

Reactors Identified for Conversion

Reduced Enrichment for Research and Test Reactors (RERTR) Program

By Christopher Landers

Abstract

The Reduced Enrichment for Research and Test Reactors (RERTR) program was initiated in 1978 to develop the technology necessary to convert research reactors to the use of low enriched uranium (LEU) fuel and targets. Now, with the incorporation of the RERTR program into the Global Threat Reduction Initiative (GTRI), the RERTR program is responsible for facilitating the actual conversion of research reactors and medical isotope production processes to LEU in addition to the development of the technology necessary for conversion. The RERTR program has identified 106 research and test reactors in the United States and abroad for conversion to LEU fuel. The driving force for identifying these reactors is the availability or active development of a suitable LEU fuel for conversion. To date, 42 of the 106 research and test reactors identified as eligible for conversion to LEU fuel have been fully or partially converted (32 full, 10 partial). High-density LEU fuels have been developed that enable the conversion of an additional 41 of these reactors, and the program is currently focusing on the development of additional advanced higher-density LEU fuels, particularly U-Mo fuels, that will make feasible the conversion of the remaining 23 identified research reactors.

The RERTR Program

In 1978, DOE initiated the Reduced Enrichment for Research and Test Reactors (RERTR) program to develop the technology necessary to convert research reactors and medical isotope production processes to the use of low enriched uranium (LEU) fuel and targets. Now, with the incorporation of the RERTR program into the Global Threat Reduction Initiative (GTRI), the program is responsible for facilitating the actual conversion of research reactors and medical isotope production processes to LEU in addition to the development of the technology necessary for conversion. The mission of the RERTR program is to minimize and, to the extent possible, eliminate the use of highly enriched uranium (HEU) in civil nuclear applications by developing necessary LEU fuels and targets and converting research reactors and radioisotope production throughout the world to the use of LEU fuel and targets. The RERTR program coordinates closely with other programs in the GTRI in support of HEU minimization and maximizes synergies between conversion and HEU removal activities.

Research Reactors Identified as Eligible for Conversion

Originally, the RERTR program identified for conversion only civil U.S.-supplied research reactors that operated on HEU fuel. However, over time, the program expanded its list of reactors identified for conversion to include additional civil HEU-fueled reactors as well as civil Russian-supplied research reactors. By May 2004, the list of RERTR program identified reactors included 105 reactors. Recently, the RERTR program reviewed this list of 105 research reactors identified as eligible for conversion and updated the list to reflect current USG foreign policy, operating status of reactors around the world, and LEU fuel development activities. The primary criterion used to identify reactors for conversion under the RERTR program is the availability or active development of a suitable LEU fuel for conversion. Due to increased international support for the minimization of HEU and due to the development of high-density LEU fuels, the RERTR program is looking beyond its current commitment and has identified 106 research reactors for conversion by 2014. As a result, eight (8) research reactors were removed from the original list of reactors and nine (9) Chinese-supplied Miniature Neutron Source Reactors (MNSRs) were added for a new total of 106 research reactors identified as eligible for conversion to LEU fuel by 2014 under current RERTR program activities. To date, 42 reactors have converted (10 of which currently operate on mixed LEU-HEU cores), leaving 64 reactors remaining to complete the RERTR's goal of 106 research reactor conversions by 2014. The RERTR program is committed to work with the remaining 64 reactors and assist, as necessary, in a successful conversion by no later than 2014.

The research reactors on the RERTR program list of 106 identified for conversion are, or will be, convertible with an LEU fuel currently available or under development by the RERTR program. All 106 reactors fall into one of three categories: (1) reactors that have converted to LEU fuel; (2) reactors that can convert with currently available technology; or (3) reactors that in order to convert require new LEU fuels that are under development. However, as the status of research reactors is not constant (e.g., reactors shut down, new reactors are built, and reactors' missions shift), the current list of 106 reactors identified for conversion is not considered a fixed number, but is instead a dependent variable

reliant upon a variety of issues, such as foreign policy, operational status of reactors, and technical feasibility.

The RERTR program periodically will review the list as changes in USG foreign policy, operating status of reactors, and LEU fuel development activities occur. This list likely will change again in the future. The RERTR program continues to maintain and update an inventory of research and test reactors around the world that use HEU. Periodic review of this inventory ensures that the program is identifying appropriate research reactors for conversion to LEU fuel. The focus of this inventory is to maintain the most up-to-date information regarding the 64 remaining reactors identified for conversion. Based on information already gathered, the RERTR program estimates that there are over 150 research and test reactors that use HEU fuel in their cores. Maintenance of the inventory provides key data to the RERTR program when considering future expansion.

Criteria for Identifying Research Reactors for Conversion

Of the core criteria for identifying a civil research reactor for conversion, the primary criterion is technical limitations. The availability of an LEU fuel for conversion of a reactor is the primary driving force of the program. Therefore, if a reactor can convert with either currently available LEU fuel or an LEU fuel being developed, the reactor will meet the first criterion for being identified for conversion. This assessment may be difficult due to the fact that materials, configurations of reactors, and other data at reactor facilities are often proprietary information and not shared freely. A second criterion – political feasibility – is not as easily defined. An assessment of political feasibility requires the absence of a major political obstacle. However, not all political impediments may prevent a research reactor from being identified for conversion. In fact, the desire of an owner/operator to participate in the RERTR program may help to overcome the political obstacles. Without the desire and willingness of owners/operators of research reactors worldwide to convert to LEU fuel, the goal of HEU minimization and increased global security will not be achieved. The final core criterion for including a research reactor under the RERTR program is the consideration of special circumstances. Special circumstances may include but are not limited to: (1) shutdown schedules; (2) prohibitive costs for conversion; and/or (3) reactor missions that do not support conversion to LEU fuel, such as military utilization. Analysis of these three core criteria assists in identifying the appropriate research reactors for conversion under the RERTR program.

Conclusion

To date, 42 of the 106 research reactors identified for conversion have been fully or partially converted (32 full, 10 partial). High-density LEU fuels have been developed that enable the conversion of 41 reactors, and the program is currently focusing on the development of additional advanced higher-density LEU fuels, particularly U-Mo fuels, that will make feasible the conversion of the remaining 23 research reactors on the list of 106 identified research reactors. The development of these higher-density LEU fuels is scheduled for completion by 2010 allowing the RERTR program to fulfill its goal of converting 106 research reactors by 2014.

APPENDIX A
106 Reactors Identified for Conversion

Country	Reactor	Conversion Status
Argentina	RA-6	Can convert with currently available LEU fuel
Argentina	RA-3	Fully converted to LEU fuel
Australia	HIFAR	Partially converted
Austria	ASTRA	Fully converted to LEU fuel
Austria	TRIGA II Vienna	Partially converted
Belgium	BR-2	Requires new LEU fuel under development to convert
Brazil	IEA-R1	Fully converted to LEU fuel
Bulgaria	IRT-2000 Sofia	Can convert with currently available LEU fuel
Canada	Slowpoke-2 Halifax	Can convert with currently available LEU fuel
Canada	Slowpoke-2 Alberta	Can convert with currently available LEU fuel
Canada	Slowpoke-Saskatchewan	Can convert with currently available LEU fuel
Canada	NRU	Fully converted to LEU fuel
Canada	Slowpoke 2-Montreal	Fully converted to LEU fuel
Canada	MNR McMaster	Partially converted
Chile	La Reina RECH 1	Partially converted
China	MNSR - IAE	Can convert with currently available LEU fuel
China	MNSR - SD	Can convert with currently available LEU fuel
China	MNSR - SH	Can convert with currently available LEU fuel
China	MNSR - SZ	Can convert with currently available LEU fuel
Colombia	IAN-R1	Fully converted to LEU fuel
Czech Republic	LWR-15 Rez	Requires new LEU fuel under development to convert
Czech Republic	VR-1 Sparrow	Fully converted to LEU fuel
Denmark	DR-3	Fully converted to LEU fuel; Shutdown
France	MINERVE	Can convert with currently available LEU fuel
France	ORPHEE	Requires new LEU fuel under development to convert
France	RHF High Flux Reactor	Requires new LEU fuel under development to convert
France	Ulysee-Saclay	Can convert with currently available LEU fuel
France	OSIRIS	Fully converted to LEU fuel
Germany	FRJ-2 (DIDO)	Can convert with currently available LEU fuel
Germany	FRM-II	Requires new LEU fuel under development to convert
Germany	ZLFR	Can convert with currently available LEU fuel
Germany	BER-II	Fully converted to LEU fuel
Germany	FRG-1	Fully converted to LEU fuel
Ghana	MNSR GHARR-1	Can convert with currently available LEU fuel
Greece	GRR-1	Partially converted
Hungary	BRR	Can convert with currently available LEU fuel
Iran	MNSR - ENTC	Can convert with currently available LEU fuel

Country	Reactor	Conversion Status
Iran	TRR	Fully converted to LEU fuel
Israel	IRR-1	Can convert with currently available LEU fuel
Jamaica	UWI CNS Slowpoke	Can convert with currently available LEU fuel
Japan	KUCA	Can convert with currently available LEU fuel
Japan	KUR	Can convert with currently available LEU fuel
Japan	JRR-4	Fully converted to LEU fuel
Japan	JMTR	Partially converted
Japan	UTR-10 Kinki	Can convert with currently available LEU fuel
Kazakhstan	WWR-K	Requires new LEU fuel under development to convert
Kazakhstan	WWR-K Critical Assembly	Requires new LEU fuel under development to convert
Libya	Critical Facility	Can convert with currently available LEU fuel
Libya	IRT-1	Can convert with currently available LEU fuel
Mexico	TRIGA Mark III Salazar	Partially converted
Netherlands	HFR	Fully converted to LEU fuel
Netherlands	HOR	Fully converted to LEU fuel
Netherlands	LFR	Can convert with currently available LEU fuel
Nigeria	MNSR NIRR-0001	Can convert with currently available LEU fuel
Pakistan	MNSR PARR-2	Can convert with currently available LEU fuel
Pakistan	PARR-1	Fully converted to LEU fuel
Philippines	PRR-1	Fully converted to LEU fuel; Shutdown
Poland	MARIA	Requires new LEU fuel under development to convert
Portugal	RPI	Can convert with currently available LEU fuel
Romania	SSR TRIGA II	Partially converted
Russia	CA.MIR-M1	Requires new LEU fuel under development to convert
Russia	IR-8	Requires new LEU fuel under development to convert
Russia	IRT- MEPhI	Requires new LEU fuel under development to convert
Russia	IRT-T (Tomsk)	Requires new LEU fuel under development to convert
Russia	IVV-2M	Requires new LEU fuel under development to convert
Russia	MIR-M1	Requires new LEU fuel under development to convert
Russia	WWR-M	Requires new LEU fuel under development to convert
Russia	WWR-TS	Requires new LEU fuel under development to convert
Slovenia	TRIGA MARK II LJUBLJANA	Fully converted to LEU fuel
South Africa	SAFARI-1	Can convert with currently available LEU fuel
Sweden	R2-0	Fully converted to LEU fuel
Sweden	R2	Partially converted
Switzerland	SAPHIR	Fully converted to LEU fuel; Shutdown
Syria	MNSR - SSR-1	Can convert with currently available LEU fuel
Taiwan	THOR	Fully converted to LEU fuel

Country	Reactor	Conversion Status
Turkey	TR-2	Partially converted
UK	Imperial College - Consort	Can convert with currently available LEU fuel
UK	Viper	Can convert with currently available LEU fuel
Ukraine	WWR-M	Can convert with currently available LEU fuel
USA	ATR	Requires new LEU fuel under development to convert
USA	ATRC	Requires new LEU fuel under development to convert
USA	GE NTR	Can convert with currently available LEU fuel
USA	HFIR	Requires new LEU fuel under development to convert
USA	MITR-II	Requires new LEU fuel under development to convert
USA	MURR	Requires new LEU fuel under development to convert
USA	NBSR	Requires new LEU fuel under development to convert
USA	NRAD	Can convert with currently available LEU fuel
USA	NSCR - Texas A & M	Can convert with currently available LEU fuel
USA	OSTR - Oregon State	Can convert with currently available LEU fuel
USA	PUR 1 - Purdue	Can convert with currently available LEU fuel
USA	UFTR - Florida	Can convert with currently available LEU fuel
USA	UWNR -Wisconsin	Can convert with currently available LEU fuel
USA	WSUR - Washington State Univ.	Can convert with currently available LEU fuel
USA	Lowell	Fully converted to LEU fuel
USA	OSURR - Ohio State	Fully converted to LEU fuel
USA	RINSC	Fully converted to LEU fuel
USA	RPI	Fully converted to LEU fuel
USA	UMRR	Fully converted to LEU fuel
USA	WPI - Worcester Poly	Fully converted to LEU fuel
USA	GTRR	Fully converted to LEU fuel; Shutdown
USA	MCZPR	Fully converted to LEU fuel; Shutdown
USA	Michigan, Ford	Fully converted to LEU fuel; Shutdown
USA	UTR-10	Fully converted to LEU fuel; Shutdown
USA	UVAR -Virginia	Fully converted to LEU fuel; Shutdown
Uzbekistan	WWR-CM TASHKENT	Requires new LEU fuel under development to convert
Vietnam	Dalat Research Reactor - DRR	Can convert with currently available LEU fuel