Thorium and Nuclear Weapons
By Gordon Edwards

There are many exaggerated claims made by promoters of thorium-based nuclear reactor technology as an alternative to the present generation of uranium-based reactors.

One of those claims is that the use of thorium "fuel" instead of uranium fuel eliminates the threat of nuclear weapons proliferation because "thorium-fueled reactors" do not produce plutonium as a byproduct.

This claim is profoundly misleading.

Thorium is a naturally occurring radioactive element, but it is not a nuclear fuel, nor is it a nuclear explosive. The phrase "thorium fuel" is a misnomer. Thorium is not a fuel.

However, when thorium is bombarded with neutrons, it is transmuted into a type of uranium that does not exist in nature: uranium-233. This manufactured material, U-233, can subsequently be used as a nuclear fuel or as a nuclear explosive.

Oliver Tickell's article - *The Promise and Peril of Thorium* is highly recommended. It provides a good discussion of the weapons proliferation risks associated with thorium-based nuclear reactor technologies.

To better grasp the proliferation risk, some background on nuclear explosives is helpful.

Background on Nuclear Weapons:

All existing nuclear weapons use either uranium or plutonium as the primary nuclear explosive material. All nuclear fuels (fuels for nuclear reactors) are also based on either uranium or plutonium.

The story begins with naturally occurring uranium....

A. Uranium-235 -- Uranium Enrichment

Uranium is the only naturally occurring material that can be utilized as a nuclear explosive.

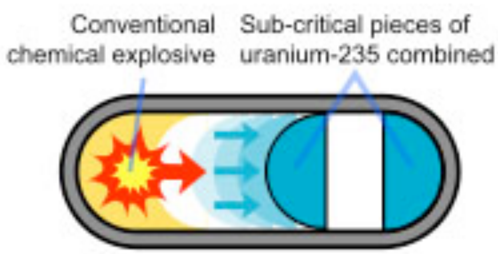
However, not all kinds of uranium can be used to make nuclear weapons. One cannot use natural uranium (the stuff that is mined), or low-enriched uranium (the stuff that is used as fuel in most commercial power reactors around the world) as a nuclear explosive. The problem with these materials is that there is too much uranium-238 (which is NOT a nuclear explosive) and too little uranium-235 (which IS a nuclear explosive).

Uranium enrichment is a technological process for increasing the concentration of uranium-235 by separating out and discarding much of the unwanted uranium-238. The end product of this separation process is called "enriched uranium" -- uranium with a higher concentration of U-235 than that found in naturally occurring uranium. The discarded material -- mostly uranium-238 -- is called "depleted uranium" because it has even less uranium-235 per kilogram than is found in natural uranium ore deposits (0.7 percent).

Technically, any type of uranium in which the concentration of uranium-235 is 20 percent or more is called Highly Enriched Uranium (HEU). HEU of any kind can be used as a nuclear explosive material, if available in sufficient quantity. Nuclear weapons designers prefer HEU that is more than 90 percent enriched -- i.e. more than 90 percent U-235. Such HEU is called "weapons-grade uranium".

Any type of HEU is weapons-usable, even if it is not weapons-grade. Most commercial power reactors use only Low Enriched Uranium (LEU) as fuel; LEU cannot be used as a nuclear explosive due to the excessive amount of uranium-238 that it contains.

It is a slow, difficult, time-consuming process to enrich uranium -- but once weapons-grade uranium is produced, it is rather easy to make a powerful atomic bomb with it. All that is needed is a "gun-type" mechanism to bring two pieces of HEU together very rapidly, by firing a uranium "bullet" into a uranium "target". The Hiroshima bomb was made in this fashion. The gun-type mechanism is so simple there is no need to test it. It was guaranteed to work the very first time it was tried. As indeed it did....



Gun-type assembly method

If weapons-grade uranium falls into criminal hands, the construction of a powerful atomic bomb is a relatively simple matter. No testing is needed. That is why the civilian use of HEU is being phased out -- it's just too dangerous to allow this material to remain in commercial circulation.

B. Plutonium -- Created from Uranium-238

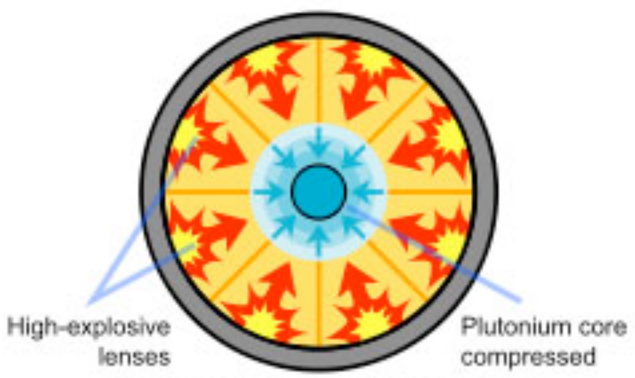
Plutonium does not exist in nature; but it is created inside every reactor that uses natural uranium or low-enriched uranium as fuel. Some of the uranium-238 atoms in the fuel absorb stray neutrons, and those atoms are transmuted into plutonium atoms.

It turns out that plutonium is a more powerful nuclear explosive than HEU. Plutonium is in fact more powerful than weapons-grade uranium.

Obtaining plutonium involves a chemical extraction process that requires dissolving highly radioactive "used nuclear fuel" in boiling nitric acid -- not an easy task! This makes it difficult to divert the plutonium from civilian nuclear reactors into bombs, unless the plutonium has already been extracted ahead of time.

Once the plutonium has been separated from the rest of the radioactive garbage, it can be packaged and transported without detection fairly easily.

Using plutonium as a nuclear explosive does require a more elaborate bomb mechanism than the "gun-type" uranium bomb design. A sophisticated "implosion mechanism" is needed. That requires the simultaneous detonation of shaped charges (conventional explosives) surrounding a perfectly spherical ball of plutonium.



Implosion assembly method

Such an implosion device is by no means simple; it requires painstaking engineering and careful testing. The Nagasaki bomb was made in this fashion. It was tested months ahead of time at Alamogordo, New Mexico.

All reactor-produced plutonium is weapons-usable, but nuclear weapons designers prefer to use plutonium with a very high percentage of plutonium-239 and a low percentage of plutonium-240. Such material is called "weapons grade plutonium".

Although plutonium-240 is a nuclear explosive material, its presence complicates the job of the bomb-maker in two ways: (1) it makes the explosive material more difficult to handle because of higher levels of radioactivity and heat; (2) it makes the power of the nuclear explosion less predictable because it produces a lot of stray neutrons.

Despite these complications, any type of plutonium can be used to make reliable, highly effective nuclear weapons at all levels of technical sophistication. (See http://www.ccnr.org/Findings_plute.html)

C. Uranium-233 -- Created from Thorium-232

As previously remarked, naturally occurring thorium -- thorium-232 -- is the raw material from which a new kind of uranium -- uranium-233 -- can be created. All that's needed is to bombard thorium-232 with neutrons. The easiest way to do that is to put the thorium inside a nuclear reactor, where neutrons are abundant. (Of course the reactor has to be fueled by uranium or plutonium, otherwise there will be no neutrons.)

When a thorium-232 atom absorbs a stray neutron it is transmuted into an atom of protactinium-233, which then spontaneously transmutes itself into an atom of uranium-233 -- a type of uranium not found in nature.

It turns out that uranium-233 is immediately weapons usable without the need for any kind of enrichment. It is a more powerful explosive than uranium-235, and -- unlike plutonium -- it can be used in a simple gun-type device, like the Hiroshima bomb.

Thus uranium-233 avoids one of the complications posed by the use of uranium-235 (the need for enrichment) as well as one of the complications associated with plutonium (the need for an implosion mechanism).

There is however another complication that arises. When thorium is placed inside a nuclear reactor, there is another type of uranium created called uranium-232. Although uranium-232 is also a nuclear explosive material, it is highly undesirable because it gives off an extremely powerful burst of gamma radiation -- so powerful, in fact, that it can seriously damage electronic equipment.

The more uranium-233 is contaminated with uranium-232 the more difficult it is to use it as a nuclear explosive. But, as Tickell's article points out, it is relatively easy to avoid this contamination problem. All that is required is to chemically separate the protactinium-233 at an early stage, remove it from the reactor environment, and then simply wait until it has almost all changed into uranium-233. In this way a stockpile of weapons-grade uranium-233 can be produced that is uncontaminated with uranium-232 and virtually trouble-free for making any type of nuclear weapon, including gun-type A-bombs.

The reason this works is due to the absence of neutrons outside the reactor environment. Uranium-232 is created only in the presence of neutrons, and outside the reactor there aren't any neutrons -- so no uranium-232 is being produced.

But protactinium-233 becomes uranium-233 spontaneously, without any need for neutrons. So by separating the protactinium-233 from the rest of the irradiated thorium, the potential bomb-maker gets lots of uranium-233, and virtually no uranium-232.

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