press the Enter key, you may correct it using the backspace key (the left-pointing arrow key on the upper right of the keyboard).

After you type in the value, you must press the Enter key. Only then will the machine recognize that you have given it the value it has asked for. If the program is looking for a numerical value and you press Enter without giving it one, it will not proceed but will simply wait for you to give it the value. It will not ask you for it again; it will simply stare back at you.

3.3 BEGINNING MESSAGE

The first thing that will show on your screen is an introductory message with a brief description of the code. To continue, simply press the Enter key.

3.4 OUTPUT TO PRINTER OR FILE

The program first asks you whether you wish to have your output sent directly to the printer or stored in a file on a disk. If you choose the printer, the output will be printed as you go along. You must have your printer turned on, or the program will not run. If you choose to have your output sent to a file, the program will ask you for a file name. If you want the output file to be stored on a disk other than the default disk, you must supply the name of the disk drive along with the file name; e.g., B:REPORT.DAT to store it on drive B.

Before printing the results, align the paper in the printer so that the output will not overlap from page to page; align the top of the sheet with the print head. Turn the printer off momentarily and then back on. (Some printers will advance the paper to the position it was in when the printer was first turned on.)

3.5 TITLE

The program asks you to type in a title for your problem. You may type in anything you like, up to 78 characters and numbers.

3.6 TITLE PAGE

You will be asked to supply your company name, the name of your facility, its address, and the name and telephone number of a contact person.

3.7 NUMBER OF RELEASE POINTS

The program will ask if you have more than one release point. If the response is Y for yes, it will then ask how many release points (vents) there are. If you have more than one, you may be able to run them all in one problem, or you may have to make several runs. (See the discussion in Section 3.16, Multiple Release Points.)

Each release point in a problem is treated individually; that is, you must supply the release rates, release height, etc., for each point. It is very important to keep track of which parameters go with each release point. We strongly suggest that you fill out Worksheet D in the guidance document (EPA89).

3.8 RELEASE RATES

The program next asks you whether you want to put in release rates in Curies/year or Curies/second. After you have told it which you want (Y for years, S for seconds), it will ask you for the release rates from each release point one at a time. When the release rates have been specified for each vent, the program will show on the screen what you have put in and ask you if the values are satisfactory. If you don't like what you see, enter an N and the program will instruct you on how to fix the incorrect values. If you enter a Y, it will proceed to the next step.

3.9 RELEASE HEIGHT

If you have multiple release points, and have not completed Worksheet D of EPA89, we suggest you do so. It is a useful way to keep track of all your vent parameters if you have more than one vent. The release height is the elevation view distance (in meters) from the ground to the point of release.

If you specify a release height other than zero, the program will ask you about the configuration of the vent. If the vent is not vertical or the flow is impeded by a restriction such as a rain cover, momentum rise will be zero.

3.10 VENT DIAMETER

You may or may not be asked for the inside exit diameter (in meters) of the vent. This number is needed only if the release height is greater than zero.

3.11 VOLUMETRIC FLOW RATE

You may be asked for the volumetric flow rate from the vent [cubic meters per second (m^3/s)]. The logic of when you are asked for this is the same as for the vent diameter. To convert from cubic feet per minute (ft^3/min) to m^3/s, multiply ft^3/min by $4.7x10^{-4}$.

3.12 DISTANCE FROM SOURCE TO RECEPTOR

This is the straight-line distance (in meters) from the source to the nearest receptor measured along the ground. If you choose to put in a wind rose, you must also supply the straight-line distance to the nearest receptor for each of 16 sectors. This is discussed in the description of the wind rose in Section 3.15.

3.13 VENT AND AIR TEMPERATURES

If the vent height is greater than zero, the program will ask you for the annual average outside air temperature in degrees F. This has a default value of 55 ^{o}F. The program will then ask for the vent temperature in degrees F. This, too, has a default value of 55 ^{O}F. If you choose the default values for both of these temperatures, the plume rise due to buoyancy effects will be zero. The vent temperature must be equal to or greater than the air temperature.

3.14 WIND SPEED

The program will ask if you want to use the default wind speed of 2 m/s. This is the annual average wind speed (m/s) without regard to the wind direction. It is used if you do not put in a wind rose. If you do not know the wind speed, you may use the default value; however, this is fairly conservative. If you do not want to use the default value, the program will ask you for your value.

3.15 WIND ROSE

A wind rose is a table showing how frequently the wind blows from a given direction with a given speed. You will be asked if you wish to put in a wind rose. If you do not choose to put in a wind rose, the wind is assumed to blow toward the receptor 25 percent of the time. This is conservative, because at most sites the maximum frequency for a given direction is about 10-15 percent. If you choose to put in a wind rose, enter Y; if not, enter N. If you choose to use a wind rose, then the program will ask you for a distance table for each release point. The distances correspond to the directions FROM the release point TO the closest receptor in each of 16 sectors and must be greater than zero. You may put these distances in from the keyboard (following the instructions on the screen) or you may set up distance files ahead of time and use these. If you put them in from the keyboard, the program will create files for you so that you do not have to enter them again if you re-run the problem.

Before the program creates each file, it will ask you for a file name. The name you give it should include the disk drive you want it on (if other than the default drive). For example, if you want to call the file STKDISK.DAT and you would like it to be on drive B, you would type B:STKDISK.DAT. To put it on the default drive, you would type only STKDISK.DAT. The DAT extension (.DAT) makes it easy to identify your data files. If there is already a file by that name, the program will ask you for a different name. You will need to supply one set of distances for each release point.

Wind rose data can be obtained from several sources: on-site measurements, a local meteorological station (usually at the local airport), and the National Climatic Data Center in Asheville, North Carolina. See Appendix C for a description of data available from the National Climatic Data Center and how to put such data in the form needed here. If you do not have an onsite meteorological tower, you must use data from another source. In general, the data must be from measurements made at a location meeting the guidelines given in Appendix D. However, specific exceptions might be made on a case-by-case basis, depending on how close the dose estimates are to the limits and the similarity of the terrain in the local area to the terrain where the data were collected. The data should either be for the period covered by the assessment or be long-term average data (covering at least 5 years). The averaging period does not have to include the assessment period.

Meteorologists have adopted the convention of presenting these data in terms of the direction the wind is blowing from, for each of 16 sectors. This can easily lead to errors when supplying the wind rose data. Before you start the problem, check to make sure that your wind rose data are in the form of FROM rather than TO. Embarrassing errors have been caused by putting in wind rose data that were exactly the reverse of what the user thought they were.

If you indicate that you want to put in a wind rose, then the program will ask you whether you want to put it in from a file or from the keyboard. The first time you run the code, you must put in the wind rose data from the keyboard. Before asking you for the wind rose data, the program will ask you to provide the following information:

1. Source of the data,
2. Dates covered,
3. Location where the measurements were made,
4. The distance from your facility to the measurement location, and
5. Units for the wind speed (just follow the instructions on the screen).

The source of the data might be one of those listed above; e.g., the National Climatic Data Center. The dates covered correspond to the period during which the meteorological measurements were made. The location of the measurements is the name of the weather station, and the distance is the distance from your facility to that weather station.

The program next asks you for the percentage of calms. Usually given on wind roses, this represents the period of time the wind speed is less than (generally) 3 mph. If it is not given, check your source of data to see if it has been factored in. If the calms have been factored into the data, enter a zero for the fraction of calms when the program asks for it.

Wind speed data are usually given in either miles per hour (mph) or knots, and the program requires meters/second (m/s). The conversion factors are as follows:

To obtain m/s from mph, multiply mph by 0.45.

To obtain m/s from knots, multiply knots by 0.51.

The program will ask you what your wind speed units are and will do the conversion for you. All the instructions for entering the wind rose data will appear on your screen. We suggest that you have the data ready when you are asked for it. To that end, Table C-7 in Appendix C is supplied for use in preparing your wind rose data. When the data have all been entered, they will be displayed on the screen, and you will be asked if they are correct. If you answer Y for yes, the computer will use the data you typed in to create a wind rose file. This is done for your convenience, so that if you want to re-run the problem for some reason, you do not have to put in the wind rose data again. If the wind rose is not correct, answer N for no, and the program will give you instructions for fixing it.

These restrictions apply to the values for the distances, frequencies, and wind speeds:

- All the frequencies (except for calms) must be greater than zero.

- The sum of all the frequencies (including calms) must be between 0.99 and 1.01.

- All the wind speeds must be greater than 0.1 meter/second.

Before the program creates the file, it will ask you for a file name. The name you give it should include the disk drive that you want it on (if other than the default drive). For example, if you decide to name the file WINDROSE.DAT and you would like it to be put on drive B, then you would type in B:WINDROSE.DAT. If you want to put it on the default drive, you need type only WINDROSE.DAT. It is handy to put a DAT extension (the .DAT) on all data files to make it easy to identify them.

When you run a problem and tell the computer you want to use a wind rose file, the program will ask you for the file name. If the file is not on the same disk as the program, you must tell the program where it is. For example, if the default drive is drive C and the wind rose file is called ROSIE.DAT on drive B, you would type B:ROSIE.DAT.

An abbreviated version of a wind rose is given in Table 3-1.

Table 3-1. Abbreviated Sample Wind Rose

Wind FROM	Frequency	Speed m/s
Calm	0.063	---
' N '	0.022	2.1
'NNE'	0.034	3.2
.	.	.
.	.	.
.	.	.
'NNW'	0.042	2.5

Whether you enter the wind rose from a file or from the keyboard, the program will print it out and ask you if it is correct. If you enter Y for yes, it will proceed with the problem. If you enter N, the program will allow you to fix it. The instructions will appear on the screen.

3.16 MULTIPLE RELEASE POINTS

The way you handle multiple release points depends in part on whether you are using a wind rose. When you have multiple release points, you must supply the distance from each release point to each receptor.

3.16.1 MULTIPLE RELEASE POINTS WITH NO WIND ROSE

<u>Option 1</u>. If you are not using a wind rose, you may run multiple vents in one problem. The program adds the dose to the closest individual from release point 1 to that from release point 2, and so on. This will over-estimate the dose if different individuals in widely separated locations are exposed to the various release points, because Option 1 assumes the same individual is in all the locations at once.

<u>Option 2</u>. The other option is to run N separate problems if there are N release points, and use the multiple vent option. This method is more complicated; however, it eliminates the conservatism inherent in Option 1. The method is best explained by the table below, which illustrates the procedure for three release points.

Release Point	Receptor a	b	c
1	$D(x_{1a})$	$D(x_{1b})$	$D(x_{1c})$
2	$D(x_{2a})$	$D(x_{2b})$	$D(x_{2c})$
3	$D(x_{3a})$	$D(x_{3b})$	$D(x_{3c})$
	-------	-------	-------
Sum	D_a	D_b	D_c

In this table, receptor a is the closest receptor to release point 1, receptor b to release point 2, and so on. The distance x_{1a} is the distance from release point 1 to receptor a, x_{1b} is the distance from release point 1 to receptor b, and so on. The dose $D(x_{1a})$ is the dose to receptor a from stack 1, and so on. The total dose D_a to receptor a is the output from problem a, D_b the output from problem b, and so on. Each of the three columns represents a single problem. You will not see the individual doses $D(X_{1a}$, etc.), only the totals (D_a, D_b, and D_c). The dose to be reported is the maximum of D_a, D_b, or D_c.

3.16.2 MULTIPLE RELEASE POINTS WITH A WIND ROSE

Option 1. The first option is to run one multivent problem. This will require a distance file for each vent but only one wind rose file. All of the meteorological parameters will be the same; only the distances from the release points to the receptors will be different. This is similar to the first option for multiple release points with no wind rose because it is as if the person simultaneously lives in all the worst locations at once.

Option 2. The other option is to run 2N problems for N release points. This will require 2N sets of distances. If you choose this option, you must do the following:

1. Run a single-vent problem for release point 1 using the actual distances from the release point to the nearest receptors in all 16 sectors. This will give you the dose from vent 1 to receptor 1 (the receptor receiving the highest dose from release point 1) and will tell you which sector he lives in.

2. Having done step 1, determine from the output the location of receptor 1. Create new distance files for release point 2, 3, etc., setting all the distances except the one in the direction from each release point to receptor 1 to a very large number (we suggest 10^6 meters). This will prevent the program from calculating the dose to someone in a sector other than the one of interest. For each distance file in the direction of receptor 1, put in the actual distance from the release point to receptor 1. Then run this problem using the multiple stack option. This gives you the dose to receptor 1 from all the release points.

3. Repeat steps 1 and 2 for the remaining release points to get the doses to receptor 2 from release points 1, 2, 3, etc. The dose to use in determining whether or not you are in compliance is that of the problem having the highest total dose from all the release points.

1. Run [illegible] using [illegible] is on the release point [illegible] actual distances from the release point to the [illegible] receptors [illegible]. This [illegible] data [illegible] from [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible].

2. Having done step 1, determine from the output the [illegible] to receptor [illegible] distance [illegible] point 1, [illegible] all the distances each, the one in the direction from each release point to receptor [illegible] a very large number [illegible] suggest [illegible] However the program then calculates the dose to receptor [illegible] actual [illegible] than the one [illegible]. For each [illegible] distance [illegible] direction [illegible] receptor [illegible] actual distance from the release point to receptor. [illegible] this [illegible] using the multiple [illegible] option. This gives you the dose to receptor [illegible] from all the release points.

3. Repeat steps 1 and 2 for the remaining release points to get the dose to receptor 2 from [illegible] release [illegible] etc. The dose [illegible] determining whether or not you are in compliance [illegible] that of the [illegible] having the highest total dose from all the release points.

4.0 OUTPUT

The output is self-explanatory. The input is printed out just as you entered it.

If you elected to have the output sent to a printer, it will appear there automatically. (You must have the printer turned on.) If you choose to have it sent to a file, you may examine the file on the screen or you may print it out. One way to examine the file on the screen is to use the MORE command. If the file is named MYOUT on drive A, type in

```
MORE < A:MYOUT
```

This will result in the file being displayed on the screen 23 lines at a time. You can see 23 more lines by pressing any key. The next 23 lines will then scroll up. In this way, you can work your way through the file (but only from front to back).

If you want to print the file, make sure the printer is turned on and that the top of the sheet is lined up with the printhead. Then type

```
PRINT A:MYOUT
```

This will cause the file to be printed.

REFERENCES

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APPENDIX A - HOW TO HANDLE ERRORS

In most cases, if you make an incorrect entry, the program will tell you what is wrong and allow you to correct it. In some cases, the program cannot identify the error. In those cases, we have programmed the machine to suggest possible problems, but finding the difficulty is up to you. These types of problems are covered here. We have included here all the potential difficulties anticipated. If you encounter one that is not on the list, please notify your EPA Regional Office.

1. <u>MACHINE DOES NOT RESPOND AFTER YOU HAVE TYPED IN VALUE</u>

Have you pressed Enter? You must press Enter to have the machine digest your answer to its question.

Have you pressed Enter without typing in a value? If the program wants you to type in a number, and you just press Enter, it will wait patiently for you to enter a number.

2. <u>ERROR MESSAGE: "There is something wrong with your input value..."</u>

You may have made a typographical error. Try typing in the value again. Be sure to use the proper format. You may have used the lower case "L" for a numeral 1. Unlike most typewriters, the computer keyboard has a separate key for the numeral 1.

You may have entered a value using an improper format. The program allows you to enter numerical values in a number of different ways. For example, to enter 1400 you may type either 1400, 1400., 1.4e3, 1.4E3, 1.4e+3, 1.4E+3, or 1.4+3. To enter 0.012, you may type 0.012, .012, 1.2e-2, 1.2E-2, or 1.2-2.

The following formats are NOT correct: 1,400 or 1.4x10+3, and 012 or 1.2x10-2.

If you type 1,400, the program will not recognize this as 1400, but it will not give you an error message. It will ignore everything after the comma and treat the value as 1. The program will read 012 as 12, not .012. The other two incorrect forms will result in an error message.

3. ERROR MESSAGE: "I can't find (file name). It's not on the default drive..."

The data files supplied with the program must be on the default drive. If for some reason they are not there, you will get this error message and the program will stop.

If the missing file is your wind rose or distance file, check to see that it has the name you think it has and that it is on the disk drive you think it is. If the name is not what you thought it was, or it is on a different drive, start over and give the program the correct file name when asked. If it is not on the default drive, you must tell the machine where it is. For example, if the default drive is drive A or C, and the wind rose file is named WINDROSE.DAT and is on drive B, then you must enter B:WINDROSE.DAT when the machine asks you for the file name.

4. <u>ERROR MESSAGE FOR DISTANCE OR WIND ROSE FILE:</u>

(a) "There is something wrong with DATA line..."

(b) "Error at line *** in GETWRF..."

(c) "Error at line *** in GETWDF..."

You should never get these messages. If you do, delete the file that is causing the problem (by typing DEL file name) and start over using the program to make a new file.

APPENDIX B - SAMPLE PROBLEM

The sample problem that follows is intended to show the output from COMPLY-R and how the program calculates dose.

40 CFR Part 61
National Emission Standards
for Hazardous Air Pollutants

REPORT ON COMPLIANCE WITH

THE CLEAN AIR ACT LIMITS FOR RADIONUCLIDE EMISSIONS

FROM THE COMPLY-R CODE, VERSION 1.2

Prepared by:

ABC ENERGY INC.
NICE MINE
SOMEWHERE, CO

JOHN DOE
(555) 555-5555

Prepared for:

U.S. Environmental Protection Agency
Office of Radiation Programs
Washington, D.C. 20460

Stack	Release Rate (curies/YEAR)
1	5.000E+03
2	2.000E+03

SITE DATA FOR VENT 1.

Release Height 2.00 meters.

Vertical momentum present for vent 1

Vent diameter 2.50 meters.

Volumetric flow rate is 40.000 cu m/sec.

STACK DISTANCES, FILE: N

DIR	Distance (meters)
N	30000.0
NNE	25000.0
NE	25000.0
ENE	25000.0
E	20000.0
ESE	20000.0
SE	20000.0
SSE	20000.0
S	15000.0
SSW	15000.0
SW	20000.0
WSW	20000.0
W	15000.0
WNW	20000.0
NW	25000.0
NNW	30000.0

SITE DATA FOR VENT 2.

Release Height 1.00 meters.

Vertical momentum NOT present for vent 2

Vent diameter 1.50 meters.

Volumetric flow rate is 35.000 cu m/sec.

STACK DISTANCES, FILE: N

DIR	Distance (meters)
N	30000.0
NNE	25000.0
NE	25000.0
ENE	25000.0
E	20000.0
ESE	20000.0
SE	20000.0
SSE	20000.0
S	15000.0
SSW	15000.0
SW	20000.0
WSW	20000.0
W	15000.0
WNW	20000.0
NW	25000.0
NNW	30000.0

WINDROSE DATA, FILE: W

Source of wind rose data: GRAND JUNCTION
Dates of coverage: 5/88-5/89
Wind rose location: GRAND JUNCTION
Distance to facility: 40

Percent calm: 0.01

Wind FROM	Frequency	Speed (meters/s)
N	0.054	3.84
NNE	0.081	4.62
NE	0.113	3.89
ENE	0.053	2.91
E	0.071	2.44
ESE	0.043	2.85
SE	0.047	3.95
SSE	0.038	4.86
S	0.145	4.83
SSW	0.104	5.18
SW	0.074	4.91
WSW	0.029	4.21
W	0.036	4.01
WNW	0.038	5.54
NW	0.044	5.03
NNW	0.021	4.69

NOTES:

Default air temperature not used.
Air temperature 54.0 (degrees F).

Default vent temperature used (55.0 degrees F). Vent 1.

The receptor exposed to the highest concentration is located 15000. meters to the W. Vent 1.

Default vent temperature not used. Vent 2.
Vent temperature 57.0 (degrees F).

The receptor exposed to the highest concentration is located 15000. meters to the W. Vent 2.

Input parameters outside the "normal" range:

None.

RESULTS:

Effective dose equivalent: 1.6 (mrem/year).

Complies with emission standards.

*** This facility is in COMPLIANCE ***

********** END OF COMPLIANCE REPORT **********

APPENDIX C - OBTAINING AND ORGANIZING WIND ROSE DATA

As noted in the body of this report, there are three possible sources of wind rose data: (1) onsite measurements, (2) a local weather station (usually located at airports), and (3) the National Climatic Data Center in Asheville, North Carolina (telephone 704-259-0682).

If you do not have an onsite meteorological tower, you must get wind rose data from another source. See Appendix D for guidelines as to what constitutes acceptable data.

For offsite data, we recommend that you contact the National Climatic Data Center because (1) they have trained personnel who can advise you regarding the locations for which they have data, (2) it is fairly easy to put their data in the proper form, and (3) data are available for several hundred locations around the country. Data from local airports may not have been reduced to usable form; that is, the measurements may be hourly or daily, which would mean you would have to consolidate between about 400 and 9000 data points for one year. Moreover, the airport data may already be in the National Climatic Data Center data base.

Three kinds of data are available from the National Climatic Data Center: Wind Direction Versus Wind Speed Tabulations, STability ARray (STAR) data, and Wind-Ceiling-Visibility data. Each of these is discussed below.

C.1 WIND DIRECTION VERSUS WIND SPEED TABULATIONS

If the National Climatic Data Center has one of these tabulations available that is suitable for your site, we recommend that it be your first choice, because it is already in the form you need. Table C-1 is a sample tabulation; the last two columns are what you use to create your wind rose.

C.2 STABILITY ARRAY (STAR) DATA

The second kind of data available from the National Climatic Data Center is the so-called STAR data. These data (or their equivalent) are fairly extensive, but a subset can be used for COMPLY. The data are on tape or hard copy. Unless you have access to a tape reader, you should not order the tape. The data consist of 13 tables; only the last 2 are of interest here. The next-to-last column of the next-to-last sheet contains the average wind speed (in knots) for each sector. The last column of the last sheet contains the fraction of the time the wind blows from each direction.

> NOTE: The calms are distributed among the frequencies, so that if you use the STAR data you should put in a 0 for calms when you run COMPLY.

Tables C-2 and C-3 show the organization of the last 2 of the 13 STAR tables. The appropriate columns are marked.

While the STAR data are as convenient as the Wind Direction Versus Wind Speed Tabulations, not as many locations have been put into this data base. Thus, you may not be able to find data from a nearby location.

C.3 WIND-CEILING-VISIBILITY DATA

The Wind-Ceiling-Visibility data are, for the most part, 30-year averages (1948-1978). Compiled for the Federal Aviation Administration, they are not in the exact form required for use in COMPLY. They consist of both tables and graphs. The graphic data are in the form shown in Figure C-1. The tabular data supplied with the graphic data are not useful for your purpose. You must use the data from the graphic wind rose to construct a table of wind speeds and frequencies.

To construct your table from Figure C-1, follow this procedure.

The numbers inside the segments represent the percentage of the time that the wind blows from a particular direction within a range of wind speeds. The speed range lies between the values shown on the concentric circles in the sector marked N.

In the sector marked N, the first of the concentric circles has a 4 on it. This represents the lower limit of the wind speed. The next concentric circle has a 13 on it. Inside the segment bounded by these two sectors is a 4.3. This means that 4.3 percent of the time the wind is from the north, with a speed between 4 and 12 miles per hour. The convention is to use the lower value as the lower limit of the range and the higher value minus 1 mi/h as the upper limit.

From the graph in Figure C-1, we can construct Table C-4. To construct the simplified wind rose needed for the COMPLY program, we need the average wind speed from each direction and the fraction of the time the wind blows from that direction. The average wind speeds for each class are as given in Table C-5.

We first sum the frequencies in each sector to get the fraction of time the wind blows from that direction; i.e.,

$$f_i = \sum_j f_{ij} ,$$

where f_{ij} is the frequency of the time the wind speed in sector i is in class j.

To compute the average speed for the sector, we multiply the average speed in each class by its frequency, sum them, and divide by the sum of the frequencies in that sector.

$$U_i = \sum_j (u_j f_{ij}) / \sum_j f_{ij} = \sum_j (u_j f_{ij}) / f_i ,$$

where U_i is the average wind speed in sector i, and u_j is the average wind speed for class j (from Table C-4).

This is not the true average speed for the sector, because we did not account for calms. The program will ask you for the fraction of the time the wind is calm (in this case, 0.118) and make the correction for you.

An example of a calculation is as follows: with the wind from the north, the sum of the frequencies is 4.3 + 0.8 + 0.2 = 5.3, and the average wind speed is (8x4.3 + 14x0.8 + 17x0.2)/5.3 = 9.2.

The result of these operations for the sample data is given in Table C-6. The last column has the wind speed in m/s, the unit required for COMPLY. The conversion factor is m/s = mi/h times 0.447. Table C-7 is provided to assist you in preparing the wind rose data.

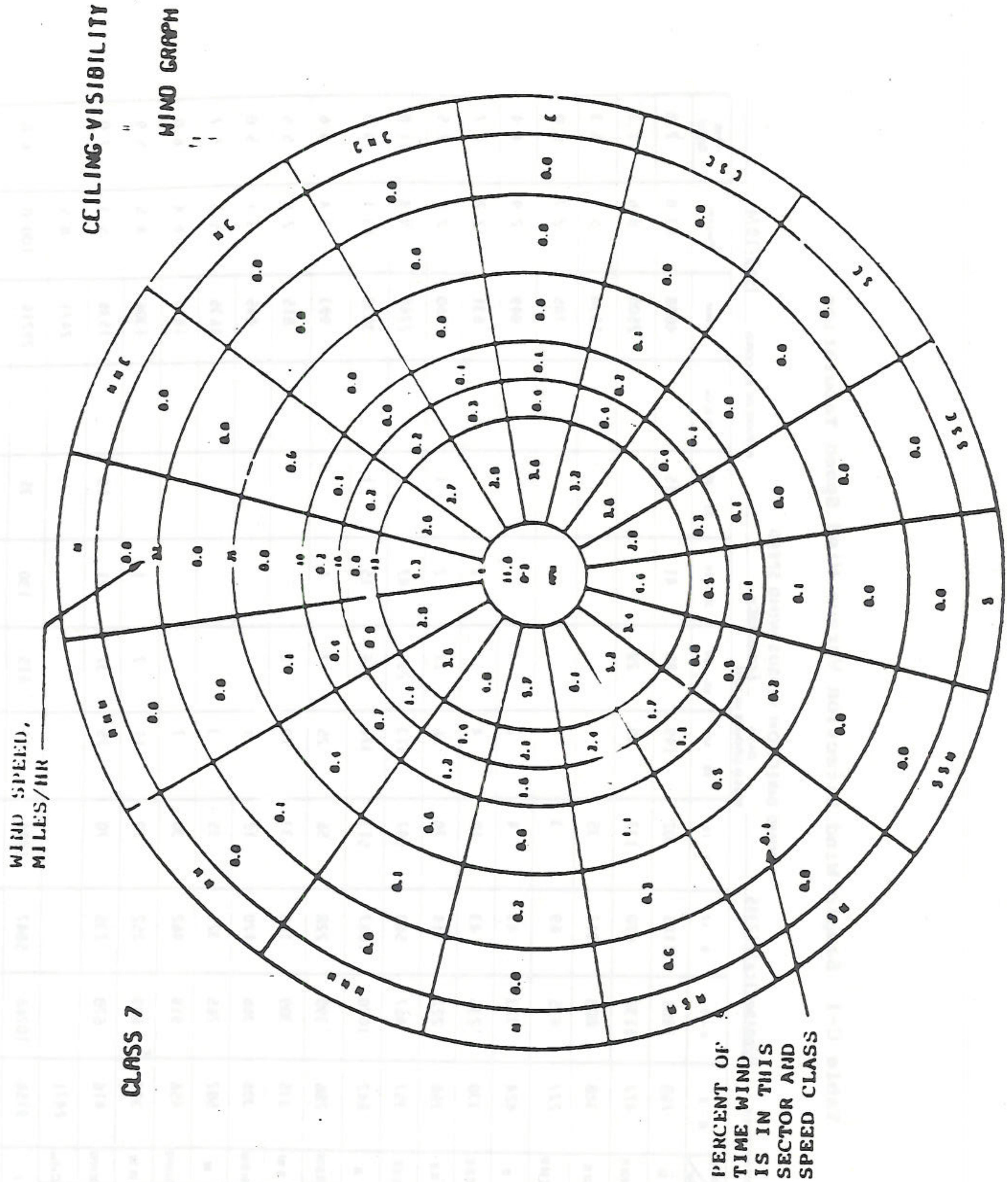


Figure C-1. Sample graphic wind rose

Table C-1 Sample Wind Direction Versus Wind Speed Tabulation

WIND DIRECTION VERSUS WIND SPEED

STATION NAME/NUMBER Hypothetical/12345 DATA Frequency PERIOD OF RECORD 1965-1974

SPEED GROUPS IN MPH

Mo	Code	Speed / Dir	0 - 3	4 - 7	8 - 12	13 - 15	16 - 18	19 - 24	25 - 31	32 - 38	39 & Gr	Total	Percent	Avg Speed
AN		N	769	1491	1186	302	149	85	41	15		4038	13.8	7.8
		NNE	477	1137	670	137	50	29				2500	8.6	7.3
		NE	348	808	347	35						1538	5.3	6.3
		ENE	277	435	69	3	1					785	2.7	5.0
		E	424	373	43	4	2	3				849	2.9	4.4
		ESE	330	235	43	10	4	7	2			631	2.2	4.7
		SE	268	222	114	70	56	27	2	1		760	2.6	7.5
		SSE	357	467	560	547	513	255	47	3		2749	9.4	11.8
		S	642	1070	1067	513	374	156	15	1		3838	13.1	9.3
		SSW	286	390	228	56	25	7	1			993	3.4	6.6
		SW	335	309	126	33	10	2				815	2.8	5.5
		WSW	396	366	120	12	1					895	3.1	5.0
		W	507	765	325	35	3					1635	5.6	5.7
		WNW	456	919	462	30	7					1874	6.4	6.0
		NW	397	609	252	29	11	7	1			1306	4.5	5.9
		NNW	416	670	235	70	75	37	21	15		1539	5.3	7.0
		Calm	2471									2471	8.5	
Total			9156	10266	5847	1886	1281	615	130	35		29216	100.0	6.8
Percent			31.3	35.1	20.0	6.5	4.4	2.1	0.4	0.1				

MO : AN = Annual; 1 = January; 2 = February; ......; 12 = December.
CODE : Blank = All Weather; 10 = VFR; 20 = IFR; 30 = ILS

Table C-2 Sample STAR Data

ANNUAL FREQUENCY DISTRIBUTION STATION #94823 PITTSBURGH,PA [illegible] 1970

SPEED(KTS)

DIRECTION	1 - 3	4 - 6	7 - 10	11-16	17-21	GREATER THAN 21	AVG SPD	TOTAL
N	39	216	309	99	0	0	7.7	719
NNE	33	119	93	0	0	0	6.1	222
NE	40	173	93	12	0	0	5.9	223
ENE	36	114	142	30	1	0	7.1	329
E	72	104	139	43	0	1	6.6	440
ESE	43	106	79	33	0	0	6.6	262
SE	60	193	107	28	0	0	6.4	420
SSE	20	180	112	19	0	0	9.9	330
S	83	209	210	43	0	0	6.3	635
SSW	33	93	141	70	4	1	8.1	390
SW	43	100	301	194	17	20	9.3	743
WSW	49	143	242	200	37	33	10.4	700
W	90	222	330	349	72	20	10.0	1060
WNW	40	160	190	190	31	9	8.9	600
NW	30	95	160	110	12	1	8.8	425
NNW	20	70	212	136	2	0	8.0	494
AVG	3.0	5.1	8.4	12.9	18.9	25.0	7.6	
TOTAL	760	2320	2954	1650	176	83		

TOTAL NUMBER OF OBSERVATIONS = 8760

TOTAL NUMBER OF CALMS = 809

Table C-3 Sample STAR Data

ANNUAL RELATIVE FREQUENCY DISTRIBUTION STATION =94823 PITTSBURGH,PA 26095 1970

SPEED(KTS)

DIRECTION	0 - 3	4 - 6	7 - 10	11 - 16	17 - 21	GREATER THAN 21	TOTAL
N	0.009844	0.024690	0.041667	0.010849	0.000000	0.000000	0.087013
NNE	0.006901	0.013984	0.010849	0.000913	0.000000	0.000000	0.032323
NE	0.009112	0.019977	0.010616	0.001712	0.000000	0.000000	0.041418
ENE	0.007201	0.013014	0.010210	0.004110	0.000114	0.000000	0.040729
E	0.013344	0.010721	0.010151	0.004909	0.000000	0.000114	0.039239
ESE	0.008330	0.012100	0.009010	0.003653	0.000000	0.000000	0.033101
SE	0.013201	0.022032	0.012219	0.005936	0.000000	0.000000	0.053444
SSE	0.010971	0.020940	0.012785	0.001598	0.000000	0.000000	0.045502
S	0.017340	0.032991	0.0[illegible]	0.004909	0.000000	0.000000	0.079212
SSW	0.006702	0.010616	0.010096	0.008676	0.000457	0.000114	0.042661
SW	0.009590	0.018990	0.030301	0.022140	0.001941	0.002283	0.089279
WSW	0.009653	0.016324	0.027626	0.031963	0.004224	0.003995	0.093786
W	0.012562	0.029457	0.030504	0.039840	0.000219	0.002283	0.124946
WNW	0.010040	0.019170	0.022603	0.010037	0.003939	0.000571	0.073973
NW	0.007150	0.010849	0.010205	0.013804	0.001370	0.000114	0.051320
NNW	0.005395	0.008676	0.020201	0.015525	0.000228	0.000000	0.054025
TOTAL	0.157192	0.287671	0.337214	0.180356	0.020091	0.009475	

TOTAL RELATIVE FREQUENCY OF OBSERVATIONS = 1.000001

TOTAL RELATIVE FREQUENCY OF CALMS DISTRIBUTED ABOVE = 0.089921

Table C-4. Tabular form of graphical wind rose

	Frequency Wind Speed is in Class j, percent						
j=	1	2	3	4	5	6	7
	Wind Speed, mi/h						
Sector	0-3	4-12	13-15	16-18	19-24	25-31	32
Calms	11.8	-	-	-	-	-	-
N	-	4.3	0.8	0.2	0	0	0
NNE	-	2.6	0.2	0.1	0	0	0
NE	-	2.7	0.2	0	0	0	0
ENE	-	2.9	0.3	0.1	0	0	0
E	-	3.6	0.4	0.1	0	0	0
ESE	-	3.2	0.4	0.2	0.1	0	0
SE	-	3.6	0.4	0.1	0	0	0
SSE	-	2.9	0.3	0.1	0	0	0
S	-	4.4	0.5	0.1	0.1	0	0
SSW	-	3.4	0.8	0.5	0.2	0	0
SW	-	5.2	1.7	1.1	0.5	0.1	0
WSW	-	6.1	2.4	1.9	1.1	0.3	0
W	-	5.7	2.1	1.6	0.8	0.2	0
WNW	-	4.0	1.4	1.2	0.6	0.1	0
NW	-	3.6	1.1	0.7	0.4	0.1	0
NNW	-	2.9	0.9	0.4	0.1	0	0

Table C-5. Average wind speeds for each class

Class	Speed Range	Average Speed mi/h
1	0-3 (calm)	Calm
2	4-12	8
3	13-15	14
4	16-18	17
5	19-24	21
6	25-31	28
7	32	32

Table C-6. Wind rose data suitable for use in the COMPLY code

Wind From	Frequency	Average Speed mi/h	m/s
Calm	0.118	---	---
N	0.053	9.2	4.1
NNE	0.029	8.7	3.9
NE	0.029	8.4	3.8
ENE	0.033	8.8	3.9
E	0.041	8.8	3.9
ESE	0.039	9.4	4.2
SE	0.041	8.8	3.9
SSE	0.033	8.8	3.9
S	0.051	9.0	4.0
SSW	0.049	10	4.5
SW	0.086	11	4.9
WSW	0.118	12	5.4
W	0.104	12	5.4
WNW	0.073	12	5.4
NW	0.059	11	4.9
NNW	0.043	10	4.5

Sum	0.999		

The frequencies must sum to between 0.99 and 1.01 to be accepted by COMPLY. Use three decimal places with the frequencies, to make sure their sum is within these limits.

Table C-7. Form for wind rose data

Wind FROM	Frequency[1]	Wind Speed[2]
CALM		XXXXXXXXXXXXX
N		
NNE		
NE		
ENE		
E		
ESE		
SE		
SSE		
S		
SSW		
SW		
WSW		
W		
WNW		
NW		
NNW		
Total[3]		

Notes:

1. Expressed as fraction, NOT percent; i.e. .025, not 2.5%.
2. Must be greater than 0.1 m/s.
3. Must be between 0.99 and 1.01.

APPENDIX D - SUITABILITY OF WIND ROSE DATA FROM AN OFFSITE LOCATION

In general, it is very unlikely that the wind rose data from somewhere else will exactly duplicate the weather patterns at your site. Thus, you must find a location, fairly close, that duplicates the conditions at your location as closely as possible. The factors that most affect the wind speed and direction are as follows:

1. <u>The elevation relative to the surrounding area</u>

   A location on a hill or plateau can have different wind conditions than the lower surrounding area.

2. <u>Presence of a valley</u>

   A location in a valley can have different wind conditions than the terrain around it. The wind tends to channel through a valley.

3. <u>Presence of a large body of water</u>

   The presence of large bodies of water can influence the wind patterns.

4. <u>Topography</u>

   The wind patterns for hilly terrain can be quite different from those for flat terrain.

5. Urban versus rural

The wind patterns for urban locations can be quite different from those in the surrounding rural or suburban areas because of the heat island effect.

The measurements should come from a meteorological tower located within 50 miles of the site.

The measurements should either cover the same year as the assessment period, or be long-term averages (at least 5 years). The period over which the long-term average data were obtained does not have to include the assessment period.

It is unlikely that any facility not having onsite measurements will be able to obtain data having all these factors at their optimum conditions. Moreover, there are no firm guidelines as to what constitutes "good" data; that is, data representative of the conditions at your site. If your calculated doses are well below the limits, then the representativeness of the meteorological data is not critical. However, if you are close to the dose limits, or exceed them, you should consult a qualified meteorologist. The EPA will make the final determination as to whether or not the data you chose are satisfactory.

APPENDIX G - METEOROLOGICAL MODEL

The meteorological model is similar to that used in NCRP Commentary 3 (NCRP89). It is described below.

The air concentration is

$$C = fQP(x,H)/u \quad ,$$

where f is the fraction of the time the wind blows from the source to the receptor (taken to be 0.25 unless there is a wind rose), Q is the release rate (Ci/sec), u is the annual average wind speed (m/s), H is the vent height (m), and P(x,H) (m^{-2}) is defined by

$$P(x,H) = (2.032/x\sigma_z)\exp[-0.5(H/\sigma_z)^2], \qquad (1)$$

where $\sigma_z = 0.06x(1 + 0.0015x)^{-1/2}$, and x is the distance between the source and the receptor (m). The equation for σ_z is based on neutral atmospheric stability (Class D). The function P(x,H) is zero at x = 0, rises to a maximum at some distance x_{max}, and then declines as x is increased beyond x_{max}. For distances less than x_{max}, P is taken to be $P(x_{max},H)$. This produces a conservative (over-estimate) of the concentration at distances less than x_{max} and leads to the curves shown in Figure 3 of NCRP Commentary 3.

Plume Rise

Plume rise is used only when the vent is vertical and has no rain protector or other impediment to flow. The larger of momentum or buoyant plume rise is used, not their sum.

Momentum plume rise is estimated using a simplified method based on the equations in BRIGGS84. The momentum flux, F_m, is given by BRIGGS84 (the equation following Briggs' equation 8.36); i.e.,

$$F_m = \rho_s w_s V/(3.14 \rho_a), \qquad (2)$$

where w_s is the stack velocity, V the volumetric flow rate, and ρ_a and ρ_s are the air and stack gas densities.

Equation 8.99 of BRIGGS84 is as follows:

$$\Delta h = 0.93[F_m/(\beta^2 U u_*)]^{3/7}(h_s + \Delta h)^{1/7} \qquad (3)$$

where U is the mean wind speed (with a wind rose $U = \Sigma f_i u_i$, where f is the frequency and u the wind speed for direction i), u_* is the friction velocity (taken to be U/12 per BRIGGS86), h_s the stack height, and Δh the plume rise.

This equation must be solved iteratively. However, by using equation 8.100 of BRIGGS84 to approximate the Δh on the right hand side [$\Delta h = 0.9(U/u_*)^{1/2} F_m^{1/2}/(\beta U)$], we can circumvent the need for an iterative solution. By using $\beta = 0.4 + 1.2/R$ ($R = w_s/U$) as suggested in BRIGGS84, and assuming that $U/u_* = 12$ (a moderately conservative value, from BRIGGS86), then equation (8) becomes

$$\Delta h = 0.93\left[75F_m/(1+3/R)^2U^2\right]^{3/7}\left[(h_s + 7.79F_m^{1/2}/U(1+3/R)\right]^{1/7} \qquad (4)$$

Buoyant plume rise is estimated using a simplified method suggested in BRIGGS84 and based on the equations given in that study.

The buoyant flux, F_b, is given by the equation following equation 8.35 of BRIGGS84; i.e.,

$$F_b = g(\rho_a - \rho_s)V/\rho_a \qquad (5)$$

where g is the acceleration of gravity (9.81 m/s).

Equation 8.97 of BRIGGS84 is as follows:

$$\Delta h = 1.2[F_b/(Uu_*^2)]^{3/5}(h_s + \Delta h)^{2/5}. \qquad (6)$$

Assuming that $U/u_* = 12$ as above, and assuming for the moment that h_s on the right hand side is 0, then

$$\Delta h = (23.7)^{5/3}F_b/U^3 = 195F_b/U^3 \ . \qquad (7)$$

Using this approximation for h on the right hand side of equation (11) leads to

$$\Delta h = 23.7[F_b/U^3]^{3/5}(h_s + 195F_b/U^3)^{2/5}. \qquad (8)$$

The effective stack height, h_{eff}, is $h_s + \Delta h$, where Δh is the larger of momentum or buoyant plume rise.

APPENDIX H - DOSE CALCULATIONS

The dose from radon and its daughters is calculated as follows:

$$\text{Dose} = C \times 10^{12} \times 10^{-3} \times 10^{-2} \times 8760/170 \times DF \times$$

$$[F_{indoors}\, F_{in} + (1-F_{indoor})\, F_{out}]$$

where C = radon concentration at the receptor, Ci/m^3

10^{12} = pCi/Ci

10^{-3} = m^3/liter

10^{-2} = Wl-liter/pCi

8760/170 = Wl months/yr

F_{indoor} = fraction of time spent indoors (0.75)

F_{in} = indoor equilibrium fraction

F_{out} = outdoor equilibrium fraction

DF = dose factor, 920 mrem-WLM

The indoor equilibrium fraction is obtained from an outdoor equilibrium fraction.

$$F_{out} = 1.0 - 0.0479 \exp(-t/4.39) - 2.1963 \exp(-t/38.6)$$

$$+1.2442\exp(-t/28.4)$$

where t is the transit time in minutes.

12-1
7/12-10
4382

The above equation is based on the ingrowth model of EVANS80 and the alpha data of UNSCEAR77.

With t = 11.8 min, F_{out} = 0.2 which is consistent with the observed equilibrium fraction in mine vents. Thus

$$t = 11.8 + x/60u$$

where x is the distance to the receptor (m) and u the annual average wind speed (m/s). Thus, the outdoor equilibrium fraction at the receptor is 0.2 plus the increase that occurs during transit.

There is empirical evidence indicating that when there are no radon decay products in ventilation air the indoor equilibrium fraction is 0.35, and when the decay products in the ventilation air are in equilibrium, the indoor fraction is 0.70. Thus,

$$F_{in} = 0.35(1 + F_{out}).$$

APPENDIX I RESOLVING PROBLEMS AND CONTACTING THE EPA

I.1 EPA CONTACTS

If you do not understand any steps or have trouble with any of the calculations described in this document, you should contact the Program Manager at your regional EPA office. EPA Regional Offices are depicted in Figure I-1. A list of the EPA Regional Program Managers and their telephone numbers is included as Table I-1.

While most facilities will be able to demonstrate compliance by one of the methods described in this report, if none of these procedures works for your facility, you should contact the EPA Program Manager at your regional EPA office to determine the next step.

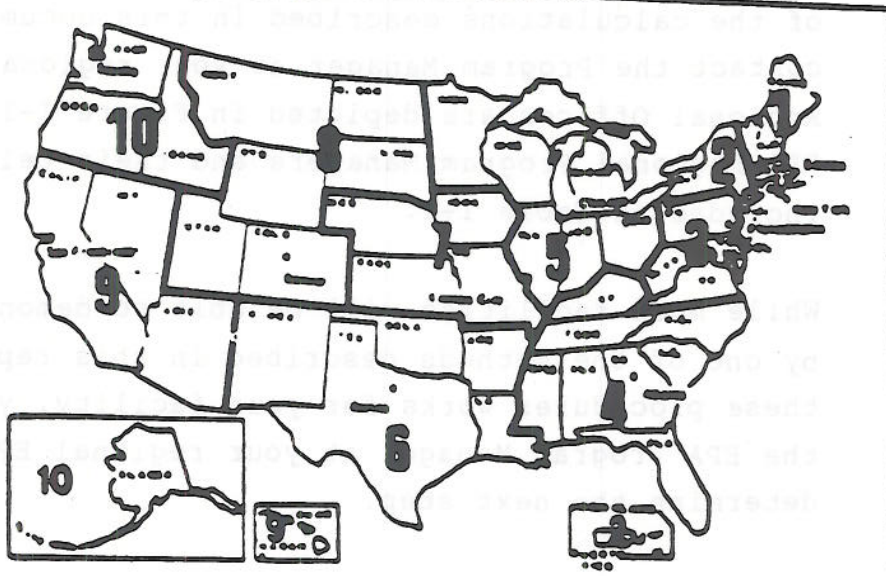
I.2 SOURCES

NCRP Commentary No. 3 may be obtained from the National Council on Radiation Protection and Measurements, 7910 Woodmont Avenue, Bethesda, Maryland 20814. The telephone number is 301-657-2652.

Additional copies of the User's Guide for the COMPLY-R Code and 5 1/4-inch diskettes containing the code and all the data files can be obtained from:

Program Management Office ANR-459
Office of Radiation Programs
Environmental Protection Agency
401 M St., SW
Washington, DC 20460.

Figure I-1 EPA Regional Offices



Regions	Regions	Regions
4 — Alabama	1 — Maine	3 — Pennsylvania
10 — Alaska	3 — Maryland	1 — Rhode Island
9 — Arizona	1 — Massachusetts	4 — South Carolina
6 — Arkansas	5 — Michigan	8 — South Dakota
9 — California	5 — Minnesota	4 — Tennessee
8 — Colorado	4 — Mississippi	6 — Texas
1 — Connecticut	7 — Missouri	8 — Utah
3 — Delaware	8 — Montana	1 — Vermont
3 — D.C.	7 — Nebraska	3 — Virginia
4 — Florida	9 — Nevada	10 — Washington
4 — Georgia	1 — New Hampshire	3 — West Virginia
9 — Hawaii	2 — New Jersey	5 — Wisconsin
10 — Idaho	6 — New Mexico	8 — Wyoming
5 — Illinois	2 — New York	9 — American Samoa
5 — Indiana	4 — North Carolina	9 — Guam
7 — Iowa	8 — North Dakota	2 — Puerto Rico
7 — Kansas	5 — Ohio	2 — Virgin Islands
4 — Kentucky	6 — Oklahoma	
6 — Louisiana	10 — Oregon	

Table I-1. EPA Regional Program Managers

	Telephone No.
Tom D'Avanzo Radiation Program Manager, Region 1 Environmental Protection Agency John F. Kennedy Federal Building Boston, MA 02203	FTS: 835-4502 COMM: (617) 565-4502
Paul A Giardina Radiation Program Manager, Region 2 Environmental Protection Agency Room 1137-L 26 Federal Plaza New York, NY 10278	FTS: 264-4110 COMM: (212) 264-4110
Lewis Felleisen Radiation Program Manager, Region 3 Special Program Section (3AM12) Environmental Protection Agency 841 Chestnut Street Philadelphia, PA 19107	FTS: 597-9705 COMM: (215) 597-9705
Chuck Wakamo Radiation Program Manager, Region 4 Environmental Protection Agency 345 Courtland Street, N.E. Atlanta, GA 30365	FTS: 257-3907 COMM: (404) 347-3907
Gary V. Gulezian Radiation Program Manager, Region 5 Environmental Protection Agency 230 S. Dearborn Street (5AR26) Chicago, IL 60604	FTS: 886-6258 COMM: (312) 353-2206
Donna Ascenzi Radiation Program Manager, Region 6 Air, Pesticides and Toxics Division Air Program Branch (6T-E) Environmental Protection Agency 1445 Ross Avenue Dallas, TX 75202-2733	FTS: 255-7223 COMM: (214) 655-7223

Table I-1. EPA Regional Program Managers

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	Telephone No.
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