# Immediate Effects of a Nuclear Attack

The yield of a nuclear weapon is usually described in terms of the quantity of the chemical explosive required to release an equivalent amount of energy; a nuclear weapon is said to the power of kilotons (thousands of tons) and of megatons (millions of tons) of TNT. A standard bomb in today's arsenals is one of 20 megatons. One of the most devastating immediate effects of a nuclear bomb is the fireball, which produces (1) the thermal pulse and (2) the blast wave.

As the fireball from a nuclear explosion expands, energy is absorbed in the form of x-rays by the surrounding air, and the air reradiates a portion of that energy into the environment in the form of the thermal pulse. The fireball also sends out a blast wave in all directions. Expanding as large as three miles in diameter, the fireball pulverizes and then vaporizes all that it engulfs.

## Thermal Pulse

When the thermal pulse is emitted, searing heat ignites everything flammable and starts to melt windows, cars, buses, lampposts, and everything made of metal or glass. People in the street immediately catch on fire and are shortly reduced to charred corpses. The thermal pulse of a one megaton bomb lasts for about ten seconds and can cause second-degree burns in exposed human beings at a distance of 9-1/2 miles, or in an area of more than 280 square miles; that of a 20-megaton bomb lasts for about 20 seconds and can produce the same consequences at a distance of 28 miles, or in an area of 2460 square miles. Such burns caused by the pulse over half the body result in serious shock and are likely to be fatal unless promptly treated. Thermal pulse can ignite newspapers at 2 miles in a 12.5 kiloton weapon and at 25 miles in a 20-megaton weapon [10:67-69].

The thermal pulse gets weaker at it travels outward because of absorption by the atmosphere as well geometrical spreading. The attenuation depends on atmospheric conditions; it is greatest in haze or fog. The intense visible light can cause temporary "flashblindness" in anyone who is looking in the direction of the explosion. A person whose eyes are focusing directly on the fireball will suffer serious retinal damage and possibly permanent blindness.

## Blast Wave

The mechanical motions of a nuclear explosion are analogous to those of a tidal wave. The blast wave is literally a wall of compressed air. As it passes, structures are exposed to a nearly instantaneous rise in the local atmospheric pressure and may be crushed. Following the shock front are strong winds analogous to the water currents that follow a moving ocean wave. The forces resulting from these winds may also lead to the collapse of structures in the target area. Depending on their shape and construction, buildings may be vulnerable either to the blast wave or to the winds that follow it, or to both (see Table 1).

| **Table 1. Effects of Blast from a Nuclear Explosion** [1:37]. | | |
|---|---|---|
| **Peak over-pressure** | **Effects** | **Distance to which effects are felt** [1] |
| 20 psi[2] | Multi-story reinforced concrete buildings demolished; winds, 500 miles per hour. | 1.8 mi |
| 10 psi | Most factories and commercial buildings collapsed; small wood and brick residences destroyed; winds, 300 miles per hour. | 2.7 mi |
| 5 psi | Unreinforced brick and wood houses destroyed; heavier construction, severely damaged; winds, 160 miles per hour. | 4 mi |
| 2 psi | Moderate damage to houses (wall frames cracked, severe damage to roofs, interior walls knocked down); people injured by flying glass and debris; winds, about 60 miles per hour. | 7-8 mi |
| [1] One-megaton burst at 6000 feet.<br>[2] Pounds per square inch. | | |

The blast wave of a one-megaton bomb can flatten or severely damage all but the strongest buildings within a radius of 4 and 1/2 miles, and that of a 20-megaton bomb can do the same within a radius of 12 miles. The walls, roofs, and floors of any building that has not been flattened would be collapsed, and the people and furniture inside swept out into the street. The blast wave of a sizeable nuclear weapon endures for several seconds. People of course would be picked up and hurled away from the blast along with the rest of the debris. As far away as 10 miles from ground zero, pieces of glass and other sharp objects would be hurled about by the blast at lethal velocities. At a distance of 2 miles or so from ground zero, winds would reach 400 miles per hour. The 400-mile-per-hour wind would die down after a few seconds and then blow in the reverse direction with diminished intensity [3:34-37].

## Electromagnetic Pulse

Electromagnetic pulse (EMP) is a type of nuclear fallout. The principal victims of EMP are the solid state circuits that form the groundwork of our modern world. In 1962 the United States set off a 1.4 megaton hydrogen bomb 248 miles above Johnston Island. On Ohau, 800 miles northeast, 300 streetlights went dark, and hundreds of burglar alarms began ringing [12:55].

EMP is produced when gamma rays emitted during the first few nanoseconds (a nanosecond is one-billionth of a second) of a high-altitude nuclear burst collide with upper-atmosphere. Electrons scattered by gamma rays accelerate and deflect off the earth's magnetic field. These electrons produce an extremely high-voltage electric current; the current then sets up EMPs, which radiate to earth. Figure 1 shows the EMP ground coverage for nuclear bursts at 100, 300, and 500 kilometers above the United States. Any metal object such as an.antenna, cable, pipeline, fence, or powerline, can act as a pulse collector, gathering energy from the transitory charge. EMP travels through the collector to damage the machinery.

Electromagnetic pulse is short lived, having a duration 100 times shorter than that of a lightning bolt and does not carry a large amount of energy. One-millionth of the energy of a nuclear explosion goes into EMP; therefore, it is harmless to humans. Everything from TVs to cars, from home appliances to industrial control equipment, from power current sensors to broadcast devices and computers are likely to malfunction as a result of EMP. It may also affect electronic controls in nuclear power plants and initiate meltdowns in every nuclear reactor in the country.

The military has begun shielding or "hardening" its equipment against EMP. The Department of Defense is now buying fiberoptic cables to replace the old ones for its ground-based communications network. Computers, power, and communications are the basic systems affected by EMP. Old fashioned electronic equipment (high-voltage motors and vacuum tubes) are EMP resistant; however, the types of computer chips in military and civilian telecommunications systems are EMP fragile. No one knows whether the "red alert" network (the president's wartime communications network) will function in a nuclear attack [7:1118].

## Mass Fires

Under certain weather conditions each one-megaton burst could ignite fires as much as ten miles away. Flash-induced fires would be joined by blast-induced fires from toppled furnaces, stoves, and boilers. Scattered debris and ruptured tanks and pipelines would add fuel to the resulting fires. Firebreaks would be bridged by materials hurled from the blast. After the attack the suppression of possibly hundreds small fires per acre would be a monumental task; water mains would be shattered, and firefighting equipment and crews would be destroyed or disabled. Care of burn victims would be particularly difficult. Treatment of serious burns requires highly specialized facilities, which are rare; in the entire United States there are now only one or two thousand hospital beds dedicated to burn care. Even in a single-city attack, a vast number of burn victims, who might otherwise have been saved, would die for lack of adequate treatment.

Depending on weather conditions and the characteristics of the target area (particularly the density of flammable structures), the many individual fires could easily consolidate into one of the two types of mass fires: a firestorm or a conflagration. A firestorm is driven by a strong vertical updraft of heated air, which is replaced by cool air sucked in from the periphery of the fire. A conflagration is driven also by strong ground wind present before the attack. Whereas a firestorm continues only as long as its centripetal winds do, a conflagration can continue as long as fuel is available [10: 91-93].

The consequence of a mass fire is total devastation within the affected area. The temperature in a mass fire can exceed 1000 degrees Celsius, a temperature higher than necessary to melt glass and metal and to burn ordinary fireproof materials. In addition to the burn casualties, carbon monoxide and other toxic gases generated by the fire would be deadly.

## Radioactive Fallout

A well-known effect of nuclear warfare is fallout. Exposure to radioactivity in human beings is measured in units called rems.an acronym for "roentgen equivalent in man." The roentgen is a standard measurement of gamma and x-ray radiation, and the expression "equivalent in man" indicates that an adjustment has been made to take into account the differences in the degree of biological damage that is caused by radiation of different types. The effects of radioactive fallout on humans and nature are catastrophic.

**Effects on Humans**. Radioactive harm to humans is calculated by the amount of radiation one will accumulate in one week. Doses in thousands of rems, which could be expected throughout a target city, would attack the central nervous system and bring death within a few hours. Doses of around a thousand rems, which would be delivered some tens of miles downwind from the blast, would kill within two weeks everyone exposed to them. Doses of around 500 rems, which be delivered as far as 150 miles downwind, would kill half of all healthy adults.

At this level of exposure, in the weeks after the bombing, many survivors would begin to notice the appearance of petechiae, small spots caused by hemorrhages, on their skin. These usually signal the onset the critical stage of radiation sickness.

In the first stage of radiation sickness, the victims usually vomit repeatedly, run a fever, and develop an abnormal thirst. Then, after a few hours or days, there is a deceptively hopeful period of the remission of symptoms, called the latency period, which lasts between one and four weeks. Radiation attacks the reproductive function of cells, and those that reproduce most frequently are therefore the most vulnerable. Among these are the bone-marrow cells, which are responsible for the production of blood cells. During the latency period, the count of white blood cells, which are instrumental in fighting infection, and the count of platelets, which are instrumental in clotting, drop precipitously so that the body is poorly defended against infection and is liable to hemorrhaging. In the third and final stage, which may last for several weeks, the victim's hair may fall out, and he may suffer from diarrhea and may bleed from the intestines, the mouth, or other parts of the body; in the end, he will either recover or die [2:169-172].

**Effects on Nature.** Radioactivity penetrates the environment in many ways. The two most important components of radiation from fallout are gamma rays, which are electromagnetic radiation of the highest intensity, and beta particles, which are electrons fired at high speed from decaying nuclei. Gamma rays subject organisms to penetrating whole-body doses and are responsible for most of the ill effects of radiation from fallout. Beta particles, which are less penetrating than gamma rays, act at short range, doing harm when they collect on the skin or on the surfaces of plants.

**Effects on Animals**. The lethal doses for most mammals lie between a few hundred rads and a thousand rads of gamma radiation (a "rad," for "roentgen absorbed dose, is a roentgen of radiation absorbed by an organism, roughly equal to a rem). For example, the lethal doses of gamma radiation for animals in pasture, where fallout would descend directly and where animals would eat grass with the fallout on it and thus suffer doses of beta radiation as well, would be 180 rads for cattle; 240 rads for sheep; 550 rads for swine; 350 rads for horses; and 800 rads for poultry.

In a full-scale attack, which would create levels of radiation around the country averaging more than 10,000 rads, most of the mammals in the United States would be killed off. The lethal doses for birds are roughly the same as those for mammals, and birds would be killed off too. Fish are killed at doses of between 1100 and 5600 rads, but their fate is less predictable. On the one hand, water is a shield from radiation and would afford some protection; on the other hand, fallout might concentrate in bodies of water as it ran off from the land [1:44-48].

Because radiation causes no pain, animals, wandering at will through the environment, would not avoid it. The one class of animals containing a number of species quite likely to survive, at least in the short run, is the insect class, for which the lethal dose lies between about 2000 rads and 10,000 rads. Insects, instead, would be destroyed selectively.

**Effects on Plants**. Plants in general have a higher tolerance to radioactivity than animals do. Nevertheless, a gamma-ray dose of 10,000 rads would devastate most vegetation in the United States. As a general rule, large plants are more vulnerable to radiation than small ones.

Trees are among the first to die, grasses among the last. The most sensitive trees are pine and the other conifers, for which lethal doses are in roughly the same range as those for mammals. Any survivors coming out of their shelters a few months after the attack would find that all the pine trees still standing were already dead. The lethal doses for most deciduous trees range from about 2000 rads of gamma-ray radiation to about 10,000 rads, with lethal doses for 80 percent of deciduous species falling between 2000 and 8000 rads. Since the addition of the beta-ray burden could lower these lethal doses for gamma rays by as much as 50 percent, the actual lethal doses in gamma rays for these trees during an attack might be from 1000 to 4000 rads; in a full-scale attack, they would die.

Lethal doses for grasses on which tests have been done range between 6000 and 33,000 rads, and a good deal of grass would therefore survive, except where the attack had been the most direct. The lethal dose for spring barley seedlings, for example, is 1990 rads; for spring wheat seedlings, 3090 rads. In any event, when vegetation is killed off in this manner, the land on which it grew is degraded and loses its ability to grow new vegetation [5:142].

## Information Sources

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