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A 'Proliferation-Proof' Reactor?

As inspiring as is the oft-repeated quote from the prophet Isaiah, "They shall beat their swords into plowshares," it should also be remembered that Isaiah has a dark epitaph in the book of Joel, which warns, "And ye shall beat your plowshares into swords." The sad fact is that even the best-intended efforts to burn weapons materials in conventional LWRs results in the creation of additional supplies of fissile materials.

As explained in last month's *NMR*, all uranium-fueled reactors create a certain amount of plutonium when neutrons are captured by the predominant isotope U-238. Even when the fuel strategy is configured to incinerate plutonium, as in a MOX-burning LWR, approximately 2 kg of fresh reactor-grade plutonium are created for every 3 kg of plutonium burned as fuel.

One promising solution to this paradox is an innovative core design called the Radkowsky Thorium Reactor. The idea of using thorium together with uranium fuel is not new. The principle is that while thorium is not itself a fissile material, atoms of thorium, when bombarded by neutrons, can be converted to atoms of U-233, which has fissile properties comparable to U-235. The U233 (discovered, by the way, by Glenn Seaborg, the discoverer of plutonium) then substitutes for U-235 as the latter fissions away. This was the principle behind the 60-MW Shippingport (Pennsylvania) reactor that successfully used an experimental thorium core design in the period 1977-1982.

The Radkowsky thorium core design builds on the work at Shippingport, a reactor originally built in the early 1950s to run on 93% enriched U-235. The Shippingport reactor, it should be noted, was the first civilian application of the naval propulsion reactor brought into being by the redoubtable Admiral Hyman Rickover. Not coincidentally, Alvin Radkowsky was the chief scientist of the U.S. Naval propulsion program, and Rickover's right hand man.

One of the downsides of the Shippingport design was its use of 93% enriched fuel, a proliferation risk all by itself. Consequently, the proposed Radkowsky design addresses this issue head-on, using uranium enriched to just under 20%, the cut-off point below which uranium is considered by the IAEA to be unsuitable for nuclear weapons. Even better, by replacing the bulk of the U-238 present in a conventional LWR core with either U-235 or thorium, plutonium production is cut by about 90%. In addition, by the time the thorium fuel blankets are removed (about once every ten years), the plutonium itself is so rich in Pu-238 and other non-fissile plutonium isotopes that it, too, is useless for military applications. The essence of the Radkowsky core is a "seed and blanket" fuel design. A hexagonal blanket of thorium mixed with uranium surrounds a hexagonal "seed" of uranium enriched to 20% U-235. (The relatively high enrichment is necessary to overcome the thorium's irradiation resistance.) Each seed and blanket unit measures around 1.5 cm. in diameter, and would be packed into bundles measuring about 24 cm. in diameter. The bundles can then be assembled as a replacement core for existing light water reactors (LWRs). The basic idea is that while the uranium "seeds" would be replaced on a schedule comparable to that of conventional uranium fuels, the thorium-uranium "blankets" would stay in place for ten years at a time. Since the U-233 generated out of the thorium would be burned in situ, the U-233 does not become a proliferation risk. To the extent that some remains even when the blanket is removed, it will be mixed in with other isotopes of uranium (one of the main reasons for spiking the thorium with uranium), so separating it will be substantially harder than making fresh U-235 to begin with. The Radkowsky core design can be optimized to burn either HEU blended down to 20% enrichment or comparable enrichments of plutonium. Either way, it consumes warhead material considerably faster than would a conventional LWR core design. The Radkowsky project is being promoted by both private investors in the Radkowsky Thorium Power Corporation (NY, New York), other nuclear companies, and governmental organizations in both the U.S. and Russia. Among the providers of technical and engineering assistance in the U.S. corporate sector are Raytheon Nuclear, Inc. On the government side, DOE has recently provided a $550,000 matching grant (from the Nunn-Lugar program that supports non-proliferation efforts for Russia), while in Russia the project is being pursued by the prestigious Kurchatov Institute under the supervision of Vice President Nikolai Ponomrev-Stepnoi.

The current plan calls for retrofitting an existing large reactor within four years. In the short term, Kurchatov plans to do preliminary testing with a retrofitted VVER-440, or possibly an LWR test reactor. The Radkowsky team hopes ultimately to be able re-core large numbers of LWRs, in both the U.S. and Russia, rendering them radically more proliferation resistant, reducing the attendant waste streams (another benefit of thorium technology), and fostering a nuclear industry that's both safer and more economic. According to Seth Grae, a vice president in the Washington, D.C. office of the Radkowsky Thorium Power Corporation, the project is very much on track, both here and in Russia. "Initially we had planned to build thorium reactors," he says, "but we found it would be far less costly and controversial to re-core existing ones than to build new ones. We definitely expect to see thorium test assemblies in a Russian reactor within four to five years," Asked about response from the environmental community, Grae acknowledged having had extensive contact and discussions with numerous environmental organizations. "To the extent that we're just acting as retrofitters," says Grae, "making existing reactors safer and more proliferation resistant, I think I can say that many environmental groups would be supportive of our work."