INTRODUCTION

The Department of Energy's (DOE) National Nuclear Security Administration (NNSA) has a primary mission of stewardship and maintenance of nuclear weapons. In the handling and transporting of these weapons by NNSA (or the Department of Defense [DOD]), there is a remote possibility that an accident can occur. However, extensive safety measures are in place to prevent these accidents, and trained DOE/NNSA and DOD teams are ready to respond should one occur.

WHAT IS A NUCLEAR WEAPON?

A nuclear weapon is a device whose violent explosive power is due to the sudden release of energy resulting from the splitting of nuclei of a heavy chemical element, such as plutonium or uranium, or the fusing of nuclei from a light element, hydrogen. Such a weapon is made of electrical and mechanical components, conventional high explosives, other chemicals, and special nuclear materials. The actual design of a nuclear weapon is classified.

There are two basic types of nuclear weapons, fission and fusion. Both types are found today in the U.S. nuclear weapons stockpile.

Fission Reaction

Fission refers to the splitting of a heavy nucleus of an atom into approximately two equal parts, accompanied by the release of a relatively large amount of energy and generally one or more neutrons. These neutrons, in turn, split more nuclei, leading to a chain reaction that results in a massive explosion. The nuclear detonation occurs in about one microsecond.

Nuclear Weapons Guide

Before the explosion can occur, there must be a critical mass of fissionable material, such as plutonium or uranium. A critical mass is the smallest amount of fissionable material that will support a self-sustaining chain reaction.

Fusion Reaction

Fusion refers to the formation of a heavier nucleus from two lighter ones, such as hydrogen isotopes (forms of an element), with the attendant release of energy. It takes energy input to achieve the extremely high temperatures required to get fusion fuel to fuse, but once fused it releases much more energy than that put in. In these weapons, often called thermonuclear or hydrogen bombs, this energy input is provided by a fission reaction.

Once a nuclear weapon explodes from a fission or fusion reaction, the magnitude of the blast is called its yield. The yield of a nuclear weapon is measured in tons, kilotons (thousands), and megatons (millions). The smallest nuclear weapons had yields of less than one ton, while the largest were 15 megatons by the United States and 58 megatons by the Soviet Union.

SAFETY FACTORS

The NNSA objective of nuclear explosive safety is to prevent the accidental or unauthorized prearming, arming, launching, firing, releasing, or detonation (high explosive or nuclear) of, and unauthorized access to, nuclear explosives involved in operations conducted or sponsored by NNSA. Another goal is to assure accomplishment of NNSA responsibilities for the resolution of safety matters associated with nuclear weapons transferred to the custody of DOD.

NNSA safety factors include:

- A positive nuclear weapon safety program to prevent a nuclear yield as a result of accidental or unauthorized means.
- Safety studies and reviews of nuclear weapon systems conducted on a regular basis.
- Checks on adequacy of system design safety and operational procedures.
- Investigation of any possible unsafe conditions resulting from modifications or retrofits.
- Reviews to assure safety procedures are incorporated into systems development.
- Positive measures to prevent deliberate prearming, arming, launching, firing, or releasing of nuclear weapons, except on execution of emergency war orders or when directed by authorized person.
- Positive measures to prevent inadvertent prearming, arming, launching, firing, or releasing of nuclear weapons in all normal or credible off-normal environments.
- Assurance of adequate security to prevent unauthorized access to weapons.
- Features that prevent electrical current from getting into the weapon, which could cause detonation.
- Not putting in batteries until the weapon is ready for use.
- Devices to interrupt load avertent power.
- Denial devices to keep people away from weapons.

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- Mechanisms to prevent a person from getting energy into the weapon even if he or she should get close.
- Actuation of destruct devices if foul play occurs.

POTENTIAL HAZARDS FROM NUCLEAR WEAPONS ACCIDENTS

While there is an intense and continuing effort to make nuclear weapons safer and less vulnerable to terrorist attack or theft, there remains a very remote chance that something of this nature could happen.

Nuclear weapons are capable of producing two types of explosions, a chemical explosion involving only the conventional "high explosive" (HE) charge in a weapon or an explosion with a nuclear yield involving the uranium or plutonium (or both) in a weapon.

HE Component

Nuclear weapons contain varying amounts of HE, which could explode if it were dropped from a height or be involved in a severe truck, railroad, or airplane crash. Also, the breakage of a weapon due to impact or due to a small explosion would probably result in scattering of small pieces of HE, which might burn or possibly explode.

Rough handling of HE can lead to the formation of powdered explosive. Under these conditions, most explosive materials are more unstable than in solid form and are more apt to be detonated by shock or change in temperature.

If a weapon becomes engulfed in flames during an accident, it is possible that the fire could detonate the HE.

The development of insensitive high explosive (IHE) has greatly reduced the chance of a HE detonation caused by impact in those weapons now containing IHE.

Should terrorists get access to a weapon, it is possible they might detonate the HE with a bullet or hand grenade, but this in itself would not create a nuclear yield.

Nuclear Component

While the steps required to make a weapon give a nuclear yield are classified, nuclear yield accidents are extremely remote.

There is a concern about the possibility of a terrorist group stealing a weapon and having under its control a person who might know how to prepare a weapon to give a nuclear yield. Extremely tight security measures are in place to prevent this from happening.

WHAT HAPPENS IF HE EXPLODES?

Detonation of HE is a chemical explosion, resulting in rapidly expanding heat and gases. It is the single most important concern in a nuclear weapon accident or fire.

Such an explosion will disperse the radioactive material in a weapon and propel shrapnel up to a distance of some 2,000 feet from the weapon. The size of the dispersed radioactive material may range in size from chunks to particles less than 10 microns across. Particles below 10 microns are considered respirable. How far and wide they are dispersed depends on how much HE there was in the weapon, the velocity of the wind, and other weather factors.

Nuclear Yield

In the unlikely event of an HE explosion leading to a nuclear yield, here basically is what would happen:

A sudden liberation of energy, thousands or millions of times greater than that caused by a conventional explosion, causes a vast increase of temperature and pressure, so that all the materials present are converted into hot, compressed gases.

These gases expand rapidly and initiate a shock wave in the surrounding medium—air, water, or earth. The characteristic of the shock wave is a sudden increase of pressure at the front, with a gradual decrease behind it. A shock wave in the air is sometimes called a blast wave.

A large proportion of the energy in a nuclear explosion is emitted in the form of light and heat, generally referred to as "thermal radiation." This is capable of causing skin burns that can be fatal or otherwise extremely serious. Thermal radiation can cause damage to humans or start fires at great distances.

Highly penetrating and harmful invisible rays, called "initial nuclear radiation", accompany the nuclear explosion. This consists mainly of gamma rays, which are electromagnetic radiations of high energy originating in atomic nuclei and neutrons. Gamma rays can travel great distances through air and can penetrate considerable thicknesses of material. Although they can neither be seen nor felt by human beings, except at very high intensities that cause a tingling sensation, gamma rays and neutrons can produce harmful effects even at a distance from their source.

The substances remaining after a nuclear explosion are radioactive, emitting radiations over an extended period of time. This is known as the "residual nuclear radiation." This delayed radiation arises mainly from the fission products created by the explosion from the nuclear materials that were in the weapon. In the course of their radioactive decay, these fission products emit gamma rays and another type of nuclear radiation called beta particles, which also are invisible. They are much less penetrating than gamma rays but represent a potential hazard. Residual radiation is most intense soon after the explosion but diminishes in the course of time.

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