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USERS GUIDE FOR MICROCOM (OTHER PROGRAMS CONVERTED AND EDITED BY ARMY LABORATORY) IMPACT, "FUNDAMENTALS OF PROTECTIVE DESIGN FOR CONVENTIONAL WEAPONS"

by

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This user's guide documents two computer programs that supplement the recently revised Army Technical Manual TM 5-855-1, "Fundamentals of Protective Design for Conventional Weapons." FunPro allows the user to display and scroll through the text of the manual, search for key words and/or phrases, display the curves and illustrations on a microcomputer monitor and produce hard copies, and retrieve data points from curves. ConWep performs a variety of conventional weapons effects calculations, including an assortment of airblast routines, fragment and projectile penetrations, cratering, and ground shock.

In their current configuration, the programs will run on commonly available desktop microcomputers using Microsoft's Disk Operating System (DOS) version 2.1 or a later version. Both programs are capable of producing graphic output on a microcomputer equipped with a Color Graphics Adapter, an Enhanced Graphics Adapter, or any pen plotter supporting the Hewlett Packard Graphics Language. Keywords:

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Available from National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161. ~~Microcomputer programs CONVAR and PONTRO are included in diskette form in an envelope attached to the back cover of this report~~.

19. ABSTRACT (Continued).

The programs and all associated data files are available to government agencies on the Waterways Experiment Station (WES) microcomputer bulletin board, at phone no. (601) 634-3053. Nongovernment offices should submit a written request for the programs to:

Commander
US Army Corps of Engineers
ATTN: CEEC-ET
20 Massachusetts Avenue NW
Washington, DC 20314-1000

PREFACE

This user's guide documents two computer programs that supplement the recently revised Army Technical Manual TM 5-855-1, "Fundamentals of Protective Design for Conventional Weapons" (Reference 1). FunPro allows the user to display and scroll through the text of the manual, search for key words and/or phrases, display the curves and illustrations on a microcomputer monitor and produce hard copies, and retrieve data points from curves. ConWep performs a variety of conventional weapons effects calculations, including an assortment of airblast routines, fragment and projectile penetrations, cratering, and ground shock. The work on these programs was accomplished using funds provided to US Army Engineer Waterways Experiment Station (WES) by the Directorate of Engineering Construction, Office, Chief of Engineers, US Army, under the Microcomputer Adaptation of TM 5-855-1 program.

This work was performed by personnel of the Structures Laboratory (SL), WES, during the period April 1986 through May 1987. This work was accomplished under the general supervision of Messrs. Bryant Mather, Chief, SL, Mr. James T. Ballard, Assistant Chief, SL, and Dr. Jimmy P. Balsara, Chief, Structural Mechanics Division (SMD), SL; and under the direct supervision of Dr. Sam A. Kiger, Research Group, SMD. The programs and this report were written by Mr. David W. Hyde, Research Group, SMD.

COL Dwayne G. Lee, CE, is Commander and Director of WES. Technical Director is Dr. Robert W. Whalin.

The disk in this report can be obtained from:
U. S. Army Engineer Waterways Experiment Station, Structures Laboratory, P. O. Box 631, Vicksburg, MS 39180-0631
Per Mr. Randy Holmes, USAEWES/Structures Lab.

CONTENTS

CONVERSION FACTORS, NON-SI TO SI (METRIC) UNITS OF MEASUREMENT

Non-SI units of measurement used in this report can be converted to SI (metric) units as follows:

Multiply	By	To Obtain
inches	25.4	millimetres
feet	0.3048	metres
square inches	6.4516	square centimetres
pounds (force) per square inch	6.894757	kilopascals
pounds (force)	0.45359	kilograms (force)

USER'S GUIDE FOR MICROCOMPUTER PROGRAMS CONWEP AND FUNPRO APPLICATIONS OF TM 5-855-1, "FUNDAMENTALS OF PROTECTIVE DESIGN FOR CONVENTIONAL WEAPONS"

PART I: INTRODUCTION

Background

1. The Waterways Experiment Station (WES) has recently completed a revision of Department of the Army Technical Manual (TM) 5-855-1, "Fundamentals of Protective Design for Conventional Weapons". The latest version of this technical manual contains updated information on a variety of conventional weapons effects and structural response. Copies of TM 5-855-1 are available from the US Army AG Publication Center, 2800 Eastern Blvd., Baltimore, MD 21220-2896. The manual has been adopted for microcomputer usage by the Structural Mechanics Division, Structures Laboratory, WES, in the form of the two computer programs presented here--FunPro and ConWep.

Purpose and Capabilities

2. FunPro allows the user to display the text of the manual on a microcomputer monitor and search for key words and phrases. This program also allows the user to display the figures from the manual on a monitor, produce hard copies on a plotter, retrieve data points from curves, and compare test data to the theoretical curves from the manual.

3. ConWep performs a variety of weapons effects calculations, including airblast, fragment and projectile penetration, cratering, and ground shock. The user may select a weapon from a menu of cased munitions, including general purpose (GP) bombs, artillery rounds, and mortar rounds, or alternatively enter other parameters for a cased weapon, bare charge, or inert projectile not included in the program.

Program Updates

4. Updates to ConWep and FunPro, as well as all associated data files, are available to government agencies on the WES microcomputer bulletin board, at phone no. (601) 634-3053. Nongovernment offices should submit a written request for the programs to:

Commander
US Army Corps of Engineers
ATTN: CEEC-ET
20 Massachusetts Avenue NW
Washington, DC 20314-1000

Minimum Requirements

5. Both programs require the following:

- o IBM PC, PC/XT, PC/AT, or 100% compatible personal computer
- o Disk Operating System (DOS) version 2.1 or later
- o 1.2 megabyte (MB) diskette drive, or a hard disk
- o 400 KB available Random Access Memory (RAM)

In addition, all graphics routines require one of the following:

- o IBM Color Graphics Adapter or close compatible
- o IBM Enhanced Graphics Adapter or close compatible
- o Any pen plotter that supports the Hewlett Packard Graphics Language (HPGL)

6. This documentation assumes that the reader has some familiarity with the Disk Operating System (DOS). In particular, the user should have a working knowledge of file specifications, directories, and DOS commands. Questions concerning the operating system should be referred to the user's DOS reference manual.

User Responses

7. Throughout this documentation, entries that the user should type are surrounded by single quotes (' '). Quotation marks should not be included when typing these entries. Also, the symbol <CR> represents the "Enter" key on the keyboard. On some personal computer models, this key may be labeled "Return". Requests for character responses are not case sensitive, e.g. "(D)isplay or (P)lotter?" will accept 'D', 'd', 'P', or 'p'.

Installation

8. ConWep, FunPro, and all associated text and data files are generally distributed on two double-sided, high-density (DS/HD) diskettes, as found in the back of this manual. Although the programs are available in other formats, this documentation assumes that the programs were obtained on the DS/HD diskettes.

9. After reading this document, the user should prepare backup copies of each of the diskettes, especially if the programs will be run primarily from diskettes rather than a hard disk. Unless the text and figures of the manual will be referred to on a frequent basis, it will probably be preferable to copy only the two executable programs to a hard disk, as the text files and data files for the figures take up about one megabyte (1,048,576 bytes) of disk space. On systems equipped with a hard disk, the user should perform the following steps:

a. At the C:> prompt, type 'MD TM5-855'<CR> to create a subdirectory for these programs. Any valid name may be used in place of "TM5-855".

b. Type 'CD TM5-855'<CR>.

c. Insert the diskette labeled "FUNPRO" in drive A and type:

'COPY A:TM.BAT' <CR>

'COPY A:TMCOVER.COM'<CR>

'COPY A:FUNPRO.EXE'<CR>

'COPY A:CONWEP.EXE'<CR>

'COPY A:INSTALL.COM'<CR>

10. Both ConWep and FunPro require installation by the INSTALL program. INSTALL modifies these two programs by writing information concerning the system's display monitor, graphics adapter, and plotter to them. A sample installation of FUNPRO.EXE is shown in Appendix A.

11. A short batch file, TM.BAT, has been included to facilitate switching from one program to another. ConWep and FunPro are completely independent of each other, however, and it is not necessary to use TM.BAT to run either program. If both programs are on a hard disk along with TM.BAT, either one may be invoked by typing 'TM' <CR> at the DOS prompt. Otherwise, the programs are started by typing the name of the program without the .EXE extension, e.g. 'FUNPRO'<CR>.

Graphics

12. FunPro and ConWep support graphics on the following graphics adapter/monitor combinations:

Graphics Card/Monitor	Video Mode	Resolution/Colors
Color Graphics Adapter w/ Color Display	6	640x200x2
Enhanced Graphics Adapter w/ Monochrome Display	15	640x350x4
Enhanced Graphics Adapter w/ Color Display	14	640x200x16
Enhanced Graphics Adapter w/ Enhanced Display, 64 KB video memory installed	14	640x200x16
Enhanced Graphics Adapter w/ Enhanced Display, >64 KB video memory installed	16	640x350x16/64*
NEC GB-1 Graphics Card w/ NEC Multisync Monitor	16	640x480x16/64*

Plotters that support the Hewlett-Packard Graphics Language are also supported.

13. If a plotter is used, the following should be typed before running the programs:

MODE COM<n>:<rate>,n,8,1,p

where <n> specifies the communications port number (1 or 2) where the plotter is attached and <rate> is the baud rate to which the plotter is set with the switches on the rear panel. This command will prevent "Write fault" and/or "Device timeout" errors when plotting. This line may alternatively be included in the AUTOEXEC.BAT file in the root directory of the host computer.

Portability

14. The major routines of both ConWep and FunPro are written in ANSI standard FORTRAN-77. However, both programs make considerable use of Assembly language subroutines to perform graphics operations. Because of extensive use of assembler routines for menu generation and other video output, it would be

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* 16 simultaneous colors from a palette of 64 colors.

difficult at best to move FunPro to another computer and/or operating system. With the exception of the graphics routines, ConWep would require relatively few changes to operate on another system. The source code for both ConWep and FunPro is available through the same procedures explained in paragraph 4.

PART II: FUNPRO

Starting FunPro

15. Before running FunPro, the diskettes labeled "TEXT" and "FIGURES" should be available, unless the data files are on a hard disk. The program may be started in either of two ways: (1) by typing 'FUNPRO'<CR>, or (2) by typing 'TM'<CR>, then selecting "FunPro" from the menu using the cursor control keys on the right side of the keyboard. FunPro is simple to use, and instructions for operating it are contained in the program itself.

Selecting Options

16. The cursor control keys on the right side of the keyboard are used to scroll the "highlight bar" up or down the list of menu options. An option is selected by pressing <CR> when it is highlighted. The options for the main menu are explained below:

a. Display instructions -- Displays a help screen explaining the operations performed by the function keys and cursor control keys.

b. Select a chapter -- Displays another menu from which the user may select a passage to read. Selections include the preface and table of contents, the body of the manual, and the appendices. Alternatively, the desired subject may be selected from an index, or the chapter selected when the program last terminated may be chosen. If a subject is selected from the index, the program will automatically display the selected passage on the screen. Otherwise, once a selection has been made the program will return to the main menu.

c. Read selected chapter -- If a chapter has been selected, displays that passage on the screen. Scrolling through the text and other functions described below may then be performed.

d. Print selected chapter -- If a chapter has been selected, prints the entire chapter from start to finish. Printing may be aborted by pressing any key. The program expects to find the printer at the first parallel port (LPT1:).

e. Display figures -- Switches to the figures menu, and allows the user to display figures from the manual on a display or plotter. (See "Displaying Figures").

f. Set default drive -- This feature is only useful if the text files are located on a different drive than the main program. The default drive will be reset to the original one if the program is terminated normally.

g. Search figures and tables -- Search the list of figures and tables for key words. The search strategy is not case sensitive.

h. Exit -- Exits to DOS. Before terminating, the program will save the chapter and line number being read and the screen colors in effect.

Displaying Text

17. Once a passage has been selected and displayed, all of the functions of the program are controlled by the cursor control keys on the right side of the keyboard and the function keys F1-F10. The cursor control keys are used to scroll up or down one line or one screen at a time. Scrolling may be repeated rapidly by holding down the cursor control keys. The <Home> key returns to the top of the chapter; <End> moves to the last page of the chapter. The <Esc> key returns to the main menu. The function keys perform the following functions:

a. <F1> -- Display help screen.

b. <F2> -- Change screen colors - the screen colors selected will be saved to disk and used the next time the program is run.

c. <F3> -- Mark the line at the top of the screen in inverse video. This function saves the current position in the chapter and, when used with the <F4> key, allows the user to return to the marked line after reading another passage from the same chapter.

d. <F4> -- Return to line of text marked with <F3>.

e. <F5> -- Search forward through the text for a word or phrase. The search is not case sensitive.

f. <F6> -- Search backward through the text for a word or phrase.

g. <F7> -- Print the currently displayed page. The printout will be aborted if any key is pressed. The program expects to find the printer at LPT1.

h. <F8> -- Toggle EGA 43 line mode. Switches between the normal 25 rows of text per screen to 43 rows of text if an Enhanced Graphics Adapter (EGA) and an Enhanced Color Display are present. This feature has no effect if an EGA is not present.

i. <F9> -- Speed up the PC/AT keyboard. This routine changes the pace of the typematic action of the PC/AT keyboard. The normal keyboard response may be slower than desired for scrolling through the text. This routine will only work with a PC/AT, and will have no effect with standard PC's or PC/XT's. The program checks the machine ID byte in ROM to see if the computer is an AT. Some IBM compatible AT's may not use this byte, so the program will falsely assume that the host machine is not an AT. Since it is not possible to check the repeat rate of the AT keyboard, only to set it, the keyboard will keep the same repeat rate after the program terminates and until the system is

initialized. The values for the repeat delay and repeat per second are:

	delay	repeat/second
SLOWEST -	0.5 sec	10 (default at initialization)
SLOWER -	0.25	15
FASTER -	0.25	20
FASTEST -	0.25	30

j. <F10> -- Switch to the figures routine. After exiting the figures routine the program returns to the passage of text previously displayed.

18. FunPro achieves fast screen output by writing directly to display memory, bypassing the slower Basic Input/Output System (BIOS) video functions. To prevent "snow" from appearing on the standard color monitor with the Color Graphics Adapter (CGA), FunPro updates the screen only when the CRT controller is in a horizontal retrace period. For other installed adapters, screen writing is almost instantaneous.

Displaying Figures

19. Data for each of the figures from the manual is stored in separate files. The data files for illustrations contain drawing instructions recognized by FunPro. The files for figures consisting of curves contain either the data points neccessary to recreate the curves, or the coefficients and exponents of polynomial equations used to generate the curves. In the latter case, FunPro will generate 200 equally spaced data points for each curve in the figure.

20. The file FIGLST.DOC, found on the diskette labeled "FIGURES", should be available before running the figures routine. FIGLST.DOC contains a list and description of all figures in the manual. It's presence is not essential, but helpful.

21. The major features of the figures routine are:

a. Display any figures (curve or illustration) on a monitor or plotter.

b. Retrieve data points from curves.

c. Zoom in on curves.

d. Compare user's data to curves from the technical manual.

22. The figures routine, like the reading routine, is driven by menu selections. A summary of the actions taken by each of these selections follows:

a. Select a figure -- Prompts the user to enter the number for the figure to be viewed. It is not necessary to type in the full name of the data file for the desired figure. For example, to view Figure 4-11, the proper response is '4-11'.

b. Plot selected figure -- If an output device is not selected, the display is assumed.

c. Select output device -- Select from Display, Plotter, or Plot File. The default output device is the display when the program is started.

d. Set default drive -- This feature is only useful if the data files for the figures are located on a different drive than the main program. The default drive will be reset to the original one if the program is terminated normally.

e. List available figures -- Displays a list of the figure numbers and their descriptions. The file "FIGLST.DOC" must be present to use this selection.

f. Select format for curves -- Draw a grid or a box around a set of curves. This feature is primarily intended for creating presentation graphics with a plotter, and generally has a much better appearance on a hard copy than on the display. Some of the figures contain labels that may overlap the grid or box, and a grid will not be appropriate.

g. Enter other data -- Test data may be compared to figures from the manual by reading up to 200 data pairs from a file. The file should contain one data pair per line (X followed by Y), and the X and Y values should be separated by a comma or a space. The first column in the file should be reserved for the sign of the X coordinate. FunPro will sort the data pairs, if necessary, in increasing X order. Data may be displayed using either line segments between points, markers at the points, or both. Each additional data set may have a label of up to 30 characters. The limit on the total number of curves displayed, including those in the original figure, is 20.

23. If a figure consisting of a curve or a set of curves (rather than an illustration) is plotted on the display, when the plot is completed the message "(R)ead, (Z)oom, or (Q)uit" will be displayed at the lower edge of the screen.

a. (Q) -- clears the screen and returns to the main menu.

b. (R) -- allows the user to retrieve data points from the curves.

(1) If more than one curve is present, a graphic cursor will appear in the middle of the screen, and the message "Which curve?" will appear at the lower edge of the display. Cursor movement is controlled with the cursor keys on the right side of the keyboard. A curve is selected by pressing <Enter>

when the cursor is at or near a point on the desired curve. The message "Enter X value " will then appear at the bottom of the screen. After the desired X coordinate is entered, the program will return the corresponding Y value.

(2) The data retrieval function returns a Y value which is interpolated from the data points for each figure. The accuracy of this function is dependent on the spacing between data points. As an example, if the user wants to find the incident pressure due to the detonation of a 1 lb* spherical free-air burst at a range of 1 foot from Figure 3-4 of the manual (Figure 1), the program will return the values "X = 1.00, Y = 844.7" signifying 844.7 psi. The actual value from the original equations for the incident pressure at that range is 844.8 psi. The small error can be attributed to the interpolation between data points.

c. (Z) -- allows the user to zoom in on a portion of the figure.

(1) After 'Z' is pressed, the message "(A)ll or (W)indow" is displayed at the lower edge of the screen. If 'A' is pressed, the full extents of the figure will be plotted. If 'W' is pressed, the cursor control keys may be used to select two opposing corners of a window to plot, and the figure will be redrawn with the specified lower and upper bounds. Figures with logarithmic scales will always be plotted with at least one full log cycle regardless of how small a window is specified, but linear plots may be zoomed in on indefinitely. Zooming may be necessary to distinguish between curves when there are several curves in a figure, particularly if the monitor in use does not support color in high resolution graphics mode.

(2) To display a "zoomed" figure on the plotter, the user should plot the figure on the display monitor, zoom in to the desired limits, 'Q'uit, select "Plotter" from the device menu, and plot the figure again (Figure 2).

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* A table of factors for converting non-SI units of measurement to SI (metric) units is presented on page 3.

Figure 3-4a Blast Wave Parameters
1 lb Spherical Free-Air Burst

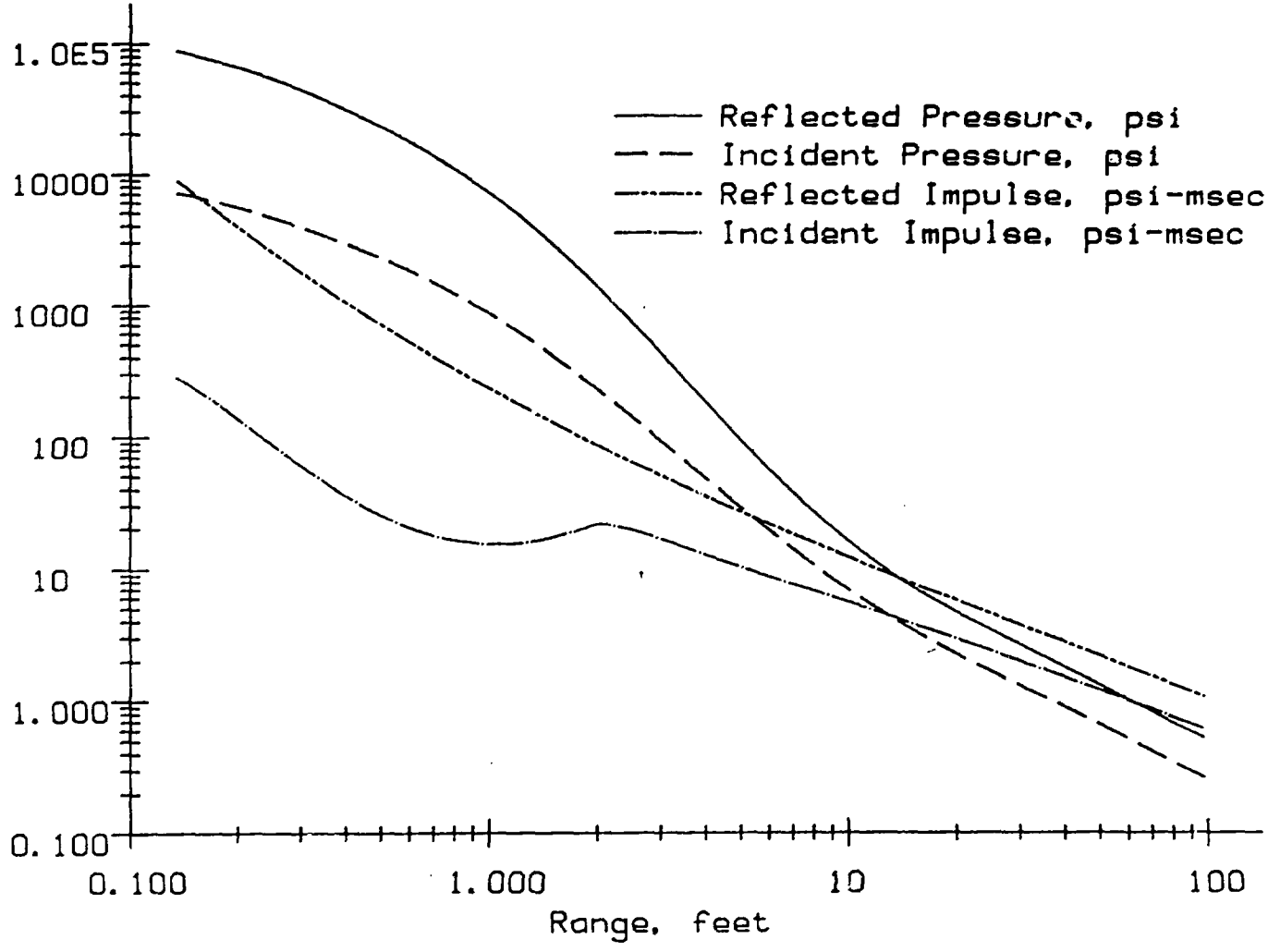
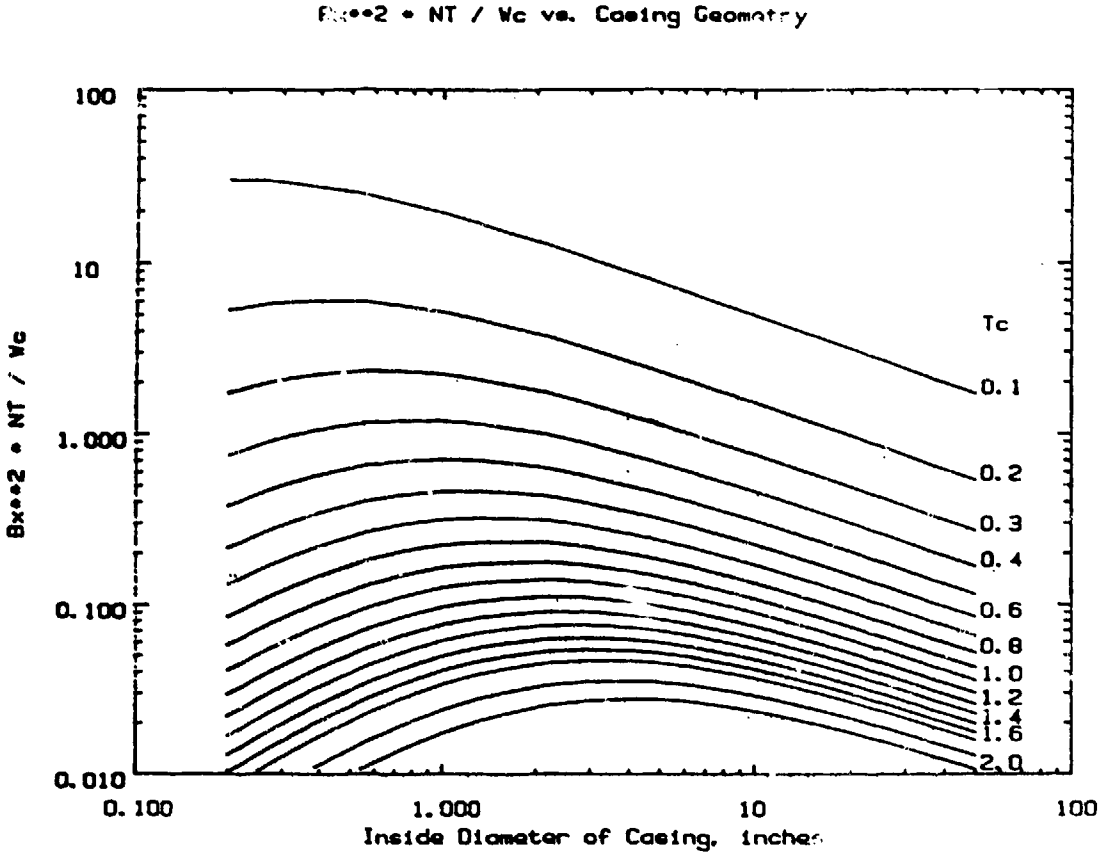


Figure 1. Airblast curves recreated by FunPro



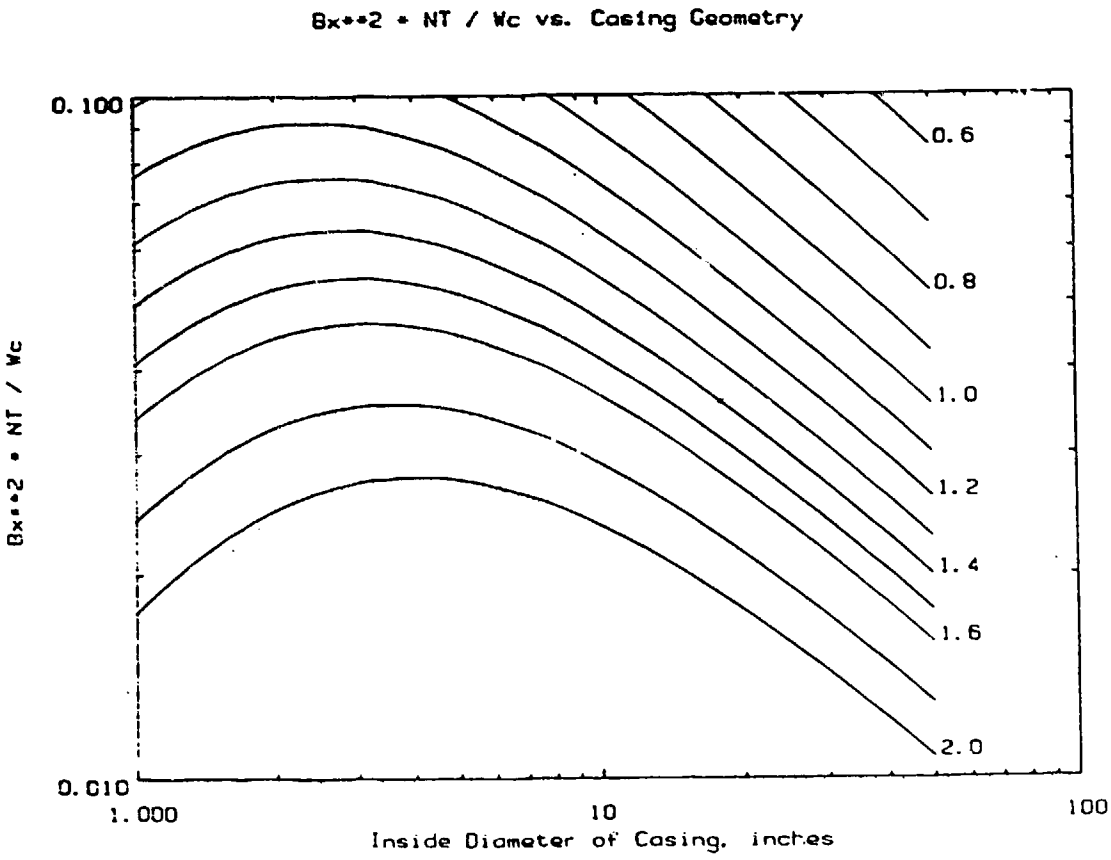


Figure 2. Example of FunPro's zoom feature

PART III: CONWEP

Starting ConWep

24. ConWep is a collection of conventional weapons effects calculations from the equations and curves of TM 5-855-1. This program is not intended as a tutorial on weapons effects, and users should be thoroughly familiar with TM 5-855-1 and supporting references before using ConWep as a design tool. As with FunPro, the program may be started in either of two ways: (1) by typing 'CONWEP'<CR>, or (2) by typing 'TM'<CR>, then selecting "ConWep" from the menu using the cursor control keys on the right side of the keyboard.

Available Weapons Effects Routines

25. A summary of weapons effects routines incorporated in ConWep follows:

a. Airblast

(1) Aboveground detonations
   (a) Find peak pressure due to given charge weight and range.
   (b) Find range for a given peak pressure and charge weight.
   (c) Find charge weight for a given peak pressure and range.
(2) Airblast attenuation in tunnels
(3) Quasistatic pressure due to internal detonations
(4) Airblast due to subsurface detonations
(5) Pressure distribution on a wall due to a surface burst

b. Fragment penetration into:

(1) Concrete
(2) Steel
(3) Wood
(4) Soil

c. Projectile penetration into:

(1) Concrete
(2) Rock
(3) Homogeneous armor

d. Path of long projectiles into earth (J-hook)

e. Shaped charge penetration of various materials

f. Cratering

g. Ground shock

Weapon Selection

26. After the user has selected a weapons effects option, ConWep first checks to see if an appropriate weapon has been selected. For example, the routines performing airblast calculations check for a positive charge weight. If an appropriate weapon has not been selected, the user will be prompted to select a weapon from a menu. ConWep has several general purpose (GP) bombs, artillery rounds, and mortar rounds built in. Alternatively, parameters for a bare HE charge, an inert projectile, or a cased weapon may be used. A weapons catalog may also be created or updated by entering parameters for GP bombs, artillery rounds, or mortar rounds not listed in the program. The program will then permanently store these parameters in a separate file (WEAPON.DAT), and will recall these new parameters each time the weapon selection routine is called. If a built in weapon is selected, ConWep will display some of the technical information about that weapon which can be found in TM 5-855-1. ConWep will retain the selected weapon until the user selects another one, or until the program is terminated.

Assumptions

27. Most of the calculations in ConWep are taken directly from the equations and curves of TM 5-855-1. Both ConWep and the technical manual make several simplifying assumptions and/or approximations concerning weapons effects calculations. In addition, ConWep will in some cases use a more rigorous calculation than called for by the manual, if that method clearly provides a better solution.

Equivalent weight factor

28. All airblast calculations are based on an explosive weight of TNT. For other explosive types, ConWep uses the average of the equivalent weight factors for pressure and impulse (Table 3-1, Reference 1) to find an equivalent weight of TNT.

Charge shape and casing effects

29. Airblast calculations assume either a hemispherical charge shape for surface bursts or a spherical shape for airbursts, and assume that casing effects are negligible. Reference 1 states "Casing effects on reducing the effective weight of the explosive should be ignored since they are not well defined and could produce an unconservative design if considered." At present

there is insufficient test data to develop equations for elongated shapes typical of most general purpose bombs. The error associated with the assumption of charge shape decreases with distance from the charge.

Incident pressure decay

30. Though TM 5-855-1 suggests using a triangular waveform to approximate a pressure-time (P-T) history, ConWep uses a more accurate exponential decay (Reference 3) of the form:

$$P(t) = P_{so} * (1 - (t-t_a) / t_d) * \exp(-A * (t-t_a) / t_d)$$

where

$P(t)$ = pressure at time t

P_{so} = peak incident overpressure at $t = t_a$

t_a = time of arrival

t_d = positive phase duration

A = decay coefficient

The program uses equations derived by the Ballistic Research Laboratory (Reference 2) to find the peak pressure, duration, time of arrival, and impulse, then solves for the decay coefficient A. Note that the negative phase of the shock wave is ignored both by ConWep and TM 5-855-1. At close range, the negative phase is insignificant for design purposes. The negative phase takes on greater importance, however, at more distant ranges. More information concerning the negative phase may be found in references 3 and 4.

Reflected pressure decay

31. ConWep uses the same procedures detailed above to find the reflected P-T history. The calculated reflected P-T history assumes an infinitely large reflecting surface, so that edge effects and clearing times are not taken into account. This assumption will always yield conservative (high) estimates of the reflected impulse.

Fragment size and shape

32. The program uses a confidence level of 95% to find the design fragment weight of a weapon. This means that there is a 95% certainty that no fragment will be larger than the design fragment weight. The fragment velocity and penetration equations are based on the bullet-shaped fragment shown in Figure 6-6 of Reference 1.

Crater shape

33. Both the apparent and true crater shapes are assumed to be parabolic. Optimum crater depth is assumed to be at a scaled depth of 1.5 ft/lb**1/3 for all materials. Scaled true depth is the greater of the scaled

apparent depth or the depth of burst + 0.4 ft/lb**1/3. True diameter is the apparent diameter + 15% up to optimum DOB, and remains constant for DOB's greater than optimum. The crater lip shown in crater profile plots is drawn for aesthetic purposes only, and should not be considered an accurate measure of lip formation. The crater volume is based on the assumption of a parabolic shape, not on empirical data.

Ground shock

34. ConWep calculates the peak free-field stress due to the directly transmitted shock wave, and optionally allows the addition of a reflected wave from a deeper layer. Relief (tension) waves reflected from the ground surface are not calculated and are assumed to be negligible. This assumption will yield conservative (high) values for the peak stress. The rise times associated with both the directly transmitted shock wave and the reflected wave are assumed to be 1/10 of the arrival times.

File Formats

35. Several of the routines in ConWep either write to or read from data files. The format for these files is explained in the following paragraphs.

Weapons file

36. The weapon selection routine reads from the file 'WEAPON.DAT' if it exists, and updates this file if the user selects 'Update Weapons Data File' from the weapons menu. This file stores information concerning cased munitions not included in the program. If desired, WEAPON.DAT may be edited with a word processor capable of writing ASCII files. All numeric entries may be separated by a comma or by one or more spaces, and may be included on the same line or on separate lines. Character strings, however, should be on separate lines. The file format as produced by ConWep is shown below:

line	variable names	description
1	NBOMB NMORT NARTY	Number of bombs, mortar rounds, and artillery rounds, respectively, that are described in WEAPON.DAT
2	GROUP	Four (4) letter code word indicating which type of weapon will be described in the following lines. GROUP should be either 'BOMB', 'MORT', or 'ARTY', indicating a general purpose bomb, a mortar round, or an artillery round, respectively. The GROUP name should be upper-case letters.

3	NAME	Character string, up to 25 characters long, describing the weapon; e.g. 'U.S. Mk 83'. ConWep does not use NAME; it is included for the convenience of the user.
4	TYPE	Character string, up to 25 characters long, describing the class of weapon; e.g. 'GP 1000'. Again, TYPE is included only for the convenience of the user.
5	XLEN	Total length of the weapon, inches.
	DIA	Outside diameter of the weapon, inches.
	WTOT	Total weight, pounds.
	WEXP	Weight of explosives, pounds.
	WCASE	Case weight, pounds.
	BH	Brinell Hardness Number (BHN) for the case material.
	XNS	Nose shape factor.
6	EXP	Character string, up to 25 characters long, describing the type of explosive used; e.g. 'Composition C-4'.
7	WTNT	The equivalent weight of TNT for 'WEXP' pounds of 'EXP'.
	WFRAG	Design fragment weight, ounces.
	VINIT	Initial velocity of the design fragment, feet per second.

The format then repeats itself, starting with 'GROUP', for each bomb, mortar round, and artillery round stored. The last line in WEAPON.DAT should be the code word 'END' (upper case), which indicates to ConWep where to start writing when a new weapon is saved.

Pressure-time histories

37. The "Aboveground detonations" routines allow the user to save pressure vs. time histories to a file. Time is written in units of milliseconds (msec), pressure in units of pounds per square inch (psi) or kilopascals (kPa).

Load distributions

38. The "Loads on Structures" routine allows the user to save peak pressure and impulse values across the face of a wall. The file format is shown below:

line	variable names	description
1	X1,Y1,X2,Y2	The cartesian coordinates of the lower left and upper right corners of the target wall, in feet or meters.
2	N,M	The number of grid columns and grid rows. There are N+1 node columns and M+1 node rows.

3	Z(1,1)	The magnitude of the pressure or impulse at node (Lower left corner). Pressure is in units of psi or kPa, impulse is in units of psi-msec or kPa-msec.
	Z(1,2)	
	.	
	Z(1,M+1)	
	Z(2,1)	
	.	
	Z(N+1,M+1)	

REFERENCES

1. Headquarters, Department of the Army. 1986. "Fundamentals of Protective Design for Conventional Weapons," Technical Manual 5-855-1, Washington, D.C.

2. Kingery, C., and Bulmash, G. 1984. "Airblast Parameters from TNT Spherical Air Burst and Hemispherical Surface Burst," Technical Report ARBRL-TR-02555, US Army Ballistic Research Laboratory, Aberdeen Proving Ground, Maryland 21005.

3. Baker, W. 1973. Explosions in Air. University of Texas Press, Austin, Texas.

4. Headquarters, Department of the Army. 1969. "Structures to Resist the Effects of Accidental Explosions," Technical Manual 5-1300, Washington, D.C.

APPENDIX A

SAMPLE PROGRAM INSTALLATION

1. Presented below is a sample installation of FunPro. User responses and comments are shown in boldface type. Default values are enclosed in brackets. Program installation will proceed much faster if the files are placed on a hard disk rather than diskettes. The user should not attempt to install the programs using a high-capacity (1.2 MB) diskette drive if the files are on double-density (360 KB) diskettes.

2. Care should be taken to insure that ConWep and FunPro are installed for the proper video adapter. If either program is installed improperly, attempts to perform graphics on the display will not work and will likely cause the system to freeze up (see Appendix C).

```
C:\TM5-855>INSTALL<CR>
INSTALL  20 Oct 1987

What program do you want to install?
Type the filename (e.g. CONWEP.EXE)
 and press RETURN ... FUNPRO.EXE<CR>

Enter the code for the display adapter / monitor
combination that best matches your system:
                                    Resolution x Colors
  0) Monochrome Display Adapter     NO GRAPHICS SUPPORTED
     w/ Monochrome Display
  1) Color Graphics Adapter         640 x 200 x 2
     w/ Color Display
  2) Enhanced Graphics Adapter      640 x 350 x 4
     w/ Monochrome Display
  3) Enhanced Graphics Adapter      640 x 200 x 16
     w/ Color Display
  4) Enhanced Graphics Adapter      640 x 200 x 16
     w/ Enhanced Color Display, 64K
  5) Enhanced Graphics Adapter      640 x 350 x 16/64
     w/ Enhanced Color Display, >64K
  6) NEC GB-1, or other 24 MHz EGA  640 x 480 x 16/64
     w/ NEC Multisync Monitor

Enter selection [1] ...  5          ( No <CR> )

Enter serial port no. for plotter:
  1) COM1:    2) COM2:
Enter selection [1] .... 1          ( No <CR> )
Please wait ...

Finished installing FUNPRO.EXE
C:\TM5-855>
```

APPENDIX B

SAMPLE CONWEP SESSION

A typical ConWep session is presented below. User responses are shown in boldface type.

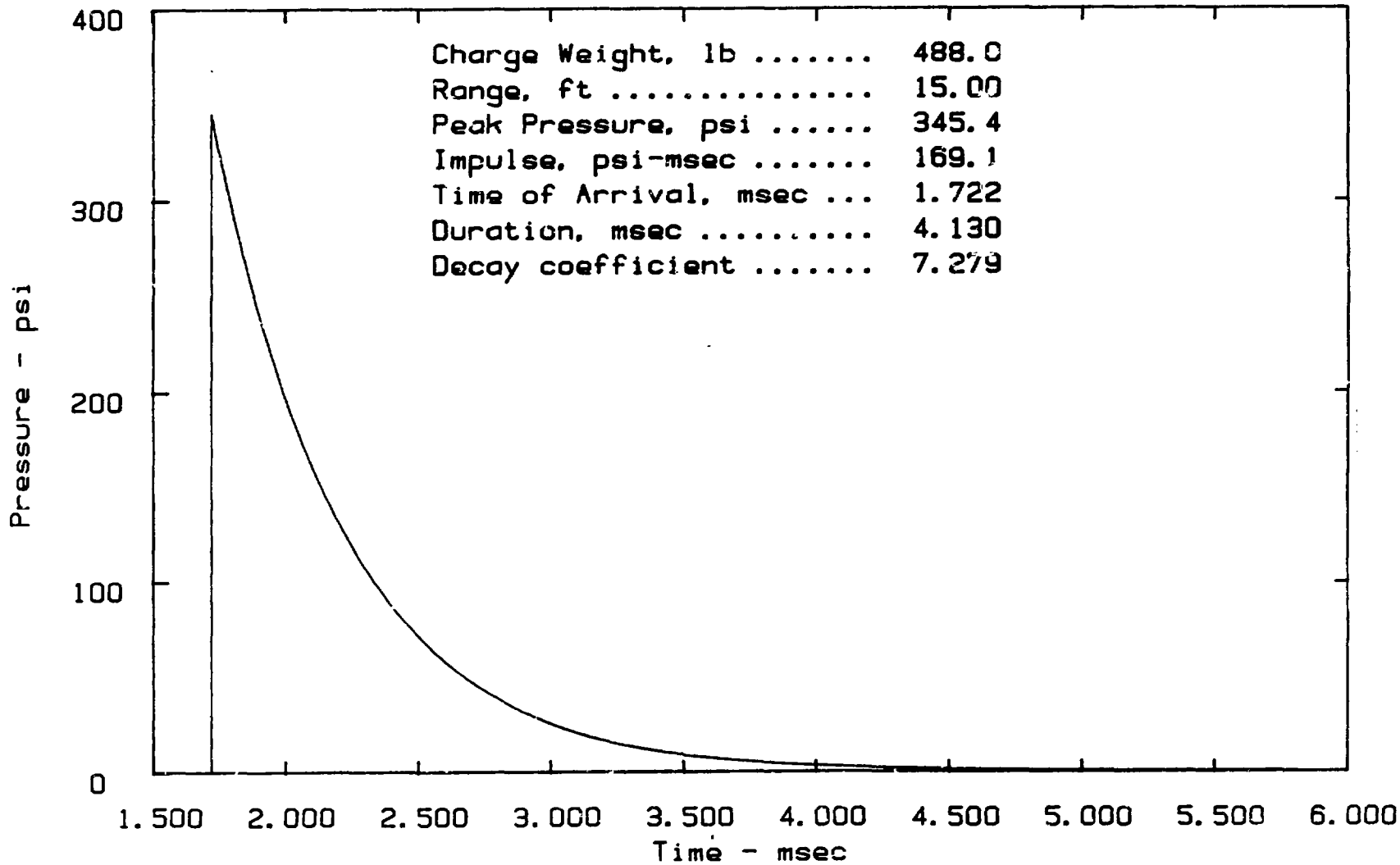
```
                    CONVENTIONAL WEAPONS EFFECTS

                              MAIN MENU

                       SELECT FROM THE FOLLOWING:

                        1. Airblast
                        2. Fragment penetration
                        3. Projectile penetration
                        4. Projectile path into earth
                        5. Shaped charge penetration
                        6. Cratering
                        7. Ground shock
                        8. Change weapon
                        9. Change units
                       10. Exit

                       Enter Selection...   1

                    Use (1) U.S. or (2) SI units? 1

                              AIRBLAST MENU

                       SELECT FROM THE FOLLOWING:

                    1. Aboveground detonation
                    2. Pressure attenuation in a tunnel
                    3. Internal detonation
                    4. Subsurface detonation
                    5. Loads on structures
                    6. Return to main menu

                    Enter Selection ...    1

                    PRESSURE-TIME HISTORY DUE TO A
                  CHEMICAL EXPLOSION, FROM ARBRL-TR-02555,
                "Airblast Parameters from TNT Spherical Air
                  Burst and Hemispherical Surface Burst"

                1. Find peak pressure given charge weight and range
                2. Find range given charge weight and peak pressure
                3. Find charge weight given peak pressure and range

                Enter Selection ...   1
```

```
                    WEAPONS MENU

          1. General Purpose (GP) Bomb
          2. Artillery Round
          3. Mortar Round
          4. Bare HE
          5. Inert Projectile
          6. User Defined Cased Weapon
          7. Update Weapons Data File

          Enter Selection...   1

            GENERAL PURPOSE BOMBS

        1. GP  250 Low-Drag Bomb (Snakeye)
        2. GP  250 Low-Drag Bomb (Mod 1)
        3. GP  500 Low-Drag Bomb (Snakeye)
        4. GP  500 Low-Drag Bomb (Mod 1)
        5. GP  750 Bomb
        6. GP  750 Low-Drag Bomb
        7. GP 1000 Low-Drag Bomb
        8. GP 2000 Low-Drag Bomb

       Enter Selection...    6
    WEAPON CHARACTERISTICS

    Name                              U.S. M117 (Retarded)
    Type                              GP 750 Bomb, Low-Drag
    Total weight, lb                  854.0
    Explosive weight, lb              386.0
    Case weight, lb                   345.0
    Explosive used                    H-6
    Assembled length, inches          82.00
    Case diameter, inches             16.00
    Brinell hardness no. for frag.    150.0

    DERIVED CHARACTERISTICS

    Equivalent weight of TNT, lb      488.0
    Design fragment weight, ounces    1.362
    Initial fragment velocity, fps    7828.


    Press <Enter> to continue ...  <CR>

Enter H for hemispherical surface burst,
 or S for spherical free-air burst  H

Enter range to target, ft      15
```

```
****************** ANSWERS **********************

Hemispherical surface burst
Equivalent weight of TNT, lb .......      488.0
Range to target, ft     ............      15.00

                YIELDS

Peak incident pressure, psi ........      345.4
Normally reflected pressure, psi ...      2395.
Time of arrival, msec ..............      1.722
Duration, msec .....................      4.130
Incident impulse, psi-msec .........      169.1
Reflected impulse, psi-msec ........      1141.
Shock front velocity, fps ..........      5103.
Decay coefficient A, where
 P(t)=Pso*(1-t/to)*exp(-A*t/to) ....      7.279

Press <Enter> when ready ...  <CR>

Options:
     1. List Incident P-T History
     2. Plot Incident P-T History
     3. Save Incident P-T History to disk
     4. List Reflected P-T History
     5. Plot Reflected P-T History
     6. Save Reflected P-T History to disk
     7. Re-run with new input
     8. List references/assumptions
     9. Exit to Airblast menu

     Enter selection ...   2

          (D)isplay or (P)lotter?     P
```

01-28-1988

Incident P-T History
Hemispherical Surface Burst



Options:

1. List Incident P-T History
2. Plot Incident P-T History
3. Save Incident P-T History to disk
4. List Reflected P-T History
5. Plot Reflected P-T History
6. Save Reflected P-T History to disk
7. Re-run with new input
8. List references/assumptions
9. Exit to Airblast menu

Enter selection ... 8

Assumptions/References:

The airblast parameters (peak incident & reflected pressure and impulse, positive phase duration, and time of arrival) are calculated using the equations found in ARBRL-TR-02555, "Airblast Parameters from TNT Spherical Air Burst and Hemispherical Surface Burst", by Charles N. Kingery and Gerald Bulmash, April 1984. This report contains a compilation of data from explosive tests using charge weights from less than 1 kg to over 400,000 kg. The authors used curve-fitting techniques to represent the data with polynomial equations, which are used by this program. These equations are presented in graphical form only in Figures 3-4 and 3-7 of TM 5-855-1, "Fundamentals of Protective Design for Conventional Weapons".

Press <Enter> to continue ... <CR>

Although TM 5-855-1 proposes using an approximate equivalent triangular pulse to represent the decay of the incident & reflected pressure, the program takes a more realistic approach, assuming an exponential decay of the pressure with time of the form:

$$P(t) = Pso*[1 - (t-Ta)/To]*exp[-A*(t-Ta)/To]$$

where P(t) = pressure at time t
Pso = peak incident pressure
To = positive phase duration
Ta = arrival time
A = decay coefficient

The above equation is usually referred to as the modified Friedlander equation. For more information on this and other approximations, see "Explosions in Air", by Wilfred Baker, University of Texas Press, 1973. Using the peak pressure, impulse, and duration from the equations explained above, the program iterates to find the decay coefficient A, which is dimensionless. The program then uses Friedlander's equation to find pressure values at various time steps.

Press <Enter> to continue ... <CR>

Options:

1. List Incident P-T History
2. Plot Incident P-T History
3. Save Incident P-T History to disk
4. List Reflected P-T History
5. Plot Reflected P-T History
6. Save Reflected P-T History to disk
7. Re-run with new input
8. List references/assumptions
9. Exit to Airblast menu

Enter selection ... 9

AIRBLAST MENU

SELECT FROM THE FOLLOWING:

1. Aboveground detonation
2. Pressure attenuation in a tunnel
3. Internal detonation
4. Subsurface detonation
5. Loads on structures
6. Return to main menu

Enter Selection ... 6

CONVENTIONAL WEAPONS EFFECTS

MAIN MENU

SELECT FROM THE FOLLOWING:

1. Airblast
2. Fragment penetration
3. Projectile penetration
4. Projectile path into earth
5. Shaped charge penetration
6. Cratering
7. Ground shock
8. Change weapon
9. Change units
10. Exit

Enter Selection... 6

CRATERING CALCULATION BASED ON TM 5-855-1,
"Fundamentals of Protective Design
for Conventional Weapons"

Choose from the following soil conditions:

1. Dry Sand
2. Dry Sandy Clay
3. Wet Sand
4. Dry Clay
5. Wet Sandy Clay
6. Wet Clay

Enter soil type selection number 2

Enter depth of burial, feet 18

********** ANSWERS **********
Backfill type ..... Dry Sandy Clay
Charge weight, lb 488.0
Depth of burial, feet 18.00

YIELDS

Apparent crater depth, feet 9.020

Apparent crater diameter, feet ... 29.61

Apparent crater volume, ft**3 .... 3106.

True crater depth, feet 21.15

True crater diameter, feet 35.61

Press <Enter> to continue ... <CR>

Options:
1. Plot crater profile
2. Plot apparent crater dimensions vs. DOB
3. Re-run with all new input
4. Change weapon only
5. Change soil conditions only
6. Change DOB only
7. List assumptions, references
8. Exit to main menu

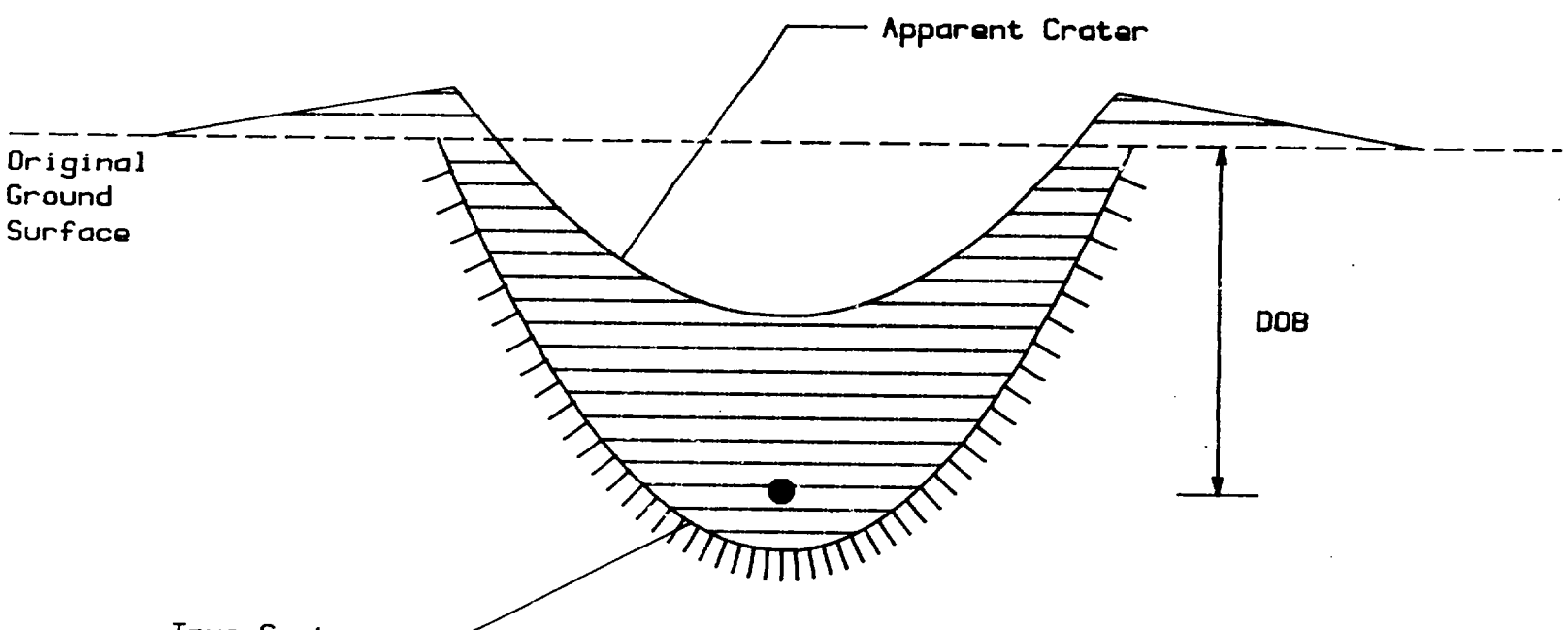
Enter selection 1

(D)isplay or (P)lotter ? P

Crater formation in Dry Sandy Clay

02-29-1988

Explosive weight	=	488.0 lb
Depth of burial	=	18.00 feet
Apparent depth	=	9.020 feet
Apparent diameter	=	29.61 feet
Apparent volume	=	3106. ft**3
True depth	=	21.15 feet
True diameter	=	35.61 feet



Options:

1. Plot crater profile
2. Plot apparent crater dimensions vs. DOB
3. Re-run with all new input
4. Change weapon only
5. Change soil conditions only
6. Change DOB only
7. List assumptions, references
8. Exit to main menu

Enter selection 7

Assumptions/References:

Procedures for determining crater dimensions are found in Chapter 5 of TM 5-855-1, "Fundamentals of Protective Design for Conventional Weapons". Apparent crater depth and diameter are determined using values from Figure 5-7 of TM 5-855-1.

Assumptions made in the manual:

The true crater diameter is assumed to be the apparent crater diameter + 15% up to the optimum DOB, after which it remains constant. The true crater depth is the greater of 1) the apparent crater depth and 2) the DOB + 0.4 * W**1/3 ft, where W is the explosive weight in pounds.

Assumptions made by this program:

For ALL soil types, the optimum DCB is assumed to be 1.5 * W**1/3 ft: Both the apparent and true craters are assumed to have a parabolic shape. The apparent crater volume is NOT based on any empirical data. It is based solely on the assumption of a parabolic shape.

Press <Enter> to continue ... <CR>

Options:

1. Plot crater profile
2. Plot apparent crater dimensions vs. DOB
3. Re-run with all new input
4. Change weapon only
5. Change soil conditions only
6. Change DOB only
7. List assumptions, references
8. Exit to main menu

Enter selection 8

```
                    CONVENTIONAL WEAPONS EFFECTS

                            MAIN MENU

                     SELECT FROM THE FOLLOWING:

                      1. Airblast
                      2. Fragment penetration
                      3. Projectile penetration
                      4. Projectile path into earth
                      5. Shaped charge penetration
                      6. Cratering
                      7. Ground shock
                      8. Change weapon
                      9. Change units
                     10. Exit

                     Enter Selection...   10

C:\TM5-855>
```

APPENDIX C
ERROR MESSAGES

Errors Common to Both Programs

"This program has not been installed for the
display adapter in use. Please run the INSTALL
program. Press any key to continue ... "

Self-explanatory. The program (either FunPro or ConWep) first looks at it's internal data to find a code for the graphics adapter/monitor in use. The above message is displayed if the code is not valid. Run the INSTALL program as explained in paragraph 10. If either program is installed for the incorrect video adapter, subsequent attempts to display graphics will likely cause the system to freeze up. If this occurs, the user should initialize the computer (press the <Ctrl>, <Alt>, and <Del> keys simultaneously) and run the INSTALL program again.

"Insufficient memory"

There is not enough available memory (RAM) on the host system to run the program. Both FunPro and ConWep require about 400 KB (409,600 bytes) of RAM. If the host system is equipped with enough memory, then the user should check to see if any memory resident programs are installed. It may be necessary to remove some or all of these programs from memory to run ConWep and/or FunPro.

"Write fault error writing device COM<n>: Abort, Retry, Ignore?"

This is an operating system error message that usually occurs when sending graphics to a plotter. If a plot has already started when this error message occurs, it indicates that the plotter's data buffer is full. The user may either continually press 'R' for "Retry", or prevent this error from occurring by using the "MODE" statement explained in paragraph 13. If the plotter has not started, the probable cause of this error message is the program being installed for the wrong serial port.

"Incorrect DOS version"

Both FunPro and ConWep require PC-DOS or MS-DOS (Disk Operating System) version 2.10 or a later version.

FunPro Error Messages

"Cannot find (filename.ext)
Enter a new filespec, or press <Enter> to
cancel ..."

The program cannot find the named file in the current subdirectory on the current default drive. Either 1) Type in the full file specification (d:\path\filename.ext), or 2) Press <Enter>, which causes FunPro to return to the main menu, where the default drive specification may be changed to the one where the text and/or figure data files are located. From the figures routine, it is not necessary to type in the full name of the data file for the desired figure. For example, to view Figure 4-11, after choosing "Select a figure", the proper response is '4-11'.

"Printer does not respond"

Either 1) The printer is not turned on or is off line, 2) The printer is currently busy, or 3) The printer is not found at the first parallel port (LPT1).

"ERROR: The selected figure has a logarithmic
scale on the X (or Y) axis, and the data file
(filename.ext)
has (n) zero or negative X (Y) value(s)."

This error indicates that the user has attempted to plot a non-positive value on a logarithmic scale using the "Enter other data" feature of the figures routine in FunPro.

ConWep Error Messages

"PLEASE SELECT A WEAPON WITH A CHARGE WEIGHT!" or "CASE WEIGHT", etc.

Not all of the weapons built into ConWep are appropriate for all of the weapons effects routines. For example, the airblast routines expect a weapon with some explosive content (not an inert projectile). The program will return to the weapons menu until an appropriate weapon for the current routine is selected.

"ConWep has detected an error while reading the file WEAPON.DAT. The error is probably due to a premature termination of this program at an earlier time. To correct this situation, delete the file WEAPON.DAT"

Self-explanatory.