Highly Enriched Uranium and the Production of Medical Isotopes

by Gordon Edwards, Ph.D., March 4, 2013

Weapons-Grade Uranium and the Hiroshima Bomb

I and many others have long been opposed to the continued use of weapons-grade uranium at Chalk River. It is gratifying that the Government of Canada recently announced they will be phasing out the use of Weapons Grade Uranium at Chalk River in 2016, but even that is pushing the envelope. This practice should have been discontinued many years ago. It sets a terrible precedent for the entire world. Now, for example, Iran is justifying the production of HEU (= Highly Enriched Uranium = Weapons-Grade Uranium) on the grounds that they "need" HEU for the production of medical isotopes. And Iran can of course point to Canada and a few others who are doing exactly that.

Thus the continued use of HEU at Chalk River is indirectly sabotaging non-proliferation efforts around the world. Because of course HEU is perfect for use as a nuclear explosive material, and the warning time (once the HEU is obtained) is extremely short. So no one should be having HEU available to them -- or we will never have the possibility of a nuclear weapons free world.

The mechanism needed to make an atomic bomb using HEU is actually quite simple. It is called a "gun-type" atomic bomb because all you have to do is fire one piece of HEU into another piece of HEU and -- voilà! The Hiroshima bomb was exactly this type of device, and it never had to be tested ahead of time because it was so simple it couldn't fail (unlike the Nagasaki bomb that used plutonium -- it had a much more complicated design and had to be tested in the Nevada desert).

Medical Isotope Production Using HEU

The principal medical isotope we are talking about here is technetium-99m (Tc-99m), which has a short half-life of only 6 hours. It is therefore

impractical to transport freshly-made Tc-99m over long distances because the amount of the isotope will diminish so rapidly that virtually the whole amount will be completely gone in a matter of days.
So instead, hospitals purchase a "moly cow" made of molybdenum -99 (Mo-99) -- an isotope which has a 66-hour half-life, and which "decays" directly into technetium-99m. Thus medical personnel can "milk the cow" -- that is, harvest the technetium-99m -- on a daily basis, and use the Tc-99m for that day's work. Because of its longer half-life, Mo-99 diminishes in amount at a much slower rate, and the original amount will not be completely gone for several weeks.

So the question is, how to get the molybdenum-99 in the first place? Well, one way is to use the fact that it is a fission product of uranium-235. That means that inside every uranium-fuelled nuclear reactor, Mo-99 is being produced all the time -- but it is mixed in with dozens of other fiercely radioactive fission products (such as cesium-137, iodine-131, strontium-90), activation products (such as cobalt-60, iron-55, niobium-93m) and transuranic actinides (such as plutonium, americium and curium). To get the Mo-99 you have to dissolve the fiercely radioactive irradiated fuel in boiling nitric acid and separate out the tiny amount of Mo-99 by chemical means, leaving a large volume of highly radioactive liquid waste.

So to make the job easier, research reactors are used -- no electricity production -- and instead of "reprocessing" the irradiated fuel, special "targets" are introduced into the core of the reactor made of highly-enriched uranium (93.3 percent Uranium-235) and withdrawn at a predetermined time so that the "target" can be dissolved in nitric acid etc. This has several advantages: (1) you can limit the time the target is in the reactor, cutting down on the superfluous inventory of other fission products etc; (2) you can vastly reduce the mass of material that needs to be dissolved because the U-235 is so concentrated; (3) you can control the schedule more easily and achieve a kind of "assembly-line" procedure without shutting the reactor down.

Even using this nasty method for producing Mo-99 inside a nuclear reactor, and then reprocessing, you can use LEU (Low Enriched Uranium) instead of High Enriched Uranium (HEU) -- it just means it takes longer and is more expensive, mainly because there is a much larger mass of material to "reprocess" in order to extract the Mo-99. Argentina has been doing it this way for quite some time.

The alternative to using a nuclear reactor is to use a "particle accelerator" to produce Mo-99. There are various ways to do this, using a cyclotron (a circular accelerator) or a linear accelerator (one that is arranged in a straight line).

Inside any particle accelerator, isotopes of various kinds can be produced by bombarding a "target" of some kind with a "beam" of very energetic (high-speed) charged particles. This is how a university or hospital can produce most if not all of the isotopes it needs without the need for a nuclear reactor. For many years, starting in 1949, McGill University got all of its isotopes this way.

Here are some older texts I have written on the subject:

http://www.ccnr.org/isotope_shortage.html

http://www.ccnr.org/isotopes.html

Actually there is an absurdly elevated use of Tc-99m around the world -- it is, in my opinion, GREATLY over-used! And, by the way, Tc-99m has a half-life of 6 hours, it is true, but it immediately disintegrates to form Tc-99 (without the "m"), which has a half-life of 210,000 years!!! So, short-lived it is NOT.

> *Note: In Tc-99m, the "m" stands for the word "metastable", which means that the nucleus of the atom is "excited" and it can only relieve that excitement by giving off a "gamma ray" -- similar to an x-ray but more energetic. Once that gamma ray has been emitted, however, the resulting atom Tc-99 (without the "m") is a very long-lived emitter of beta radiation, with a half-life of 210,000 years.*
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> *It is the gamma radiation from the metastable atoms that is useful to medical personnel wanting to obtain a clear picture of what's going on inside the patient's body. When Tc-99m is inserted into the patient's body, it's as if you have an x-ray machine inside the body and all you have to do is use x-ray film outside the body to "map" the various structures in the body that are revealed in this way.*

There are only a handful of reactors used to produce isotopes in the whole world, The 55-year old NRU reactor at Chalk River produces 1/3 to 1/2 of all the Tc-99m used in the whole world! And it is only a research reactor with a capacity of 135 megawatts of heat (MWth). By comparison, a 1000 MWe power reactor, in order to produce 1000 megawatts of electricity, needs to produce about 3000 megawatts of heat. So the NRU reactor is not even 5 percent as powerful as a more-or-less standard power reactor. It's a very small "drop in the bucket".

Does Iran Need HEU to Make Medical Isotopes?

The point is that HEU is Not Needed to produce Medical Isotopes, but countries like Canada and Belgium have contributed to the mistaken and dangerous idea that HEU is a perfectly sensible and legitimate material to use for this purpose.

This gives Iran a golden excuse to justify the production of HEU using Canada and Belgium as examples – and justifications. Whatever Iran's real intention may be, the use of HEU for civilian purposes has "blurred the line" between atoms for peace and atoms for war. If there were NO peaceful uses of HEU (as should be the case!) then it would be crystal-clear that anyone producing HEU has only one objective in mind : nuclear weapons.

An analogy can be made in the case of India's first nuclear explosion ("Smiling Buddha") in 1974, using plutonium from a Canadian research reactor that was given to India as a gift as part of the "Atoms For Peace" initiative, and using the reprocessing technology needed to extract the plutonium from the irradiated nuclear fuel, that was given to them by the USA. Ironically, the reactor that produced the nuclear explosive material was called CIRUS symbolizing Canadian, Indian, and US Cooperation -- so maybe the first Indian A-bomb should have been called a "Canadian-American-Indian Atomic Bomb".

Of course Canada and the US were shocked that India should so betray their trust by using their "peaceful" nuclear gifts for military purposes. (Even though the USA was building and testing nuclear weapons all the time, and Canada had sold huge quantities of uranium and smaller amounts of plutonium for use in the American bomb program without even blinking.)

But the unflappable Indians had a perfect come-back. "This is not a bomb," they said, "nor is it in any way a military application of nuclear energy. It is simply a peaceful nuclear explosive, or PNE" -- such as those that both the USA and USSR had championed in their own political spheres. (e.g. "Operation Gasbuggy", whereby Americans planned to use nuclear explosives to tap into large underground reservoirs of natural gas -- fracking on an enormous scale!).

Like dynamite, it was felt that peaceful nuclear explosives could be used for large scale civic projects -- to create harbours where there are none, or even to build a major canal like the Panama Canal by exploding a large number of A-bombs in a row like Chinese fire-crackers.

The language of Peaceful Nuclear Explosives is in fact enshrined in the text of the Non-Proliferation Treaty:

> **Article V**
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> **Each party to the Treaty undertakes to take appropriate measures to ensure that, in accordance with this Treaty, under appropriate international observation and through appropriate international procedures, potential benefits from any peaceful applications of nuclear explosions will be made available to non-nuclear-weapon States Party to the Treaty on a nondiscriminatory basis and that the charge to such Parties for the explosive devices used will be as low as possible and exclude any charge for research and development.**

So, of course, India could make a plausible argument (that nobody, including themselves, actually believed!) that their first A-bomb was just a glorified stick of dynamite. They didn't have to invent this rationale, it was handed to them on a silver platter ... by the superpowers' behaviour and the text of the Non-Proliferation Treaty.

The same dangerous game -- giving a civilian veneer to an essentially military product -- goes for the use of HEU for medical isotope production. This practice should be stopped immediately.

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