STATUS OF REDUCED ENRICHMENT PROGRAM

FOR RESEARCH REACTORS IN JAPAN

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ABSTRACT

The reduced enrichment programs for the JRR-3M, JRR-4 and JMTR of Japan Atomic Energy Research Institute (JAERI) has been completed until 1999. The KUR of Kyoto University Research Reactor Institute (KURRI) has been partially completed and is still in progress under the Joint Study Program with Argonne National Laboratory (ANL).

The JRR-3M using LEU silicide fuel elements has done a functional test by the Japanese Government in 2000, and the property of the reactor core was satisfied.

JAERI established a "U-Mo fuel ad hoc committee" for feasibility study concerning future LEU fuel instead of the silicide fuel in 2001, and an installation of the U-Mo fuel was estimated from 2012, even the irradiation tests are carried out successfully.

The U.S. Policy of Foreign Research Reactor Spent Nuclear Fuels is strongly expected to expand the policy until U-Mo fuel installed.

The Japanese Government approved a cancellation of the KUHFR Project in February 1991, and in April 1994 the U.S. Government gave an approval to utilize HEU fuel in the KUR instead of the KUHFR. Therefore, the KUR will be operated with HEU fuel until March 2006, then the full core conversion with LEU fuel will be done. All KUR spent fuel elements will be sent to the U.S. by March 2008.

1. Introduction

Among sixteen research reactors and critical assemblies in operation in Japan, which are listed in Tables 1 and 2, those concerned with the RERTR program are the JRR-3M, JRR-4 and JMTR of JAERI and KUR of KURRI. These research reactors are shown in Table 3. In JAERI, the High Temperature Engineering Test Reactor (HTTR), which uses LEU fuel, reached the first criticality in November 1998, and a full power test was completed in 2001. The RERTR program in Japan had been pursued extensively under the direction of the Five Agency Committee on Highly Enriched Uranium, which consisted of the Science and Technology Agency (STA), the Ministry of Education, Science and Culture (MOE), the Ministry of Foreign Affairs, JAERI and KURRI, which was held every three months [1-19] . It had played a remarkable role in deciding policies related to the program, and the 92nd

Table 1. Japanese Research Reactors in Operation

Name	Owner	Site	Type and enrichment			Max.Power	Start-up date
UTR KINKl	Kinki University	Higashi-osaka	H_2O(UTR)	U-Al	90%	1W	1961.11
JRR-3M	JAERI	Tokai	D_2O(tank) H_2O(pool)	U UO_2 UAlx-Al U_3Si_2-Al	Natural 1.5% 20% 20%	10MW 10MW 20MW 20MW	1963.9 1972.1 1990.3 1999.9
MuITR	Musashi Inst.Tech.	Kawasaki	H_2O(TRIGA)	U-ZrH	20%	100kW	1962.3
KUR	KURRI	Kumatori	H_2O(tank)	U-Al U_3Si_2-Al	93% 20%	5MW 5MW	1964.6 1991.4
JRR-4	JAERI	Tokai	H_2O(pool)	U-Al U_3Si_2-Al	93% 20%	3.5MW 3.5MW	1965.1 1998.7
JMTR	JAERI	Oarai	H_2O(MTR)	U-Al UAl_x-Al U_3Si_2-Al	93% 45% 20%	50MW 50MW 50MW	1968.3 1986.7 1994.1
YAYOI	University of Tokyo	Tokai	fast(horizontally movable)	U	93%	2kW	1971.4
NSRR	JAERI	Tokai	H_2O(TRIGA)	U-ZrH	20%	300kW	1975.6
HTTR	JAERI	Oarai	Graphite-He(gas)	UO_2 particle	9.9% (Max)	30MW	2002.3

Table 2. Japanese Critical Assemblies in Operation

Name	Owner	Site	Type and enrichment			Max. Power	Start-up date
TCA	JAERI	Tokai	H_2O(tank)	UO_2 UO_2-PuO_2	2.6% 4%	200W	1962. 8
NCA	Toshiba	Kawasaki	H_2O(tank)	UO_2	1-5%	200kW	1963. 12
FCA	JAERI	Tokai	Fast Horizontally Split	U U Pu	93% 20%	2kW	1967. 4
DCA	JNC	Oarai	D_2O(tank)	UO_2 UO_2-PuO_2	1.2% 1.5%	1kW	1969.12
KUCA	KURRI	Kumatori	Various multi-core	U-Al UAl_X	93% 45%	100W 1kW(short time)	1974. 8 1981. 5
STACY	JAERI	Tokai	Homogeneous Heterogeneous Tank type	U Pu	4, 6, 10%	200W	1995. 2
TRACY	JAERI	Tokai	Homogeneous Tank type	U	10%	10kW $5x10^9$W (transient)	1995.12

Table 3. Research Reactors Relevant to RERTR in Japan

Name	Power(MW)	First Critical	Fuel Enrichment	Conversion
KUR(KURRI)	5	1964	HEU-LEU	(2006)
KUHFR(KURRI)	30	canceled		
JRR-3M(JAERI)	20	1962	LEU-LEU	1990
JRR-4(JAERI)	3.5	1965	HEU-LEU	1998
JMTR (JAERI)	50	1968	MEU-LEU	1994
Related Critical Assembly				
KUCA(KURRI)	0.0001	1974	HEU-MEU	1981

Committee was held in December 2000. After this meeting, MOE and STA were joined as one Ministry (Ministry of Education, Culture, Sports, Science and Technology : MEXT) under the administrative reorganization policy in January 2001. However, the Committee has not opened after MEXT started. The history of RERTR program in Japan is tabulated in Table 4.

Table 4. History of Reduced Enrichment Program for Research and Test Reactors in Japan

1977. 11	Japanese Committee on INFCE WC-8 was started.
1977. 11	Joint Study Program was proposed at the time of the application of export license of HEU for the KUHFR.
1978. 5	ANL-KURRI Joint Study Phase A was started.
1978. 6	Five Agency Committee on Highly Enriched Uranium was organized.
1978. 9	ANL-KURRI Joint Study Phase A was completed.
1979. 5	Project team for RERTR was formed in JAERI.
1979. 7	ANL-KURRI Joint Study Phase B was started.
1980. 1	ANL-JAERI Joint Study Phase A was started.
1980. 8	ANL-JAERI Joint Study Phase A was completed.
1980. 9	ANL-JAERI Joint Study Phase B was started.
1981. 5	MEU UAl_x-AI full core experiment was started in the KUCA.
1983. 3	ANL-KURRI Phase B was completed.
1983. 8	MEU $UA1_x$-Al full core experiment in the JMTRC was started.
1983.11	ANL-KURRI Phase C was started.
1984. 3	ANL-JAERI Phase B was completed.
1984. 4	ANL-JAERI Phase C was started.
1984. 4	MEU-HEU mixed core experiment in the KUCA was started.
1984. 9	Irradiation of 2 MEU and l LEU $UA1_x$-Al full size elements in the JRR-2 was started.
1984. 10	Irradiation of LEU UAl_x-Al full size elements in the JRR-4 was started.
1984. 11	Thermal-hydraulic calculations for the KUR core conversion from HEU to

	LEU were performed.
1985. 1	Irradiation of MEU UAl_x-Al full size elements in the JMTR was started.
1985. 3	Irradiation of MEU UAl_x-Al full size elements in the JMTR was completed.
	Irradiation of LEU U_xSi_y-Al miniplates in the JMTR was started.
1985. 6	Irradiation of LEU U_xSi_y-Al miniplates in the JMTR was completed.
1985. 10	Neutronics calculations for the KUR core conversion from HEU to LEU was performed.
1986. 1	Irradiation of MEU UAl_x-Al full size elements in the JRR-2 was started.
1986. 5	Irradiation of MEU $UA1_x$-Al full size elements in the JRR-2 was completed.
1986. 8	The JMTR was fully converted from HEU to MEU fuels.
1987.11	MEU UAl_x-Al full core in the JRR-2 was started.
1988. 7	PIE of MEU, LEU UAl_x-Al full size elements in the JRR-2 was completed.
1988. 12	Irradiation of LEU UAl_x-Al full size elements in the JRR-4 was completed.
1990. 3	LEU UAl_x-Al full core test in the new JRR-3 (JRR-3M) was started.
1990. 11	Full power operation of 20MW in the JRR-3M was started.
1992.5	Two LEU U_3Si_2-Al elements were inserted into the KUR core.
1993.11	Two LEU U_3Si_2-Al elements were inserted into the JMTR core.
1994.1	The JMTR was fully converted from MEU to LEU with U_3Si_2-Al fuel.
1994.9	ANL-JAERI Phase C was completed.
1995.12	The JMTRC was shutdown.
1996.12	The JRR-2 was shutdown.
1998.7	The JRR-4 was full converted from HEU to LEU with U_3Si_2-Al fuel.
1999.9	The JRR-3M was fully converted from LEU UAl_x-Al fuel to LEU U_3Si_2-Al fuel.
2000.3	The decommissioning plan for the VHTRC was submitted to the Japanese Government.
2002.3	The HTTR operation has been started after the Functional Test completed by the Japanese Government.

2. Current situation of research reactors relevant to the RERTR program in Japan

2.1 Japan Atomic Energy Research Institute (JAERI)

(1) JRR-3M

The JRR-3M was fully converted to LEU silicide fuel (4.8gU/cm^3) with cadmium wires of burnable absorber in September 1999 so as to decrease the number of spent fuels generated in a year.

After converted to LEU silicide fuel in September 1999, the JRR-3M already finished a functional test by Japanese regulation and a routine-use has been started from 2000, and no special problem was reported so far.

(2) JRR-4 and JMTR

JRR-4 and JMTR are in very good condition for operation after the conversion to LEU silicide fuels.

The JMTR was completely converted to the LEU fuel in January 1994. The LEU fuel is a silicide fuel (U_3Si_2) with 4.8gU/cm^3, and burnable absorber of cadmium wires is placed in each side plate of fuel element. The LEU silicide fuels allowed an extension of JMTR operating days without refueling that has been taken a 26-day operation from a 12-day operation by HEU fuels core.

After the conversion, the LEU fuel elements have been used in JMTR without any trouble related fuel until October 2002.

(3) Spent Fuel Management

Spent fuels from JRR-3M, JRR-4, JMTR and JMTRC are stored in their storage facilities. They will be shipped to U.S. under the Foreign Research Reactor Spent Nuclear Fuel Acceptance Program of the U.S., and seven shipments of JAERI have been successfully completed since 1997.

2.2 Research Reactor Institute, Kyoto University (KURRI)

The Kyoto University Research Reactor (KUR, 5MW) has been operated since 1964 using HEU fuel. The KUR has been still utilized for boron neutron capture therapy. Since February 1990, over 100 patients of cancer were treated by ten chief medical doctors of six groups. In order to increase the number of patients, the upgrade of the KUR Heavy Water Facility was completed. The main improvement of the facility is (1) to realize an epithermal neutron field in addition to thermal neutrons, and (2) to irradiate patients during continuous operation of the KUR, which were licensed in June 1998. Recently, treatment of head and neck cancer patients is increasing in addition to brain tumor and melanoma.

According to the government policy, Kyoto University tried to convert the KUR to use the LEU fuel, and two LEU silicide fuel elements have been loaded to the core in May 1992. In 1991, the Japanese Government approved cancellation of the Kyoto University High Flux Reactor (KUHFR) project. In 1994, the U. S. Government gave an approval to utilize HEU fuel in the KUR instead of the KUHFR, since we already prepared HEU fuel for KUHFR.

Therefore, the KUR will be operated with HEU fuel until the end of March, 2006.

As to spent fuel, the 4th shipment was done in June 2002 and the 5th in 2003 under the U.S. spent fuel acceptance policy of foreign research reactors. All KUR spent fuel elements produced in the KUR operation with HEU fuel will be sent completely by March 2008.

Kyoto University has a strong intention to continue the KUR operation with LEU fuel after 2006. In order to realize the plan, the issue of LEU spent fuel management is needed to be solved as soon as possible.

2.3 Other Facilities

The Rikkyo University TRIGA Mark II reactor was shut down in 2002 and its spent fuel will be returned to U.S. in 2003.

Musashi Institute of Technology also has a TRIGA Mark II reactor and its spent fuel will be sent to the U.S. in near future.

The TTR spent fuels of Toshiba Company will be returned to the U.S. in 2003.

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