

Nuclear Explosion : 100.0 kT Surface Burst

Personnel exposed to a nuclear explosion may be killed or suffer injuries of various types. Casualties are primarily caused by blast, thermal radiation, and ionizing radiation. The distribution and severity of these injuries depends on device yield, height of burst, atmospheric conditions, body orientation, protection afforded by shelter, and the general nature of the terrain.

The energy of a nuclear explosion is partitioned as follows,

- 50% Blast and ground shock
- 35% Thermal Radiation
- 15% Ionizing Radiation
 - 5% Prompt (first minute)
 - 10% Delayed (minutes to years)

The 100.0 kT nuclear explosion produces a fireball of incandescent gas and vapor. Initially, the fireball is many times more brilliant than the sun at noon, but quickly decreases in brightness and continues to expand. In about 1 second, the fireball will have reached its maximum diameter of about 550 meters. After 1 minute, the fireball will have cooled sufficiently so that it no longer glows.

BLAST

Blast casualties may occur due to the direct action of the pressure wave, impact of missiles and fragments, and whole body translation and impact. The destructiveness of the blast is a function of its peak overpressure and duration of the positive pressure wave (or impulse). The 100.0 kT explosion will produce in excess of the blast required to produce 100% lethality out to a distance of 0.56 km (0.35 miles). Injuries associated with shattered glass windows can occur out to a distance of 5.41 km (3.36 miles).

THERMAL RADIATION

Burn casualties may result from the absorption of thermal radiation energy by the skin, heating or ignition of clothing, and fires started by the thermal pulse or as side effects of the air blast or the ground shock. Exposed eyes are at risk of permanent retinal burns and flash blindness out to relatively large distances (especially at night when the diameter of the pupil is maximum). Under daytime conditions of very good visibility (80 km or 50 miles), the 100.0 kT explosion could produce flash blindness out to a distance of 29 km (18 miles). Individuals who directly view the initial fireball could experience retinal burns out to a distance of 160 km (99 miles). Unprotected individuals could receive in excess of the thermal radiation dose required for third degree burns, out to a distance of 5.7 km (3.5 miles).

IONIZING RADIATION

Radiation casualties may be caused by prompt nuclear radiation or by radioactive fallout. Prompt ionizing radiation consists of x rays, gamma rays, and neutrons produced in the first minute following the nuclear explosion. Unprotected individuals could receive in excess of the prompt ionizing radiation dose required for 50% lethality (within weeks), out to a distance of 2.1 km (1.31 miles).

The delayed ionizing radiation is produced by fission products and neutron-induced radionuclides in surrounding materials (soil, air, structures, nuclear device debris). These radioactive products will be dispersed downwind with the fireball/debris cloud. As the cloud travels downwind, the radioactive material that has fallen and settled on the ground creates a footprint of deposited material (fallout).

The exposure to the fallout is the dominant source of radiation exposure for locations beyond the prompt effects of the nuclear detonation. The dose received depends upon the time an individual remains in the contaminated area. Unprotected individuals remaining in the contamination zone for the first hour following the nuclear explosion could receive in excess of the fallout dose required for 50% lethality (within weeks), out to a distance of

Hotspot Table Output

about 17 km (11 miles). The idealized maximum width of the fallout footprint (actual width could be larger or smaller) is about 2.4 km (1.5 miles). This distance increases to about 50 km (31 miles), for individuals remaining in the contamination for the first 24 hours. The idealized width increases to about 6.9 km (4.3 miles).

ELECTROMAGNETIC PULSE (EMP)

The EMP range for the 100.0 kT detonation is approximately 6 km (4 miles). This range is the outer extent that any EMP effects are expected to occur. Not all equipment within the EMP-effects circle will fail. The amount of failure will increase the closer to ground zero the equipment is located, the larger the equipment's effective receptor antenna, and the equipment's sensitivity to EMP effects. Solid state devices are more sensitive than vacuum tube devices. Least affected by EMP are electro-mechanical devices such as electric motors, lamps, heaters, etc. Cell phones and handheld radios have relatively small antennas and if they are not connected to electrical power supplies during the EMP pulse, will probably not be affected by the EMP.

The effects of EMP occur at the instant of the nuclear detonation and ends within a few seconds. Any equipment that will be damaged by EMP will be damaged within those seconds. Electronic equipment entering the area after the detonation will function normally as long as they do not rely on previously damaged equipment, e.g., repeaters, power supplies, etc.

Nuclear Yield	:	100.0 kT		
Cloud Radius	:	6.71	km	
Cloud Top	:	14300	m	
Cloud Bottom	:	9200	m	
Cloud 2/3 Stem	:	6100	m	
Time of Fall	:	2.6	hr	
Wind Direction	:	270	degrees	wind from the West
Effective wind Speed	:	6.8	m/s	

Radial Distances for Prompt Effects (first minute following nuclear explosion)

Prompt Ionizing Radiation Effects : whole-body Dose - Includes Gamma and Neutron Radiation

10,000 rad (cGy)	[100% death, < 1 day].....	1.31 km (0.81 miles)
1,000 rad (cGy)	[100% death, days].....	1.81 km (1.12 miles)
300 rad (cGy)	[50% death, weeks].....	2.11 km (1.31 miles)
150 rad (cGy)	[10% death, years].....	2.21 km (1.37 miles)
30 rad (cGy)	[1% death, years].....	2.61 km (1.62 miles)

Prompt Blast Effects : Lethality

Threshold 30 psi (30-50).....	0.84 km (0.52 miles)
50 % 50 psi (50-75).....	0.66 km (0.41 miles)
100 % 75 psi (75-115).....	0.56 km (0.35 miles)

Prompt Blast Effects : Lung Damage

Threshold 8 psi (8-15).....	1.61 km (1.00 miles)
Severe 20 psi (20-30).....	1.01 km (0.63 miles)

Prompt Blast Effects : Eardrum rupture

Threshold 5 psi.....	2.11 km (1.31 miles)
50 % 15 psi (15-20).....	1.21 km (0.75 miles)

Prompt Blast Effects : Shattered window glass injury

Threshold 0.5 psi.....	5.41 km (3.36 miles)
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Prompt Thermal Effects : Skin burns and Eye Damage

Visibility :	20 km (12 miles)	
50 % 1st Degree (2.9 cal/cm2).....	5.91 km (3.67 miles)	
50 % 2nd Degree (5.5 cal/cm2).....	4.81 km (2.99 miles)	
50 % 3rd Degree (8.5 cal/cm2).....	4.11 km (2.55 miles)	

Hotspot Table Output

Flash blindness (0.16 cal/cm2).....	13 km (8.1 miles)
Retinal burns (0.0001 cal/cm2).....	39 km (24 miles)
Visibility : 40 km (25 miles)	
50 % 1st Degree (2.9 cal/cm2).....	7.41 km (4.60 miles)
50 % 2nd Degree (5.5 cal/cm2).....	5.81 km (3.61 miles)
50 % 3rd Degree (8.5 cal/cm2).....	4.91 km (3.05 miles)
Flash blindness (0.16 cal/cm2).....	19 km (11.8 miles)
Retinal burns (0.0001 cal/cm2).....	66 km (41 miles)
Visibility : 80 km (50 miles)	
50 % 1st Degree (2.9 cal/cm2).....	9.21 km (5.72 miles)
50 % 2nd Degree (5.5 cal/cm2).....	6.91 km (4.29 miles)
50 % 3rd Degree (8.5 cal/cm2).....	5.71 km (3.55 miles)
Flash blindness (0.16 cal/cm2).....	29 km (18.0 miles)
Retinal burns (0.0001 cal/cm2).....	161 km (100 miles)
Electromagnetic Pulse (EMP)	
Maximum extent of radial EMP effects...	6 km (4 miles).

Centerline Distance 0.030 km (0.019 mi)

Blast (maximum overpressure)	1.1E+06 psi
Prompt Neutron	3.0E+07 rad
Prompt Gamma	6.6E+06 rad
Total Prompt Ionizing Radiation	3.7E+07 rad
Thermal @ Visibility = 20 km (12 miles):	3.5E+05 cal/cm2
Thermal @ Visibility = 40 km (25 miles):	3.5E+05 cal/cm2
Thermal @ Visibility = 80 km (50 miles):	3.5E+05 cal/cm2

Centerline Distance 0.100 km (0.062 mi)

Blast (maximum overpressure)	1.0E+04 psi
Prompt Neutron	1.5E+07 rad
Prompt Gamma	4.0E+06 rad
Total Prompt Ionizing Radiation	1.9E+07 rad
Thermal @ Visibility = 20 km (12 miles):	3.1E+04 cal/cm2
Thermal @ Visibility = 40 km (25 miles):	3.2E+04 cal/cm2
Thermal @ Visibility = 80 km (50 miles):	3.2E+04 cal/cm2

Centerline Distance 0.200 km (0.124 mi)

Blast (maximum overpressure)	1.1E+03 psi
Prompt Neutron	6.0E+06 rad
Prompt Gamma	2.1E+06 rad
Total Prompt Ionizing Radiation	8.0E+06 rad
Thermal @ Visibility = 20 km (12 miles):	7.6E+03 cal/cm2
Thermal @ Visibility = 40 km (25 miles):	7.8E+03 cal/cm2
Thermal @ Visibility = 80 km (50 miles):	7.9E+03 cal/cm2

Centerline Distance 0.300 km (0.186 mi)

Blast (maximum overpressure)	3.6E+02 psi
Prompt Neutron	2.4E+06 rad
Prompt Gamma	1.1E+06 rad
Total Prompt Ionizing Radiation	3.5E+06 rad
Thermal @ Visibility = 20 km (12 miles):	3.3E+03 cal/cm2
Thermal @ Visibility = 40 km (25 miles):	3.4E+03 cal/cm2
Thermal @ Visibility = 80 km (50 miles):	3.5E+03 cal/cm2

Centerline Distance 0.400 km (0.248 mi)

Blast (maximum overpressure)	1.7E+02 psi
Prompt Neutron	1.0E+06 rad
Prompt Gamma	5.7E+05 rad
Total Prompt Ionizing Radiation	1.6E+06 rad
Thermal @ Visibility = 20 km (12 miles):	1.8E+03 cal/cm2
Thermal @ Visibility = 40 km (25 miles):	1.9E+03 cal/cm2
Thermal @ Visibility = 80 km (50 miles):	2.0E+03 cal/cm2

Hotspot Table Output

Centerline Distance 0.500 km (0.311 mi)

Blast (maximum overpressure)	9.7E+01 psi
Prompt Neutron	4.3E+05 rad
Prompt Gamma	3.2E+05 rad
Total Prompt Ionizing Radiation	7.5E+05 rad
Thermal @ Visibility = 20 km (12 miles):	1.2E+03 cal/cm2
Thermal @ Visibility = 40 km (25 miles):	1.2E+03 cal/cm2
Thermal @ Visibility = 80 km (50 miles):	1.3E+03 cal/cm2

Centerline Distance 0.600 km (0.373 mi)

Blast (maximum overpressure)	6.3E+01 psi
Prompt Neutron	1.9E+05 rad
Prompt Gamma	2.0E+05 rad
Total Prompt Ionizing Radiation	3.9E+05 rad
Thermal @ Visibility = 20 km (12 miles):	7.8E+02 cal/cm2
Thermal @ Visibility = 40 km (25 miles):	8.3E+02 cal/cm2
Thermal @ Visibility = 80 km (50 miles):	8.7E+02 cal/cm2

Centerline Distance 0.700 km (0.435 mi)

Blast (maximum overpressure)	4.4E+01 psi
Prompt Neutron	8.6E+04 rad
Prompt Gamma	1.3E+05 rad
Total Prompt Ionizing Radiation	2.2E+05 rad
Thermal @ Visibility = 20 km (12 miles):	5.7E+02 cal/cm2
Thermal @ Visibility = 40 km (25 miles):	6.1E+02 cal/cm2
Thermal @ Visibility = 80 km (50 miles):	6.4E+02 cal/cm2

Centerline Distance 0.800 km (0.497 mi)

Blast (maximum overpressure)	3.3E+01 psi
Prompt Neutron	4.0E+04 rad
Prompt Gamma	8.4E+04 rad
Total Prompt Ionizing Radiation	1.2E+05 rad
Thermal @ Visibility = 20 km (12 miles):	4.2E+02 cal/cm2
Thermal @ Visibility = 40 km (25 miles):	4.6E+02 cal/cm2
Thermal @ Visibility = 80 km (50 miles):	4.9E+02 cal/cm2

Centerline Distance 0.900 km (0.559 mi)

Blast (maximum overpressure)	2.5E+01 psi
Prompt Neutron	1.9E+04 rad
Prompt Gamma	5.5E+04 rad
Total Prompt Ionizing Radiation	7.4E+04 rad
Thermal @ Visibility = 20 km (12 miles):	3.3E+02 cal/cm2
Thermal @ Visibility = 40 km (25 miles):	3.6E+02 cal/cm2
Thermal @ Visibility = 80 km (50 miles):	3.8E+02 cal/cm2

Centerline Distance 1.000 km (0.621 mi)

Blast (maximum overpressure)	2.0E+01 psi
Prompt Neutron	9.3E+03 rad
Prompt Gamma	3.4E+04 rad
Total Prompt Ionizing Radiation	4.3E+04 rad
Thermal @ Visibility = 20 km (12 miles):	2.6E+02 cal/cm2
Thermal @ visibility = 40 km (25 miles):	2.9E+02 cal/cm2
Thermal @ Visibility = 80 km (50 miles):	3.1E+02 cal/cm2

Fallout Information

Shielding: No Shielding (Shielding Attenuation Factor = 1)

Cloud Arrival Time (hr:min)	00:02
Dose Rate at 1 hr post detonation (H+1)	9.6E+08 rem/hr
Actual Dose Rate @ Cloud Arrival Time	4.5E+10 rem/hr
External Dose in First Hour	4.3E+09 rem
External Dose in First 6-hours	5.8E+09 rem
External Dose in First Day	6.6E+09 rem

Hotspot Table Output

External Dose in First 4-days	7.2E+09 rem
External Dose in First week	7.4E+09 rem
External Dose in First Month	7.8E+09 rem
External Dose in First Year	8.3E+09 rem
External Dose in 50-years	8.8E+09 rem

Centerline Distance 2.000 km (1.242 mi)

Blast (maximum overpressure)	5.3E+00 psi
Prompt Neutron	2.1E+01 rad
Prompt Gamma	3.1E+02 rad
Total Prompt Ionizing Radiation	3.3E+02 rad
Thermal @ Visibility = 20 km (12 miles):	5.3E+01 cal/cm2
Thermal @ Visibility = 40 km (25 miles):	6.5E+01 cal/cm2
Thermal @ Visibility = 80 km (50 miles):	7.5E+01 cal/cm2

Fallout Information

Shielding: No Shielding (Shielding Attenuation Factor = 1)

Cloud Arrival Time (hr:min)	00:04
Dose Rate at 1 hr post detonation (H+1)	3.1E+06 rem/hr
Actual Dose Rate @ Cloud Arrival Time	6.2E+07 rem/hr
External Dose in First Hour	1.0E+07 rem
External Dose in First 6-hours	1.5E+07 rem
External Dose in First Day	1.7E+07 rem
External Dose in First 4-days	1.9E+07 rem
External Dose in First week	2.0E+07 rem
External Dose in First Month	2.1E+07 rem
External Dose in First Year	2.3E+07 rem
External Dose in 50-years	2.4E+07 rem

Centerline Distance 4.000 km (2.484 mi)

Blast (maximum overpressure)	1.6E+00 psi
Prompt Neutron	Minimal Neutron
Prompt Gamma	Minimal Gamma
Thermal @ Visibility = 20 km (12 miles):	8.9E+00 cal/cm2
Thermal @ Visibility = 40 km (25 miles):	1.3E+01 cal/cm2
Thermal @ Visibility = 80 km (50 miles):	1.8E+01 cal/cm2

Fallout Information

Shielding: No Shielding (Shielding Attenuation Factor = 1)

Cloud Arrival Time (hr:min)	00:09
Dose Rate at 1 hr post detonation (H+1)	5.8E+04 rem/hr
Actual Dose Rate @ Cloud Arrival Time	5.1E+05 rem/hr
External Dose in First Hour	1.3E+05 rem
External Dose in First 6-hours	2.1E+05 rem
External Dose in First Day	2.6E+05 rem
External Dose in First 4-days	3.0E+05 rem
External Dose in First week	3.1E+05 rem
External Dose in First Month	3.4E+05 rem
External Dose in First Year	3.7E+05 rem
External Dose in 50-years	4.0E+05 rem

Centerline Distance 6.000 km (3.727 mi)

Blast (maximum overpressure)	Minimal Blast
Prompt Neutron	Minimal Neutron
Prompt Gamma	Minimal Gamma
Thermal @ Visibility = 20 km (12 miles):	2.7E+00 cal/cm2
Thermal @ Visibility = 40 km (25 miles):	4.9E+00 cal/cm2
Thermal @ Visibility = 80 km (50 miles):	7.4E+00 cal/cm2

Fallout Information

Shielding: No Shielding (Shielding Attenuation Factor = 1)

Cloud Arrival Time (hr:min)	00:14
Dose Rate at 1 hr post detonation (H+1)	1.1E+04 rem/hr
Actual Dose Rate @ Cloud Arrival Time	6.0E+04 rem/hr
External Dose in First Hour	1.8E+04 rem
External Dose in First 6-hours	3.5E+04 rem
External Dose in First Day	4.4E+04 rem

Hotspot Table Output

External Dose in First 4-days	5.1E+04 rem
External Dose in First Week	5.4E+04 rem
External Dose in First Month	5.9E+04 rem
External Dose in First Year	6.5E+04 rem
External Dose in 50-years	6.9E+04 rem

Centerline Distance 8.000 km (4.969 mi)

Blast (maximum overpressure)	Minimal Blast
Prompt Neutron	Minimal Neutron
Prompt Gamma	Minimal Gamma
Thermal @ Visibility = 20 km (12 miles):	1.0E+00 cal/cm2
Thermal @ Visibility = 40 km (25 miles):	2.2E+00 cal/cm2
Thermal @ Visibility = 80 km (50 miles):	3.9E+00 cal/cm2

Fallout Information

Shielding: No Shielding (Shielding Attenuation Factor = 1)

Cloud Arrival Time (hr:min)	00:19
Dose Rate at 1 hr post detonation (H+1)	4.4E+03 rem/hr
Actual Dose Rate @ Cloud Arrival Time	1.7E+04 rem/hr
External Dose in First Hour	5.5E+03 rem
External Dose in First 6-hours	1.2E+04 rem
External Dose in First Day	1.6E+04 rem
External Dose in First 4-days	1.9E+04 rem
External Dose in First week	1.9E+04 rem
External Dose in First Month	2.1E+04 rem
External Dose in First Year	2.4E+04 rem
External Dose in 50-years	2.6E+04 rem

Centerline Distance 10.000 km (6.211 mi)

Blast (maximum overpressure)	Minimal Blast
Prompt Neutron	Minimal Neutron
Prompt Gamma	Minimal Gamma
Thermal @ Visibility = 20 km (12 miles):	4.3E-01 cal/cm2
Thermal @ Visibility = 40 km (25 miles):	1.2E+00 cal/cm2
Thermal @ Visibility = 80 km (50 miles):	2.4E+00 cal/cm2

Fallout Information

Shielding: No Shielding (Shielding Attenuation Factor = 1)

Cloud Arrival Time (hr:min)	00:24
Dose Rate at 1 hr post detonation (H+1)	2.4E+03 rem/hr
Actual Dose Rate @ Cloud Arrival Time	7.0E+03 rem/hr
External Dose in First Hour	2.3E+03 rem
External Dose in First 6-hours	5.9E+03 rem
External Dose in First Day	7.9E+03 rem
External Dose in First 4-days	9.5E+03 rem
External Dose in First week	1.0E+04 rem
External Dose in First Month	1.1E+04 rem
External Dose in First Year	1.2E+04 rem
External Dose in 50-years	1.3E+04 rem

Centerline Distance 20.000 km (12.422 mi)

Blast (maximum overpressure)	Minimal Blast
Prompt Neutron	Minimal Neutron
Prompt Gamma	Minimal Gamma
Thermal @ Visibility = 20 km (12 miles):	1.5E-02 cal/cm2
Thermal @ Visibility = 40 km (25 miles):	1.1E-01 cal/cm2
Thermal @ Visibility = 80 km (50 miles):	4.4E-01 cal/cm2

Fallout Information

Shielding: No Shielding (Shielding Attenuation Factor = 1)

Cloud Arrival Time (hr:min)	00:49
Dose Rate at 1 hr post detonation (H+1)	6.0E+02 rem/hr
Actual Dose Rate @ Cloud Arrival Time	7.6E+02 rem/hr
External Dose in First Hour	1.2E+02 rem
External Dose in First 6-hours	1.0E+03 rem
External Dose in First Day	1.5E+03 rem
External Dose in First 4-days	1.9E+03 rem

Hotspot Table Output

External Dose in First week	2.0E+03 rem
External Dose in First Month	2.3E+03 rem
External Dose in First Year	2.6E+03 rem
External Dose in 50-years	2.9E+03 rem

Centerline Distance 40.000 km (24.845 mi)

Blast (maximum overpressure)	Minimal Blast
Prompt Neutron	Minimal Neutron
Prompt Gamma	Minimal Gamma
Thermal @ Visibility = 20 km (12 miles):	6.7E-05 cal/cm2
Thermal @ Visibility = 40 km (25 miles):	3.6E-03 cal/cm2
Thermal @ Visibility = 80 km (50 miles):	6.0E-02 cal/cm2

Fallout Information

Shielding: No Shielding (Shielding Attenuation Factor = 1)

Cloud Arrival Time (hr:min)	01:38
Dose Rate at 1 hr post detonation (H+1)	2.3E+02 rem/hr
Actual Dose Rate @ Cloud Arrival Time	1.3E+02 rem/hr
External Dose in First Hour	0.0E+00 rem
External Dose in First 6-hours	2.4E+02 rem
External Dose in First Day	4.4E+02 rem - 460
External Dose in First 4-days	5.9E+02 rem
External Dose in First week	6.4E+02 rem
External Dose in First Month	7.4E+02 rem
External Dose in First Year	8.7E+02 rem
External Dose in 50-years	9.7E+02 rem

Centerline Distance 60.000 km (37.267 mi)

Blast (maximum overpressure)	Minimal Blast
Prompt Neutron	Minimal Neutron
Prompt Gamma	Minimal Gamma
Thermal @ Visibility = 20 km (12 miles):	Minimal Thermal
Thermal @ Visibility = 40 km (25 miles):	2.2E-04 cal/cm2
Thermal @ Visibility = 80 km (50 miles):	1.5E-02 cal/cm2

Fallout Information

Shielding: No Shielding (Shielding Attenuation Factor = 1)

Cloud Arrival Time (hr:min)	02:27
Dose Rate at 1 hr post detonation (H+1)	1.4E+02 rem/hr
Actual Dose Rate @ Cloud Arrival Time	4.8E+01 rem/hr
External Dose in First Hour	0.0E+00 rem
External Dose in First 6-hours	9.6E+01 rem
External Dose in First Day	2.2E+02 rem
External Dose in First 4-days	3.1E+02 rem - 310
External Dose in First week	3.4E+02 rem
External Dose in First Month	4.0E+02 rem
External Dose in First Year	4.7E+02 rem
External Dose in 50-years	5.4E+02 rem

Centerline Distance 80.000 km (49.689 mi)

Blast (maximum overpressure)	Minimal Blast
Prompt Neutron	Minimal Neutron
Prompt Gamma	Minimal Gamma
Thermal @ Visibility = 20 km (12 miles):	Minimal Thermal
Thermal @ Visibility = 40 km (25 miles):	1.7E-05 cal/cm2
Thermal @ Visibility = 80 km (50 miles):	4.5E-03 cal/cm2

Fallout Information

Shielding: No Shielding (Shielding Attenuation Factor = 1)

Cloud Arrival Time (hr:min)	03:16
Dose Rate at 1 hr post detonation (H+1)	9.5E+01 rem/hr
Actual Dose Rate @ Cloud Arrival Time	2.3E+01 rem/hr
External Dose in First Hour	0.0E+00 rem
External Dose in First 6-hours	4.3E+01 rem
External Dose in First Day	1.2E+02 rem
External Dose in First 4-days	1.8E+02 rem - 180
External Dose in First week	2.0E+02 rem

		Hotspot Table Output	
External Dose in First Month	2.5E+02	rem	
External Dose in First Year	3.0E+02	rem	
External Dose in 50-years	3.4E+02	rem	— 340
