Preventing Nuclear Terrorism

A Project of the Union of Concerned Scientists

Fact sheet

If a terrorist group exploded just one nuclear weapon, hundreds of thousands of people could die. Because there is no effective protection against nuclear terrorism, the only solution is to prevent terrorists from obtaining nuclear weapons, and the fissile materials needed to make them, in the first place.

Fissile Materials Basics

Nuclear reactors and nuclear weapons derive power through the fission (splitting) of nuclei of uranium or plutonium atoms, a process that releases large amounts of energy. These fissile materials are used for a variety of civil and military purposes, as shown in the table below.

Uranium. Uranium occurs naturally, but fortunately not in a form that is directly usable for nuclear weapons. Natural uranium consists mostly of two different "isotopes"—atoms of the same element that differ only in their numbers of neutrons and thus have slightly different weights. Natural uranium contains approximately 0.7 percent uranium-235 (the isotope essential for nuclear weapons) and 99.3 percent uranium-238. To convert natural uranium into a form that can be used in nuclear weapons, it must be "enriched" to increase the concentration of uranium-235.

Enriching uranium is both technically difficult and expensive, as it requires separating isotopes that have very similar chemical and physical properties. The enrichment process is thus the main barrier to producing uranium suitable for use in nuclear weapons.

Type of Fissile Material	Main Uses *(Nuclear weapons uses in italics)*
Natural Uranium	some power reactors *military plutonium production reactors*
Low-Enriched Uranium (LEU)	most operating power reactors some research reactors French naval propulsion reactors
Highly Enriched Uranium (HEU)	many research reactors U.S., British, and Russian naval propulsion reactors *nuclear weapons* *military plutonium and tritium production reactors*
Mixed Plutonium-Uranium Oxide (MOX)	some research and experimental reactors some power reactors
Plutonium	*nuclear weapons*

Low-enriched uranium (LEU) contains between 0.7 percent and 20 percent uranium-235, and highly enriched uranium (HEU) contains 20 percent or more uranium-235. LEU is not directly usable for weapons. HEU produced for weapons ("weapon-grade" uranium) is typically enriched to 90 percent uranium-235 or greater, but all HEU can be used to make nuclear weapons. The difficulty and expense of the enrichment process has an important consequence: HEU can be diluted with natural uranium to produce LEU, effectively eliminating the risk that it could be used to make a nuclear weapon if stolen by terrorists.

However, as sophisticated enrichment technology spreads around the world, more groups will be able to overcome the technical barriers to producing HEU for weapons. For this reason, Pakistan's illicit transfer of advanced enrichment technology to Iran, Libya, and North Korea is of grave concern to the international community. Moreover, the commercial enrichment facilities used to make LEU fuel for power reactors can be reconfigured to produce HEU for weapons. Without strong regulations in place, these dual-use facilities pose major risks of nuclear terrorism. In addition, the continued use of HEU for both civilian research and naval propulsion reactors increases the risk of terrorist access to this material.

Plutonium. Plutonium occurs only in trace amounts in nature. It is produced as a matter of course in power reactors when the uranium-238 in reactor fuel absorbs neutrons. Countries producing plutonium for weapons have generally

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operated their reactors to maximize the production of plutonium-239—the isotope most useful for nuclear weapons—and to minimize the production of other plutonium isotopes such as plutonium-240. Weapon-grade plutonium contains less than 7 percent plutonium-240. Under normal nuclear power plant operation, the plutonium in spent reactor fuel contains roughly 24 percent plutonium-240; such plutonium is often referred to as "reactor-grade." However, essentially all isotopic mixtures of plutonium—including reactor-grade plutonium—can be used for nuclear weapons.

In order to use plutonium in nuclear weapons or nuclear fuel, however, it must be separated from the rest of the spent fuel in a reprocessing facility. Plutonium separation is easier than uranium enrichment because it involves separating different elements rather than different isotopes of the same element, and it uses well-known chemical separation techniques. However, since the spent fuel is highly radioactive, this process requires heavily shielded facilities with remote-handling equipment.

Relatively large amounts of plutonium-240, as would be contained in reactor-grade plutonium, can cause a weapon to detonate early and "fizzle," causing a smaller explosion than intended. However, even a weapon that fizzles would cause an explosion roughly equivalent to 1,000 tons (1 kiloton) of TNT. A weapon of this size could kill tens of thousands of people if detonated in a city, which clearly demonstrates that even reactor-grade plutonium would present a potent danger in the hands of terrorists.

Another terrorist risk arises from the manufacture, transportation, and storage of mixed plutonium-uranium oxide (MOX) fuel, used in some research and power reactors. While MOX fuel itself is unlikely to be used to make nuclear weapons, the plutonium can be separated from the uranium by a straightforward chemical process. Moreover, MOX does not contain the highly radioactive components that make spent fuel difficult and dangerous to reprocess. As a result, MOX is as great a terrorist and proliferation concern as plutonium itself.

How much is needed to build a bomb?

The amount of HEU needed to make a nuclear weapon varies with the degree of enrichment and the sophistication of the weapon design. In general, the higher the enrichment level, the less HEU is needed to make a bomb. For a HEU-based nuclear weapon, there are two basic design options: a "gun-type" weapon where two pieces of HEU are brought together quickly and explode, and an "implosion" weapon, where a sphere of HEU is rapidly compressed in a highly symmetrical manner. Gun-type weapons are far simpler in design and could likely be built by some terrorist groups. The second is more difficult technically but requires less HEU. Plutonium-based nuclear weapons only work as implosion weapons, with more sophisticated weapons using less plutonium.

Amount of fissile material needed to build an atomic bomb		
HEU (enriched to 90 percent U-235)	Simple gun-type nuclear weapon	90 to 110 lbs. (40 to 50 kg)
	Simple implosion weapon	33 lbs. (15 kg)
	Sophisticated implosion weapon	20 to 26 lbs. (9 to 12 kg)
Plutonium	Simple implosion weapon	14 lbs. (6 kg)
	Sophisticated implosion weapon	4.5 to 9 lbs. (2 to 4 kg)

The Union of Concerned Scientists' Preventing Nuclear Terrorism Project seeks to prevent terrorists from acquiring nuclear weapons and the fissile materials—plutonium or highly enriched uranium (HEU)—needed to make them. This fact sheet series covers specific problems relating to nuclear terrorism and the steps the United States and other countries should take to address them.

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