LA-UR-98-5459

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Form No. 836 R5
ST 2629 10/91

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USING PROLIFERATION RESISTANT FUELS TO MANAGE GLOBAL PLUTONIUM INVENTORIES: GOING BEYOND THE SPENT FUEL STANDARD

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SUMMARY

Current light water reactor fuel cycles (LWRs) were originally envisioned to include continuos reprocessing of spent fuel and the eventual use of fast reactor technology to close the fuel cycle. Failure to evolve beyond current once-through fuel cycles has resulted in unabated growth in plutonium inventories. Globally, civilian reactors have discharged some 1400 metric tons (MT) of plutonium, and this inventory is projected to grow by 75 MT per year [Albright et. al. 1997]. In addition, some 100 MT of US and Russian military plutonium has been declared excess and is earmarked for disposition. In recognition of the proliferation risks associated with both military and civilian, separated and unseparated plutonium stocks, many experts have called for burning plutonium beyond the spent fuel standard [NAS 1994].

Nuclear transmutation is the only way to reduce existing plutonium inventories. Advanced nuclear systems such as accelerators and fast-spectrum reactors are not likely to be constructed on any significant scale for three or more decades. Thus, by default, LWRs are the only vehicles available to destroy significant quantities of plutonium in the near term. Mixed uranium-plutonium dioxide (MOX) fuels are already used to burn plutonium in the LWRs of several nations. Unfortunately, some of neutrons produced when MOX fuel plutonium fissions are captured in MOX's uranium which breeding more plutonium. This *in situ* plutonium production substantially reduces the maximum net plutonium destruction possible in MOX. Proliferation resistant fuels (PRFs) encapsulate the plutonium and burnable poisons in a non-uranium matrix. Because they do not contain uranium, PRFs do not produce plutonium. Consequently, the use of PRFs can destroy more plutonium than the use of MOX over identical reactor cycles. Both one-third MOX and one-third PRF LWR cores produce plutonium in the two-thirds of the core that is loaded with UO_2. However, the one-third PRF core yields a net consumption of 90 kg of plutonium whereas a one-third MOX core produces 70 kg as shown in Figure 1. This is because the one-third of the core loaded with MOX fuel consumes only 30% of its original plutonium content whereas PRF fuel consumes as much as 80% as shown in Figure 2. In addition, the spent PRF plutonium isotopics are significantly more denatured than that of spent MOX and contain negligible ^{239}Pu and over 50wt% ^{242}Pu as shown in Figure 3. Thus, PRF plutonium is burned well beyond the spent fuel standard. PRFs can be incorporated into steady state LWR fuel cycles, meeting existing safety envelopes without reactor modification. The PRF is burned and then disposed of without any further reprocessing. The Swiss, Japanese and French are also interested in the advantages of managing their plutonium inventories with proliferation resistant fuels [Akie 1994, Degueldre 1995]. By varying cycle and PRF parameters, a full spectrum of global plutonium inventory management strategies ranging from sharp reductions to controlled growth, including maintenance of an equilibrium inventory, could be achieved.

Figure 1.

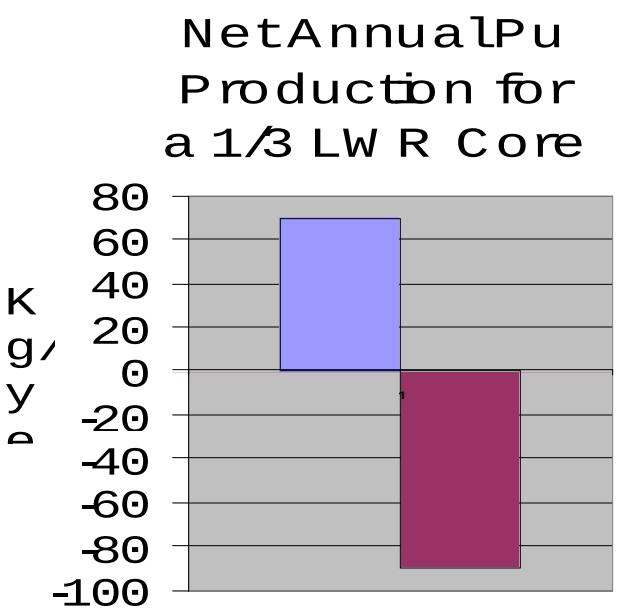


Figure 2.

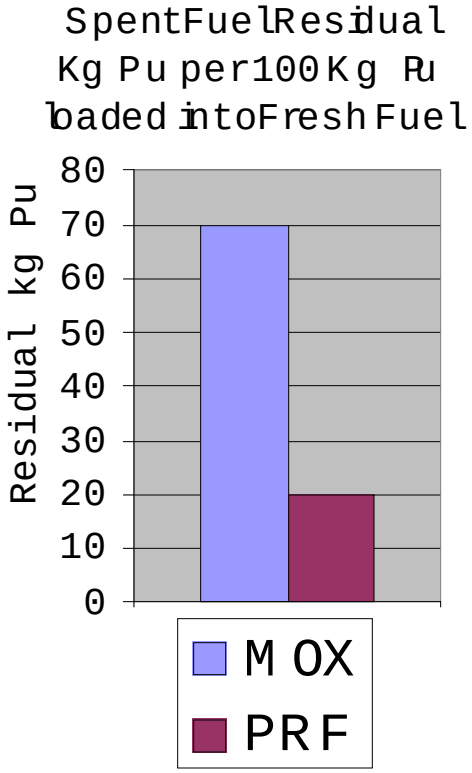
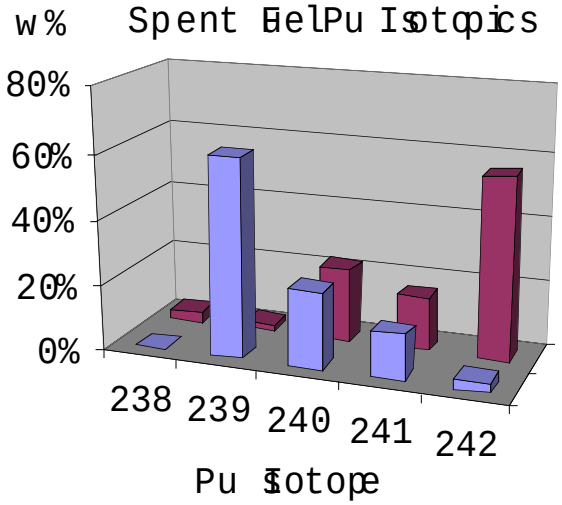


Figure 3.



PRFs can also be used to reduce long-term repository risk. Actinides and long-lived fission products (LLFPs) are the primary source of geologic repository health risks. PRFs contain no uranium which significantly reduces the production of actinides. Although a smaller advantage, LLFPs can be incorporated into fresh PRF and burned in LWRs. In addition, proposed PRF ceramic matrices are more chemically durable waste forms than MOX, which reduces nuclide release rates and further reduces overall repository risk. This enhanced chemical durability also prevents the use of common commercial chemical processing technology to recover plutonium from PRFs, thus raising the chemical proliferation barrier above that of MOX fuels.

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