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HAND CALCULATOR PROGRAMS FOR WEAPONS EFFECTS ANALYSES – THE PHYSICAL VULNERABILITY SYSTEM

Vaughn E. Culler

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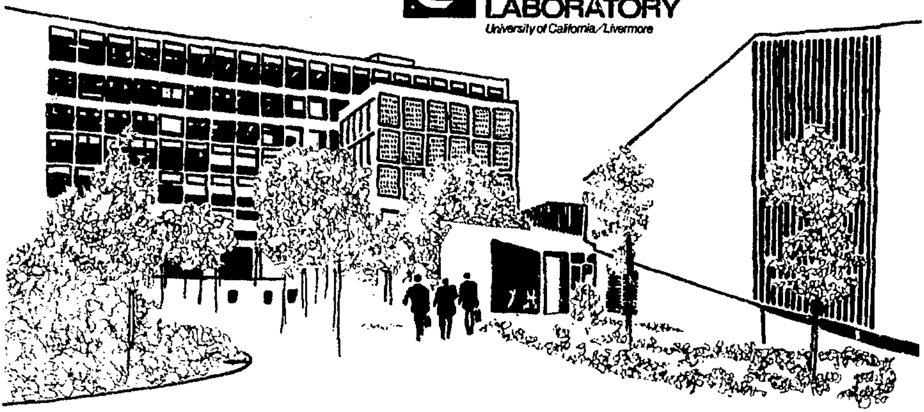

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LAWRENCE LIVERMORE LABORATORY
University of California Livermore, California 94550

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HAND CALCULATOR PROGRAMS FOR WEAPONS EFFECTS ANALYSES — THE PHYSICAL VULNERABILITY SYSTEM

Abstract

The physical vulnerability system for evaluating probable damage from a nuclear blast has received wide acceptance because it is a simple but general system applicable to a wide variety of target classes. We describe here a series of hand-calculator programs using this system that permit equally accurate but faster calculations than the conventional handbook method. The programs cover various interrelationships among peak overpressures, peak dynamic pressures, vulnerability numbers, weapons radii, and kill probability. The use of a programmable calculator greatly reduces the chance of operator error by eliminating individual hand calculations and graphical determinations of parameter values.

Introduction

Nuclear-blast damage evaluations are usually prepared from a variety of graphs, nomographs, tables, and hand calculations.[1] Opportunities for error abound. Cross checks are either difficult or impossible. The tedium of a parameter study can be onerous; one often tries to lessen the burden by making simplifying approximations that can sometimes lead to erroneous conclusions.

We have found that exploitation of the capabilities of a programmable calculator — in our case, the Hewlett-Packard HP-65* — leads to faster, more accurate calculations with fewer operator error. A tenfold, even hundredfold, increase in speed is often attainable. In Table 1 we list the titles of some weapons effects programs we have developed for the HP-65. The symbolism, basically that of Ref. 1, is explained in the individual programs. In Table 2 we give the input parameters, the output (what is calculated), and the typical running time for each program.

The balance of this document is given over to the individual programs. Each is presented in the same format: a short description, then user instructions, example(s) of use, and finally a program listing that can be recorded

Table 1. Weapons effects programs for the HP-65.

Program number	Title
WE-975-1	Target Hardness Distribution Functions
WE-975-2	Determination of Adjusted Vulnerability Numbers for P-Type Targets
WE-975-3	Peak Overpressures and Adjusted Vulnerability Numbers for P-Type Targets
WE-975-4	P_k, WE_0, and WR for P-Type Point Targets — Surface Burst
WE-975-5	P_k, WE_0, and WR for P-Type Point Targets — Optimum Height of Burst
WE-975-6	Determination of Adjusted Vulnerability Numbers for Q-Type Targets
WE-975-7	Peak Dynamic Pressures and Adjusted Vulnerability Numbers for Q-Type Targets
WE-975-8	P_k, WR_0, and WR for Q-Type Point Targets — Surface Burst
WE-975-9	Overpressure or Dynamic Pressure from the Adjusted Vulnerability Number
WE-975-10	Peak Overpressure Given Yield and Range for Surface Burst or Free Air Burst
WE-975-11	Peak Overpressure to/from VN_{adj}
WE-975-12	Peak Dynamic Pressure to/from VN_{adj}

on a program card. The categorizing number system for the programs is somewhat arbitrary: first, there are identifiers WE (for Weapons Effects) and 975 (September 1975) to date the program, then there is a cardinal number to distinguish each program from others of the same family and age.

Because the procedures for weapons effects analyses have not yet been metricated, we retain English units in the programs but do include SI units if calculator memory is large enough to permit their inclusion. The trend is toward larger memories which, when available, will permit the use of either type units with very simple modifications. Many of the programs have been designed with the transition to more powerful calculators in mind. For example, input parameters and calculated results are stored in memory whenever conveniently possible.

Table 2. Input parameters, outputs (what is calculated), and typical running times of weapons effects programs.

Program number	Input	Output	Typical running time, s
WE-975-1	p and $p_{0.5}$ or q and $q_{0.5}$	P_k	15
WE-975-2	VN_0, K, W	VN_{adj}	<10
WE-975-3	VN_0, K, W	p, VN_{adj}	10
WE-975-4	VN_{adj} and W (either entered directly or from WE-975-2 or -11), CEP	P_k, WR_0, WR (surface burst)	<10
WE-975-5	VN_{adj} and W (either entered directly or from WE-975-2), CEP	P_k, WR_0, WR (optimum HOB)	<10
WE-975-6	VN_0, K, W	VN_{adj}	15
WE-975-7	VN_0, K, W	q, VN_{adj}	20
WE-975-8	VN_{adj} and W (either entered directly or from WE-975-6 or -12), CEP	P_k, WR_0, WR (surface burst)	<10
WE-975-9	P-type VN_{adj} or Q-type VN_{adj}	p or q	<5
WE-975-10	W,R	p	5
WE-975-11	VN_{adj} or p	p or VN_{adj}	<5
WE-975-12	VN_{adj} or q	q or VN_{adj}	<5

The programs with the longer running times have the common characteristic of using inefficient iterations, because of limited calculator memory. The choice of inefficient iterations over approximations of limited range or accuracy was deliberate; even the longest program has a typical running time of only 20 s, iterations and all.

Although we do not know of any "bugs" in the programs, we cannot guarantee there are none. If any are discovered, we would appreciate hearing about them.

Washing of hands — an author's caveat! These programs were written in self-defense. I need to speak the "lingo" of the physical vulnerability system and to understand what others were saying when that lingo was used. *Use the programs as tools, not as oracles!*

Programs

Our weapons effects programs for the HP-65 are described on the following pages.

Description

A fundamental requirement of any handbook-type treatment of blast effects is that the effects must be calculable for a wide range of target types.

To meet this requirement, the physical vulnerability system is based on likelihood or probability that a specified level of damage to a given class of structures can often be described by a lognormal distribution of peak overpressure or peak dynamic pressure. Thus, the same types of equations, but with different constants, apply to a wide range of different target classes.

For "P-type" targets — those vulnerable primarily to peak overpressure (p) — the lognormal distribution describing the expected damage is

$$F(p,W) = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{z} e^{-t^2/2}\, dt, \tag{1}$$

where F(p,W) is the probability that a target selected at random from the population will have a blast hardness less than or equal to p for a nuclear explosion of yield W and for z given by

$$z = \frac{1}{\alpha_p} \ln \left(p/p_{0.5}\right). \tag{2}$$

Note that $p_{0.5}$ is the value of p for which F(p,W) is equal to 1/2.

One of the great generalizations of the physical vulnerability system for nuclear weapons is that, for *every* class of targets vulnerable to peak overpressure, α_p has the *same* value. A second great generalization is that the same types of relations hold for "Q-type" targets — those vulnerable to peak dynamic pressure (q) — and that the corresponding α_q also has the *same* value for *every* class of such targets.

We therefore describe all peak-overpressure targets by Eqs. (1) and (2) or, in differential form,

$$f(p,W) = \frac{dF(p,W)}{dx} = \frac{1}{\sqrt{2\pi}\,\alpha_p} e^{-x^2/2\alpha_p^2}, \tag{3}$$

where $x = \ln (p/p_{0.5})$ and $f(p,W)$ is interpreted as a probability density function. Thus $f(p,W)dx$ is the probability that a target selected at random will have a hardness in the logarithmic increment x to $x + dx$.

Equations formally identical to (1), (2), and (3) apply for Q-type targets in that q, $q_{0.5}$ and α_q replace p, $p_{0.5}$, and α_p:

$$F(q,W) = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{z} e^{-t^2/2} \, dt; \tag{4}$$

$$z = \frac{1}{\alpha_q} \ln (q/q_{0.5}); \tag{5}$$

$$f(q,W) = \frac{dF(q, W)}{dx} = \frac{1}{\sqrt{2\pi}\, \alpha_q} e^{-x^2/2\alpha_q^2}, \tag{6}$$

where $x = \ln(q/q_{0.5})$.

This program calculates f and F for either P-type or Q-type targets as functions of either p (given $p_{0.5}$) or q (given $q_{0.5}$). The constants $\alpha_p = 0.29718$ and $\alpha_q = 1.0419$ are contained in the program. The appropriate one is generated in a preliminary operation. Once α_p or α_q is selected, there are some built-in constraints that keep the proper value locked into the program and hence tamperproof to any but a deliberate change. The results are calculated correctly to at least three significant figures.

User Instructions

Step	Instructions/ comments	Input data/units	Key	Output data/units
1	Enter program.			
2	Preliminary calculation:			
	for P-type		D	α_p/0.30
	for Q-type		E	α_q/1.04
	The remaining instructions are for a P-type calculation. A Q-type would be identical except q would appear instead of p.			
3	Enter p.		A	p
4	Enter $p_{0.5}$, calculate f(p,W).		R/S	f(p,W)

Users Instructions (Cont.)

Step	Instructions comments	Input data/units	Key	Output data/units
5	Continue calculation to obtain F(p,W).		R/S	F(p,W)

For new problem of same type, return to step 3.

N.B.: If f is not wanted, the R/S stop at key entry 37 (just before "LBL" may be deleted. Then step 5 above is deleted because the output from step 4 output will be F.

Typical running time: 15 s.

Example

At a given yield, $p_{0.5}$ is 75 psi. What fraction of the same type targets would be expected to be damaged at least to the same characteristic level if p were 150 psi? 90 psi?

Step	Instructions/ Comments	Input data/units	Key	Output data/units
1	Enter program.			
2	P-type calculation, initialize accordingly.		D	0.30
3	Enter p.	150 psi	A	150.00
4	Enter $p_{0.5}$, calculate f(p,W) or output. Note there are now three decimal places in answer.	75	R/S	f/0.088
5	Continue calculation to obtain F(p,W) for p = 150 psi.		R/S	F/0.990
Return to Step 3 for p = 90 psi calculations:				
3	Enter p.	90	A	90.000
4	Enter $p_{0.5}$, calculate f.	75	R/S	f/1.112
5	Continue calculation to obtain F for p = 90 psi.		R/S	F/0.730

Answer: For p = 150 psi, 99.0%; for p = 90 psi, 73.0%.

Program WE-975-1 Listing

Key entry	Code shown	Key entry	Code shown	Key entry	Code shown	Key entry	Code shown
LBL	23	÷	81	RCL 4	34 04	0	00
A	11	f	31	X	71	4	04
↑	41	$\sqrt{x}$	09	RCL 7	34 07	1	01
R/S	84	STO 4	33 04	X	71	9	09
÷	81	RCL 5	34 05	•	83	STO 5	33 05
f	31	÷	81	5	05	RTN	24
LN	07	R/S	84	÷	61	GTO	22
RCL 5	34 05	LBL	23	RTN	24	E	15
÷	81	1	01	LBL	23		
DSP	21	RCL 1	34 01	B	12		
•	83	RCL 3	34 03	0	00		
3	03	÷	81	R/S	84		
STO 7	33 07	RCL 6	34 06	GTO	22		
↑	41	X	71	B	12		
X	71	STO 6	33 06	LBL	23		
STO 1	33 01	STO	33	D	14		
1	01	+	61	•	83		
STO 6	33 06	2	02	2	02		
STO 2	33 02	2	02	9	09		
2	02	STO	33	7	07		
+	61	+	61	1	01		
STO 3	33 03	3	03	8	08		
RCL 1	34 01	EEX	43	STO 5	33 05		
CHS	42	CHS	42	RTN	24		
f^{-1}	32	4	04	GTO	22		
LN	07	RCL 6	34 06	D	14		
g	35	g x>y	35 24	LBL	23		
π	02	GTO	22	E	15		
↑	41	1	01	1	01		
+	61	RCL 2	34 02	•	83		

Registers	
R_1	Used
R_2	Used
R_3	Used
R_4	Used
R_5	α_p or α_q
R_6	Used
R_7	Used
R_8	–
R_9	Used

PROGRAM WE-975-2. DETERMINATION OF ADJUSTED VULNERABILITY NUMBERS FOR P-TYPE TARGETS

Description

From the vulnerability number VN, of the form VN_0 P K, and the weapon yield W, the adjusted vulnerability number VN_{adj} is calculated. No approximations are made in the program. Parametric studies of VN_{adj} as a function of either K or W are readily effected.

User Instructions

Step	Instructions/ comments	Input data/units	Key	Output data/units
1	Enter program			
	Vulnerability number is of form VN_0 P K.			
2	Enter VN_0.	VN_0	A	VN_0
3	Enter K.	K	B	K/10
4	Enter W in Mt.	W(Mt)	C	VN_{adj}
	Step 4 may be repeated for other values of W.			
	If it is desired to determine VN_{adj} as a function of K for fixed W, key entry 11 (see listing) may be changed from R/S to RCL5 and W must be entered separately, once, in register 5. Then step 3 above will calculate VN_{adj} as its output and may be repeated for other values of K. Step 4 will be deleted.			

Typical running time: less than 10 s.

Example

The VN of a target is 25P6. What is VN_{adj} for a weapon yield of 0.1 Mt? 1 Mt?

Step	Instructions/ comments	Input data/units	Key	Output data/units
1	Enter program.			
2	Enter VN_0.	25	A	25.00
3	Enter K.	6	B	0.60

Example (Cont.)

Step	Instructions/ comments	Input data/units	Key	Output data/units
4	Enter W in Mt.	0.1	C	22.98
	Answer: VN_{adj} for W = 0.1 Mt is 22.98 for a 25P6 target.			
	For W = 1 Mt, we need only repeat step 4:			
4	Enter W in Mt.	1	C	21.38
	Answer: VN_{adj} for W = 1 Mt is 21.38 for a 25P6 target.			

Program WE-975-2 Listing

Key entry	Code shown	Key entry	Code shown	Key entry	Code shown	Key entry	Code shown
LBL	23	RCL 4	34 04	STO 7	33 07	f	31
A	11	-	51	1	01	LN	07
STO 3	33 03	STO 6	33 06	+	61	÷	81
R/S	84	RCL 4	34 04	+	31	RCL 3	34 03
LBL	23	↑	41	$\sqrt{x}$	09	+	61
B	12	X	71	1	01	RTN	24
1	01	÷	81	+	61	LBL	23
0	00	4	04	↑	41	D	14
÷	81	X	71	+	61	RCL 3	34 03
STO 4	33 04	RCL 5	34 05	RCL 7	34 07	RTN	24
R/S	84	5	05	÷	81	Registers	
LBL	23	0	00	1	01	R_1	-
C	13	X	71	+	61	R_2	-
STO 5	33 05	2	02	RCL 6	34 06	R_3	VN_0
RCL 4	34 04	↑	41	X	71	R_4	K/10
0	00	3	03	f	31	R_5	W(Mt)
g x=y	35 23	÷	81	LN	07	R_6	1-K/10
GTO	22	g	35	1	01	R_7	Used
D	14	y^x	05	•	83	R_8	-
1	01	X	71	2	02	R_9	Used

PROGRAM WE-975-3. PEAK OVERPRESSURES AND ADJUSTED VULNERABILITY NUMBERS FOR P-TYPE TARGETS

Description

This program is similar to WE-975-2 but has the added feature of computing the peak overpressure p corresponding to VN_{adj} as well as VN_{adj} itself. If the peak overpressure (ordinarily interpreted as that associated with a 50% probability of damage; i.e., $P_{0.5}$ of Ref. 1) is not desired, WE-975-2 is preferable. No approximations are made in the program.

User Instructions

Step	Instructions/ comments	Input data/units	Key	Output data/units
1	Enter program.			
	Vulnerability number is of form VN_0 P K.			
2	Enter VN_0	VN_0	A	VN_0
3	Enter K.	K	B	K/10
4	Enter W in Mt.	W(Mt)	C	p(psi)
5	Optional step to obtain peak overpressure, p, in kPa.		E	p(kPa)
6	Optional step to obtain VN_{adj}.		RCL 1	VN_{adj}
	For other values of W, repeat, starting with step 4.			
	If it is desired to determine p as a function of K for fixed W, key entry 11 may be changed from R/S to RCL5 and W must then be entered separately, once, in register 5. Then step 3 (and 5 and/or 6) above may be repeated for other values of K, and step 4 is omitted.			

Typical running time: 10 s.

Example

The VN of a target is 25P6. What are p and VN_{adj} for a weapon yield of 0.1 Mt? 1 Mt?

Step	Instructions comments	Input data/units	Key	Output data/units
1	Enter program.			
2	Enter VN_0.	25	A	25.00
3	Enter K.	6	B	0.60
4	Enter W in Mt.	0.1	C	74.03 (psi)
5	(for p in kPa).		E	510.41 (kPa)
6	(for VN_{adj}).		RCL 1	22.98
	Repeat for W = 1 Mt:			
4	Enter W in Mt.	1	C	55.33 (psi)
5	(for p in kPa).		E	381.50 (kPa)
6	(for VN_{adj}).		RCL 1	21.38

Answer: For a weapon yield of 0.1 Mt and a 25P6 target, p is 74.03 psi or 510.41 kPa, and VN_{adj} is 22.98. For 1 Mt, we find p is 55.33 psi or 381.50 kPa, and VN_{adj} is 21.38.

Program WE-975-3 Listing

Key entry	Code shown	Key entry	Code shown	Key entry	Code shown	Key entry	Code shown
LBL	23	5	05	f	31	•	83
A	11	0	00	LN	07	8	08
STO 3	33 03	X	71	÷	81	9	09
R/S	84	2	02	RCL	34 03	5	05
LBL	23	↑	41	+	61	X	71
B	12	3	03	GTO	22	RTN	24
1	01	÷	81	1	01		
0	00	g	35	LBL	23		
÷	81	y^x	05	D	14		
STO 4	33 04	X	71	RCL 3	34 03		
R/S	84	STO 7	33 07	LBL	23		
LBL	23	1	01	1	01		
C	13	+	61	STO 1	33 01		
STO 5	33 05	f	31	1	01		
RCL 4	34 04	√x	09	•	83		
0	00	1	01	2	02		
g x=y	35 23	+	61	RCL 1	34 01		
GTO	22	↑	41	g	35		
D	14	÷	61	y^x	05		
1	01	RCL 7	34 07	1	01		
RCL 4	34 04	÷	81	•	83		
-	51	1	01	1	01		
STO 6	33 06	+	61	2	02		
RCL 4	34 04	RCL 6	34 06	1	01		
↑	41	X	71	6	06		
X	71	f	31	X	71		
÷	81	LN	07	RTN	24		
4	04	1	01	LBL	23		
X	71	•	83	E	15		
RCL 5	34 05	2	02	6	06		

Registers	
R_1	VN_{adj}
R_2	-
R_3	VN_0
R_4	K/10
R_5	W(Mt)
R_6	1-K/10
R_7	Used
R_8	-
R_9	Used

PROGRAM WE-975-4. P_k, WR_0, AND WR FOR P-TYPE POINT TARGETS — SURFACE BURST

Description

The adjusted vulnerability number VN_{adj}, the weapon yield W (Mt), and the CEP (ft) of the delivery vehicle are the input parameters for this calculation. Ordinarily, this program is used after WE-975-2 without clearing the calculator, in which case VN_{adj} and W are already entered for calculation and only the CEP must be entered by the operator. P_k, the probability of a "kill" at the damage level appropriate to the vulnerability number, is determined, as are the scaled weapon radius WR_0 and the weapon radius WR. Parametric studies based on CEP are particularly facile.

Note that the calculation is for P-type point targets and for a surface burst. Error, defined as deviation from the results obtained using Ref. 1, results from an analytic fit[2] to obtain WR_0 from VN_{adj}. Typically this "error" is less than 5%. No further approximations are made in obtaining WR and P_k, so the "error" in WR is the same as that for WR_0 and the "error" in the value of P_k is typically no more than ±0.02.

User Instructions

Step	Instructions comments	Input data/units	Key	Output data/units
1	Enter program. If used after WE-975-2, W is in register 5, VN_{adj} is in the x-register. If not, enter them in the correct registers.		A	$WR_0(ft/kt^{1/3})$
2	Enter CEP.	CEP(ft)	B	P_k
3	Optional step to obtain WR if desired.		RCL 4	WR(ft)
	Step 2 may be repeated for other CEP's:			
2	Enter CEP.		B	P_k
3	Optional step to obtain WR if desired.		RCL 4	WR(ft)

Typical running time: less than 10 s.

Example

What are P_k, WR_0, and WR for the first examole of WE-975-2 (a 25P6 target with W of 0.1 Mt) for a 1000-ft CEP?

For these conditions, we found in WE-975-2 that VN_{adj} was 22.98. Ordinarily, however, WE-975-4 is used as a continuation of WE-975-2, so that program is run first.

Step	Instructions/ comments	Input data/units	Key	Output data/units
Preliminary	Run WE-975-2 for a 25P6 target, W = 0.1 Mt.			22.98
1	Enter this program (WE-975-4).	22.98	A	381.20
2	Enter CEP.	1000	B	0.84
3	Obtain WR.		RCL 4	1769.35
	Answer: P_k is 0.84, WR_0 is 381.20 ft/kt$^{1/3}$, and WR is 1769.35 ft.			
	Question: If the CEP were 1500 ft instead of 1000 ft, what would P_k, WR_0, and WR be?			
2	Enter CEP.	1500	B	0.59
3	Obtain WR.		RCL 4	1769.35
	Answer: P_k for 1500 ft CEP is 0.59. WR_0 and WR are unchanged because neither is a function of the CEP.			

Note: Since we knew VN_{adj} was 22.98, we could have entered W in register 5 and VN_{adj} in the x-register without first running WE-975-2. We would obtain, for the 1000 ft CEP, P_k = 0.84, WR_0 = 381.18 ft/kt$^{1/3}$, and WR = 1769.30 ft. The negligible numerical difference from the above example are, of course, a result of rounding in the direct entry of VN_{adj}.

Program WE-975-4 Listing

Key entry	Code shown	Key entry	Code shown	Key entry	Code shown	Key entry	Code shown
LBL	23	•	83	X	71	↑	41
A	11	9	09	2	02	+	61
STO 1	33 01	RCL 1	34 01	f	31	÷	81
1	01	g	35	LN	07	CHS	42
2	02	y^x	05	2	02	f^{-1}	32
RCL 1	34 01	3	03	X	71	LN	07
g x=y	35 23	7	07	÷	81	CHS	42
GTO	22	3	03	STO 2	33 02	1	01
1	01	0	00	RCL 5	34 05	+	61
2	02	X	71	3	03	RTN	24
2	02	STO 1	33 01	g	35		
RCL 1	34 01	RTN	24	1/x	04		
g x=y	35 23	LBL	23	g	35		
GTO	22	2	02	y^x	05		
2	02	•	83	1	01		
•	83	9	09	0	00		
9	09	1	01	X	71		
4	04	RCL 1	34 01	RCL 1	34 01		
RCL 1	34 01	g	35	X	71		
g	35	y^x	05	STO 4	33 04		
y^x	05	3	03	↑	41		
1	01	2	02	X	71		
5	05	8	08	↑	41		
8	08	0	00	↑	41		
0	00	X	71	•	83		
X	71	STO 1	33 01	0	00		
STO 1	33 01	RTN	24	4	04		
RTN	24	LBL	23	X	71		
LBL	23	B	12	RCL 2	34 02		
1	01	↑	41	+	61		

Registers	
R_1	WR_0
R_2	Used
R_3	-
R_4	WR
R_5	W(Mt)
R_6	-
R_7	-
R_8	-
R_9	Used

PROGRAM WE-975-5. P_k, WR_0, AND WR FOR P-TYPE POINT TARGETS — OPTIMUM HEIGHT OF BURST

Description

The adjusted vulnerability number VN_{adj}, the weapon yield W (Mt), and the CEP (ft) of the delivery vehicle are the input parameters for this calculation. Ordinarily, this program is used after WE-975-2 without clearing the calculator, in which case VN_{adj} and W are already entered for calculation and only the CEP must be entered by the operator. P_k, the probability of a "kill" at the damage level appropriate to the vulnerability number, is determined, as are the scaled weapon radius WR_0 and the weapon radius WR.

Note that the calculation is for P-type point targets and for optimum height of burst. Optimum height of burst for this program is defined by an empirical fit,[2] based on Table I-16 of Ref. 1, that maximizes the scaled weapon radius as a function of scaled height of burst. Error, defined as deviation from the results obtained using Ref. 1, is typically less than 5%. No further approximations are made in obtaining WR and P_k, so the "error" for WR is the same as that for WR_0 and the "error" in the value of P_k is typically no more than ±0.02.

User Instructions

Step	Instructions Comments	Input data/units	Key	Output data/units
1	Enter program. If used after program WE-975-2, W is the register 5, VN_{adj} is in the x-register. If not, enter them in the correct registers.		A	$WR_0(ft/kt^{1/3})$
2	Enter CEP.	CEP(ft)	B	P_k
3	Optional step to obtain WR if desired.		RCL 4	WR(ft)
	Step 2 may be repeated for other CEP's:			
2	Enter CEP.		B	P_k
3	Optional step to obtain WR if desired.		RCL 4	WR(ft)

Typical running time: less than 10 s.

Example

What are P_k, WR_0, and WR for the first example of WE-975-2 (a 25P6 target with W of 0.1 Mt) for a 1000-ft CEP?

For these conditions, we found in WE-975-2 that VN_{adj} was 22.98. Ordinarily, however, WE-975-5 is used as a continuation of WE-975-2, so that program is run first.

Step	Instructions/ comments	Input data/units	Key	Output data/units
Preliminary	Run WE-975-2 for a 25P6 target, W = 0.1 Mt.			22.98
1	Enter this program (WE-975-5).	22.98	A	416.96
2	Enter CEP.	1000	B	0.88
3	Obtain WR.		RCL 4	1935.35

Answer: P_k is 0.88, WR_0 is 416.96 ft/kt$^{1/3}$ and WR is 1935.35 ft.

Question: If the CEP were 1500 ft instead of 1000 ft, what would P_k, WR_0, and WR be?

Step	Instructions/ comments	Input data/units	Key	Output data/units
2	Enter CEP.	1500	B	0.65
3	Obtain WR.		RCL 4	1935.35

Answer: P_k for 1500 ft CEP is 0.65. WR_0 and WR are unchanged because neither is a function of the CEP.

Note: Since we knew VN_{adj} was 22.98, we could have entered W in register 5 and VN_{adj} in the x-register without first running WE-975-2. We would obtain, for the 1000-ft CEP, P_k = 0.88, WR_0 = 416.95 ft/kt$^{1/3}$, and WR = 1935.29 ft. The negligible numerical differences from the above example are, of course, a result of rounding in the direct entry of VN_{adj}.

Program WE-975-5 Listing

Key entry	Code shown	Key entry	Code shown	Key entry	Code shown	Key entry	Code shown
LBL	23	•	83	3	03	+	61
A	11	9	09	g	35	RTN	24
STO 1	33 01	3	03	1/x	04		
2	02	7	07	g	35		
1	01	6	06	y^x	05		
•	83	2	02	1	01		
3	03	RCL 1	34 01	0	00		
4	04	g	35	x	71		
g x≤y	35 22	y^x	05	RCL 1	34 01		
GTO	22	1	01	X	71		
1	01	8	08	STO 4	33 04		
•	83	3	03	↑	41		
8	08	1	01	X	71		
8	08	•	83	STO 3	33 03		
4	04	9	09	•	83		
6	06	X	71	0	00		
RCL 1	34 01	STO 1	33 01	4	04		
g	35	RTN	24	X	71		
y^x	05	LBL	23	RCL 2	34 02		
6	06	B	12	+	61		
3	03	↑	41	↑	41		
4	04	X	71	+	61		
3	03	2	02	RCL 3	34 03		
•	83	↑	41	g x⇄y	35 07		
5	05	f	31	÷	81		
X	71	LN	07	CHS	42		
STO 1	33 01	X	71	f^{-1}	32		
RTN	24	÷	81	LN	07		
LBL	23	STO 2	33 02	CHS	42		
1	01	RCL 5	34 05	1	01		

Registers	
R_1	WR_0
R_2	Used
R_3	Used
R_4	WR
R_5	W(Mt)
R_6	-
R_7	-
R_8	-
R_9	Used

PROGRAM WE-975-6. DETERMINATION OF ADJUSTED VULNERABILITY NUMBERS FOR Q-TYPE TARGETS

Description

From the vulnerability number VN, of the form VN_0 Q K, and the weapon yield W, the adjusted vulnerability number WN_{adj} is calculated. An iteration made in the program could result in an "error" of no more than 1 in the second decimal place of VN_{adj}. Parametric studies of VN_{adj} as a function of either K or W are readily effected.

User Instructions

Step	Instructions comments	Input data/units	Key	Output data/units
1	Enter program. Vulnerability number is of form VN_0 Q K.			
2	Enter VN_0.	VN_0	A	VN_0
3	Enter K.	K	B	K/10
4	Enter W in Mt.	W(Mt)	C	VN_{adj}

Step 4 may be repeated for other values of W.

If it is desired to determine VN_{adj} as a function of K for fixed W, key entry 11 (see listing) may be changed from R/S to RCL 5, and W must then be entered separately, once, in register 5. Then, step 3 above will calculate VN_{adj} as its output and may be repeated for other values of K. Step 4 will be deleted.

Typical running time: 15 s.

Example

The VN of a target is 25Q6. What is VN_{adj} for a weapon yield of 0.1 Mt? 1 Mt?

Step	Instructions/ comments	Input data/units	Key	Output data/units
1	Enter program.			
2	Enter VN_0.	25	A	25.00
3	Enter K.	6	B	0.60

Example (Cont.)

Step	Instructions/ comments	Input data/units	Key	Output data/units
4	Enter W in Mt.	0.1	C	24.07

Answer: VN_{adj} for W = 0.1 Mt is 24.07 for a 25Q6 target.

For W = 1 Mt, we need only repeat step 4:

Step	Instructions/ comments	Input data/units	Key	Output data/units
4	Enter W in Mt.	1	C	23.27

Answer: VN_{adj} for W = 1 Mt is 23.27 for a 25Q6 target.

Program WE-975-6 Listing

Key entry	Code shown	Key entry	Code shown	Key entry	Code shown	Key entry	Code shown
LBL	23	g	35	1	01	f	31
A	11	1/x	04	+	61	LN	07
STO 3	33 03	g	35	RCL 4	34 04	1	01
R/S	84	y^x	05	–	51	•	83
LBL	23	RCL 4	34 04	STO 6	33 06	4	04
B	12	X	71	RCL 1	34 01	4	04
1	01	STO 2	33 02	–	51	f	31
0	00	1	01	g	35	LN	07
÷	81	STO 6	33 06	ABS	06	÷	81
STO 4	33 04	LBL	23	EEX	43	RCL 3	34 03
R/S	84	1	01	CHS	42	+	61
LBL	23	RCL 6	34 06	3	03	RTN	24
C	13	STO 1	33 01	g x>y	35 24		
STO 5	33 05	3	03	GTO	22		
•	83	g	35	D	14		
0	00	1/x	04	GTO	22		
2	02	g	35	1	01		
g x⇄y	35 07	y^x	05	LBL	23		
÷	81	RCL 2	34 02	D	14		
3	03	X	71	RCL 6	34 06		

Registers	
R_1	Used
R_2	Used
R_3	VN_0
R_4	K/10
R_5	W(Mt)
R_6	Used
R_7	–
R_8	–
R_9	Used

PROGRAM WE-975-7. PEAK DYNAMIC PRESSURES AND ADJUSTED VULNERABILITY NUMBERS FOR Q-TYPE TARGETS

Description

This program is similar to WE-975-6 but has the added feature of computing the peak dynamic pressure corresponding to VN_{adj} as well as VN_{adj} itself. If the peak dynamic pressure (ordinarily interpreted as that associated with a 50% probability of damage; i.e., $q_{0.5}$ of Ref. 1) is not desired, WE-975-6 is preferable. An interation made in the program could result in an "error" of no more than 1 in the second decimal place of VN_{adj}. No other approximations are made in the program.

User Instructions

Step	Instructions comments	Input data/units	Key	Output data/units
1	Enter program. Vulnerability number is of form VN_0 Q K.			
2	Enter VN_0.	VN_0	A	VN_0
3	Enter K.	K	B	K/10
4	Enter W in Mt.	W(Mt)	C	q(psi)
5	Optional step to obtain peak dynamic pressure q in kPa.		E	q(kPa)
6	Optional step to obtain VN_{adj}.		RCL 1	VN_{adj}

For other values of W, repeat, starting with step 4.

If it is desired to determine q as a function of K for fixed W, key entry 11 may be changed from R/S to RCL5, and W must then be entered separately, once, in register 5. Then step 3 (and 5 and/or 6) above may be repeated for other values of K, and step 4 is deleted, step 3 calculating q (psi) without stopping for the entry of W.

Typical running time: 20 s.

Example

The VN of a target is 25Q6. What are q and VN_{adj} for a weapon yield of 0.1 Mt? 1 Mt?

Step	Instructions/ comments	Input data/units	Key	Output data/units
1	Enter program.			
2	Enter VN_0.	25	A	25.00
3	Enter K.	6	B	0.60
4	Enter W in Mt.	0.1	C	187.89 (psi)
5	(for q in kPa)		E	1295.50 (kPa)
6	(for VN_{adj})		RCL 1	24.07
	Repeat for W = 1 Mt:			
4	Enter W in Mt.	1	C	140.06 (psi)
5	(for q in kPa)		E	965.70 (kPa)
6	(for VN_{adj})		RCL 1	23.27

Answer: For a weapon yield of 0.1 Mt and a 25Q6 target, q is 187.89 psi or 1295.50 kPa and VN_{adj} is 24.07. For 1 Mt, we find q is 140.06 psi or 965.70 kPa and VN_{adj} is 23.27.

Program WE-975-7 Listing

Key entry	Code shown	Key entry	Code shown	Key entry	Code shown	Key entry	Code shown
LBL	23	1	01	f	31	•	83
A	11	RCL 6	34 06	LN	07	8	08
STO 3	33 03	STO 1	33 01	1	01	9	09
R/S	84	3	03	•	83	5	05
LBL	23	g	35	4	04	X	71
B	12	1/x	04	4	04	RTN	24
1	01	g	35	f	31		
0	00	y^x	05	LN	07		
÷	81	RCL 2	34 02	÷	81		
STO 4	33 04	X	71	RCL 3	34 03		
R/S	84	1	01	+	61		
LBL	23	+	61	STO 1	33 01		
C	13	RCL 4	34 04	1	01		
STO 5	33 05	-	51	.	83		
•	83	STO 6	33 06	4	04		
0	00	RCL 1	34 01	4	04		
2	02	-	51	RCL 1	34 01		
g x⇄y	35 07	g	35	g	35		
÷	81	ABS	06	y^x	05		
3	03	EEX	43	•	83		
g	35	CHS	42	0	00		
1/x	04	3	03	2	02		
g	35	g x>y	35 24	8	08		
y^x	05	GTO	22	9	09		
RCL 4	34 04	D	14	3	03		
X	71	GTO	22	X	71		
STO 2	33 02	1	01	RTN	24		
1	01	LBL	23	LBL	23		
STO 6	33 06	D	14	E	15		
LBL	23	RCL 6	34 06	6	06		

Registers	
R_1	VN_{adj}
R_2	Used
R_3	VN_0
R_4	K/10
R_5	W(Mt)
R_6	Used
R_7	-
R_8	-
R_9	Used

PROGRAM WE-975-8. P_k, WR_0, AND WR FOR Q-TYPE POINT TARGETS — SURFACE BURST

Description

The adjusted vulnerability number VN_{adj}, the weapon yield W (Mt), and the CEP (ft) of the delivery vehicle are the input parameters for this calculation. Ordinarily, this program is used after WE-975-6 without clearing the calculator, in which case VN_{adj} and W are already entered for calculation and only the CEP must be entered by the operator. P_k, the probability of a "kill" at the damage level appropriate to the vulnerability number, is determined, as are the scaled weapon radius WR_0 and the weapon radius WR. Parametric studies based on CEP are particularly facile.

Note that the calculations is for Q-type point targets and for a surface burst. Error, defined as deviation from the results obtained using Ref. 1, results from an analytic fit[2] to obtain WR_0 from VN_{adj}. Typically, this "error" is less than 5%. No further approximations are made in obtaining WR and P_k, so the "error" in WR is the same as that for WR_0 and the "error" in the value of P_k is typically no more than ±0.02.

User Instructions

Step	Instructions comments	Input data/units	Key	Output data/units
1	Enter program.			
	If used after WE-975-6,			
	W is in register 5,			
	VN_{adj} is in the x-register.			
	If not, enter them in the			
	correct registers.		A	WR_0(ft/kt$^{1/3}$)
2	Enter CEP	CEP(ft)	B	P_k
3	Optional step to obtain WR			
	if desired.		RCL 4	WR(ft)
	Step 2 may be repeated for other CEP's:			
2	Enter CEP.		B	P_k
3	Optional step to obtain WR			
	if desired.		RCL 4	WR(ft)

Typical running time: less than 10 s.

Example

What are P_k, WR_0, and WR for the first example of WE-975-6 (a 25Q6 target with W of 0.1 Mt) for a 1000-ft CEP?

For these conditions, we found in WE-975-6 that VN_{adj} was 24.07. Ordinarily, however, WE-975-8 is used as a continuation of WE-975-6, so that program is run first.

Step	Instructions/ comments	Input data/units	Key	Output data/units
Preliminary	Run WE-975-6 for a 25Q6 target, W = 0.1 Mt.			24.07
1	Enter this program (WE-975-8).		A	365.15
2	Enter CEP.	1000	B	0.77
3	Obtain WR.		RCL 4	1694.87
	Answer: P_k is 0.77, WR_0 is 365.15 ft/kt$^{1/3}$, and WR is 1694.87.			
	Question: If the CEP were 1500 ft instead of 1000 ft, what would P_k, WR_0, and WR be?			
2	Enter CEP.	1500	B	0.53
3	Obtain WR.		RCL 4	1694.87
	Answer: P_k for 1500 ft CEP is 0.53. WR_0 and WR are unchanged because neither is a function of the CEP.			

Note: Since we knew VN_{adj} was 24.07, we could have entered W in register 5 and VN_{adj} in the x-register without first running WE-975-6. We would obtain, for the 1000-ft CEP, P_k = 0.77, WR_0 = 365.31 ft/kt$^{1/3}$, and WR = 1695.61 The negligible numerical differences from the above example are, of course, a result of rounding in the direct entry of VN_{adj}.

Program WE-975-8 Listing

Key entry	Code shown	Key entry	Code shown	Key entry	Code shown	Key entry	Code shown
LBL	23	0	00	0	00		
A	11	RCL 1	34 01	x	71		
STO 1	33 01	•	83	RCL 1	34 01		
1	01	1	01	x	71		
5	05	0	00	STO 4	33 04		
RCL 1	34 01	9	09	↑	41		
g x≤y	35 22	x	71	x	71		
GTO	22	f^{-1}	32	↑	41		
1	01	LN	07	↑	41		
3	03	:	81	•	83		
1	01	STO 1	33 01	0	00		
8	08	RTN	24	9	09		
0	00	LBL	23	x	71		
RCL 1	34 01	B	12	RCL 2	34 02		
•	83	↑	41	+	61		
0	00	x	71	↑	41		
8	08	2	02	+	61		
9	09	f	31	:	81		
9	09	LN	07	CHS	42		
x	71	2	02	f^{-1}	32		
f^{-1}	32	x	71	LN	07		
LN	07	:	81	CHS	42		
:	81	STO 2	33 02	1	01		
STO 1	33 01	RCL 5	34 05	+	61		
RTN	24	3	03	RTN	24		
LBL	23	g	35				
1	01	1/x	04				
4	04	g	35				
1	01	y^x	05				
0	00	1	01				

Registers	
R_1	WR_0
R_2	Used
R_3	-
R_4	WR
R_5	W(Mt)
R_6	-
R_7	-
R_8	-
R_9	VN_{adj}

PROGRAM WE-975-9. OVERPRESSURE OR DYNAMIC PRESSURE FROM THE ADJUSTED VULNERABILITY NUMBER.

Description

This program determines the peak overpressure or peak dynamic pressure from VN_{adj} for either P-type or Q-type targets. The pressures obtained are ordinarily interpreted as those associated with 50% probability of damage — $P_{0.5}$ or $q_{0.5}$ of Ref. 1. Results may be obtained in either psi or kPa or both.

This program does not in any way equate the two types of vulnerability numbers or pressures. Because the individual calculations are short, both the P-type and the Q-type calculations are contained in one program but they are not used together. Calculations will be accurate to at least four significant figures.

User Instructions

Step	Instructions/ comments		Input data/units	Key	Output data/units
1	Enter program.				
2	Enter VN_{adj} in keyboard if it has not been left in the x-register from the previous calculation.				
	For P-type targets		VN_{adj}	A	P(psi)
		or	VN_{adj}	B	P(kPa)
	For Q-type targets:		VN_{adj}	C	Q(psi)
		or	VN_{adj}	D	Q(kPa)
3	If p or q has been determined in psi and its value in kPa is also wanted.		p(psi) or q(psi)	E	P(kPa) or Q(kPa)

Note: Values of p or q determined by these calculations are ordinarily interpreted as 50% probability values.

Typical running time: less than 5 s.

Example

1. For a P-type target, VN_{adj} has been determined to be 22.98. To what peak overpressure does this correspond?

2. For a Q-type target, VN_{adj} has been determined to be 24.07. To what peak dynamic pressure does this correspond?

Step	Instructions/ comments	Input data/units	Key	Output data/units
Solution to question 1:				
1	Enter program.			
2	Enter VN_{adj}	22.98	A	74.03(psi)
3	For p in kPa also.		E	510.45(kPa)
Solution to question 2:				
1	Enter program.			
2	Enter VN_{adj}.	24.07	C	187.56(psi)
3	For q in kPa also.		E	1293.21(kPa)

Note that labels B and D were not used because the answers were determined in both psi and kPa. If the answers had been wanted only in kPa, labels B and D would have been keyed in step 2 and step 3 would (and could) not have been used.

Program WE-975-9 Listing

Key entry	Code shown	Key entry	Code shown	Key entry	Code shown	Key entry	Code shown
LBL	23	6	06	8	08	9	09
A	11	•	83	9	09	5	05
STO 1	33 01	8	08	3	03	X	71
1	01	9	09	X	71	RTN	24
•	83	5	05	RTN	24		
2	02	X	71	LBL	23		
RCL 1	34 01	RTN	24	D	14		
g	35	LBL	23	C	13		
y^x	05	C	13	6	06		
1	01	STO 1	33 01	•	83		
•	83	1	01	8	08		
1	01	•	83	9	09		
2	02	4	04	5	05		
1	01	4	04	X	71		
6	06	RCL 1	34 01	RTN	24		
X	71	g	35	LBL	23		
RTN	24	y^x	05	E	15		
LBL	23	•	83	6	06		
B	12	0	00	•	83		
A	11	2	02	8	08		

Register	
R_1	VN_{adj}
R_2	-
R_3	-
R_4	-
R_5	-
R_6	-
R_7	-
R_8	-
R_9	-

PROGRAM WE-975-10. PEAK OVERPRESSURE GIVEN YIELD AND RANGE FOR SURFACE BURST OR FREE AIR BURST

Description

This program combines the analytic approximations given by Brode[3] for surface bursts and free air bursts. Because no approximations are made in this program, the error discussion in Chapter III of Brode's report applies.

Yield entries are in Mt, and range is in thousands of feet (kilofeet) or in kilometres. The peak overpressure is determined in both psi and kPa.

User Instructions

Step	Instructions/ comments	Input data/units	Key	Output data/units
1	Enter program.			
2	Enter W in Mt.			
	If surface burst:	W(Mt)	A	
	If free air burst:	W(Mt)	E	
3	Enter R			
	If R is in kilofeet:	R(kft)	B	p(psi)
	If R is in kilometres:	R(km)	C	p(psi)
4	If p is wanted in kPa:		D	p(kPa)

Typical running time: 5 s.

Examples

We list a few examples in shorthand notation:

Q. What is the peak overpressure from a 5-Mt surface burst at 10 000 ft?

A. 5 A 10 B; read 32.85 psi
D; read 226.50 kPa.

Q. What is the peak overpressure in psi from a 1-Mt free air burst at 1 km?

A. 1 E 1 C; read 73.37 psi.

Q. What is the peak overpressure in both psi and kPa 1000 ft from a 1-Mt surface burst?

A. 1 A 1 B; read 3393.40 psi
D; read 23397.48 kPa.

Iteration may be used to answer questions such as:

Q. At what distance from a 500-kt surface burst is the peak overpressure 2 psi?

A. Try: 0.5 A 10 B; read 6.99 psi
0.5 A 20 B; read 2.13 psi
0.5 A 21 B; read 1.97 psi.

The distance is thus about 21 000 ft.

Program WE-975-10 Listing

Key entry	Code shown	Key entry	Code shown	Key entry	Code shown	Key entry	Code shown
LBL	23	5	05	X	71	GTO	22
E	15	2	02	RCL 2	34 02	B	12
2	02	RCL 1	34 01	÷	81	LBL	23
÷	81	X	71	+	61	D	14
LBL	23	RCL 2	34 02	•	83	6	06
A	11	↑	41	0	00	•	83
1	01	X	71	2	02	8	08
0	00	÷	81	1	01	9	09
0	00	RCL 2	34 02	5	05	5	05
0	00	÷	81	+	61	X	71
X	71	RCL 1	34 01	STO 3	33 03	RTN	24
STO 1	33 01	RCL 2	34 02	R/S	84		
RCL 2	34 02	÷	81	LBL	23		
R/S	84	f	31	C	13		
LBL	23	$\sqrt{x}$	09	•	83		
B	12	7	07	3	03		
STO 2	33 02	•	83	0	00		
3	03	6	06	4	04		
•	83	3	03	8	08		
1	01	3	03	÷	81		

Registers	
R_1	Used
R_2	Used
R_3	Used
R_4	-
R_5	-
R_6	-
R_7	-
R_8	-
R_9	-

PROGRAM WE-975-11. PEAK OVERPRESSURE TO/FROM VN_{adj}

Description

This program determines the peak overpressure p, ordinarily interpeated as that pressure associated with 50% probability of damage ($p_{0.5}$ of Ref. 1), from the adjusted vulnerability number VN_{adj} of a P-type target. It also performs the reverse calculation: determining VN_{adj} from the peak overpressure. Either conventional or SI units of pressure may be used or determined in the calculations.

User Instructions

Step	Instructions/ comments	Input data/units	Key	Output data/units
1	Enter program.			
2	Prepare for calculation. If W (Mt) is entered at this point, it will be stored in register 5.	No entry required	A	1.12
3	For $VN_{adj} \rightarrow p(psi)$, enter VN_{adj}	Vn_{adj}	B	p(psi)
	or			
3	For $VN_{adj} \rightarrow p(kPa)$, enter VN_{adj}	VN_{adj}	C	p(kPa)
	or			
3	For $p(psi) \rightarrow VN_{adj}$, enter p(psi)	p(psi)	D	VN_{adj}
	or			
3	For $p(kPa) \rightarrow VN_{adj}$, enter p(kPa).	p(kPa)	E	VN_{adj}

Since each of the four possible step 3's is an independent calculation, any one may be repeated after any other.

Typical running time: less than 5 s.

Examples

We use a "shorthand" notation to illustrate uses of the program:

Q. What is p(psi) if VN_{adj} is 28?

A. Enter: (A) 28 B; read p = 184.89 psi.

The parentheses around A indicate that LBL A must be keyed in once only and does not necessarily have to be keyed in for subsequent calculations.

Q. What is VN_{adj} for a 1000-psi target?

A. This is a sloppy question. We assume it means "What is VN_{adj} if $p_{0.5}$ is 1000 psi?"

Enter 1000 D; read Vn_{adj} = 37 26. If no previous calculation has been made enter A 1000 D; read VN_{adj} = 37.26.

Q. What is VN_{adj} if $p_{0.5}$ is 7000 kPa for a 500-kt surface burst with a 1000-ft CEP?

A. If the intent is to go on to a calculation of P_k using WE-975-4, it is better to get W stored before calculating VN_{adj}. Remember that W is entered in Mt: Enter 0.5 A 7000 E; read VN_{adj} = 37.34. The calculator is now ready to accept WE-975-4.

Q. What is p(kPa) if VN_{adj} is 12?

A. Enter 12 C; read $p_{0.5}$ = 68.95 kPa.

Program WE-975-11 Listing

Key entry	Code shown	Key entry	Code shown	Key entry	Code shown	Key entry	Code shown
LBL	23	RCL 2	34 02	•	83		
A	11	X	71	2	02		
STO 5	33 05	RTN	24	f	31		
1	01	LBL	23	LN	07		
•	83	C	23	:	81		
1	01	B	12	STO 1	33 01		
2	02	6	06	RTN	24		
1	01	•	83	LBL	23		
6	06	8	08	E	15		
STO 2	33 02	9	09	6	06		
RTN	24	5	05	•	83		
LBL	23	X	71	8	08		
B	12	RTN	24	9	09		
STO 1	33 01	LBL	23	5	05		
1	01	D	14	÷	81		
•	83	RCL 2	34 02	GTO	22		
2	02	÷	81	D	14		
RCL 1	34 01	f	31				
g	35	LN	07				
y^x	05	1	01				

Registers	
R_1	Used
R_2	Used
R_3	-
R_4	-
R_5	W(Mc)
R_6	-
R_7	-
R_8	-
R_9	-

PROGRAM WE-975-12. PEAK DYNAMIC PRESSURE TO/FROM VN_{adj}

Description

This program determines the peak dynamic pressure q, ordinarily interpreted as that pressure associated with 50% probability of damage ($q_{0.5}$ of Ref. 1), from the adjusted vulnerability number VN_{adj} of a Q-type target. It also performs the reverse calculation: determining VN_{adj} from the peak dynamic pressure. Either conventional or SI units may be used or determined in the calculations.

User Instructions

Step	Instructions/ comments	Input data/units	Key	Output data/units
1	Enter program.			
2	Prepare for calculation. If W (Mt) is entered at this point, it will be stored in register 5.	No entry required	A	0.03
3	For VN_{adj} → q(psi), enter VN_{adj} or	VN_{adj}	B	q(psi)
3	For VN_{adj} → q(kPa), enter VN_{adj} or	VN_{adj}	C	q(kPa)
3	For q(psi) → VN_{adj}, enter q(psi) or	q(psi)	D	VN_{adj}
3	For q(kPa) → VN_{adj},	q(kPa)	E	VN_{adj}

Since each of the four possible step 3's is an independent calculation, any one may be repeated after any other.

Typical running time: less than 5 s.

Examples

We use a "shorthand" notation to illustrate uses of the program:

Q. What is q(psi) if VN_{adj} is 28?

A. Enter (A) 28 B; read $q_{0.5}$ = 786.14 psi.

The parentheses around A indicate that LBL A must be keyed in once only and does not necessarily have to be keyed in for subsequent calculations.

Q. What is VN_{adj} for a 1000-psi target?

A. This is a sloppy question. We assume it means "What is VN_{adj} if $q_{0.5}$ is 1000 psi?"
Enter 1000 D; read VN_{adj} = 28.66 if no previous calculations has been made
Enter A 1000 D; read VN_{adj} = 28.66.

Q. What is VN_{adj} if $q_{0.5}$ is 7000 kPa for a 500-kt surface burst with a 1000-ft CEP?

A. If the intent is to go on to a calculation of P_k using WE-975-8, it is better to get W stored before calculating VN_{adj}. Remember that W is entered in Mt: Enter 0.5 A 7000 E; read VN_{adj} = 28.70. The calculator is now ready to accept WE-975-8.

Q. What is q(kPa) if VN_{adj} is 12?

A. Enter 12 C; read q = 15.86 kPa.

Program WE-975-12 Listing

Key entry	Code shown	Key entry	Code shown	Key entry	Code shown	Key entry	Code shown
LBL	23	y^x	05	1	01		
A	11	RCL 2	34 02	•	83		
STO 5	33 05	X	71	4	04		
•	83	RTN	24	4	04		
0	00	LBL	23	f	31		
2	02	C	13	LN	07		
8	08	B	12	÷	81		
9	09	6	06	STO 1	33 01		
3	03	•	83	RTN	24		
STO 2	33 02	8	08	LBL	23		
RTN	24	9	09	E	15		
LBL	23	5	05	6	06		
B	12	X	71	•	83		
STO 1	33 01	RTN	RTN	8	08		
1	01	LBL	23	9	09		
•	83	D	14	5	05		
4	04	RCL 2	34 02	÷	81		
4	04	÷	81	GTO	22		
RCL 1	34 01	f	31	D	14		
g	35	LN	07				

Registers
R_1 -
R_2 -
R_3 -
R_4 -
R_5 W(Mt)
R_6 -
R_7 -
R_8 -
R_9 -

References

1. *Physical Vulnerability Handbook — Nuclear Weapons*, Defense Intelligence Agency, Washington, D.C., Rept. AP-550-1-2-INT (1969; with changes, 1974) (title U, report C). The material pertinent to this report is also included in two unclassified reports: *Mathematical Background and Programming Aids for the Physical Vulnerability System for Nuclear Weapons*, Defense Intelligence Agency, Rept. DI-550-27-74 (1974); *Kill Probability and the Related Analysis for Blast-Type Targets*, TRW Systems Group, Redondo Beach, Calif., TRW Sales No. 23942 (1974).
2. O. J. Loper and W. A. Barletta, Lawrence Livermore Laboratory, private communication, (1975).
3. H. L. Brode, *Height of Burst Effects at High Overpressures*, RAND Corp., Santa Monica, Calif., Rept. DASA-2506 or RM-6301-DASA (1970).

CSM/af/lmc