INTRODUCTION

The World's Fissile Material Inventory Poster & Guide

"The World's Fissile Material Inventory" poster is an illustration of the materials which can be used for nuclear weapons (namely highly enriched uranium and separated plutonium), with the information organized by country and by purpose for easier understanding. This poster was made by the Nagasaki Council for Nuclear Weapons Abolition (PCU-NC) and the Research Center for Nuclear Weapons Abolition, Nagasaki University (RECNA) for all audiences, from elementary school students to adults. As part of the peace education efforts carried out every August at Hiroshima's and Nagasaki's Atomic Bomb Memorials, we present annual updates on the latest information every June.

The detailed data of this poster, which was compiled by the Fissile Material Data Monitoring Team, including RECNA staff, has been published on our website (http://www.recna.nagasaki-u.ac.jp/recna/en-nuclear). Please see the website for further details. We hope this guide will aid those using the poster in understanding background information and terminology in simple, plain terms. It should be especially useful in the education field, particularly in schools.

July 2017

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A Guide to the World's Fissile Material Inventory

July 2017

106,157

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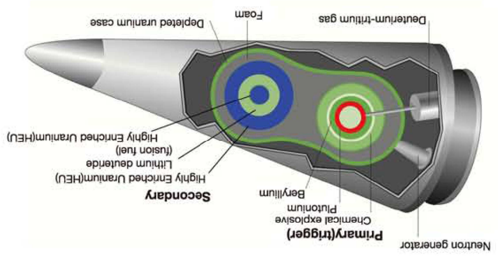
Nuclear Weapons and Fissile Materials



Conceptual diagram of a typical nuclear warhead

Source: Frank von Hippel, et al. "Unmaking the Bomb," MIT Press, 2014, p. 40 (with some modifications)

There are two types of nuclear weapons: an atomic bomb (A-bomb), which uses nuclear fission reactions to release energy, and a hydrogen bomb (H-bomb), also known as a thermonuclear weapon, which uses nuclear fission and fusion reactions. An atomic bomb releases an amount of energy equivalent to one kiloton of TNT, whereas a hydrogen bomb releases an amount of energy equivalent to a megaton of TNT.

The figure above is a conceptual diagram of a typical nuclear warhead. Nuclear fusion reactions are triggered by the energy from the plutonium bomb, and highly enriched uranium is used to sustain this reaction efficiently. The model shown in the figure is based on the design of a W-87 nuclear warhead of a U.S. Intercontinental Ballistic Missile, which has an estimated yield of about 300 kilotons.

Modern nuclear weapons usually contain both highly enriched uranium and plutonium. These fissile materials are acquired through either uranium enrichment facilities or reprocessing facilities and technologies.

Separated Plutonium around the World

COUNTRY	Military use (tons)	Non-military use (tons)
Russia	94.0	89.4
United States	38.3	49.3
France	6.0	63.4
China	1.8	0.03
United Kingdom	3.2	106.2
Israel	0.88	
Pakistan	0.22	
India	6.19	0.4
North Korea	0.03	
Japan		47.9
Germany		1.8
Other non-nuclear weapon states *		2.4
Subtotal	150.6	360.8
Total	511.4	

Non-separated plutonium that remains in spent nuclear fuel is not included. Estimates for military plutonium except those for the U.S. and U.K. contain large uncertainties. It is estimated that the Nagasaki bomb contained 6 kg of plutonium.

*Netherlands, Italy, Spain, etc.

All of the five major nuclear powers have closed their military reprocessing facilities. However, India, Pakistan, Israel, and North Korea have small-scale military reprocessing facilities.

Three nuclear powers, namely the United Kingdom, Russia, and France, operate large-scale reprocessing facilities for non-military use, and China plans to import this technology from France. Non-nuclear weapon states such as Germany and Belgium have operated research facilities in the past. Currently, only Japan has a large-scale reprocessing facility, which is pending approval for operation. Non-nuclear countries other than Japan are intending to significantly reduce, and eventually eliminate, their supplies of separated plutonium.

Highly Enriched Uranium around the World

COUNTRY	Military use (tons)	Non-military use (tons)
Russia	670.0	9.0
United States	468.6	98.6
France	26.0	4.7
China	18.0	0.2
United Kingdom	19.8	1.4
Israel	0.3	
Pakistan	3.3	
India	3.6	
North Korea	0.04	
Other non-nuclear weapon states *		15.0
Subtotal	1,209.6	128.9
Total	1,338.6	

Estimates for military HEU (Highly Enriched Uranium) except those for the U.S. and U.K. contain large uncertainties. It is estimated that the Hiroshima bomb contained 64 kg of HEU.

*17 countries are estimated to have at least 1 kg of HEU (see the poster. Spain has only plutonium and no HEU). The data on the amount each country has is considered confidential, and is not made public.

All five of the major nuclear powers have ceased producing military-use highly enriched uranium (HEU). However, India and Pakistan' s production facilities continue to be operational. Israel possesses some military-use HEU acquired from other countries, but has no enrichment facilities of its own.

France, Germany, the Netherlands, Russia, the United Kingdom, China, Japan, and the United States have non-military enrichment facilities. Other countries, including Brazil and Iran, are also attempting to construct similar facilities. In addition, the United States has plans to build new non-military enrichment facilities.

The Raw Materials Used in Making Nuclear Weapons

Plutonium

Plutonium is an artificial radioactive element that does not exist in nature and is generated from a nuclear reactor. Spent nuclear fuel discharged from light water reactors, which are dominantly used throughout the world, contains about 1% plutonium by weight. Plutonium can be recovered from spent nuclear fuel, leaving uranium and fission products, in what is referred to as "reprocessing".

Several isotopes of plutonium exist, but compositions can vary with the operational conditions of the nuclear reactors. The plutonium recovered from spent fuel at nuclear power plants typically contains about 60% plutonium-239 (reactor-grade). In contrast, the plutonium recovered from spent fuel at military production reactors contain 90% or more plutonium-239 (weapons-grade).

Reactor-grade plutonium contains a large amount of plutonium-240, which can reduce the yield, and is considered not optimal for nuclear weapons. However, this does not change the fact that reactor-grade plutonium has an explosive power that surpasses conventional weapons. Reactor-grade plutonium can still be incorporated into more advanced design techniques, and can make large weapons more destructive.

Uranium

Uranium is a natural radioactive element. In nature, most uranium is found as the less fissionable uranium-238 (99.3%). Only 0.7% of uranium is the fissile uranium-235. Thus nuclear fission is used to increase the concentration of uranium-235 in a process called "uranium enrichment."

Uranium enriched to 20% or more is believed to be usable for weapons, and is referred to as "Highly Enriched Uranium (HEU)." Typical nuclear weapons use uranium enriched to 90% or higher. On the other hand, nuclear fuel used in a nuclear power plant typically has a 3–5% concentration, and is referred to as "low-enriched uranium (LEU)."

It is still possible to produce highly enriched uranium, even in civilian facilities that produce low-enriched uranium. Take for example an enrichment facility with a supply capacity of 130 tons of low-enriched uranium per year, which enables operation of a gigawatt class power plant for a year. From 150 tons of natural uranium it is possible to produce 100 kg of 93% highly enriched uranium (equivalent to four atomic bombs) in one year. In addition, from 4% low-enriched uranium it is possible to also produce 100 kg of 93% highly enriched uranium, but in just eight days. However, thanks to inspections conducted by the International Atomic Energy Agency, it is not easy for non-nuclear weapon states to secretly manufacture highly enriched uranium in safeguarded civilian nuclear facilities.

Highly enriched uranium and plutonium are essential raw materials for producing nuclear weapons. These are obtained via uranium enrichment or reprocessing technologies and facilities. Some countries have so-called "nuclear fuel cycle" facilities for nuclear power generation. However, even small-scale nuclear fuel cycle facilities have the capability to produce fissile materials for military purposes, significantly increasing the risk of nuclear weapons proliferation.

The International Atomic Energy Agency (IAEA) believes it is possible to manufacture a nuclear weapon with 25 kg of uranium-235 or 8 kg of plutonium.

Military and Non-military Plutonium

Military: Plutonium used in nuclear warheads or stored for use in weapons; plutonium that is reserved for possible military uses in the future

Non-military: Plutonium separated from spent nuclear fuel from a nuclear reactor for non-military purposes; plutonium declared as surplus for nuclear weapons

Military and Non-military Highly Enriched Uranium (HEU)

Military: HEU used in nuclear warheads or stored for use in weapons; HEU used in reactor fuel for naval nuclear propulsion (including spent fuel)

Non-military: HEU used in fuel for research and testing reactors; HEU declared as surplus for military purposes

Existing Raw Materials Can Create Many Atomic Bombs

It is estimated that the Hiroshima bomb had 64 kg of HEU, and that the Nagasaki bomb had 6 kg of plutonium. The amount of fissile material that each country has is represented by this bar graph and corresponds to the number of these bombs that could be produced with these materials. Both dark colors represent raw materials for military use.

Downward Trend in HEU and Upward Trend in Plutonium

Military-use HEU accounts for 90% of all highly enriched uranium. In the last ten years, 82 tons of military HEU and 310 tons of non-military-use HEU have been eliminated. In contrast, non-military-use plutonium accounts for 71% of all plutonium. In the last ten years, the amount of military-use plutonium has been reduced by 10.0 tons, but there has been an increase in non-military-use plutonium of 28.6 tons.

Japan's High Amount of Plutonium as a Non-Nuclear Weapon State

Japan has almost 10% of the world' s separated plutonium, possessing the fifth largest amount of separated plutonium after Russia, the United Kingdom, the United States, and France. In contrast, the other non-nuclear weapon states combined possess only 0.8% of the world's separated plutonium. From this one can tell that Japan is a very unique outlier.

Reducing Fissile Materials is a Huge Challenge

All of the global fissile materials combined are equivalent to more than 100,000 of the Hiroshima and Nagasaki bombs. It is estimated that there are 14,900 nuclear warheads in the world. In other words, the world is capable of developing many times more nuclear weapons than it currently possesses.

Fissile materials will remain even if all of the world's nuclear weapons are dismantled. The elimination of fissile materials must be done in a manner that ensures we never again return to manufacturing nuclear warheads.