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Title

TECHNOLOGIES FOR DESTRUCTION OF LONG-LIVED RADIONUCLIDES IN HIGH-LEVEL NUCLEAR WASTE -OVERVIEW AND REQUIREMENTS

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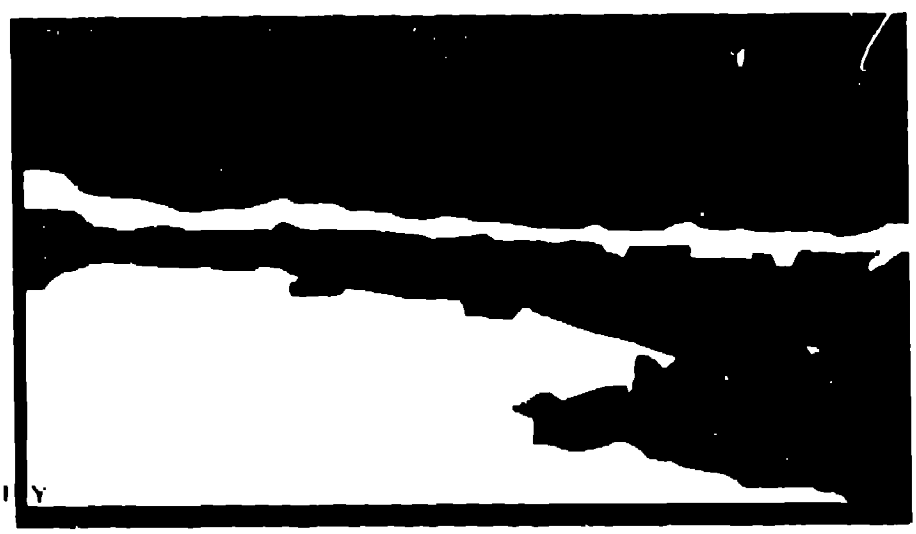

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TECHNOLOGIES FOR DESTRUCTION OF LONG-LIVED RADIONUCLIDES IN HIGH-LEVEL NUCLEAR WASTE -- OVERVIEW AND REQUIREMENTS

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Introduction

A major issue surrounding present nuclear power generation is the management and disposal of long-lived, high-level waste (HLW). The planned, and scientifically acceptable, destination for this waste is in deep underground, geologically stable, repositories. However, public concerns surrounding such disposal of long-lived nuclear wastes and other issues such as proliferation and safety negatively impact the potential role that nuclear power can play in meeting current and future national energy needs.

This paper, and this topical session on Nuclear Waste Minimization, Management and Remediation, focuses on two nuclear systems, and their associated technologies, that have the potential to address concerns surrounding long-lived radionuclides in high-level waste. Both systems offer technology applicable to HLW from present light-water reactors (LWR). Additionally these systems represent advanced nuclear power concepts that have important features associated with integrated management of wastes, long-term fuel supplies, and enhanced safety.

The first system is the Integral Fast Reactor (IFR) concept. This system incorporates a metal fueled fast reactor coupled with chemical separations based on pyroprocessing to produce power while simultaneously burning long lived actinide waste. IFR applications include burning of actinides from current LWR spent fuel and energy production in a breeder environment. The second concept, Accelerator Transmutation of Waste (ATW), is based upon an accelerator induced intense source of thermal neutrons and is aimed at destruction of long lived actinides and fission products. This concept can be applied to long lived radionuclides in spent fuel HLW as well as a future fission power source built around use of natural thorium or uranium as fuels coupled with concurrent waste destruction

Both these concepts represent technologies important to energy and environment portions of the national critical technologies list. They employ approaches based on separations and transmutation for radioactive waste destruction. They are both being assessed under the National Academy of Sciences special study on the impact of partitioning and transmutation(P/T) on management and disposal of long-term HLW via the Separations Technology and Transmutation Systems (STATS) Panel. Internationally, transmutation and separations technology is being pursued in France, Japan, Sweden, and Russia[1] as a means to complement repository-based approaches for nuclear waste disposal.

Transmutation Systems Performance Requirements and Impacts

HLW management strategies based upon partitioning and transmutation must target major drivers associated with geologic disposal of wastes. The first class includes the actinides (plutonium, neptunium, americium) that dominate intrusion risks resulting from natural phenomena (earthquake, volcanic activities, etc) as well as possible human efforts to recover such energy producing materials. Intrusion risks associated with repository storage appear to be receiving increased emphasis because of proliferation concerns resulting from plutonium in disposed nuclear wastes. Examples include a recent high-level French study on plutonium-burning in the Phenix reactor and a National Academy of Sciences study on surplus plutonium disposition.[2] The second area includes long-lived fission products such as technetium99, iodine129, cesium135 which dominate long-term risks[3] associated with geologic storage because of their relatively large mobility in Yucca Mountain-like environments.

The coupled partitioning-transmutation process also provides a means for separating shorter-lived radioisotopes (30 year cesium137 and strontium90) that drive repository capacities because of heat load limitations. It can also address special problem areas such as carbon14 inventories which present difficulties for meeting Yucca Mountain regulatory requirements.

To realize significant impact on HLW disposal and management, transmutation systems and their inherent technologies must meet several important requirements summarized here. (1) Reduction factors in material inventories associated with the major risk drivers described above must be large. This places requirements of high transmutation rates and efficient separations performance on systems components. (2) Waste streams from integral processing components must be minimized so as to produce a favorable system material balance. Material balance assessments of transmutation systems compare the amounts of long lived radionuclide destroyed to other long lived radionuclides produced during system operation as well as waste types, forms, and amounts created by the transmutation system. (3) The system must have enhanced safety features under conditions of burning significant amounts of higher actinides or plutonium. (4) The proliferation resistant features of the system must be attractive.

Technology Development Needs

The nuclear systems that are the focus of this Topical Session provide options for dealing with long-lived radioactive wastes and for advanced nuclear energy systems. For these systems to be successful, significant technology development is required in areas that include advanced reactor and nuclear system design, high-power accelerators, and efficient chemical separations. Although transmutation technology is highlighted in reports such as the Department of Energy Defense Critical Technologies Plan[4], national budgetary pressures and a short-term focus on meeting energy needs negatively impact prospects for funding to support needed technology development. Several steps could counter such negative outlooks in transmutation technology development. The first would require a governmental commitment to support research and technology development to assess P/T impacts on HLW management and disposal in a fashion similar to programs in France and Japan. Closely associated with such a step would be an aggressive effort to actively involve U.S. industry in such technology development and demonstration. The final effort should involve significant interaction with foreign efforts and programs, particularly those in areas such as large scale chemical separations where significant foreign expertise exists.

References

1. M. Skalberg and J. Liljenzin, "Partitioning and Transmutation: A Review of the Current State of the Art", Swedish Nuclear Fuel and Waste Management Co. report SKB 92-19 (1992)

2. M. Curien, "Treatment of Products from the End of the Nuclear Cycle and the Possible Contribution of Super Phenix", Ministry of Research and Space report, Paris, December 17, 1992

3. T. Pigford, "Actinide Burning and Waste Disposal", University of California Berkeley report, UCB-NE-4176 (1990)

4. J. B. Gerardo, P. Goldstone, M. Finger, G. D'Alessio, 1993 DOE Defense Critical Technologies Plan, Department of Energy report DOE/DP-0097T (1993)