704451

COMPARATIVE EFFECTS DATA *of* BIOLOGICAL INTEREST

by

CLAYTON S. WHITE, M. D.
I. G. BOWEN, M. S.

LOVELACE FOUNDATION
FOR MEDICAL EDUCATION AND RESEARCH
ALBUQUERQUE, NEW MEXICO

o

OFFICE OF THE SURGEON

HEADQUARTERS FIELD COMMAND
ARMED FORCES SPECIAL WEAPONS PROJECT
SANDIA BASE, ALBUQUERQUE, NEW MEXICO

o

REPOSITORY DOE - FORRESTAL
COLLECTION MARKEY FILES
BOX No. 3 of 6
FOLDER ACCIDENT FILE #1

1003935

Office of the Surgeon
HEADQUARTERS FIELD COMMAND
ARMED FORCES SPECIAL WEAPONS PROJECT
SANDIA BASE, ALBUQUERQUE, NEW MEXICO

FOREWORD

1. The purpose of this booklet is to provide medical officers of the Armed Forces with data of biological interest in order that they can better understand material presented in medical training programs conducted by Commander, Field Command. Specific training programs are:

a. Armed Forces Medical Symposia, which are related to current special weapons and their effects, and to the application of nuclear energy other than weapons which will present medical problems and accidents involving nuclear fission and radioactive contamination.

b. Advanced Course in Radiobiology for Medical Officers.

2. Material herein was compiled by Clayton S. White, M. D., and I. G. Bowen, M. S., Lovelace Foundation for Medical Education and Research, Albuquerque, New Mexico.

3. The authors' reference to The Effects of Nuclear Weapons on pages throughout the booklet specifically refers to data as presented by Samuel Glasstone, Editor, AFP 136-1-3, The Effects of Nuclear Weapons, published by the United States Atomic Energy Commission in cooperation with the United States Department of Defense in June 1957.

FOR THE COMMANDER:

L. B. HANSON
Colonel, MC
Surgeon

1003936

APPROXIMATE RANGES FROM GROUND ZERO FOLLOWING AIR DETONATION

Chart 1 presents a tabulation of the approximate ranges from ground zero following an air detonation (except where noted) to which various explosive effects extend, and the areas contained within circles of corresponding radii. These data are given for various explosive yields from 1 KT to 20 MT.

All distances shown are slant ranges with the exception of those for overpressure which are horizontal ranges. It was assumed that slant ranges were a reasonable approximation of ground ranges. However, it is true that the computed areas for thermal and ionizing radiation are overestimated for the air burst.

A 20 MT yield is 1000 times that of a 20 KT yield. It is interesting to note that for the larger yield the area enclosed within the 100 REM line increases over that for the smaller yield by a factor of 8.47, while the areas within the 1 PSI and second degree burn lines increase by factors of 100 and 344, respectively.

1003937

OM GROUND
TONATION

approximate ranges from
xcept where noted) to which
areas contained within cir-
are given for various explo-

s with the exception of those
nges. It was assumed that
ation of ground ranges. How-
or thermal and ionizing ra-
t.

a 20 KT yield. It is inter-
area enclosed within the
smaller yield by a factor
and second degree burn lines
ctively.

COMPARATIVE EFFECTS DATA OF BIOLOGICAL INTEREST

Explosive Yield	1 KT	20 KT	100 KT	1 MT	10 MT	20 MT
	Range (mi) from Ground Zero for Various Parameters					
700 REM (Initial)	0.42	0.70	0.96	1.44	2.04	2.27
100 REM "	0.62	0.99	1.29	1.81	2.55	2.88
30 REM "	0.74	1.18	1.51	2.07	2.91	3.30
5 PSI (Typical Air Burst)	0.39	1.06	1.81	3.90	8.40	10.6
5 PSI (Sfc Burst)	0.28	0.77	1.32	2.85	6.14	7.74
1 PSI (Typical Air Burst)	1.00	2.71	4.64	10.0	21.5	27.1
1 PSI (Sfc Burst)	0.86	2.35	4.02	8.65	18.6	23.5
Second Degree Burns	0.48	1.72	3.40	9.00	23.8	31.9
First Degree Burns	0.69	2.47	4.97	13.3	36.0	49.2
	Area (sq mi) Corresponding to Above Ranges					
700 REM (Initial)	0.55	1.54	2.90	6.51	13.1	16.2
100 REM "	1.21	3.08	5.23	10.3	20.4	26.1
30 REM "	1.72	4.37	7.16	13.5	26.6	34.2
5 PSI (Typical Air Burst)	0.48	3.53	10.3	47.8	222	353
5 PSI (Sfc Burst)	0.25	1.86	5.47	25.5	119	188
1 PSI (Typical Air Burst)	3.14	23.2	67.6	314	1460	2320
1 PSI (Sfc Burst)	2.35	17.3	50.8	235	1090	1740
Second Degree Burns	0.74	9.29	36.3	254	1780	3200
First Degree Burns	1.50	27.7	77.6	556	4070	7600

Data from The Effects of Nuclear Weapons

Chart 1

VALUES OF INITIAL IONIZING RADIATION, OVERPRESSURE, AND THERMAL RADIATION

Chart 2 gives the approximate ranges in miles for various values of initial ionizing radiation, overpressure, and thermal radiation, computed for typical air bursts with yields from 1 KT to 20 MT. For each such range, values of the remaining parameters are listed in REM, PSI, or cal/cm^2. For example, the 1 PSI line is 10.0 miles from the detonation for a 1 MT yield. At this distance the initial ionizing radiation is less than 10 REM and the thermal radiation is 5.90 cal/cm^2. It is then noted at the bottom of the chart that for a 1 MT yield 3.2 cal/cm^2 produces first degree burns and 6.2 cal/cm^2 produces second degree burns.

These data are for typical air bursts for which no significant close-in fallout would occur. Horizontal ranges are given for overpressure and slant ranges for initial ionizing and thermal radiation. Thus, the relative importance of the latter phenomena would be overemphasized.

COMPARATIVE EFFECTS DATA OF BIOLOGICAL INTEREST

1003939

RADIATION,
L RADIATION

s in miles for various val-
ure, and thermal radiation,
from 1 KT to 20 MT. For
arameters are listed in
1 PSI line is 10.0 miles
his distance the initial ion-
thermal radiation is 5.90
the chart that for a 1 MT
rns and 6.2 cal/cm^2 pro-

for which no significant
anges are given for over-
ng and thermal radiation.
phenomena would be over-

COMPARATIVE EFFECTS DATA OF BIOLOGICAL INTEREST

Explosive Yield	1 KT	20 KT	100 KT	1 MT	10 MT	20 MT
30 REM Range, mi	0.74	1.18	1.51	2.07	2.91	3.30
Pressure, psi	1.70	4.16	6.60	11.1	15.6	17.0
Thermal, cal/cm^2	1.70	12.4	36.0	182	880	>1000
100 REM Range, mi	0.62	0.99	1.29	1.81	2.55	2.88
Pressure, psi	2.30	5.55	8.30	12.4	17.4	18.8
Thermal, cal/cm^2	2.50	18.0	52.0	240	>1000	>1000
1 PSI Range, mi	1.00	2.71	4.64	10.0	21.5	27.1
Radiation, REM	<10	<10	<10	<10	<<10	<<10
Thermal, cal/cm^2	0.88	2.02	3.30	5.90	11.4	13.8
5 PSI Range, mi	0.39	1.06	1.81	3.90	8.40	10.6
Radiation, REM	900	64	<10	<10	<10	<10
Thermal, cal/cm^2	7.00	15.8	24.5	46.0	89.0	105
Second Degree Burn						
Range, mi	0.48	1.72	3.40	9.00	23.8	31.9
Pressure, psi	3.6	2.2	1.7	1.2	<1	<1
Radiation, REM	380	<10	<10	<10	<<10	<<10
First Degree Burn Dose, cal/cm^2	2.0	2.5	2.7	3.2	3.7	3.8
Second Degree Burn Dose, cal/cm^2	4.1	4.9	5.4	6.2	7.2	7.5
Third Degree Burn Dose, cal/cm^2	6.0	7.3	8.1	9.4	10.8	11.4

Data from The Effects of Nuclear Weapons
Chart 2

1003940

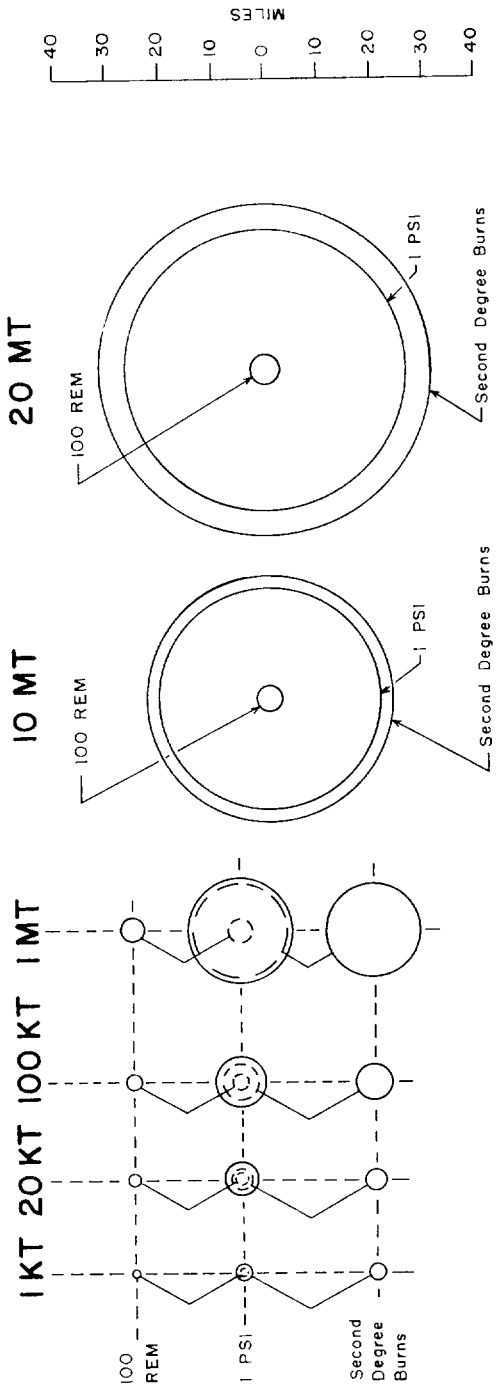
AIR BURSTS INVOLVING EXPLOSIVE YIELDS

A graphic comparison for typical air burst involving explosive yields from 1 KT to 20 MT is presented in chart 3. The parameters noted include (1) initial ionizing radiation at 100 REM or more, (2) overpressure at 1 PSI or higher, and (3) thermal radiation sufficient to produce at least second degree burns. It is evident that the areas of initial ionizing radiation increase with the explosive yield to a much lesser extent than do those for overpressure and thermal radiation. For yields of 1 MT or less, the areas of second degree burns are smaller than those for 1 PSI overpressure; whereas, for the higher yields depicted, the reverse is true. Slant range figures used for ionizing and thermal radiation are assumed to be reasonable approximations of the true horizontal range.

1003941

LVING
LDS

air burst involving explosive
l in chart 3. The parameters
on at 100 REM or more, (2)
3) thermal radiation sufficient
s. It is evident that the areas
th the explosive yield to a much
ssure and thermal radiation.
of second degree burns are
ure; whereas, for the higher
Slant range figures used for
med to be reasonable approxi-



ENVIRONMENTAL VARIATIONS DUE TO BLAST, THERMAL, AND INITIAL IONIZING RADIATION FOR INDICATED EXPLOSIVE YIELDS.

(DATA FROM EFFECTS OF NUCLEAR WEAPONS FOR TYPICAL AIR BURSTS)

CHART 3

1003942

AIR BURSTS TABULATED IN CHARTS 1 AND 2

Charts 4a, 4b, and 4c present graphically the effects data for typical air bursts tabulated in charts 1 and 2. To facilitate comparison, all three charts are plotted to the same scale.

1 MT

100 KT

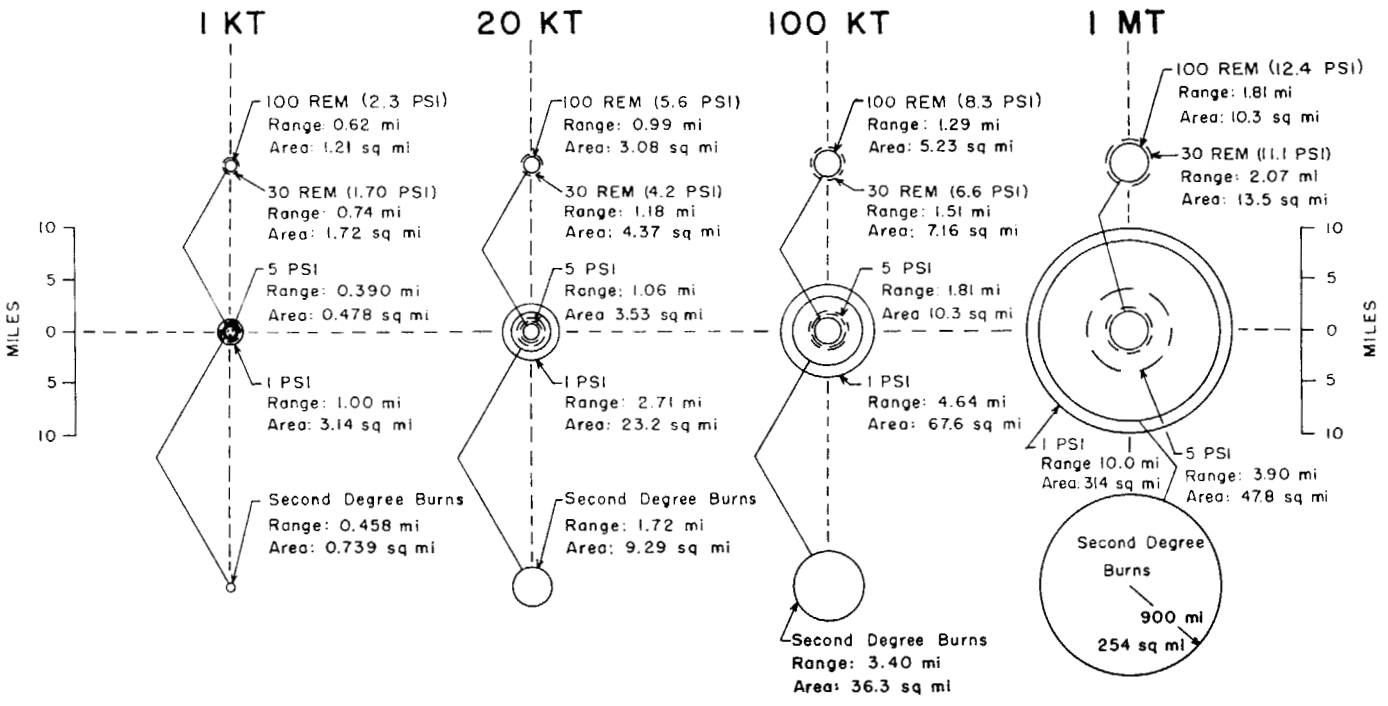
20 KT

1 KT

1003943

ATED IN
) 2

phically the effects data for
and 2. To facilitate compari-
same scale.



ENVIRONMENTAL VARIATIONS DUE TO BLAST, THERMAL, AND INITIAL IONIZING RADIATION FOR 1, 20, 100, AND 1000 KT EXPLOSIVE YIELDS.
(DATA FROM EFFECTS OF NUCLEAR WEAPONS)

PRESSURE DATA ARE FOR TYPICAL AIR BURSTS.
SLANT RANGES SHOWN FOR IONIZING AND THERMAL RADIATION.

CHART 4a

1003944

AIR BURSTS TABULATED IN CHARTS 1 AND 2

Charts 4a, 4b, and 4c present graphically the effects data for typical air bursts tabulated in charts 1 and 2. To facilitate comparison, all three charts are plotted to the same scale.

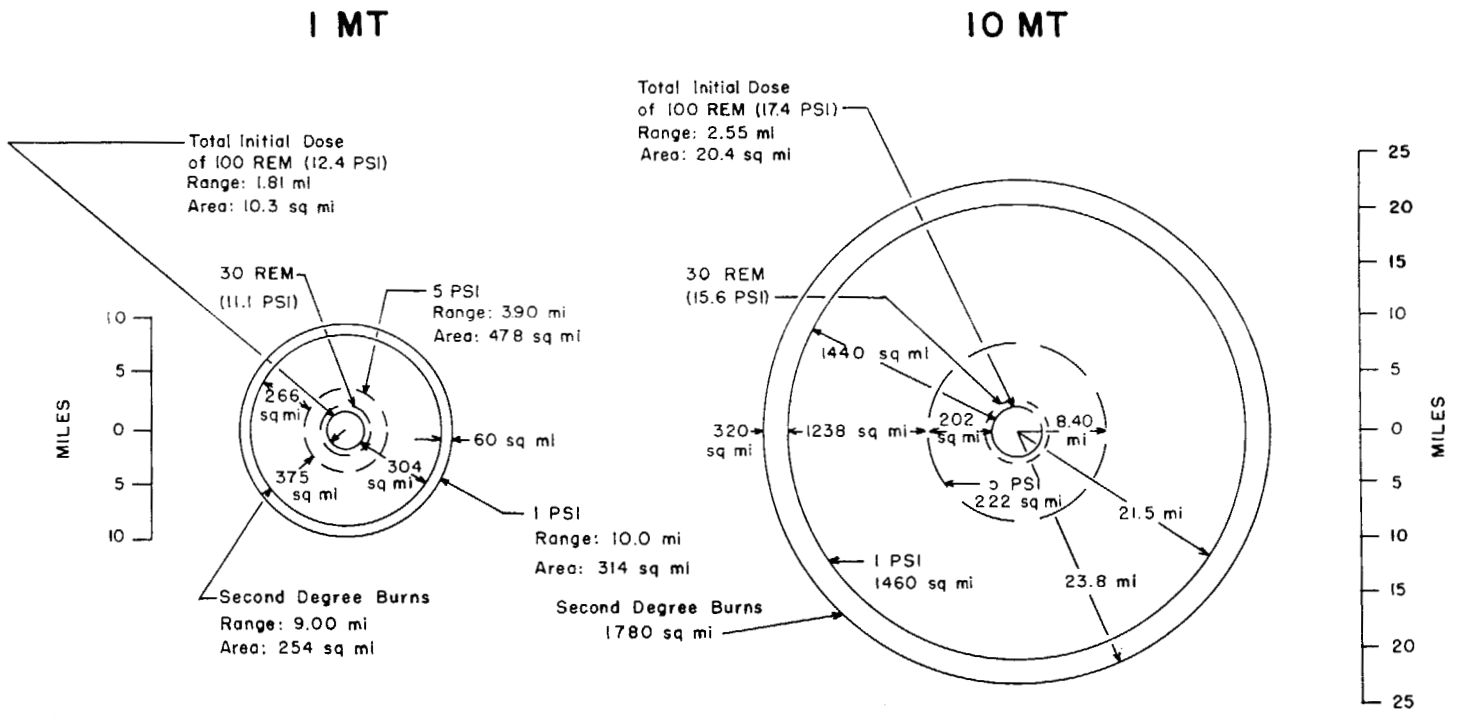
10 MT

1 MT

1003945

ILATED
ND 2

aphically the effects data for and 2. To facilitate compari- same scale.



ENVIRONMENTAL VARIATIONS DUE TO BLAST, THERMAL, AND INITIAL IONIZING RADIATION FOR 1 MT AND 10 MT EXPLOSIVE YIELDS.

(DATA FROM EFFECTS OF NUCLEAR WEAPONS)

PRESSURE DATA ARE FOR TYPICAL AIR BURSTS.
SLANT RANGES SHOWN FOR IONIZING AND THERMAL RADIATION.

CHART 4b

1003946

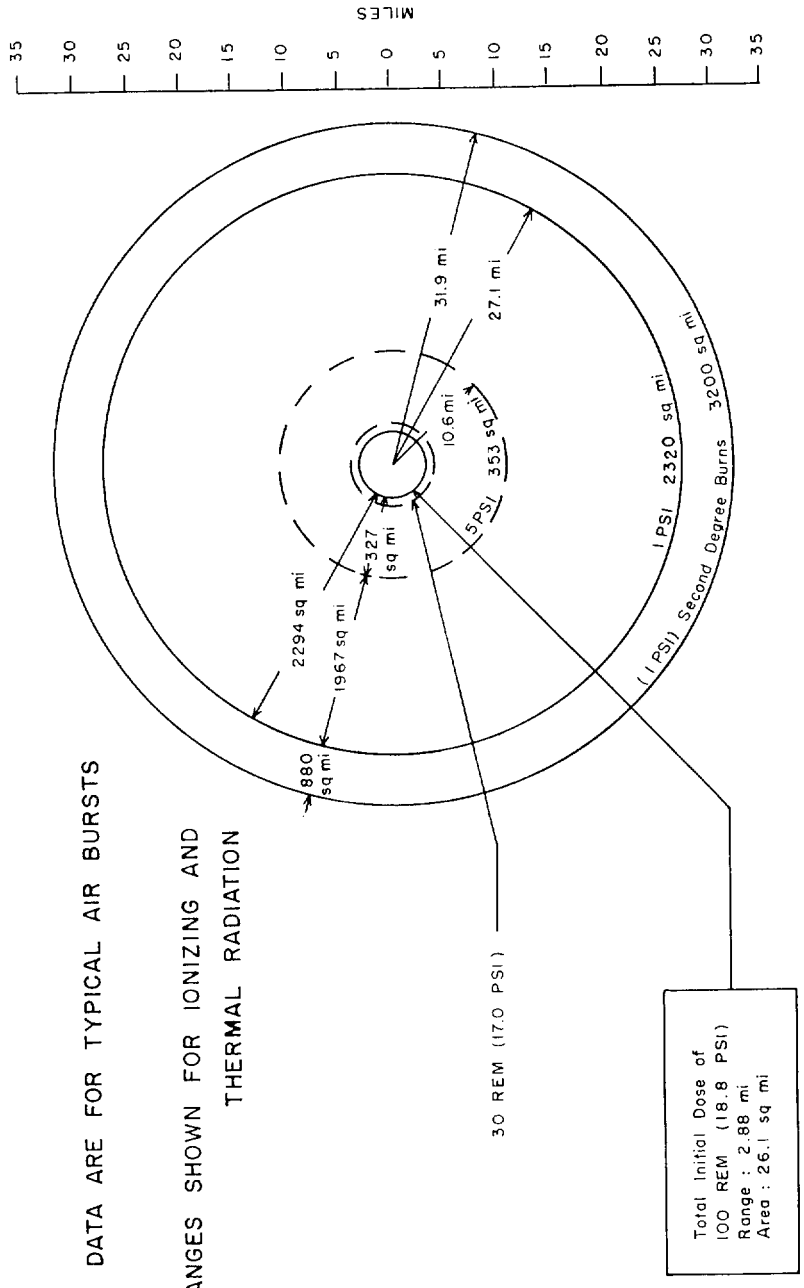
AIR BURSTS TABULATED IN CHARTS 1 AND 2

Charts 4a, 4b, and 4c present graphically the effects data for typical air bursts tabulated in charts 1 and 2. To facilitate comparison, all three charts are plotted to the same scale.

1003947

LATED
ND 2

phically the effects data for
and 2. To facilitate compari-
same scale.



PRESSURE DATA ARE FOR TYPICAL AIR BURSTS

SLANT RANGES SHOWN FOR IONIZING AND THERMAL RADIATION

ENVIRONMENTAL VARIATIONS DUE TO BLAST, THERMAL, AND INITIAL IONIZING RADIATION FOR 20MT EXPLOSIVE YIELD

(DATA FROM EFFECTS OF NUCLEAR WEAPONS)

CHART 4c

1003948

EXPANDED PLOTS OF EFFECTS DATA
(KT YIELDS FOR TYPICAL AIR BURSTS)

Charts 5a, 5b, and 5c are expanded plots of effects data shown in chart 4a for 1, 20, and 100 KT yields for typical air bursts.

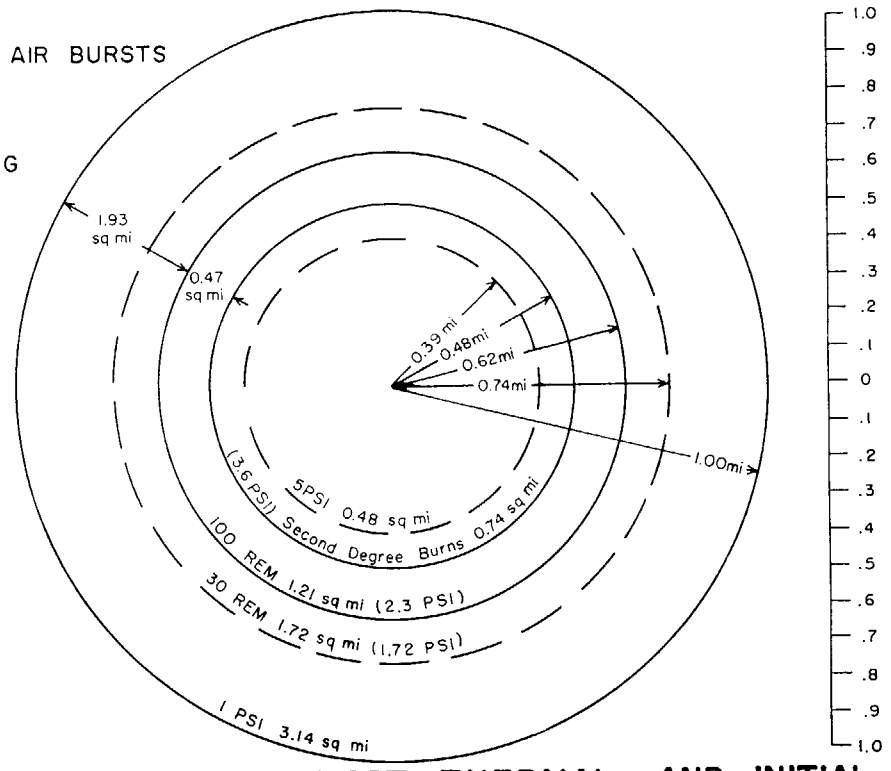
1003949

FECTS DATA
AIR BURSTS)

d plots of effects data shown
for typical air bursts.

PRESSURE DATA ARE FOR TYPICAL AIR BURSTS

SLANT RANGES SHOWN FOR IONIZING
AND THERMAL RADIATION



ENVIRONMENTAL VARIATIONS DUE TO BLAST, THERMAL, AND INITIAL IONIZING RADIATION FOR 1KT EXPLOSIVE YIELD

(DATA FROM EFFECTS OF NUCLEAR WEAPONS)

CHART 5a

1003950

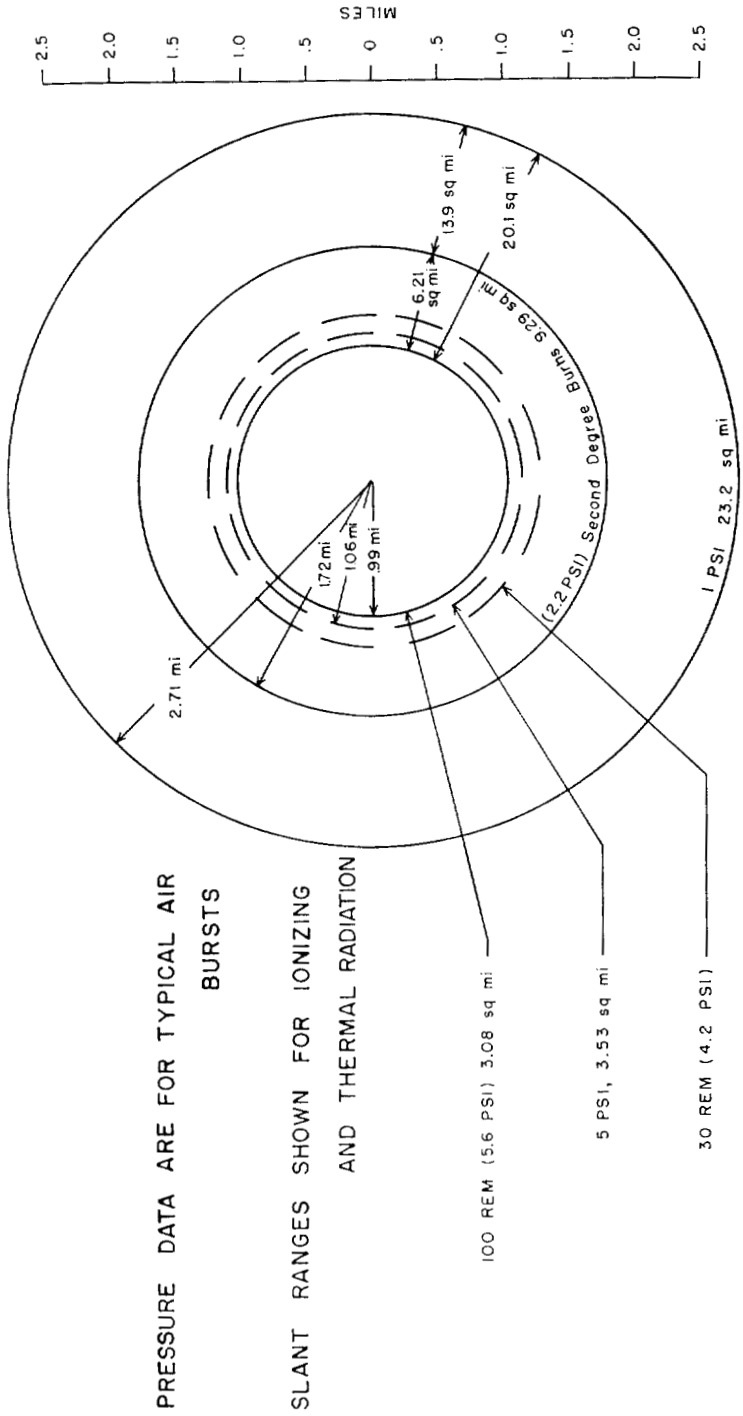
EXPANDED PLOTS OF EFFECTS DATA
(KT YIELDS FOR TYPICAL AIR BURSTS)

Charts 5a, 5b, and 5c are expanded plots of effects data shown in chart 4a for 1, 20, and 100 KT yields for typical air bursts.

1003951

FFECTS DATA
AL AIR BURSTS)

ed plots of effects data shown
s for typical air bursts.



ENVIRONMENTAL VARIATIONS DUE TO BLAST, THERMAL, AND INITIAL IONIZING RADIATION FOR 20KT EXPLOSIVE YIELD

(DATA FROM EFFECTS OF NUCLEAR WEAPONS)

CHART 5b

1003952

EXPANDED PLOTS OF EFFECTS DATA
(KT YIELDS FOR TYPICAL AIR BURSTS)

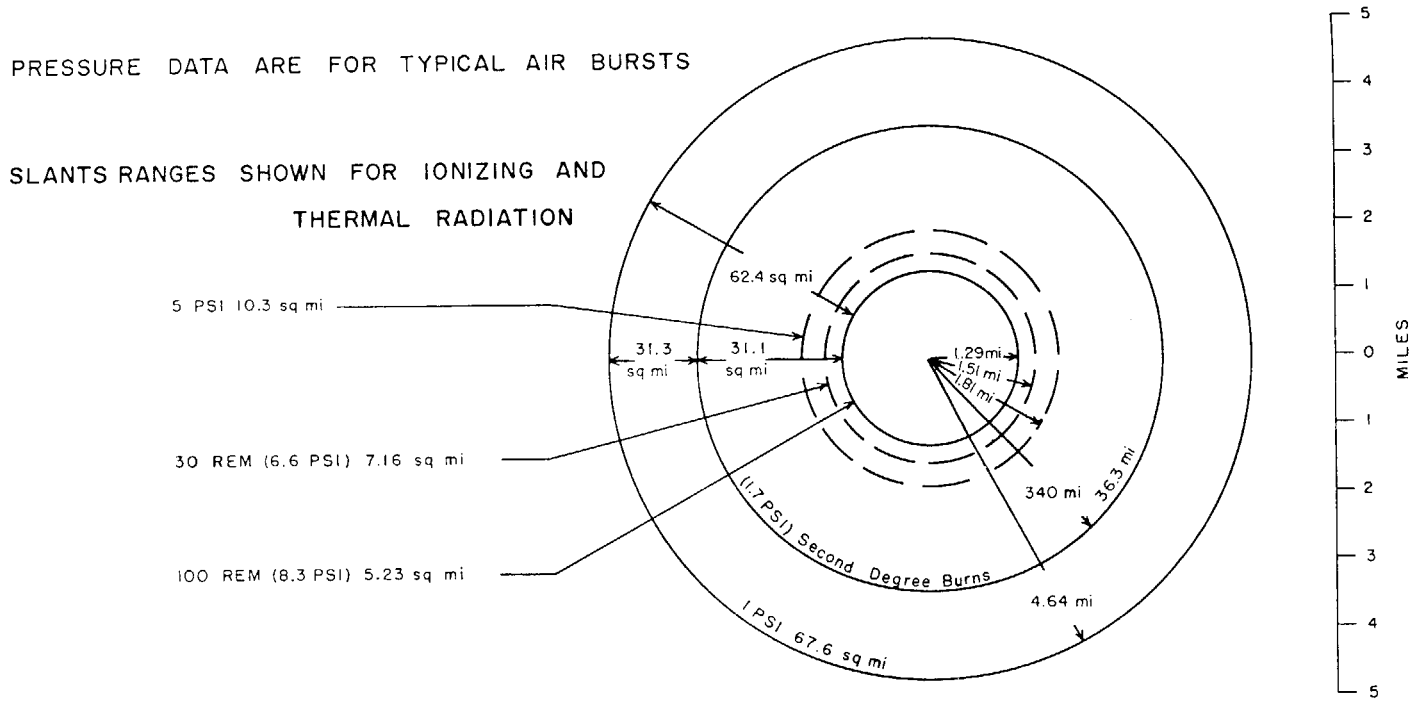
Charts 5a, 5b, and 5c are expanded plots of effects data shown in chart 4a for 1, 20, and 100 KT yields for typical air bursts.

PRESSURE DATA ARE FOR TYPICAL AIR BURSTS

1003953

ECTS DATA
AIR BURSTS)

plots of effects data shown
or typical air bursts.



ENVIRONMENTAL VARIATIONS DUE TO BLAST, THERMAL, AND INITIAL IONIZING RADIATION FOR 100KT EXPLOSIVE YIELD

(DATA FROM EFFECTS OF NUCLEAR WEAPONS)

CHART 5c

1003954

COMPARATIVE EFFECTS DATA OF A 10 MT SURFACE BLAST

Chart 6 presents approximate comparative effects data for a 10 MT surface burst. The presence of local fallout radiation is the principle difference between this type of explosion and one detonated in the air. Ranges for the 1 and 5 PSI lines are somewhat shorter for the surface burst, compared with the air burst.

Assumptions made in computing the fallout pattern were (1) an effective wind of 15 mph which makes little difference in the pattern for close-in fallout, and (2) all the explosive energy was derived from fission. Since the fusion process does not contribute to the radioactivity of the fallout, the estimates presented here can be considered to be maximal.

The somewhat hypothetical "1 hour reference dose rates" in roentgens per hour are used as a measure of fallout radiation. The 1 hour reference dose rate is defined as the estimated dose rate 1 hour after the detonation, assuming that the fallout is complete at that time. The significance of these dose rates in terms of accumulated dose is discussed in connection with chart 8.

1003955

TS DATA OF
BLAST

nparative effects data for a
local fallout radiation is the
f explosion and one detonated
lines are somewhat shorter
e air burst.

he fallout pattern were (1) an
ttle difference in the pattern
osive energy was derived from
not contribute to the radioac-
nted here can be considered

r reference dose rates" in
re of fallout radiation. The
the estimated dose rate 1
t the fallout is complete at
se rates in terms of accumu-
th chart 8.

COMPARATIVE EFFECTS DATA OF BIOLOGICAL INTEREST
FOR A 10 MT SURFACE BURST

	Range (mi)	Area (mi^2)
>First Degree Burns	36.0	4070
>Second Degree Burns	23.8	1780
>Third Degree Burns	22.0	1520
>1 PSI	18.6	1087
>5 PSI	6.14	119
>30 REM (Initial)	2.91	26.6
>100 REM (Initial)	2.55	20.4
>30 R/hr Fallout (1 hr Reference Dose)		1734*
>100 R/hr " " " "		1023*
>300 R/hr " " " "		729 *
>1000 R/hr " " " "		559 *
>3000 R/hr " " " "		343 *
>1 PSI, <30 R/hr		12.3
>1 PSI, <100 R/hr		455
>Second Degree Burns, <1 PSI		693
>Second Degree Burns, <30 R/hr		389
>Second Degree Burns, <100 R/hr		1043

*Measured only to First Degree Burn Line.
Effective wind assumed to be 15 mph.

Data from The Effects of Nuclear Weapons

Chart 6

1003956

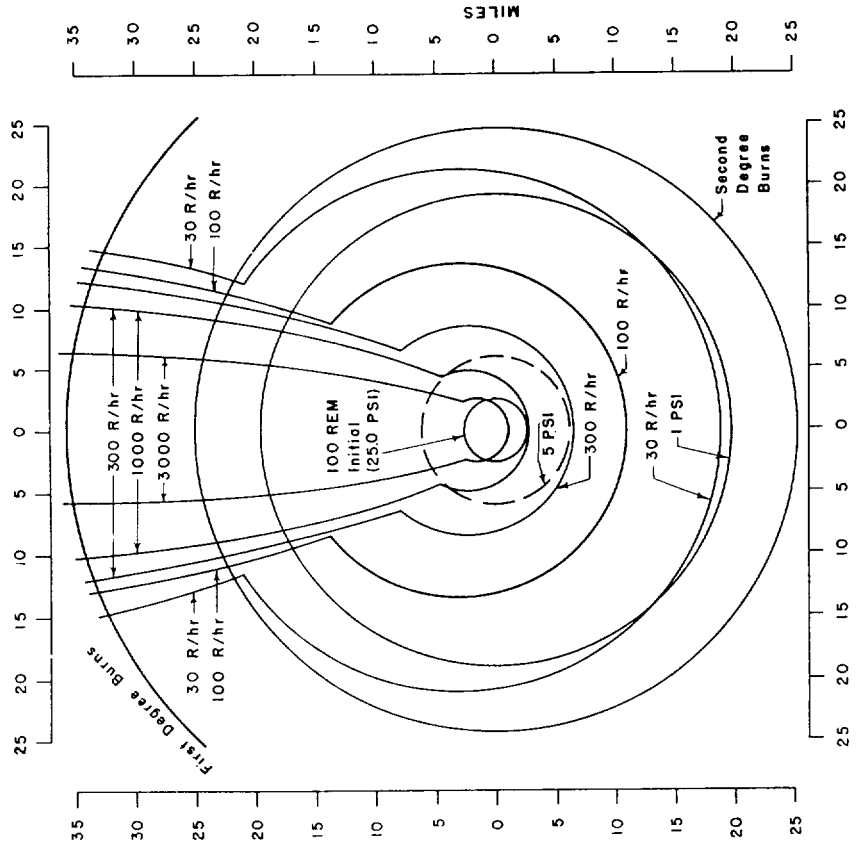
GRAPHICAL PRESENTATION OF EFFECTS DATA OF A 10 MT SURFACE BLAST

Chart 7 is a graphical presentation of the effects data in chart 6 for a 10 MT surface burst. The somewhat hypothetical fallout contours in terms of various 1 hour reference doses are depicted only to the first degree burn limit (36 miles from ground zero), although the fallout would actually extend several hundred miles distance downwind. An effective wind of 15 mph is assumed to be blowing toward the top of the chart.

1003957

TION OF EFFECTS
JRFACE BLAST

ation of the effects data in chart
omewhat hypothetical fallout con-
erence doses are depicted only
es from ground zero), although
eral hundred miles distance down-
s assumed to be blowing toward



Fallout values are one hour reference dose rates for an effective wind of 15 mph.

(Data from EFFECTS OF NUCLEAR WEAPONS)

ENVIRONMENTAL VARIATIONS DUE TO BLAST, THERMAL, INITIAL IONIZING RADIATION, AND FALLOUT RADIATION FOR A 10 MT SURFACE BURST

CHART 7

1003958

SIGNIFICANCE OF 1 HOUR REFERENCE DOSE RATE USED IN CHARTS 6 AND 7

Chart 8 illustrates the significance of the 1 hour reference dose rate used in charts 6 and 7. As an example, a person in a location where the 1 hour reference dose rate is 100 r/hr would accumulate 633 roentgens in the first hour after the detonation. In the succeeding hour he would receive an additional 68 r, making a total of 701 r. These estimates are somewhat inaccurate since they are based on the assumption inherent in estimating the reference doses used.

Comparative data are presented for the accumulated dose received within a shelter with an attenuation factor of 1000 (3 feet of earth). For example, a person in the 100 r/hr region would receive an accumulated dose of only 0.87 r during the first 24 hours if he remained in such a shelter, providing he entered the structure before the fallout arrived. If he then spent 12 hours on the outside he would receive an additional 23 r.

1003959

. REFERENCE
ARTS 6 AND 7

e of the 1 hour reference dose
nple, a person in a location
100 r/hr would accumulate
detonation. In the succeed-
68 r, making a total of 701 r.
ate since they are based on
ne reference doses used.

or the accumulated dose re-
on factor of 1000 (3 feet of
00 r/hr region would receive
ng the first 24 hours if he
e entered the structure be-
t 12 hours on the outside he

ACCUMULATED RADIATION DOSE (ROENTGENS) AS A FUNCTION
OF 1 HR REFERENCE DOSE AND TIME AFTER DETONATION
FOR A 10 MT SURFACE BURST ASSUMING
AN EFFECTIVE WIND OF 15 MPH

1 hr Ref. Dose:	30 R/hr		100 R/hr		300 R/hr		1000 R/hr		3000 R/hr	
Time	Open	Shelter*	Open	Shelter*	Open	Shelter*	Open	Shelter*	Open	Shelter*
1 hr	190	0.19	633	0.63	1,898	1.90	6,328	6.33	18,980	18.98
(1 hr)#	(20)#		(68)		(204)		(678)		(2,040)	
2 hrs	210	0.21	701	0.70	2,102	2.10	7,006	7.01	21,020	21.02
(2 hrs)	(17)		(56)		(169)		(565)		(1,690)	
4 hrs	227	0.23	757	0.76	2,271	2.27	7,571	7.57	22,710	22.71
(2 hrs)	(7)		(23)		(68)		(226)		(680)	
6 hrs	234	0.23	780	0.78	2,339	2.34	7,797	7.80	23,390	23.39
(6 hrs)	(13)		(45)		(136)		(452)		(1,360)	
12 hrs	247	0.25	825	0.82	2,475	2.48	8,249	8.25	24,750	24.75
(12 hrs)	(14)		(45)		(135)		(452)		(1,350)	
24 hrs	261	0.26	870	0.87	2,610	2.61	8,701	8.70	26,100	26.10
(12 hrs)	(7)		(23)		(68)		(226)		(680)	
36 hrs	268	0.27	893	0.89	2,678	2.68	8,927	8.93	26,780	26.78
(12 hrs)	(3)		(11)		(34)		(113)		(340)	
48 hrs	271	0.27	904	0.90	2,712	2.71	9,040	9.04	27,120	27.12
	(68)		(226)		(678)		(2,260)		(6,780)	
Infinity Dose	339	0.34	1,130	1.13	3,390	3.39	11,300	11.3	33,90[illegible]	33.90

*Assuming attenuation factor of 1000 (3 ft of earth).
#Numbers in parentheses represent differences between adjacent values.

Data from The Effects of Nuclear Weapons
Chart 8

1003960

NOTES

1003961

CONTENTS

	PAGE
Approximate Ranges From Ground Zero Following Air Detonation	2
Chart 1.	3
Values of Initial Ionizing Radiation, Overpressure, and Thermal Radiation.	4
Chart 2.	5
Air Bursts Involving Explosive Yields.	6
Chart 3.	7
Air Bursts Tabulated in Charts 1 and 2.	8
Chart 4a.	9
Air Bursts Tabulated in Charts 1 and 2.	10
Chart 4b.	11
Air Bursts Tabulated in Charts 1 and 2.	12
Chart 4c.	13
Expanded Plots of Effects Data (KT Yields for Typical Air Bursts).	14
Chart 5a.	15
Expanded Plots of Effects Data (KT Yields for Typical Air Bursts).	16
Chart 5b.	17
Expanded Plots of Effects Data (KT Yields for Typical Air Bursts).	18
Chart 5c.	19
Comparative Effects Data of a 10 MT Surface Blast.	20

1003962

Chart 6. 21

Graphical Presentation of Effects Data of a 10 MT Surface Blast. 22

Chart 7. 23

Significance of 1 Hour Reference Dose Rate Used in Charts 6 and 7. 24

Chart 8. 25

1003963