UCRL-MA-118617

HOTSPOT TRAINING MANUAL

Health Physics Codes for the PC

Lawrence Livermore National Laboratory

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The examples in this manual are excerpted from UCRL-MA-106315.

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HOTSPOT Training Manual

Health Physics Codes for the PC

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HOTSPOT HEALTH PHYSICS CODES

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Lesson 1
HOTSPOT Health Physics Codes Overview

LESSON PLAN
HOTSPOT HEALTH PHYSICS CODES

LESSON 1 – HOTSPOT HEALTH PHYSICS CODES OVERVIEW

TIME:

30 minutes

LESSON LEARNING OBJECTIVES

Terminal: At the end of this lesson, students will be able to describe the HOTSPOT Health Physics Codes program.

Enabling:

- At the end of this lesson, students should be able to:

  — Describe the HOTSPOT program in terms of its capabilities, uses, system basics, general outputs, models and principles, HOTSPOT Library, terminology, formulas, and menus and their use

  — Identify the basic hardware and software required for running HOTSPOT

  — Describe the keyboard layout and basics of keyboard usage

  — Log-on and start HOTSPOT

INSTRUCTIONAL APPROACH

The mode of delivery for this lesson is lecture, using several job aids and reference materials to provide students with an overview of HOTSPOT.

EQUIPMENT AND INSTRUCTIONAL AIDS

Overhead projector
IBM PC, XT, AT, or compatible
HOTSPOT User's Manual (*HOTSPOT Health Physics Codes for the PC*)

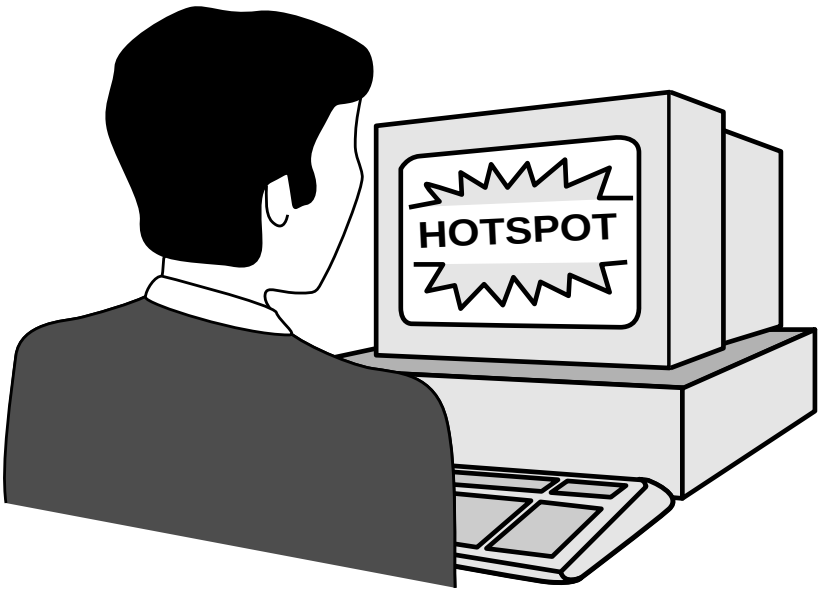
STUDENT MATERIALS

Student Manual

REFERENCES

HOTSPOT User's Manual (*HOTSPOT Health Physics Codes for the PC*)

Lesson Objectives



1-#1

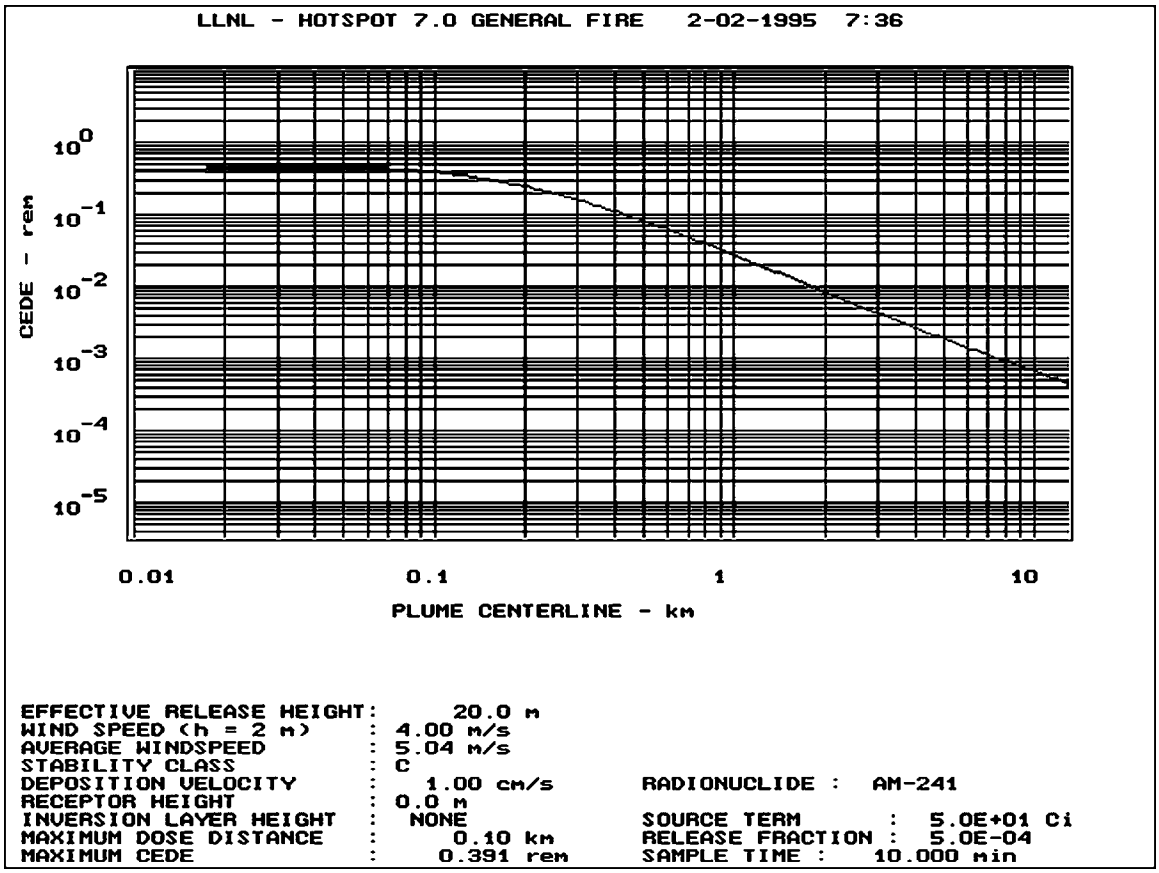
Notes:

- Briefly define Atmospheric Dispersion Modeling and describe the HOTSPOT Health Physics Code Program (HOTSPOT).
- Have students read the Lesson Objectives on the Reference page.

Lesson Objectives

- At the end of this lesson, trainees will be able to:
  - — Describe the HOTSPOT Health Physics Codes program (HOTSPOT)
  - — Describe HOTSPOT capabilities, uses, system basics, general outputs, models and principles, HOTSPOT Library, terminology, formulas, and menus and their use
  - — Identify the basic hardware and software required for running HOTSPOT
  - — Describe the keyboard layout and basics of keyboard usage

HOTSPOT Functions



1-#2

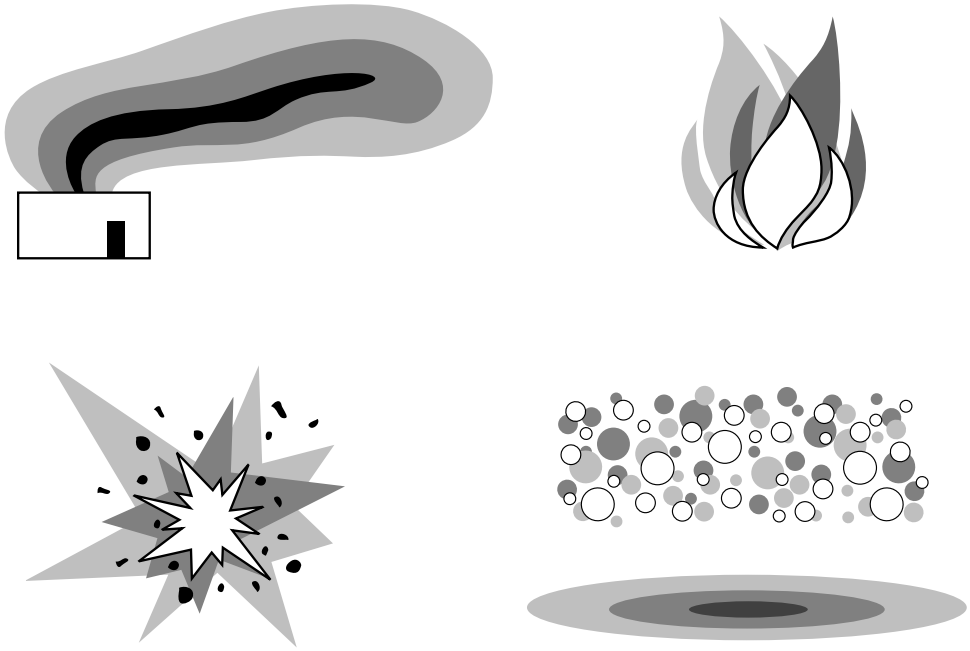
Notes:

- HOTSPOT provides a first-order approximation of the radiation effects of released materials.
- The codes are reasonably accurate and provide for consistent output.
- The use of HOTSPOT will help minimize the probability of errors in subsequent response actions.

HOTSPOT Functions

- HOTSPOT provides Health Physics personnel with a fast, field-portable calculational tool for evaluating accidents involving radioactive materials.
- HOTSPOT codes are a first-order approximation of the radiation effects associated with the atmospheric release of radioactive materials.
- HOTSPOT is reasonably accurate for a timely initial assessment.
- HOTSPOT codes produce a consistent output for the same input assumptions.
- HOTSPOT codes minimize the probability of errors associated with reading a graph incorrectly or scaling a universal nomogram during an emergency.

HOTSPOT Applications



1-#3

Notes:

- HOTSPOT consists of four general programs: Plume, Explosion, Fire, and Resuspension.
- HOTSPOT also includes other material-specific programs: Plutonium, Uranium, and Tritium.
- HOTSPOT also has programs for Radiation in the Workplace, FIDLER Calibration, LUNG Screening, and Nuclear Explosion.

HOTSPOT Applications

- HOTSPOT contains four general programs:
  - Plume
  - Explosion
  - Fire
  - Resuspension

  These programs are used to calculate a downwind assessment following the release of radioactive material resulting from a continuous or puff release, explosive release, fuel fire, or an area contamination event.

- Other HOTSPOT programs are used to initially assess plutonium, uranium, and tritium releases:
  - Plutonium Explosion
  - Plutonium Fire
  - Plutonium Resuspension
  - Uranium Explosion
  - Uranium Fire
  - Tritium Release
- HOTSPOT also includes programs for the following:
  - Radiation in the Workplace
  - FIDLER Calibration
  - LUNG Screening
  - Nuclear Explosion

Output Options

- HOTSPOT provides, for screen, printer, disk file, and graphics, several output options:

1:	**SCREEN**	Output	Default	Distances
2:	**SCREEN**	Output	You Enter	Distances
3:	**PRINTER**	Output	Default	Distances
4:	**PRINTER**	Output	You Enter	Distances
5:	**DISK FILE**	Output	Default	Distances
6:	**DISK FILE**	Output	You Enter	Distances
G:	**GRAPHICS**	Displays results in graphical format		

1-#4

Notes:

- These options enable you to perform real-time assessments, as well as create images and files for reporting purposes.
- Explain Screen options (selection 1 or 2):
  - — Type 1 for data output tables containing input values, maximum dose distance and maximum CEDE; press Enter for additional tables showing 50-year dose commitment.
  - — Type 2 for data output tables where you enter an off-axis position.
- Explain the Printer options (selection 3 or 4): Typing 3 or 4 allows you to select the HOTSPOT printer.
- Explain the Disk File options (selection 5 or 6): Typing 5 or 6 allows you to enter the destination drive and filename by which to file the data output.
- Explain the Graphics options (selection G): They are CEDE contours, Ground Deposition Contours, Centerline 50-yr CEDE vs. Distance, and Centerline Ground Deposition vs Distance.

Output Options

- HOTSPOT provides output options for screen, printer, disk file and graphics; these options enable you to perform real-time assessments, as well as create images and files for reporting purposes:

  — Type **1** for data output tables containing input values, maximum dose distance and maximum CEDE; for example:

HOTSPOT 7.0 GENERAL PLUME			
HALFLIFE:	10.720 yr	RADIONUCLIDE: KR-85	Inhalation Class: N/A
RELEASE FRACTION:	1.00E+00	SOURCE TERM:	2.0E+04 Ci
EFFECTIVE RELEASE HEIGHT:	10.00 m	FILTER EFFICIENCY:	0.000000 %
WIND SPEED (h=H-eff):	1.1 m/s	WIND SPEED (h=2 m):	1.0 m/s
DEPOSITION VELOCITY:	0.0E+00 cm/s	STABILITY CLASS:	A
INVERSION LAYER HEIGHT:	5000.0 m	RECEPTOR HEIGHT:	0.0 m
MAXIMUM DOSE DISTANCE:	<0.1 km	SAMPLE TIME	10.000 min
		MAXIMUM CEDE:	>5.4E-03 rem

  — Press **Enter** for additional tables showing 50-year dose commitment; for example:

PLUME CENTERLINE					
D =	0.10 km	D =	0.20 km	D =	0.50 km
CHI =	1.1E+01 (Ci-s)/m^3	CHI =	3.2E+00 (Ci-s)/m^3	CHI =	5.3E-01 (Ci-s)/m^3
50-YR DOSE COMMITMENT:		**50-YR DOSE COMMITMENT:**		**50-YR DOSE COMMITMENT:**	
EFFECTIVE DOSE EQUIVALENT	5.4E-03 rem	EFFECTIVE DOSE EQUIVALENT	1.5E-03 rem	EFFECTIVE DOSE EQUIVALENT	1.00E+00 2.5E-04 rem

  — Type **2** for data output tables where you enter an off-axis position.

```
Enter Distance, km, and push “Enter”
To enter an off-axis position (x, Y),
enter x  y, e. g., 3  6 for x = 3 km and y = 6 km
Push “Enter” w/o data entry to QUIT
```

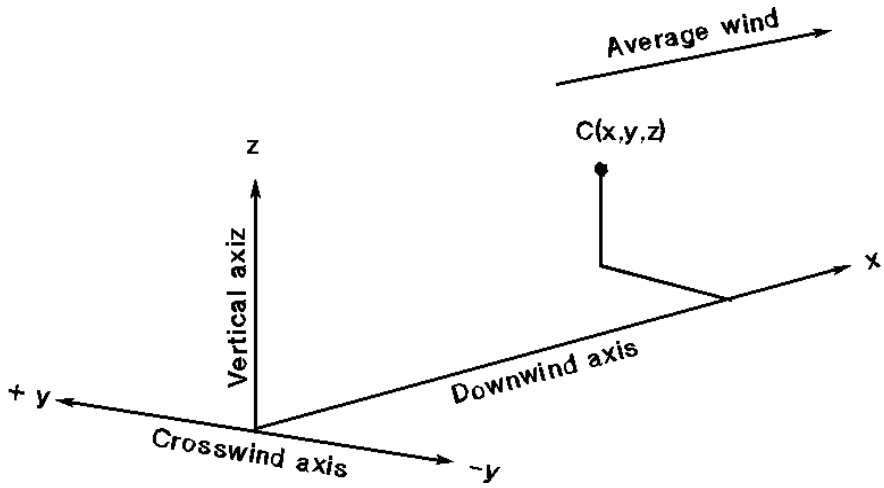
- Typing 3 or 4 allows you to select the HOTSPOT printer.

- Typing 5 or 6 allows you to enter the destination drive and filename by which to file the data output;for example:

  FILENAME . TXT
  C:\FILENAME . TXT
  B:\SUB\FILENAME . TXT
  B:\SPDSHEET . WQ1

- Graphics options (selection G): They are CEDE contours, Ground Deposition Contours, Centerline 50-yr CEDE vs. Distance, and Centerline Ground Deposition vs Distance.

Models/Principles



1-#5

Notes:

- HOTSPOT codes are based on the Gaussian Plume Model.
- Have students read the Reference page for a discussion of the following:
  - — Gaussian Plume Model
  - — HOTSPOT algorithms
  - — The dosimetric methods of ICRP Publication 30
  - — Individual doses (unweighted); 50-year committed effective dose equivalent (CEDE)
  - — Classic units (rem, rad, curie, and SI units)
  - — Dose values (inhalation)
  - — Noble gases
  - — Specific dose conversion factors
  - — Ground shine dose
  - — Alpha-emitting radionuclides

Models/Principles

- HOTSPOT uses the well-established Gaussian Plume Model, widely used for an initial emergency assessment or safety analysis planning of a radionuclide release.
- Appendix B of the *HOTSPOT Health Physcis Codes for the PC* User Manual describes the HOTSPOT algorithms in detail.
- The dosimetric methods of ICRP Publication 30 were used throughout the HOTSPOT programs.
- Individual doses (unweighted) are produced, along with the 50-year committed effective dose equivalent (CEDE).
- HOTSPOT supports both the Classic units (such as rem, rad, curie) and SI units.
- HOTSPOT dose values are due solely to the inhalation of released material during the passage of the plume.
- In the specific case of noble gases, e.g., Kr-85, the submersion dose is output.
- The specific dose conversion factors for all of the radionuclides in the HOTSPOT Library can be viewed in the “HOTSPOT Library” program.
- The ground shine dose is not included because the effective dose equivalent (per hour of stay time in the contaminated area) due to ground shine is typically several orders of magnitude less than the CEDE due to plume passage.
- For alpha-emitting radionuclides (e.g., Pu-239, Am-241), the hourly ground-shine component is at least seven orders of magnitude less than the inhalation component.

Equations

The following Gaussian model equations are used to determine the atmospheric concentration of a gas or an aerosol.

$$C(x,y,z,H) = \frac{Q}{2\pi\sigma_y\sigma_z u}\exp\left[-\frac{1}{2}\left(\frac{y}{\sigma_y}\right)^2\right]\left\{\exp\left[-\frac{1}{2}\left(\frac{z-H}{\sigma_z}\right)^2\right]+\exp\left[-\frac{1}{2}\left(\frac{z+H}{\sigma_z}\right)^2\right]\right\}\exp\left[-\frac{\lambda x}{u}\right]$$

If the inversion layer option is in effect, and s exceeds the inversion height L, the following equation is used.

$\sigma_z \rangle L$:

$$C(x,y,z,H) = \frac{Q}{\sqrt{2\pi}\sigma_y L u}\exp\left[-\frac{1}{2}\left(\frac{y}{\sigma_y}\right)^2\right]\exp\left[-\frac{\lambda x}{u}\right]$$

1-#6

Notes:

- Have students refer to the *HOTSPOT Health Physics Codes for the PC* User Manual, Appendix B.
- Discuss the Gaussian Model Algorithms, Coordinate System, and Gaussian Equations.

Equations

- Refer to Appendix A the *HOTSPOT Health Physics Codes for the PC* User Manual, Appendix B for a discussion of Gaussian Model Algorithms, Coordinate System, and Gaussian Equations.

Terminology Used to Describe HOTSPOT Output

HOTSPOT
Health Physics Codes
for the PC
User Manual

Appendix C
Glossary

1-#7

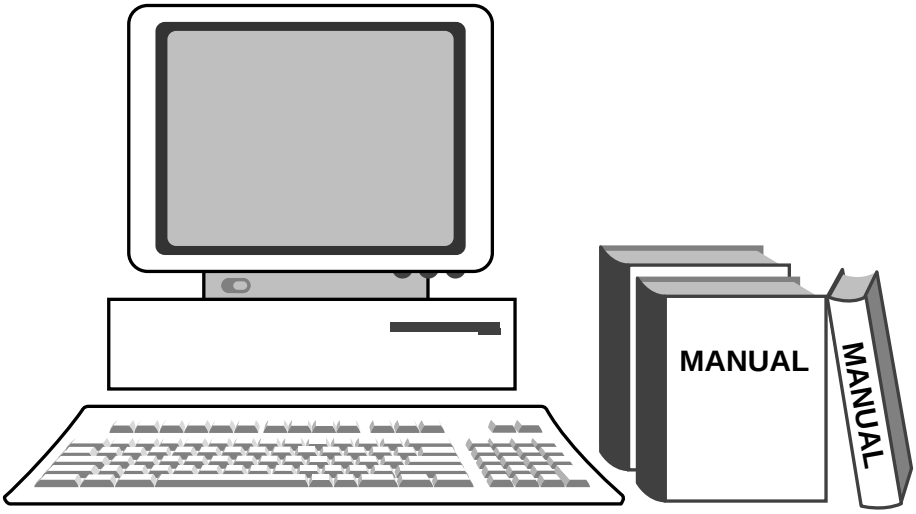
Notes:

- Have students read the HOTSPOT *Health Physics Codes for the PC* User Manual, Appendix C, the Glossary of HOTSPOT Output Definitions.

Terminology Used to Describe HOTSPOT Output

- Read the *HOTSPOT Health Physics Codes for the PC* User Manual, Appendix C, the Glossary of HOTSPOT Output Definitions.

Materials and Course Logistics



1-#8

Notes:

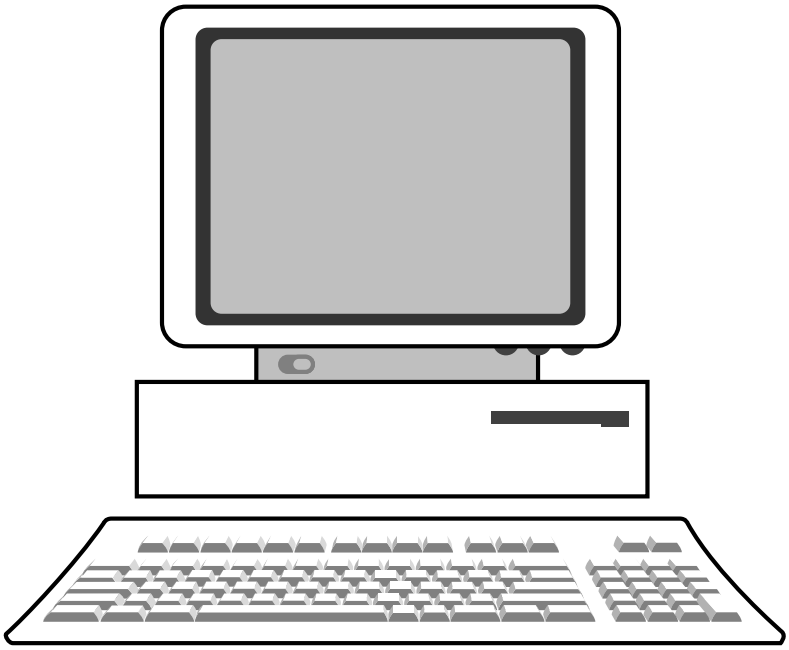
- Course materials include a Training Manual and a User Manual.
- The course includes 16 lessons, is approximately 4 hours long, and includes in-class exercises.
- Your training consists of several resources:
  - — Course instructor
  - — Course manuals
  - — HOTSPOT
  - — List of references
  - — Glossary of terms

Materials and Course Logistics

- The titles of the course manuals are as follows:
  - *HOTSPOT Health Physics Codes for the PC* by Steven G. Homann (User Manual)
  - *HOTSPOT Health Physics Codes Training Manual: Atmospheric Dispersion Modeling Training Program* by Darvin Wilson
- The titles of the course lessons are as follows:
  - Lesson 1: HOTSPOT Health Physics Codes Overview

    This lesson provides an overview of the HOTSPOT Training Program course, the computer system, HOTSPOT (specifically the Main Menu, Setup, Codes A-T, the Quit key, and the HOTSPOT Library).
  - Lesson 2: Plutonium Explosion (Code A)
  - Lesson 3: Plutonium Fire (Code B)
  - Lesson 4: Plutonium Resuspension (Code C)
  - Lesson 5: Uranium Explosion (Code D)
  - Lesson 6: Uranium Fire (Code E)
  - Lesson 7: Tritium Release (Code T)
  - Lesson 8: Nuclear Explosion (Code F)
  - Lesson 9: General Plume (Code H)
  - Lesson 10: General Explosion (Code I)
  - Lesson 11: General Fire (Code N)
  - Lesson 12: General Resuspension (Code J)
  - Lesson 13: Radiation Workplace (Code G)
  - Lesson 14: FIDLER Calibration (Code M)
  - Lesson 15: LUNG Screening (Code M)
  - Lesson 16: Output Options C, M, Z, D, O, and I

Computer System



1-#9

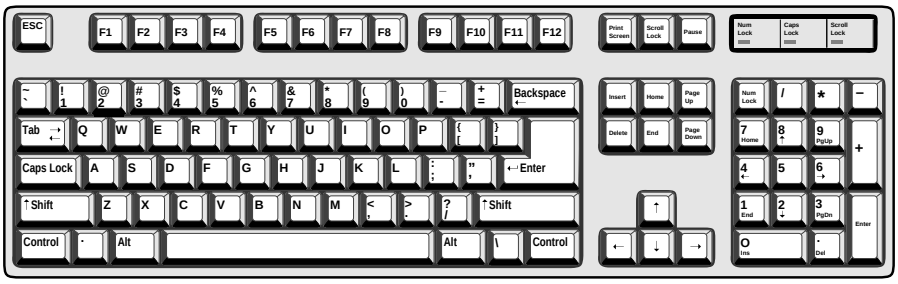
Notes:

- Hardware—HOTSPOT runs on an IBM PC, XT, AT, or compatible computer.
- Software—The required software includes HOTSPOT Health Physics Codes 7.0 and the DOS operating system (version 3.0 or later version).
- Refer to system in class.

Computer System

- The **hardware** requirements for this course are as follows:
  - — IBM PC, XT, AT, or compatible.
  - — Minimum of 512 kbytes of RAM.
  - — Single floppy disk drive (the programs run more efficiently when they reside on a hard disk).
  - — The software supports either monochrome or color monitors (CGA, EGA, VGA).
  - — Operating system = MS-DOS version 3.0 or later.
  - — HOTSPOT supports high-resolution (300 dpi) output to printers, and also to graphics files (.PCX and .BMP Files).
- The required **software** is HOTSPOT Health Physics Codes 7.01 by Steven G. Homann.

Keyboard



1-#10

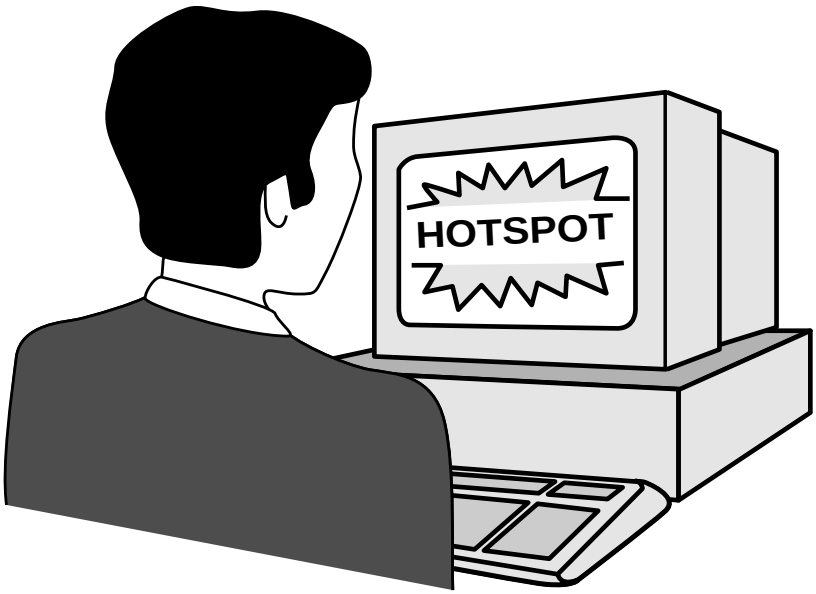
Notes:

- Explain the following common features of the keyboard:
  - — letter keys
  - — shift keys
  - — punctuation keys
  - — spacebar
  - — tab key
- Describe the keyboard's specialized keys:
  - — function keys
  - — numeric keys
  - — arrow keys
  - — ALT, CTRL, DEL, INS
  - — Home
  - — Enter
  - — Page up, Page down
  - — End
- Explain that the software in use determines the function of these keys.

Keyboard

- The keyboard is used for communicating with the computer. Using it, you can type instructions, commands, and information to be processed and stored.
- The keyboard used for inputting data into the HOTSPOT program is the standard QWERTY keyboard.
- Some features of the keyboard are like those of a typewriter: the letter keys, shift keys, punctuation keys, spacebar and tab key.
- The keyboard also contains some specialized keys: function keys, numeric keys, arrow keys, ALT, CTRL, DEL, INS, Home, Enter, Page up, Page down, Home, End. The software you are using determines what task each of these keys (or combination of keys) performs.
- Pressing the Enter key (or the Return key) allows you to enter information you have previously typed into the computer system.
- Use the Shift key together with any letter to make a capital letter.
- Use the Backspace, INS, and DEL to edit text you type.
- Page up, Page down, Home, and End keys are not used with HOTSPOT.

Logging-on and Starting HOTSPOT



1-#11

Notes:

- Describe the start-up procedure when using HOTSPOT from a single disk drive system. (Refer to Reference page.)
- Describe the start-up procedure when starting HOTSPOT from a hard disk drive. (Refer to Reference page.)
- If equipment is available in the classroom, demonstrate both procedures or have students perform these procedures at their terminals.

Logging-on and Starting HOTSPOT

- Single disk drive system

  — To access the HOTSPOT program, first load the standard DOS operating system into your computer.

  — Put the “HOTSPOT” disk in the ‘A’ drive.

  — At the DOS prompt (i.e., A>), type “**HOTSPOT**” and push **Return** (**Enter** on some computers). The HOTSPOT main menu appears.

- Starting HOTSPOT from a hard disk system

  1. Copy HOTSPOT files

  If your have a hard disk, you will probably want to copy all of the HOTSPOT files onto it. The following instructions assume that you have DOS on your hard disk and that your hard disk is assigned to be drive “C.”

  — At the DOS prompt (C>), type **MD\HOTSPOT** and push **Return**. This creates a directory named HOTSPOT.

  — Type **CD\HOTSPOT** and push **Return**. This makes HOTSPOT the current directory.

  — Place the HOTSPOT program disk into drive A.

  — Type **COPY A;*.*** and push **Return**. DOS then copies all of the files from the HOTSPOT disk to your hard disk in the current directory, HOTSPOT.

  2. Start HOTSPOT

  — Make sure the default drive letter at the DOS prompt is for the hard disk prompt, C>. If not, at the DOS prompt, type the **letter** of the hard disk and a colon. e.g., C: and push **Return**.

  — If the current directory is HOTSPOT, proceed to the next step. Otherwise, you need to access the HOTSPOT directory. At the DOS prompt, type **CD\HOTSPOT** and push **Return**. This makes HOTSPOT the current directory.

  — Type **HOTSPOT** and push **Return**. The HOTSPOT main menu appears.

Monitors

HOTSPOT
SETUP PROCEDURE

This program configures your system PRINTER and MONITOR.
HOTSPOT will automatically adjust the screen output for most monochrome monitors. However, if the display is hard to read, you should select MONOCHROME from the following options. If the contour grids displayed on the concentration contours are not square, select Option R, and adjust the GRID RATIO.

ENTER A SELECTION

M	:	MONOCHROME	**S**	:	SCREEN RESOLUTION
P	:	PRINTER/FILE	**I**	:	I/O PORT
C	:	COLOR	**R**	:	CHANGE GRID RATIO
V	:	VIEW SETTINGS	**U**	:	UNITS
L	:	SET PLOT CONTOURS	**Q**	:	QUIT
			W	:	WIND HEIGHT

1-#12

Notes:

- HOTSPOT can be run with all IBM monitors (monochrome, CGA, EGA, VGA), although a monochrome monitor may require you to reconfigure HOTSPOT.
- The following settings can be changed:
  - — **M**: Monochrome (Select M for a monochrome monitor.)
  - — **C**: Color (Select C for a color monitor.)
  - — **S: S**creen Resolution (Select S if the screen is hard to read. **S** = **L** or **H**. L is Low resolution; H is High resolution.)
  - — **R:** Change Grid Ratio. (If the contour grids displayed on the concentration contours are not square, select Option R, and adjust the Grid Ratio.)

Monitors

- HOTSPOT will automatically adjust its output to most types of monochrome monitors, but some types of monochrome monitors will require that you configure HOTSPOT differently.
- If the monochrome display is difficult to read, you will need to change the monitor setting using the SETUP program.
- At the HOTSPOT main menu, select “**S**” for SETUP, and follow the prompted instructions.
- The following settings can be changed:
  - **M**: Monochrome (Select M for a monochrome monitor.)
  - **C**: Color (Select C for a color monitor.)
  - **S**: Screen Resolution (Select S if the screen is hard to read. **S** = **L** or **H**. **L** is Low resolution; **H** is High resolution.)
  - **R**: Change Grid Ratio. (If the contour grids displayed on the concentration contours are not square, select Option R, and adjust the Grid Ratio.)

HOTSPOT Library

HOTSPOT RADIONUCLIDE LIBRARY	
1:	Look up a specific radionuclide
2:	List all radionuclides
Q:	**Quit**

1-#13

Notes:

- If equipment is available in the classroom, demonstrate these procedures or have students perform these procedures at their terminals.
- Have students select L from the HOTSPOT Main Menu.
- Ask students to look up a specific radionuclide.
- Ask students to list all radionuclides.

HOTSPOT Library

- **Step 1** Type **L** from the HOTSPOT Main Menu to select the HOTSPOT Library.
- Result The HOTSPOT Radionuclide Library Menu appears.
- **Step 2** Type **1** to look up a specific nuclide.
- **Step 3** Type in the name of a nuclide (for example, type **KR-85**).
- Result The following table appears:

Nuclide Name	**:**	KR-85
Nuclide	**:**	KRYPTON
Atomic Number	**:**	85
Particle Class	**:**	N
HalfLife	**:**	1.072E–01 years
Specific Activity	**:**	3.9E+02 Ci / g
CEDE	**:**	4.7E-04 (rem-m3) / (Ci-sec) Submersion

- **Step 4** Push **Return** to continue.
- **Step 5** Type **2** to list all radionuclides in the library.

  Press **Return** until you find the nuclide of interest.
- Result The Library displays the nuclide half-life and 50-yr CEDE conversion factor:

NUCLIDE	HALF-LIFE	50-YR CEDE CONVERSION FACTOR
KR-85	1.0720E+01	4.7E-04 (rem-m3) / (Ci-sec) SUBMERSION

- Step 6 Press **Return**
- Result You return to the HOTSPOT Radionuclide Library Menu.
- Step 7 When finished, type **Q** to quit.

HOTSPOT Main Menu and SETUP

HOTSPOT Health Physics Codes
VERSION 7.01
HAZARDS CONTROL DEPARTMENT
LAWRENCE LIVERMORE
NATIONAL LABORATORY

S: SETUP

A	**:**	Plutonium Explosion	**B**	**:**	Plutonium Fire	**C**	**:**	Plutonium Resuspension
D	**:**	Uranium Explosion	**E**	**:**	Uranium Fire	**F**	**:**	Nuclear Explosion
G	**:**	Radiation Workplace	**H**	**:**	General Plume	**I**	**:**	General Explosion
J	**:**	General Resuspension	**K**	**:**	Inhalation Dose	**T**	**:**	Tritium Release
L	**:**	HOTSPOT Library	**M**	**:**	FIDLER Calibration and LUNG Screening	**N**	**:**	General Fire

Q: QUIT

Enter Selection

1-#14

Notes:

- Describe the various Main Menu choices.
- Describe the SETUP option and explain its purpose, which is to configure the system monitor and printer.

HOTSPOT Main Menu and SETUP

- The HOTSPOT Main menu contains HOTSPOT title box and S: Setup; Q: Quit; and A through T (for specific radioactive material and type of incident).

- If you select **S** (SETUP), the HOTSPOT SETUP PROCEDURE screen appears:

HOTSPOT
SETUP PROCEDURE

This program configures your system PRINTER and MONITOR.

HOTSPOT will automatically adjust the screen output for most monochrome monitors. However, if the display is hard to read, you should select MONOCHROME from the following options. If the contour grids displayed on the concentration contours are not square, select Option R, and adjust the GRID RATIO.

ENTER A SELECTION

M	**:**	MONOCHROME	**S**	**:**	SCREEN RESOLUTION
P	**:**	PRINTER/FILE	**I**	**:**	I/O PORT
C	**:**	COLOR	**R**	**:**	CHANGE GRID RATIO
V	**:**	VIEW SETTINGS	**U**	**:**	UNITS
L	**:**	SET PLOT CONTOURS	**Q**	**:**	QUIT
			W	**:**	WIND HEIGHT

- If you enter a selection, the HOTSPOT program will adjust the setting or prompt you for more information.

- Note: Select **V** to view settings when you want to know current settings (or after you have changed settings).

Codes A-T

A	**:**	Plutonium Explosion	**B**	**:**	Plutonium Fire	**C**	**:**	Plutonium Resuspension
D	**:**	Uranium Explosion	**E**	**:**	Uranium Fire	**F**	**:**	Nuclear Explosion
G	**:**	Radiation Workplace	**H**	**:**	General Plume	**I**	**:**	General Explosion
J	**:**	General Resuspension	**K**	**:**	Inhalation Dose	**T**	**:**	Tritium Release
L	**:**	HOTSPOT Library	**M**	**:**	FIDLER Calibration and LUNG Screening	**N**	**:**	General Fire
						Q: QUIT		

Enter Selection

1-#15

Notes:

- Codes A-T

Codes A-T

- The HOTSPOT Main Menu includes Codes A-T.
- To use HOTSPOT, type in the appropriate letter to make your selection. The codes are as follows:

A	**:**	Plutonium Explosion	**B**	**:**	Plutonium Fire	**C**	**:**	Plutonium Resuspension
D	**:**	Uranium Explosion	**E**	**:**	Uranium Fire	**F**	**:**	Nuclear Explosion
G	**:**	Radiation Workplace	**H**	**:**	General Plume	**I**	**:**	General Explosion
J	**:**	General Resuspension	**K**	**:**	Inhalation Dose	**T**	**:**	Tritium Release
L	**:**	HOTSPOT Library	**M**	**:**	FIDLER Calibration and LUNG Screening	**N**	**:**	General Fire
						Q:		**QUIT**

Enter Selection

QUIT (Q Key)

A	**:**	Plutonium Explosion	**B**	**:**	Plutonium Fire	**C**	**:**	Plutonium Resuspension
D	**:**	Uranium Explosion	**E**	**:**	Uranium Fire	**F**	**:**	Nuclear Explosion
G	**:**	Radiation Workplace	**H**	**:**	General Plume	**I**	**:**	General Explosion
J	**:**	General Resuspension	**K**	**:**	Inhalation Dose	**T**	**:**	Tritium Release
L	**:**	HOTSPOT Library	**M**	**:**	FIDLER Calibration and LUNG Screening	**N**	**:**	General Fire
						Q:		**QUIT**

Enter Selection

1-#16

Notes:

- Explain the QUIT option and the Q Key.

QUIT (Q Key)

- The HOTSPOT Main Menu contains a Q: QUIT selection.
- To quit the program from the Main Menu, simply type **Q**
- Some other HOTSPOT screens include the Quit option; in such cases, type **Q** if you wish to return to the main menu or quit the program.

Lesson 2
Plutonium Explosion
Code A

LESSON PLAN
HOTSPOT HEALTH PHYSICS CODES

LESSON 2 – Plutonium Explosion, Code A

TIME:

30 minutes

LESSON LEARNING OBJECTIVES

Terminal: At the end of this lesson, students will be able to model a plutonium explosion involving released material, using the Plutonium Explosion Code A Atmospheric Dispersion Model of the HOTSPOT Health Physics program.

Enabling:

- When you complete this lesson, you should be able to do the following:
  - — Describe the graphical output for a Plutonium Explosion Atmospheric Dispersion Model
  - — Explain the assumptions involved in deriving Plutonium Explosion output (tabular and graphical)
  - — Given mock data, generate Plutonium Explosion output (tabular and graphical)

INSTRUCTIONAL APPROACH

The mode of delivery for this lesson is lecture, using several job aids and reference materials to provide students with an overview of the HOTSPOT Health Physics Codes application.

EQUIPMENT AND INSTRUCTIONAL AIDS

Overhead projector
IBM PC, XT, AT, or compatible
HOTSPOT User's Manual (*HOTSPOT Health Physics Codes for the PC*)
Exercise Number 2–1

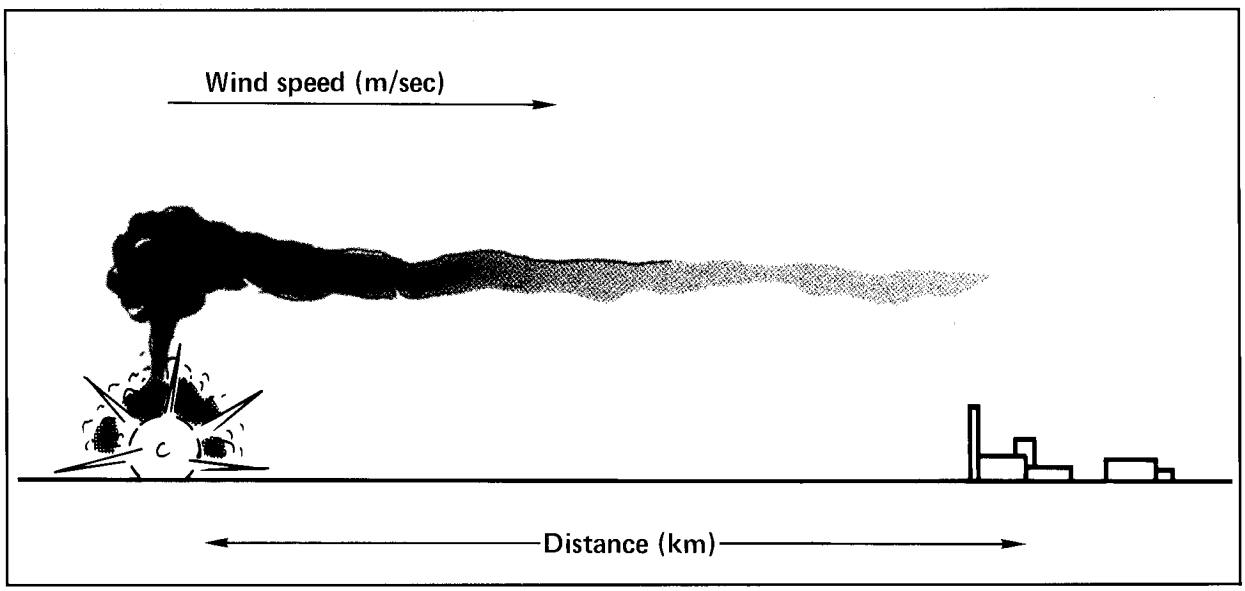
STUDENT MATERIALS

Student Manual

REFERENCES

HOTSPOT User's Manual (*HOTSPOT Health Physics Codes for the PC)*

Lesson Objectives



2-#1

Notes:

Lesson Objectives

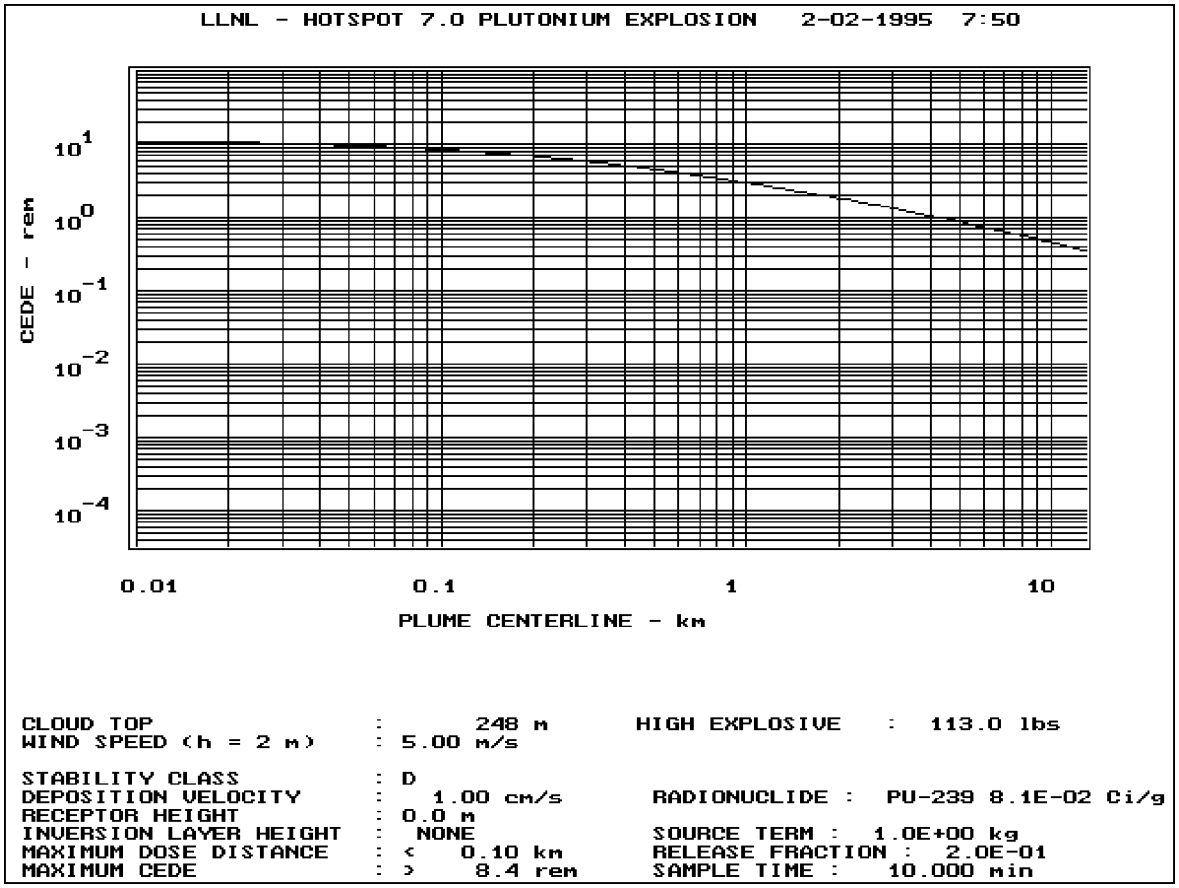
- At the end of this lesson, students will be able to model a plutonium explosion involving released material, using the Plutonium Explosion Code A Atmospheric Dispersion Model of the HOTSPOT Health Physics Codes program.

- Explain the Lesson Objectives.

Lesson Objectives

- At the end of this lesson, students should be able to:
  - — Describe the graphical output for a Plutonium Explosion Atmospheric Dispersion Model
  - — Explain the assumptions involved in deriving Plutonium Explosion output (tables and graphs)
  - — Given mock data, generate Plutonium Explosion output (tables and graphs)

Graphical Output and Assumptions—Plutonium Explosion



2-#2

Notes:

- Have students refer to Page 2-3, Plutonium Explosion: Graphical Output.
- Discuss the assumptions concerning the Plutonium Explosion incident.

Graphical Output and Assumptions—Plutonium Explosion

- Page 2-3 illustrates output for a Plutonium Explosion Atmospheric Dispersion Model derived from the HOTSPOT Health Physics Codes program.

- This example is based on the following assumptions:

  — Deposition velocity of the respirable fraction (AMAD = 1 micron) is 1 cm/sec.

  — Deposition velocity of the non-respirable fraction (AMAD = 40 micron) is 8 cm/sec. The non-respirable fraction equals 1-f, where f is the respirable fraction. The default value for f is 0.2 (20 % of the material involved in the explosion has an AMAD of 1 micron). The non-respirable fraction is used for deposition estimates only, and does not contribute to the inhalation dose values.

  — Default alpha specific activity of weapons-grade plutonium is 0.081 Curies/gram.

  — Inhalation class is Y.

  — Standard-person breathing rate is 1.2 cubic meters/hour.

  — In Operation Roller Coaster, a series of explosive release mitigation studies was carried out at the Department of Energy's Nevada Test Site. One of the tests, named Double Tracks, involved the explosive release of plutonium using 113 pounds of high explosive. The test was performed at three in the morning and the wind speed was 5 meters/second at a height of 2 meters. Compare the HOTSPOT estimates with the actual test measurements. The experimental results were normalized to a 1 kilogram initial mass of plutonium, so use 1 kg as the total mass of plutonium involved in the explosion (Dewart et al, 1982). The HOTSPOT output is in good agreement with the measured air concentration and ground deposition data.

Code Description: Plutonium Explosion

HOTSPOT 7.0	**PLUTONIUM EXPLOSION**		
RADIONUCLIDE:	PU-239 Inhalation Class : Y		
HALFLIFE	2.4E+04 yrs		
SOURCE TERM:	1.0E+00 kg		
RELEASE FRACTION:	2.0E-01		
HIGH EXPLOSIVE:	113.0 lbs		
CLOUD TOP	248 m		
WIND SPEED (h = 2 m)	5.0 m/s		
STABILITY CLASS:	D	DEPOSITION VELOCITY:	1.00 cm/s
RECEPTOR HEIGHT	0.0 m	INVERSION LAYER HEIGHT:	NONE
MAXIMUM DOSE DISTANCE:	<0.10 km	MAXIMUM CEDE:	>8.4 rem
Plume Centerline			

D =	0.10 km	**D =**	0.20 km	**D =**	0.50 km
DEP =	2.4E+01 mCi/m^2	**DEP =**	1.9E+01 mCi/m^2	**DEP =**	1.2E+01 mCi/m^2
CHI =	7.7E–05 (Ci-s)/m^3	**CHI =**	6.3E–05 (Ci-s)/m^3	**CHI =**	4.1E–05 (Ci-s)/m^3
50-YR DOSE COMMITMENT:		**50-YR DOSE COMMITMENT:**		**50-YR DOSE COMMITMENT:**	
LUNG	3.1E+01 rem	**LUNG**	2.5E+01 rem	**LUNG**	1.6E+01 rem
SURFACE BONE	9.0E+01 rem	**SURFACE BONE**	7.3E+01 rem	**SURFACE BONE**	4.8E+01 rem
RED MARROW	7.2E+00 rem	**RED MARROW**	5.8E+00 rem	**RED MARROW**	3.8E+00 rem
LIVER	2.0E+01 rem	**LIVER**	1.6E+01 rem	**LIVER**	1.1E+01 rem
EFFECTIVE DOSE EQUIVALENT	8.4E+00 rem	**EFFECTIVE DOSE EQUIVALENT**	6.9E+00rem	**EFFECTIVE DOSE EQUIVALENT**	4.5E+00 rem
D =	1.00 km	**D =**	2.00 km	**D =**	5.00 km
DEP =	8.1E+00 mCi/m^2	**DEP =**	4.8E+00 mCi/m^2	**DEP =**	2.1E+00 mCi/m^2
CHI =	2.7E–05 (Ci-s)/m^3	**CHI =**	1.7E–05 (Ci-s)/m^3	**CHI =**	8.0E–06 (Ci-s)/m^3
50-YR DOSE COMMITMENT:		**50-YR DOSE COMMITMENT:**		**50-YR DOSE COMMITMENT:**	
LUNG	1.1E+01 rem	**LUNG**	6.7E+00 rem	**LUNG**	3.2E+00 rem
SURFACE BONE	3.2E+01 rem	**SURFACE BONE**	1.9E+01 rem	**SURFACE BONE**	9.3E+00 rem
RED MARROW	2.5E+00 rem	**RED MARROW**	1.6E+00 rem	**RED MARROW**	7.5E–01 rem
LIVER	7.0E+00 rem	**LIVER**	4.3E+00 rem	**LIVER**	2.1E+00 rem
EFFECTIVE DOSE EQUIVALENT	3.0E–00 rem	**EFFECTIVE DOSE EQUIVALENT**	1.8E+00 rem	**EFFECTIVE DOSE EQUIVALENT**	8.8E–01 rem
D =	10.00 km	**D =**	20.00 km	**D =**	50.00 km
DEP =	1.0E+00 mCi/m^2	**DEP =**	3.7E–01 mCi/m^2	**DEP =**	7.1E–02 mCi/m^2
CHI =	4.2E–06 (Ci-s)/m^3	**CHI =**	2.0E–06 (Ci-s)/m^3	**CHI =**	6.9E–07 (Ci-s)/m^3
50-YR DOSE COMMITMENT:		**50-YR DOSE COMMITMENT:**		**50-YR DOSE COMMITMENT:**	
LUNG	1.7E+00 rem	**LUNG**	8.0E–01 rem	**LUNG**	2.7E–01 rem
SURFACE BONE	4.9E+00 rem	**SURFACE BONE**	2.3E+00 rem	**SURFACE BONE**	8.0E–01 rem
RED MARROW	3.9E–01 rem	**RED MARROW**	1.9E–01 rem	**RED MARROW**	6.4E–02 rem
LIVER	1.1E+00 rem	**LIVER**	5.2E–01 rem	**LIVER**	1.8E–01 rem
EFFECTIVE DOSE EQUIVALENT	4.6E–01 rem	**EFFECTIVE DOSE EQUIVALENT**	2.2E–01 rem	**EFFECTIVE DOSE EQUIVALENT**	7.5E–02 rem

2-#3

Notes:

- Describe the code used to derive the Plutonium Explosion Atmospheric Dispersion Model discussed in this lesson.

Code Description: Plutonium Explosion

- Code description — Study the table on page 2-5.

Demonstration: Plutonium Explosion

HOTSPOT Health Physics Codes
VERSION 7.0
HAZARDS CONTROL DEPARTMENT
LAWRENCE LIVERMORE
NATIONAL LABORATORY

S: SETUP

A : Plutonium Explosion	**B** : Plutonium Fire	**C** : Plutonium Resuspension
D : Uranium Explosion	**E** : Uranium Fire	**F** : Nuclear Explosion
G : Radiation Workplace	**H** : General Plume	**I** : General Explosion
J : General Resuspension	**K** : Inhalation Dose	**T** : Tritium Release
L : HOTSPOT Library	**M** : FIDLER Calibration and LUNG Screening	**N** : General Fire
		Q: QUIT

Enter Selection

2-#4

Notes:

- Describe the steps involved in using HOTSPOT to model Explosion incident involving Plutonium.
- Explain that the students should use the reference for detailed information.
- Code—Explain that the students must select the specific code related to the type of incident. In this example, the students must select Code A (Plutonium Explosion) from the HOTSPOT Main Menu.
- Inform the students that sometimes they must press Enter (or Return) in order for the computer system to accept data which they type.
- MASS (Pu), kg—Define mass as the total quantity of plutonium involved in the explosion (kilograms).
- ALPHA SPECIFIC ACTIVITY = 0.081 Ci/g ? (Y/N)—This is the default weapons-grade value; explain alpha specific activity to the students.

Demonstration: Plutonium Explosion

- Select Plutonium Explosion from the HOTSPOT Main Menu.
- **Step 1** Type **A**
- MASS (Pu), kg

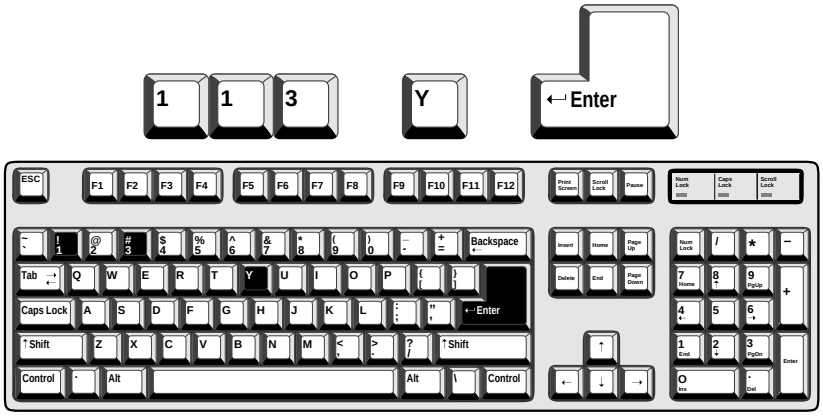
Enter the total quantity of plutonium involved in the explosion (kilograms), and push Enter.

- **Step 2** Type **1**; press **Enter**
- ALPHA SPECIFIC ACTIVITY = 0.081 Ci/g ? (Y/N)

Enter “Y” to accept the default weapons-grade value, or “N” if you wish to enter a new value.

- **Step 3** Type **Y**; press **Enter**

Demonstration: Plutonium Explosion



2-#5

Notes:

- HIGH EXPLOSIVE, LB?—Tell the students that this field requires the quantity of explosive (pounds). In this example, it is 113.
- F = 2.000E–01? (Y/N)—Explain the concept of “fraction of the entered activity.”

Demonstration: Plutonium Explosion

- HIGH EXPLOSIVE, LB?

Enter the quantity of explosive (pounds), and push Enter. Input must be greater than or equal to 0.1.

- **Step 4** Type **113**; press **Enter**
- F = 2.000E–01 ? (Y?N)

F is the fraction of entered activity released and dispersed into an AMAD of one micron. Enter “Y” to accept the default value, or “N” if you wish to enter a new value.

- **Step 5** Type **Y**; press **Enter**

Demonstration: Plutonium Explosion

• Meteorological Conditions

Choose appropriate meteorological conditions from the following menu—Enter a NUMBER or LETTER.

1. Sun HIGH in the sky
2. Sun LOW in the sky or cloudy
3. NIGHT

Or, if you prefer to enter a specific stability classification,

A	:	A stability	Very unstable
B	:	B stability	Moderately unstable
C	:	C stability	Slightly unstable
D	:	D stability	Neutral
E	:	E stability	Slightly stable
F	:	F stability	Moderately stable
G	:	G stability	Special nighttime, low wind

Enter selection

2-#6

Notes:

- Meteorological Conditions—Explain that the students may enter a number (1, 2, or 3) to specify the meteorological condition (sun high in sky; sun low in sky or cloudy; night) or a letter (A–G) to specify a stability class.
- Refer students to the Meteorological Conditions screen display.
- In this example, the number 3 indicates the correct meteorological condition (NIGHT).

Demonstration: Plutonium Explosion

- Meteorological Conditions

Enter a number or a letter to indicate appropriate meteorological conditions.

- **Step 6** Type **3** to indicate the meteorological condition (NIGHT).

Demonstration: Plutonium Explosion

NAME OF WIND	OBSERVABLE FEATURES	MPH	M/S
calm	Smoke rises vertically	<1	<0.5
light Atmospheric	Smoke drifts downward	1 – 3	0.5 – 1
light breeze	Wind felt on face; leaves rustle	3 – 7	1 – 3
gentle breeze	Leaves and twigs in constant motion	7 – 12	3 – 5
moderate breeze	Raises dust and loose paper	12 – 18	5 – 8
fresh breeze	Small tress begin to sway	18 – 24	8 – 11
strong breeze	Large branches in motion	24 – 31	11 – 14
moderate gale	Whole trees in motion	31 – 38	14 – 17
fresh gale	Twigs break off; walking impeded	38 – 46	17 – 21
strong gale	Slight structural damage occurs	46 – 54	21 – 24
whole gale	Tree uprooted; structural damage	54 – 63	24 – 28
storm	Very rare, widespread destruction	63 – 75	28 – 34
hurricane		>75	>34

2-#7

Notes:

- Wind—Refer students to the Wind screen display.

Demonstration: Plutonium Explosion

- WIND?

  Enter the ground wind speed, in meters/second, and press ENTER (1 mph = 0.45 m/s).

- **Step 7** Type **5**

  Press the **Enter** key.

Demonstration: Plutonium Explosion

- Main Output Options Menu

Main Output Options Menu					
1	:	SCREEN	Output	Default	Distances
2	:	SCREEN	Output	You Enter	Distances
3	:	PRINTER	Output	Default	Distances
4	:	PRINTER	Output	You Enter	Distances
5	:	DISK FILE	Output	Default	Distances
6	:	DISK FILE	Output	You Enter	Distances
G	:	GRAPHICS			
C	:	Change DEFAULT CONTOUR SETTINGS			
M	:	Change METEOROLOGICAL PARAMETERS and Release Height			
Z	:	Change RECEPTOR HEIGHT (z)			
D	:	Change DEPOSITION VELOCITY			
O	:	Enable prompt for OFF AXIS Positions			
I	:	INVERSION HEIGHT (Mixing Layer)			
Q	:	Enter to Main HOTSPOT Menu.			

2-#8

Notes:

- Screen output—Explain that students should select **1**, screen output using the default distances.

- Data tables—The students must type **1** and press **Return** to view the data tables.

Demonstration: Plutonium Explosion

- Main Outputs Options Menu
- Screen output
- **Step 8** Type **1** to view data tables.

  Press **Enter** view more data.

  Continue pressing **Enter** until you view all the data.

  After you have viewed all the data, the following message appears:

“Enter the appropriate Output option number from the following menu.”

- Look at the Output Option Number Menu.

Demonstration: Plutonium Explosion

- Output Option Number Menu

1: Enter a new Downwind Distance
2: Return to Output Menu
Q: Return to Main HOTSPOT Menu

2-#9

Notes:

- Explain that students must type **2** at the Output Option Number Menu to return to the Main HOTSPOT Menu.

Demonstration: Plutonium Explosion

- Output Option Number Menu
- **Step 9** Type **2** at the Output Option Number Menu to return to the Output Menu.

  Press **Enter**

Demonstration: Plutonium Explosion

- Main Output Options Menu—Option G

Main Output Options Menu

1	:	SCREEN	Output	Default	Distances
2	:	SCREEN	Output	You Enter	Distances
3	:	PRINTER	Output	Default	Distances
4	:	PRINTER	Output	You Enter	Distances
5	:	DISK FILE	Output	Default	Distances
6	:	DISK FILE	Output	You Enter	Distances
G	:	GRAPHICS			
C	:	Change DEFAULT CONTOUR SETTINGS			
M	:	Change METEOROLOGICAL PARAMETERS and Release Height			
Z	:	Change RECEPTOR HEIGHT (z)			
D	:	Change DEPOSITION VELOCITY			
O	:	Enable prompt for OFF AXIS Positions			
I	:	INVERSION HEIGHT (Mixing Layer)			
Q	:	Enter to Main HOTSPOT Menu.			

2-#10

Notes:

- Main Output Options Menu: Option G—Explain that students need to use option G to see graphical representations of the results of the example incident.

Demonstration: Plutonium Explosion

- Option G—Graphics
- **Step 10** Type **G** for Graphics.
- Result An Output option number menu appears.

Demonstration: Plutonium Explosion

1:	CEDE Contours
2:	GROUND DEPOSITION Contours
3:	Centerline 50-yr. CEDE vs. Distance
C:	Change Graphics Output File Name

TO PRINT GRAPHICS—PUSH the “P” key when the screen output is complete.

Select your printer using the SETUP option at the Main HOTSPOT MENU.

2-#11

Notes:

- Output Option Number Menu
- Students may view Centerline 50-yr. CEDE vs. Distance graphical output by typing the number 3.
- Color/Monochrome—Have students type the number 1 or 2.
- Downwind Plotting Range—Have the students type 1 or 2.
- Print—If they have printer capability, the students may press P to print the graphical results (same graph as Page 2-3).

Demonstration: Plutonium Explosion

- **Step 11** Type **3** to view Centerline 50-yr. CEDE vs. Distance graphical output.

- Result The following selection box appears:

1: COLOR
2: MONOCHROME / LCD

- **Step 12** Type **2** for monochrome, unless you have a color monitor, in which case, you must type 1

- Result The following selection box appears:

DOWNWIND PLOTTING RANGE **ENTER SELECTION NUMBER**
1: 0.01 TO 10 km
2: 0.1 TO 100 km

- **Step 13** Type **1**

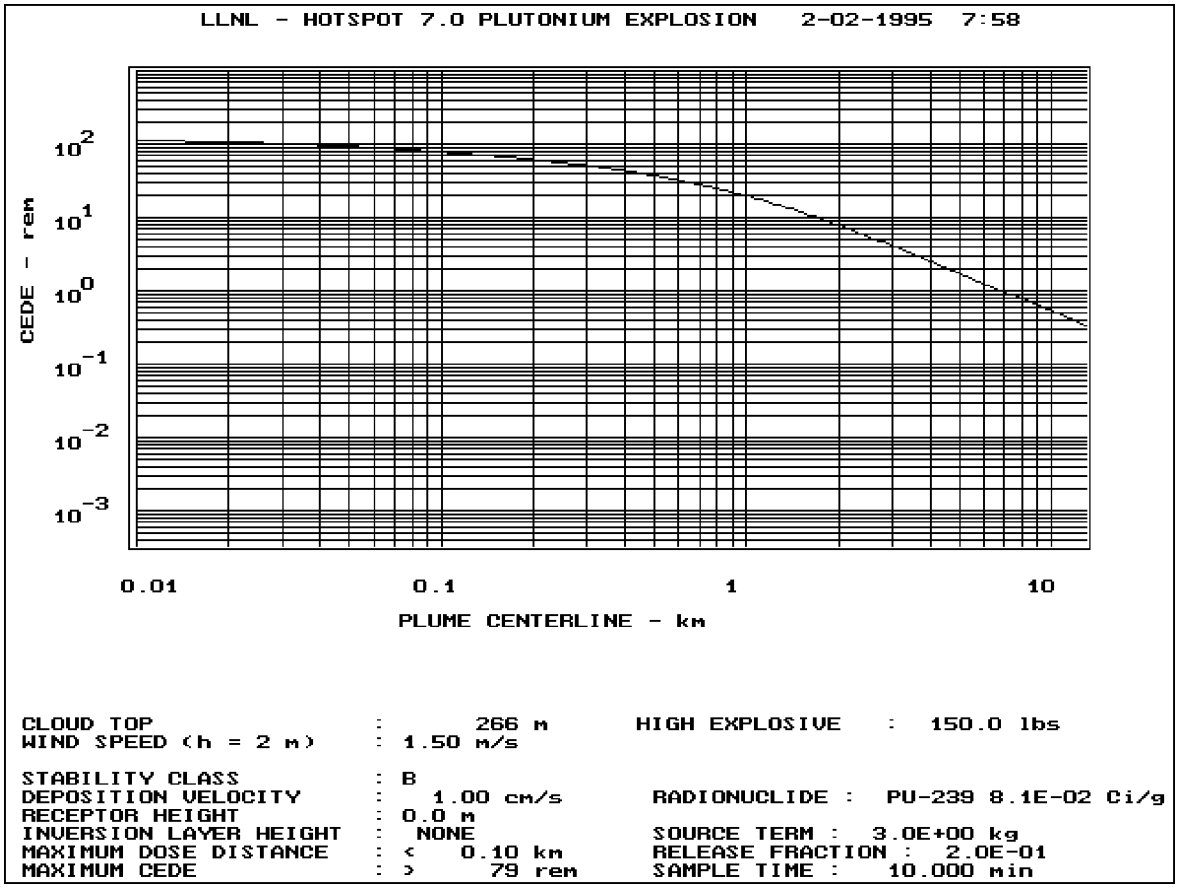
  The result is a graph.

- Print (if you have printer capability).

  Step 14 Press **P** to print the graph.

Exercise 2-1: Plutonium Explosion

- Exercise (Pu-239)



2-#12

Notes:

- Distribute Exercise for Plutonium Explosion involving pu-239 (Appendix B contains all exercises; use these to duplicate as many copies as needed for trainees).
- Display Overhead.
- Explain that students may consult the Reference page if they wish.
- Exercise Answers: Maximum Dose Distance = <0.1 km
  Maximum CEDE = >79 rem

Exercise 2-1: Plutonium Explosion

- Page 2-23 illustrates the graphical output for a Plutonium Explosion Atmospheric Dispersion Model derived from the HOTSPOT Health Physics Codes program.

- The example for this exercise is based on the following assumptions:

  — Three kilograms of weapons-grade plutonium are involved in a one-point detonation (150 pounds of high explosive). The sun is low, and the wind speed is 1.5 meters per second. Estimate the ground contamination and dose commitments for locations downwind (centerline of plume) from the event. Assume default release fraction (20%) and specific activity (0.081 Ci/g).

- **Step 1** From the HOTSPOT Main Menu, select **A**

- **Step 2** MASS? Type **3**; press **Enter**

- **Step 3** Alpha Specific Activity? Type **Y**; press **Enter**

- **Step 4** High Explosive? Type **150**; press **Enter**

- **Step 5** F= ? Type **Y** to accept the default value.

- **Step 6** Condition? Type **2** (for sun LOW in sky).

- **Step 7** Wind? Type **1.5** (for 1.5 meters/second); press **Enter**

- **Step 8** Type **1** at the Main Outputs Options Menu to view data table; press **Enter** as desired to view more data.

- **Step 9** Type **1** at the Outputs Option Number Menu to enter downwind distance.

- **Step 10** Type **2** to return to the Output Menu.

- **Step 11** Type **G** (graphics).

- **Step 12** Type **3** to view Centerline 50-yr. CEDE vs. Distance.

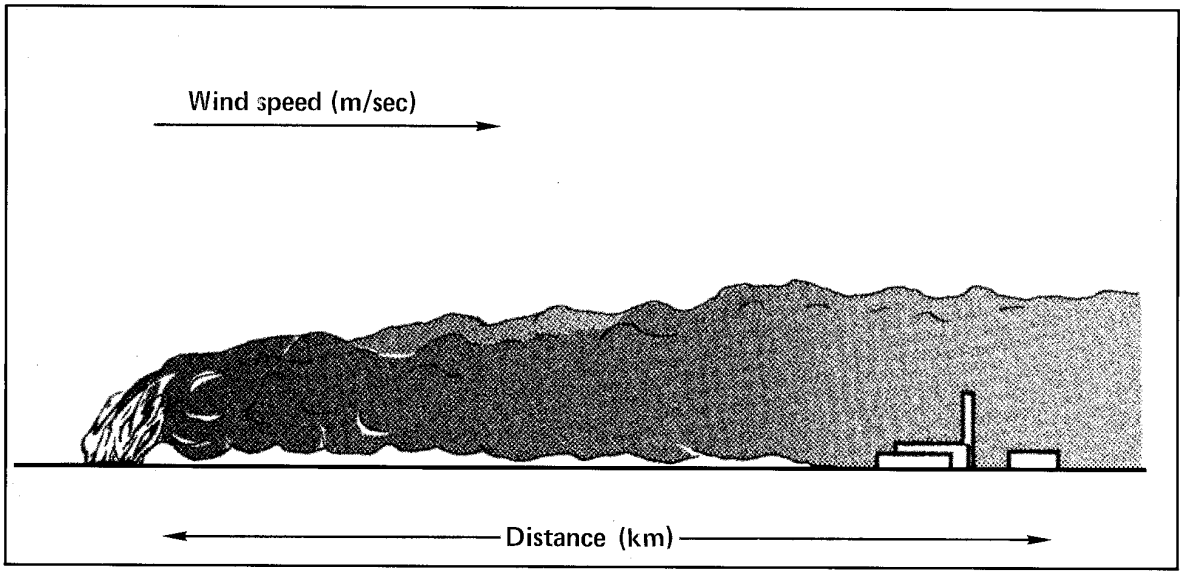
- **Step 13** Type **1** to select color.

- **Step 14** Type **1** to enter downwind plotting range.

The result is the graph shown on the previous page of this manual.

Lesson 3
Plutonium Fire
Code B

Lesson Objectives



3-#1

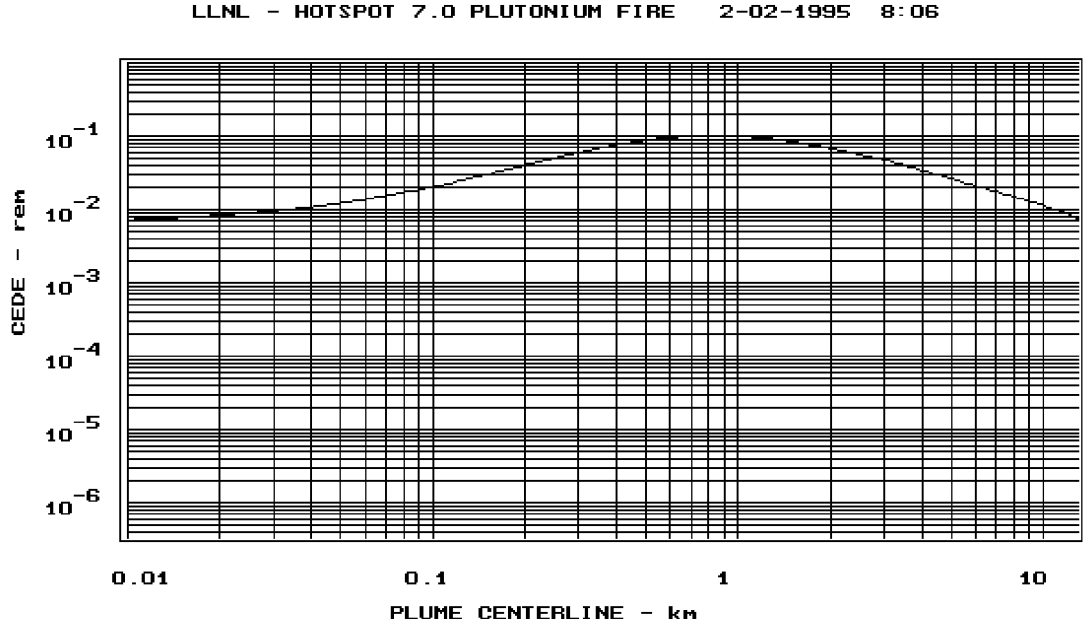
Notes:

- At the end of this lesson, students should be able to model a plutonium fire involving released material, using the Plutonium Fire Code B Atmospheric Dispersion Model.
- Explain the Lesson Objectives.

Lesson Objectives

- At the end of this lesson, students should be able to:
  - Describe the graphical output for a Plutonium Fire Atmospheric Dispersion Model
  - Explain the assumptions involved in deriving Plutonium Fire output (tables and graphs)
  - Given mock data, generate Plutonium Fire output (tables and graphs)

Graphical Output and Assumptions—Plutonium Fire



FIRE DURATION	: 20.00 min		
EFFECTIVE RELEASE HEIGHT	: 47 m	FUEL :	3.0E+01 gal
WIND SPEED (h = 2 m)	: 2.00 m/s		
AVERAGE WINDSPEED	: 6.05 m/s	FIRE DURATION :	20.00 min
STABILITY CLASS	: E	RELEASE RADIUS :	1.9 m
DEPOSITION VELOCITY	: 1.00 cm/s	RADIONUCLIDE :	PU-239 8.1E-02 Ci/g
RECEPTOR HEIGHT	: 0.0 m		
INVERSION LAYER HEIGHT	: NONE	SOURCE TERM :	3.0E+00 kg
MAXIMUM DOSE DISTANCE	: 0.84 km	RELEASE FRACTION :	5.0E-04
MAXIMUM CEDE	: 0.102 rem	SAMPLE TIME :	10.000 min

3-#2

Notes:

- Have students refer to Page 3-3,Plutonium Fire: Graphical Output.
- Discuss the assumptions concerning the Plutonium Fire incident, as described on the Reference page.

Graphical Output and Assumption—Plutonium Fire

- Page 3-3 illustrates output for a Plutonium Fire Atmospheric Dispersion Model derived from the HOTSPOT Health Physics Codes program.

- This example is based on the following assumptions:

  — The default respirable fraction of the total plutonium involved in the fire that is released is $5x10^{-4}$ (0.05 %). The respirable fraction is defined as the fraction of the released material associated with an Activity Median Aerodynamic Diameter (AMAD), of 1 micrometer (See User Manual, Appendix A). The default ICRP-30 internal dosimetry conversion factors also assume a 1 m AMAD particle size distribution.

  — The effective release height is determined using the methodology contained in the "Fuel Fire" section of Appendix A. Once the effective release height is determined, the radius of the final bent-over plume is set equal to 60% of the effective release height (Hanna, 1982). An upwind virtual point source, which results in an initial $_y$ and $_z$ equal to 50% of the plume radius at the origin (i.e., plume radius = 2), is used to model the fire scenario.

  — Deposition velocity is 1 cm/sec.

  — Default alpha specific activity of weapons-grade plutonium is 0.081 Curies/gram.

  — Inhalation class is Y.

  — Standard-person breathing rate is 1.2 cubic meters/hour.

  — Three kilograms of weapons-grade plutonium are involved in a fire due to 30 gallons of fuel burning for fourteen minutes. The effective diameter of the fire zone is 20 meters. Use the default release fraction of 0.05% and assume the material was released during a 10-minute time period (10 minutes is the default HOTSPOT value) during the 14-minute fire duration. The sun has set, the wind speed is 2 meters/second, and the temperature is 20 degrees centigrade. Estimate the 50-year committed effective dose commitments to individuals remaining downwind throughout the entire fire.

Code Description: Plutonium Fire

```
HOTSPOT 7.0                          PLUTONIUM FIRE
RADIONUCLIDE :                       PU-239 Inhalation Class : Y
HALFLIFE     :                       2.4E+04 Years
SOURCE TERM      :                   3.0E+00 kg
RELEASE FRACTION :                   5.0E-04
FUEL           :                     3.0E+01 gal        FIRE DURATION    :        14.00 min
EFFECTIVE RELEASE HEIGHT :           40.00 m
WIND SPEED (h = 2 m)     :           2.0 m/s            RELEASE RADIUS :          10 m
WIND SPEED (h = H-eff)   :           5.7 m/s
STABILITY CLASS          :           E                  DEPOSITION VELOCITY     :  1.00 cm/s
RECEPTOR HEIGHT          :           0.0 m              INVERSION LAYER HEIGHT  : NONE
SAMPLE TIME              :           10.0 min
MAXIMUM DOSE DISTANCE    :           0.67 km            MAXIMUM CEDE   :          0.160 rem
Plume Centerline

D   =      0.10 km                   D   =      0.20 km                   D   =  0.50 km
DEP =      3.7E-03 uCi/m^2           DEP =      7.3E-03 uCi/m^2           DEP =  1.4E-02 uCi/m^2
CHI =      3.7E-07 (Ci-s)/m^3        CHI =      7.3E-07 (Ci-s)/m^3        CHI =  1.4E-06 (Ci-s)/m^3

50-YR DOSE COMMITMENT:               50-YR DOSE COMMITMENT:               50-YR DOSE COMMITMENT:
-----------------------------------  -----------------------------------  -----------------------------------
LUNG                 1.5E-01 rem     LUNG                 2.9E-01 rem     LUNG                 5.6E-01 rem
SURFACE BONE  4.3E-01 rem            SURFACE BONE  8.5E-01 rem            SURFACE BONE  1.6E+00 rem
RED MARROW       3.4E-02 rem         RED MARROW       6.8E-02 rem         RED MARROW       1.3E-01 rem
LIVER                9.6E-02 rem     LIVER                1.9E-01 rem     LIVER                3.6E-01 rem
EFFECTIVE DOSE                       EFFECTIVE DOSE                       EFFECTIVE DOSE
EQUIVALENT           4.1E-02 rem     EQUIVALENT           8.0E-02 rem     EQUIVALENT           1.5E-01 rem

D   =      1.00 km                   D   =      2.00 km                   D   =      5.00 km
DEP =      1.3E-02 uCi/m^2           DEP =      7.9E-03 uCi/m^2           DEP =      2.7E-03 uCi/m^2
CHI =      1.3E-06 (Ci-s)/m^3        CHI =      7.9E-07 (Ci-s)/m^3        CHI =      2.7E-07 (Ci-s)/m^3

50-YR DOSE COMMITMENT:               50-YR DOSE COMMITMENT:               50-YR DOSE COMMITMENT:
-----------------------------------  -----------------------------------  -----------------------------------
LUNG                 5.3E-01 rem     LUNG                 3.1E-01 rem     LUNG                 1.1E-01 rem
SURFACE BONE  1.6E+00 rem            SURFACE BONE  9.2E-01 rem            SURFACE BONE  3.1E-01 rem
RED MARROW       1.2E-01 rem         RED MARROW       7.3E-02 rem         RED MARROW       2.5E-02 rem
LIVER                3.5E-01 rem     LIVER                2.0E-01 rem     LIVER                6.9E-02 rem
EFFECTIVE DOSE                       EFFECTIVE DOSE                       EFFECTIVE DOSE
EQUIVALENT           1.5E-01 rem     EQUIVALENT           8.6E-02 rem     EQUIVALENT           2.9E-02 rem
```

3#3

Notes:

- Describe the code used to derive the Plutonium Fire Atmospheric Dispersion Model illustrated in this lesson.

Code Description: Plutonium Fire

- Code description — Study the table on page 3-5.

Demonstration: Plutonium Fire

HOTSPOT Health Physics Codes
VERSION 7.01
HAZARDS CONTROL DEPARTMENT
LAWRENCE LIVERMORE
NATIONAL LABORATORY

S: SETUP

A: Plutonium Explosion	B: Plutonium Fire	C: Plutonium Resuspension
D: Uranium Explosion	E: Uranium Fire	F: Nuclear Explosion
G: Radiation Workplace	H: General Plume	I: General Explosion
J: General Resuspension	K: Inhalation Dose	T: Tritium Release
L: HOTSPOT Library	M: FIDLER Calibration and LUNG Screening	N: General Fire
		Q: QUIT

Enter Selection

3-#4

Notes:

- Describe the steps involved in using HOTSPOT to model the plutonium fire incident.
- Explain that the student can use the Reference page for detailed information.
- Code—Explain that the students must select the specific code related to the ttype of incident. In this example, they must select Code B (Plutonium Fire) from the HOTSPOT Main Menu.
- Effective Release Height—Explain the conditions under which the students would select 1, 2, or 3 from the Effective Release Height menu.
- MASS (PU), kg—Explain that the students must enter the total quanity (in kilograms) of plutonium involved in the fire.

Demonstration: Plutonium Fire

- Select Plutonium Fire from the HOTSPOT Main Menu.
- **Step 1** Type **B**
- Result The Effective Release Height menu appears:

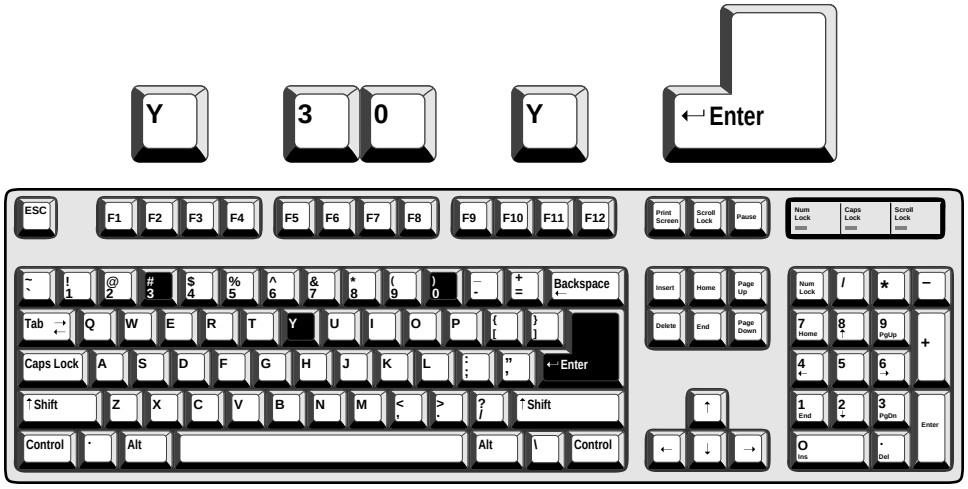
1: Fire –You enter Effective Release Height. 2: Fire – HOTSPOT calculates Effective Release Height using input fuel and burn duration. 3: Fire – HOTSPOT calculates Effective Release Height using input Heat Emission (calories per second).

- **Step 2** Type **2**
- MASS (Pu), kg

Enter the total quantity of plutonium involved in the explosion (kilograms), and push Enter.

- **Step 3** Type **3;** press **Enter**

Demonstration: Plutonium Fire



3-#5

Notes:

- ALPHA SPECIFIC ACTIVITY= 0.081 Ci/g?—This is the default weapons-grade value; explain alpha specific activity to the students.
- Volume of FUEL (gallons)—This is the total amount of fuel burned in the fire; in this example, it is 30 gallons.
- Release Radius = 10 m? (Y/N)—Describe the effective radius of the fire; for example, radius of the fuel pool.

Demonstration: Plutonium Fire

- ALPHA SPECIFIC ACTIVITY = 0.081 Ci/g ? (Y/N)

Enter “Y” to accept the default weapons-grade value, or “N” if you wish to enter a new value.

- **Step 4** Type **Y**

- Volume of FUEL (gallons)?

Enter the total amount of fuel burned in the fire, and push Enter. Note: assumed heat of combustion is 12,000 calories/gram.

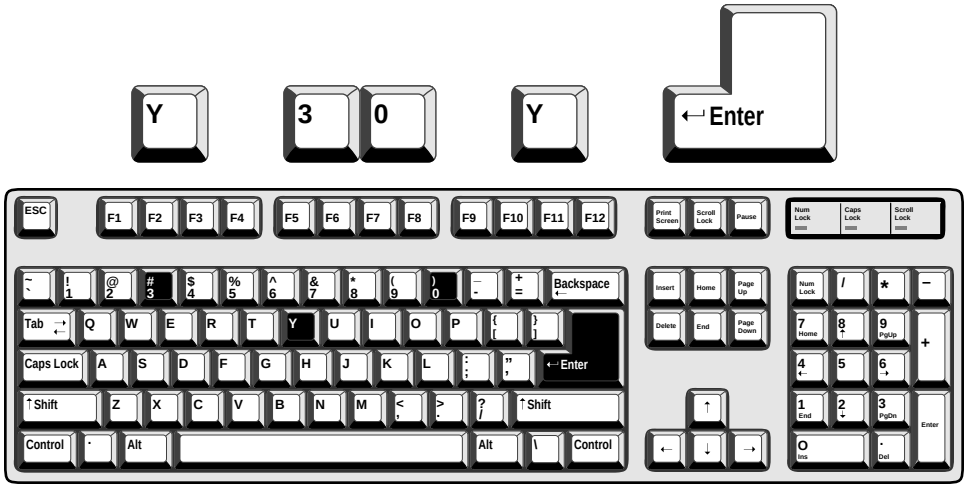
- **Step 5** Type **30**; press **Enter**

- **Release Radius = 10 (m)?**

Release radius is the effective radius of the fire, e. g., radius of burning fuel pool. The default is 10 meters.

- **Step 6** Type **Y**

Demonstration: Plutonium Fire



3-#6

Notes:

- Burn Time (minutes)—Explain burn time; in this example, it is 20 minutes.
- Ambient Air Temperature = 20 degrees C? (Y/N)—Define the ambient air temperature.
- F= 5.000E-04? (Y/N)—Explain the concept of “fraction of the entered activity.”

Demonstration: Plutonium Fire

- Burn Time (minutes)?

Enter the burn time duration of the fire, and push Enter.

- **Step 7** Type **20;** press **Enter**

- Ambient Air Temperature = 20 degrees C? (Y/N)

The default value for the ambient temperature is 20 degrees centigrade (293 kelvin). Note: centigrade = (Fahrenheit–32) / 1.8

- **Step 8** Type **Y**

- F = 5.000E^{-04}? (Y/N)

The default respirable fraction of the plutonium involved in the fire that is released is 5 X 1^{-4} (0.05%).

- **Step 9** Type **Y**

Demonstration: Plutonium Fire

- Meteorological Conditions

Choose appropriate meteorological conditions from the following menu—Enter a NUMBER or LETTER.

1. Sun HIGH in the sky
2. Sun LOW in the sky or cloudy
3. NIGHT

Or, if you prefer to enter a specific stability classification,

A:	A stability	Very unstable
B:	B stability	Moderately unstable
C:	C stability	Slightly unstable
D:	D stability	Neutral
E:	E stability	Slightly stable
F:	F stability	Moderately stable
G:	G stability	Special nighttime, low wind

Enter selection

3#7

Notes:

- Meteorological Conditions—Explain that the students may enter a number (1, 2, or 3) to specify the meteorological condition or enter a letter (A-G) to specify a stability class.
- Refer students to the Meteorological Conditions screen display.
- In this example, the number 3 indicates the correct meteorological condition (NIGHT).

Demonstration: Plutonium Fire

- Meteorological Conditions

Enter a number or a letter to indicate appropriate meteorological conditions.

- **Step 10** Type **3** to indicate meteorological condition (NIGHT).

Demonstration: Plutonium Fire

- Wind

NAME OF WIND	OBSERVABLE FEATURES	MPH	M/S
calm	Smoke rises vertically	< 1	< 0.5
light Atmospheric	Smoke drifts downward	1 – 3	0.5 – 1
light breeze	Wind felt on face; leaves rustle	3 – 7	1 – 3
gentle breeze	Leaves and twigs in constant motion	7 – 12	3 – 5
moderate breeze	Raises dust and loose paper	12 – 18	5 – 8
fresh breeze	Small tress begin to sway	18 – 24	8 – 11
strong breeze	Large branches in motion	24 – 31	11 – 14
moderate gale	Whole trees in motion	31 – 38	14 – 17
fresh gale	Twigs break off; walking impeded	38 – 46	17 – 21
strong gale	Slight structural damage occurs	46 – 54	21 – 24
whole gale	Tree uprooted; structural damage	54 – 63	24 – 28
storm	Very rare, widespread destruction	63 – 75	28 – 34
hurricane		> 75	> 34

3-#8

Notes

- Wind—Refer students to the Wind screen display.

Demonstration: Plutonium Fire

- WIND?

Enter the ground wind speed, in meters/second, and press ENTER (1 mph = 0.45 m/s).

- **Step 11** Type **2**

  Press the **Enter** key.

- Plume Rise Summary Information

  The Plume Rise Summary Information table allows you to verify that you have entered the correct information in each of the fields.

Plume Rise Summary Information

Fuel Burned	:	30.00 gallons
Burn Duration	:	14 minutes
Heat Emission	:	9.2 E+05 calories/second
Buouancy Flux	:	3.4E+01 meters^4/second^3
Ambient Air Temperature	:	20.0 degrees centigrade
Released Radius	:	10.0 meters
Average Windspeed	:	5.7 meters/sec
Effective Release Height	:	40 meters

- **Step 12** Press **Enter**

Demonstration: Plutonium Fire

- Main Output Options Menu

```
Main Output Options Menu

1:  SCREEN    Output     Default     Distances
2:  SCREEN    Output     You Enter   Distances
3:  PRINTER   Output     Default     Distances
4:  PRINTER   Output     You Enter   Distances
5:  DISK FILE Output     Default     Distances
6:  DISK FILE Output     You Enter   Distances

G:  GRAPHICS
C:  Change DEFAULT CONTOUR SETTINGS
M:  Change METEOROLOGICAL PARAMETERS and Release
          Height
Z:  Change RECEPTOR HEIGHT (z)
D:  Change DEPOSITION VELOCITY
O:  Enable prompt for OFF AXIS Positions
I:  INVERSION HEIGHT (Mixing Layer)
P:  Plume Rise
T: Sample Time
R:  Review Plume Rise Data
Q:  Enter to Main HOTSPOT Menu.
```

3-#9

Notes:

- Screen ouput—Explain that students should select 1, screen output using the default distances.

- Data tables—The students must type 1 and press Return to view the data tables.

Demonstration: Plutonium Fire

- Main Outputs Options Menu
- Screen output
- **Step 13** Type **1** to view data tables.

  Press **Enter** to view more data.

  Continue pressing **Enter** until you view all the data.

  After you have viewed all the data, the following message appears:

"Enter the appropriate Output option number from the following menu."

- Look at the Output Option Number Menu.

Demonstration: Plutonium Fire

- Output Option Number Menu

1: Enter a new Downwind Distance.

2: Return to Output Menu.

Q: Return to Main HOTSPOT Menu.

3-#10

Notes:

- Explain that students must type 2 at the Output Option Number Menu to return to the Main HOTSPOT Menu.

Demonstration: Plutonium Fire

- Output Option Number Menu
- **Step 14** Type **2** at the Output Option Number Menu to return to the Output Menu.

  Press **Enter**

Demonstration: Plutonium Fire

- Main Output Options Menu—Option G

```
Main Output Options Menu

1:  SCREEN    Output     Default     Distances
2:  SCREEN    Output     You Enter   Distances
3:  PRINTER   Output     Default     Distances
4:  PRINTER   Output     You Enter   Distances
5:  DISK FILE Output     Default     Distances
6:  DISK FILE Output     You Enter   Distances

G:  GRAPHICS
C:  Change DEFAULT CONTOUR SETTINGS
M:  Change METEOROLOGICAL PARAMETERS and Release
        Height
Z:  Change RECEPTOR HEIGHT (z)
D:  Change DEPOSITION VELOCITY
O:  Enable prompt for OFF AXIS Positions
I:  INVERSION HEIGHT (Mixing Layer)
P:  Plume Rise
T: Sample Time
R:  Review Plume Rise Data
Q:  Enter to Main HOTSPOT Menu.
```

3-#11

Notes:

- Main Output Options Menu: Option G—Explain that students need to use option G to see graphical representations of the results of the example incident.

Demonstration: Plutonium Fire

- Option G—Graphics
- **Step 15** Type **G** for Graphics.
- Result An Output option number menu appears.

Demonstration: Plutonium Fire

1: CEDE Contours

2: GROUND DEPOSITION Contours

3: Centerline 50-yr. CEDE vs. Distance

C: Change Graphics Output File Name

TO PRINT GRAPHICS—PUSH the “P” key when the screen output is complete.

Select your printer using the SETUP option at the Main HOTSPOT MENU.

3-#12

Notes:

- Output Option Number Menu—Explain this menu.
- Students may view Centerline 50-yr CEDE vs. Distance graphical output by typing the number 3.
- Color/Monochrome—Have students type 1 for color.
- Downwind Plotting Range—Have students type 1 or 2.
- Print—If they have printer capability, the students may press P to print the graphical results (same results as on Page 3-3).

Demonstration: Plutonium Fire

- **Step 16** Type **3** to view Centerline 50-yr. CEDE vs. Distance graphical output.
- Result The following selection box appears:

```
1: COLOR
2: MONOCHROME / LCD
```

- **Step 17** Type **1** for color monitor.
- Result The following selection box appears:

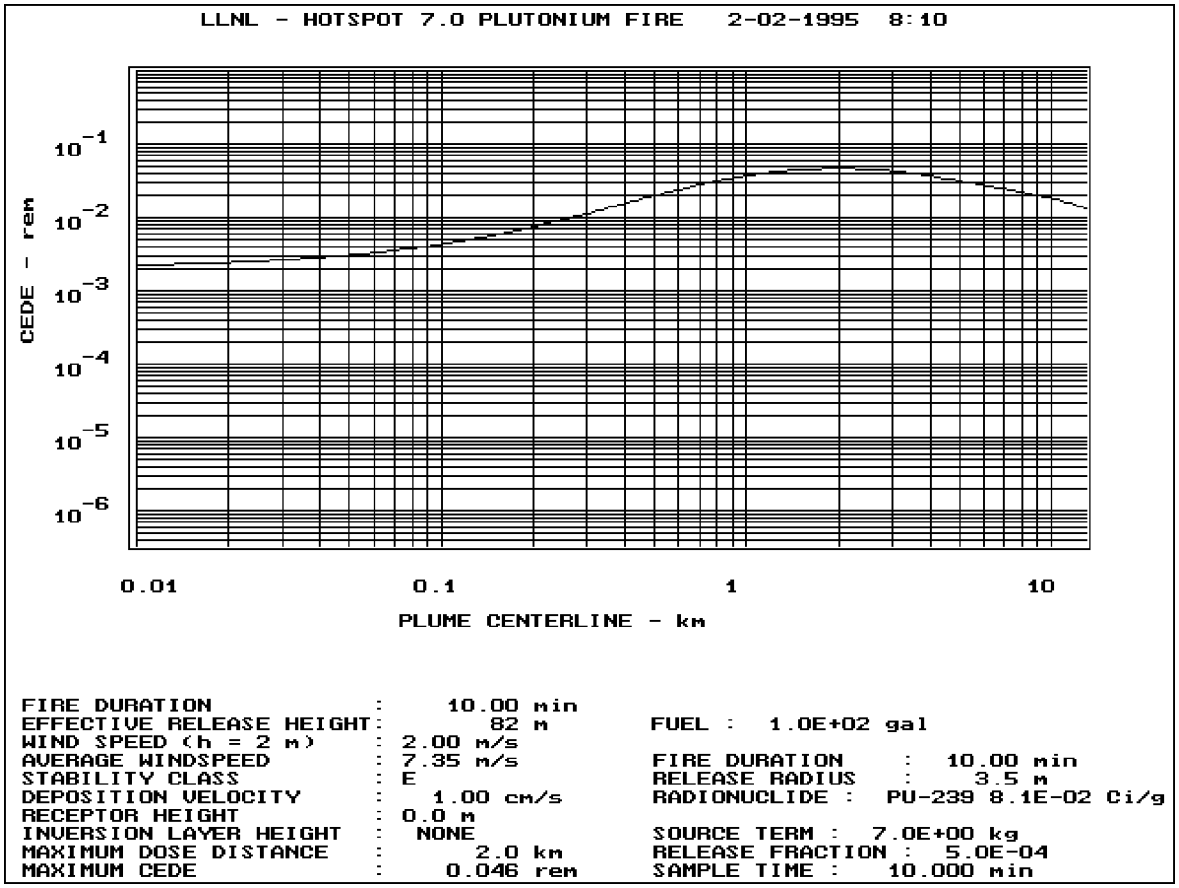
```
DOWNWIND PLOTTING RANGE
ENTER SELECTION NUMBER

1: 0.01 TO 10 km
2: 0.1 TO 100 km
```

- **Step 18** Type **1**

  The result is a graph.
- Print (if you have printer capability).
- **Step 19** Press **P** to print the graph.

Exercise 3-1: Plutonium Fire

- Exercise (Pu-239)



3#13

Notes:

- Distrubute Exercise for Plutonium Fire involving PU-239.
- Display Overhead.
- Explaijn that students may consult the Reference page if they wish.
- Exercise Answers: Maximum Dose Distance = 2.0 km,
  Maximum CEDE = 0.045 rem

Exercise 3-1: Plutonium Fire

- Page 3-25 illustrates the graphical output for a Plutonium Fire Atmospheric Dispersion Model derived from the HOTSPOT Health Physics Codes program.

- The example for this exercise is based on the following assumptions:

  — Seven kilograms of weapons-grade plutonium are involved in a fire due to 100 gallons of fuel burning for twenty minutes. The effective radius of the fire zone is 3 meters. Use the default release fraction of 0.05%. It is nighttime, the wind speed is 2 meters/second, and the temperature is 10 degrees centigrade. Estimate the 50-year committed effective dose commitments to individuals remaining downwind throughout the entire fire.

• **Step 1**	From the HOTSPOT Main Menu, select **B**	
• **Step 2**	Output Option	Type **2**
• **Step 3**	MASS?	Type **7**; press **Enter**
• **Step 4**	Alpha Specific Activity?	Type **Y**
• **Step 5**	Volume of FUEL?	Type **100**; press **Enter**
• **Step 6**	Release Radius = 3.47 m? (Y/N)	Type **N**; type **3**; press **Enter**
• **Step 7**	Burn Time?	Type **10**; press **Enter**
• **Step 8**	Ambient Air Temp. = 20°C?	Type **N**; type **10**; press **Enter**
• **Step 9**	F = 5.000E^{-04}? (Y/N)	Type **Y**
• **Step 10**	Conditions?	Type **3** for NIGHT.
• **Step 11**	Wind?	Type **2** (for 2 meters/second); press **Enter**
• **Step 12**	Plume Rise Summary Information appears; press **Enter**	
• **Step 13**	Type **1** at the Main Outputs Options Menu to view data table; press **Enter** as desired to view more data.	
• **Step 14**	Type **1** at the Outputs Option Number Menu to enter downwind distance.	
• **Step 15**	Type **2** to return to the Output Menu.	
• **Step 16**	Type **G** (graphics).	
• **Step 17**	Type **3** to view Centerline 50-yr. CEDE vs. Distance.	
• **Step 18**	Type **1** to select COLOR.	
• **Step 19**	Type **1** to enter downwind plotting range.	

The result is the graph shown on the previous page of this manual.

Lesson 4
Plutonium Resuspension
Code C

LESSON PLAN
HOTSPOT HEALTH PHYSICS CODES

LESSON 4 – Plutonium Resuspension, Code C

TIME:

30 minutes

LESSON LEARNING OBJECTIVES

Terminal: At the end of this lesson, students will be able to model a plutonium resuspension involving released material, using the Plutonium Resuspension Code C Atmospheric Dispersion Model

Enabling:

- At the end of this lesson, students should be able to:
  - — Describe the graphical output for a Plutonium Resuspension Atmospheric Dispersion Model
  - — Explain the assumptions involved in deriving Plutonium Resuspension output (tabular and graphical)
  - — Given mock data, generate Plutonium Resuspension output (tabular and graphical)

INSTRUCTIONAL APPROACH

The mode of delivery for this lesson is lecture, using several job aids and reference materials to provide students with an overview of the HOTSPOT Health Physics Codes application.

EQUIPMENT AND INSTRUCTIONAL AIDS

Overhead projector
IBM PC, XT, AT, or compatible
HOTSPOT User's Manual (*HOTSPOT Health Physics Codes for the PC*)
Exercise Number 4–1

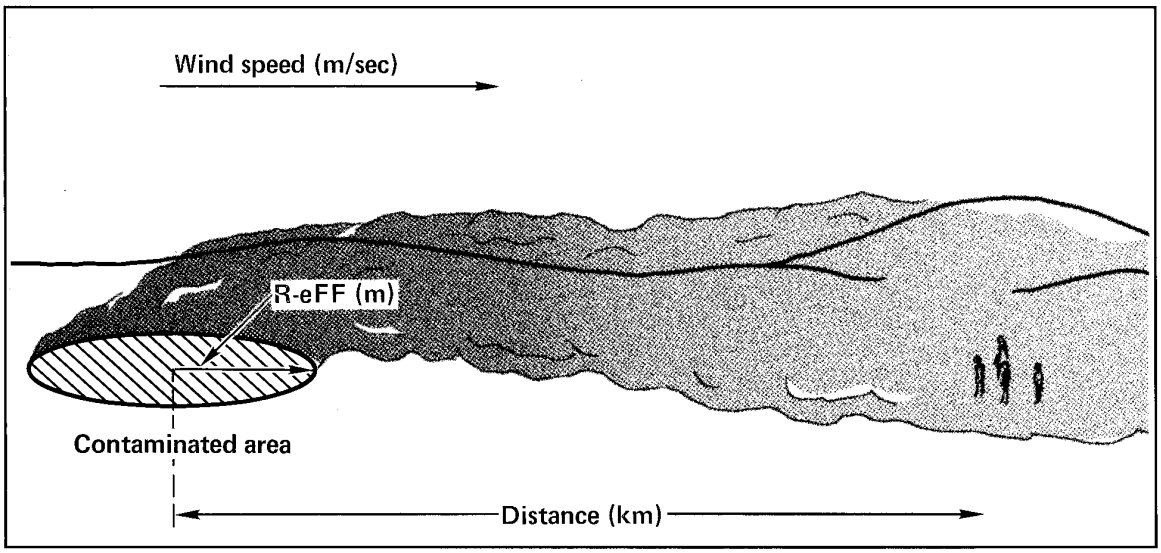
STUDENT MATERIALS

Student Manual

REFERENCES

HOTSPOT User's Manual (*HOTSPOT Health Physics Codes for the PC*)

Lesson Objectives



4-#1

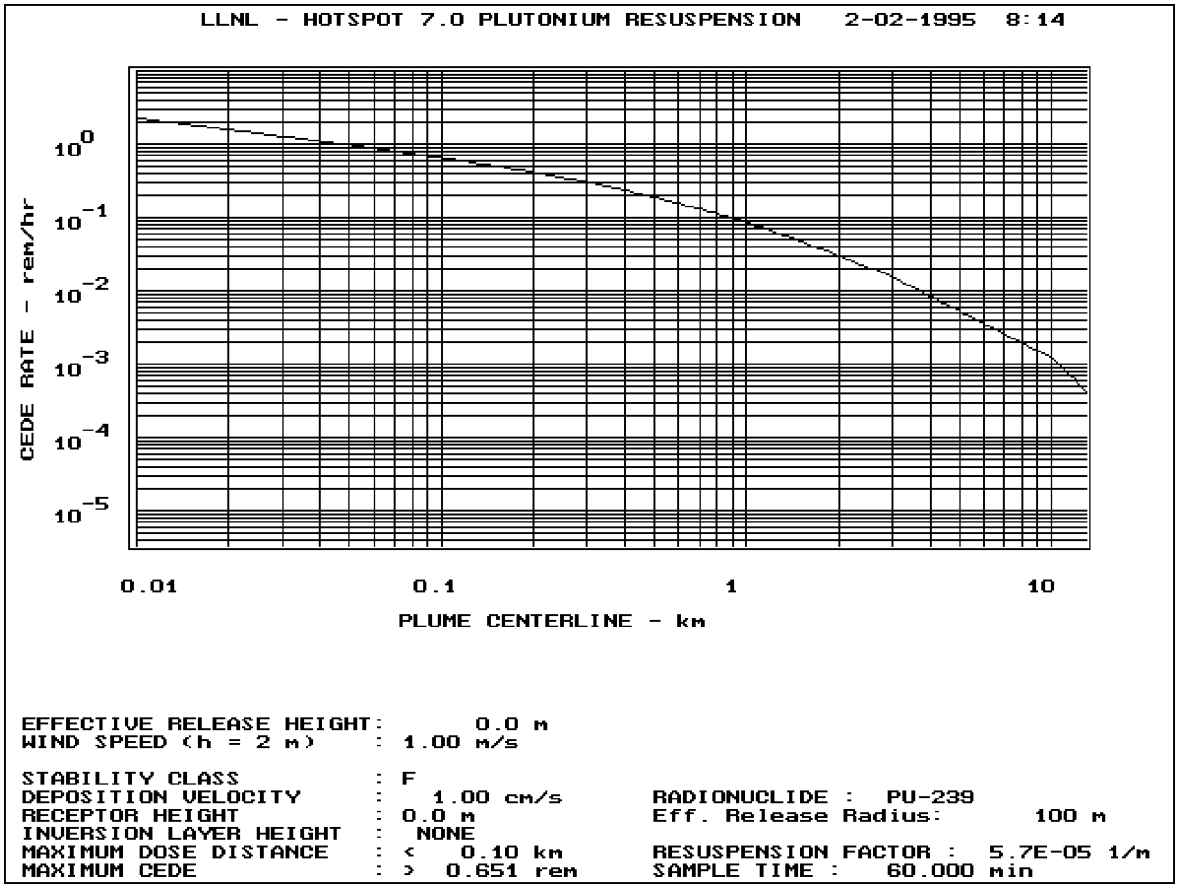
Notes:

- At the end of this lesson, students will be able to model a plutonium resuspension involving released material, using the Plutonium Resuspension Code C Atmospheric Dispersion Model.
- Explain the Lesson Objectives.

Lesson Objectives

- At the end of this lesson, students should be able to do the following:
  - Identify the graphical output for a Plutonium Resuspension Atmospheric Dispersion Model
  - Explain the assumptions involved in deriving Plutonium Resuspension output (tables and graphs)
  - Given mock data, generate Plutonium Resuspension output (tables and graphs)

Graphical Output for Plutonium Resuspension



EFFECTIVE RELEASE HEIGHT: 0.0 m
WIND SPEED (h = 2 m) : 1.00 m/s

STABILITY CLASS : F
DEPOSITION VELOCITY : 1.00 cm/s
RECEPTOR HEIGHT : 0.0 m
INVERSION LAYER HEIGHT : NONE
MAXIMUM DOSE DISTANCE : < 0.10 km
MAXIMUM CEDE : > 0.651 rem

RADIONUCLIDE : PU-239
Eff. Release Radius: 100 m
RESUSPENSION FACTOR : 5.7E-05 1/m
SAMPLE TIME : 60.000 min

4-#2

Notes:

- Have the students refer to Page 4-3, Plutonium Resuspension: Graphical Output.
- Discuss the assumptions involved in this incident, as described on the Reference page.

Graphical Output and Assumptions—Plutonium Resuspension

- Page 4-3 illustrates output for a Plutonium Resuspension Atmospheric Dispersion Model derived from the HOTSPOT Health Physics Codes program
- This example is based on the following assumptions:
  - Resuspension is modeled using the methodology contained in the "Resuspension" section of Appendix A (User Manual).
  - Inhalation class is Y.
  - Standard-person breathing rate is 1.2 cubic meters/hour.
  - There has been a plutonium contamination event. Estimate the 50-year committed effective dose equivalent rates (i.e., dose commitment per hour of downwind exposure) to individuals downwind from a two-week-old plutonium contamination event. Most of the plutonium is contained in an area with an effective radius of 100 meters. The average contamination level is 150 microcuries/square meter. Assume nighttime conditions with a wind speed of 1 meter/second.

Code Description: Plutonium Resuspension

HOTSPOT 7.0	**PLUTONIUM RESUSPENSION**		
RADIONUCLIDE:	PU-239 Inhalation Class : Y		
HALFLIFE	2.4E+04 yrs		
RESUSPENSION FACTOR:	5.7E-05 1/m		
EFF. RADIUS	100 m		
AVG. DEPOSITION	1.5E+02uCi/m^2		
CONTAMINATION AGE;	14 days		
EFFECTIVE RELEASE HEIGHT:	0.00 m		
WIND SPEED (h = 2 m)	1.0 m/s	DEPOSITION VELOCITY:	1.00 cm/s
STABILITY CLASS:	F	INVERSION LAYER HEIGHT:	NONE
RECEPTOR HEIGHT	0.0 m	MAXIMUM CEDE:	>0.651 rem
SAMPLE TIME;	60.0 min		
MAXIMUM DOSE DISTANCE:	< 0.10 km		
Plume Centerline			

D =	0.10 km	**D =**	0.20 km	**D =**	0.50 km
CHI =	1.6E-09 Ci/m^3	**CHI =**	1.0E–09 Ci/m^3	**CHI =**	4.8E–10 Ci/m^3
50-YR DOSE COMMITMENT:		**50-YR DOSE COMMITMENT:**		**50-YR DOSE COMMITMENT:**	
LUNG	2.4E+00 rem	**LUNG**	1.5E+00rem	**LUNG**	6.9E+01 rem
SURFACE BONE	6.9E+00rem	**SURFACE BONE**	4.4E+00 rem	**SURFACE BONE**	2.0E+00 rem
RED MARROW	5.5E+01 rem	**RED MARROW**	3.5E-01 rem	**RED MARROW**	1.6E-01 rem
LIVER	1.5E+00rem	**LIVER**	9.8E-01 rem	**LIVER**	4.5E–01 rem
EFFECTIVE DOSE EQUIVALENT	6.5E-01 rem	**EFFECTIVE DOSE EQUIVALENT**	4.1E-01 rem	**EFFECTIVE DOSE EQUIVALENT**	1.9E-01 rem
D =	1.00 km	**D =**	2.00 km	**D =**	5.00 km
CHI =	2.2E-10 Ci/m^3	**CHI =**	7.7E–11 Ci/m^3	**CHI =**	1.3E–11 Ci/m^3
50-YR DOSE COMMITMENT:		**50-YR DOSE COMMITMENT:**		**50-YR DOSE COMMITMENT:**	
LUNG	3.2E+01 rem	**LUNG**	1.1E-01 rem	**LUNG**	1.9E-02 rem
SURFACE BONE	9.2E-01 rem	**SURFACE BONE**	3.2E-01 rem	**SURFACE BONE**	5.6E-02 rem
RED MARROW	7.4E-02 rem	**RED MARROW**	2.6E-02 rem	**RED MARROW**	4.5E-03 rem
LIVER	2.1E-01 rem	**LIVER**	7.2E-02 rem	**LIVER**	1.3E-02 rem
EFFECTIVE DOSE EQUIVALENT	8.7E–02 rem	**EFFECTIVE DOSE EQUIVALENT**	3.0E-02 rem	**EFFECTIVE DOSE EQUIVALENT**	5.3E-03 rem

4-#3

Notes:

- Describe the code used to derive the Plutonium Resuspension Atmospheric Dispersion Model illustrated in this lesson.

Code Description: Plutonium Resuspension

- Code description — Study the table on page 4-5.

Demonstration: Plutonium Resuspension

HOTSPOT Health Physics Codes
VERSION 7.01
HAZARDS CONTROL DEPARTMENT
LAWRENCE LIVERMORE
NATIONAL LABORATORY

S: SETUP

A : Plutonium Explosion	**B** : Plutonium Fire	**C** : Plutonium Resuspension
D : Uranium Explosion	**E** : Uranium Fire	**F** : Nuclear Explosion
G : Radiation Workplace	**H** : General Plume	**I** : General Explosion
J : General Resuspension	**K** : Inhalation Dose	**T** : Tritium Release
L : HOTSPOT Library	**M** : FIDLER Calibration and LUNG Screening	**N** : General Fire
		Q: QUIT

Enter Selection

4-#4

Notes:

- Describe the steps involved in using HOTSPOT to model the incident involving a Plutonium Resuspension event.
- Explain that the students should use the Reference page for detailed information.
- Inform the students that sometimes they must press Enter (or Return) in order for the computer system to accept data which they type.
- Code—Explain that the students must select the specific code related to the type of incident. In this example, the students must select Code C (Plutonium Resuspension) from the HOTSPOT Main Menu.
- DEP, (µCi/square meter)—Define “average ground deposition” for the students.
- Release Radius? (m)—Explain that release radius is the effective radius of a circle containing 95% of the contamination (meters).

Demonstration: Plutonium Resuspension

- Select Plutonium Resuspension from the HOTSPOT Main Menu.
- **Step 1** Type **C**
- DEP, (µCi/square meters)

Enter the average ground deposition (microcuries/square meter), and push Enter.

- **Step 2** Type **150**
- Release Radius? (m)

Enter the effective radius of a circle containing 95% of the contamination.

- **Step 3** Type **100**; press **Enter**

Demonstration: Plutonium Resuspension

- Meteorological Conditions

Choose appropriate meteorological conditions from the following menu—Enter a NUMBER or LETTER.

1. Sun HIGH in the sky
2. Sun LOW in the sky or cloudy
3. NIGHT

Or, if you prefer to enter a specific stability classification,

A: A stability	Very unstable
B: B stability	Moderately unstable
C: C stability	Slightly unstable
D: D stability	Neutral
E: E stability	Slightly stable
F: F stability	Moderately stable
G G stability	Special stability, low wind

Enter selection

4-#6

Notes:

- Meteorological Conditions—Explain that the students may enter a number (1, 2, or 3) to specify the meteorological condition (sun high in sky; sun low in sky or cloudy; night) or a letter (A–G) to specify a stability class.
- Refer students to the Meteorological Conditions screen display.
- In this example, the number 3 indicates the correct meteorological condition (NIGHT).

Demonstration: Plutonium Resuspension

- Meteorological Conditions

Enter a number or a letter to indicate appropriate meteorological conditions.

- **Step 4** Type **3** to indicate meteorological conditions (NIGHT).

Demonstration: Plutonium Resuspension

- Wind

NAME OF WIND	OBSERVABLE FEATURES	MPH	M/S
calm	Smoke rises vertically	< 1	< 0.5
light Atmospheric	Smoke drifts downward	1 – 3	0.5 – 1
light breeze	Wind felt on face; leaves rustle	3 – 7	1 – 3
gentle breeze	Leaves and twigs in constant motion	7 – 12	3 – 5
moderate breeze	Raises dust and loose paper	12 – 18	5 – 8
fresh breeze	Small tress begin to sway	18 – 24	8 – 11
strong breeze	Large branches in motion	24 – 31	11 – 14
moderate gale	Whole trees in motion	31 – 38	14 – 17
fresh gale	Twigs break off; walking impeded	38 – 46	17 – 21
strong gale	Slight structural damage occurs	46 – 54	21 – 24
whole gale	Tree uprooted; structural damage	54 – 63	24 – 28
storm	Very rare, widespread destruction	63 – 75	28 – 34
hurricane		> 75	> 34

4#7

Notes:

- Wind—Refer students to the Wind screen display.

Demonstration: Plutonium Resuspension

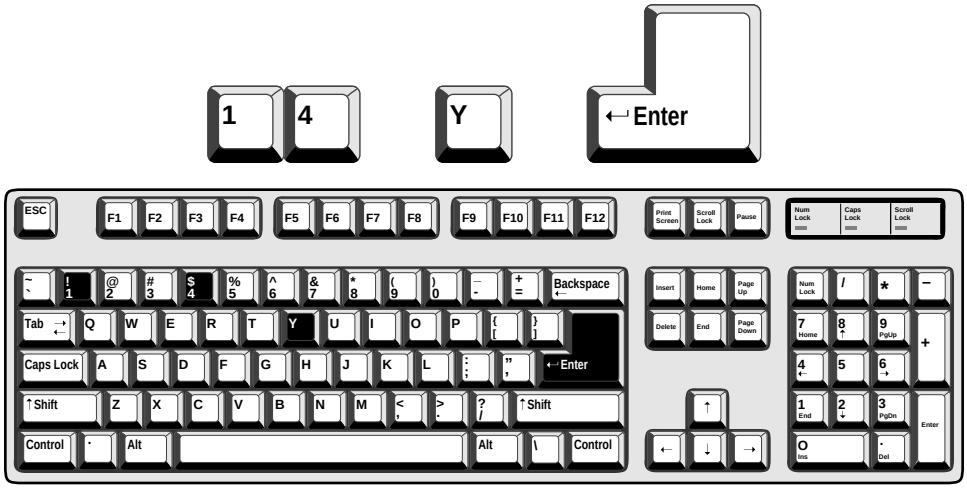
- WIND?

Enter the ground wind speed, in meters/second, and press ENTER (1 mph = 0.45 m/s).

- **Step 5** Type **1**

  Press the **Enter** key.

Demonstration: Plutonium Resuspension



4-#5

Notes:

- AGE, Days—Tell the students that AGE is the time since the contamination event; in this example, it is 14 days.
- S = 5.7E^{-05}? (Y/N)—Discuss with the students the resuspension factor for this 14-day-old contamination event. The default is Y, the correct choice in this example.

Demonstration: Plutonium Resuspension

- Age, Day

Enter the time since the contamination event, (days), and push Enter.

- **Step 6** Type **14**; press **Enter**
- S = 5.7E^{-05}? (Y/N)

S is the resuspension factor (1/meter), for the 14-day-old contamination event. Enter “Y” to accept the above default value, or “N” if you wish to enter a new value.

- **Step 7** Type **Y**

Demonstration: Plutonium Resuspension

- Main Output Options Menu

Main Output Options Menu

1:	SCREEN	Output	Default	Distances
2:	SCREEN	Output	You Enter	Distances
3:	PRINTER	Output	Default	Distances
4:	PRINTER	Output	You Enter	Distances
5:	DISK FILE	Output	Default	Distances
6:	DISK FILE	Output	You Enter	Distances
G:	GRAPHICS			
C:	Change DEFAULT CONTOUR SETTINGS			
M:	Change METEOROLOGICAL PARAMETERS and Release Height			
Z:	Change RECEPTOR HEIGHT (z)			
D:	Change DEPOSITION VELOCITY			
O:	Enable prompt for OFF AXIS Positions			
I:	INVERSION HEIGHT (Mixing Layer)			
T	SAMPLE TIME			
Q:	Enter to Main HOTSPOT Menu.			

4-#8

Notes:

- Screen output—Explain that students should select 1, screen output using the default distances.
- Data tables—The students must type 1 and press Enter to view the data tables.

Demonstration: Plutonium Resuspension

- Main Outputs Options Menu
- Screen output
- **Step 8** Type **1** to view data tables.
- **Step 9** Press **Enter** to view more data.

  Continue pressing **Enter** until you view all the data.

  After you have viewed all the data, the following message appears:

  > "Enter the appropriate Output option number from the following menu."

- Look at the Output Option Number Menu.

Demonstration: Plutonium Resuspension

- Output Option Number Menu

1: Enter a new Downwind Distance.
2: Return to Output Menu.
Q: Return to Main HOTSPOT Menu.

4-#9

Notes:

- Screen output—Explain that students should select 2 to return to the output menu.

Demonstration: Plutonium Resuspension

- Output Option Number Menu
- **Step 10** Type **2** at the Output Option Number Menu to return to the Output Menu.

  Press **Enter**

Demonstration: Plutonium Resuspension

- Main Output Options Menu—Option G

Main Output Options Menu

1:	SCREEN	Output	Default	Distances
2:	SCREEN	Output	You Enter	Distances
3:	PRINTER	Output	Default	Distances
4:	PRINTER	Output	You Enter	Distances
5:	DISK FILE	Output	Default	Distances
6:	DISK FILE	Output	You Enter	Distances
G:	GRAPHICS			
C:	Change DEFAULT CONTOUR SETTINGS			
M:	Change METEOROLOGICAL PARAMETERS and Release Height			
Z:	Change RECEPTOR HEIGHT (z)			
D:	Change DEPOSITION VELOCITY			
O:	Enable prompt for OFF AXIS Positions			
I:	INVERSION HEIGHT (Mixing Layer)			
T	SAMPLE TIME			
Q:	Enter to Main HOTSPOT Menu.			

4-#10

Notes:

- Main Output Options Menu: Option G—Explain that students need to use option G to see graphical representations of the results of the example incident's air dispersion model.

Demonstration: Plutonium Resuspension

- Option G—Graphics
- **Step 11** Type **G** for Graphics.
- Result An Output option number menu appears.

Demonstration: Plutonium Resuspension

1: CEDE Contours

2: Centerline 50-yr. CEDE vs. Distance

TO PRINT GRAPHICS—PUSH the “P” key when thescreen output is complete.

Select your printer using the SETUP option at the Main HOTSPOT MENU.

4-#11

Notes:

- Output Option Number Menu
- Students may view Centerline 50-yr. CEDE vs. Distance graphical output by typing the number 2.
- Color/Monochrome—Have students type the number 1 or 2.
- Downwind Plotting Range—Have the students type 1 or 2.
- Print—If they have printer capability, the students may press P to print the graphical results (same as Page 4-3).

Demonstration: Plutonium Resuspension

- **Step 12** Type **2** to view Centerline 50-yr. CEDE vs. Distance graphical output.
- Result The following selection box appears:

1: COLOR
2: MONOCHROME / LCD

- **Step 13** Type **2** for monochrome, unless you have a color monitor, in which case, you must type 1
- Result The following selection box appears:

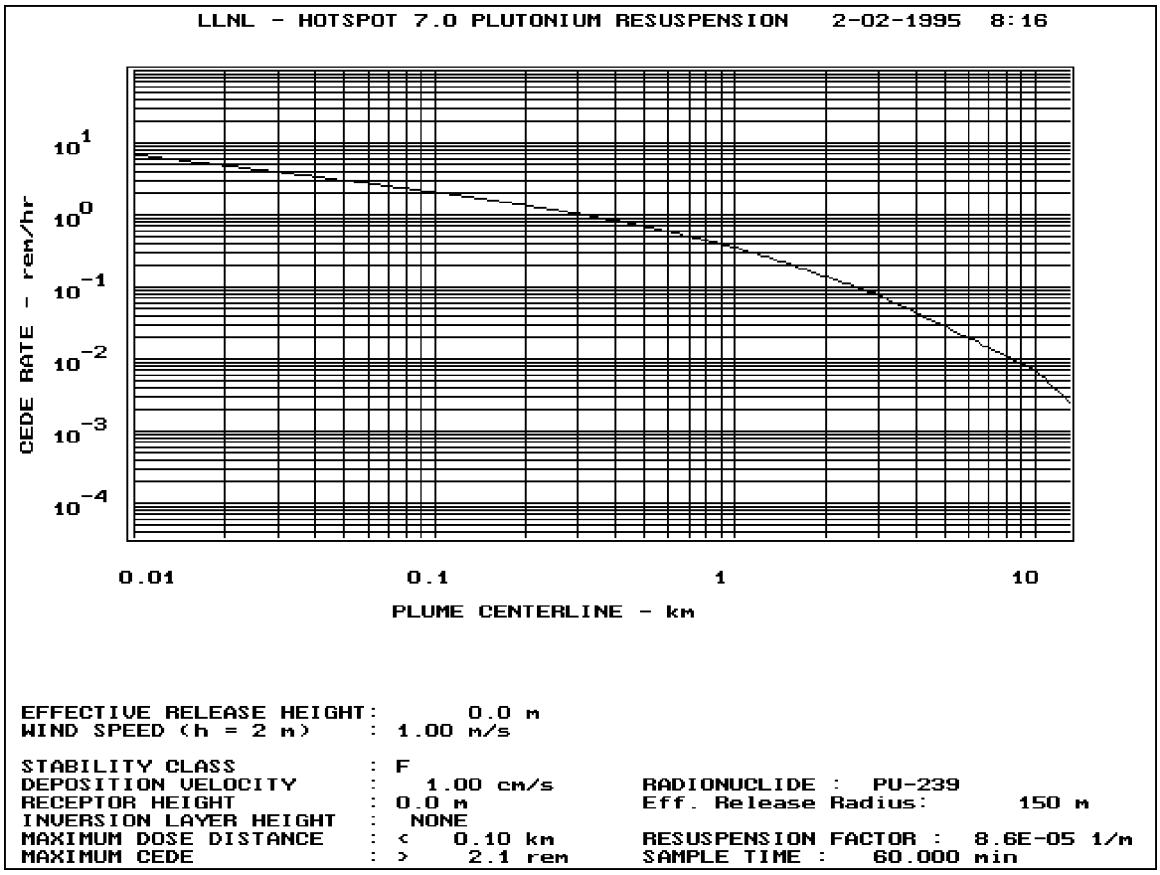
DOWNWIND PLOTTING RANGE ENTER SELECTION NUMBER
1: 0.01 TO 10 km
2: 0.1 TO 100 km

- **Step 14** Type **2**

  The result is a graph.
- Print (if you have printer capability).
- **Step 15** Press **P** to print the graph.

Exercise 4-1: Plutonium Resuspension

- Exercise (Pu-239)



4-#12

Notes:

- Distribute Exercise for Plutonium Resuspension involving pu-239 (Appendix B contains all exercises; use these to duplicate as many copies as needed for trainees).
- Display Overhead.
- Explain that students may consult Reference page if they wish.
- Exercise Answers: Maximum Dose Distance = <0.1 km
  Maximum CEDE = >2.1 rem

Exercise 4-1: Plutonium Resuspension

- Page 4-23 illustrates the graphical output for a Plutonium Resuspension Atmospheric Dispersion Model derived from the HOTSPOT Health Physics Codes program.
- The example for this exercise is based on the following assumptions:
  - There has been a plutonium contamination event. Estimate the 50-year committed effective dose equivalent rates (i.e., dose commitment per hour of downwind exposure) to individuals downwind from a one-day-old plutonium contamination event. Most of the plutonium is contained in an area with an effective radius of 150 meters. The average contamination level is 300 microcuries/square meter. Assume nighttime conditions with a wind speed of 1 meter/second.
- **Step 1** From the HOTSPOT Main Menu, select **C**
- **Step 2** Deposition? Type **300**; press **Enter**
- **Step 3** Release Radius? Type **150**
- **Step 4** Conditions? Type **3** for NIGHT.
- **Step 5** Wind? Type **1** (for 1 meter/second); press **Enter**
- **Step 6** Age, Day? Type **1**; press **Enter**
- **Step 7** S = 8.6E^{-05}? (Y/N) Type **Y**
- **Step 8** Type **1** at the Main Outputs Options Menu to view data table.
- **Step 9** Press **Enter** as desired to view more data.
- **Step 10** Type **2** to return to the Output Menu.
- **Step 11** Type **G** (graphics).
- **Step 12** Type **2** to view Centerline 50-yr. CEDE vs. Distance.
- **Step 13** Type **1** to select COLOR.
- **Step 14** Type **1** to enter downwind plotting range.

The result is the graph shown on the previous page of this manual.

Lesson 5
Uranium Explosion
Code D

LESSON PLAN
HOTSPOT HEALTH PHYSICS CODES

LESSON 5 – Uranium Explosion, Code D

TIME:

30 minutes

LESSON LEARNING OBJECTIVES

Terminal: At the end of this lesson, students will be able to model a uranium explosion involving released material, using the Uranium Explosion Code D Atmospheric Dispersion Model of the HOTSPOT Health Physics program.

Enabling:

- At the end of this lesson, students should be able to:
  - — Describe the graphical output for a Uranium Explosion Atmospheric Dispersion Model
  - — Explain the assumptions involved in deriving Uranium Explosion output (tabular and graphical)
  - — Given mock data, generate Uranium Explosion output (tabular and graphical) using HOTSPOT

INSTRUCTIONAL APPROACH

The mode of delivery for this lesson is lecture, using several job aids and reference materials to provide students with an overview of the HOTSPOT Health Physics Codes application.

EQUIPMENT AND INSTRUCTIONAL AIDS

Overhead projector
IBM PC, XT, AT, or compatible
HOTSPOT User's Manual (*HOTSPOT Health Physics Codes for the PC*)
Exercise Number 5–1

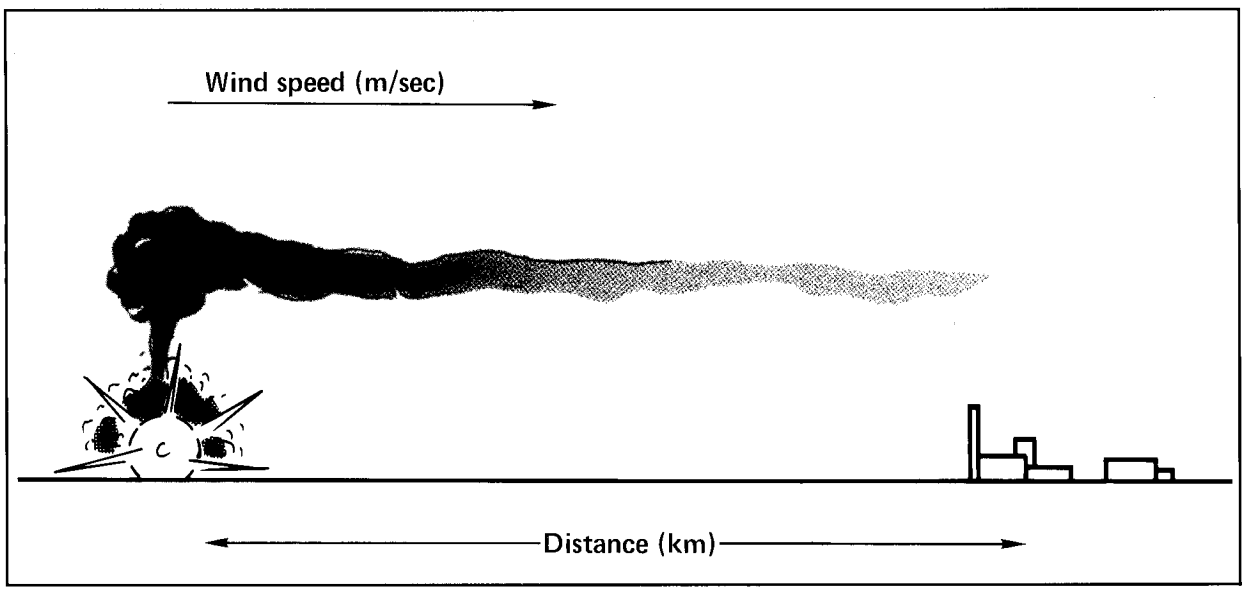
STUDENT MATERIALS

Student Manual

REFERENCES

HOTSPOT User's Manual (*HOTSPOT Health Physics Codes for the PC*)

Lesson Objectives



5-#1

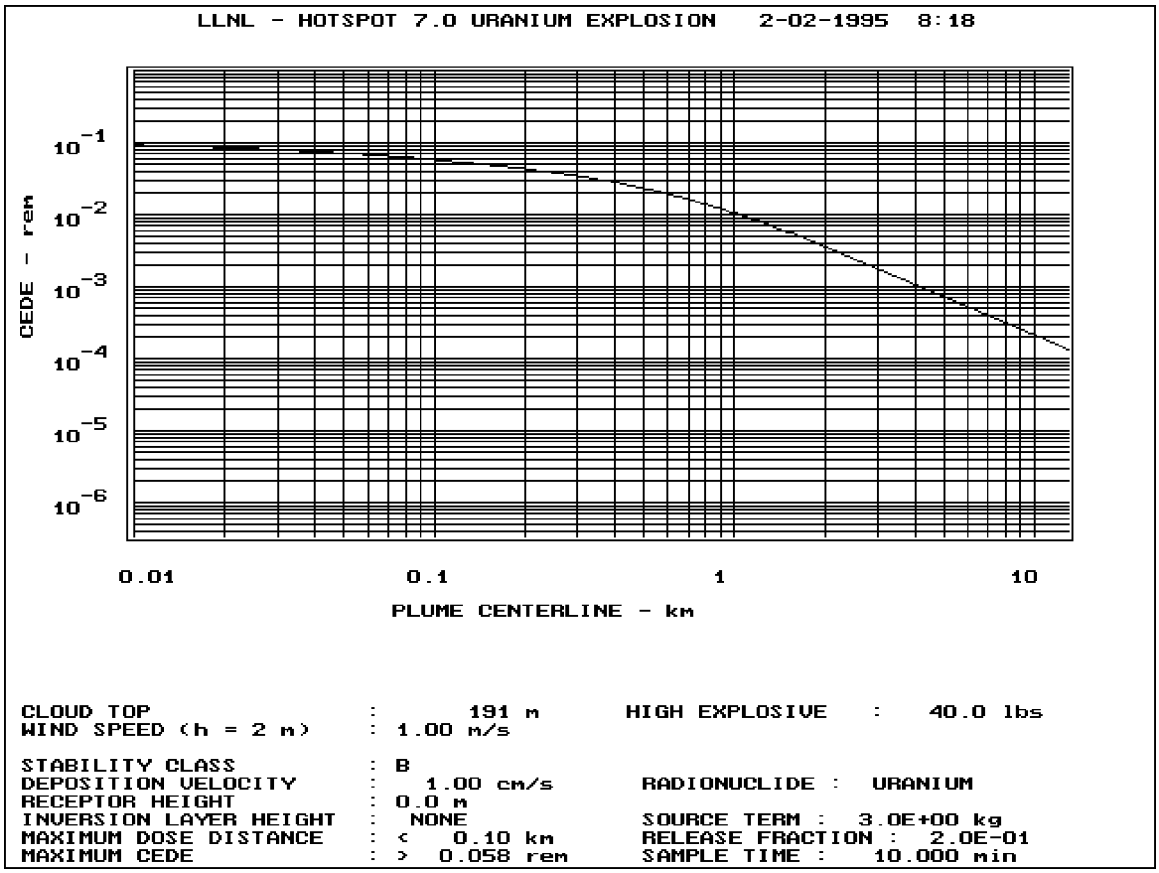
Notes:

- At the end of this lesson, students will be able to model a uranium explosion involving released material, using the Uranium Explosion Code D Atmospheric Dispersion Model.
- Explain the Lesson Objectives.

Lesson Objectives

- At the end of this lesson, students should be able to:
  - Describe the graphical output for a Uranium Explosion Atmospheric Dispersion Model
  - Explain the assumptions involved in deriving Uranium Explosion output (tables and graphs)
  - Given mock data, generate Uranium Explosion output (tables and graphs)

Graphical Output and Assumptions—Uranium Explosion



5-#2

Notes:

- Have students refer to Page 5-3, Uranium Explosion: Graphical Output.
- Discuss the assumptions concerning the Uranium Explosion incident.

Graphical Output and Assumptions—Uranium Explosion

- Page 5-3 illustrates output for a Uranium Explosion Atmospheric Dispersion Model derived from the HOTSPOT Health Physics Codes program.

- This example is based on the following assumptions:

  — The default respirable fraction of the total uranium involved in the explosion that is released is 0.20 (20 %). The respirable fraction is defined as the fraction of the released material associated with an Activity Median Aerodynamic Diameter (AMAD) of 1 micrometer (see User Manual, Appendix A). The default ICRP-30 internal dosimetry conversion factors also assume a 1 m AMAD particle size distribution.

  — The release fraction is partitioned as described in Appendix A, “Explosive Release,” (User Manual).

  — Deposition velocity of the respirable fraction (AMAD = 1 micron) is 1 cm/sec.

  — Deposition velocity of the non-respirable fraction (AMAD = 40 micron) is 8 cm/sec. The non-respirable fraction equals 1-f, where f is the respirable fraction. The default value for f is 0.2 (20 % of the material involved in the explosion has an AMAD of 1 micron). The non-respirable fraction is used for deposition estimates only, and does not contribute to the inhalation dose values.

  — Specific activity, S (Ci/g), as a function of U-235 enrichment, is (Alexander, 1974) $S = (0.4 + 0.38E + 0.0034E^2)(10^{-6})$, where E = percent enrichment. This equation includes the contribution from U-234.

  — Inhalation class is Y.

  — Standard-person breathing rate is 1.2 cubic meters/hour.

  — Three kilograms of weapons-grade uranium (90% U-235, 10% U-238) are involved in a one-point detonation of a weapon containing 40 pounds of high explosive. The sun is low in the sky, and the wind speed is 1 meter/second. Estimate the ground contamination and 50-year committed effective dose equivalents as a function of down-wind centerline distance.

Code Description: Uranium Explosion

```
HOTSPOT  7.0       URANIUM EXPLOSION
RADIONUCLIDE :  URANIUM Inhalation Class : Y
SPECIFIC ACTIVITY :  6.2E-05 Ci/g
SOURCE TERM      :  3.0E+00 kg
RELEASE FRACTION :  2.0E-01
HIGH EXPLOSIVE   :   40.0 lbs
CLOUD TOP        :      191 m
WIND SPEED (h=2 m): 1.0 m/s
STABILITY CLASS         : B                    DEPOSITION VELOCITY      :   1.00 cm/s
RECEPTOR HEIGHT         : 0.0 m                INVERSION LAYER HEIGHT   : NONE
MAXIMUM DOSE DISTANCE   : <    0.1 km          MAXIMUM CEDE   :         >  0.058 rem
Plume Centerline


D  =       0.10 km                  D  =       0.20 km                  D  =  0.50 km
DEP =      4.4E-01 uCi/m^2          DEP =      3.3E-01 uCi/m^2          DEP =  1.7E-01 uCi/m^2
CHI =      1.4E-06 (Ci-s)/m^3       CHI =      1.1E-06 (Ci-s)/m^3       CHI =  5.8E-07 (Ci-s)/m^3

50-YR DOSE COMMITMENT:              50-YR DOSE COMMITMENT:              50-YR DOSE COMMITMENT:
----------------------------------- ----------------------------------- -----------------------------------
LUNG                4.8E-01 rem     LUNG                3.6E-01 rem     LUNG                1.9E-01 rem
EFFECTIVE DOSE                      EFFECTIVE DOSE                      EFFECTIVE DOSE
EQUIVALENT          5.8E-02 rem     EQUIVALENT          4.3E-02 rem     EQUIVALENT          2.3E-02 rem


D  =       1.00 km                  D  =       2.00 km                  D  =       5.00 km
DEP =      7.3E-02 uCi/m^2          DEP =      2.2E-02 uCi/m^2          DEP =      3.6E-03 uCi/m^2
CHI =      2.7E-07 (Ci-s)/m^3       CHI =      9.2E-08 (Ci-s)/m^3       CHI =      1.8E-08 (Ci-s)/m^3

50-YR DOSE COMMITMENT:              50-YR DOSE COMMITMENT:              50-YR DOSE COMMITMENT:
----------------------------------- ----------------------------------- -----------------------------------
LUNG                8.8E-02 rem     LUNG                3.0E-02 rem     LUNG                6.1E-03 rem
EFFECTIVE DOSE                      EFFECTIVE DOSE                      EFFECTIVE DOSE
EQUIVALENT          1.1E-02 rem     EQUIVALENT          3.7E-03 rem     EQUIVALENT          7.4E-04 rem


D  =       10.00 km                 D  =       20.00 km                 D  =       50.00 km
DEP =      8.8E-04 uCi/m^2          DEP =      2.2E-04 uCi/m^2          DEP =      3.8E-05 uCi/m^2
CHI =      5.4E-09 (Ci-s)/m^3       CHI =      1.6E-09 (Ci-s)/m^3       CHI =      3.5E-10 (Ci-s)/m^3

50-YR DOSE COMMITMENT:              50-YR DOSE COMMITMENT:              50-YR DOSE COMMITMENT:
----------------------------------- ----------------------------------- -----------------------------------
LUNG                1.8E-03 rem     LUNG                5.3E-04 rem     LUNG                1.1E-04 rem
EFFECTIVE DOSE                      EFFECTIVE DOSE                      EFFECTIVE DOSE
EQUIVALENT          2.1E-04 rem     EQUIVALENT          6.4E-05 rem     EQUIVALENT          1.4E-05 rem
```

5-#3

Notes:

- Describe the code used to derive the Uranium Explosion Atmospheric Dispersion Model discussed in this lesson.

Code Description: Uranium Explosion

- Code description — Study the table on page 5-5.

Demonstration: Uranium Explosion

HOTSPOT Health Physics Codes
VERSION 7.01
HAZARDS CONTROL DEPARTMENT
LAWRENCE LIVERMORE
NATIONAL LABORATORY

S: SETUP

A: Plutonium Explosion	**B: Plutonium Fire**	**C: Plutonium Resuspension**
D: Uranium Explosion	**E: Uranium Fire**	**F: Nuclear Explosion**
G: Radiation Workplace	**H: General Plume**	**I: General Explosion**
J: General Resuspension	**K: Inhalation Dose**	**T: Tritium Release**
L: HOTSPOT Library	**M: FIDLER Calibration and LUNG Screening**	**N: General Fire**
		Q: QUIT

Enter Selection

5-#14

Notes:

- Describe the steps in using HOTSPOT to model the explosion incident involving uranium.
- Explain that the students should use the Reference page for detailed information.
- Inform the students that sometimes they must press Enter (or Return) in order for the computer system to accept data which they type.
- Code—Explain that the students must select the specific code related to the type of incident. In this example, the students must select Code D (Uranium Explosion) from the HOTSPOT Main Menu.
- Natural Uranium? (Y/N)—Describe natural uranium to the students. They need to type N to enter a new value (% U-235); in this example, they type 90 after they type N.
- Specific Activity = 6.21E^{-05} Ci/g ? (Y/N)—This is the default weapons-grade value; explain specific activity to the students.

Demonstration: Uranium Explosion

- Select Uranium Explosion from the HOTSPOT Main Menu.
- **Step 1** Type **D**
- Natural Uranium? (Y/N)

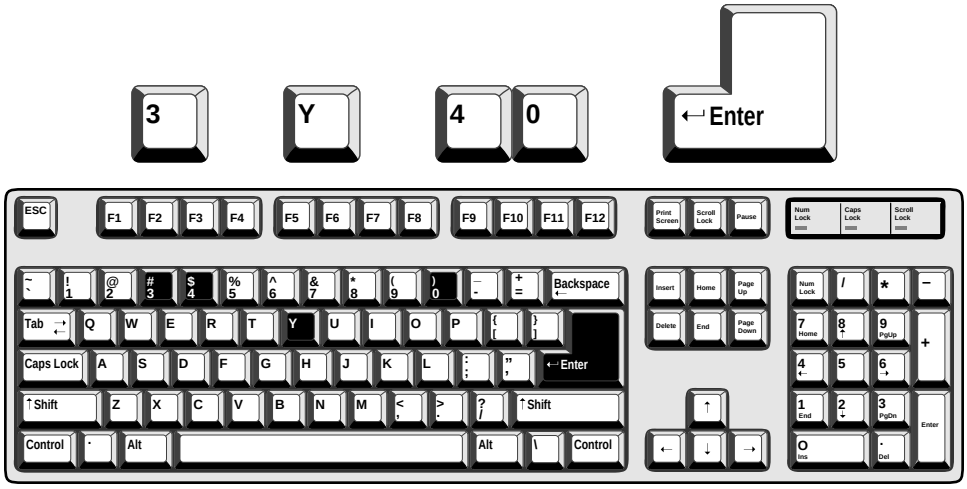
Enter percent U-235, and push Enter.

- **Step 2** Type **N**; type **90**; press **Enter**
- Specific Activity = 6.21E^{-05} Ci/g (Y/N)?

Enter “Y” to accept the default weapons-grade value, or “N” if you wish to enter a new value.

- **Step 3** Type **Y**

Demonstration: Uranium Explosion



5-#5

Notes:

- MASS?—Define mass for the students. It is the total quantity of uranium involved in the explosion (kilograms).

- Fraction = $2.000E^{-01}$?—Define “fraction” and explain that the default respiration fraction of the total material involved in the explosion is dependent upon the type of material. Typing “Y” means that they accept the default.

- High Explosive, lb?—Tell the students to enter the quantity of explosive (pounds).

Demonstration: Uranium Explosion

- MASS, kg?

Enter the total quantity of uranium involved in the explosion (kilograms), and push Enter.

- **Step 4** Type **3**; press **Enter**

- F= 2.000E^{-01}?

F is the fraction of entered activity released and dispersed into an AMAD of one micron. Enter “Y” to accept the default value, or “N” if you wish to enter a new value.

- **Step 5** Type **Y**

- High Explosive, lb?

Enter the quantity of explosive (pounds), and push Enter. Input must be greater than or equal to 0.l.

- **Step 6** Type **40**

Demonstration: Uranium Explosion

- Meteorological Conditions

Choose appropriate meteorological conditions from the following menu—Enter a NUMBER or LETTER.

1. Sun HIGH in the sky
2. Sun LOW in the sky or cloudy
3. NIGHT

Or, if you prefer to enter a specific stability classification,

A: A stability Very unstable
B: B stability Moderately unstable
C: C stability Slightly unstable
D: D stability Neutral
E: E stability Slightly stable
F: F stability Moderately stable
G: G stability Special nighttime, low wind
Enter selection

5-#6

Notes:

- Meteorological Conditions—Explain that the students may enter a number (1, 2, or 3) to specify the meteorological condition (sun high in sky; sun low in sky or cloudy; night) or a letter (A–G) to specify a stability class.

- Refer students to the Meteorological Conditions screen display.

- In this example, the number 2 indicates the correct meteorological condition.

Demonstration: Uranium Explosion

- Meteorological Conditions

Enter a number or a letter to indicate appropriate meteorological conditions.

- **Step 7** Type **2** to indicate meteorological condition (sun LOW in the sky).

Demonstration: Uranium Explosion

- Wind

NAME OF WIND	OBSERVABLE FEATURES	MPH	M/S
calm	Smoke rises vertically	< 1	< 0.5
light Atmospheric	Smoke drifts downward	1 – 3	0.5 – 1
light breeze	Wind felt on face; leaves rustle	3 – 7	1 – 3
gentle breeze	Leaves and twigs in constant motion	7 – 12	3 – 5
moderate breeze	Raises dust and loose paper	12 – 18	5 – 8
fresh breeze	Small tress begin to sway	18 – 24	8 – 11
strong breeze	Large branches in motion	24 – 31	11 – 14
moderate gale	Whole trees in motion	31 – 38	14 – 17
fresh gale	Twigs break off; walking impeded	38 – 46	17 – 21
strong gale	Slight structural damage occurs	46 – 54	21 – 24
whole gale	Tree uprooted; structural damage	54 – 63	24 – 28
storm	Very rare, widespread destruction	63 – 75	28 – 34
hurricane		> 75	> 34

5-#7

Notes:

- Wind—Refer students to the Wind screen display.

Demonstration: Uranium Explosion

- WIND?

Enter the ground wind speed, in meters/second, and press ENTER (1 mph = 0.45 m/s).

- **Step 8** Type **1**

  Press the **Enter** key.

Demonstration: Uranium Explosion

- Main Output Options Menu

```
Main Output Options Menu

1:  SCREEN    Output     Default     Distances
2:  SCREEN    Output     You Enter   Distances
3:  PRINTER   Output     Default     Distances
4:  PRINTER   Output     You Enter   Distances
5:  DISK FILE Output     Default     Distances
6:  DISK FILE Output     You Enter   Distances

G:  GRAPHICS
C:  Change DEFAULT CONTOUR SETTINGS
M:  Change METEOROLOGICAL PARAMETERS and Release
    Height
Z:  Change RECEPTOR HEIGHT (z)
D:  Change DEPOSITION VELOCITY
O:  Enable prompt for OFF AXIS Positions
I:  INVERSION HEIGHT (Mixing Layer)
Q:  Enter to Main HOTSPOT Menu.
```

5-#8

Notes:

- Screen output—Explain that students should select 1, screen output using the default distances.

- Data tables—The students must type 1 and press Return to view the data tables.

Demonstration: Uranium Explosion

- Main Outputs Options Menu
- Screen output
- **Step 9** Type **1** to view data tables.
- **Step 10** Press **Enter** view more data

  Continue pressing **Enter** until you view all the data.

  After you have viewed all the data, the following message appears:

  > "Enter the appropriate Output option number from the following menu."

- Look at the Output Option Number Menu.

Demonstration: Uranium Explosion

- Output Option Number Menu

1: Enter a new Downwind Distance.
2: Return to Output Menu.
Q: Return to Main HOTSPOT Menu.

5-#9

Notes:

- Tell students to type 2 at the Output Option Number Menu to return to the Output Menu.

Demonstration: Uranium Explosion

- Output Option Number Menu
- **Step 11** Type **2** at the Output Option Number Menu to return to the Output Menu.

  Press **Enter**

Demonstration: Uranium Explosion

- Main Output Options Menu—Option G

```
Main Output Options Menu

1:  SCREEN    Output     Default     Distances
2:  SCREEN    Output     You Enter   Distances
3:  PRINTER   Output     Default     Distances
4:  PRINTER   Output     You Enter   Distances
5:  DISK FILE Output     Default     Distances
6:  DISK FILE Output     You Enter   Distances

G:  GRAPHICS
C:  Change DEFAULT CONTOUR SETTINGS
M:  Change METEOROLOGICAL PARAMETERS and Release
     Height
Z:  Change RECEPTOR HEIGHT (z)
D:  Change DEPOSITION VELOCITY
O:  Enable prompt for OFF AXIS Positions
I:  INVERSION HEIGHT (Mixing Layer)
Q:  Enter to Main HOTSPOT Menu.
```

5-#10

Notes:

- Main Output Options Menu: Option G—Explain that students need to use option G to see graphical representations of the results of the example incident’s air dispersion model.

Demonstration: Uranium Explosion

- Option G—Graphics
- **Step 12** Type **G** for Graphics.
- Result An Output option number menu appears.

Demonstration: Uranium Explosion

1: CEDE Contours
2: Centerline 50-yr. CEDE vs. Distance

TO PRINT GRAPHICS—PUSH the “P” key when the screen output is complete.

Select your printer using the SETUP option at the Main HOTSPOT MENU.

5-#11

Notes:

- Students may view Centerline 50-yr. CEDE vs. Distance graphical output by typing the number 3.
- Color/Monochrome—Have students type the number 1 or 2.
- Downwind Plotting Range—Have the students type 1 or 2.
- Print—If they have printer capability, the students may press P to print the graphical results (same as Page 5-3).

Demonstration: Uranium Explosion

- **Step 13** Type **2** to view Centerline 50-yr. CEDE vs. Distance graphical output.
- Result The following selection box appears:

```
1: COLOR
2: MONOCHROME / LCD
```

- **Step 14** Type **2** for monochrome, unless you have a color monitor, in which case, you must type 1.
- Result The following selection box appears:

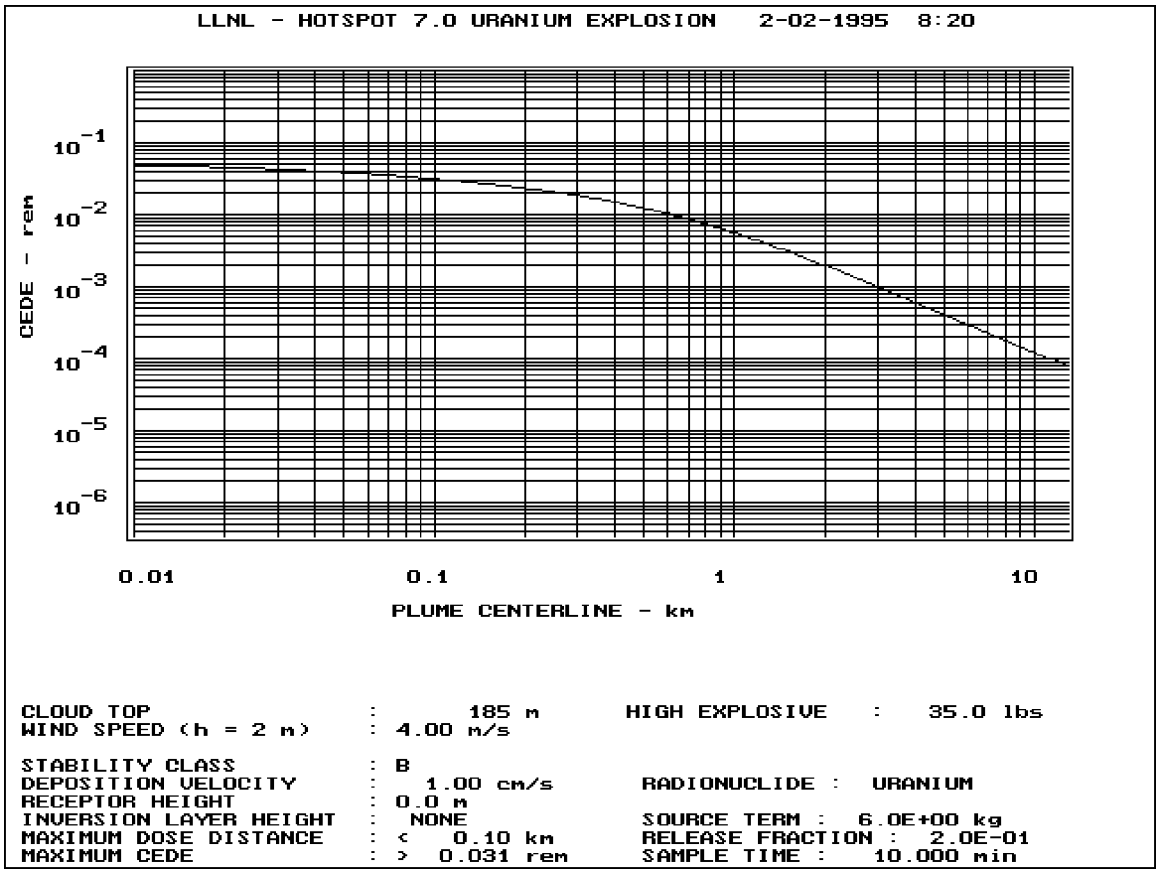
```
DOWNWIND PLOTTING RANGE
ENTER SELECTION NUMBER

1: 0.01 TO 10 km
2: 0.1 TO 100 km
```

- **Step 15** Type **1**

  The result is a graph.
- Print (if you have printer capability).
- **Step 16** Press **P** to print the graph.

Exercise 5-1: Uranium Explosion

- Exercise (Uranium: U-235, U238)



5-#12

Notes:

- Distribute Exercise for Uranium Explosion (Appendix B contains all exercises; use these to duplicate as many copies as needed for trainees).
- Display Overhead.
- Explain that students may consult the Reference page if they wish.
- Exercise Answers: Maximum Dose Distance = <0.1 km
  Maximum CEDE = >0.031 rem

Exercise: Uranium Explosion

- Page 5-23 illustrates the graphical output for a Uranium Explosion Atmospheric Dispersion Model derived from the HOTSPOT Health Physics Codes program.

- The example for this exercise is based on the following assumptions:

  — Six kilograms of weapons-grade uranium (90% U-=235, 10% U-238) are involved in a one-point detonation of a weapon containing 35 pounds of high explosive. The sun is high in the sky, and the wind speed is 4 meters/second. Estimate the ground contamination and 50-year committed effective dose equivalents as a function of down-wind centerline distance.

- **Step 1** From the HOTSPOT Main Menu: Type **D**
- **Step 2** Natural Uranium? (Y/N) Type **N**; type **90**; press **Enter**
- **Step 3** Specific Activity: S = 6.21E^{-05} Ci/g? (Y/N) Type **Y**
- **Step 4** Mass? Type **6**
- **Step 5** Fraction = 2.00E^{-01}? (Y/N) Type **Y**
- **Step 6** High Explosive, lb? Type **35**
- **Step 7** Conditions? Type **1** for sun HIGH in the sky.
- **Step 8** Wind? Type **4** (for 4 meters/second); press **Enter**
- **Step 9** Type **1** at the Main Outputs Options Menu to view data table.
- **Step 10** Press **Enter** as desired to view more data.
- **Step 11** Type **2** to return to the Output Menu.
- **Step 12** Type **G** (graphics).
- **Step 13** Type **3** to view Centerline 50-yr. CEDE vs. Distance.
- **Step 14** Type **1** to select COLOR.
- **Step 15** Type **1** to enter downwind plotting range.

The result is the graph shown on the previous page of this manual.

Lesson 6
Uranium Fire
Code E

LESSON PLAN
HOTSPOT HEALTH PHYSICS CODES

LESSON 6 – Uranium Fire, Code E

TIME:

30 minutes

LESSON LEARNING OBJECTIVES

Terminal: At the end of this lesson, trainees will be able to model a uranium fire involving released material, using the Uranium Fire Code E Atmospheric Dispersion Model of the HOTSPOT Health Physics program.

Enabling:

- At the end of this lesson, students should be able to:
  - — Describe the graphical output for a Uranium Fire Atmospheric Dispersion Model
  - — Explain the assumptions involved in deriving Uranium Fire output (tabular and graphical)
  - — Given mock data, generate Uranium Fire output (tabular and graphical)

INSTRUCTIONAL APPROACH

The mode of delivery for this lesson is lecture, using several job aids and reference materials to provide students with an overview of the HOTSPOT Health Physics Codes application.

EQUIPMENT AND INSTRUCTIONAL AIDS

Overhead projector
IBM PC, XT, AT, or compatible
HOTSPOT User's Manual (*HOTSPOT Health Physics Codes for the PC*)
Exercise Number 6–1

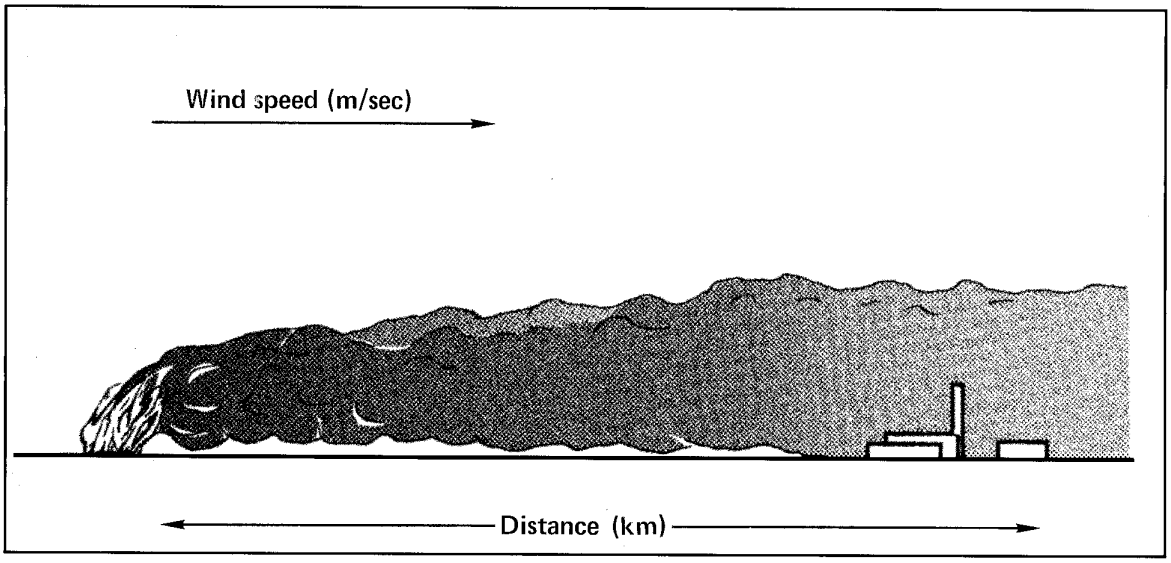
STUDENT MATERIALS

Student Manual

REFERENCES

HOTSPOT User's Manual (*HOTSPOT Health Physics Codes for the PC*)

Lesson Objectives



6#1

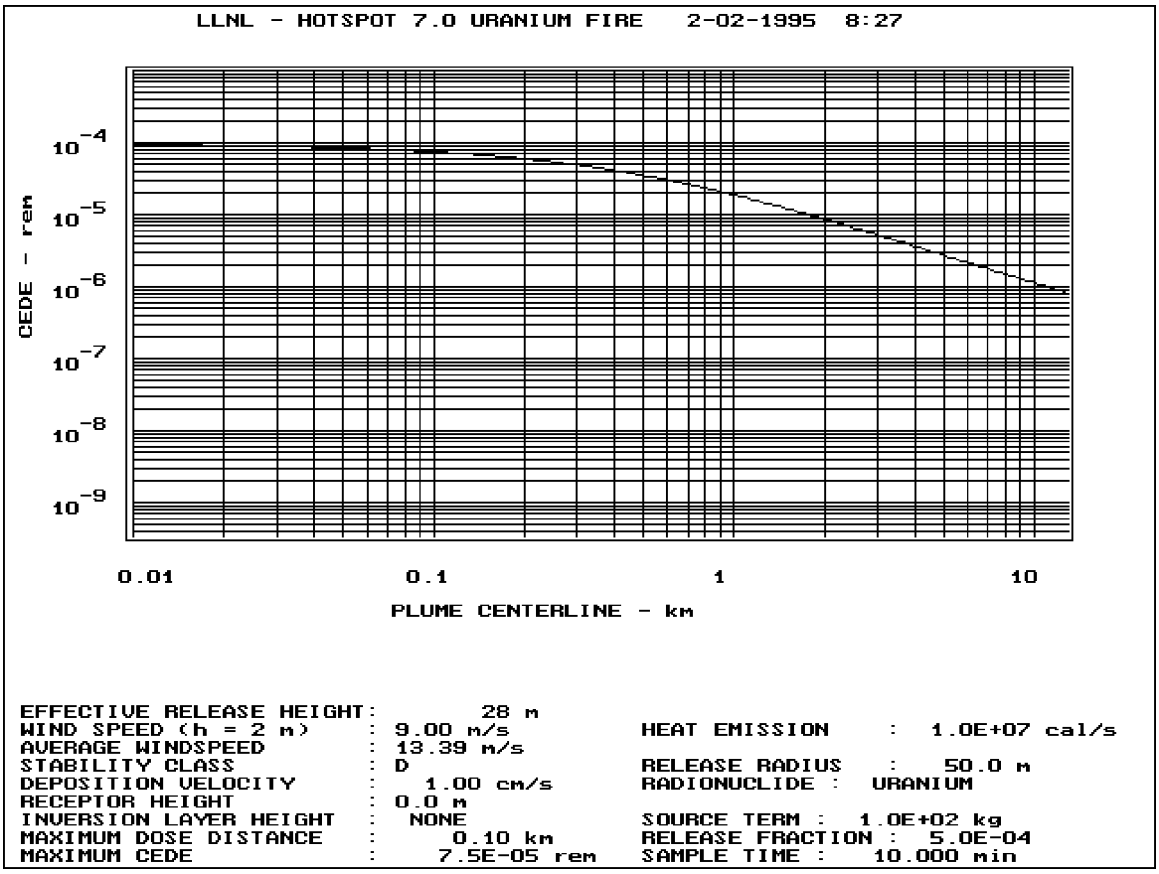
Notes:

- At the end of this lesson, students will be able to model a uranium fire involving released material, using the Uranium Fire Code E Atmospheric Dispersion Model.
- Explain the Lesson Objectives.

Lesson Objectives

- At the end of this lesson, students should be able to:
  - Describe the graphical output for a Uranium Fire Atmospheric Dispersion Model
  - Explain the assumptions involved in deriving Uranium Fire output (tables and graphs)
  - Given mock data, generate Uranium Fire output (tables and graphs)

Graphical Output and Assumptions—Uranium Fire



6-#2

Notes:

- Have students refer to Page 6-3, graphical output for the Uranium Fire incident.
- Discuss the assumptions concerning the Uranium Fire incident.

Graphical Output and Assumptions—Uranium Fire

- Review Page 6-3, graphical output for the Uranium Fire Atmospheric Dispersion Model derived from HOTSPOT.

- This example is based on the following assumptions:

  — The default respirable fraction of the total uranium involved in the fire that is released is $5x10^{-4}$ (0.05 %). The respirable fraction is defined as the fraction of the released material associated with an Activity Median Aerodynamic Diameter (AMAD) of 1 micrometer (see User Manual, Appendix A). The default ICRP-30 internal dosimetry conversion factors also assume a 1 micrometer AMAD particle size distribution.

  — The effective release height is determined using the methodology contained in the “Fuel Fire” section of Appendix A. Once the effective release height is determined, the radius of the final bent-over plume is set equal to 60% of the effective release height (Hanna, 1982). An upwind virtual point source, which results in an initial σ_y and σ_z equal to 50% of the plume radius at the origin (i.e., plume radius = 2), is used to model the fire scenario.

  — Deposition velocity is 1 cm/sec.

  — Specific activity, S (Ci/g), as a function of U-235 enrichment is (Alexander, 1974)

  $$S = (0.4 + 0.38E + 0.0034E^2)(10^{-6})$$
  where E = percent enrichment.

  This equation includes the contribution from U-234.

  — Inhalation class is Y.

  — Standard-person breathing rate is 1.2 cubic meters/hour.

  — 100 kilograms of uranium (95% U-238, 5% U-235) being used in an isotope separation experiment are involved in a significant building fire (Heat Emission = $1x10^7$ calories/sec, effective radius of building fire is 50 meters). The sun has set, the wind speed is approximately 9 meters/second, and the ambient air temperature is 20 degrees C. The nearest occupied location is at a downwind distance of 0.5 kilometer. What is the maximum expected 50-year committed effective dose equivalent for this location?

Code Description: Uranium Fire

```
HOTSPOT 7.0 URANIUM FIRE
RADIONUCLIDE :  URANIUM Inhalation Class : Y          SPECIFIC ACTIVITY :  2.38E-06 Ci/g
SOURCE TERM      :  1.0E+02 kg
RELEASE FRACTION :  5.00E-04
HEAT EMISSION    :  1.0E+07 cal/s                     RELEASE RADIUS   :    50.0 m
EFFECTIVE RELEASE HEIGHT :    28.0 m
WIND SPEED (h=2 m): 9.0 m/s                            AVERAGE WINDSPEED: 13.4 m/s
STABILITY CLASS          : D                          DEPOSITION VELOCITY      :   1.00 cm/s
RECEPTOR HEIGHT          : 0.0 m                      INVERSION LAYER HEIGHT   : NONE
SAMPLE TIME              :   10.000 min
MAXIMUM DOSE DISTANCE    :      0.1 km                MAXIMUM CEDE   :    7.5E-05 rem
```

6-#3

Notes:

- Describe the code used to derive the Uranium Fire Atmospheric Dispersion Model illustrated in this lesson.

Code Description: Uranium Fire

- Code description — Study the table on page 6-5.

Demonstration: Uranium Fire

HOTSPOT Health Physics Codes
VERSION 7.01
HAZARDS CONTROL DEPARTMENT
LAWRENCE LIVERMORE
NATIONAL LABORATORY

S: SETUP

A: Plutonium Explosion	**B: Plutonium Fire**	**C: Plutonium Resuspension**
D: Uranium Explosion	**E: Uranium Fire**	**F: Nuclear Explosion**
G: Radiation Workplace	**H: General Plume**	**I: General Explosion**
J: General Resuspension	**K: Inhalation Dose**	**T: Tritium Release**
L: HOTSPOT Library	**M: FIDLER Calibration and LUNG Screening**	**N: General Fire**
		Q: QUIT

Enter Selection
6-#4

Notes:

- Describe the steps involved to model the uranium fire incident.
- Explain that students should use the Reference page for detailed information.
- Code—Explain that the students must select the specific code related to the type of incident. In this example, the students must select Code E (Uranium Fire) from the HOTSPOT Main Menu.
- Inform the students that sometimes they must press Enter (or Return) in order for the computer system to accept data which they type.
- Effective Release Height—Explain the conditions under which the students would select 1, 2, or 3 from the Effective Release Height menu.
- Heat Emission— Define “heat emissions.”
- Release Radius—Explain that the release radius is the effective radius of the fire, e.g., radius of burning fuel pool.
- Ambient Air Temperature—Define “ambient air temperature.”
- Natural Uranium (Y/N)—Tell students this incident does not involve natural uranium; they must enter the percent U-235 by typing the number 5.

Demonstration: Uranium Fire

- Select Uranium Fire from the HOTSPOT Main Menu.
- **Step 1** Type **E**
- Result The Effective Release Height menu appears:

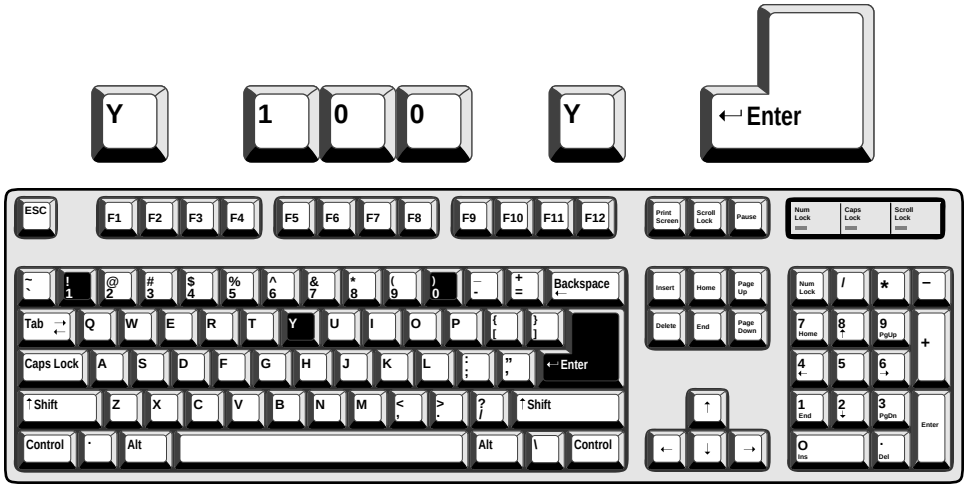
1: Fire –	You enter Effective Release Height.
2: Fire –	HOTSPOT calculates Effective Release Height using input fuel and burn duration.
3: Fire –	HOTSPOT calculates Effective Release Height using input Heat Emission (calories per second).

- **Step 2** Type **3**
- Heat Emission?
- **Step 3** Type **1E7**
- Release Radius = 10 m? (Y/N)
- **Step 4** Type **N**; type **50**; press **Enter**
- Ambient Air Temperature?
- **Step 5** Type **Y**
- Natural Uranium? (Y/N)

Enter percent U-235, and push Enter.

- **Step 6** Type **N**; type **5**; press **Enter**

Demonstration: Uranium Fire



6-#5

Notes:

- Specific Activity = 2.38E–06 Ci/g?—This is the default weapons-grade value; explain alpha specific activity to the students.
- MASS (U), kg?—Explain that students must enter the total quantity of uranium involved in the fire (kilograms).
- Fraction = 5.000E–04?—Explain the concept of “fraction of the entered activity.”

Demonstration: Uranium Fire

- Specific Activity = 2.38E^{-06} Ci/g (Y/N)?

Enter “Y” to accept the default weapons-grade value, or “N” if you wish to enter a new value.

- **Step 7** Type **Y**

- MASS, (U), kg?

Enter the total quantity of uranium involved in the explosion (kilograms), and push Enter.

- **Step 8** Type **100**; press **Enter**

- F= 2.000E^{-01}?

F is the fraction of entered activity released and dispersed into an AMAD of one micron. Enter “Y” to accept the default value, or “N” if you wish to enter a new value.

- **Step 9** Type **Y**

Demonstration: Uranium Fire

- ## Meteorological Conditions

Choose appropriate meteorological conditions from the following menu—Enter a NUMBER or LETTER.

1. Sun HIGH in the sky
2. Sun LOW in the sky or cloudy
3. NIGHT

Or, if you prefer to enter a specific stability classification,

A: A stability Very unstable
B: B stability Moderately unstable
C: C stability Slightly unstable
D: D stability Neutral
E: E stability Slightly stable
F: F stability Moderately stable
G: G stability Special nighttime, low wind
Enter selection

6-#6

Notes:

- Meteorological Conditions—Explain that the students may enter a number (1, 2, or 3) to specify the meteorological condition (sun high in sky; sun low in sky or cloudy; night) or a letter (A–G) to specify a stability class.

- Refer students to the Meteorological Conditions screen display.

- In this example, the number 3 indicates the correct meteorological condition (NIGHT).

Demonstration: Uranium Fire

- Meteorological Conditions

Enter a number or a letter to indicate appropriate meteorological conditions.

- **Step 10** Type **3** to indicate meteorological condition (NIGHT).

Demonstration: Uranium Fire

- Wind

NAME OF WIND	OBSERVABLE FEATURES	MPH	M/S
calm	Smoke rises vertically	< 1	< 0.5
light Atmospheric	Smoke drifts downward	1 – 3	0.5 – 1
light breeze	Wind felt on face; leaves rustle	3 – 7	1 – 3
gentle breeze	Leaves and twigs in constant motion	7 – 12	3 – 5
moderate breeze	Raises dust and loose paper	12 – 18	5 – 8
fresh breeze	Small tress begin to sway	18 – 24	8 – 11
strong breeze	Large branches in motion	24 – 31	11 – 14
moderate gale	Whole trees in motion	31 – 38	14 – 17
fresh gale	Twigs break off; walking impeded	38 – 46	17 – 21
strong gale	Slight structural damage occurs	46 – 54	21 – 24
whole gale	Tree uprooted; structural damage	54 – 63	24 – 28
storm	Very rare, widespread destruction	63 – 75	28 – 34
hurricane		> 75	> 34

6-#7

Notes:

- Wind—Refer students to the Wind screen display.
- Explain the Plume Rise Summary Information table.

Demonstration: Uranium Fire

- WIND?

Enter the ground wind speed, in meters/second, and press ENTER (1 mph = 0.45 m/s).

- **Step 11** Type **9**

  Press the **Enter** key.

- Result The Plume Rise Summary Information table appears.

Plume Rise Summary Information	
Heat Emission:	1.0E+07 calories/ second
Buoyancy Flux:	3.7E+02 meter^4/ second^3
Ambient Air Temp.:	20.0 degrees centigrade
Release Radius:	50.0 meters
Average Wind Speed.:	13.4 meters/ second
Effective Release Height:	28 meters

Demonstration: Uranium Fire

- Main Output Options Menu

```
Main Output Options Menu

1:  SCREEN    Output     Default     Distances
2:  SCREEN    Output     You Enter   Distances
3:  PRINTER   Output     Default     Distances
4:  PRINTER   Output     You Enter   Distances
5:  DISK FILE Output     Default     Distances
6:  DISK FILE Output     You Enter   Distances

G:  GRAPHICS
C:  Change DEFAULT CONTOUR SETTINGS
M:  Change METEOROLOGICAL PARAMETERS and Release
     Height
Z:  Change RECEPTOR HEIGHT (z)
D:  Change DEPOSITION VELOCITY
O:  Enable prompt for OFF AXIS Positions
I:   INVERSION HEIGHT (Mixing Layer)
P:   Plume Rise
R:   Review Plume Rise Data
T:   Sample Time
Q:  Enter to Main HOTSPOT Menu.
```

6-#8

Notes:

- Screen output—Explain that students should select 1, screen output using the default distances.

- Data tables—The students must type 1 and press Return to view the data tables.

Demonstration: Uranium Fire

- Main Outputs Options Menu
- Screen output
- **Step 12** Type **1** to view data tables.
- **Step 13** Press **Enter** view more data.

  Continue pressing **Enter** until you view all the data.

  After you have viewed all the data, the following message appears:

“Enter the appropriate Output option number from the following menu.”

- Look at the Output Option Number Menu.

Demonstration: Uranium Fire

- Output Option Number Menu

1: Enter a new Downwind Distance.

2: Return to Output Menu.

Q: Return to Main HOTSPOT Menu.

6-#9

Notes:

- Explain that students must type 2 at the Output Option Number Menu to return to the Main HOTSPOT Menu.

Demonstration: Uranium Fire

- Output Option Number Menu
- **Step 14** Type **2** at the Output Option Number Menu to return to the Output Menu.

  Press **Enter**

Demonstration: Uranium Fire

- Main Output Options Menu—Option G

```
Main Output Options Menu

1:  SCREEN    Output     Default     Distances
2:  SCREEN    Output     You Enter   Distances
3:  PRINTER   Output     Default     Distances
4:  PRINTER   Output     You Enter   Distances
5:  DISK FILE Output     Default     Distances
6:  DISK FILE Output     You Enter   Distances

G:  GRAPHICS
C:  Change DEFAULT CONTOUR SETTINGS
M:  Change METEOROLOGICAL PARAMETERS and Release
     Height
Z:  Change RECEPTOR HEIGHT (z)
D:  Change DEPOSITION VELOCITY
O:  Enable prompt for OFF AXIS Positions
I:   INVERSION HEIGHT (Mixing Layer)
P:   Plume Rise
R:   Review Plume Rise Data
T:   Sample Time
Q:  Enter to Main HOTSPOT Menu.
```

6-#10

Notes:

- Main Output Options Menu: Option G—Explain that students need to use option G to see graphical representations of the results of the example incident.

Demonstration: Uranium Fire

- Option G—Graphics
- **Step 15** Type **G** for Graphics.
- Result An Output option number menu appears.

Demonstration: Uranium Fire

1: CEDE Contours
2: Centerline 50-yr. CEDE vs. Distance

TO PRINT GRAPHICS—PUSH the “P” key when the screen output is complete.

Select your printer using the SETUP option at the Main HOTSPOT MENU.

6-#11

Notes:

- Output Option Number Menu
- Students may view Centerline 50-yr. CEDE vs. Distance graphical output by typing the number 3.
- Color/Monochrome—Have students type the number 1 or 2.
- Downwind Plotting Range—Have the students type 1 or 2.
- Print—If they have printer capability, the students may press P to print the graphical results.

Demonstration: Uranium Fire

- **Step 16** Type **3** to view Centerline 50-yr. CEDE vs. Distance graph.
- Result The following selection box appears:

```
1: COLOR
2: MONOCHROME / LCD
```

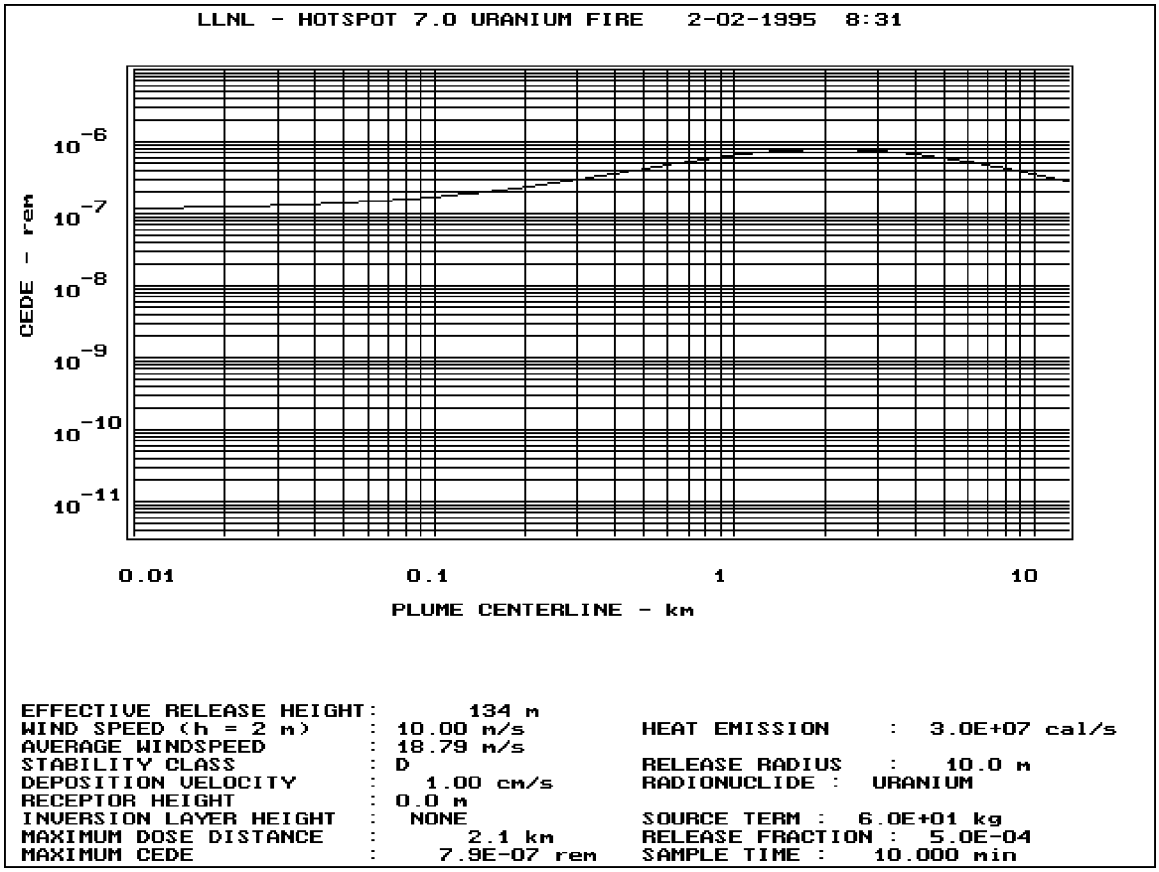
- **Step 17** Type **2** for monochrome, or type **1** for color.
- Result The following selection box appears:

```
DOWNWIND PLOTTING RANGE
ENTER SELECTION NUMBER

1: 0.01 TO 10 km
2: 0.1 TO 100 km
```

- **Step 18** Type **1**; the result is a graph.
- Print (if you have printer capability).
- **Step 19** Press **P** to print the graph.

Exercise 6-1: Uranium Fire

- Exercise (Uranium: U-238, U235)



6-#12

Notes:

- Distribute Exercise for Uranium Fire (Appendix B contains all exercises; use these to duplicate as many copies as needed for trainees).
- Display Overhead.
- Explain that students may consult the Reference page if they wish.
- Exercise Answers: Maximum Dose Distance = 2.1 km
  Maximum CEDE = 7.9E-07 rem

Exercise 6-1: Uranium Fire

- Review the graphical output for this exercise (Uranium Fire Atmospheric Dispersion Model derived from HOTSPOT).

- The example for this exercise is based on the following assumptions:

  — Sixty kilograms of uranium (95% U-=238, 5% U-235) are involved in a significant building fire (Heat Emission = $3x10^7$ calories/sec, effective radius of building fire is 10 meters). It is a cloudy day, the wind speed is 10 meters/second, and the ambient air temperature is 16 degrees C. Estimate the ground contamination and 50-year committed effective dose equivalents as a function of down-wind centerline distance.

- **Step 1** From the HOTSPOT Main Menu: Type **E**
- **Step 2** Effective Release Height? Type **3**
- **Step 3** Heat Emissions? Type **3E7**
- **Step 4** Release Radius = 10 m? (Y/N) Type **Y**
- **Step 5** Ambient Air Temperature? Type **N**; type **16**; press **Enter**
- **Step 6** Natural Uranium? (Y/N) Type **N**; type **5** ; press **Enter**
- **Step 7** Specific Activity: S = $2.38E^{-06}$ Ci/g? (Y/N) Type **Y**
- **Step 8** Mass (U), kg Type **60**; press **Enter**
- **Step 9** Fraction = $5.000E^{-04}$? (Y/N) Type **Y**
- **Step 10** Conditions? Type **2** for cloudy day.
- **Step 11** Wind? Type **10** (for 10 meters/second); press **Enter**
- Result The Plume Rise Summary Information table appears.
- **Step 12** Type **1** at the Main Outputs Options Menu to view data table.
- **Step 13** Press **Enter** as desired to view more data.
- **Step 14** Type **2** to return to the Output Menu.
- **Step 15** Type **G** (graphics).
- **Step 16** Type **3** to view Centerline 50-yr. CEDE vs. Distance.
- **Step 17** Type **1** to select COLOR.
- **Step 18** Type **1** to enter downwind plotting range.

The result is the graph shown on the previous page of this manual.

Lesson 7
Tritium Release
Code T

LESSON PLAN
HOTSPOT HEALTH PHYSICS CODES

LESSON 7 – Tritium Release, Code T

TIME:

30 minutes

LESSON LEARNING OBJECTIVES

Terminal: At the end of this lesson, students will be able to model a tritium release, using the Tritium Release Code T Atmospheric Dispersion Model of the HOTSPOT Health Physics program.

Enabling:

- At the end of this lesson, students should be able to:
  - — Describe the graphical output for a Tritium Release Atmospheric Dispersion Model
  - — Explain the assumptions involved in deriving Tritium Release output (tabular and graphical)
  - — Given mock data, generate Tritium Release output (tabular and graphical)

INSTRUCTIONAL APPROACH

The mode of delivery for this lesson is lecture, using several job aids and reference materials to provide students with an overview of the HOTSPOT Health Physics Codes application.

EQUIPMENT AND INSTRUCTIONAL AIDS

Overhead projector
IBM PC, XT, AT, or compatible
HOTSPOT User's Manual (*HOTSPOT Health Physics Codes for the PC*)
Exercise Number 7–1

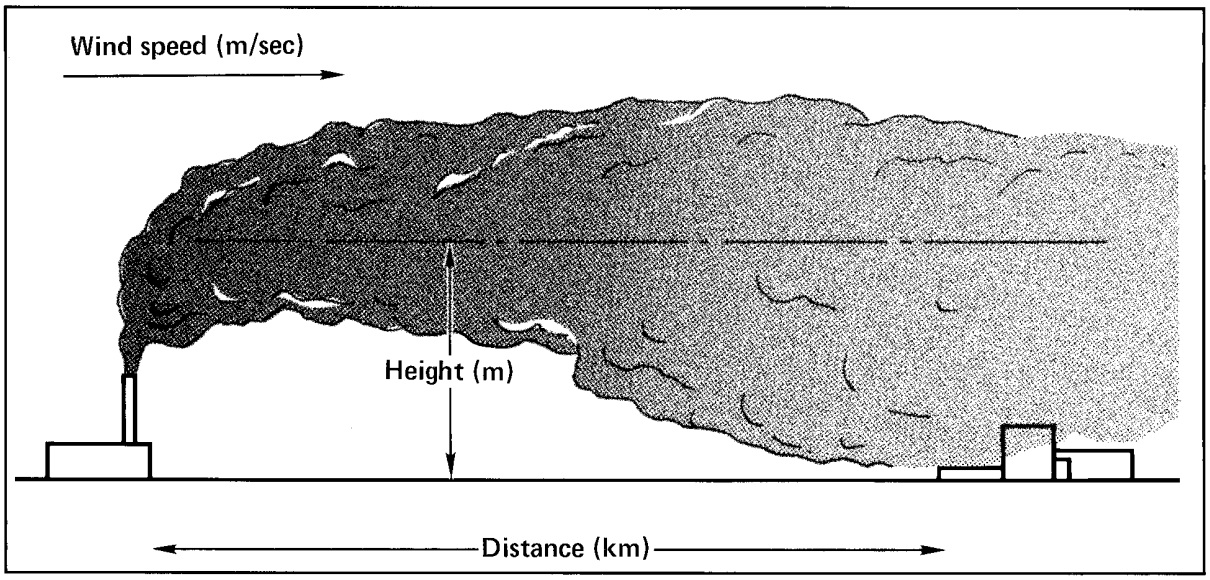
STUDENT MATERIALS

Student Manual

REFERENCES

HOTSPOT User's Manual (*HOTSPOT Health Physics Codes for the PC*)

Lesson Objectives



7-#1

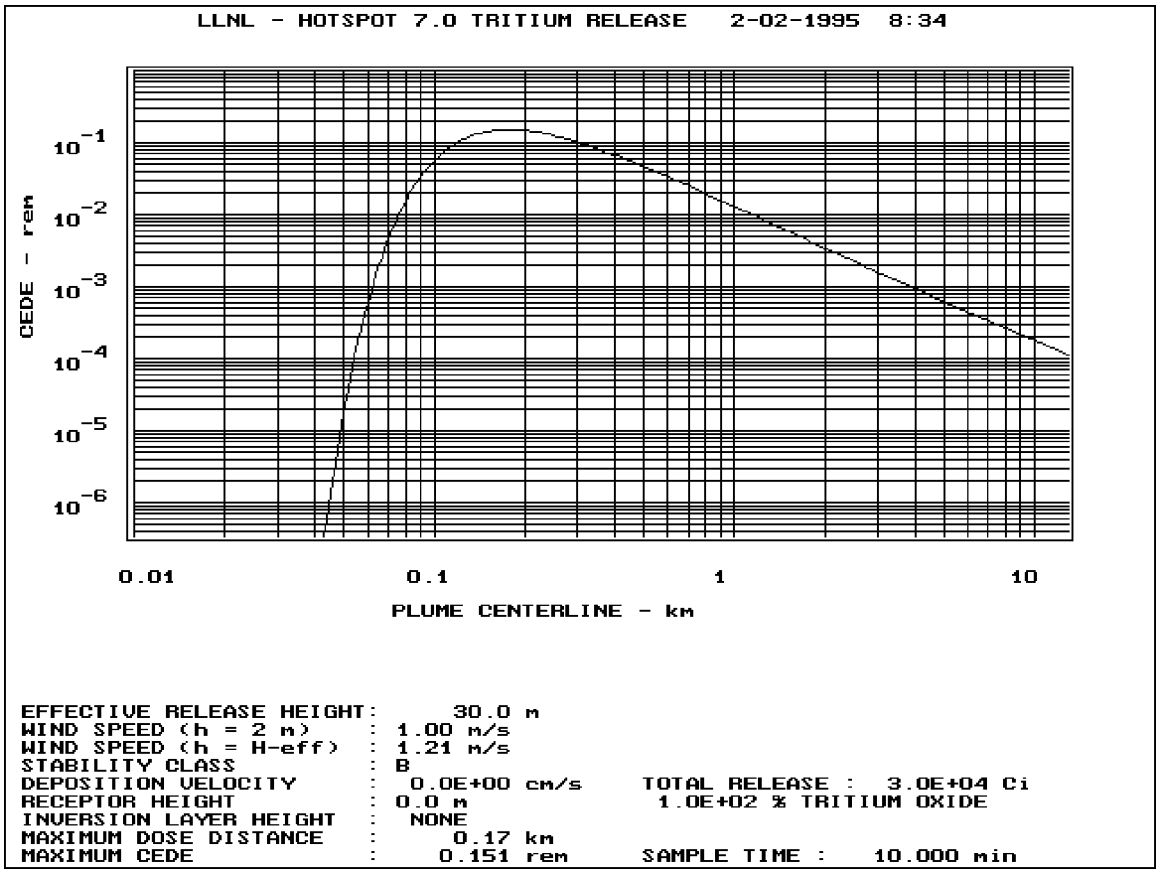
Notes:

- At the end of this lesson, students will be able to model a tritium release, using the Tritium Release Code T Atmospheric Dispersion Models.
- Explain the Lesson Objectives.

Lesson Objectives

- At the end of this lesson, students should be able to:
  - — Describe the graphical output for a Tritium Release Atmospheric Dispersion Model
  - — Explain the assumptions involved in deriving Tritium Release output (tables and graphs)
  - — Given mock data, generate Tritium Release output (tables and graphs) using HOTSPOT

Graphical Output and Assumptions—Tritium Release




```
EFFECTIVE RELEASE HEIGHT:      30.0 m
WIND SPEED (h = 2 m)     : 1.00 m/s
WIND SPEED (h = H-eff)   : 1.21 m/s
STABILITY CLASS          : B
DEPOSITION VELOCITY      :  0.0E+00 cm/s     TOTAL RELEASE :  3.0E+04 Ci
RECEPTOR HEIGHT          : 0.0 m              1.0E+02 % TRITIUM OXIDE
INVERSION LAYER HEIGHT   :  NONE
MAXIMUM DOSE DISTANCE    :      0.17 km
MAXIMUM CEDE             :     0.151 rem     SAMPLE TIME :   10.000 min
```

7-#2

Notes:

- Have students refer to Page 7-3, graphical output for the Tritium Release incident.
- Discuss the assumptions concerning the Tritium Release incident.

Graphical Output and Assumptions—Tritium Release

- Review the graphical output for a Tritium Release Atmospheric Dispersion Model derived from HOTSPOT.
- This example is based on the following assumptions:

  — 50-year committed effective dose equivalent (rem-m3)/(Ci-sec):

  TRITIATED WATER:

  In the HOTSPOT Codes, it is assumed that 2/3 of the CEDE is due to inhalation and 1/3 of the CEDE is due to absorption through the intact skin (ICRP 30 Part 1, 1978, p 65).

  CEDE : = 0.031 (0.021 inhalation) + 0.010 absorption)

  ELEMENTAL TRITIUM:

  CEDE : 1.2×10^{-6}
  LUNG : 1.0×10^{-5}

  — 30,000 curies of HTO are released from a 30-meter stack. The wind speed is 1 meter/second; on a cloudy day. What distance is associated with the maximum 50-year committed effective dose equivalent to an individual remaining at this location throughout the release?

Code Description: Tritium Release

```
HOTSPOT 7.0                          TRITIUM RELEASE
TOTAL TRITIUM RELEASE :              3.0E+04 curies   100.000 % TRITIUM OXIDE
Dose Results Include Skin Absorption
EFFECTIVE RELEASE HEIGHT :           30.00 m
WIND SPEED (h=2 m):                  1.0 m/s
WIND SPEED (h=H-eff):                1.2 m/s
STABILITY CLASS        :             B
DEPOSITION VELOCITY     :            0.0E+00 cm/s
RECEPTOR HEIGHT        :                     0.0 m
INVERSION LAYER HEIGHT  :            NONE
SAMPLE TIME            :             10.0 min
MAXIMUM DOSE DISTANCE   :            0.17 km
MAXIMUM CEDE  :                      0.151 rem
Plume Centerline

D  =      0.10 km                    D  =      0.20 km                    D  =      0.50 km
CHI =     1.8E+00 (Ci-s)/m^3         CHI =     4.8E+00 (Ci-s)/m^3         CHI =     1.5E+00 (Ci-s)/m^3

50-YR DOSE COMMITMENT:               50-YR DOSE COMMITMENT:               50-YR DOSE COMMITMENT:
----------------------------------   ----------------------------------   ----------------------------------
EFFECTIVE DOSE                       EFFECTIVE DOSE                       EFFECTIVE DOSE
EQUIVALENT        5.6E-02 rem        EQUIVALENT        1.5E-01 rem        EQUIVALENT        4.6E-02 rem


D  =      1.00 km                    D  =      2.00 km                    D  =      5.00 km
CHI =     4.2E-01 (Ci-s)/m^3         CHI =     1.1E-01 (Ci-s)/m^3         CHI =     2.0E-02 (Ci-s)/m^3

50-YR DOSE COMMITMENT:               50-YR DOSE COMMITMENT:               50-YR DOSE COMMITMENT:
----------------------------------   ----------------------------------   ----------------------------------
EFFECTIVE DOSE                       EFFECTIVE DOSE                       EFFECTIVE DOSE
EQUIVALENT        1.3E-02 rem        EQUIVALENT        3.5E-03 rem        EQUIVALENT        6.2E-04 rem
```

7-#3

Notes:

- Describe the code used to derive the Tritium Release Atmospheric Dispersion Model illustrated in this lesson.

Code Description: Tritium Release

- Code description — Study the table on page 7-5.

Demonstration: Tritium Release

HOTSPOT Health Physics Codes
VERSION 7.01
HAZARDS CONTROL DEPARTMENT
LAWRENCE LIVERMORE
NATIONAL LABORATORY

S: SETUP

A: Plutonium Explosion	**B: Plutonium Fire**	**C: Plutonium Resuspension**
D: Uranium Explosion	**E: Uranium Fire**	**F: Nuclear Explosion**
G: Radiation Workplace	**H: General Plume**	**I: General Explosion**
J: General Resuspension	**K: Inhalation Dose**	**T: Tritium Release**
L: HOTSPOT Library	**M: FIDLER Calibration and LUNG Screening**	**N: General Fire**
		Q: QUIT

Enter Selection
7-#4

Notes:

- Describe the steps involved in using HOTSPOT to model the incident involving a tritium release.
- Explain that the students should use the Reference page for detailed information.
- Code—Explain that the students must select the specific code related to the type of incident. In this example, the students must select Code T (Tritium Release) from the HOTSPOT Main Menu.
- Curies—Tell students to enter the total tritium release (curies).
- Tritiated Water—Have students enter the percent of the total tritium released in the form of tritiated water; in this example, it is 100%.
- Effective Release Height—Explain the conditions under which the students would select 1, 2, or 3 from the Effective Release Height menu; in this example, it is 30 meters.

Demonstration: Tritium Release

- Select Tritium Release from the HOTSPOT Main Menu.
- **Step 1** Type **T**
- Curies?

Enter the total tritium release (curies), and push Enter.

- **Step 2** Type **30000;** press **Enter**
- Tritiated Water?

Enter percent (e. g., 50%) of the total tritium released in the form of tritiated water, and push Enter.

- **Step 3** Type **100**; press **Enter**
- Effective Release Height?
- **Step 4** Type **30**

Demonstration: Tritium Release

- Meteorological Conditions

Choose appropriate meteorological conditions from the following menu—Enter a NUMBER or LETTER.

1. Sun HIGH in the sky
2. Sun LOW in the sky or cloudy
3. NIGHT

Or, if you prefer to enter a specific stability classification,

A:	A stability	Very unstable
B:	B stability	Moderately unstable
C:	C stability	Slightly unstable
D:	D stability	Neutral
E:	E stability	Slightly stable
F:	F stability	Moderately stable
G:	G stability	Special nighttime, low wind

Enter selection

7-#5

Notes:

- Meteorological Conditions—Explain that the students may enter a number (1, 2, or 3) to specify the meteorological condition (sun high in sky; sun low in sky or cloudy; night) or a letter (A–G) to specify a stability class.
- Refer students to the Meteorological Conditions screen display .
- In this example, type 2 to indicate cloudy meteorological condition.

Demonstration: Tritium Release

- Meteorological Conditions

Enter a number or a letter to indicate appropriate meteorological conditions.

- **Step 5** Type **2** to indicate meteorological condition (cloudy day).

Demonstration: Tritium Release

- Wind

NAME OF WIND	OBSERVABLE FEATURES	MPH	M/S
calm	Smoke rises vertically	< 1	< 0.5
light Atmospheric	Smoke drifts downward	1 – 3	0.5 – 1
light breeze	Wind felt on face; leaves rustle	3 – 7	1 – 3
gentle breeze	Leaves and twigs in constant motion	7 – 12	3 – 5
moderate breeze	Raises dust and loose paper	12 – 18	5 – 8
fresh breeze	Small tress begin to sway	18 – 24	8 – 11
strong breeze	Large branches in motion	24 – 31	11 – 14
moderate gale	Whole trees in motion	31 – 38	14 – 17
fresh gale	Twigs break off; walking impeded	38 – 46	17 – 21
strong gale	Slight structural damage occurs	46 – 54	21 – 24
whole gale	Tree uprooted; structural damage	54 – 63	24 – 28
storm	Very rare, widespread destruction	63 – 75	28 – 34
hurricane		> 75	> 34

7-#6

Notes:

- Wind——Refer students to the Wind screen display.

Demonstration: Tritium Release

- WIND?

Enter the ground wind speed, in meters/second, and press ENTER (1 mph = 0.45 m/s).

- **Step 6** Type **1**

  Press the **Enter** key.

Demonstration: Tritium Release

- Main Output Options Menu

```
Main Output Options Menu

1:  SCREEN    Output     Default     Distances
2:  SCREEN    Output     You Enter   Distances
3:  PRINTER   Output     Default     Distances
4:  PRINTER   Output     You Enter   Distances
5:  DISK FILE Output     Default     Distances
6:  DISK FILE Output     You Enter   Distances

G:  GRAPHICS
C:  Change DEFAULT CONTOUR SETTINGS
M:  Change METEOROLOGICAL PARAMETERS and Release
     Height
Z:  Change RECEPTOR HEIGHT (z)
D:  Change DEPOSITION VELOCITY
O:  Enable prompt for OFF AXIS Positions
I:  INVERSION HEIGHT (Mixing Layer)
Q:  Enter to Main HOTSPOT Menu.
```

7-#7

Notes:

- Screen output—Explain that students should select 1, screen output using the default distances.

- Data tables—The students must type 1 and press Return to view the data tables.

Demonstration: Tritium Release

- Main Outputs Options Menu
- Screen output
- **Step 7** Type **1** to view data tables.

  Press **Enter** view more data.

  Continue pressing **Enter** until you view all the data.

  After you have viewed all the data, the following message appears:

“Enter the appropriate Output option number from the following menu.”

- Look at the Output Option Number Menu.

Demonstration: Tritium Release

- Output Option Number Menu

1: Enter a new Downwind Distance.
2: Return to Output Menu.
Q: Return to Main HOTSPOT Menu.

7-#8

Notes:

- Explain that students must type 2 at the Output Option Number Menu to return to the Main HOTSPOT Menu.

Demonstration: Tritium Release

- Output Option Number Menu
- **Step 8** Type **2** at the Output Option Number Menu to return to the Output Menu.

  Press **Enter**

Demonstration: Tritium Release

- Main Output Options Menu—Option G

```
Main Output Options Menu

1:  SCREEN    Output     Default     Distances
2:  SCREEN    Output     You Enter   Distances
3:  PRINTER   Output     Default     Distances
4:  PRINTER   Output     You Enter   Distances
5:  DISK FILE Output     Default     Distances
6:  DISK FILE Output     You Enter   Distances

G:  GRAPHICS
C:  Change DEFAULT CONTOUR SETTINGS
M:  Change METEOROLOGICAL PARAMETERS and Release
     Height
Z:  Change RECEPTOR HEIGHT (z)
D:  Change DEPOSITION VELOCITY
O:  Enable prompt for OFF AXIS Positions
I:  INVERSION HEIGHT (Mixing Layer)
Q:  Enter to Main HOTSPOT Menu.
```

7-#9

Notes:

- Main Output Options Menu: Option G—Explain that students need to use option G to see graphical representations of the results of the example incident.

Demonstration: Tritium Release

- Option G—Graphics
- **Step 9** Type **G** for Graphics.
- Result An Output option number menu appears.

Demonstration: Tritium Release

1: CEDE Contours

2: GROUND DEPOSITION Contours

3: Centerline 50-yr. CEDE vs. Distance

C: Change Graphics Output File Name

TO PRINT GRAPHICS—PUSH the “P” key when the screen output is complete.

Select your printer using the SETUP option at the Main HOTSPOT MENU.

7-#10

Notes:

- Output Option Number Menu
- Students may view Centerline 50-yr. CEDE vs. Distance graphical output by typing the number 3.
- Color/Monochrome—Have students type the number 1 for COLOR.
- Downwind Plotting Range—Have the students type 1 or 2.
- Print—If they have printer capability, the students may press P to print the graphical results.

Demonstration: Tritium Release

- **Step 10** Type **3** to view Centerline 50-yr. CEDE vs. Distance graphical output.
- Result The following selection box appears:

```
1: COLOR
2: MONOCHROME / LCD
```

- **Step 11** Type **1** for color monitor.
- Result The following selection box appears:

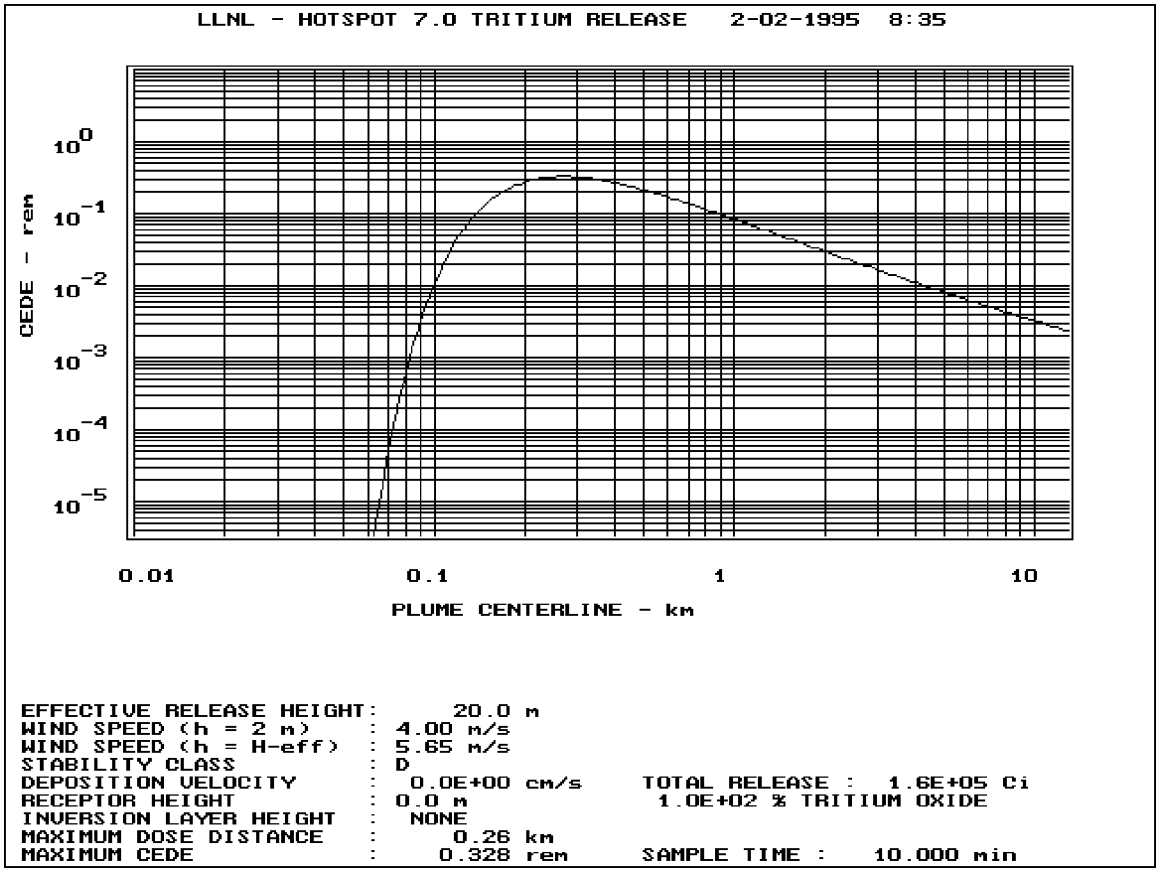
```
DOWNWIND PLOTTING RANGE
ENTER SELECTION NUMBER

1: 0.01 TO 10 km
2: 0.1 TO 100 km
```

- **Step 12** Type **1**

  The result is a graph.
- Print (if you have printer capability).
- **Step 13** Press **P** to print the graph.

Exercise 7-1: Tritium Release

- Exercise (Tritium Release)



7-#11

Notes:

- Distribute Exercise for Tritium Release.
- Display Overhead.
- Explain that students may consult Reference page if they wish.
- Exercise Answers: Maximum Dose Distance = 0.26 km
  Maximum CEDE = 0.328 rem

Exercise 7-1: Tritium Release

- Review the graphical output for this exercise (Tritium Release Atmospheric Dispersion Model derived from HOTSPOT).

- The example for this exercise is based on the following assumptions:

  — 160,000 curies of HTO are released from a 20-meter stack. the wind speed is 4 meters/second, and the sun has set. What distance is associated with the maximum 50-year committed effective dose equivalent to an individual remaining at this location throughout the release?

- **Step 1** From the HOTSPOT Main Menu, select **T**
- **Step 2** Total Tritium Released? Type **160,000**; press **Enter**
- **Step 3** Percent Tritiated Water? Type **100**; press **Enter**
- **Step 4** Effective Release Height? Type **20**; press **Enter**
- **Step 5** Condition? Type **3** (for NIGHT).
- **Step 6** Wind? Type **4** (for 4 meters/second); press **Enter**
- **Step 7** Type **1** at the Main Outputs Options Menu to view data table; press **Enter** as desired to view more data.
- **Step 8** Type **1** at the Outputs Option Number Menu to enter downwind distance.
- **Step 9** Type **2** to return to the Output Menu.
- **Step 10** Type **G** (graphics).
- **Step 11** Type **3** to view Centerline 50-yr. CEDE vs. Distance.
- **Step 12** Type **2** to select MONOCHROME/LCD.
- **Step 13** Type **1** to enter downwind plotting range.

The result is the graph shown on the previous page of this manual.

Lesson 8
Nuclear Explosion
Code F

LESSON PLAN
HOTSPOT HEALTH PHYSICS CODES

LESSON 8 – Nuclear Explosion, Code F

TIME:

30 minutes

LESSON LEARNING OBJECTIVES

Terminal: At the end of this lesson, students will be able to model a general plume of released material, using the Nuclear Explosion Code F Air Dispersion Model of the HOTSPOT Health Physics Codes program.

Enabling:

- At the end of this lesson, students should be able to:
  - — Describe the graphical output for a Nuclear Explosion Atmospheric Dispersion Model
  - — Explain the assumptions involved in deriving Nuclear Explosion output (tabular and graphical)
  - — Given mock data, generate Nuclear Explosion output (tabular and graphical)

INSTRUCTIONAL APPROACH

The mode of delivery for this lesson is lecture, using several job aids and reference materials to provide students with an overview of the HOTSPOT Health Physics Codes application.

EQUIPMENT AND INSTRUCTIONAL AIDS

Overhead projector
IBM PC, XT, AT, or compatible
HOTSPOT User's Manual (*HOTSPOT Health Physics Codes for the PC*)
Exercise Number 8–1

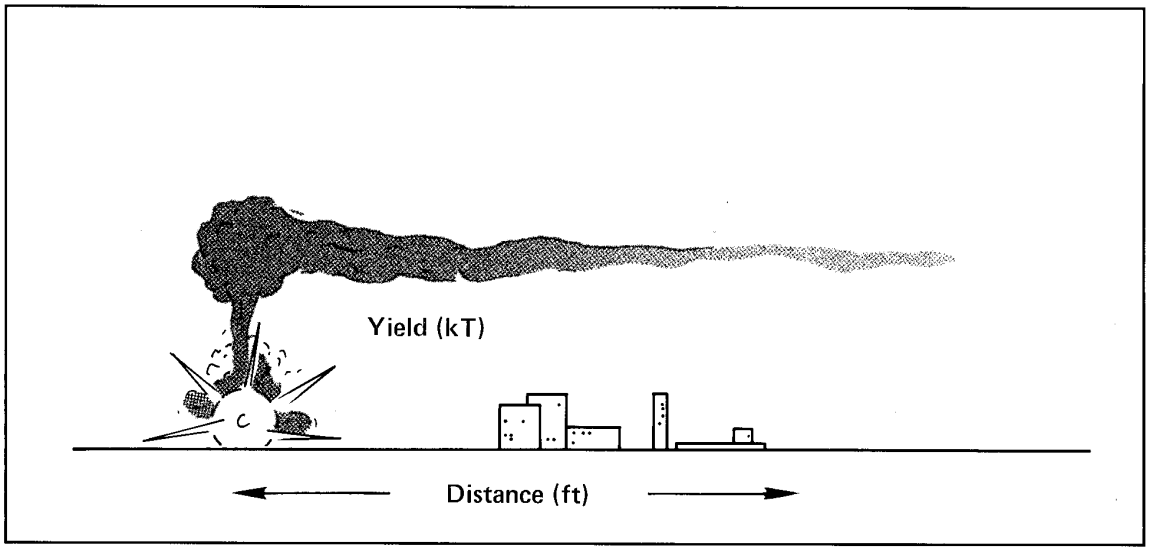
STUDENT MATERIALS

Student Manual

REFERENCES

HOTSPOT User's Manual (*HOTSPOT Health Physics Codes for the PC*)

Lesson Objectives



8-#1

Notes:

- At the end of this lesson, students will be able to model a nuclear explosion involving released material, using the Nuclear Explosion Code F Atmospheric Dispersion Model of the HOTSPOT Health Physics Codes program.
- Explain the Lesson Objectives.

Lesson Objectives

- At the end of this lesson, students should be able to:
  - Explain the assumptions involved in estimating the effects of a surface-burst nuclear explosion.
  - Given mock data, generate Nuclear Explosion output.

Assumptions—Nuclear Explosion

SURFACE-BURST NUCLEAR DETONATION

YIELD: 1.00 kilotons
EFFECTIVE WIND SPEED: 15.00 mph
BLAST DATA ARE MAXIMUM OVERPRESSURE

COLOR CODE:	BLAST	RADIATION	THERMAL
	>30 psi	>400 rad	>3rd degree burns
	>5 psi	>25 rad	>2nd degree burns

NOTE: Temporary flash blindness can occur at 0.0001 cal/cm^2 and retinal burns at approximately 0.2 cal/cm^2.

Push “Enter” to Continue with Data Output

Notes:

- Discuss the assumptions concerning the Nuclear Explosion calculations

.

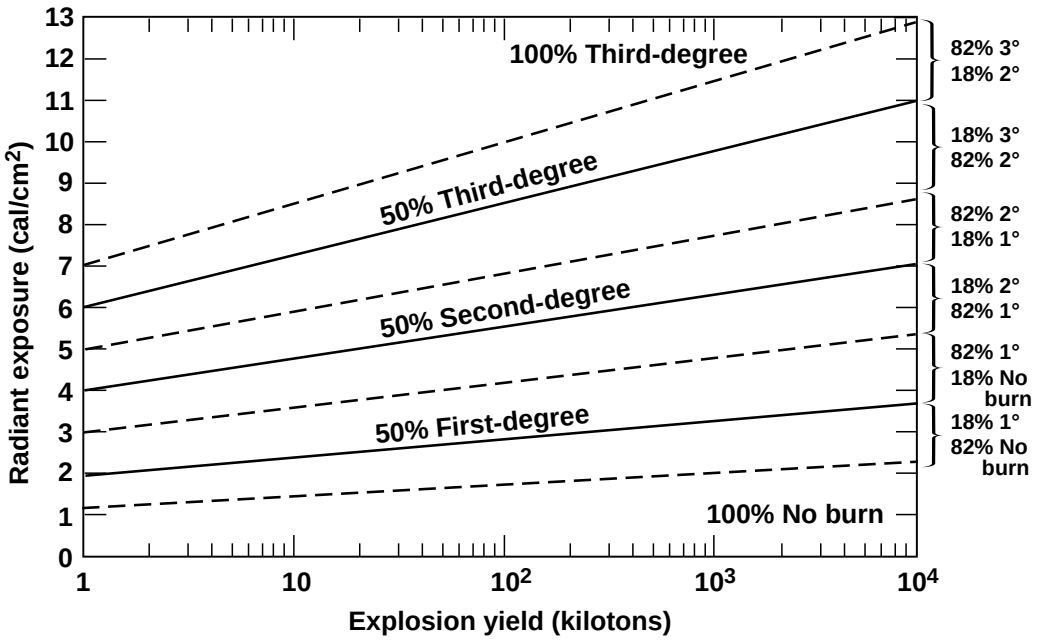
Assumptions—Nuclear Explosion

- This example is based on the following assumptions:
  - — The Nuclear Explosion code estimates the effects of a surface-burst nuclear weapon, based on the information in *The Effects of Nuclear Weapons* by Samuel Glasstone and Philip J. Dolan (3rd. ed., U. S. Department of Defense and the U. S. Department of Energy, 1977). As Glasstone and Dolan state, the predictive data are not exact. Users are strongly urged to refer to the book for detailed discussions and limitations of the effects data (see following tables on blast effects).
  - — The code estimates the maximum overpressure (psi), prompt neutron and gamma doses (rad), and the thermal radiation (cal/cm^2), as a function of radial distance from the point of detonation. For distances greater than 1 km, the following fallout prediction data are generated
    - Arrival time of fallout.
    - Reference dose rate at one hour post-detonation (H + 1).
    - Initial dose rate at actual cloud arrival time.
    - Integral dose from external ionizing radiation in first hour, day, etc., since detonation.
    - Fallout assumptions: default effective windspeed is 15 miles per hour with a wind shear of 15°.

  Notes:

  1. The RBE for neutrons varies with the energy and type of injury. For the neutron energy spectrum of nuclear weapons, the RBE for acute radiation injury is close to 1.0. However, the RBE is significantly larger (4-10) for the occurrence of opacities of the lens of the eye, leukemia, and genetic changes.

  2. Approximate thermal exposure required to produce skin burns for yields 20 kT (Fig. 8-4).
     - First degree 2 cal/cm^2.
     - Second degree 4 cal/cm^2.
     - Third degree 7 cal/cm^2.



Tentative criteria for direct (primary) blast effects in people from fast-rising, long-duration pressure pulses.

Effect	Peak Pressure (psi)
Lung damage:	
Threshold	12(8–15)
Severe	25(20–30)
Lethality:	
Threshold	40(30–50)
50 percent	62(50–75)
100 percent	92(75–115)
Eardrum rupture:	5
Threshold	15–20 (more than 20 years old)
50 percent	30–35 (less than 20-years old)

Approximate radiant exposures for ignition of various materials.

Material	Weight (oz/yd^2)	Color	Effect on Material	Radiant Exposure (cal/cm^2) 35 kt	1.4 Mt	20 Mt
Household Tinder Materials						
Newspaper, shredded	2		Ignites	4	6	11
Newspaper, dark picture area	2		Ignites	5	7	12
Newspaper, printed text area	2		Ignites	6	8	15
Crepe paper	1	Green	Ignites	6	9	16
Kraft paper	3	Tan	Ignites	10	13	20
Bristol board, 3 ply	10	Dark	Ignites	16	20	40
Kraft paper carton, used (flat side)	16	Brown	Ignites	16	20	40
New bond typing paper	2	White	Ignites	24	30	50
Cotton rags		Black	Ignites	10	15	20
Rayon rags		Black	Ignites	9	14	21
Cotton string scrubbing mop (used)		Gray	Ignites	10	15	21
Cotton string scrubbing mop (weathered)		Cream	Ignites	10	19	26
Paper book matches, blue head exposed			Ignites	11	14	20
Excelsior, ponderosa pine		Light yellow	Ignites		23	23
Outdoor Tinder Materials						
Dry rotted wood punk (fir)			Ignites	4	6	11
Deciduous leaves (beech)			Ignites	4	6	8
Fine grass (cheat)			Ignites	5	8	10
Coarse grass (sedge)			Ignites	6	9	11
Pine needles, brown (pnderosa)			Ignites	10	16	21
Construction Materials						
Roll roofing, mineral surface			Ignites		>34	>116
Roll roofing, smooth surface			Ignites		30	77
Plywood, douglas fir			Flaming during exposure	9	16	20
Rubber, pale latex				50	80	110
Rubber, black			Ignites Ignites	10	20	25
Other Materials						
Aluminum aircrraft skin (0.020 in. thick) coated with 0.002 in. of standard white aircraft paint			Blisters	15	30	40
Cotton canvas sandbags, dry-filled			Failure	10	18	32
Coral sand			Explodes (popcorning)	15	27	47
Siliceous sand			Explodes (popcorning	11	19	35

Conditions of failure of overpressure sensitive elements.

Structural Element	Failure	Peak Overpressure (psi)
Glass windows, large and small	Shattering usually, occasional frame failure	0.5–1.0
Corrugated asbestos siding	Shattering	1.0–2.0
Corrugated steel or aluminum paneling	Connection failure followed by buckling	1.0–2.0
Brick wall panel, 8- or 12-in. thick (not reinforced)	Shearing and flexure failures	3.0–10.0
Wood siding panels, standard house construction	Usually failure occurs at the main connections allowing a whole panel to be blown in	1.0–2.0
Concrete or cinder-block wall panels, 8- or 12-in. thick (not reinforced)	Shattering of the wall	1.5–5.5

Example—Nuclear Explosion

- What are the prompt radiation effects from the surface detonation of a l-kt fission device? Assume the atmospheric visibility is 50 miles, and the effective wind speed is 15 mph.

Code Description: Nuclear Explosion

SURFACE-BURST NUCLEAR DETONATION

YIELD: 1.00 kt

EFFECTIVE WIND SPEED: 15.00 mph

BLAST DATA ARE MAXIMUM OVERPRESSURE

NOTE: Temporary flash blindness cn occur at 0.0001 cal/cm^2
and retinal burns at 0.16 cal/cm^2

D = 0.10 km		**D = 0.20 km**		**D = 0.50 km**	
BLAST	1.1E+02 psi	BLAST	2.3E+01 psi	BLAST	4.1E+00 psi
NEUTRON	1.2E+07 rad	NEUTRON	1.1E+05 rad	NEUTRON	1.8E+03 rad
GAMMA	1.7E+04 rad	GAMMA	9.1E+03 rad	GAMMA	1.3E+03 rad
TOTAL	1.2E+07 rad	TOTAL	1.2E+05 rad	TOTAL	3.1E+03 rad
THERMAL	3.2E+02 cal/cm^2	THERMAL	7.9E+01 cal/cm^2	THERMAL	1.3E+01 cal/cm^2
D = 1.00 km		**D = 2.00 km**		**D = 5.00 km**	
BLAST	1.5E+00 psi	BLAST	6.3E–0.1 psi	BLAST	2.6E-01 psi
NEUTRON	4.4E+01 rad	NEUTRON	1.1E–01 rad		
GAMMA	6.1E+01 rad	GAMMA	5.0E–01 rad		
TOTAL	1.0E+02 rad	TOTAL	6.1E–01 rad		
THERMAL	3.1E+00 cal/cm^2	THERMAL	7.5E–01 cal/cm^2	THERMAL	1.1E–01 cal/cm^2
FALLOUT		**FALLOUT**		**FALLOUT**	
ARRIVES IN	0.04 hour	ARRIVES IN	0.08 hour	ARRIVES IN	0.21 hour
H+1:	6.6E+03 rem/hr	H+1:	2.1E+03 rem/hr	H+1:	4.5E+02 rem/hr
INITIAL EXTERNAL RATE AT CLOUD ARRIVAL TIME IS 3.0E+05 rem/hr		INITIAL EXTERNAL RATE AT CLOUD ARRIVAL TIME IS 4.2E+04 rem/hr		INITIAL EXTERNAL RATE AT CLOUD ARRIVAL TIME IS 3.0E+03 rem/hr	
DOSE IN FIRST:		DOSE IN FIRST:		DOSE IN FIRST:	
HOUR	3.0E+04 rem	HOUR	6.7E+03 rem	HOUR	8.4E+02 rem
DAY	4.5E+04 rem	DAY	1.2E+04 rem	DAY	1.9E+03 rem
WEEK	5.1E+04 rem	WEEK	1.3E+04 rem	WEEK	2.3E+03 rem
MONTH	5.4E+04 rem	MONTH	1.4E+04 rem	MONTH	2.5E+03 rem
YEAR	5.7E+04 rem	YEAR	1.5E+04 rem	YEAR	2.7E+03 rem
50 YEARS	6.0E+04 rem	50 YEARS	1.6E+04 rem	50 YEARS	2.9E+03 rem
D = 1.00 km		**D = 2.00 km**		**D = 5.00 km**	
BLAST	1.6E-01 psi	MINIMAL BLAST	1.0E-01 psi	MINIMAL BLAST AND RAD	
THERMAL	2.4E-02 cal/cm^2	THERMAL	4.4E–03 cal/cm^2	THERMAL	2.8E–04 cal/cm^2
FALLOUT		**FALLOUT**		**FALLOUT**	
ARRIVES IN	0.41 hour	ARRIVES IN	0.83 hour	ARRIVES IN	2.07 hour
H+1:	1.4E+02 rem/hr	H+1:	4.5E+01 rem/hr	H+1:	3.0E+00 rem/hr
INITIAL EXTERNAL RATE AT CLOUD ARRIVAL TIME IS 4.1E+02 rem/hr		INITIAL EXTERNAL RATE AT CLOUD ARRIVAL TIME IS 5.6E+01 rem/hr		INITIAL EXTERNAL RATE AT CLOUD ARRIVAL TIME IS 1.3E+00 rem/hr	
DOSE IN FIRST:		DOSE IN FIRST:		DOSE IN FIRST:	
HOUR	1.4E+02 rem	HOUR	8.6E+00 rem	HOUR	0.0E+00 rem
DAY	4.7E+02 rem	DAY	1.1E+02 rem	DAY	5.0E+00 rem
WEEK	5.9E+02 rem	WEEK	1.5E+02 rem	WEEK	7.6E+00 rem
MONTH	6.6E+02 rem	MONTH	1.7E+02 rem	MONTH	9.0E+00 rem
YEAR	7.3E+02 rem	YEAR	2.0E+02 rem	YEAR	1.1E+01 rem
50 YEARS	7.9E+02 rem	50 YEARS	2.2E+02 rem	50 YEARS	1.2E+01 rem

8-#2

Notes:

- Describe the code used to derive the Nuclear Explosion Atmospheric Dispersion Model discussed in this lesson.

Code Description: Nuclear Explosion

- Code description — Study the table on page 8-9.

Demonstration: Nuclear Explosion

HOTSPOT Health Physics Codes
VERSION 7.01
HAZARDS CONTROL DEPARTMENT
LAWRENCE LIVERMORE
NATIONAL LABORATORY

S: SETUP

A: Plutonium Explosion	B: Plutonium Fire	C: Plutonium Resuspension
D: Uranium Explosion	E: Uranium Fire	F: Nuclear Explosion
G: Radiation Workplace	H: General Plume	I: General Explosion
J: General Resuspension	K: Inhalation Dose	T: Tritium Release
L: HOTSPOT Library	M: FIDLER Calibration and LUNG Screening	N: General Fire
		Q: QUIT

Enter Selection

8-#3

Notes:

- Describe the steps involved in using HOTSPOT to model a Nuclear Explosion incident.
- Explain that the students should use the reference for detailed information.
- Code—Explain that the students must select the specific code related to the type of incident. In this example, the students must select Code F (Nuclear Explosion) from the HOTSPOT Main Menu.
- Inform the students that sometimes they must press Enter (or Return) in order for the computer system to accept data which they type.
- Effective wind speed.
- Atmospheric visibility.

Demonstration: Nuclear Explosion

- Select Nuclear Explosion from the HOTSPOT Main Menu.
- **Step 1** Type **F**
- YIELD-kt

Enter the yield (kilotons), and push Enter.

- **Step 2** Type **1;** press **Enter**
- Effective wind speed

Default EFFECTIVE WIND SPEED is 15 mph. Do you want to enter a different value? (Y/N) DEFAULT = N

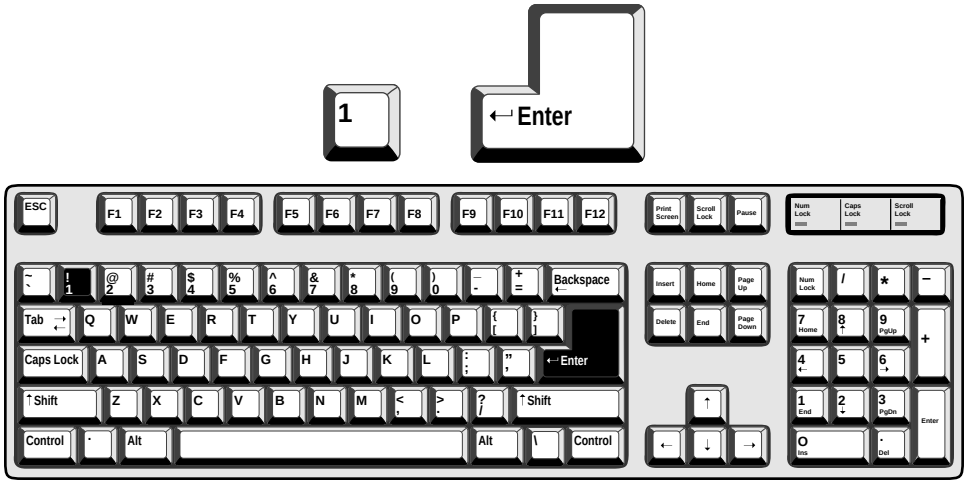
- **Step 4** Type **N**
- Atmospheric visibility

Choose the appropriate atmospheric visibility from the following menu—Enter a LETTER, and push Enter.

A:	20 km	(12 miles)
B:	40 km	(25 miles)
C:	80 km	(50 miles)

- **Step 5** Type **C**

Demonstration: Nuclear Explosion



8-#4

Notes:

- Explains the Output options

Demonstration: Nuclear Explosion

- Output options

  Enter the appropriate Output option Number from the following menu:

1:	SCREEN	Output	—	Default Distances
2:	SCREEN	Output	—	You Enter Distances
3:	PRINTER	Output	—	Default Distances
4:	PRINTER	Output	—	You Enter Distances
5:	START	OVER	—	Enter a new YIELD
Q:	Return to Main HOTSPOT Menu			

- **Step 6** Type **I**

SURFACE-BURST NUCLEAR DETONATION

YIELD: 1.00 kilotons
EFFECTIVE WIND SPEED: 15.00 mph
BLAST DATA ARE MAXIMUM OVERPRESSURE

COLOR CODE:	BLAST	RADIATION	THERMAL
	>30 psi	>400 rad	>3rd degree burns
	>5 psi	>25 rad	>2nd degree burns

NOTE: Temporary flash blindness can occur at 0.0001 cal/cm^2 and retinal burns at approximately 0.2 cal/cm^2.

Push “Enter” to Continue with Data Output

- **Step 7** Press **Enter**
- Output Option Number Menu

  Enter the appropriate Output option Number from the following menu

1:	Enter a new Distance
2:	Return to Output Menu
Q:	Return to Main HOTSPOT Menu

- **Step 8** Type 1, 2, or Q.

Exercise 8-1: Nuclear Explosion

- Exercise

D = 3.0 km

Blast	1.3E+00 psi
Neutron	1.2E-02 rad
Gamma	2.4E-01 rad
Total	2.5E-01 rad
Thermal	3.9E+00 cal/cm^2

Fallout arrive in 0.07 Hour

H+1 :	1.6E+04 rem/hr

Initial External Rate At Cloud Arrival Time: 3.7E+05 rem/hr

Dose in First:

Hour	5.5E+04 rem
Day	9.4E+04 rem
Week	1.1E+05 rem
Month	1.2E+05 rem
Year	1.2E+05 rem
50-Years	1.3E+05 rem

Enter Distance, km, and push “Enter”

8-#5

Notes:

- Distribute Exercise for Nuclear Explosion.
- Display Overhead.
- Explain that students may consult the Reference page if they wish.

Exercise 8-1: Nuclear Explosion

- Page 8-15 illustrates the output for a Nuclear Explosion Atmospheric Dispersion Model derived from the HOTSPOT Health Physics Codes program.
- The example for this exercise is based on the following assumptions:
  - What are the prompt radiation effects at a distance of 3 km from a surface detonation of a 20-kt fission device?
  - Assume visibility is only 20 miles and the effective windspeed is 25 mph.

- **Step 1** From the HOTSPOT Main Menu, select **F**
- **Step 2** YIELD-kt? Type **20**; press **Enter**
- **Step 3** Type **Y**
- **Step 4** Enter **25**; press **Enter**
- **Step 5** Type **A**
- **Step 6** Distances? Type **2** (You enter distances)
- **Step 7** Type 3; press **Enter**

The result is the table shown on the previous page of this manual.

Lesson 9
General Plume
Code H

LESSON PLAN
HOTSPOT HEALTH PHYSICS CODES

LESSON 9 – General Plume, Code H

TIME:

30 minutes

LESSON LEARNING OBJECTIVES

Terminal: At the end of this lesson, students will be able to model a general plume of released material, using the General Plume Code H Air Dispersion Model of the HOTSPOT Health Physics Codes program.

Enabling:

- At the end of this lesson, students should be able to:
  - — Describe the graphical output for a General Plume Atmospheric Dispersion Model
  - — Explain the assumptions involved in deriving General Plume output (tabular and graphical)
  - — Given mock data, generate General Plume output (tabular and graphical)

INSTRUCTIONAL APPROACH

The mode of delivery for this lesson is lecture, using several job aids and reference materials to provide students with an overview of the HOTSPOT Health Physics Codes application.

EQUIPMENT AND INSTRUCTIONAL AIDS

Overhead projector
IBM PC, XT, AT, or compatible
HOTSPOT User's Manual (*HOTSPOT Health Physics Codes for the PC*)
Exercise Number 9–1

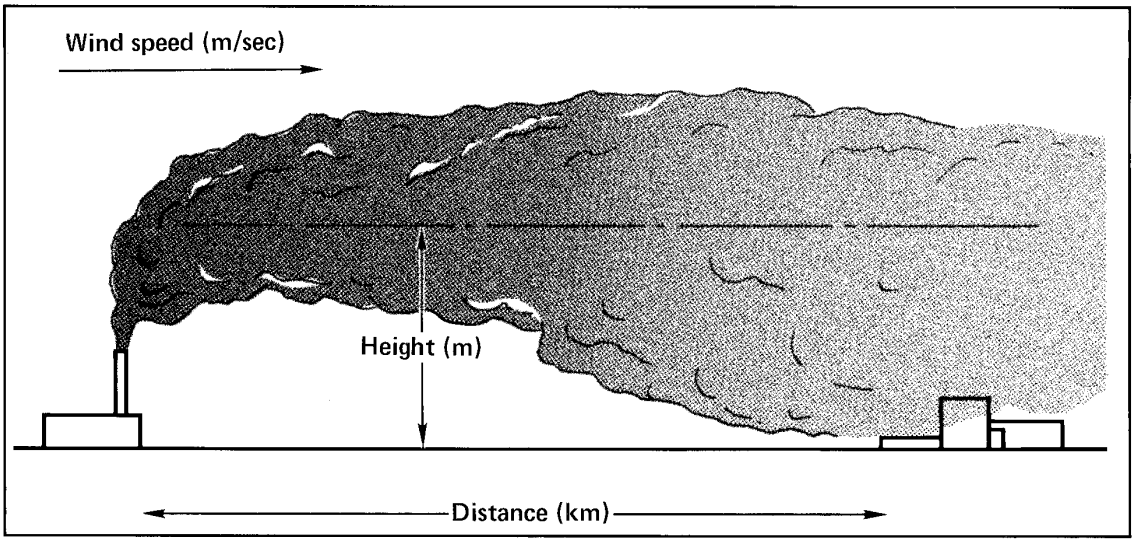
STUDENT MATERIALS

Student Manual

REFERENCES

HOTSPOT User's Manual (*HOTSPOT Health Physics Codes for the PC*)

Lesson Objectives



9-#1

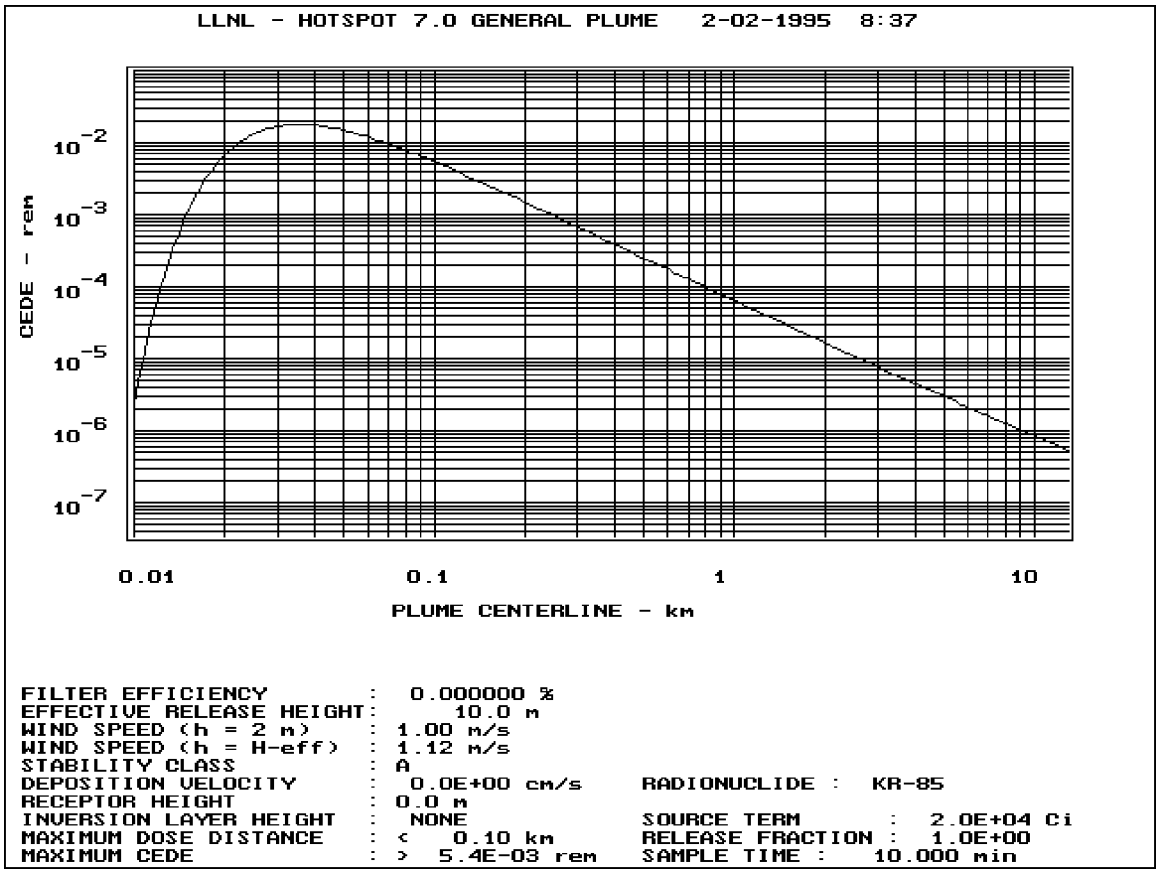
Notes:

- At the end of this lesson, students will be able to model a general plume of released material, using the General Plume Code H Air Dispersion Model of the HOTSPOT Health Physics Codes program (HOTSPOT).
- Explain the Lesson Objectives.

Lesson Objectives

- At the end of this lesson, students should be able to:
  - Describe the graphical output for a General Plume Atmospheric Dispersion Model
  - Explain the assumptions involved in deriving General Plume output (tabular and graphical)
  - Given mock data, generate General Plume output (tabular and graphical)

Graphical Output and Assumptions—General Plume



9-#2

Notes:

- Have students refer to page 9-3, General Plume: Graphical Output.
- Discuss the assumptions concerning the General Plume incident, as described on the Reference page.

Graphical Output and Assumptions—General Plume

- Page 9-3 illustrates graphical output for a General Plume Air Dispersion Model derived from the HOTSPOT program.
- This example is based on the following assumptions:
  - The default respirable fraction of the total material involved in the release is dependent upon the type of material input, e.g., 1.00 for noble gases, 0.0005 for plutonium, etc. For non-noble gas radionuclides, the respirable fraction is defined as the fraction of the released material associated with an Activity Median Aerodynamic Diameter (AMAD) of 1 micrometer (see User Manual, Appendix A). The default ICRP-30 internal dosimetry conversion factors also assume a 1μm AMAD particle size distribution.
  - Standard-person breathing rate is 1.2 cubic meters/hour.
  - The wind is from the east at 1 meter/second on a sunny day.
- The students' goal is to estimate the dose commitments from a release of 20,000 curies of krypton-85 from a 10 meter stack.

Code Description: General Plume

```
HOTSPOT 7.01 GENERAL PLUME
RADIONUCLIDE :  KR-85      Inhalation Class : N/A
HALFLIFE     : 10.720 years
SOURCE TERM      :  2.0E+04 Ci
RELEASE FRACTION :  1.00E+00
FILTER EFFICIENCY:  0.000000 %
EFFECTIVE RELEASE HEIGHT :    10.00 m
WIND SPEED (h=2 m): 1.0 m/s
WIND SPEED (h=H-eff): 1.1 m/s
STABILITY CLASS          : A                    DEPOSITION VELOCITY      :  0.0E+00 cm/s
RECEPTOR HEIGHT          : 0.0 m                INVERSION LAYER HEIGHT   : 5000.0 m
SAMPLE TIME              :   10.000 min
MAXIMUM DOSE DISTANCE    : <    0.1 km          MAXIMUM CEDE   : >  5.4E-03 rem
Plume Centerline

D   =  0.10 km                 D   =  0.20 km                 D   =  0.50 km
CHI =  1.1E+01 (Ci-s)/m^3      CHI =  3.2E+00 (Ci-s)/m^3      CHI =  5.3E-01 (Ci-s)/m^3

50-YR DOSE COMMITMENT:         50-YR DOSE COMMITMENT:         50-YR DOSE COMMITMENT:
-----------------------------  -----------------------------  -----------------------------
EFFECTIVE DOSE                 EFFECTIVE DOSE                 EFFECTIVE DOSE
EQUIVALENT    5.4E-03 rem      EQUIVALENT    1.5E-03 rem      EQUIVALENT    2.5E-04 rem


D   =  1.00 km                 D   =  2.00 km                 D   =  5.00 km
CHI =  1.4E-01 (Ci-s)/m^3      CHI =  3.5E-02 (Ci-s)/m^3      CHI =  6.3E-03 (Ci-s)/m^3

50-YR DOSE COMMITMENT:         50-YR DOSE COMMITMENT:         50-YR DOSE COMMITMENT:
-----------------------------  -----------------------------  -----------------------------
EFFECTIVE DOSE                 EFFECTIVE DOSE                 EFFECTIVE DOSE
EQUIVALENT    6.4E-05 rem      EQUIVALENT    1.7E-05 rem      EQUIVALENT    3.0E-06 rem


D   = 10.00 km                 D   = 20.00 km                 D   = 50.00 km
CHI =  1.8E-03 (Ci-s)/m^3      CHI =  5.6E-04 (Ci-s)/m^3      CHI =  1.3E-04 (Ci-s)/m^3

50-YR DOSE COMMITMENT:         50-YR DOSE COMMITMENT:         50-YR DOSE COMMITMENT:
-----------------------------  -----------------------------  -----------------------------
EFFECTIVE DOSE                 EFFECTIVE DOSE                 EFFECTIVE DOSE
EQUIVALENT    8.7E-07 rem      EQUIVALENT    2.7E-07 rem      EQUIVALENT    6.0E-08 rem
```

9-#3

Notes:

- Describe the code used to derive the General Plume Atmospheric Dispersion Model illustrated in this lesson.

Code Description: General Plume

- Code description — Study the table on page 9-5.

Demonstration: General Plume

HOTSPOT Health Physics Codes
VERSION 7.01
HAZARDS CONTROL DEPARTMENT
LAWRENCE LIVERMORE
NATIONAL LABORATORY

S: SETUP

A: Plutonium Explosion	B: Plutonium Fire	C: Plutonium Resuspension
D: Uranium Explosion	E: Uranium Fire	F: Nuclear Explosion
G: Radiation Workplace	H: General Plume	I: General Explosion
J: General Resuspension	K: Inhalation Dose	T: Tritium Release
L: HOTSPOT Library	M: FIDLER Calibration and LUNG Screening	N: General Fire
		Q: QUIT

Enter Selection

9-#4

Notes:

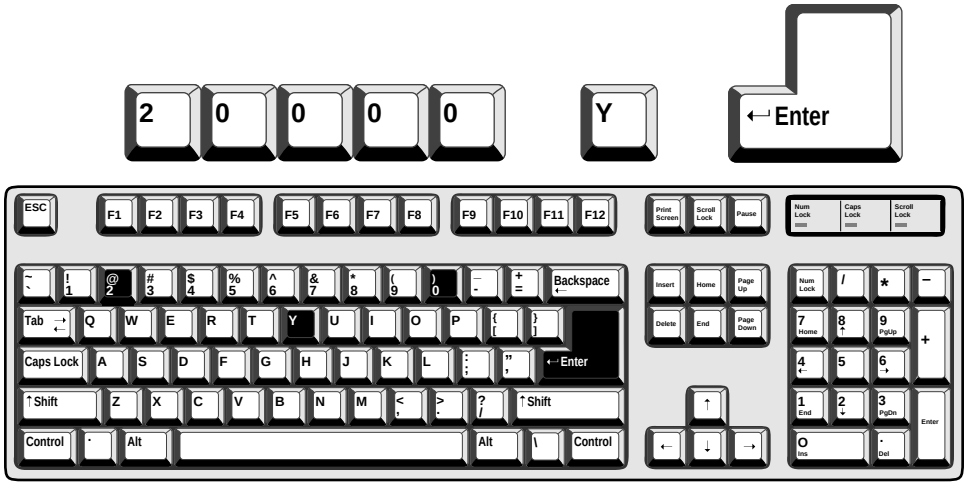
- Describe the steps involved in using HOTSPOT to model the incident involving the release of krypton-85.
- Explain that the students should use the Reference pages for detailed information.
- Code—Explain that the students must select the specific code related to the type of incident; in this example, the students must select Code H (General Plume) from the HOTSPOT Main Menu.
- Nuclide—What nuclide is involved in this incident? Tell the students that this example involves the release of krypton–85 (KR–85).
- Inform the students that sometimes they must press Enter (or Return) in order for the computer system to accept data which they type.

Demonstration: General Plume

- Code?
- **Step 1** Type **H** to select General Plume from the HOTSPOT Main Menu.
- Nuclide?
- **Step 2** Type **KR–85** (always in the form XX–NN, where XX represents the letters representing the nuclide name, and where NN represents the nuclide number).

  Press the **Enter** key.

Demonstration: General Plume



9-#5

Notes:

- Curies—How many curies were released from the stack? The answer is 20,000. Remind the students to review the Assumptions on page 9-4 of this lesson.

- F = 1.000E+00? (Y/N)—Explain that the default respiration fraction of the total material involved in the release is dependent upon the type of material and that typing Y means that you accept the default.

Demonstration: General Plume

- Curies? How many curies were released in this example incident?
- **Step 3** Enter **20,000**

  Press the **Enter** key.

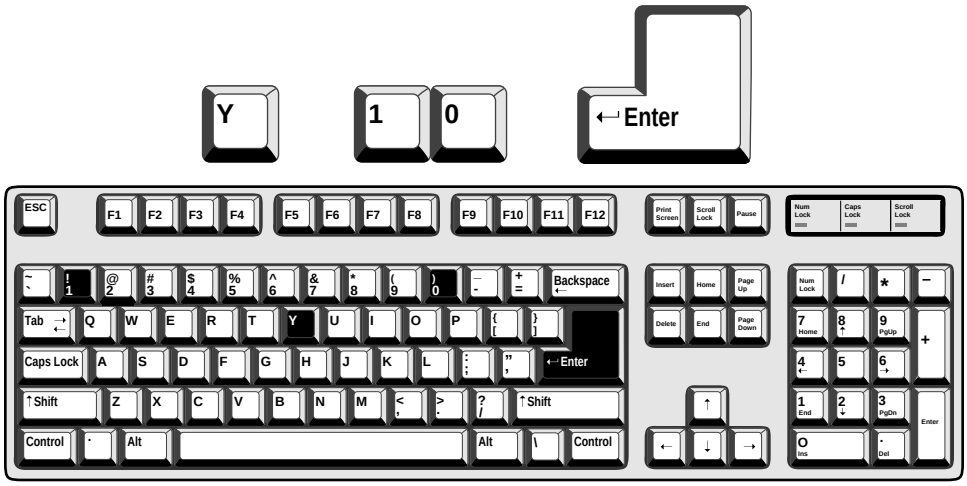
- F = 1.000E+00? (Y/N)

  F is the fraction of the entered activity released and dispersed into an AMAD of one micron.

  Enter “Y” to accept the default value, or “N” if you wish to enter a new value.

- **Step 4** Enter **Y** to accept the default value.

Demonstration: General Plume



9-#6

Notes:

- Filter = 0%? (Y/N)—Explain the mitigation factor.
- HEIGHT—Explain the effective release height.

Demonstration: General Plume

- Filter = 0%? (Y/N)

  Filter is the mitigation factor for the entered nuclide. The 0 is the default value, i.e., none of the nuclide entering the “FILTER” will be trapped. EXAMPLES:

  FILTER = 99.97% for a single HEPA filter
  FILTER = 99.999991% for a two-stage HEPA

- **Step 5** Enter **Y** to accept the default value.

- HEIGHT?

  Enter the effective release height, in meters, and press the Enter key.

- **Step 6** Enter **10**

  Press the **Enter** key.

Demonstration: General Plume

- Meteorological Conditions

Choose appropriate meteorological conditions from the following menu—Enter a NUMBER or LETTER.

1. Sun HIGH in the sky
2. Sun LOW in the sky or cloudy
3. NIGHT

Or, if you prefer to enter a specific stability classification,

A: A stability Very unstable
B: B stability Moderately unstable
C: C stability Slightly unstable
D: D stability Neutral
E: E stability Slightly stable
F: F stability Moderately stable
G: G stability Special nighttime, low wind
Enter selection

9-#7

Notes:

- Meteorological Conditions—Explain that the students may enter a number (1, 2, or 3) to specify the meteorological condition (sun high in sky; sun low in sky or cloudy; night) or a letter (A–G) to specify a stability class.

- Refer students to the Meteorological Conditions screen display.

- In this example, the number 1 indicates the correct meteorological condition.

Demonstration: General Plume

- Meteorological Conditions

  Enter a number or a letter to indicate appropriate meteorological condition.

- **Step 7** Type **1**

Demonstration: General Plume

- Wind

NAME OF WIND	OBSERVABLE FEATURES	MPH	M/S
calm	Smoke rises vertically	< 1	< 0.5
light air	Smoke drifts downward	1 – 3	0.5 – 1
light breeze	Wind felt on face; leaves rustle	3 – 7	1 – 3
gentle breeze	Leaves and twigs in constant motion	7 – 12	3 – 5
moderate breeze	Raises dust and loose paper	12 – 18	5 – 8
fresh breeze	Small tress begin to sway	18 – 24	8 – 11
strong breeze	Large branches in motion	24 – 31	11 – 14
moderate gale	Whole trees in motion	31 – 38	14 – 17
fresh gale	Twigs break off; walking impeded	38 – 46	17 – 21
strong gale	Slight structural damage occurs	46 – 54	21 – 24
whole gale	Tree uprooted; structural damage	54 – 63	24 – 28
storm	Very rare, widespread destruction	63 – 75	28 – 34
hurricane		> 75	> 34

9-#8

Notes:

- Wind—Refer students to the Wind screen display.

Demonstration: General Plume

- WIND?

  Enter the ground wind speed, in meters/second, and press ENTER (1 mph = 0.45 m/s).

- **Step 8** Type **1**

  Press the **Return** key.

Demonstration: General Plume

- Main Output Options Menu

```
Main Output Options Menu

1:  SCREEN    Output     Default     Distances
2:  SCREEN    Output     You Enter   Distances
3:  PRINTER   Output     Default     Distances
4:  PRINTER   Output     You Enter   Distances
5:  DISK FILE Output     Default     Distances
6:  DISK FILE Output     You Enter   Distances

G :  GRAPHICS

C :  Change DEFAULT CONTOUR SETTINGS
M :  Change METEOROLOGICAL PARAMETERS and Release
      Height
Z :  Change RECEPTOR HEIGHT (z)
D :  Change DEPOSITION VELOCITY
O :  Enable prompt for OFF AXIS Positions
I :   INVERSION HEIGHT (Mixing Layer)
Q :  Return to Main HOTSPOT Menu

T :  Sample Time
Q :  Return to Main HOTSPOT Menu
```

9-#9

Notes:

- Screen output—Explain that students should select 1, screen output using the default distances.

- Data tables—The students must type 1 and press Return to view the data tables.

Demonstration: General Plume

- Main Outputs Options Menu
- Screen output
- **Step 9** Type **1** to view data tables.

  Press **Return** to view more data.

  Continue pressing **Return** until you view all the data.

  After you have viewed all the data, the following message appears:

  > "Enter the appropriate Output option number from the following menu."

  Look at the Output Option Number Menu.

Demonstration: General Plume

1: Enter a new Downwind Distance

2: Return to Output Menu

Q: Return to Main HOTSPOT Menu

9-#10

Notes:

- Explain that students may enter a new downwind distance by selecting option 1 from the Output Option Number Menu.
- Explain the results table.

Demonstration: General Plume

- Output Option Number Menu

- **Step 10** Type **1** to enter a new distance.

  The following message appears:

  Enter Distance, km, and push “Enter.”
  To enter an off-axis position (x, y),
  enter x y, e.g., 3 6 for x = 3 km and y = 6 km
  Push “Enter” without data entry to QUIT.

- **Step 11** Type **3 6** to enter an off-axis position.

  The results table shows the following:

  D = 3.00 km
  OFF-AXIS – Y = 6.00 km
  CHI = 7.7E–26 (Ci–s)/m^3
  <u>50-YR DOSE COMMITMENT</u>
  EFFECTIVE DOSE
  EQUIVALENT 3.6E–29 rem

  Press **Return**

- **Step 12** Type **2** at the Output Option Number Menu to return to the Main Output Options Menu.

Demonstration: General Plume

- Main Output Options Menu—Option G

```
Main Output Options Menu

1:  SCREEN    Output     Default     Distances
2:  SCREEN    Output     You Enter   Distances
3:  PRINTER   Output     Default     Distances
4:  PRINTER   Output     You Enter   Distances
5:  DISK FILE Output     Default     Distances
6:  DISK FILE Output     You Enter   Distances

G:  GRAPHICS

C:  Change DEFAULT CONTOUR SETTINGS
M:  Change METEOROLOGICAL PARAMETERS and Release
     Height
Z:  Change RECEPTOR HEIGHT (z)
D:  Change DEPOSITION VELOCITY
O:  Enable prompt for OFF AXIS Positions
I:  INVERSION HEIGHT (Mixing Layer)

T :  SAMPLE TIME
Q:  Return to Main HOTSPOT Menu.
```

9-#11

Notes:

- Main Output Options Menu: Option G—Explain that students need to use option G to see graphical representations of the results of the example incident.

Demonstration: General Plume

- Option G—Graphics
- **Step 13** Type G for Graphics.
- Result An Output option number menu appears.

Demonstration: General Plume

1: CEDE Contours

2: GROUND DEPOSITION Contours

3: Centerline 50-yr. CEDE vs. Distance

C: Change Graphics Output File Name

TO PRINT GRAPHICS—PUSH the “P” key when the screen output is complete.

Select your printer using the SETUP option at the Main HOTSPOT MENU.

9-#12

Notes:

- Output Option Number Menu
- Students may view Centerline 50-yr. CEDE vs. Distance graphical output by typing the number 3.
- Color—Have students type the number 1.
- Downwind Plotting Range—Have the students type 1 or 2.
- Print—If they have printer capability, the students may press P to print the graphical results (same as on page 9-3).

Demonstration: General Plume

- **Step 14** Type **3** to view Centerline 50-yr. CEDE vs. Distance graphical output.

  The following selection box appears:

```
1: COLOR
2: MONOCHROME / LCD
```

- **Step 15** Type **1** for color monitor.

  The following selection box appears:

```
DOWNWIND PLOTTING RANGE
ENTER SELECTION NUMBER

1: 0.01 TO 10 km
2: 0.1 TO 100 km
```

- **Step 16** Type **1**

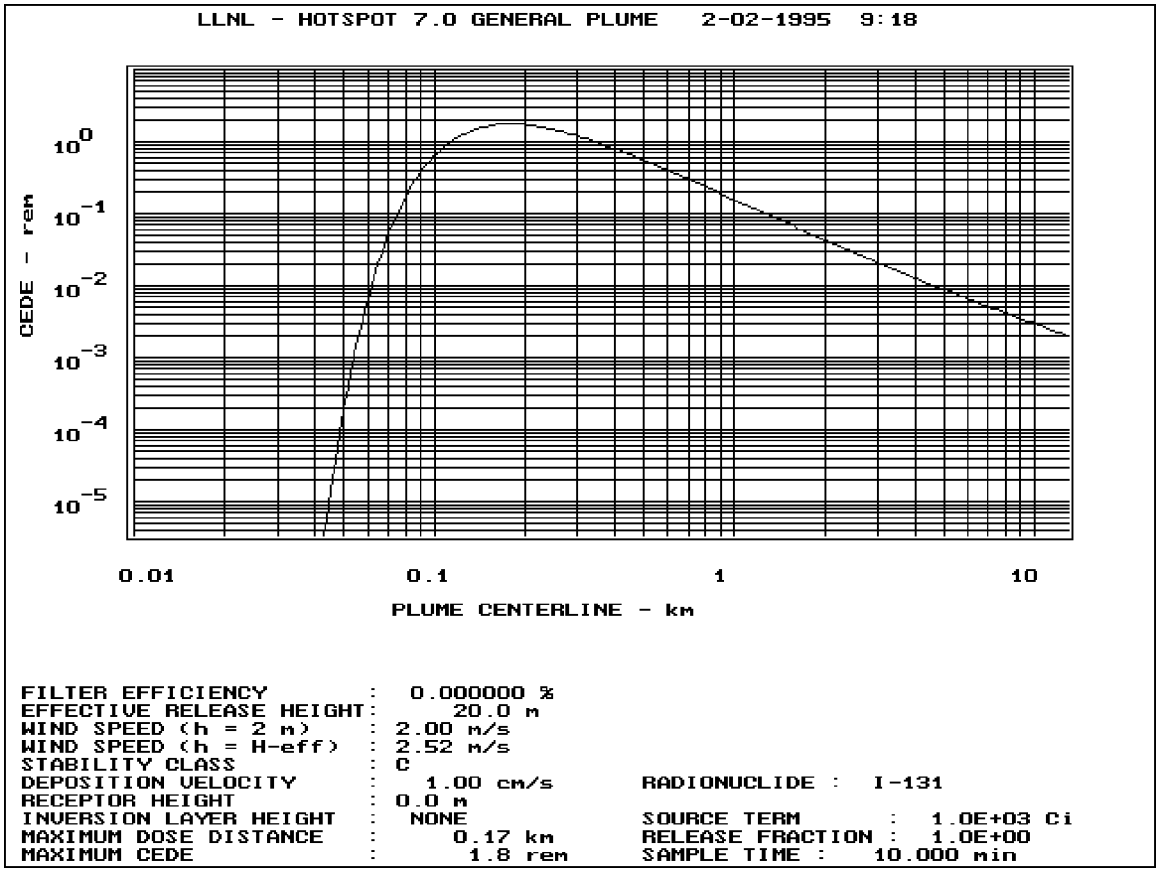
  The result is a graph.

- Print?

- **Step 17** Press **P** to print the graph (if you have printer capability).

Exercise 9-1: General Plume

- Exercise (I131)



9-#21

Notes:

- Distribute Exercise for General Plume (Appendix B contains all exercises; use these to duplicate as many copies as needed for trainees).
- Display Overhead.
- Explain that students may consult Reference page if they wish.
- Exercise Answers: Maximum Dose Distance = 0.17 km
  Maximum CEDE = 1.8 rem

Exercise 9-1: General Plume

- Page 9-25 illustrates the graphical output for a General Plume Air Dispersion Model derived from the HOTSPOT Health Physics Codes program.
- The example for this exercise is based on the following assumptions:
  - The default respirable fraction of the total material involved in the release is dependent upon the type of material input, e.g., 1.00 for noble gases, 0.0005 for plutonium, etc. For non-noble gas radionuclides, the respirable fraction is defined as the fraction of the released material associated with an Activity Median Aerodynamic Diameter (AMAD) of 1 micrometer (see Appendix A). The default ICRP-30 internal dosimetry conversion factors also assume a 1µm AMAD particle size distribution.
  - Standard-person breathing rate is 1.2 cubic meters/hour.
  - The wind is from the east at 2 meter/second on a cloudy day.
- The students' goal is to estimate the dose commitments from a release of 1000 curies of iodine-131 from a 20 meter stack.

- **Step 1** From the HOTSPOT Main Menu, select **H**
- **Step 2** Nuclide? Type **I-131**
- **Step 3** Curies? Type **1000**
- **Step 4** Fraction? Type **Y**
- **Step 5** Filter? Type **Y**
- **Step 6** Height? Type **20**
- **Step 7** Conditions? Type **2** (for Cloudy).
- **Step 8** Wind? Type **2** (for 2 m/s); press **Return**
- **Step 9** Type **1** at the Main Outputs Options Menu to view data table; press **Enter** as desired to view more data.
- **Step 10** Type **1** at the Outputs Option Number Menu to enter a new downwind distance.
- **Step 11** Type **4 7** to enter an off-axis position.
- **Step 12** Type **2** to return to the Output Menu.
- **Step 13** Type **G** (graphics).
- **Step 14** Type **3** to view Centerline 50-yr. CEDE vs. Distance.
- **Step 15** Type **1** to select COLOR.
- **Step 16** Type **1** to enter downwind plotting range.

The result is the graph shown on the previous page of this manual.

Lesson 10
General Explosion
Code I

LESSON PLAN
HOTSPOT HEALTH PHYSICS CODES

LESSON 10 – General Explosion, Code I

TIME:

30 minutes

LESSON LEARNING OBJECTIVES

Terminal: At the end of this lesson, students will be able to model a general explosion of released material, using the General Explosion Code I Atmospheric Dispersion Model of the HOTSPOT Health Physics Codes program.

Enabling:

- At the end of this lesson, students should be able to:
  - — Describe the graphical output for a General Explosion Atmospheric Dispersion Model
  - — Explain the assumptions involved in deriving General Explosion output (tabular and graphical)
  - — Given mock data, generate General Explosion output (tabular and graphical)

INSTRUCTIONAL APPROACH

The mode of delivery for this lesson is lecture, using several job aids and reference materials to provide students with an overview of the HOTSPOT Health Physics Codes application.

EQUIPMENT AND INSTRUCTIONAL AIDS

Overhead projector
IBM PC, XT, AT, or compatible
HOTSPOT User's Manual (*HOTSPOT Health Physics Codes for the PC*)
Exercise Number 10–1

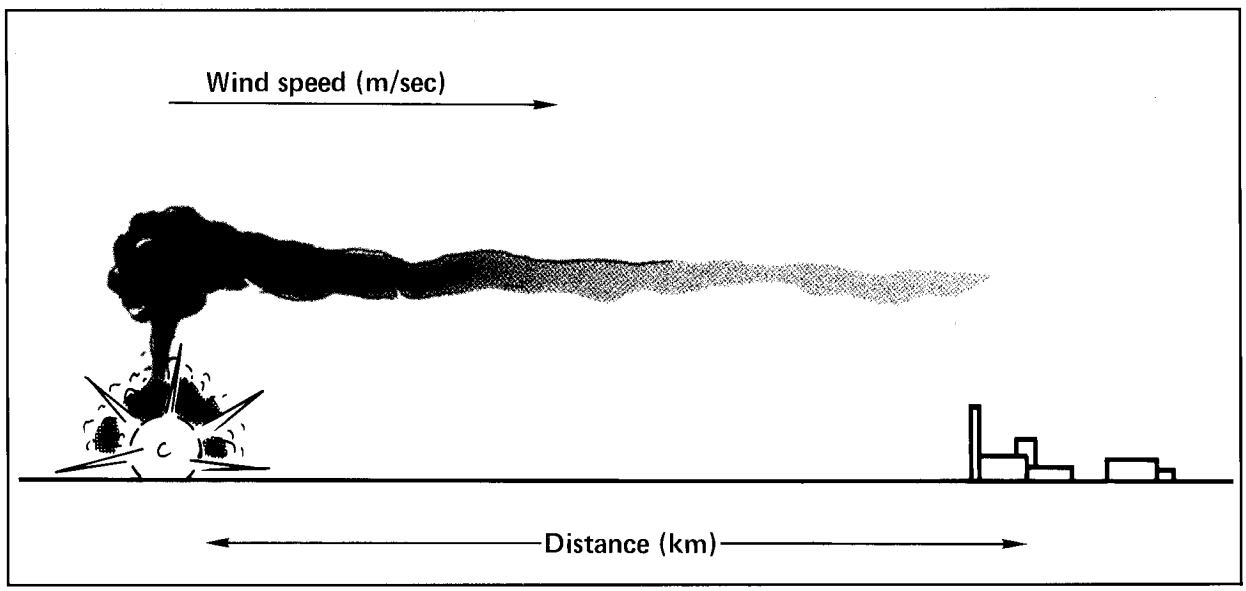
STUDENT MATERIALS

Student Manual

REFERENCES

HOTSPOT User's Manual (*HOTSPOT Health Physics Codes for the PC*)

Lesson Objectives



10-#1

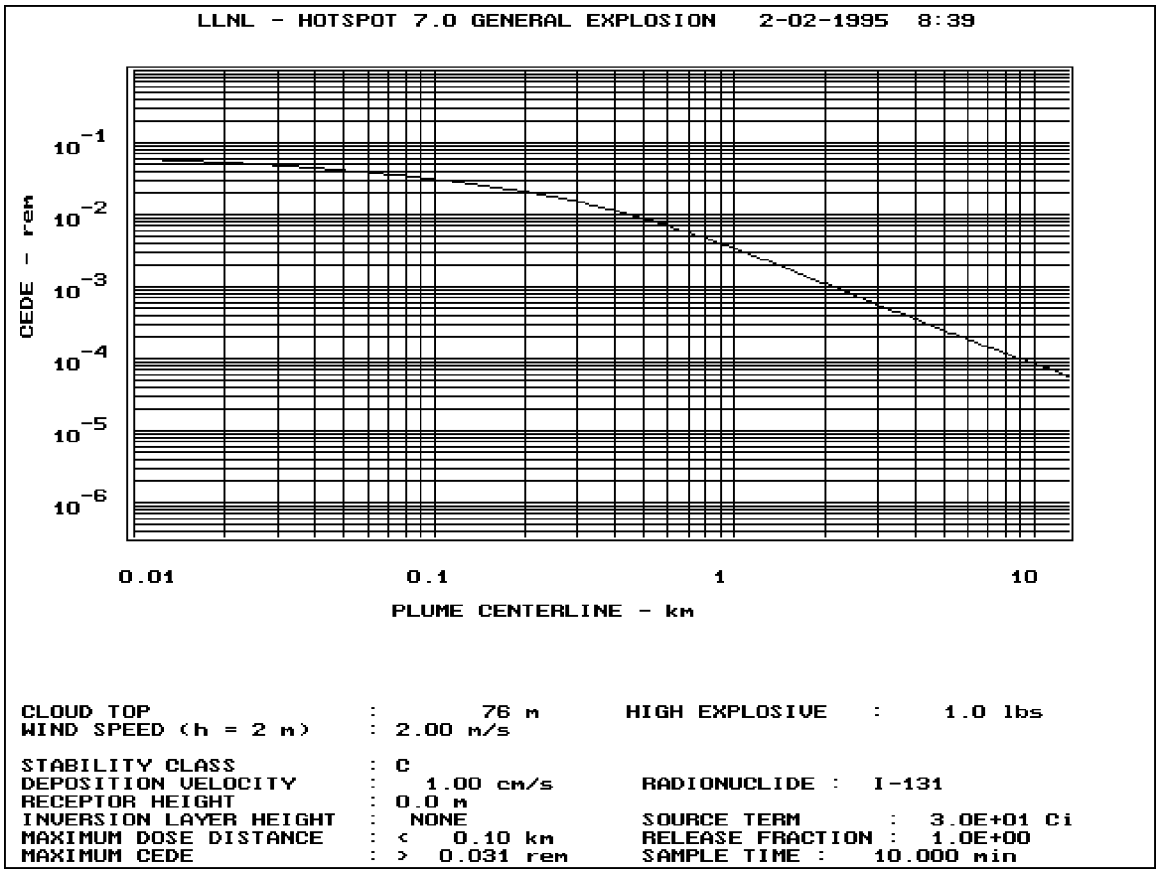
Notes:

- At the end of this lesson, students will be able to model a general explosion of released material, using the General Explosion Code I Atmospheric Dispersion Model of the HOTSPOT Health Physics Codes program (HOTSPOT).
- Explain the Lesson Objectives.

Lesson Objectives

- At the end of this lesson, students should be able to do the following:
  - Describe the graphical output for a General Explosion Atmospheric Dispersion Model
  - Explain the assumptions involved in deriving General Explosion output (tables and graphs)
  - Given mock data, generate General Explosion output (tables and graphs)

Graphical Output and Assumptions—General Explosion



CLOUD TOP	: 76 m	HIGH EXPLOSIVE	: 1.0 lbs
WIND SPEED (h = 2 m)	: 2.00 m/s		
STABILITY CLASS	: C		
DEPOSITION VELOCITY	: 1.00 cm/s	RADIONUCLIDE	: I-131
RECEPTOR HEIGHT	: 0.0 m		
INVERSION LAYER HEIGHT	: NONE	SOURCE TERM	: 3.0E+01 Ci
MAXIMUM DOSE DISTANCE	: < 0.10 km	RELEASE FRACTION	: 1.0E+00
MAXIMUM CEDE	: > 0.031 rem	SAMPLE TIME	: 10.000 min

10-#2

Notes:

- Have students refer to Page 10-3, General Explosion: Graphical Output.
- Discuss the assumptions concerning the General Explosion incident, as described on the Reference page.

Graphic Output and Assumptions—General Explosion

- Page 10-3 illustrates output for a General Explosion Atmospheric Dispersion Model derived from the HOTSPOT Health Physics Codes program.

- This example is based on the following assumptions:

  — The default respirable fraction of the total material involved in the explosion is dependent upon the type of material input, e.g., 1.00 for noble gases, 0.20 for plutonium, etc. For non-noble gas radionuclides, the respirable fraction is defined as the fraction of the released material associated with an Activity Median Aerodynamic Diameter (AMAD), of 1 micrometer (see User Manual, Appendix A). The default ICRP-30 internal dosimetry conversion factors also assume a 1 micrometer AMAD particle size distribution.

  — For non-noble gas radionuclides, the deposition velocity of the non-respirable fraction (AMAD = 40 micron) is 8 cm/sec. The non-respirable fraction equals 1-f, where f is the respirable fraction. The non-respirable fraction is used for deposition estimates only, and does not contribute to the inhalation dose values.

  — Standard-person breathing rate is 1.2 cubic meters/hour.

  — A vehicle, transporting 30 curies of iodine-131 is involved in a severe accident that results in the detonation of the vehicle's gas tank. The wind is from the west at 2 meters/second on a cloudy day. Assuming the release fraction is 1.0, estimate the radiation dose commitments downwind from this accident scene. NOTE: A conservative estimate of the TNT equivalent of an exploding vehicle gas tank is one pound.

Code Description: General Explosion

```
HOTSPOT 7.01 GENERAL EXPLOSION
RADIONUCLIDE :  I-131 Inhalation Class : D
HALFLIFE     :  8.045 days
SOURCE TERM      :  3.0E+01 Ci
RELEASE FRACTION :  1.00E+00
HIGH EXPLOSIVE   :    1.0 lbs
CLOUD TOP        :      76 m
WIND SPEED (h=2 m): 2.0 m/s
STABILITY CLASS          : C                    DEPOSITION VELOCITY      :   1.00 cm/s
RECEPTOR HEIGHT          : 0.0 m                INVERSION LAYER HEIGHT   : NONE
MAXIMUM DOSE DISTANCE    : <    0.1 km          MAXIMUM CEDE   : >  0.031 rem
Plume Centerline

D   =  0.10 km                  D   =  0.20 km                  D   =  0.50 km
DEP =  2.9E+01 uCi/m^2          DEP =  2.0E+01 uCi/m^2          DEP =  8.3E+00 uCi/m^2
CHI =  2.9E-03 (Ci-s)/m^3       CHI =  2.0E-03 (Ci-s)/m^3       CHI =  8.3E-04 (Ci-s)/m^3

50-YR DOSE COMMITMENT:          50-YR DOSE COMMITMENT:          50-YR DOSE COMMITMENT:
----------------------------    ----------------------------    ----------------------------
THYROID      1.1E+00 rem        THYROID      7.2E-01 rem        THYROID      3.0E-01 rem
EFFECTIVE DOSE                  EFFECTIVE DOSE                  EFFECTIVE DOSE
EQUIVALENT    3.1E-02 rem       EQUIVALENT    2.1E-02 rem       EQUIVALENT    8.8E-03 rem

D   =  1.00 km                  D   =  2.00 km                  D   =  5.00 km
DEP =  3.2E+00 uCi/m^2          DEP =  1.0E+00 uCi/m^2          DEP =  2.3E-01 uCi/m^2
CHI =  3.2E-04 (Ci-s)/m^3       CHI =  1.0E-04 (Ci-s)/m^3       CHI =  2.3E-05 (Ci-s)/m^3

50-YR DOSE COMMITMENT:          50-YR DOSE COMMITMENT:          50-YR DOSE COMMITMENT:
----------------------------    ----------------------------    ----------------------------
THYROID      1.2E-01 rem        THYROID      3.8E-02 rem        THYROID      8.5E-03 rem
EFFECTIVE DOSE                  EFFECTIVE DOSE                  EFFECTIVE DOSE
EQUIVALENT    3.4E-03 rem       EQUIVALENT    1.1E-03 rem       EQUIVALENT    2.5E-04 rem
```

10-#3

Notes:

- Describe the code used to derive the General Explosion Atmospheric Dispersion Model discussed in this lesson.

Code Description: General Explosion

- Code description — Study the table on page 10-5.

Demonstration: General Explosion

HOTSPOT Health Physics Codes
VERSION 7.01
HAZARDS CONTROL DEPARTMENT
LAWRENCE LIVERMORE
NATIONAL LABORATORY

S: SETUP

A: Plutonium Explosion	B: Plutonium Fire	C: Plutonium Resuspension
D: Uranium Explosion	E: Uranium Fire	F: Nuclear Explosion
G: Radiation Workplace	H: General Plume	I: General Explosion
J: General Resuspension	K: Inhalation Dose	T: Tritium Release
L: HOTSPOT Library	M: FIDLER Calibration and LUNG Screening	N: General Fire
		Q: QUIT

Enter Selection

10-#4

Notes:

- Describe the steps in using HOTSPOT to model the explosion incident involving I-131.
- Explain that the students should use the reference for detailed information.
- Code—Explain that the students must select the specific code related to the type of incident. In this example, the students must select Code I (General Explosion) from the HOTSPOT Main Menu.
- Nuclide—What nuclide is involved in this incident? Tell the students that this example involves iodine–131 (I–131).
- Inform the students that sometimes they must press Enter (or Return) in order for the computer system to accept data which they type.

Demonstration: General Explosion

- Select General Explosion Atmospheric Dispersion Model from the HOTSPOT Main Menu.

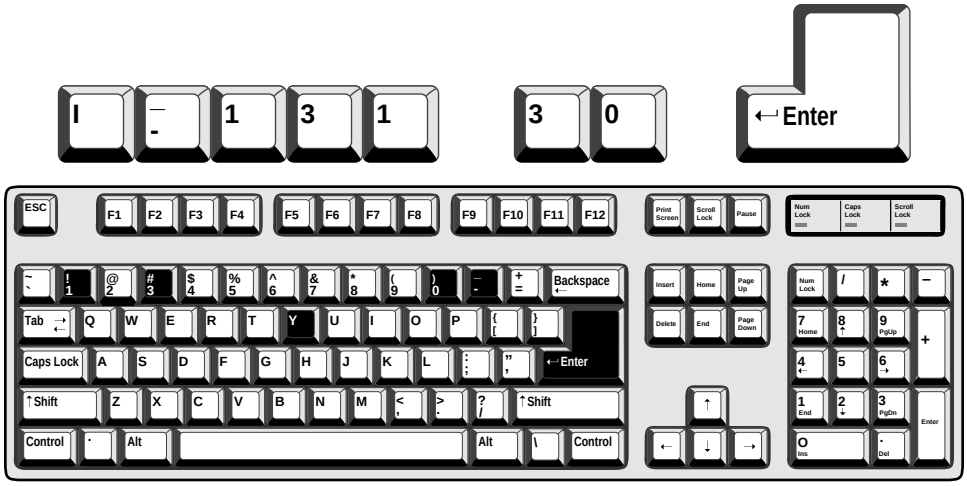
- **Step 1** Type **I** to select General Explosion from the HOTSPOT Main Menu.

- Nuclide?

- **Step 2** Type **I-131** (always in the form XX-NN, where XX represents the letters representing the nuclide name, and where NN represents the nuclide number).

  Press the **Enter** key.

Demonstration: General Explosion



10-#5

Notes:

- Curies—How many curies were released in this explosion? The answer is 30. Remind the students to review the Assumptions on page 10-4 of this lesson.

- F = 1.000E+00? (Y/N)—Explain that the default respiration fraction of the total material involved in the explosion is dependent upon the type of material, and that typing “Y” means that they accept the default.

Demonstration: General Explosion

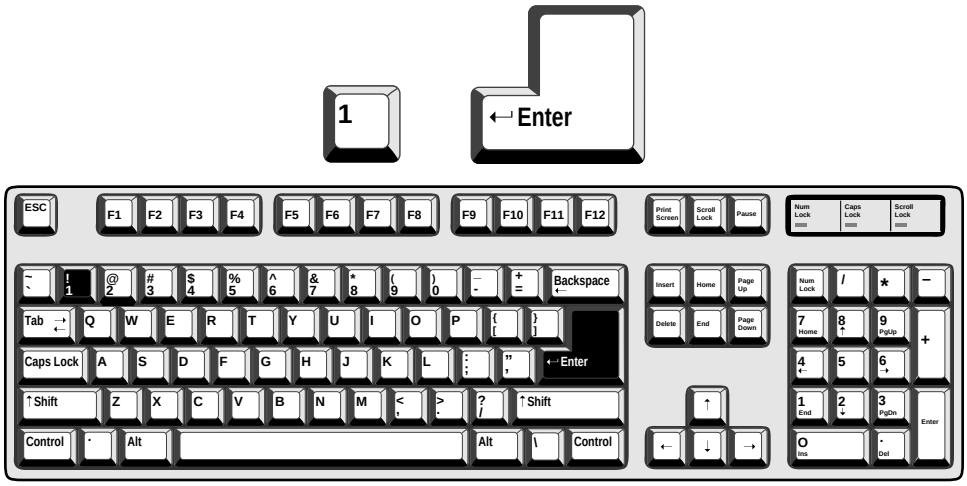
- Curies?
- **Step 3** Enter **30**

  Press the **Enter** key.
- F = 1.000E+00? (Y/N)

  F is the fraction of the entered activity released and dispersed into an AMAD of one micron.

  Enter “Y” to accept the default value, or “N” if you wish to enter a new value.
- **Step 4** Enter **Y** to accept the default value.

Demonstration: General Explosion



10-#6

Notes:

- High Explosive, lb?—Tell the students that they must enter the quantity of explosive (pounds)
- In this example, they must type 1.0 (for 1 pound) and press Enter

Demonstration: General Explosion

- High Explosive, lb?
- **Step 5** Type **1.0** for 1 pound.

  Press the **Enter** key.

Demonstration: General Explosion

- Meteorological Conditions

```
Choose appropriate meteorological conditions from the following
menu—Enter a NUMBER or LETTER.

    1. Sun HIGH in the sky
    2. Sun LOW in the sky or cloudy
    3. NIGHT

    Or, if you prefer to enter a specific stability classification,

    A:  A stability   Very unstable
    B:  B stability   Moderately unstable
    C:  C stability   Slightly unstable
    D:  D stability   Neutral
    E:  E stability   Slightly stable
    F:  F stability   Moderately stable
    G:  G stability   Special nighttime, low wind
    Enter selection
```

10-#7

Notes:

- Meteorological Conditions—Explain that the students may enter a number (1, 2, or 3) to specify the meteorological condition (sun high in sky; sun low in sky or cloudy; night) or a letter (A–G) to specify a stability class.
- Refer students to Meteorological Conditions screen display (slide 10-7).
- In this example, the number 2 indicates the correct meteorological condition.

Demonstration: General Explosion

- Meteorological Conditions

  Enter a number or a letter to indicate appropriate meteorological conditions.

- **Step 6** Type **2** to indicate cloudy day.

Demonstration: General Explosion

- Wind

NAME OF WIND	OBSERVABLE FEATURES	MPH	M/S
calm	Smoke rises vertically	< 1	< 0.5
light Atmospheric	Smoke drifts downward	1 – 3	0.5 – 1
light breeze	Wind felt on face; leaves rustle	3 – 7	1 – 3
gentle breeze	Leaves and twigs in constant motion	7 – 12	3 – 5
moderate breeze	Raises dust and loose paper	12 – 18	5 – 8
fresh breeze	Small tress begin to sway	18 – 24	8 – 11
strong breeze	Large branches in motion	24 – 31	11 – 14
moderate gale	Whole trees in motion	31 – 38	14 – 17
fresh gale	Twigs break off; walking impeded	38 – 46	17 – 21
strong gale	Slight structural damage occurs	46 – 54	21 – 24
whole gale	Tree uprooted; structural damage	54 – 63	24 – 28
storm	Very rare, widespread destruction	63 – 75	28 – 34
hurricane		> 75	> 34

10#8

Notes:

- Wind—Refer students to the Wind screen display (slide 10-8).

Demonstration: General Explosion

- WIND?

  Enter the ground wind speed, in meters/second, and press ENTER (1 mph = 0.45 m/s).

- **Step 7** Type **2**

  Press the **Enter** key.

Demonstration: General Explosion

- Main Output Options Menu

```
Main Output Options Menu

1:  SCREEN    Output     Default     Distances
2:  SCREEN    Output     You Enter   Distances
3:  PRINTER   Output     Default     Distances
4:  PRINTER   Output     You Enter   Distances
5:  DISK FILE Output     Default     Distances
6:  DISK FILE Output     You Enter   Distances

G:  GRAPHICS
C:  Change DEFAULT CONTOUR SETTINGS
M:  Change METEOROLOGICAL PARAMETERS and Release
     Height
Z:  Change RECEPTOR HEIGHT (z)
D:  Change DEPOSITION VELOCITY
O:  Enable prompt for OFF AXIS Positions
I:  INVERSION HEIGHT (Mixing Layer)
Q:  Return to Main HOTSPOT Menu.
```

10-#9

Notes:

- Screen output—Explain that students should select 1, screen output using the default distances.

- Data tables—The students must type 1 and press Return to view the data tables.

Demonstration: General Explosion

- Main Outputs Options Menu
- Screen output
- **Step 8** Type **1** to view data tables.

  Press **Return** to view more data.

  Continue pressing **Return** until you view all the data.

  After you have viewed all the data, the following message appears:

  > "Enter the appropriate Output option number from the following menu."

  Look at the Output Option Number Menu.

Demonstration: General Explosion

1: Enter a new Downwind Distance
2: Return to Output Menu
Q: Return to Main HOTSPOT Menu

10-#10

Notes:

- Explain that students may enter a new downwind distance by selecting option 1 from the Output Option Number Menu.
- Explain the results table.

Demonstration: General Explosion

- Output Option Number Menu

- **Step 9** Type **1** to enter a new distance.

  The following message appears:

  Enter Distance, km, and push “Enter.”
  To enter an off-axis position, (x, y),
  enter x y, e.g., 3 6 for x = 3 km and y = 6 km
  Push “Enter” w/o data entry to QUIT.

- **Step 10** Type **4 0.1** to enter an off-axis position.

  The results table shows the following:

  D = 4.00 km
  OFF-AXIS – Y = 0.1 km
  DEP = 3.2E-01 μCi/m^2
  CHI = 3.2E-05 (Ci–s)/m^3
  <u>50-YR DOSE COMMITMENT</u>
  THYROID 1.2E-02 rem
  EFFECTIVE DOSE
  EQUIVALENT 3.4E-04 rem

- **Step 11** Press **Return**

  Type **2** at the Output Option Number Menu to return to the Output Menu.

Demonstration: General Explosion

- Main Output Options Menu—Option G

```
Main Output Options Menu

1:  SCREEN    Output     Default     Distances
2:  SCREEN    Output     You Enter   Distances
3:  PRINTER   Output     Default     Distances
4:  PRINTER   Output     You Enter   Distances
5:  DISK FILE Output     Default     Distances
6:  DISK FILE Output     You Enter   Distances

G:  GRAPHICS
C:  Change DEFAULT CONTOUR SETTINGS
M:  Change METEOROLOGICAL PARAMETERS and Release
     Height
Z:  Change RECEPTOR HEIGHT (z)
D:  Change DEPOSITION VELOCITY
O:  Enable prompt for OFF AXIS Positions
I:  INVERSION HEIGHT (Mixing Layer)
Q:  Return to Main HOTSPOT Menu.
```

10-#11

Notes:

- Main Output Options Menu: Option G—Explain that students need to use option G to see graphical representations of the results of the example incident's air dispersion model

Demonstration: General Explosion

- Option G—Graphics
- **Step 11** Type **G** for Graphics.
- Result An Output option number menu appears.

Demonstration: General Explosion

1: CEDE Contours

2: GROUND DEPOSITION Contours

3: Centerline 50-yr. CEDE vs. Distance

C: Change Graphics Output File Name

TO PRINT GRAPHICS—PUSH the “P” key when the screen output is complete.

Select your printer using the SETUP option at the Main HOTSPOT MENU.

10-#12

Notes:

- Output Option Number Menu
- Students may view Centerline 50-yr. CEDE vs. Distance graphical output by typing the number 3.
- Color—Have students type the number 1 (for COLOR).
- Downwind Plotting Range—Have the students type 1 or 2.
- Print—If they have printer capability, the students may press P to print the graphical results (same as slide 10-2).

Demonstration: General Explosion

- **STEP 12** Type **3** to view Centerline 50-yr. CEDE vs. Distance graphical output.

  The following selection box appears:

```
DOWNWIND PLOTTING RANGE
ENTER SELECTION NUMBER

1: 0.01 TO 10 km
2: 0.1 TO 100 km
```

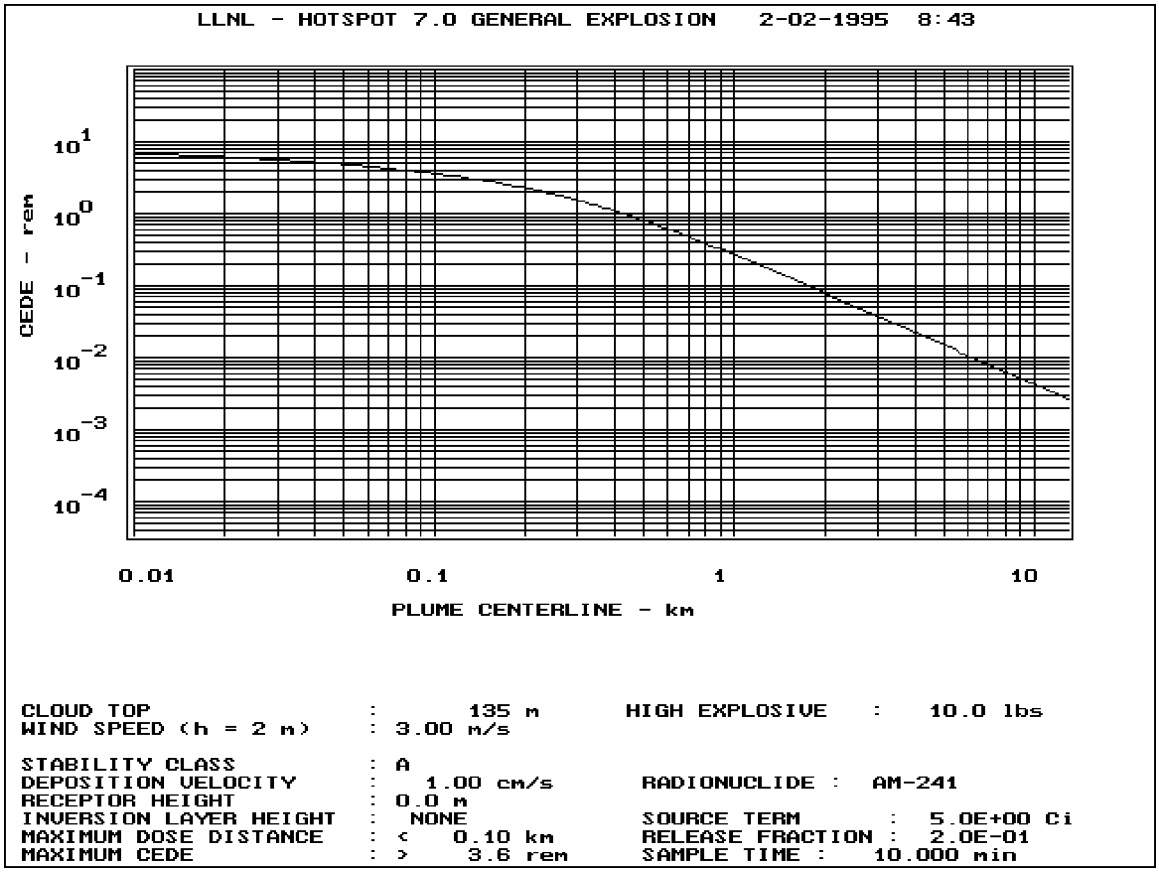
  Type **1**

  The result is a graph.

  Press **P** to print the graph (if you have printer capability).

Exercise 10-1: General Explosion

- Exercise (Am-241)



10-#13

Notes:

- Distribute Exercise for General Explosion involving Am-241.
- Display Overhead.
- Explain that students may consult Reference page if they wish.
- Exercise Answers: Maximum Dose Distance = <0.1 km
  Maximum CEDE = >3.6 rem

Exercise 10-1: General Explosion

- Page 10-25 illustrates the graphical output for a General Explosion Atmospheric Dispersion Model derived from the HOTSPOT Health Physics Codes program.

- The example for this exercise is based on the following assumptions:

  — An explosion involving 5 curies of americium-241 in a liquid solution occurs at a research facility. It is estimated that the explosion is equivalent to 10 pounds of TNT. The wind is blowing at 3 meters/second on a sunny day. Assuming the respirable fraction is 0.20 (20%), estimate the radiation dose commitments downwind from this accident scene.

- **Step 1** From the HOTSPOT Main Menu, select **I**
- **Step 2** Nuclide? Type **AM-241**
- **Step 3** Curies? Type **5;** press **Enter**
- **Step 4** Fraction? Type **Y**
- **Step 5** High Explosive? Type **10;** press **Enter**
- **Step 6** Conditions? Type **1** (for Sunny).
- **Step 7** Wind? Type **3** (for 3 meters/second); press **Return**
- **Step 8** Type **1** at the Main Outputs Options Menu to view data table; press **Enter** as desired to view more data.
- **Step 9** Type **1** at the Outputs Option Number Menu to enter downwind distance.
- **Step 10** Type **2** to return to the Output Menu.
- **Step 11** Type **G** (graphics).
- **Step 12** Type **3** to view Centerline 50-yr. CEDE vs. Distance.
- **Step 13** Type **1** to select COLOR.
- **Step 14** Type **1** to enter downwind plotting range.

The result is the graph shown on the previous page of this manual.

Lesson 11
General Fire
Code N

LESSON PLAN
HOTSPOT HEALTH PHYSICS CODES

LESSON 11 – General Fire, Code N

TIME:

30 minutes

LESSON LEARNING OBJECTIVES

Terminal: At the end of this lesson, students will be able to model a general fire involving released material, using the General Fire Code N Atmospheric Dispersion Model of the HOTSPOT Health Physics program.

Enabling:

- At the end of this lesson, students should be able to:
  - — Describe the graphical output for a General Fire Atmospheric Dispersion Model
  - — Explain the assumptions involved in deriving General Fire output (tabular and graphical)
  - — Given mock data, generate General Fire output (tabular and graphical)

INSTRUCTIONAL APPROACH

The mode of delivery for this lesson is lecture, using several job aids and reference materials to provide students with an overview of the HOTSPOT Health Physics Codes application.

EQUIPMENT AND INSTRUCTIONAL AIDS

Overhead projector
IBM PC, XT, AT, or compatible
HOTSPOT User's Manual (*HOTSPOT Health Physics Codes for the PC*)

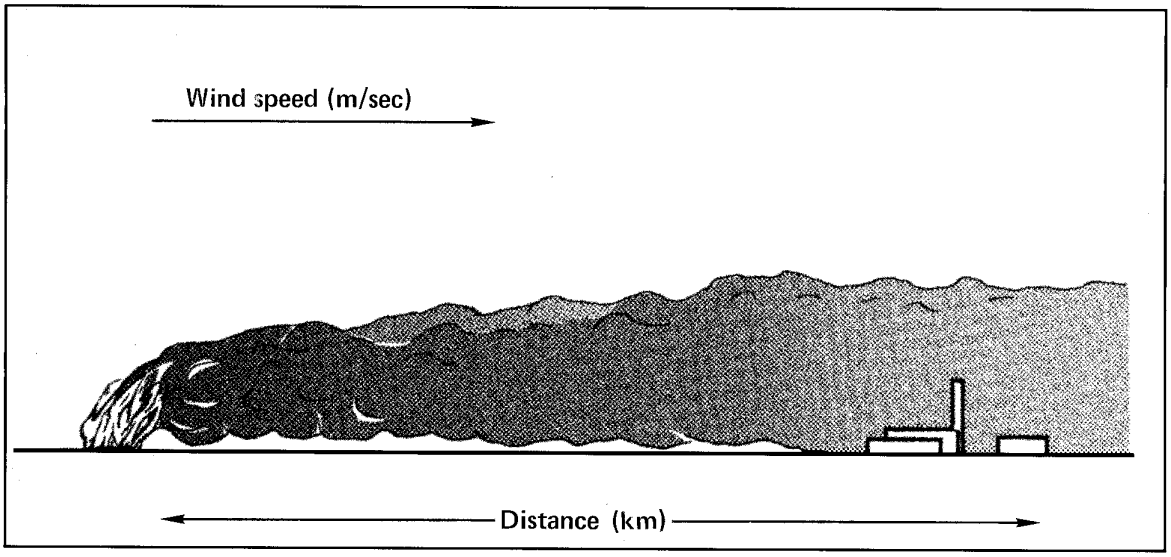
STUDENT MATERIALS

Student Manual

REFERENCES

HOTSPOT User's Manual (*HOTSPOT Health Physics Codes for the PC*)
Exercise Number 11–1

Lesson Objectives



11-#1

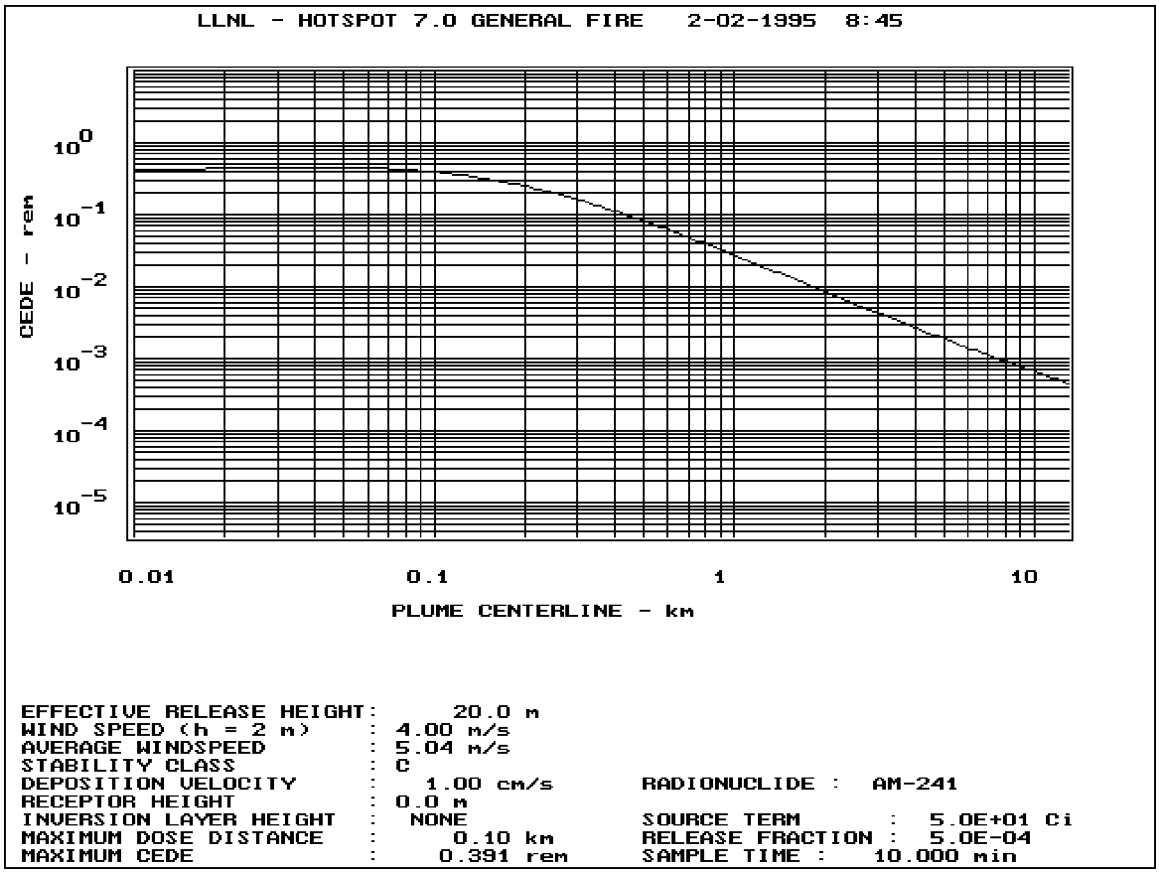
Notes:

- At the end of this lesson, students will be able to model a general fire involving released material, using the General Fire Code N Atmospheric Dispersion Model of the HOTSPOT Health Physics program.
- Explain the Lesson Objectives.

Lesson Objectives

- At the end of this lesson, students should be able to:
  - — Describe the graphical output for a General Fire Atmospheric Dispersion Model.
  - — Explain the assumptions involved in deriving General Fire output (tables and graphs).
  - — Given mock date, generate General Fire output (tables and graphs).

Graphical Output and Assumptions—General Fire



EFFECTIVE RELEASE HEIGHT	20.0 m		
WIND SPEED (h = 2 m)	4.00 m/s		
AVERAGE WINDSPEED	5.04 m/s		
STABILITY CLASS	C		
DEPOSITION VELOCITY	1.00 cm/s	RADIONUCLIDE	AM-241
RECEPTOR HEIGHT	0.0 m		
INVERSION LAYER HEIGHT	NONE	SOURCE TERM	5.0E+01 Ci
MAXIMUM DOSE DISTANCE	0.10 km	RELEASE FRACTION	5.0E-04
MAXIMUM CEDE	0.391 rem	SAMPLE TIME	10.000 min

11-#2

Notes:

- Have students refer to Page 11-3, General Fire: Graphical Output.
- Discuss the assumptions involved in this incident, as described on the Reference page.

Graphic Output and Assumptions—General Fire

- Page 11-3 illustrates output for a General Fire Atmospheric Dispersion Model derived from HOTSPOT.

- This example is based on the following assumptions:

  — The default respirable fraction of the total material involved in the fire is dependent upon the type of material input, e.g., 1.00 for noble gases, 0.0005 for plutonium, etc. For non-noble gas radionuclides, the respirable fraction is defined as the fraction of the released material associated with an Activity Median Aerodynamic Diameter (AMAD), of 1 micrometer (See User Manual, Appendix A). The default ICRP-30 internal dosimetry conversion factors also assume a 1 micrometer AMAD particle size distribution.

  — The effective release height is determined using the methodology contained in the "Fuel Fire" section of Appendix A (User Manual). Once the effective release height is determined, the radius of the final bent-over plume is set equal to 60% of the effective release height (Hanna, 1982). An upwind virtual point source, which results in an initial σ_y and σ_z equal to 50% of the plume radius at the origin (i.e., plume radius = 2), is used to model the fire scenario.

  — Standard-person breathing rate is 1.2 cubic meters/hour.

  — Fifty curies of americium-241 are involved in a laboratory fire. The effective radius of the fire is 20 meters. The sun is low in the sky, and the wind speed is approximately 4 meters/second. The observed cloud top of the plume is approximately 20 meters above the ground. Estimate the ground contamination and 50-year committed effective dose equivalents as a function of down-wind centerline distance.

Code Description: General Fire

```
HOTSPOT 7.01 GENERAL FIRE
RADIONUCLIDE :  AM-241  Inhalation Class : W   HALFLIFE     : 432.2 years
SOURCE TERM      :  5.0E+01 Ci
RELEASE FRACTION :  5.00E-04                    RELEASE RADIUS   :   20.0 m
EFFECTIVE RELEASE HEIGHT :    10.00 m
WIND SPEED (h=2 m): 4.0 m/s
WIND SPEED (h=H-eff): 4.7 m/s
STABILITY CLASS          : C                    DEPOSITION VELOCITY      :   1.00 cm/s
RECEPTOR HEIGHT          : 0.0 m                INVERSION LAYER HEIGHT   : NONE
SAMPLE TIME              :   10.000 min
MAXIMUM DOSE DISTANCE    : <    0.1 km          MAXIMUM CEDE   : >  0.673 rem

D   =  0.10 km                    D   =  0.20 km                    D   =  0.50 km
DEP =  3.9E-02 uCi/m^2            DEP =  1.9E-02 uCi/m^2            DEP =  5.3E-03 uCi/m^2
CHI =  3.9E-06 (Ci-s)/m^3         CHI =  1.9E-06 (Ci-s)/m^3         CHI =  5.3E-07 (Ci-s)/m^3

50-YR DOSE COMMITMENT:            50-YR DOSE COMMITMENT:            50-YR DOSE COMMITMENT:
------------------------------    ------------------------------    ------------------------------
SURFACE BONE  1.2E+01 rem         SURFACE BONE  6.0E+00 rem         SURFACE BONE  1.7E+00 rem
RED MARROW    9.6E-01 rem         RED MARROW    4.7E-01 rem         RED MARROW    1.3E-01 rem
LIVER         2.6E+00 rem         LIVER         1.3E+00 rem         LIVER         3.6E-01 rem
GONADS        1.6E-01 rem         GONADS        7.7E-02 rem         GONADS        2.1E-02 rem
EFFECTIVE DOSE                    EFFECTIVE DOSE                    EFFECTIVE DOSE
EQUIVALENT    6.7E-01 rem         EQUIVALENT    3.3E-01 rem         EQUIVALENT    9.3E-02 rem

D   =  1.00 km                    D   =  2.00 km                    D   =  5.00 km
DEP =  1.7E-03 uCi/m^2            DEP =  5.3E-04 uCi/m^2            DEP =  1.2E-04 uCi/m^2
CHI =  1.7E-07 (Ci-s)/m^3         CHI =  5.3E-08 (Ci-s)/m^3         CHI =  1.2E-08 (Ci-s)/m^3
50-YR DOSE COMMITMENT:            50-YR DOSE COMMITMENT:            50-YR DOSE COMMITMENT:
------------------------------    ------------------------------    ------------------------------
SURFACE BONE  5.3E-01 rem         SURFACE BONE  1.6E-01 rem         SURFACE BONE  3.6E-02 rem
RED MARROW    4.2E-02 rem         RED MARROW    1.3E-02 rem         RED MARROW    2.9E-03 rem
LIVER         1.1E-01 rem         LIVER         3.5E-02 rem         LIVER         7.7E-03 rem
GONADS        6.8E-03 rem         GONADS        2.1E-03 rem         GONADS        4.6E-04 rem
EFFECTIVE DOSE                    EFFECTIVE DOSE                    EFFECTIVE DOSE
EQUIVALENT    3.0E-02 rem         EQUIVALENT    9.1E-03 rem         EQUIVALENT    2.0E-03 rem
```

11-#3

Notes:

- Describe the code used to derive the General Fire Atmospheric Dispersion Model illustrated in this lesson.

Code Description: General Fire

- Code description — Study the table on page 11-5.

Demonstration: General Fire

HOTSPOT Health Physics Codes
VERSION 7.01
HAZARDS CONTROL DEPARTMENT
LAWRENCE LIVERMORE
NATIONAL LABORATORY

S: SETUP

A: Plutonium Explosion	B: Plutonium Fire	C: Plutonium Resuspension
D: Uranium Explosion	E: Uranium Fire	F: Nuclear Explosion
G: Radiation Workplace	H: General Plume	I: General Explosion
J: General Resuspension	K: Inhalation Dose	T: Tritium Release
L: HOTSPOT Library	M: FIDLER Calibration and LUNG Screening	N: General Fire
		Q: QUIT

Enter Selection
4-#4

Notes:

- Describe the steps involved in using HOTSPOT to model the incident where fifty curies of americium–241 are involved in a laboratory fire.
- Explain that the students should use the Reference page for detailed information.
- Code—Explain that the students must select the specific code related to the type of incident. In this example, the students must select Code N (General Fire) from the HOTSPOT Main Menu.
- Effective Release Height—Explain the conditions under which the students would select 1, 2, or 3 from the Effective Release Height menu.
- Release Radius—Explain that release radius is the effective radius of the fire. Tell the students to enter a value (in this example, it is 20 meters) rather than to accept the default.
- Inform the students that sometimes they must press Enter (or Return) in order for the computer system to accept data which they type.

Demonstration: General Fire

- Select General Fire Atmospheric Dispersion Model from the HOTSPOT Main Menu.

- **Step 1** Type **N** to select General Fire from the HOTSPOT Main Menu.

- Result The Effective Release Height menu appears:

1: Fire –You enter Effective Release Height. 2: Fire – HOTSPOT calculates Effective Release Height using input fuel and burn duration. 3: Fire – HOTSPOT calculates Effective Release Height using input Heat Emission (calories per second).

- **Step 2** Type **1**

- Result The Release Radius message appears:

Release Radius = 10 m? (Y/N) Release radius is the effective radius of the fire, e.g., radius of burning fuel pool. The default is 10 meters.

- **Step 3** Type **N**

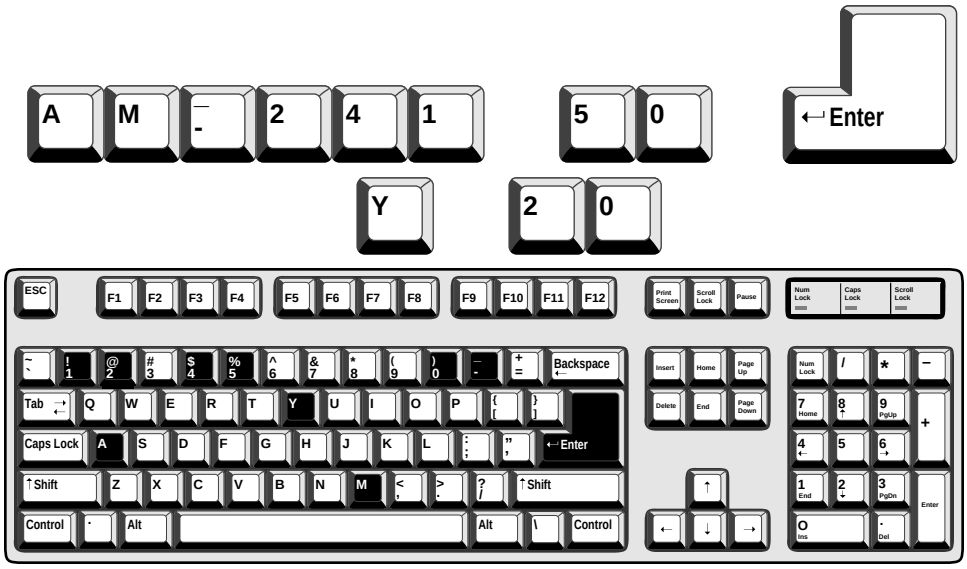
- Result The Enter Release Radius message appears:

Enter Release Radius (meters), and push Enter. Note: Release Radius must be a value greater than 1 meter.

- **Step 4** Type **20**

  Press the **Enter** key.

Demonstration: General Fire



11-#5

Notes:

- Nuclide— What nuclide is involved in this incident? Tell the students that this example involves americium–241 (am-241).
- Curies—How many curies were released in this explosion? The answer is 50. Remind the students to review the Assumptions on page 11-4 of this lesson.
- F = 1.000E+00? (Y/N)—Explain that the default respiration fraction of the total material involved in the release is dependent upon the type of material and that typing Y means that you accept the default.
- Height—Explain what is meant by effective release height.

Demonstration: General Fire

- Nuclide?

- **Step 5** Type **am–241** (always in the form XX-NN, where XX represents the letters representing the nuclide name, and where NN represents the nuclide number).

  Press the **Enter** key.

- Curies? Enter the total activity of the nuclide involved in the release.

- **Step 6** Enter **50**

  Press the **Enter** key.

- F = 1.000E+00? (Y/N)

  F is the fraction of the entered activity released and dispersed into an AMAD of one micron.

  Enter “Y” to accept the default value, or “N” if you wish to enter a new value.

- **Step 7** Enter **Y** to accept the default value.

- Height? Enter the effedtive release height.

  Note: If you are estimating the effective release height from an observation of the CLOUD TOP, input CLOUD TOP / 2, e.g., Effective Height = 0.5 * CLOUD TOP.

- **Step 8** Type **20** to enter the effective release height.

Demonstration: General Fire

- Meteorological Conditions

Choose appropriate meteorological conditions from the following menu—Enter a NUMBER or LETTER.

1. Sun HIGH in the sky
2. Sun LOW in the sky or cloudy
3. NIGHT

Or, if you prefer to enter a specific stability classification,

A: A stability Very unstable
B: B stability Moderately unstable
C: C stability Slightly unstable
D: D stability Neutral
E: E stability Slightly stable
F: F stability Moderately stable
G: G stability Special nighttime, low wind
Enter selection

11-#6

Notes:

- Meteorological Conditions—Explain that the students may enter a number (1, 2, or 3) to specify the meteorological condition (sun high in sky; sun low in sky or cloudy; night) or a letter (A–G) to specify a stability class.
- Refer students to the Meteorological Conditions screen display.
- In this example, the number 2 indicates the correct meteorological condition (sun low in sky).

Demonstration: General Fire

- Meteorological Conditions

  Enter a number or a letter to indicate appropriate meteorological conditions.

- **Step 9** Type **2** to indicate sun low in sky.

Demonstration: General Fire

- Wind

NAME OF WIND	OBSERVABLE FEATURES	MPH	M/S
calm	Smoke rises vertically	< 1	< 0.5
light Atmospheric	Smoke drifts downward	1 – 3	0.5 – 1
light breeze	Wind felt on face; leaves rustle	3 – 7	1 – 3
gentle breeze	Leaves and twigs in constant motion	7 – 12	3 – 5
moderate breeze	Raises dust and loose paper	12 – 18	5 – 8
fresh breeze	Small tress begin to sway	18 – 24	8 – 11
strong breeze	Large branches in motion	24 – 31	11 – 14
moderate gale	Whole trees in motion	31 – 38	14 – 17
fresh gale	Twigs break off; walking impeded	38 – 46	17 – 21
strong gale	Slight structural damage occurs	46 – 54	21 – 24
whole gale	Tree uprooted; structural damage	54 – 63	24 – 28
storm	Very rare, widespread destruction	63 – 75	28 – 34
hurricane		> 75	> 34

11-#7

Notes:

- Wind—Refer students to the Wind screen display.

Demonstration: General Fire

- WIND?

  Enter the ground wind speed, in meters/second, and press ENTER (1 mph = 0.45 m/s).

- **Step 10** Type **4**

  Press the **Enter** key.

Demonstration: General Fire

- Main Output Options Menu

```
Main Output Options Menu

1:  SCREEN    Output     Default     Distances
2:  SCREEN    Output     You Enter   Distances
3:  PRINTER   Output     Default     Distances
4:  PRINTER   Output     You Enter   Distances
5:  DISK FILE Output     Default     Distances
6:  DISK FILE Output     You Enter   Distances

G:  GRAPHICS
C:  Change DEFAULT CONTOUR SETTINGS
M:  Change METEOROLOGICAL PARAMETERS and Release
     Height
Z:  Change RECEPTOR HEIGHT (z)
D:  Change DEPOSITION VELOCITY
O:  Enable prompt for OFF AXIS Positions
I:  INVERSION HEIGHT (Mixing Layer)
T: SAMPLE TIME
Q:  Enter to Main HOTSPOT Menu.
```

11-#8

Notes:

- Screen output—Explain that students should select 1, screen output using the default distances.

- Data tables—The students must type 1 and press Enter to view the data tables.

Demonstration: General Fire

- Main Outputs Options Menu
- Screen output
- **Step 11** Type **1** to view data tables.

  Press **Enter** view more data.

  Continue pressing **Enter** until you view all the data.

  After you have viewed all the data, the following message appears:

  > "Enter the appropriate Output option number from the following menu."

  Look at the Output Option Number Menu.

Demonstration: General Fire

- Output Option Number Menu

1: Enter a new Downwind Distance
2: Return to Output Menu
Q: Return to Main HOTSPOT Menu

11-#9

Notes:

- Explain that students must type 2 at the Output Option Number Menu to return to the Main HOTSPOT Menu.

Demonstration: General Fire

- Output Option Number Menu
- **Step 12** Type **2** at the Output Option Number Menu to return to the Output Menu.

  Press **Enter**

Demonstration: General Fire

- Main Output Options Menu—Option G

```
Main Output Options Menu

1:  SCREEN    Output     Default     Distances
2:  SCREEN    Output     You Enter   Distances
3:  PRINTER   Output     Default     Distances
4:  PRINTER   Output     You Enter   Distances
5:  DISK FILE Output     Default     Distances
6:  DISK FILE Output     You Enter   Distances

G:  GRAPHICS
C:  Change DEFAULT CONTOUR SETTINGS
M:  Change METEOROLOGICAL PARAMETERS AND Release
    Height
Z:  Change RECEPTOR HEIGHT (z)
D:  Change DEPOSITION VELOCITY
O:  Enable prompt for OFF AXIS Positions
I:  INVERSION HEIGHT (Mixing Layer)
Q:  Enter to Main HOTSPOT Menu.
```

11-#10

Notes:

- Main Output Options Menu: Option G—Explain that students need to use option G to see graphical representations of the results of the example incident's air dispersion model.

Demonstration: General Fire

- Option G—Graphics
- **Step 13** Type **G** for Graphics.
- Result An Output option number menu appears.

Demonstration: General Fire

1: CEDE Contours

2: GROUND DEPOSITION Contours

3: Centerline 50-yr. CEDE vs. Distance

C: Change Graphics Output File Name

TO PRINT GRAPHICS—PUSH the “P” key when the screen output is complete.

Select your printer using the SETUP option at the Main HOTSPOT MENU.

11-#11

Notes:

- Output Option Number Menu
- Students may view Centerline 50-yr. CEDE vs. Distance graphical output by typing the number 3.
- Color—Have students type the number 1.
- Downwind Plotting Range—Have the students type 1 or 2.
- Print—If they have printer capability, the students may press P to print the graphical results (same as on Page 11-3).

Demonstration: General Fire

- **STEP 14** Type **3** to view Centerline 50-yr. CEDE vs. Distance graphical output.

- Result The following selection box appears:

```
1: COLOR
2: MONOCHROME / LCD
```

- Result The following selection box appears:

```
DOWNWIND PLOTTING RANGE
ENTER SELECTION NUMBER

1: 0.01 TO 10 km
2: 0.1 TO 100 km
```

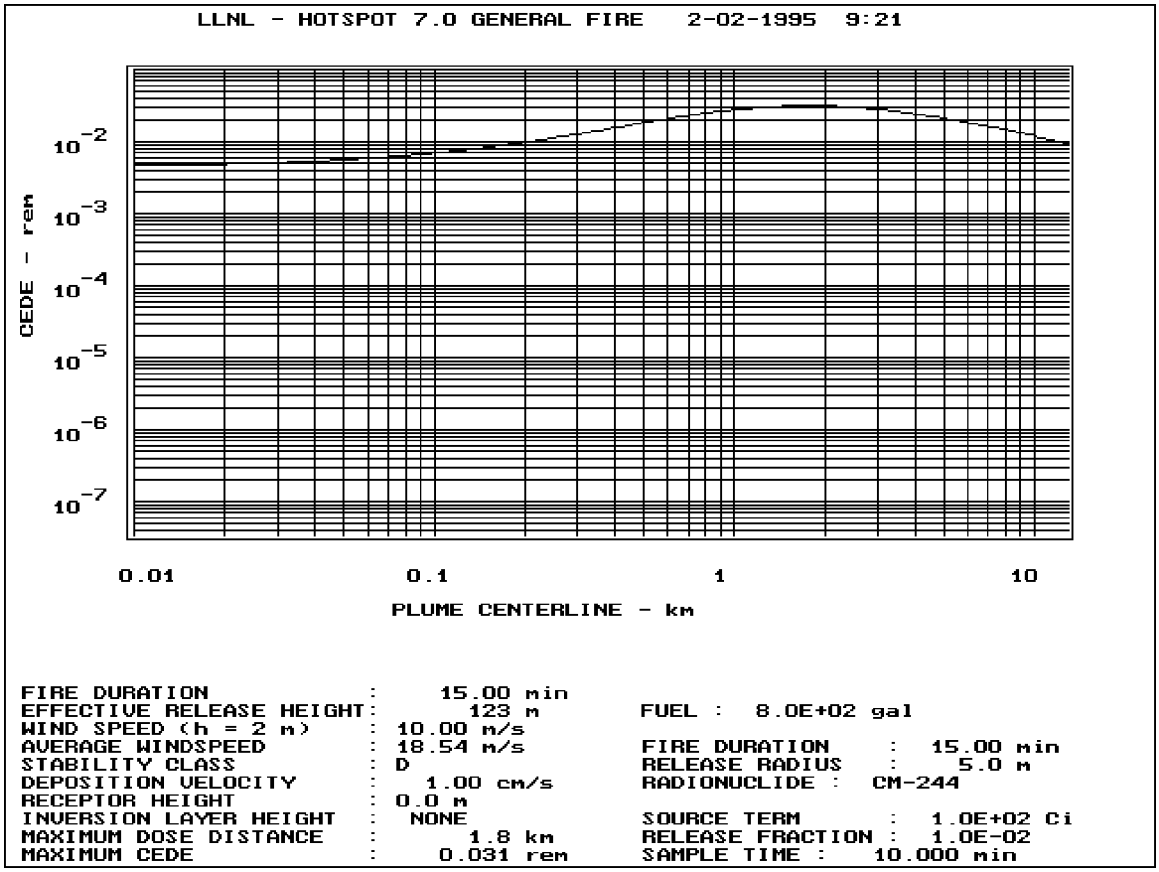
Type **1**

The result is a graph.

Press **P** to print the graph (if you have printer capability).

Exercise 11-1: General Fire

- Exercise (Cm-244)



11-#12

Notes:

- Distribute Exercise for General Fire involving curium-244.
- Display Overhead.
- Explain that students may consult the Reference page if they wish.
- Exercise Answers: Maximum Dose Distance = 1.8 km
  Maximum CEDE = 0.031 rem

Exercise 11-1: General Fire

- Page 11-23 illustrates the graphical output for a General Fire Atmospheric Dispersion Model derived from the HOTSPOT Health Physics Codes program.

- The example for this exercise is based on the following assumptions:

  — An aircraft transporting 100 curies of curium-244 crashes, and the remaining 800 gallons of aviation fuel burns for 15 minutes. The fuel is contained in a pool with an approximate radius of 5 meters. The wind is blowing at 10 meters/second on a cloudy day. Assuming the respirable release fraction is 0.01 (1%), estimate the radiation dose commitments downwind from this accident scene.

- **Step 1** From HOTSPOT Menu: Select **N**
- **Step 2** Effective Release Height? Type **2**
- **Step 3** Volume? Type **800; press Enter**
- **Step 4** Release Radius? Type **N**; then, type **5**; press **Enter**
- **Step 5** Burn Time? Type **15**; push **Enter**
- **Step 6** Ambient Temp? Type **Y**(for 20°C); press **Enter**
- **Step 7** Nuclide? Type **cm-244**; press **Enter**
- **Step 8** Curies? Type **100**; press **Enter**
- **Step 9** Fraction? Type **N**; then type **.01**
- **Step 10** Conditions? Type **2** (to indicate cloudy day).
- **Step 11** Wind? Type **10** (10 meters/second); press **Enter**
- **Result** The Plume Rise Summary Information Screen appears.
- **Step 12** Type **1** at the Main Outputs Options Menu to view data table; press **Enter** as desired to view more data.
- **Step 13** Type **1** at the Outputs Option Number Menu to enter the downwind distance.
- **Step 14** Type **2** to enter to the Output Menu.
- **Step 15** Type **G** (graphics).
- **Step 16** Type **3** to view Centerline 50-yr. CEDE vs. Distance graph.
- **Step 17** Type **1** to select COLOR.
- **Step 18** Type **1** to enter the downwind plotting range.

The result is the graph shown on the previous page of this manual.

Lesson 12
General Resuspension
Code J

LESSON PLAN
HOTSPOT HEALTH PHYSICS CODES

LESSON 12 – General Resuspension, Code J

TIME:

30 minutes

LESSON LEARNING OBJECTIVES

Terminal: At the end of this lesson, trainees will be able to model a general resuspension of released material, using the General Resuspension Code J of the HOTSPOT Health Physics program.

Enabling:

- At the end of this lesson, students should be able to do the following:

  — Describe the graphical output for a General Resuspension Atmospheric Dispersion Model

  — Explain the assumptions involved in deriving General Resuspension output (tabular and graphical)

  — Given mock data, generate General Resuspension output (tabular and graphical)

INSTRUCTIONAL APPROACH

The mode of delivery for this lesson is lecture, using several job aids and reference materials to provide students with an overview of the HOTSPOT Health Physics Codes application.

EQUIPMENT AND INSTRUCTIONAL AIDS

Overhead projector
IBM PC, XT, AT, or compatible
HOTSPOT User's Manual (*HOTSPOT Health Physics Codes for the PC*)
Exercise Number 12-1

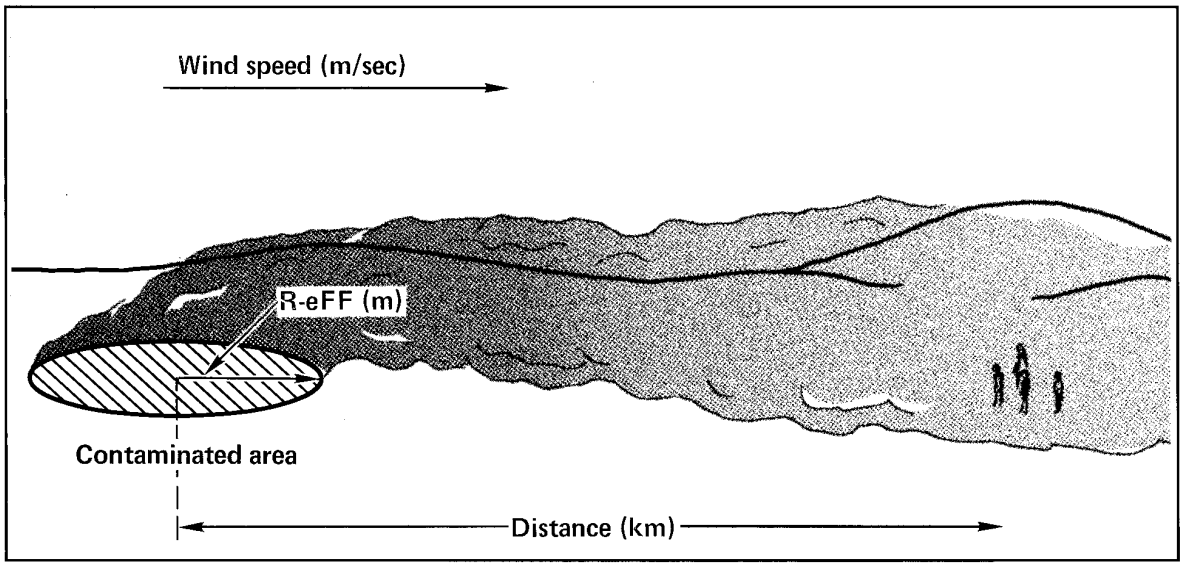
STUDENT MATERIALS

Student Manual

REFERENCES

HOTSPOT User's Manual (*HOTSPOT Health Physics Codes for the PC*)

Lesson Objectives



12-#1

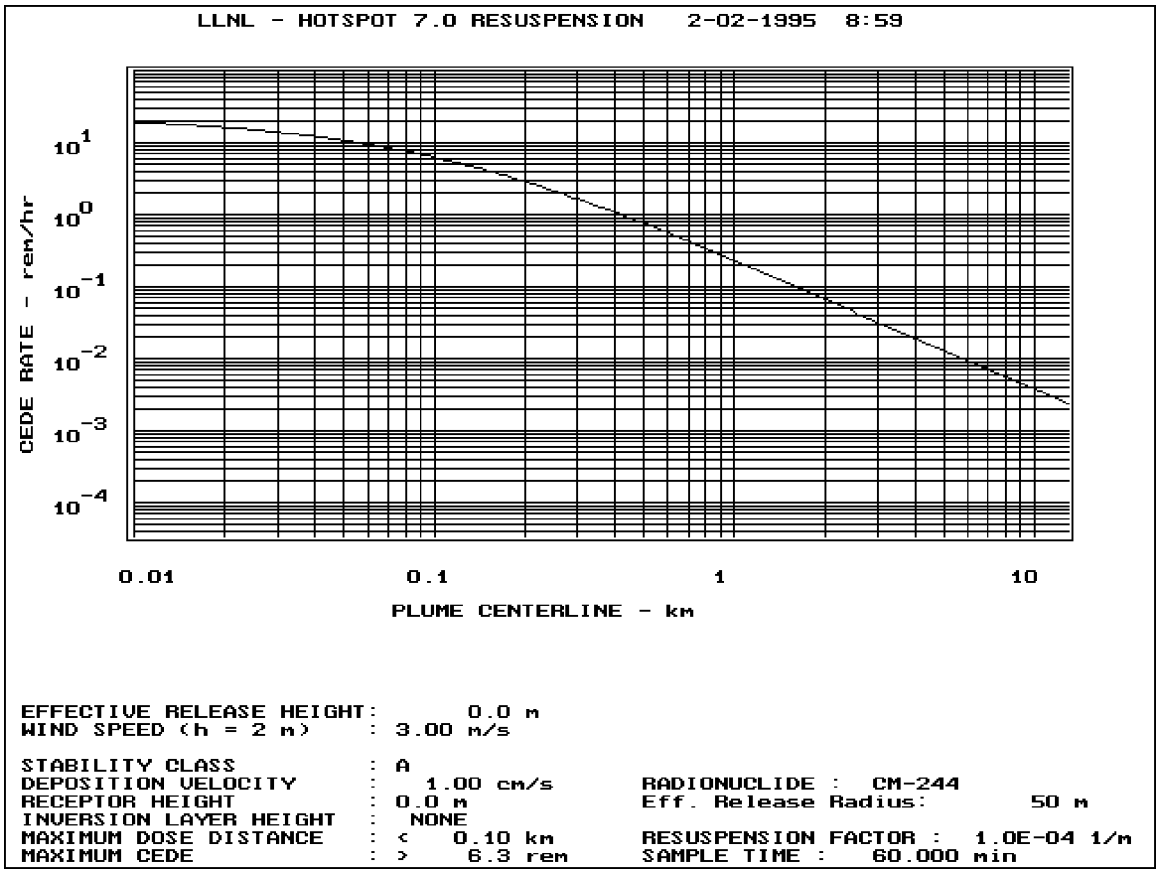
Notes:

- At the end of this lesson, student will be able to model a general resuspension of released material, using the General Resuspension Code J Atmospheric Dispersion Model.
- Explain the Lesson Objectives.

Lesson Objectives

- At the end of this lesson, students should be able to:
  - Describe the graphical output for a General Resuspension Atmospheric Dispersion Model
  - Explain the assumptions involved in deriving General Resuspension output (tables and graphs)
  - Given mock data, generate General Resuspension output (tables and graphs)

Graphical Output and Assumptions—General Resuspension



EFFECTIVE RELEASE HEIGHT: 0.0 m
WIND SPEED (h = 2 m) : 3.00 m/s

STABILITY CLASS : A
DEPOSITION VELOCITY : 1.00 cm/s
RECEPTOR HEIGHT : 0.0 m
INVERSION LAYER HEIGHT : NONE
MAXIMUM DOSE DISTANCE : < 0.10 km
MAXIMUM CEDE : > 6.3 rem

RADIONUCLIDE : CM-244
Eff. Release Radius: 50 m
RESUSPENSION FACTOR : 1.0E-04 1/m
SAMPLE TIME : 60.000 min

12-#2

Notes:

- Have the students refer to Page 12-3, General Resuspension: Graphical Output.
- Discuss the assumptions involved in this incident, as described on the Reference page.

Graphical Output and Assumptions —General Resuspension

- Page 12-3 illustrates output for a General Resuspension Atmospheric Dispersion Model derived from the HOTSPOT Health Physics Codes program.

- This example is based on the following assumptions:

  — Resuspension is modeled using the methodology contained in the "Resuspension" section of the User Manual, Appendix A.

  — Standard-person breathing rate is 1.2 cubic meters/hour.

  — A curium-244 contamination event occurs. Most of the curium is contained in an area with an effective radius of 50 meters. The average contamination level is 1,000 microcuries/square meter. Assume the resuspension factor, for the 3 meter/second prevailing wind, is $1x10^{-5}$ m^{-1}. The sun is high in a cloudless sky. Estimate the 50-year committed effective dose equivalent rates (i.e., dose commitment per hour of downwind exposure) to individuals downwind from the event.

Code Description: General Resuspension

```
HOTSPOT  7.01 RESUSPENSION                          Resuspension 4-14-94 13:03
RADIONUCLIDE:                                       CM-244 Inhalation Class: W
HALFLIFE:                                           18.110 years
RESUSPENSION FACTOR:                                1.0E-05 1/m
EFFECTIVE RADIUS:                                   50 m
AVG. DEPOSITION                                     1.0E+03  µCi/m^2
 EFFECTIVE RELEASE HEIGHT :     0.00 m
 WIND SPEED (h=2 m): 3.0 m/s
 STABILITY CLASS         : A                        DEPOSITION VELOCITY     :   1.00 cm/s
 RECEPTOR HEIGHT         : 0.0 m                    INVERSION LAYER HEIGHT   : NONE
 SAMPLE TIME             :   60.000 min
 MAXIMUM DOSE DISTANCE    : <    0.1 km             MAXIMUM CEDE   : >  0.627 rem
 Plume Centerline

D   =  0.10 km                  D   =  0.20 km                  D   =  0.50 km
CHI =  1.9E-09 Ci/m^3           CHI =  9.0E-09 Ci/m^3           CHI =  2.4E-10 Ci/m^3

50-YR DOSE COMMITMENT:          50-YR DOSE COMMITMENT:          50-YR DOSE COMMITMENT:
PER 1-HR EXPOSURE TIME          PER 1-HR EXPOSURE TIME          PER 1-HR EXPOSURE TIME
--------------------------------------------------------------------------------------------
SURFACE BONE  1.1E+01 rem       SURFACE BONE  54.0+00 rem       SURFACE BONE  1.4E+00 rem
RED MARROW      8.6E+00 rem     RED MARROW      5.7E-01 rem     RED MARROW      1.0E-01 rem
LIVER           2.6E+00 rem     LIVER           1.2E+00 rem     LIVER           3.1E-01 rem
GONADS          1.4E-01 rem     GONADS          6.3E-02 rem     GONADS          1.7E-02 rem
EFFECTIVE DOSE                  EFFECTIVE DOSE                  EFFECTIVE DOSE
EQUIVALENT      6.3E-01 rem     EQUIVALENT      2.9E-01 rem     EQUIVALENT      7.6E-02 rem

D   =  1.00 km                  D   =  2.00 km                  D   =  5.00 km
CHI =  7.2E-11 Ci/m^3           CHI =  2.1E-11 Ci/m^3           CHI =  7.6E-02 Ci/m^3

50-YR DOSE COMMITMENT:          50-YR DOSE COMMITMENT:          50-YR DOSE COMMITMENT:
PER 1-HR EXPOSURE TIME          PER 1-HR EXPOSURE TIME          PER 1-HR EXPOSURE TIME
--------------------------------------------------------------------------------------------
SURFACE BONE  4.2E-01 rem       SURFACE BONE  1.2E-01 rem       SURFACE BONE  2.3E-02 rem
RED MARROW      3.2E-02 rem     RED MARROW      9.2E-03 rem     RED MARROW      2.3E-02 rem
LIVER           9.6E-02 rem     LIVER           2.7E-02 rem     LIVER           5.2E-03 rem
GONADS          5.1E-03 rem     GONADS          1.5E-03 rem     GONADS          2.8E-04 rem
EFFECTIVE DOSE                  EFFECTIVE DOSE                  EFFECTIVE DOSE
EQUIVALENT      2.3E-02 rem     EQUIVALENT      6.7E-03 rem     EQUIVALENT      1.3E-03 rem
```

12-#3

Notes:

- Describe the code used to derive the General Resuspension Atmospheric Dispersion Model illustrated in this lesson.

Code Description: General Resuspension

- Code description — Study the table on page 12-5.

Demonstration: General Resuspension

HOTSPOT Health Physics Codes
VERSION 7.01
HAZARDS CONTROL DEPARTMENT
LAWRENCE LIVERMORE
NATIONAL LABORATORY

S: SETUP

A: Plutonium Explosion	**B: Plutonium Fire**	**C: Plutonium Resuspension**
D: Uranium Explosion	**E: Uranium Fire**	**F: Nuclear Explosion**
G: Radiation Workplace	**H: General Plume**	**I: General Explosion**
J: General Resuspension	**K: Inhalation Dose**	**T: Tritium Release**
L: HOTSPOT Library	**M: FIDLER Calibration and LUNG Screening**	**N: General Fire**
		Q: QUIT

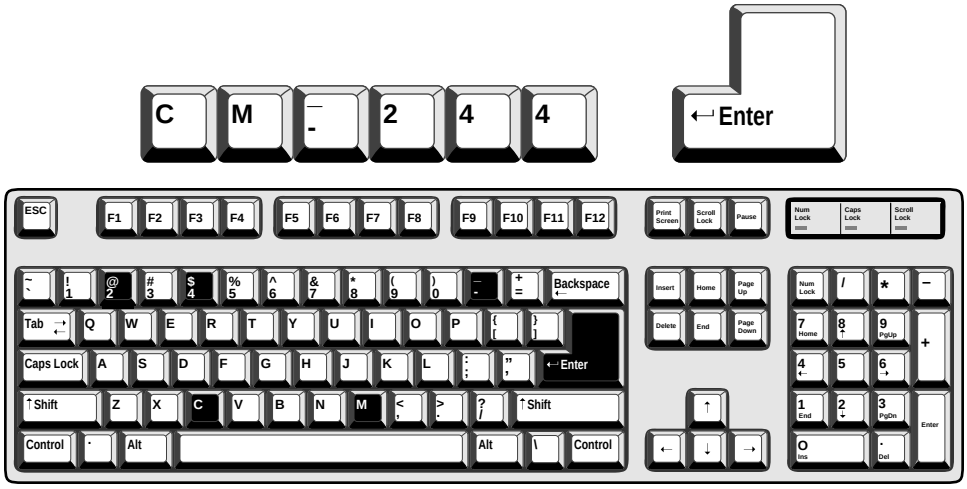
Enter Selection

12-#4

Notes:

- Describe the steps involved in using HOTSPOT to model the incident involving a curium-244 contamination event.
- Inform the students that sometimes they must press Enter (or Return) in order for the computer system to accept data which they type.
- Explain that the students should use the reference for detailed information.
- Code—Explain that the students must select the specific code related to the type of incident. In this example, the students must select Code J (General Resuspension) from the HOTSPOT Main Menu.
- Nuclide—What nuclide is involved in this incident? Tell the students that this example involves the resuspension of curium-244 (cm-44).
- Deposition—Define “average deposition” for the students.

Demonstration: General Resuspension



- Select General Resuspension Atmospheric Dispersion Model from the HOTSPOT Main Menu.

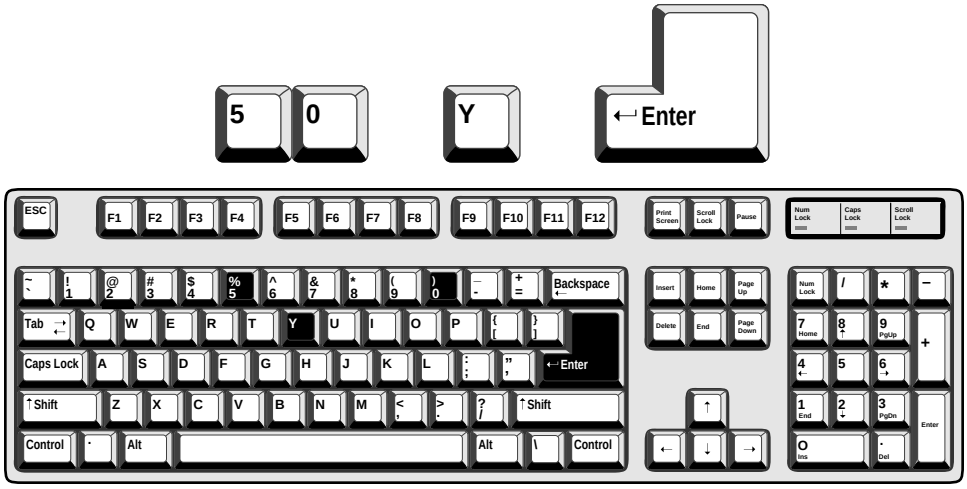
- **Step 1** Type **J** to select General Resuspension from the HOTSPOT Main Menu.

- **Step 2** Nuclide? Type **cm-244;** press **Enter**

- Result DEP, (µCi/square meter)? Enter the average ground deposition (microcuries/square meters) and press Enter.

- **Step 3** Type **1000**; press **Enter**

Demonstration: General Resuspension



12-#5

Notes:

- Release Radius—Explain that release radius is the effective radius of a circle containing 95% of the contamination (meters). In this exammple, it is 50.

Demonstration: General Resuspension

- Result The Release Radius message appears:

Release Radius = ? (m) Release radius is the effective radius of a circle containing 95% of the contamination (meters).

- **Step 4** Release Radius = ? (m) Type **50**; press **Enter**

Demonstration: General Resuspension

- Meteorological Conditions

Choose appropriate meteorological conditions from the following menu—Enter a NUMBER or LETTER.

1. Sun HIGH in the sky
2. Sun LOW in the sky or cloudy
3. NIGHT

Or, if you prefer to enter a specific stability classification,

A:	A stability	Very unstable
B:	B stability	Moderately unstable
C:	C stability	Slightly unstable
D:	D stability	Neutral
E:	E stability	Slightly stable
F:	F stability	Moderately stable
G:	G stability	Special nighttime, low wind

Enter selection

12-#6

Notes:

- Meterological Conditions—Explain that the students may enter a number (1, 2,or 3) to specifiy the meterological condition or a letter (A-G) to specify a stability class.
- Refer students to the Meteorological Conditions screen display.
- In this example, the number 1 indicated the correct meteorological condition (sun HIGH in sky).

Demonstration: General Resuspension

- Meteorological Conditions

  Enter a number or a letter to indicate appropriate meteorological condition.

- **Step 5** Type **1** to indicate sun HIGH in sky.

Demonstration: General Resuspension

- Wind

NAME OF WIND	OBSERVABLE FEATURES	MPH	M/S
calm	Smoke rises vertically	< 1	< 0.5
light Atmospheric	Smoke drifts downward	1 – 3	0.5 – 1
light breeze	Wind felt on face; leaves rustle	3 – 7	1 – 3
gentle breeze	Leaves and twigs in constant motion	7 – 12	3 – 5
moderate breeze	Raises dust and loose paper	12 – 18	5 – 8
fresh breeze	Small tress begin to sway	18 – 24	8 – 11
strong breeze	Large branches in motion	24 – 31	11 – 14
moderate gale	Whole trees in motion	31 – 38	14 – 17
fresh gale	Twigs break off; walking impeded	38 – 46	17 – 21
strong gale	Slight structural damage occurs	46 – 54	21 – 24
whole gale	Tree uprooted; structural damage	54 – 63	24 – 28
storm	Very rare, widespread destruction	63 – 75	28 – 34
hurricane		> 75	> 34

12-#7

Notes:

- Wind—Refer students to the Wind screen display.
- S = 1.0E-04? (Y/N)—Discuss the resuspension factor with the students. The default is Y, the correct choice in this example.

Demonstration: General Resuspension

- WIND?

  Enter the ground wind speed, in meters/second, and press ENTER (1 mph = 0.45 m/s).

- **Step 6** Type **3**

  Press the **Enter** key.

- S (u = 3.0 m/s) = 1.0E-04? (Y/N)

S is the resuspension factor (1/meter). Enter “Y” to accept the above default value, or “N” if you wish to enter a new value.

- **Step 7** Type **Y**; press **Enter**

Demonstration: General Resuspension

- Main Output Options Menu

```
Main Output Options Menu

1:  SCREEN    Output     Default     Distances
2:  SCREEN    Output     You Enter   Distances
3:  PRINTER   Output     Default     Distances
4:  PRINTER   Output     You Enter   Distances
5:  DISK FILE Output     Default     Distances
6:  DISK FILE Output     You Enter   Distances

G:  GRAPHICS
C:  Change DEFAULT CONTOUR SETTINGS
M:  Change METEOROLOGICAL PARAMETERS and Release
    Height
Z:  Change RECEPTOR HEIGHT (z)
D:  Change DEPOSITION VELOCITY
O:  Enable prompt for OFF AXIS Positions
I:   INVERSION HEIGHT (Mixing Layer)
T:  SAMPLE TIME
Q:  Enter to Main HOTSPOT Menu.
```

12-#8

Notes:

- Screen output—Explain that students should select 1, screen output using the default distances.

- Data Tables—The students must type1 and press Enter to view the data tables.

Demonstration: General Resuspension

- Main Output Options Menu
- Screen output
- **Step 8** Type **1** to view data tables.

  Press **Enter** view more data.

  Continue pressing **Enter** until you view all the data.

  After you have viewed all the data, the following message appears:

  > "Enter the appropriate Output option number from the following menu."

  Look at the Output Option Number Menu.

Demonstration: General Resuspension

- Output Option Number Menu

1: Enter a new Downwind Distance
2: Return to Output Menu
Q: Return to Main HOTSPOT Menu

12#9

Notes:

- Explain that students must type 2 at the Output Option Menu to return to the Main HOTSPOT Menu.

Demonstration: General Resuspension

- Output Option Number Menu
- **Step 9** Type **2** at the Output Option Number Menu to return to the Output Menu.

  Press **Enter**

Demonstration: General Resuspension

- Main Output Options Menu—Option G

```
Main Output Options Menu

1:  SCREEN    Output     Default     Distances
2:  SCREEN    Output     You Enter   Distances
3:  PRINTER   Output     Default     Distances
4:  PRINTER   Output     You Enter   Distances
5:  DISK FILE Output     Default     Distances
6:  DISK FILE Output     You Enter   Distances

G:  GRAPHICS
C:  Change DEFAULT CONTOUR SETTINGS
M:  Change METEOROLOGICAL PARAMETERS and Release
    Height
Z:  Change RECEPTOR HEIGHT (z)
D:  Change DEPOSITION VELOCITY
O:  Enable prompt for OFF AXIS Positions
I:   INVERSION HEIGHT (Mixing Layer)
T:   SAMPLE TIME
Q:  Enter to Main HOTSPOT Menu.
```

12-#10

Notes:

- Main Output Options Menu: Option G—Explain that students need to use option G to see graphical representations of the results of the example incident's air dispersion model.

Demonstration: General Resuspension

- Option G—Graphics
- **Step 10** Type **G** for Graphics.
- Result An Output option number menu appears.

Demonstration: General Resuspension

1: CEDE Contours

2: Centerline CEDE as a function of Distance

TO PRINT GRAPHICS—PUSH the “P” key when the screen output is complete.

Select your printer using the SETUP option at the Main HOTSPOT MENU.

12-#11

Notes:

- Output Option Number Menu.
- Student may view Centerline CEDE as a function of Distance graphical output by typing the number 2.
- Color/Monochrome—Have students type the number 1.
- Downwind Plotting Range—Have the students type 1 or 2.
- Print—If they have printer capability, the students may press P to print the graphical results (same as on Page 12-3).

Demonstration: General Resuspension

- **STEP 11** Type **2** to view Centerline CEDE as a function of Distance graphical output.

- Result The following selection box appears:

```
1: COLOR
2: MONOCHROME / LCD
```

- Result The following selection box appears:

```
DOWNWIND PLOTTING RANGE
ENTER SELECTION NUMBER

1: 0.01 TO 10 km
2: 0.1 TO 100 km
```

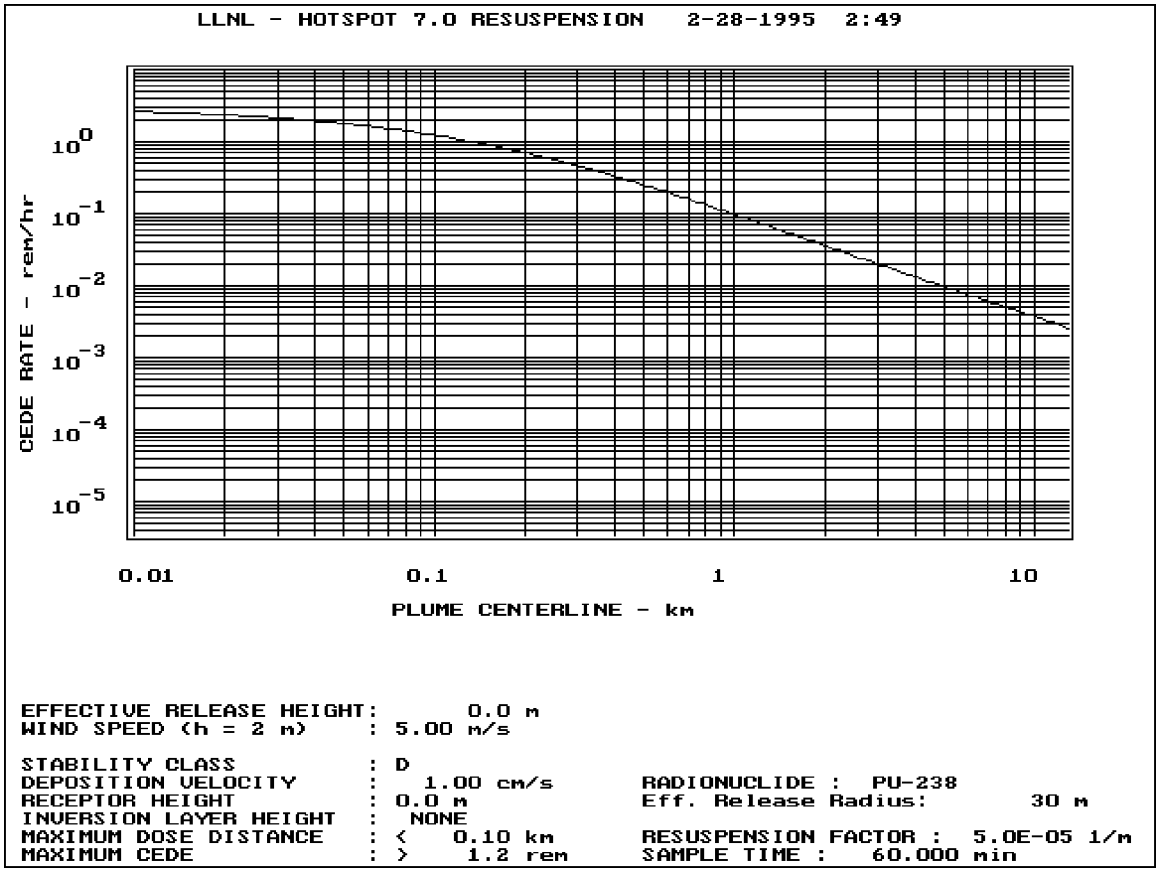
Type **1**

The result is a graph.

Press **P** to print the graph (if you have printer capability).

Exercise 12-1: General Resuspension

- Exercise (Pu-238)



12-#12

Notes:

- Distribute Exercise for General Resuspension involving pu-238 resuspension (Appendix B contains all exercises; use these to duplicate as many copies as needed for trainees).
- Display Overhead.
- Explain that students may consult the Reference page if they wish.
- Exercise Answers: Maximum Dose Distance = <0.1 km
  Maximum CEDE = >1.2 rem

Exercise 12-1: General Resuspension

- Page 12-23 illustrates the graphical output for a General Resuspension Atmospheric Dispersion Model derived from the HOTSPOT Health Physics Codes program.

- The example for this exercise is based on the following assumptions:

  — There has been a plutonium-238 contamination event. Estimate the 50-year committed effective dose equivalent rates (i.e., dose commitment per hour of downwind exposure) to individuals downwind from the event. Most of the plutonium is contained in an area with an effective radius of 30 meters. The average contamination level is 150 microcuries/square meter. Assume the resuspension factor, for the 5 meter/second prevailing wind, is $5x10^{-5}$ m^{-1}. Assume D stability.

- **Step 1** From the HOTSPOT Main Menu, select **J**
- **Step 2** Nuclide? Type **pu-238**; press **Enter**
- **Step 3** DEP? Type **150**; press **Enter**
- **Step 4** Release Radius? Type **30**; press **Enter**
- **Step 5** Condition? Type **D** (for D stability).
- **Step 6** Wind? Type **5** (for 5 meters/second); press **Enter**
- **Step 7** S (u = 5.0 m/s) = 2.8E-04? (Y/N) Type **N** and enter 5E-5; press **Enter**.
- **Step 8** Type **1** at the Main Outputs Options Menu to view data table; press **Enter** as desired to view more data.
- **Step 9** Type **1** at the Outputs Option Number Menu to enter downwind distance.
- **Step 10** Type **2** to enter to the Output Menu.
- **Step 11** Type **G** (graphics).
- **Step 12** Type **2** to view Centerline 50-yr. CEDE vs. Distance.
- **Step 13** Type **1** to select COLOR.
- **Step 14** Type **1** to enter downwind plotting range.

The result is the graph shown on the previous page of this manual.

Lesson 13
Radionuclides in the Workplace
Code G

LESSON PLAN
HOTSPOT HEALTH PHYSICS CODES

LESSON 13 – Radionuclides in the Workplace, Code G

TIME:

30 minutes

LESSON LEARNING OBJECTIVES

Terminal: At the end of this lesson, trainees will be able to use the Radiation Workplace Code G of the HOTSPOT Health Physics program as a guide for initial planning of experiments and workplace selection.

Enabling:

- At the end of this lesson, students should be able to do the following:
  - — Describe the screen output for Radiation Workplace
  - — Explain the assumptions involved in deriving Radiation Workplace output
  - — Given mock data, generate Radiation Workplace output

INSTRUCTIONAL APPROACH

The mode of delivery for this lesson is lecture, using several job aids and reference materials to provide students with an overview of the HOTSPOT Health Physics Codes application.

EQUIPMENT AND INSTRUCTIONAL AIDS

Overhead projector
IBM PC, XT, AT, or compatible
HOTSPOT User's Manual (*HOTSPOT Health Physics Codes for the PC*)
Exercise Number 13-1

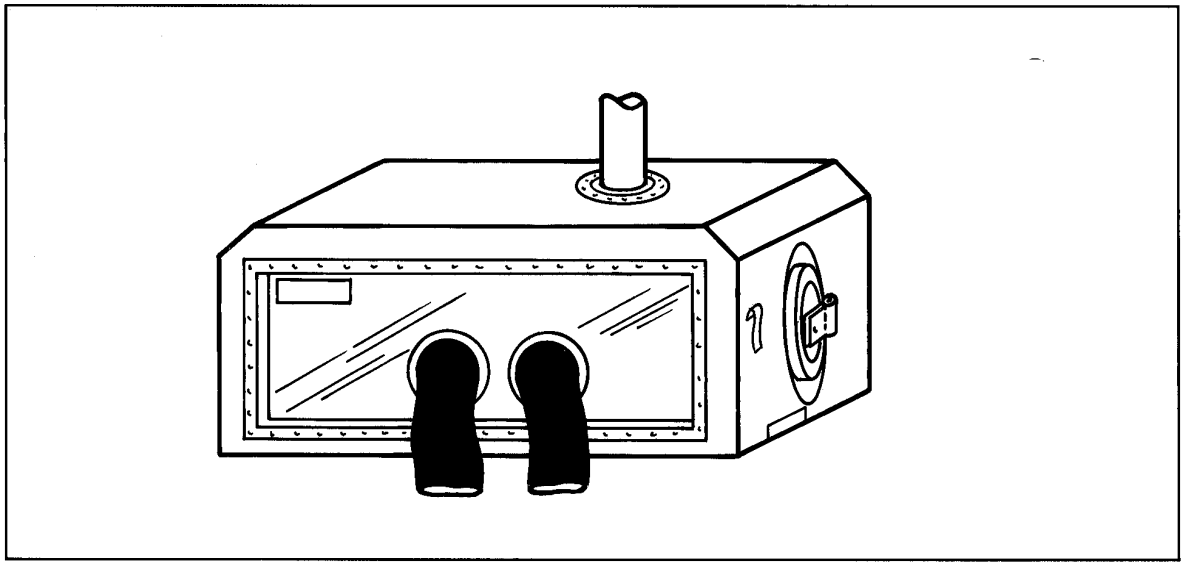
STUDENT MATERIALS

Student Manual

REFERENCES

HOTSPOT User's Manual (*HOTSPOT Health Physics Codes for the PC*)

Lesson Objectives



13-#1

Notes:

- At the end of this lesson, students will be able to use the Radiation Workplace Code G of the HOTSPOT Health Physics Codes program as a guide for initial planning of experiments and workplace selection.
- Explain the Lesson Objectives.

Lesson Objectives

- At the end of this lesson, students should be able to:
  - — Describe the screen output for Radiation Workplace.
  - — Explain the assumptions involved in deriving Radiation Workplace output.
  - — Given mock data, generate Radiation Workplace output.

Output and Assumptions—Radiation Workplace

```
Radionuclide : PLUTONIUM 239
Inhalation Class : W
HalfLife : 2.4E+04 Years

Type of Operation is Simple Wet
Quantity of material is        5.0E+02 microcuries
Hazard Guide Value:  H =  1.0+08
RECOMMENDED WORKPLACE  :  TYPE 2
```

Push “Enter” to CONTINUE

13-#2

Notes:

- Have the students read the top half of page 13-3.
- Discuss the assumptions involved in this example.

Output and Assumptions —Radiation Workplace

- Page 13-3 illustrates Radiation Workplace output derived from the HOTSPOT Health Physics Codes program.
- This example is based on the following assumptions:
  - — Radiation Workplace is modeled using the methodology contained in the "Radiation Workplace" section of the User Manual.
  - — An experimenter wants to pipette a solution containing a total of 500 μCi of class W, ^{239}Pu (PU-239W). The activity concentration of the solution is 20 μCi/g (therefore, total mass is 25g). What type of workplace should be recommended for this *simple* operation?
- Refer also to User Manual, “Radionuclides in the Workplace.”

Demonstration: Radiation Workplace

HOTSPOT Health Physics Codes
VERSION 7.01
HAZARDS CONTROL DEPARTMENT
LAWRENCE LIVERMORE NATIONAL LABORATORY

S: SETUP

A: Plutonium Explosion	B: Plutonium Fire	C: Plutonium Resuspension	
D: Uranium Explosion	E: Uranium Fire	F: Nuclear Explosion	
G: Radiation Workplace	H: General Plume	I: General Explosion	
J: General Resuspension	K: Inhalation Dose	T: Tritium Release	
L: HOTSPOT Library	M: FIDLER Calibration and LUNG Screening	N: General Fire	Q: QUIT

Enter Selection

13-#3

Notes:

- Describe the steps involved in using HOTSPOT Code G as a guide for initial planning of experiments and workplace selection.
- Explain that the students should use the Reference page for detailed information.
- Code?—Tell students to select Code G from the HOTSPOT Main Menu.
- Nuclide?—What nuclide is involved in the workplace? In this example, it is PU-239W.
- Operation—Tell students that they must enter the number of the type of operation for which they desire information.
- Quantity (µCi)?—Tell students to enter the quantity of radionuclide in microcuries.

Demonstration: Radiation Workplace

- Select Radiation Workplace from the HOTSPOT Main Menu.
- **Step 1** Type **G** to select Radiation Workplace from the HOTSPOT Main Menu.
- Result The following message appears:

> The following program provides a guide for initial planning of experiments and workplace selection. It cannot be treated as a precise hazard analysis for handling radioactive materials. Further considerations may be necessary depending on the material's physical form (solid, powder, etc.), volatility, pyrophoric properties, ability to penetrate the skin, radiation dose rate, and the experience of the experimenter and the Health Physicist.

Push "Enter" to return to Menu

- **Step 2** Type **PU-239W**.
- Result The following message appears:

> Enter the Number of the appropriate operation from the following menu:
>
> 1: Determine Maximum Activity for TYPE 1 and TYPE 2 Workplace
> 2: Determine TYPE of Workplace Required

- Operation Enter the type of operation from the menu.
- **Step 3** Type **2**.
- Qty (µCi)? Enter the quantity of radionuclide (microcurie).
- **Step 4** Type **500**; press **Enter**.

Demonstration: Radiation Workplace

1: Storage
2: Simple Wet
3: Normal
4: Simple Dry
5: Complex Wet
6: Dry Dusty

13-#4

Notes:

- Define Mass - gram (the total mass of non-radioactive material involved in the operation (gram).
- Discuss a pure radionuclide.
- Discuss the six types of operations and give examples of each.

Demonstration: Radiation Workplace

- Mass - gram?

Enter the total mass of the non-radioactive material involved in the operation (gram), and push Enter. Enter zero for a pure radionuclide.

- **Step 5** Type **25** and press **Enter**.

- Result The following message appears:

Enter the Number of the appropriate Type of Operation from the following menu.	
1: Storage	
2: Simple Wet	
3: Normal	
4: Simple Dry	
5: Complex Wet	
6: Dry Dusty	
	EXAMPLES
Simple Wet:	Diluting stock solutions, Washing precipitates.
Normal:	No production of dry material, No vigorous chemical reactions, Precipitation, Filtration or centrifuging, Solvent extraction, Chromatography, Pipetting or titrating, Ambient temperatures.
Simple Dry:	Fusion reactions, Fluorination, Transfer of dry precipitates.
Complex Wet:	Distillation, Sampling and transfer, Evaporation of dryness, Elevated temperatures.
Dry Dusty:	Machine or hand crushing, Machining or sawing, Sieving, Mixing.

- **Step 6** Type **2**.

Demonstration: Radiation Workplace

Enter the appropriate Output Option Number from the following menu.

1: SCREEN Output
2: PRINTER Output
3: Enter a new Nuclide
4: Describe Type 1, 2, 3
5: RETURN TO OUTPUT MENU
Q: QUIT

13-#5

Notes:

- Describe Output options.
- For this example, tell students to select 1, Screen Output.

Demonstration: Radiation Workplace

- Output

```
Enter the appropriate Output Option Number from the
following menu:

1: SCREEN Output
2: PRINTER Output
3: Enter a new Nuclide
4: Describe Type 1, 2, 3
5: RETURN TO OUTPUT MENU
Q: QUIT
```

- **Step 7** Type **1**.

- Result The following results table appears:

```
Radionuclide :  PLUTONIUM 239
Inhalation Class :     W
HalfLife              :   2.4E+04 Years

Type of Operation is Simple Wet
Quantity of material is 5.0E+02 microcuries
Hazard Guide Value: H =  1.0E+08
RECOMMENDED WORKPLACE  :  TYPE 2
```

Push “Enter” to CONTINUE.

- **Step 8** Press **Enter**.

- Output The Output Options Number Menu appears.

- **Step 9** Type **Q**.

Lesson 14
FIDLER Calibration
Code M

LESSON PLAN
HOTSPOT HEALTH PHYSICS CODES

LESSON 14 – FIDLER Calibration, Code M

TIME:

30 minutes

LESSON LEARNING OBJECTIVES

Terminal: At the end of this lesson, students will be able to calibrate a FIDLER (Field Instrument for the Detection of Low-Energy Radiation), using the FIDLER Calibration Code M of the HOTSPOT Health Physics program.

Enabling:

- When you complete this lesson, you should be able to do the following:
  - — Describe the graphical output for FIDLER Calibration
  - — Explain the assumptions involved in FIDLER Calibration
  - — Given mock data, calibrate a FIDLER

INSTRUCTIONAL APPROACH

The mode of delivery for this lesson is lecture, using several job aids and reference materials to provide students with an overview of the HOTSPOT Health Physics Codes application.

EQUIPMENT AND INSTRUCTIONAL AIDS

Overhead projector
IBM PC, XT, AT, or compatible
HOTSPOT User's Manual (*HOTSPOT Health Physics Codes for the PC*)
Exercise Number 14–1

STUDENT MATERIALS

Student Manual

REFERENCES

HOTSPOT User's Manual (*HOTSPOT Health Physics Codes for the PC)*

Lesson Objectives

HOTSPOT HEALTH PHYSICS CODES

FIDLER CALIBRATION

VERSION 7.01

Fidler Setup

C: CALIBRATE detector
D: DISPLAY calibration data to screen
S: SAVE calibration data to disc
R: RETRIEVE calibration data from disc
Q: QUIT
M: Current radionuclide MIXTURE
E: EDIT calibration data
L: Detector calibration LIBRARY
P: PLUTONIUM LUNG SCREENING

Enter Selection

14-#1

Notes:

- At the end of this lesson, students will be able to use the FIDLER Calibration Code M of the HOTSPOT Health Physics Codes program to calibrate a FIDLER (Field Instrument for the Detection of Low-Energy Radiation) to measure plutonium contamination on the ground. However, the program can be applied to any instrument suitable for measuring external radiation levels and non-plutonium mixtures, e.g., using a Geiger-Mueller instrument for the measurement of ^{137}Cs ground contamination.

- Explain the Lesson Objectives.

Lesson Objectives

- At the end of this lesson, students should be able to:
  - Describe the screen output for FIDLER Calibration.
  - Explain the assumptions involved in deriving FIDLER Calibration output.
  - Calibrate a FIDLER.

Output and Assumptions—FIDLER Calibration

Isotope	Halflife (yrs)	Initial (Wt %)	@Age = 20.0 YR (wt %)	
PU-238	87.74	0.0400	0.0342	Americium-241
PU-239	24065.	93.3400	93.2862	Check Source Data
PU-240	6537.	6.0000	5.9873	5.900 µCi
PU-241	14.35	0.5800	0.2207	SELF (17) = 1.000
PU-242	376300.	0.0400	0.0400	
AM-241	432.2	0.0000	0.3527	

Source-To-Detector Height = 30 cm Sample Time = 1.00 min

ALPHA Curie: 9.0E-02 curies/gram

1 microcurie of Am-241 = 7.4E+00 alpha microcurie of Mix

The following data are for µCi of MIX

WINDOW (keV)	EFFICIENCY cpm µg/m^2	(SA) cpm µCi/m^2	DETECTION Area µCi/m^2	LIMITS Point µCi	BKDG cpm	SOURCE cpm	K m^2	SDEV (%)
17	2.0E+01	2.3E+02	4.5E-01	1.5E-01	450	15048	0.34	7
60	3.8E+01	4.2E+02	3.1E-01	1.6E-01	750	36835	0.51	4

Eberline 33425 66776 7-14-93 10:21

14-#2

Notes:

- Have the students read the top half of page 14-3.
- Discuss the assumptions involved in this example.

Output and Assumptions —FIDLER Calibration

- Page 14-3 illustrates FIDLER Calibration output derived from the HOTSPOT Health Physics Codes program.

- This example is based on the following assumptions:

  — FIDLER Calibration is modeled using the methodology contained in the “FIDLER Calibration” section of the User Manual.

  — The FIDLER Calibration Code M of the HOTSPOT Health Physics Codes program calibrates a FIDLER to measure plutonium contamination on the ground.

  — Read “Calibration of the FIDLER Detector” and “Determination of the Areal Counting Efficiency” in the FIDLER Calibration section of the User Manual.

Demonstration: FIDLER Calibration

HOTSPOT Health Physics Codes
VERSION 7.01
HAZARDS CONTROL DEPARTMENT
LAWRENCE LIVERMORE
NATIONAL LABORATORY

S: SETUP

A: Plutonium Explosion	B: Plutonium Fire	C: Plutonium Resuspension
D: Uranium Explosion	E: Uranium Fire	F: Nuclear Explosion
G: Radiation Workplace	H: General Plume	I: General Explosion
J: General Resuspension	K: Inhalation Dose	T: Tritium Release
L: HOTSPOT Library	M: FIDLER Calibration and LUNG Screening	N: General Fire
		Q: QUIT

Enter Selection

14-#3

Notes:

- Describe the steps involved in using FIDLER Calibration Code M as a guide for initial planning of experiments and workplace selection.
- Explain that the students should use the Reference page for detailed information.
- Code?—Tell students to select Code M from the HOTSPOT Main Menu.
- FIDLER Main Menu—Tell students the goal of this procedure.
- Procedure—Outline the steps in this procedure.

Demonstration: FIDLER Calibration

- **Step 1** To select FIDLER Calibration from the HOTSPOT Main Menu, Type **M**.

- Result The following message may appear:

Your current RAM is not large enough to run the FIDLER program from the HOTSPOT menu. EXIT HOTSPOT and run the program named FIDLER.

If this message appears, quit the HOTSPOT program and open FIDLER at the DOS c:> prompt.

- **Step 2** Type **FIDLER** at the DOS prompt.

- Result The FIDLER Main Menu appears.

- Procedure? This procedure describes the six-point method of calibrating a FIDLER instrument with a single ^{241}Am check source. Calibrating the FIDLER to measure ^{238}Pu check source demonstrates a radionuclide-specific calibration. The primary goal of the calibration procedure is to determine the instrument's counting efficiency for an assumed uniform-area contamination per square meter of surface. This parameter is referred to as the areal counting efficiency (S_a). Additionally, the Limit of Sensitivity (LOS) for both a distributed area source and a single point source are determined.

  ^{241}AM Check Source Calibration procedure follows:

- Operation? From the FIDLER Main Menu, enter the letter which represents the type of operation.

- **Step 3** Type **R** to select RETRIEVE calibration from disc.

- Result Do you wish to browse the detector library first? (Y/N)

Demonstration: FIDLER Calibration

```
FILE #  1        :        LUNG–Roxanne Luna  FIDLER + PS-1   RASCAL 2344
FILE #  2        :        LUNG–Robert Wills  FIDLER + PS-1   RASCAL 2344
FILE #  3        :        LUNG–Kevin Anderson  FIDLER + PS-1   RASCAL 2344
FILE #  4        :        Eberline 33425  66776  333      55555
FILE #  5        :        Custom Inc. 324   445   7777777   999999999


Push "Enter" to return to menu
```

14-#4

Notes:

- Describe the list of calibration files
- Define "file number."
- Tell students to type the number 4 and to press Enter.

Demonstration: FIDLER Calibration

- **Step 4** Type **Y**; press **Enter**.
- Result Entering Y allows you to review the current list of calibration files contained on your FIDLER disc. The first file contains a standard weapons-grade plutonium mixture.

- **Step 5** Press **Enter** to be prompted for a file number.
- Result The following message appears:

Enter the Detector file; Position Number (e.g., 1, 2, ...), and Push “Enter.”

- **Step 6** Type **4**; press **Enter**.
- Result The displayed calibration chart, for calibration file number 4, contains the desired plutonium mixture.

  Note: Thisis a file from a previous FIDLER calibration session that has been stored in the FIDLER Library.

Demonstration: FIDLER Calibration

Isotope	Halflife (yrs)	Initial (Wt %)	@Age = 20.0 YR (wt %)	
PU-238	87.74	0.0400	0.0339	Americium-241
PU-239	24065.	93.3400	93.2862	Check Source Data
PU-240	6537.	6.0000	5.9867	5.900 µCi
PU-241	14.35	0.5800	0.2103	SELF (17) = 1.000
PU-242	376300.	0.0400	0.0400	
AM-241	432.2	0.0000	0.3625	

Source-To-Detector Height = 30 cm Sample Time = 1.00 min

ALPHA Curie: 9.0E-02 curies/gram

1 microcurie of Am-241 = 7.23E+00 alpha microcurie of Mix

The following data are for µCi of MIX

WINDOW (keV)	EFFICIENCY cpm µg/m^2	(SA) cpm µCi/m^2	DETECTION Area µCi/m^2	LIMITS Point µCi	BKDG cpm	SOURCE cpm	K m^2	SDEV (%)
17	5.1E+01	5.6E+02	1.8E-01	9.0E-02	450	15048	0.50	7
60	3.9E+01	4.3E+02	3.0E-01	1.5E-01	750	36835	0.51	4

Eberline 33425 66776 333 55555

14-#5

Notes:

- Describe the displayed calibration chart, for calibration file number 1.
- Explain the procedure for calibrating a new instrument.

Demonstration: FIDLER Calibration

- **Step 7** Press **Enter** to return to the FIDLER Main Menu.
- Result The FIDLER Main Menu appears. Now, calibrate a new FIDLER instrument.

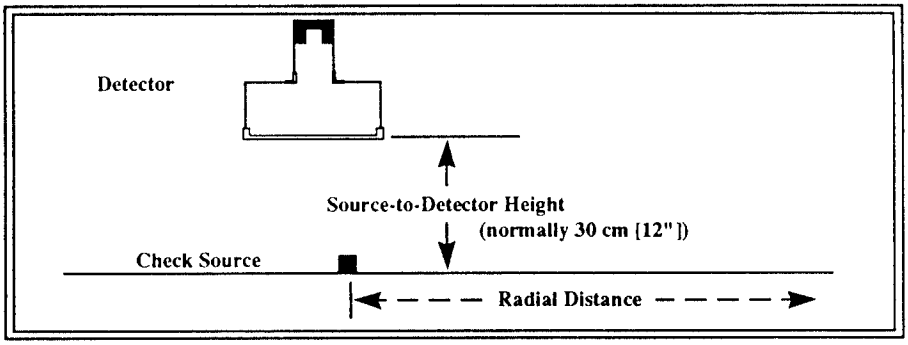
- **Step 8** Type **C**.
- Result The following message appears:

START OVER WITH NEW MIXTURE? (Y/N)

- **Step 9** Type **N** to use the currently retrieved mixture.
- Result Again, the current calibration data appear for confirmation of the mixture.

- **Step 10** Press **Enter**.
- Result An illustration and a selection NUMBER menu appear:

Demonstration: FIDLER Calibration



Enter a selection NUMBER

1: K factor known (or accept a default value)
2: Determine Sa, and K Factor (Full calibration)

Q: NO! Leave Calibration alone and RETURN to main menu

14-#6

Notes:

- Explain how to determine Sa, and K Factor (Full calibration).

Demonstration: FIDLER Calibration

- **Step 11** Type **2** to use the full six-point method.
- Result SCALER ? (Y/N)
  If you are using a scaler with the detector, enter “Y”. If you are using a rate meter, enter “N”.
- **Step 12** Type **Y** if you are using a scaler (e.g., Eberline ESP-2); otherwise, enter “N” [therefore, a rate meter (e.g., PRM-5) is assumed].
- Result You will be prompted for the SAMPLE TIME.
- **Step 13** Type **1** (for one minute); press **Enter**, etc., as required.
- Result You will be prompted for the Detector ID information (e.g., Barcode numbers, Survey meter E-243, Detector 35A, calibration date, etc. All of these fields are optional.
- **Step 14** Type **E-243 35A**; press **Enter**.
- Result You will be prompted for the Detector Height, h (cm). Note: h is the Source-to-detector distance, cm.
- **Step 15** Type **30** to enter the distance separating the face of detector and the check source, and push **Enter**.
- Result The following menu appears:

```
Select Calibration Option

1:      60 keV region
2:      17 keV region
3:      Both 60 keV and 17 keV regions
```

- **Step 16** Type **3**.
- Result Source (µCi)?
  Enter the activity of the calibration source used (microcuries).

Demonstration: FIDLER Calibration

Isotope	Halflife (yrs)	Initial (Wt %)	@Age = 20.0 YR (wt %)	
PU-238	87.74	0.0400	0.0342	Americium-241
PU-239	24065.	93.3400	93.2862	Check Source Data
PU-240	6537.	6.0000	5.9873	5.900 µCi
PU-241	14.35	0.5800	0.2207	SELF (17) = 1.000
PU-242	376300.	0.0400	0.0400	
AM-241	432.2	0.0000	0.3527	

Source-To-Detector Height = 30 cm Sample Time = 1.00 min

ALPHA Curie: 9.0E-02 curies/gram

1 microcurie of Am-241 = 7.4E+00 alpha microcurie of Mix

The following data are for µCi of MIX

WINDOW (keV)	EFFICIENCY cpm µg/m^2	(SA) cpm µCi/m^2	DETECTION Area µCi/m^2	LIMITS Point µCi	BKDG cpm	SOURCE cpm	K m^2	SDEV (%)
17	2.0E+01	2.3E+02	4.5E-01	1.5E-01	450	15048	0.34	7
60	3.8E+01	4.2E+02	3.1E-01	1.6E-01	750	36835	0.51	4

Eberline 33425 66776 7-14-93 10:21

14-#7

Notes:

- Explain how to enter 17-keV and 60-keV window data.

Demonstration: FIDLER Calibration

- **Step 17** Type **5.9**; press **Enter**.
- Result Self (17)
  The Self (17) prompt appears. Enter the 17-keV window self attenuation factor for the americium-241 check source. (Enter a fractional value between 0.001 and 1.)
- **Step 18** Type **1.0**; press **Enter**.
- Result BKGD (17-keV)?
  Enter the 17-keV window background count rate (counts/minute).
- **Step 19** Type **450**; press **Enter**.
- Result Is Count Rate Input Correct? (Y/N)
- **Step 20** Type **Y**. If the count rate is not correct, type N and you will recycle through the background input sequence.
- Result Next, you will be prompted for 60-keV window data. The next series of prompts will sequentially ask you for the 17-keV and 60-keV window count rates at the six radial positions, 0, 20, 40, 60, 80, and 100 cm. Input the values shown on the following table:

Eberline 33425 66776 333 55555
Detector Manufacturer : Harshaw Detector Model : 35 Detector S/N : 66776
Meter Manufacturer : Eberlin Meter Model : ESP2 Meter S/N : 33425
Check Source I.D. : 22132 Calibration Date : 7-16-93 Calibrated By : SGH
Source-To- Detector Height = 30 centimeters Sample-Time = 1.00 min
Plutonium Mixture : Am-241 Check Source : 5.900 microcuries Self (17) = 0.6000
17-keV Window Background : 450 Counts per minute.
60-keV Window Background : 750 Counts per minute.

Radial Posiiton (cm)	17-keV Window TOTAL (cpm)	60-keV Window TOATAL (cpm)
0	15048	336835
20	8602	23118
40	3148	9806
60	1318	4614
80	766	2584
100	582	1684

Upon confirming the final input (100-cm distance), the final calibration data appears on the computer monitor.

Lesson 15
LUNG Screening
Code M

LESSON PLAN
HOTSPOT HEALTH PHYSICS CODES

LESSON 15 – LUNG Screening, Code M

TIME:

30 minutes

LESSON LEARNING OBJECTIVES

Terminal: At the end of this lesson, students will be able to screen for plutonium uptake in the lung, using a FIDLER (Field Instrument for the Detection of Low-Energy Radiation) detector and the LUNG Screening Code M of the HOTSPOT Health Physics program.

Enabling:

- When you complete this lesson, you should be able to do the following:
  - — Explain the assumptions involved in LUNG Screening
  - — Given mock data, screen people for possible plutonium deposition in the lung

INSTRUCTIONAL APPROACH

The mode of delivery for this lesson is lecture, using several job aids and reference materials to provide students with an overview of the HOTSPOT Health Physics Codes application.

EQUIPMENT AND INSTRUCTIONAL AIDS

Overhead projector
IBM PC, XT, AT, or compatible
HOTSPOT User's Manual (*HOTSPOT Health Physics Codes for the PC*)
Exercise Number 15–1

STUDENT MATERIALS

Student Manual

REFERENCES

HOTSPOT User's Manual (*HOTSPOT Health Physics Codes for the PC)*

Lesson Objectives

FIDLER

PLUTONIUM LUNG SCREENING

F: Fidler Setup

C: CALIBRATE FIDLER for lung screening
D: DISPLAY lung screen results
S: SAVE lung screening session
R: RETRIEVE lung screening session from disc
Q: QUIT
M: Current radionuclide MIXTURE data
E: EDIT Lung Screening data

L: LUNG COUNT

Enter Selection

15-#1

Notes:

- At the end of this lesson, students will be able to use the FIDLER LUNG Screening Code M of the HOTSPOT Health Physics Codes program to screen for plutonium uptake in the lung using a FIDLER detector.

- Explain the Lesson Objectives.

Lesson Objectives

- At the end of this lesson, students should be able to:
  - — Describe the screen output for LUNG Screening.
  - — Explain the assumptions involved in deriving LUNG Screening output.
  - — Perform LUNG Screening using a FIDLER.

Output and Assumptions—LUNG Screening

Isotope	Halflife (yrs)	Initial (Wt %)	@Age = 20.0 YR (wt %)	
PU-238	87.74	0.0400	0.0339	Americium-241
PU-239	24065.	93.3400	93.2836	Check Source Data
PU-240	6537.	6.0000	5.9867	5.900 µCi
PU-241	14.35	0.5800	0.2103	
PU-242	376300.	0.0400	0.0400	
AM-241	432.2	0.0000	0.3625	

ALPHA Curie: 8.99E-02 curies/gram 1 µCi of Am-241 = 7.23E+00 alpha µCi-mix
Height: 5 ft 8 in Weight: 120 lbs Chest Wall: 1.5 cm
FIDLER EFFICIENCY : 3.3E+03 CPM/µCi of AM-241 in lung SDEV: 0.53%
MDA : AM-241 = 7.3 nCi Mix = 53nCi

	BACKGROUND	CHECK SOURCE	GROSS LUNG	NET LUNG
TIME (min):	5.0	1.0	5.0	5.0
COUNTS:	3750	36835	4500	750
RATE (cpm):	750	36835	900	150

	LUNG AM-241 (nCi)	SCREEN MIX (nCi)	RESULTS SDEV (%)
Alpha Activity Desposited in Lung :	45	328	12
50-year committed Effective Dose Equivalent (mix):		44.4E+02 rem	

LUNG SCREEN: Roxanne Luna FIDLER + PS-1 RASCAL 2344
15-#2

Notes:

- Have the students read the top half of page 15-3.
- Discuss the assumptions involved in this example.

Output and Assumptions —LUNG Screening

- Page 15-3 (Figure 15-#2) illustrates LUNG Screening output derived from the HOTSPOT Health Physics Codes program.
- This example is based on the following assumptions:
  - — LUNG Screening is modeled using the methodology contained in the “LUNG Screening” section of the User Manual.
  - — The LUNG Screening Code M of the HOTSPOT Health Physics Codes program screens for plutonium uptake in the lung using a FIDLER detector.
  - — Read the LUNG Screening section of the User Manual.

Demonstration: LUNG Screening

HOTSPOT Health Physics Codes
VERSION 7.01
HAZARDS CONTROL DEPARTMENT
LAWRENCE LIVERMORE
NATIONAL LABORATORY

S: SETUP

A: Plutonium Explosion	B: Plutonium Fire	C: Plutonium Resuspension
D: Uranium Explosion	E: Uranium Fire	F: Nuclear Explosion
G: Radiation Workplace	H: General Plume	I: General Explosion
J: General Resuspension	K: Inhalation Dose	T: Tritium Release
L: HOTSPOT Library	M: FIDLER Calibration and LUNG Screening	N: General Fire
		Q: QUIT

Enter Selection

15-#3

Notes:

- Describe the steps involved in using FIDLER Calibration Code M to screen for plutonium uptake in the lung using a FIDLER detector.
- Explain that the students should use the Reference page for detailed information.
- Code?—Tell students to select Code M from the HOTSPOT Main Menu.
- FIDLER Main Menu—Tell students the goal of this procedure.
- Procedure—Outline the steps in this procedure.

Demonstration: LUNG Screening

- **Step 1** Type **M** to select LUNG Screening from the HOTSPOT Main Menu.

- Result The following message may appear:

```
Your current RAM is not large enough to run the FIDLER
program from the HOTSPOT menu.
EXIT HOTSPOT and run the program named FIDLER.
```

If this message appears, quit the HOTSPOT program and open FIDLER at the DOS c:> prompt.

- **Step 2** Type **FIDLER** at the DOS prompt.

- Result The FIDLER Main Menu appears.

```
HOTSPOT HEALTH PHYSICS CODES

FIDLER CALIBRATION

VERSION 7.01
```

Fidler Setup

```
                    C:  CALIBRATE detector
                    D:  DISPLAY calibration data to screen
                    S:  SAVE calibration data to disc
                    R:  RETRIEVE calibration data from disc
Q:  QUIT
                    M:  Current radionuclide MIXTURE
                    E:  EDIT calibration data
                    L:  Detector calibration LIBRARY
                    P:  PLUTONIUM LUNG SCREENING
```

Enter Selection

- Procedure? This procedure screens for plutonium uptake in the lung using a FIDLER detector.

- Operation? From the FIDLER Main Menu, enter the letter which represents the type of operation.

Demonstration: LUNG Screening—Calibrate FIDLER

Isotope	Halflife (yrs)	Initial (Wt %)	@Age = 15.0 YR (wt %)
PU-238	87.74	0.0400	0.0355
PU-239	24065.	93.3400	93.2997
PU-240	6537.	6.0000	5.9905
PU-241	14.35	0.5800	0.2810
PU-242	376300.	0.0400	0.0400
AM-241	432.2	0.0000	0.2950

SPECIFIC ACTIVITY
ALPHA Curie: 0.0879 curies/gram
TOTAL Curie: 0.3773 curies/gram

1 alpha microcurie of Mix = 0.1151 microcurie of Am-241
–OR–
1 microcurie of AM-241 = 8.6883 alpha microcurie of Mix

(Figure 15-14a)

Isotope	Halflife (yrs)	Initial (Wt %)	@Age = 21.0 YR (wt %)
PU-238	87.74	0.0400	0.0339
PU-239	24065.	93.3400	93.9867
PU-240	6537.	6.0000	5.9905
PU-241	14.35	0.5800	0.2810
PU-242	376300.	0.0400	0.0400
AM-241	432.2	0.0000	0.2950

SPECIFIC ACTIVITY
ALPHA Curie: 0.0879 curies/gram
TOTAL Curie: 0.3773 curies/gram

1 alpha microcurie of Mix = 0.1151 microcurie of Am-241
–OR–
1 microcurie of AM-241 = 8.6883 alpha microcurie of Mix

(Figure 15-14b)

15-#4a & 4b

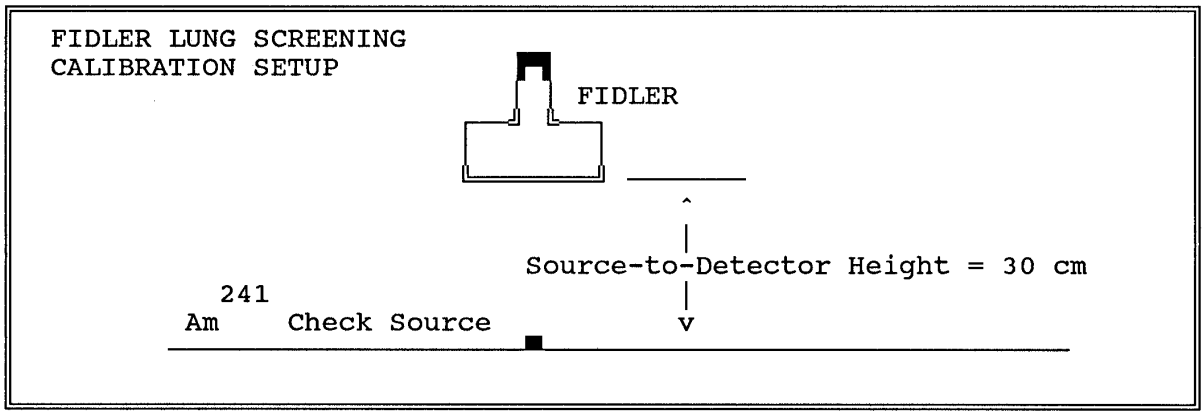
Notes:

- Explain the tables on this page.
- Tell students to type P to select PLutonium Lung Screening from the FIDLER Main Menu; type C; press Enter, type N; press Enter; type 21.

Demonstration: LUNG Screening—Calibrate FIDLER

- **Step 3** Type **P** to select Plutonium Lung Screening from the FIDLER Main Menu.
- Result The Plutonium Lung Screening Main Menu appears (see page 15–1).
- **Step 4** Type **C** to Calibrate FIDLER for lung screening; press **Enter**.
- Result MIX KNOWN? (Y/N)
  If you know the mix data, enter “Y”. If you do not know the mix data, enter “N”.
- **Step 5** Type **N**.
- Result The default MIX table appears (illustrated in Figure 15-#4a).
- **Step 6** Press **Enter**.
- Result MIX AGE?
  The MIX AGE? YR prompt requests you to enter the time (years) that has elapsed since your mix data were measured or calculated. Default is 15 Yr.
- **Step 7** Type **21**; press **Enter**.
- Result The MIX table appears (see Figure 15-#4b).

Demonstration: LUNG Screening—Calibrate FIDLER



15#5

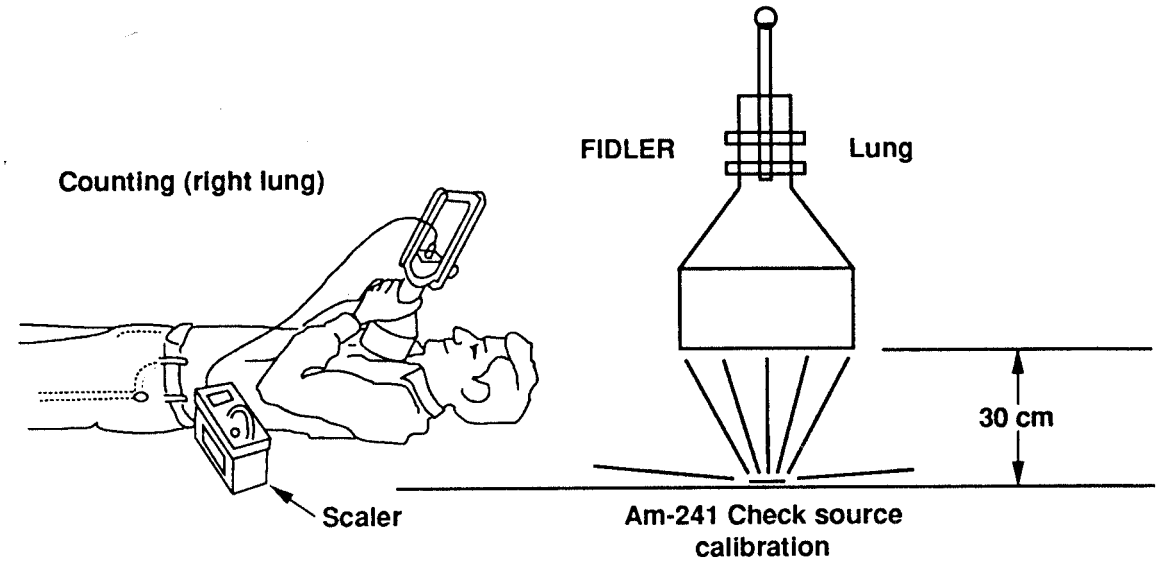
Notes:

- Describe the drawing representing the FIDLER Lung Screen Calibration Setup.
- Explain the procedure for calibrating the FIDLER.
- Define “counting time.”

Demonstration: LUNG Screening—Calibrate FIDLER

- **Step 8** After viewing the MIX table (15-#4b), press **Enter.**
- Result Source (µCi)?
  The FIDLER LUNG SCREENING CALIBRATION SETUP screen appears. Enter the activity of the Am-241 calibration source used (microcuries), and push Enter.
- **Step 9** Type **5.9**; press **Enter**; type **Y**.
- Result COUNTING TIME (minutes)?
  The system requests you to enter the counting time for the check source calibration.

Demonstration: LUNG Screening—Calibrate FIDLER



15-#6

Notes:

- Explain positioning of the FIDLER as shown in the illustration on this page.

Demonstration: LUNG Screening—Calibrate FIDLER

- **Step 10** Type **1**; press **Enter**; type **Y**.
- Result COUNTS?
  The system requests you to enter the total counts collected with the americium-241 check source positioned directly under the detector at a source-to-detector height of 30 cm.

- **Step 11** Type **36835**; press **Enter**; type **Y**.
- Result BKGD-TIME?
  Enter the background counting time (minutes), and push Enter.

- **Step 12** Type **5**; press **Enter**; type **Y**.
- Result BKDG (LUNG) Counts?
  Enter the background (Counts).

- **Step 13** Type **3750**; press **Enter**; type **Y**.
- Result This is the end of the calibration sequence.

Demonstration: LUNG Screening—Lung Count

Isotope	Halflife (yrs)	Initial (Wt %)	@Age = 20.0 YR (wt %)	
PU-238	87.74	0.0400	0.0339	Americium-241
PU-239	24065.	93.3400	93.2836	Check Source Data
PU-240	6537.	6.0000	5.9867	5.900 µCi
PU-241	14.35	0.5800	0.2103	
PU-242	376300.	0.0400	0.0400	
AM-241	432.2	0.0000	0.3625	

ALPHA Curie: 8.99E-02 curies/gram 1 µCi of Am-241 = 7.23E+00 alpha µCi-mix
Height: 5 ft 8 in Weight: 120 lbs Chest Wall: 1.5 cm
FIDLER EFFICIENCY : 3.3E+03 CPM/µCi of AM-241 in lung SDEV: 0.53%
MDA : AM-241 = 7.3 nCi Mix = 53nCi

	BACKGROUND	CHECK SOURCE	GROSS LUNG	NET LUNG
TIME (min):	5.0	1.0	5.0	5.0
COUNTS:	3750	36835	4500	750
RATE (cpm):	750	36835	900	150

	LUNG AM-241 (nCi)	SCREEN MIX (nCi)	RESULTS SDEV (%)
Alpha Activity Desposited in Lung :	45	328	12
50-year committed Effective Dose Equivalent (mix):		44.4E+02 rem	

LUNG SCREEN : E-243 35A

15-#7

Notes:

- Explain the procedure for performing a Lung Count.

Demonstration: LUNG Screening—Lung Count

Select LUNG COUNT from the FIDLER Plutonium Lung Screening Main Menu.

- **Step 1** Type **L** to select LUNG COUNT.
- Result Detector ID information?
  The system requests Detector ID information (for example, Survey meter E-243, Detector 35A). Any combination of letters or numbers (maximum 60 characters) may be input.
- **Step 2** Type **E-243 35A**; press **Enter**.
- Result HEIGHT (Feet.inches)?
  Enter the height of the person in feet and inches using the following format: f.i, where f = feet and i = inches.
- **Step 3** Type **5.08**; press **Enter**; type **Y**.
- Result WEIGHT (pounds)?
  Enter the weight of the person (pounds).
- **Step 4** Type **120**; press **Enter**; type **Y**.
- Result SAMPLE-TIME (minutes)
  Enter the counting time (minutes) for the lung scan.
- **Step 5** Type **5**; press **Enter**; type **Y**.
- Result SAMPLE COUNTS?
  Enter the total counts acquired during the lung scan.
  NOTE: FIDLER should be placed over the RIGHT LUNG between THE STERNUM and CLAVICLE (Collarbone).The sternum is the long flat chest bone joining the 2 sets of ribs. See Figure 15-#6.
- **Step 6** Type **4500**; press **Enter**; type **Y**.
- Result The LUNG SCREEN RESULTS table appears. Pressing Enter returns you to the FIDLER Plutonium Lung Screening Menu.

Lesson 16
Output Options C, M, Z, D, O, I, and T

LESSON PLAN
HOTSPOT HEALTH PHYSICS CODES

LESSON 16 – Output Options C, M, Z, D, O, I, and T

TIME:

30 minutes

LESSON LEARNING OBJECTIVES

Terminal: At the end of this lesson, students will be able to describe the Options C, M, Z, D, O, I, and T of the HOTSPOT Health Physics program.

Enabling:

- At the end of this lesson, students should be able to:

  — Describe the Options C, M, Z, D, O, I, and T used in developing Atmospheric Dispersion Models derived from the HOTSPOT Health Physics Codes program.

  — Given mock data, modify Atmospheric Dispersion Model output (tables and graphs), using the HOTSPOT Health Physics Codes program and Options C, M, Z, D, O, I, and T.

INSTRUCTIONAL APPROACH

The mode of delivery for this lesson is lecture, using several job aids and reference materials to provide students with an overview of the HOTSPOT Health Physics Codes application.

EQUIPMENT AND INSTRUCTIONAL AIDS

Overhead projector
IBM PC, XT, AT, or compatible
HOTSPOT User's Manual (*HOTSPOT Health Physics Codes for the PC*)

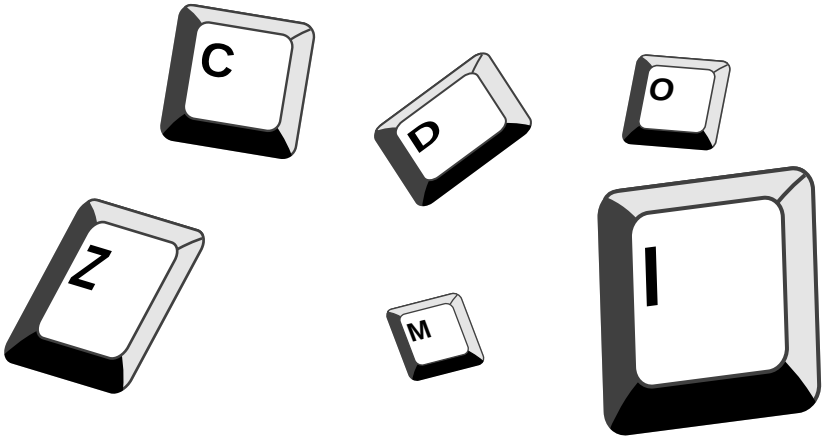
STUDENT MATERIALS

Student Manual

REFERENCES

HOTSPOT User's Manual (*HOTSPOT Health Physics Codes for the PC*)

Lesson Objectives



16-#1

Notes:

- At the end of this lesson, students will be able to describe the Output Options C, M, Z, D, O, and I and use them in developing Atmospheric Dispersion Models using the HOTSPOT Health Physics Codes program.

- Explain the Lesson Objectives.

Lesson Objectives

- At the end of this lesson, students should be able to:
  - — Describe the Options C, M, Z, D, O, and I, used in developing Atmospheric Dispersion Models derived from the HOTSPOT Health Physics Codes program.
  - — Given mock data, modify Atmospheric Dispersion Model output (tables and graphs), using the HOTSPOT Health Physics Codes program and Options C, M, Z, D, O, and I.

Options Demonstration—Option C

- Main Output Options Menu—Option C

```
Main Output Options Menu

1:  SCREEN    Output     Default     Distances
2:  SCREEN    Output     You Enter   Distances
3:  PRINTER   Output     Default     Distances
4:  PRINTER   Output     You Enter   Distances
5:  DISK FILE Output     Default     Distances
6:  DISK FILE Output     You Enter   Distances

G:  GRAPHICS
C:  Change DEFAULT CONTOUR SETTINGS
M:  Change METEOROLOGICAL PARAMETERS
Z:  Change RECEPTOR HEIGHT (z)
D:  Change DEPOSITION VELOCITY
O:  Enable prompt for OFF AXIS Positions
I:  INVERSION HEIGHT (Mixing Layer)
Q:  Return to Main HOTSPOT Menu.
```

16-#2

Notes:

- Briefly describe Options C, M, Z, D, O, and I (used to change variables which influence the results and graphical output).
- Explain the use of Option C (Default Contour Settings).

Options Demonstration—Option C

- Options C, M, Z, D, O, and I (These options allow you to change variables to influence the results and graphical output).
- Option C
- **Step 1** Type **C** to change DEFAULT CONTOUR SETTINGS.
- Result The following menu appears:

1: Change Default CEDE Contours values. 2: Change Default DEPOSITION Contour values. NOTE: To permanently change the default settings, use the SETUP procedure. Q: Return to MAIN OUTPUT OPTION MENU.

- **Step 2** Type **1** (to change default CEDE Contours values).
- Result The following menu appears:

Enter a new CEDE Target value, rem, and push Enter. HOTSPOT will bracket this value by a factor of 10. EXAMPLE Target = 2 rem : 20 rem – 2 rem – 0.2 rem

- **Step 3** Type **4** (to enter a new CEDE Target value).
- **Step 4** Press **Enter**
- Result The CEDE Target value has been changed.

Options Demonstration—Option M

- Main Output Options Menu—Option M

```
Main Output Options Menu

1:  SCREEN    Output     Default     Distances
2:  SCREEN    Output     You Enter   Distances
3:  PRINTER   Output     Default     Distances
4:  PRINTER   Output     You Enter   Distances
5:  DISK FILE Output     Default     Distances
6:  DISK FILE Output     You Enter   Distances

G:  GRAPHICS
C:  Change DEFAULT CONTOUR SETTINGS
M:  Change METEOROLOGICAL PARAMETERS and Release
Height
Z:  Change RECEPTOR HEIGHT (z)
D:  Change DEPOSITION VELOCITY
O:  Enable prompt for OFF AXIS Positions
I:  INVERSION HEIGHT (Mixing Layer)
Q:  Return to Main HOTSPOT Menu.
```

16#3

Notes:

- Meteorological Conditions—Explain that the students may enter a number (1, 2, or 3) to specify the meteorological condition (sun high in sky; sun low in sky or cloudy; night) or a letter (A–G) to specify a stability class.

- Refer students to the Meteorological Conditions screen display.

Options Demonstration—Option M

- Option M
- **Step 1** Type **M** to change METEOROLOGICAL PARAMETERS.
- Result The following menu appears:

```
Choose appropriate meteorological conditions from the following
menu—Enter a NUMBER or LETTER.

    1. Sun HIGH in the sky
    2. Sun LOW in the sky or cloudy
    3. NIGHT

    Or, if you prefer to enter a specific stability classification,

    A:  A stability   Very unstable
    B:  B stability   Moderately unstable
    C:  C stability   Slightly unstable
    D:  D stability   Neutral
    E:  E stability   Slightly stable
    F:  F stability   Moderately stable
    G:  G stability   Special nighttime, low wind
    Enter selection
```

- **Step 2** Type **1, 2, or 3** (to indicate meteorological conditions).
- Result The WIND menu appears:

Options Demonstration—Wind

- Wind Menu for Option M

NAME OF WIND	OBSERVABLE FEATURES	MPH	M/S
calm	Smoke rises vertically	< 1	< 0.5
light Atmospheric	Smoke drifts downward	1 – 3	0.5 – 1
light breeze	Wind felt on face; leaves rustle	3 – 7	1 – 3
gentle breeze	Leaves and twigs in constant motion	7 – 12	3 – 5
moderate breeze	Raises dust and loose paper	12 – 18	5 – 8
fresh breeze	Small tress begin to sway	18 – 24	8 – 11
strong breeze	Large branches in motion	24 – 31	11 – 14
moderate gale	Whole trees in motion	31 – 38	14 – 17
fresh gale	Twigs break off; walking impeded	38 – 46	17 – 21
strong gale	Slight structural damage occurs	46 – 54	21 – 24
whole gale	Tree uprooted; structural damage	54 – 63	24 – 28
storm	Very rare, widespread destruction	63 – 75	28 – 34
hurricane		> 75	> 34

16-#4

Notes:

- Wind — Refer students to the Wind screen display.

Options Demonstration—Wind

- Option M

- WIND?

- S**tep 1** Type **a number** (meters/second) to specify wind conditions.

- **Step 2** Press **Enter**

- Result The meteorological conditions used in the model have been changed.

Options Demonstration—Option Z

- Option Z—Change Receptor Height

Enter the receptor height, meters, and push “Enter.”

LIMITS: [0 – 500 meters]

NOTE: The receptor height is the distance above ground level at which the concentration is calculated. The default height is ground level (z = 0).

16-#5

Notes:

- Define “receptor height” ; discuss Option Z; have students refer to the receptor height screen display message.

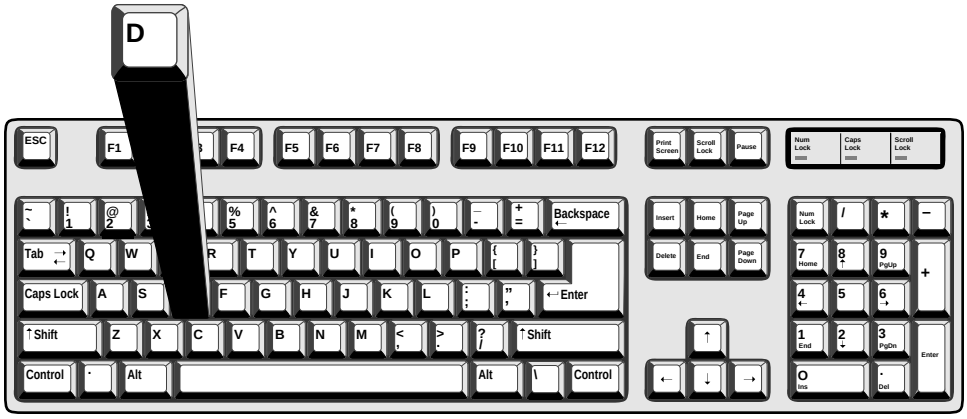
Options Demonstration—Option Z

- Option Z
- Receptor Height
- **Step 1** Type a number (**0-500**).
- **Step 2** Press **Enter**
- Result A message appears to indicate that the system is changing the value.

Working .....one moment please.

Options Demonstration—Option D

- Option D—Change Deposition Velocity



17-#6

Notes:

- Define ‘deposition velocity” and discuss why one would change it.

Options Demonstration—Option D

- Option D
- Deposition Velocity
- **Step 1** Type **D** (to change the deposition velocity).
- Result The following message appears:

```
HOTSPOT is currently using a deposition velocity
of 0.000 centimeters per second.
Do you want to change this value?
```

- **Step 2** Type **Y**

```
Enter the new deposition velocity, in centimeters per second,
and push “Enter”.

Allowable Range (0 to 10 cm/sec)
```

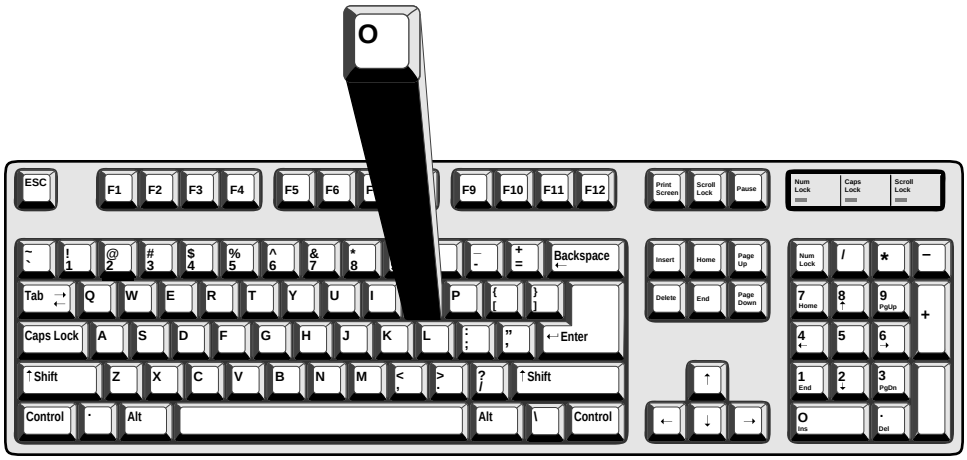
- **Step 3** Type **7**
- **Step 4** Press **Enter**
- Result The following message flashes on the screen:

```
Working ....................................one moment please.
```

Then, the system returns to the Main Output Options Menu.

Options Demonstration—Option O

- Option O—Enable prompt for OFF AXIS Positions



16#7

Notes:

- Explain changing off-axis positions (Option O).

Options Demonstration—Option O

- Option O
- OFF AXIS Positions
- **Step 1** Type **O** (to enable prompts for OFF AXIS Positions).
- Result The following message appears:

Do you wish prompts for off-axis distance? (Y/N)

- **Step 2** Type **Y**
- Result The next time you choose to view results tables or graphical output, the system will display the prompts for off-axis distance.

Options Demonstration—Option I

- Option I—Inversion Height (Mixing Layer)

16#8

Notes:

- Define “inversion height” and explain the conditions under which one would want to change it (Option I).

Options Demonstration—Option I

- Option I
- Inversion Height
- **Step 1** Type **I** (to enter a new inversion height).
- Result The following message appears:

> Do you want to enter an Inversion Height? (Y/N)
>
> Default = N (No Inversion, assumes no trapping layer)

- **Step 2** Type **Y**
- Result The following message appears:

> Enter the new Inversion Height, meters, and push “Enter.”
>
> NOTE: The inversion height must exceed the effective release height and the receptor height by a minimum of 10 meters.

- **Step 3** Type **500**
- **Step 4** Press **Enter**

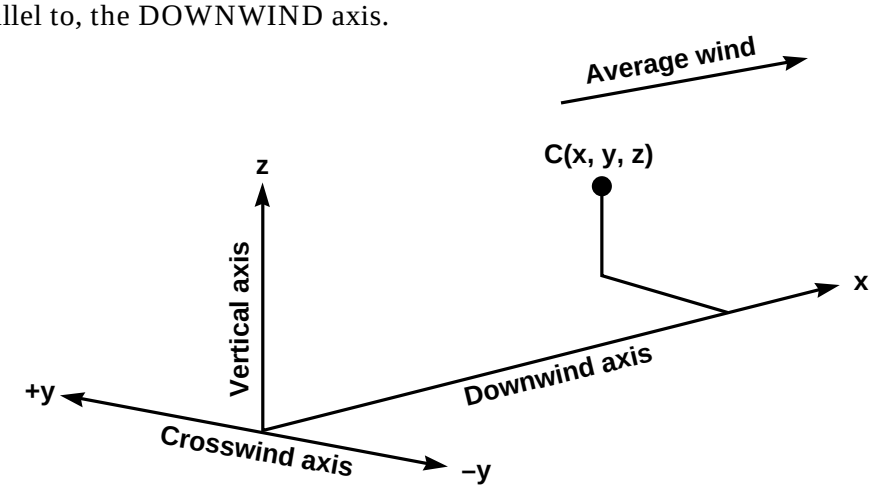
Appendix A
HOTSPOT Health Physics Codes User Manual

Appendix A: Gaussian Model Algorithms

There are many implementations of the Gaussian model, and so for completeness, the following summary is included. The Gaussian model has been widely used and verified in the scientific community and is still the basic workhorse for initial atmospheric dispersion calculations. The Gaussian model generally produces results that agree well with experimental data, and as a result, has found its way into most governmental guidebooks, and is also used and accepted by the Environmental Protection Agency (EPA, 1978). The origin of the Gaussian model is found in work by Sutton (1932), Pasquill (1961, 1974), and Gifford (1961, 1968). Additional background and supplemental information on the Gaussian model can be found in Turner (1969), Hanna, *et al.* (1982, 1987, 1989).

Coordinate System

In the HOTSPOT codes, the coordinate origin is located at ground level, beneath the point of radionuclide release ($x = 0$, $y = 0$, $z = 0$). The x axis is the DOWNWIND axis, extending horizontally with the ground in the average wind direction. The y axis is the CROSSWIND axis, perpendicular to the downwind axis, also extending horizontally. The z axis extends vertically. A plume travels along, or parallel to, the DOWNWIND axis.



HOTSPOT coordinate system

18-S/1207-B-1

Gaussian Equation

The following Gaussian model equations determine the atmospheric concentration of a gas or an aerosol:

$$C(x,y,z,H) = \frac{Q}{2\pi\sigma_y\sigma_z u}\exp\left[-\frac{1}{2}\left(\frac{y}{\sigma_y}\right)^2\right]\left\{\exp\left[-\frac{1}{2}\left(\frac{z-H}{\sigma_z}\right)^2\right] + \exp\left[-\frac{1}{2}\left(\frac{z+H}{\sigma_z}\right)^2\right]\right\}\exp\left[-\frac{\lambda x}{u}\right] \quad . \qquad \text{(Eq. B-1)}$$

If the inversion layer option is in effect, and σ_z exceeds the inversion height (L), the following equation is used.

$\sigma_z > L$:

$$C(x,y,z,H) = \frac{Q}{\sqrt{2\pi}\sigma_y L u} \exp\left[-\frac{1}{2}\left(\frac{y}{\sigma_y}\right)^2\right] \exp\left[-\frac{\lambda x}{u}\right] \quad . \qquad \text{(Eq. B-2)}$$

To avoid the sharp transition between the two above equations, the transition into the inversion layer equation begins when σ_z equals 70% of L, and is complete when σ_z equals L. Between these two values, the two equations are linearly interpolated.

where—

- C = Time-integrated atmospheric concentration (Ci-sec) / (m^3).
- Q = Source term (Ci).
- H = Effective release height (m).
- λ = Radioactive decay constant (s^{-1}).
- x = Downwind distance (m).
- y = Crosswind distance (m).
- z = Vertical axis distance (m).
- σ_y = Standard deviation of the integrated concentration distribution in the crosswind direction (m).
- σ_z = Standard deviation of the integrated concentration distribution in the vertical direction (m).
- u = Average windspeed at the effective release height (H), (m / s).
- L = Inversion layer height (m).

Atmospheric Stability Classification

Meteorologists distinguish several states of the atmospheric surface layer—unstable, neutral, and stable. These categories refer to how a parcel of air reacts when displaced adiabatically in the vertical direction. HOTSPOT allows you to select the atmospheric stability classification in two ways.

For those not familiar with the different stability classifications, HOTSPOT will select the appropriate stability classification based on user-input of direct observations. Or, users can directly select and force a particular stability classification. The simplified method requires selecting the solar insolation factor and the ground windspeed (2-m height). HOTSPOT automatically determines the atmospheric stability category from the matrix in the following table. This table contains criteria for the six stability classes, based on five categories of solar insolation. The scheme is widely used in meteorology and is accepted for stability class estimates.

Meterological conditions that define Atmospheric Stability Categories, A–F, used in HOTSPOT.

<2	A	B	F
2–3	A	C	E
3–4	B	C	D
4–6	C	D	D
>6	C	D	D

Pasquill Stability Types:

A: Extremely Unstable (σ_θ = 25 deg)

B: Moderately Unstable (σ_θ = 20 deg)

C: Slightly Unstable (σ_θ = 15 deg)

D: Neutral (σ_θ = 10 deg)

E: Slightly stable (σ_θ = 5 deg)

F: Moderately Stable (σ_θ = 2.5 deg)

Worst-Case Stability

For an elevated release, the location of the maximum concentration depends on the stability class chosen. For materials with a deposition velocity of zero and a release point at or very near GROUND LEVEL, the maximum concentration is always associated with “F” stability. However, if the deposition velocity is greater than zero, the worst-case stability at large downwind distances is not always associated with “F” stability due to the effects of plume depletion, i.e., the concentration of the plume decreases at a faster rate with increasing stability class (A-F) and increasing deposition velocity. For example, at a specific location, “E” stability could result in a higher local concentration than “F” due to LESS plume depletion associated with “E” stability. This effect is minimal for deposition velocities less than 0.1 cm / sec.

Special G Stability

Diffusion experiments under clear, nearly calm nighttime conditions suggest that horizontal diffusion is actually greater than diffusion F stability (i.e., larger σ_y) due to increased plume meander. The standard deviation of the observed wind fluctuations in the horizontal direction, σ_θ, can be very large. The observed σ_θ values during G stability conditions correspond to anything between categories A–F, i.e., diffusion in terms of tabulated dispersion parameters is indeterminate during G stability conditions (Hanna, 1982). The diffusion can best be estimated using the actual measurement of σ_θ. If the G stability class is selected, the user is prompted for σ_θ, and the applicable stability class used for the horizontal diffusion component. F stability is assumed for the vertical component.

Determining σ_y and σ_z

The most widely used scheme to estimate σ_y and σ_z was developed by Pasquill (1961). Briggs (1975) combined the Pasquill curves with curves derived from data observed at Brookhaven National Laboratory and the Tennessee Valley Authority, the latter including observations out to a downwind distance of 10 km. Briggs incorporated theoretical concepts regarding asymptotic limits of the formulas to produce a widely used set of equations for σ_y and σ_z. The equations are associated with dispersion experiments conducted over short grassy surfaces with roughness lengths in the range from 0.01 m to 0.1 m. Briggs' formulas are applicable from a distance of 0.1 km to ~10 km and are can be extended to 20 or 30 km, although Briggs does not recommend this extension. However, for lack of any other validation schemes, these formulas are commonly used out to a distance of 100 km.

Equations used to determine σ_y and σ_z. This methodology is derived from Briggs (1975).

Pasquill Type	σ_y (m)	σ_z (m)
A	$0.22x\ (1+0.0001x)^{-1/2}$	$0.20x$
B	$0.16x\ (1+0.0001x)^{-1/2}$	$0.12x$
C	$0.11x\ (1+0.0001x)^{-1/2}$	$0.080x\ (1+0.0002x)^{-1/2}$
D	$0.08x\ (1+0.0001x)^{-1/2}$	$0.060x\ (1+0.0015x)^{-1/2}$
E	$0.06x\ (1+0.0001x)^{-1/2}$	$0.030x\ (1+0.0003x)^{-1}$
F	$0.04x\ (1+0.0001x)^{-1/2}$	$0.016x\ (1+0.0003x)^{-1}$

Sample Time

The equations for the standard deviation of the Gaussian concentration distribution in cross-axis direction (σ_y) are representative of observing plume characteristics over a time period of 10 min. In the HOTSPOT codes, this averaging time is referred to as the sampling time. Concentrations downwind from a source decrease with increasing sampling time primarily because of a larger σ_y due to an increased meander of wind direction. In the HOTSPOT codes, the default release duration of radioactive material is 10 min. If you are interested in a scenario with a release duration of 1 hour, you need to change the sample time to 60 min. The sample time for the explosive-release programs is fixed at 10 min and cannot be altered. However, the sample time may be changed in non-explosive programs at the main HOTSPOT output menu using the "T: SAMPLE TIME" option. In HOTSPOT, the following equation adjusts for sampling times different than 10 min (Hanna, *et al.*, 1982; Gifford, 1975)—

$$\sigma'_y = \sigma_y \left[\frac{t}{10} \right]^{0.2} \quad , \qquad \text{(Eq. B-3)}$$

where—

σ_y = 10-min standard deviation of the concentration distribution.
σ_y' = Standard deviation for averaging time, *t*.

Effective Release Height

The actual plume height may not be the physical stack height. Plume rise can occur because of the velocity of stack emission, and the temperature differential between the stack effluent and the surrounding air. The rise of the plume results in an increase in the release height.

This effective release height leads to lower integrated concentrations at ground level. If you cannot estimate or calculate the effective release height, the actual physical release height (height of the stack) or zero for ground-level release should be used. This will always yield a conservative estimate, i.e., larger radiation doses, etc.

Wind Speed Variation with Height

The wind speed that users input is the estimate for a height of 2 m. However, the Gaussian plume equation requires the wind speed at H, the effective release height. HOTSPOT automatically uses the following power-law formula to determine the wind speed for all effective heights greater than 2 m.

$$u(H) = u(2) \left[\frac{H}{2} \right]^{P} \quad , \qquad \text{(Eq. B-4)}$$

where—

$u(2)$ = Surface wind speed (m/s) at 2-m height.
H_{eff} = Effective release height (m).
P = Factor from the following table.

Exponential factor used by HOTSPOT for calculating wind speed variation with height (from Hanna, 1982).

Stability Class					
A	B	C	D	E	F
0.07	0.07	0.10	0.15	0.35	0.55

Plume Depletion

Very small particles and gases or vapors are deposited on surfaces as a result of turbulent diffusion and Brownian motion. Chemical reactions, impaction, and other biological, chemical, and physical processes combine to keep the released substance at ground level. As this material is deposited on the ground, the plume above becomes depleted. HOTSPOT uses a source-depletion algorithm to adjust the air concentration in the plume to account for this removal of material.

The source term in HOTSPOT is allowed to decrease with downwind distance. The code accomplishes this by multiplying the original source term by a source-depletion factor [DF(x)]. The evaluation of this depletion factor has been described by Van der Hoven (in Slade, 1986).

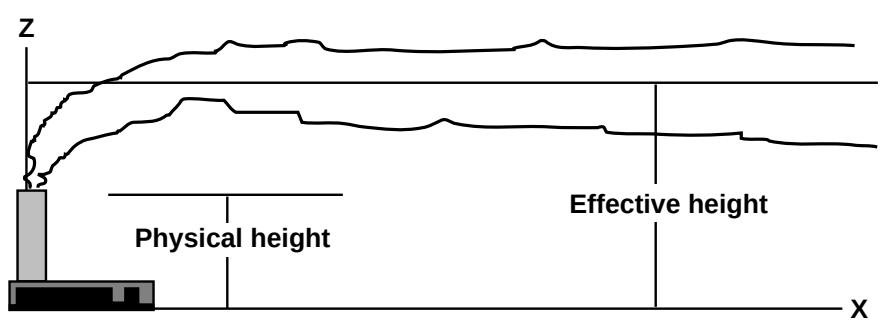
The equation used in HOTSPOT is—

$$DF(x) = \left[\exp \int_0^x \frac{1}{\sigma_z(x) \exp\left[\frac{1}{2} \left(\frac{H_{eff}}{\sigma_z(x)} \right)^2 \right]} dx \right]^{-\frac{v}{u}\sqrt{\frac{2}{\pi}}} \qquad \text{(Eq. B-5)}$$

Plume Rise

The actual plume height may not be the physical release height (the stack height). Plume rise can occur because of the velocity of the stack emission, and the temperature differential between the stack effluent and the surrounding air. The rise of the plume results in an increase in the release height, as shown in Fig. B-2.

This effective increase in release height leads to lower concentrations at the ground level. If you cannot visually estimate or calculate the effective release height, we recommend you use the actual physical release height (the height of the stack) or use zero height for a ground-level release. This will almost always yield conservative estimates.



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Fuel Fire

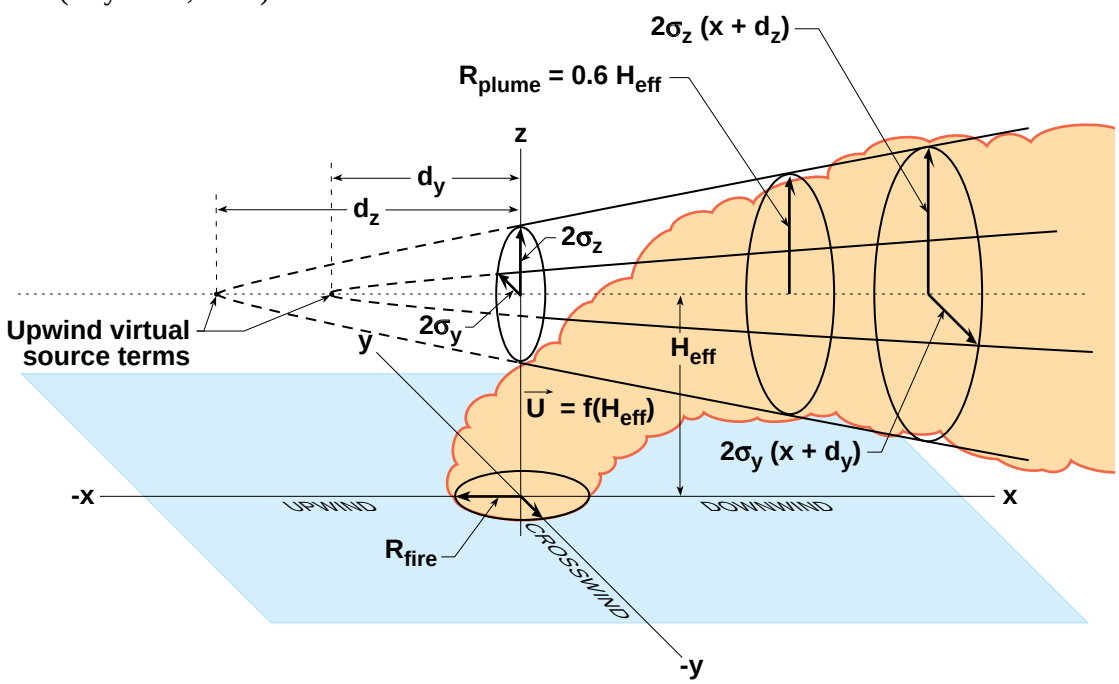
In the specific case of a fuel fire (e.g., an aircraft accident involving burning fuel), you have the option of having HOTSPOT calculate buoyant plume rise. The momentum plume rise for a fire in open terrain is minimal compared to the buoyancy rise and the former is assumed to be zero (Fig. B-3). Two important parameters in the determination of plume rise are the heat emission rate (Q_H) and the buoyancy flux (F_B). For a fuel fire, the heat emission rate is—

$$Q_H = 3785\ V\rho H_C\,(1-f)\,/\,t\ , \qquad \text{(Eq. B-6)}$$

where—

Q_H	=	Heat emission rate (cal / s).
3785	=	Volume conversion factor (cm^3 / gal).
V	=	Volume of fuel (gal) burned in time, t (s).
ρ	=	Fuel density (g / cm^3).
H_C	=	Heat of combustion (cal / g).
f	=	Fraction of the heat of combustion radiated.
t	=	Duration of fuel fire (s).

Note: The volume of fuel consumed in time t determines the buoyant plume rise. The default duration of the radioactive material release is 10 min, regardless of the duration of the fire. The default 10-min value can be changed using the "T: SAMPLE TIME" option at the main HOTSPOT output menu (see *Sample Time* in Appendix C). Experiments have shown that burn rates, given in terms of pool depth rate, generally fall within the range of 1–5 mm per minute (Drysdale, 1985).



$\sigma_y\ (x = 0) = \sigma_z\ (x = 0) = \text{Maximum}\ (0.5\ R_{plume}\ \text{or}\ 0.5\ R_{fire})$

Fire Model Geometry

18-S/1207-B-3

In HOTSPOT, it is assumed that 30% of the heat of combustion is radiated , fuel density is 0.81 g/cm^3, and the heat of combustion is 1.2×10^4 cal/g. Therefore, Eq. B-6 becomes—

$$Q_H = 2.58 \times 10^7 \, V/t \qquad \text{(Eq. B-7)}$$

Given the heat emission rate, the buoyancy flux is—

$$F_B = g\, Q_H \Big/ \pi C_p \, \rho_a \, T_a \quad , \qquad \left(\mathrm{m}^4/\mathrm{s}^3\right) \qquad \text{(Eq. B-8)}$$

where—

g = Gravitational acceleration (9.8 m/s^2).
C_p = Specific heat of effluent gases (0.24 cal/[g°K]).
ρ_a = Density of air (1.29×10^3 g/m^3).
T_a = Ambient air temperature (°K).

Therefore,

$$F_B = 1.1 \times 10^{-2} \, Q_H / T_a \ .$$

The effective release height due to buoyancy plume rise is determined as follows (Briggs, 1975):

- For atmospheric stability classifications A, B, C, and D,

$$H_{eff} = 1.6 \left(F_B\right)^{1/3} \left(X^*\right)^{2/3} \Big/ u\left(H_{eff}/2\right) \qquad \text{(Eq. B-9)}$$

where—

H_{eff} = Effective release height (m)
X^* = Distance associated with final plume height (m) [Munger, 1982]
X^* = 119 $(F_B)^{0.40}$ for $F_B \geq 55$.
X^* = 49 $(F_B)^{0.625}$ for $F_B > 55$.

- For stability classifications E and F,

for $u\left(H_{eff}/2\right) > 1.4$ m/s,

$$H_{eff} = 2.6 \left(\frac{F_B}{\mu(2) \times S} \right)^{1/3} ; \qquad \text{(Eq. B-10)}$$

for $u\left(H_{eff}/2\right) \leq 1.4$ m/s,

$$H_{eff} = 5.0 \left(F_B\right)^{1/4} \left(S\right)^{-3/8} ; \qquad \text{(Eq. B-11)}$$

where—

S = 0.020 g/T_a for stability class E.
S = 0.035 g/T_a for stability class F.

Briggs' plume-rise equations apply to the release from a stack with a negligible radius. The plume rise from a burning pool of fuel will be less than the Briggs value. For a burning pool of radius (R), the calculated plume rise is modified as follows (Mills, 1987):

$$H_{eff} = \sqrt[3]{\left(H_B\right)^3 + \left(\frac{R}{\gamma}\right)^3} - \frac{R}{\gamma} \quad , \qquad \text{(Eq. B-12)}$$

where—

H_B = Effective release height via the Briggs methodology (m).
R = Radius of burning fuel pool (m).
γ = Entrainment coefficient for buoyant plume rise, 0.6.

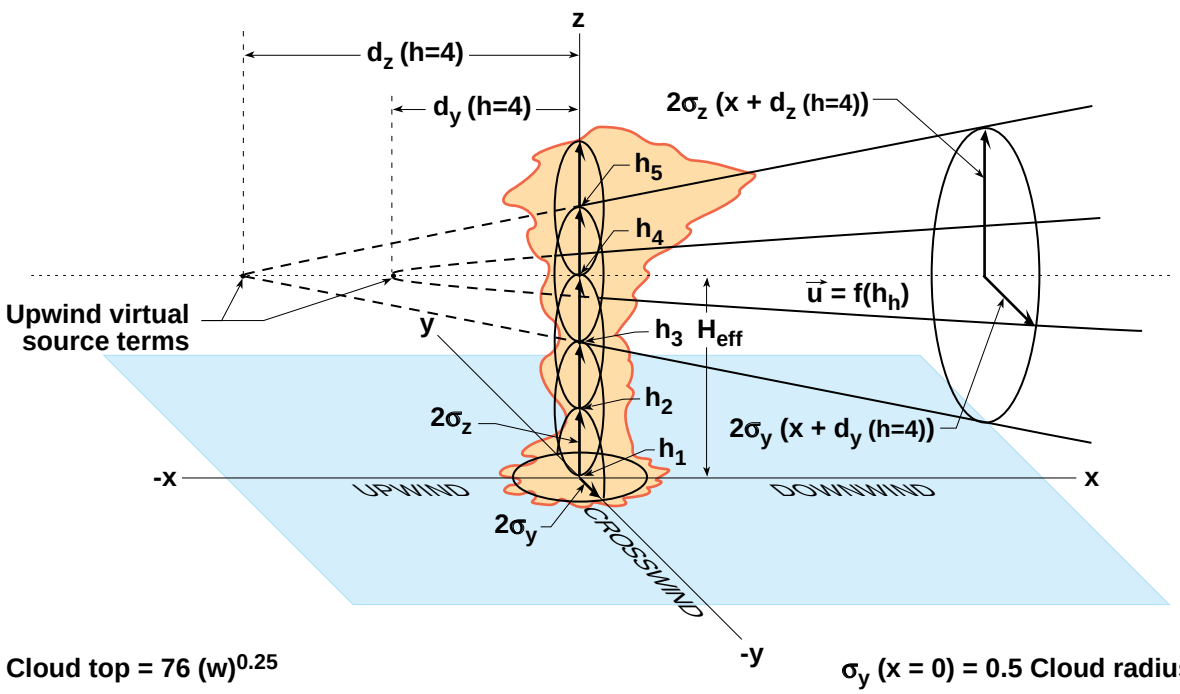
Once the effective release height is determined, the radius of the final bent-over plume is set equal to 60% of the effective release height (Hanna, *et al.* 1982). An upwind virtual-term point source is used to model the initial distribution of material. The virtual-term point spurce is positioned at an up-wind distance, resulting in a σ_y and σ_z, above the origin, equal to 50% of the final bent-over plume radius. If the input pool radius is larger than the calculated plume radius, the actual pool radius is used for the target σ_y and σ_z values.

Explosion

The release fraction is partitioned as follows (Fig. B-4, following page):

Five separate source terms model the above initial distribution of material. The sources are represented by separate elevated upwind virtual source terms in which each term results in:

- σ_y over the explosion point equal to 50% of the cloud radius defined above.
- σ_z over the explosion point equal to 20% of the cloud top.



Cloud top = 76 $(w)^{0.25}$

Cloud radius = 0.2 cloud top

Where w = pounds of high explosives (Church, 1969)

σ_y (x = 0) = 0.5 Cloud radius

σ_z (x = 0) = 0.2 Cloud top

Source distribution

20%	(h_5 = 0.8 cloud top)
35%	(h_4 = 0.6 cloud top)
25%	(h_3 = 0.4 cloud top)
16%	(h_2 = 0.2 cloud top)
4%	(h_1 = ground level)

Explosion Model Geometry

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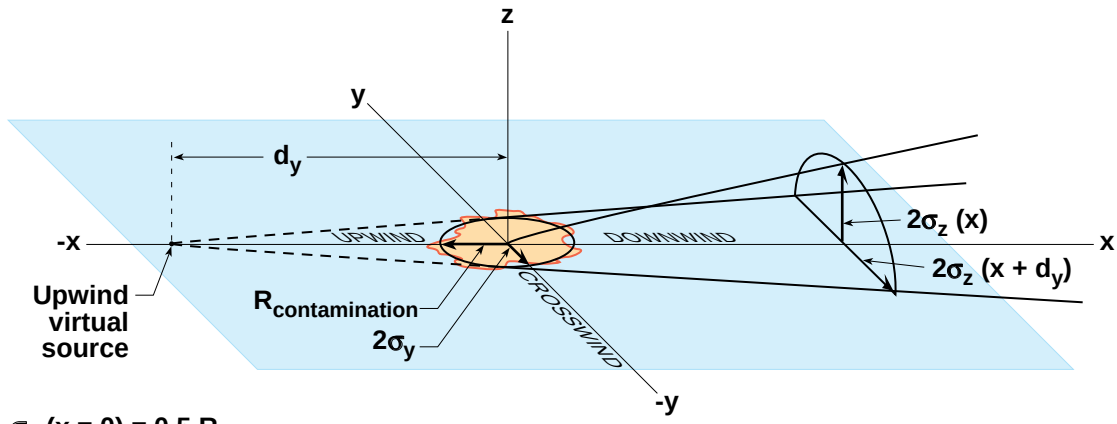
Resuspension

An upwind virtual source term models the initial distribution of material. The virtual-term point source is positioned at an upwind distance that results in a σ_y, at the center of the contamination zone, equal to 50% of the input effective radius (Fig. B-5).

The resuspension factor (S) for windspeed (u) at or below 3 m/s (Anspaugh, 1975):

$$S = 10^{-4}\, e^{-0.15\sqrt{t}} + 10^{-9} \qquad \mathrm{m}^{-1} \quad , \qquad \text{(Eq. B-13)}$$

where t = time since contamination event (days).



σ_y (x = 0) = 0.5 $R_{contamination}$

σ_z (x = 0) = 0

Resuspension Model Geometry

18-S/1207-B-5

Resuspension as a factor of wind speed:

$$S(u) = S \times (u/3)^2 \quad \text{for } u > 3 \text{ m/s}$$
$$S(u) = S \quad \text{for } u \le 3 \text{ m/s} \qquad \text{(Eq. B-14)}$$

The effective source term (Q_{eff}) associated with the observed ground contamination (G) is—

$$Q_{eff} = S(u) \times G \times \pi \times \sigma_{y,origin} \times \sigma_{z,origin} \times u \quad , \quad \text{Ci/sec} \qquad \text{(Eq. B-15)}$$

where G = ground contamination (Ci / m^2).

The Gaussian standard deviations are evaluated at a distance equal to the distance from the origin to the upwind virtual source position. Q_{eff} can then be used in the Gaussian equation (see Appendix B) to estimate the radionuclide concentration downwind from the contamination.

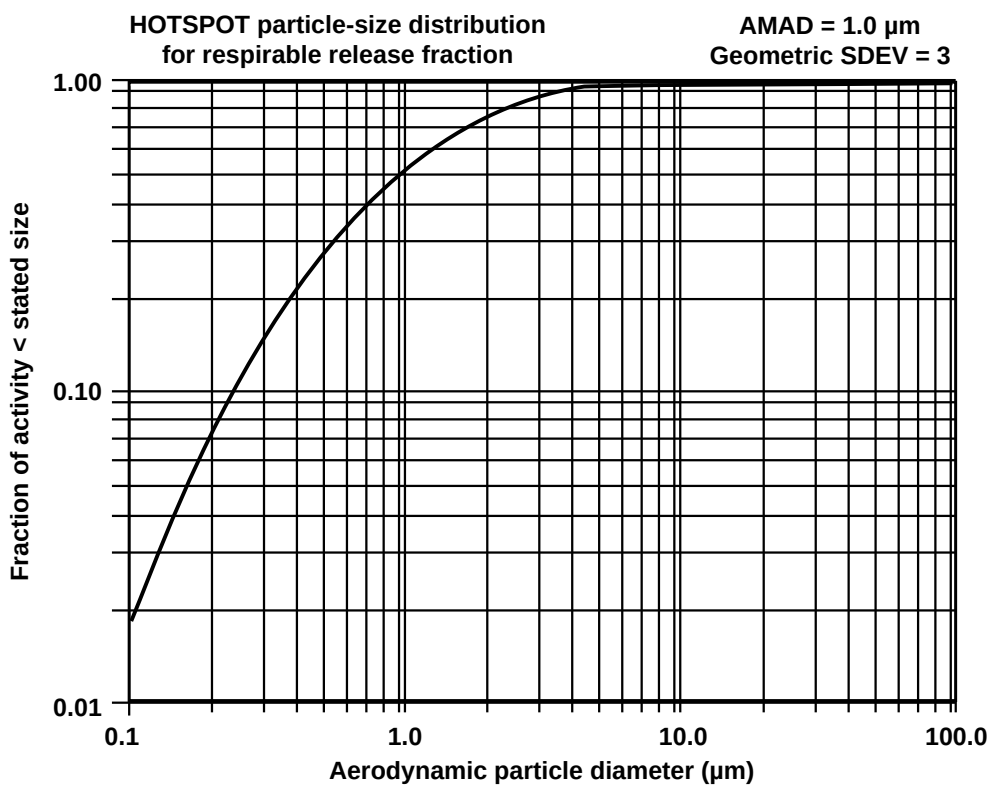
Notes: The resuspension factor is determined using measurements of the ground contamination (Ci / m^2), and the radionuclide air concentration (Ci / m^3) above the ground measurement location. The resuspension factor is then defined as the ratio of the air concentration to the ground concentration (m^{-1}).

The 50-year committed effective dose equivalents are calculated per one-hour residence time. Therefore, an individual would be committed to the output dose for each one hour at the output location. The sampling time associated with resuspension is automatically changed from the normal 10-min values to 60-min values. The calculated resuspension factor is based on experimental data associated with the Nevada Test Site, and are not necessarily applicable to wet regions, etc. However, the above equations will result in a conservative resuspension-factor estimate for an initial hazard evaluation. Once the resuspension factor is actually determined via air sampling, the new factor can update the original downwind predictions.

Particle-Size Distribution

The particle size of a monodisperse suspension of fine solid or liquid particles in the atmosphere is completely characterized by the particle diameter. However, most aerosols are polydisperse and the particle sizes range over many magnitudes. In the HOTSPOT dispersion models, we are specifically concerned with the particle-size distribution with respect to radioactivity. Just as a number distribution gives the fraction of the total number of particles in any size range, the activity distribution gives the fraction of the total activity associated with the particles in any size range.

In most polydisperse aerosols, the normal distribution function does a poor job of representing the particle-size distribution. However, the logarithm of the particle size is adequately represented by a normal distribution. Hence, the log normal distribution is commonly used to statistically describe polydisperse particle-size distributions. In the HOTSPOT programs, it is assumed that the activity median aerodynamic diameter (AMAD) is 1 µm (geometric standard deviation is 3). The following figure represents the cumulative activity distribution for a log normal distribution with an AMAD of 1 µm. Note that 50% of the activity is associated with particles with an aerodynamic diameter less than 1 µm, and essentially all of the "respirable" activity is below particles with an aerodynamic diameter of approximately 10 µm. The default ICRP-30 internal dosimetry conversion factors also assume a 1-µm AMAD particle-size distribution. In many models and studies, the respirable fraction is commonly defined as "all the material with an aerodynamic diameter less than 10 micrometers." As shown in the following graph, the 1-µm AMAD agrees with this assumption (Fig. B-6).



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Stating the distribution in terms of aerodynamic diameter standardizes the distribution in both particle shape and density. The aerodynamic diameter is the diameter of a unit density (1 g/cm^3) sphere that has the same settling velocity as the actual particle. If a particle has an aerodynamic diameter of 1 µm, it behaves in an aerodynamic sense like a 1-µm water droplet regardless of the particle's shape, density, or physical size.

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