ANL/RERTR/TM-22

Foreign Research Reactor Irradiated Nuclear Fuel Inventories Containing HEU and LEU of United States Origin

J. E. Matos
RERTR Program
Argonne National Laboratory
Argonne, IL 60439

December 1994

ARGONNE NATIONAL LABORATORY, ARGONNE, ILLINOIS
Operated by The University of Chicago
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Summary

This report provides estimates of foreign research reactor inventories of aluminum-based and TRIGA irradiated nuclear fuel elements containing highly enriched and low enriched uranium of United States origin that are anticipated in January 1996, January 2001, and January 2006. These fuels from 104 research reactors in 41 countries are the same aluminum-based and TRIGA fuels that were eligible for receipt under the Department of Energy's Offsite Fuels Policy that was in effect in 1988. All fuel inventory and reactor data that were available as of December 1, 1994, have been included in the estimates of approximately 14,300 irradiated fuel elements in January 1996, 18,800 in January 2001, and 22,700 in January 2006.

Summary of the Estimated Number of Irradiated Fuel Elements and Their Initial Uranium Content before Irradiation in January 1996, January 2001, and January 2006

	January 1996		January 2001		January 2006	
Fuel Type	Number Elements	Initial Kg U	Number Elements	Initial Kg U	Number Elements	Initial Kg U
HEU Aluminum-Based	8,172	3,232	9,554	3,989	10,109	4,528
HEU TRIGA	1,043	71	1,087	78	1,106	82
HEU Subtotal	9,215	3,303	10,641	4,067	11,215	4,610
LEU Aluminum-Based	2,078	3,305	4,536	7,993	7,672	13,654
LEU TRIGA	3,040	752	3,629	901	3,834	950
LEU Subtotal	5,118	4,057	8,165	8,894	11,506	14,604
Total	14,333	7,360	18,806	12,961	22,721	19,214

All fuel elements addressed in Environmental Assessment DOE/EA-0912, April 1994 are included in this table.
The total weight of the fuel elements is estimated to be about 64 metric tons in January 1996, 89 metric tons in January 2001, and 114 metric tons in January 2006.

Introduction

The United States Department of Energy is currently preparing (Ref. 1) an Environmental Impact Statement for potential acceptance from foreign research reactors of irradiated nuclear fuel containing highly enriched uranium (HEU, equal to or greater than 20 weight percent U-235) and low enriched uranium (LEU, less than 20 weight percent U-235) of United States origin. This Environmental Impact Statement is scheduled (Ref. 2) to be completed by the end of June 1995. If shipments of irradiated fuel to the United States are eventually authorized, a reasonable starting date to begin the acceptance policy is approximately January 1996. The purpose of this report is to provide estimates of the inventories of foreign research reactor irradiated fuel containing HEU and LEU of United States origin that are anticipated in January 1996, January 2001, and January 2006. Irradiated fuel includes spent fuel elements and fuel elements that are currently in reactor cores.

Fuel Types

Under the Offsite-Fuels Policy that was in effect during 1988 (Ref. 3), the United States Department of Energy accepted aluminum-based and TRIGA research reactor fuels[1] for disposition. This policy and the current proposed policy pertain to irradiated fuels and blanket materials from nuclear research reactors other than those involved in the conduct of research and development activities leading to demonstration of the practical value of such reactors for industrial or commercial purposes. Specifically, the Offsite-Fuels Policy in 1988 (Ref. 3) and the current proposed policy apply solely to the following types of reactor fuels:

a. Aluminum-clad reactor fuels where the uranium-235 content is equal to or greater than 20 percent, by weight, of the total uranium content. The active fuel region of these fuels may be configured as uranium-aluminum alloy, uranium oxide[2] or uranium-aluminide. Fuels containing significant quantities of uranium-233 are excluded from receipt.

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[1] Aluminum-based fuel is aluminum-clad and has an active fuel region that consists of an alloy of uranium and aluminum or a dispersion of a uranium-bearing compound (e.g., UAl_x, U_3O_8, U_3Si_2, U_3Si) in aluminum. TRIGA fuel consists of an alloy of uranium and zirconium and is clad in either aluminum or stainless steel.

[2] This uranium oxide composition refers to aluminum-clad fuel plates or tubes containing dispersions of U_3O_8 in aluminum. It does not include fuels containing UO_2 pellets clad in aluminum, zircalloy, stainless steel, or other materials.

b. Aluminum-clad reactor fuels where the uranium-235 content is less than 20 percent by weight of the total uranium content. The active fuel regions of these fuels may be configured as uranium-silicide, uranium-aluminide or uranium oxide[2]. Fuels containing significant quantities of uranium-233 are excluded from receipt.

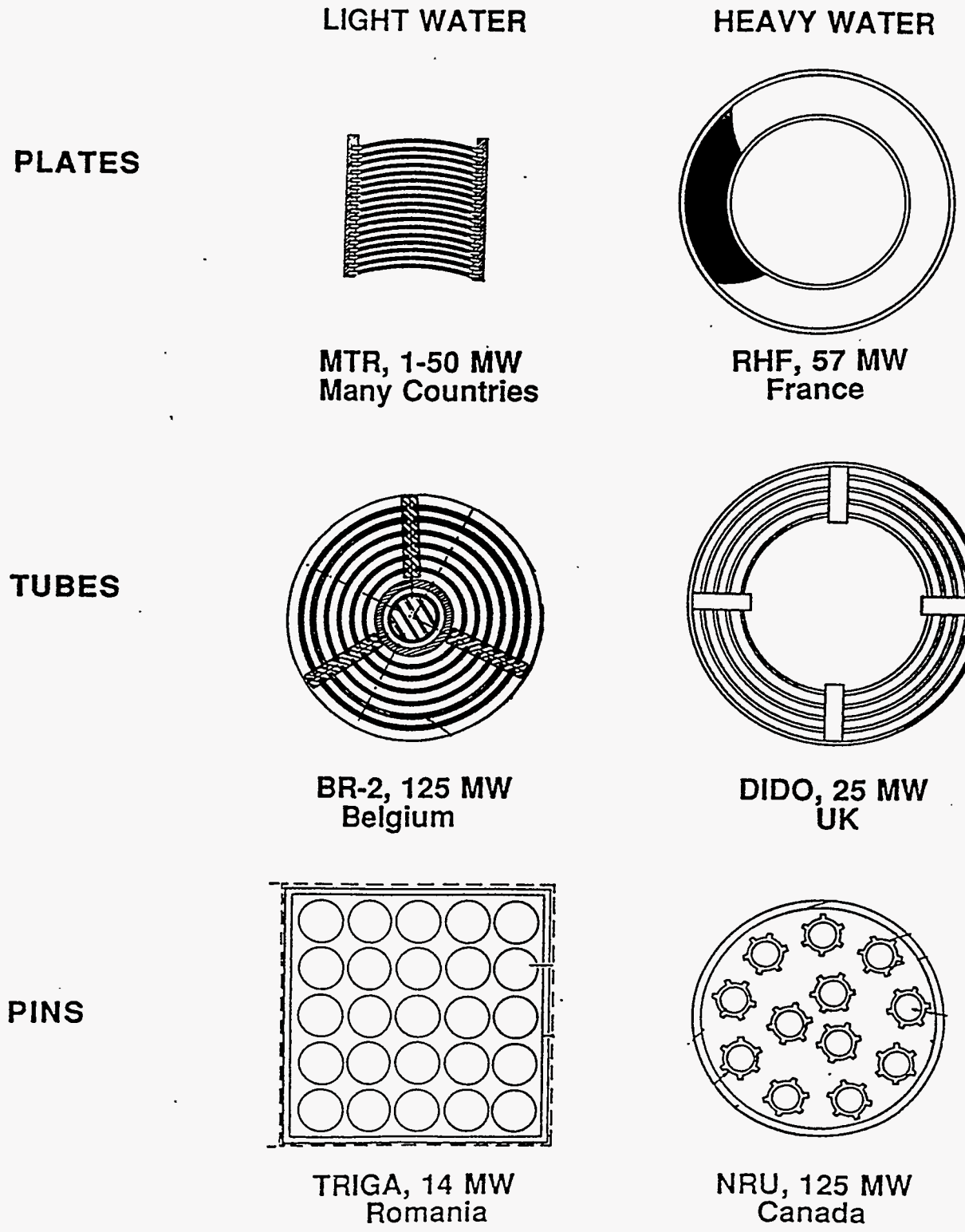
c. Aluminum or stainless steel clad, uranium-zirconium hydride (other than uranium-233) TRIGA fuel types.

Figure 1 shows cross sections of the main fuel assembly geometries: (1) aluminum-based MTR box-type assemblies containing 10-24 fuel plates per assembly (used in many countries), (2) aluminum-based involute core assemblies containing 280 fuel plates (RHF, France), (3) aluminum-based tubular fuel assemblies with 4-6 fueled tubes per assembly (BR-2, Belgium and DIDO, UK), (4) aluminum-based assemblies with 1-12 fuel pins per assembly (NRU, Canada - 12 pins per assembly and Slowpoke, Canada - single pins), and (5) single TRIGA fuel rods (used in many countries) and TRIGA fuel rod clusters with 4-25 rods per cluster (Philippines, 4 rods per cluster; Romania, 25 rods per cluster). All of these fuel assemblies are roughly 2-3 feet (60-90 cm) in length, except for the NRU assemblies which are approximately 9 feet (275 cm) long and single Slowpoke fuel pins which are about 1 foot (30 cm) long.

All of these reactor fuel types are shipped in assembly form with two exceptions: (1) TRIGA fuel rod clusters are disassembled and shipped as individual rods. For example, the TRIGA reactor core in Romania is composed of about 30 fuel clusters, each with 25 rods per cluster. A core would be shipped as 750 individual rods, which are counted as 750 fuel elements in this report. (2) Slowpoke cores contain approximately 300 fuel pins and these pins have been shipped to the Savannah River Site in bundles of approximately 150 pins. In order to maintain a consistent counting criterion in this report, each Slowpoke core is counted as two fuel elements.

In addition to the aluminum-based and TRIGA fuel types discussed above, enriched uranium of United States origin is also used in the fuel elements of several fast reactors and other special purpose reactors, in the UO_2 rodded fuel assemblies of several thermal research reactors, and in thermal homogeneous liquid and solid fueled reactors. The enrichment of the uranium ranges from 2% to 93%. These fuels do not qualify for acceptance by the United States under the current proposed policy because they were not included in the fuel types that were eligible for return to the United States under the Offsite Fuels Policy that was in effect in 1988.

Figure 1. FUEL ASSEMBLY GEOMETRIES



Data Sources and Assumptions

Information on current irradiated fuel inventories containing HEU and LEU of United States origin at foreign research reactors and temporary storage facilities were obtained from several sources: (1) questionnaires sent out by DOE and returned by research reactor organizations in 1993 and 1994, (2) data summarized from irradiated fuel questionnaires sent out by and returned to the International Atomic Energy Agency in 1993 and 1994, and (3) Reduced Enrichment for Research and Test Reactor (RERTR) Program information on research reactor fuel inventories, operation, and fuel cycles. Additional information on reactor fuel characteristics and reactor operation was obtained from directories of nuclear research reactors published by the International Atomic Energy Agency (Refs. 4, 5, and 6).

Beginning with irradiated fuel inventory data (having different dates of information) that was available on December 1, 1994, several assumptions were made, first to normalize the data to a common starting date of January 1996, and then to estimate the number of irradiated fuel elements in reactor cores and the number of spent fuel elements that are expected to be generated during the ten years between January 1996 and January 2006. These assumptions are:

1. Most reactors will continue operation during the 10 year life of the proposed policy. If a permanent shutdown date has been specified by the reactor owner, irradiated fuel was accumulated to that date only.

2. The number of irradiated fuel elements in each reactor core was determined from available reports and publications or estimated. Reactor owners who decide to shutdown their reactors during the 10 year life of the proposed policy will want to include irradiated fuel in the core for shipment along with the spent fuel in their reactor pool(s).

3. Known current and planned shutdowns for prolonged periods of maintenance and refurbishment have been incorporated into the estimates.

4. Dates for conversion from HEU to LEU fuel have been estimated, and the enrichment change was incorporated into the inventory data.

5. Estimated irradiated fuel inventories have been included for reactors that are under construction and plan to begin operation before the Record of Decision date (assumed here to be December 31, 1995) of the proposed policy using enriched uranium of United States origin.

6. Fuel from previously shutdown reactors with fuel in temporary storage has been included.

Developing Countries

The Implementation Plan for the Environmental Impact Statement on a Proposed Policy for the Acceptance of Foreign Research Reactor Spent Nuclear Fuel (Ref. 1) states that the United States would bear full costs of transport, management, and disposition of foreign research reactor spent nuclear fuel from developing countries.

For purposes of this report, developing countries are defined as countries which are classified as having low-income or middle-income economies on the basis of per capita Gross Domestic Product by the World Bank Development Report 1994 (Ref. 7). Zaire is not listed in Reference 7, but is considered here to have a low-income economy. For purposes of this report, Taiwan, with an estimated per capita Gross Domestic Product of $10,900 (1994) is considered to have a high-income economy. The countries shown in Table 1 qualify as developing countries according to this criterion:

Table 1. List of Developing Countries

Low Income Economies	Upper Middle Income Economies
Bangladesh	Argentina
Indonesia	Brazil
Pakistan	Greece
Zaire	Malaysia
	Mexico
Lower Middle Income Economies	Portugal
Chile	Slovenia
Columbia	South Africa
Iran	South Korea
Jamaica	Uruguay
Peru	Venezuela
Philippines	
Romania	
Thailand	
Turkey	

Reactors and Irradiated Fuel Inventories

The 104 research and test reactors located in 41 foreign countries that possess aluminum-based and TRIGA fuels containing enriched uranium of United States origin are shown in Attachment A. Table A1 lists 76 reactors that possess aluminum-based fuel only. These reactors are arranged in a number of categories that depend on each reactor's LEU conversion status. Table A2 lists 25

reactors that possess TRIGA fuel only. Table A3 lists three reactors that were converted from HEU aluminum-based fuel to LEU TRIGA fuel and thus possess both aluminum-based and TRIGA fuels.

Estimated irradiated fuel inventories of HEU and LEU aluminum-based and TRIGA fuel from these 104 foreign research reactors in January 1996, January 2001, and January 2006 are shown, by country, in Attachment B, Tables B1-B6, based on information available as of December 1, 1994. Table 2 summarizes the main results for all countries of the number of fuel elements, their initial uranium content before irradiation, and the total shipping weight of the elements. For the spent fuel (not including the fuel in reactor cores), the estimated final uranium content, final U-235 content, and final enrichment are also given. Table 3 provides this same data for developing countries only. The vast majority of both HEU and LEU aluminum-based fuels are expected to be generated in the developed countries. Nearly all HEU TRIGA fuel is expected to be generated in developing countries along with a majority of the LEU TRIGA fuel.

Previous and Current Inventory Estimates

The Notice of Intent to Prepare an Environmental Impact Statement (Ref. 8) stated that up to 15,000 fuel elements from about 28 foreign countries would be eligible for acceptance during a maximum 15 year period under the proposed action. This estimate was based on spent fuel inventory data available as of early 1993 and projected production for the following ten years.

This report estimates that 104 research reactors in 41 countries will have an inventory of approximately 22,700 irradiated aluminum-based and TRIGA fuel elements initially containing about 19,200 kilograms of enriched uranium of United States origin as of January 2006. The reasons for the increase in the estimated inventory are: (1) several other foreign research reactor operators notified DOE that they are interested in participating in the proposed spent fuel acceptance program after the Notice of Intent had been published; (2) the starting date used as a basis for the inventory projections was changed from early 1993 to January 1996 to conform with a realistic possible Record of Decision date for the proposed policy. As a result, three additional years of spent fuel accumulation has been included; (3) irradiated fuel in the reactor cores has been incorporated into the inventory in order to include the fuel elements from reactors that could be shut down during the life of the proposed policy; and (4) other information on research reactors and their projected operation that became available during 1994 has been incorporated.

Table 1. Summary of the Estimated Number of Irradiated Aluminum-Based and TRIGA Fuel Elements, Their Initial Uranium Content, and Their Total Weight before Irradiation in January 1996, January 2001, and January 2006.

ALL COUNTRIES

	January 1996			January 2001			January 2006		
Fuel Type	No. of Els.	Initial Kg U	Kg Total Weight	No. of Els.	Initial Kg U	Kg Total Weight	No. of Els.	Initial Kg U	Kg Total Weight
HEU Al-Based									
In Core	879	249	4,261	461	139	2,329	319	114	1,722
Spent	7,293	2,983	_	9,093	3,850	46,732	9,790	4,414	53,209
	8,172	3,232	39,672	9,554	3,989	49,061	10,109	4,528	54,931
HEU TRIGA									
In Core	945	66	1,034	420	42	692	420	42	692
Spent	98	5	69	667	36	551	686	40	612
	1,043	71	1,103	1,087	78	1,243	1,106	82	1,304
LEU Al-Based									
In Core	562	867	3,493	745	1,157	4,413	825	1,274	4,826
Spent	1,516	2,438	9,051	3,791	6,836	23,414	6,847	12,380	41,187
	2,078	3,305	12,544	4,536	7,993	27,827	7,672	13,654	46,013
LEU TRIGA									
In Core	2,078	559	6,986	2,293	628	6,723	2,104	563	6,043
Spent	962	193	3,304	1,336	273	4,600	1,730	387	5,979
	3,040	752	10,290	3,629	901	11,323	3,834	949	12,022
Subtotal InCore	4,464	1,741	15,774	3,919	1,966	14,157	3,668	1,993	13,283
Subtotal Spent	9,869	5,619	47,835	14,887	10,995	75,297	19,053	17,221	100,987
Total	14,333	7,360	63,609	18,806	12,961	89,454	22,721	19,214	114,270

Estimated Final Uranium Content in **Spent Fuel** (Fuel in Core is not included.)

	Uranium	U-235	Enrich,%	Uranium	U-235	Enrich,%	Uranium	U-235	Enrich,%
HEU Al-Based	1,965	1,200	61	2,569	1,651	64	2,960	1,959	66
HEU TRIGA	2.9	2.1	72	24	18	75	28	20	71
LEU Al-Based	2,210	212	10	6,178	573	9	11,194	1,044	9
LEU TRIGA	188	33	8	267	48	18	377	66	18
Total	4,366	1,447	33	9,038	2,290	25	14,559	3,089	21

Table 2. Summary of the Estimated Number of Irradiated Aluminum-Based and TRIGA Fuel Elements, Their Initial Uranium Content, and Their Total Weight before Irradiation in Developing Countries in January 1996, January 2001, and January 2006.

DEVELOPING COUNTRIES ONLY

	January 1996			January 2001			January 2006		
Fuel Type	No. of Els.	Initial Kg U	Kg Total Weight	No. of Els.	Initial Kg U	Kg Total Weight	No. of Els.	Initial Kg U	Kg Total Weight
HEU Al-Based									
In Core	116	25	523	37	9	161	27	7	124
Spent	663	128	2,945	751	146	3,348	770	150	3,427
	779	153	3,468	788	155	3,509	797	157	3,551
HEU TRIGA									
In Core	936	64	1,001	411	41	660	411	41	660
Spent	97	5	66	666	36	548	685	40	609
	1,033	69	1,067	1,077	77	1,208	1,096	81	1,269
LEU Al-Based									
In Core	228	249	1,341	261	302	1,552	254	296	1,518
Spent	246	196	1,344	409	430	2,375	615	725	3,669
	474	445	2,685	670	732	3,927	869	1,021	5,187
LEU TRIGA									
In Core	1,226	398	3,918	1,402	414	3,527	1,302	365	3,167
Spent	600	119	2,001	739	152	2,453	961	228	3,214
	1,826	517	5,919	2,141	566	5,980	2,263	593	6,381
Subtotal InCore	2,506	736	6,783	2,111	766	5,900	1,994	709	5,469
Subtotal Spent	1,606	448	6,356	2,565	764	8,724	3,031	1,143	10,919
Total	4,112	1,184	13,139	4,676	1,530	14,624	5,058	1,873	16,388

Estimated Final Uranium Content in **Spent Fuel** (Fuel in Core is not included.)

	Uranium	U-235	Enrich,%	Uranium	U-235	Enrich,%	Uranium	U-235	Enrich,%
HEU Al-Based	94	76	81	108	86	80	111	89	80
HEU TRIGA	2.7	2.0	74	24	17	71	28	20	71
LEU Al-Based	188	30	16	400	50	13	668	77	12
LEU TRIGA	117	21	18	148	26	18	222	38	17
Total	402	129	32	680	179	26	1,029	224	22

References

1. United States Department of Energy, Implementation Plan for the Environmental Impact Statement on a Proposed Policy for the Acceptance of Foreign Research Reactor Spent Nuclear Fuel, DOE/EIS-0218, October 1994.

2. Letter from Hazel R. O'Leary, Secretary of Energy, to Warren Christopher, Secretary of State, July 13, 1993.

3. United States Federal Register, Volume 51, No. 32, February 18, 1986 and the correction in Volume 51, No. 42, March 4, 1986; and Volume 52, No. 250, December 31, 1987.

4. International Atomic Energy Agency publication, "Nuclear Research Reactors in the World", December 1993 edition. Vienna, 1993.

5. International Atomic Energy Agency publication, "Directory of Nuclear Research Reactors" Vienna, 1989.

6. International Atomic Energy Agency publications, "Directory of Nuclear Reactors", Volumes II, III, V, VI, VIII, and X, published in Vienna between 1959 and 1976.

7. World Bank Development Report 1994, published for the World Bank by Oxford University Press, pages 162 and 163.

8. United States Department of Energy, "Notice of Intent to Prepare an Environmental Impact Statement on a Proposed Policy for the Acceptance of United States Origin Foreign Research Reactor Spent Fuel", Federal Register, Volume 58, No. 202, October 21, 1993, page 54336.

ATTACHMENT A

Foreign Research and Test Reactors Using Aluminum-Based and TRIGA Fuels Containing Uranium of United States Origin

Table A1. Foreign Research and Test Reactors That Possess Only Aluminum-Based Fuel Containing HEU and LEU of United States Origin.

	Reactor	Country	Power, MW	Fuel Geometry	Initial Enrichments* Wt-% U-235, U.S. Origin Enr.1	Enr.2	Enr.3	
HEU Reactors Fully- or Partially-Converted to LEU Fuel								
1	RA-3	Argentina	3	Plates	90	-	-	(1)
2	ASTRA	Austria	10	Plates	93	45	20	
3	IEA-R1	Brazil	2	Plates	93	-	20	
4	NRU	Canada	125	Pin Cluster	93	-	20	
5	DR-3	Denmark	10	Tubes	93	85	20	
6	OSIRIS	France	70	Plates	-	-	20	
7	FRG-1	Germany	5	Plates	93	-	20	
8	NRCRR	Iran	5	Plates	93	-	-	(2)
9	JMTR	Japan	50	Plates	93	45	20	
10	PARR	Pakistan	5	Plates	92	-	-	(2)
11	R2	Sweden	50	Plates	93	-	20	
HEU Reactors that Have Ordered LEU Fuel Elements for Conversion								
12	GRR-1	Greece	5	Plates	93	-	20	(3)
13	HOR	Netherlands	2	Plates	93	-	20	(3)
14	TR-2	Turkey	5	Plates	93	-	20	(3)
HEU Reactors That Can Be Converted to LEU Fuel								
15	RA-6	Argentina	0.5	Plates	90	-	-	
16	HIFAR	Australia	10	Tubes	80	60	20	(3)
17	MOATA	Australia	0.1	Plates	90	-	-	
18	SAR-GRAZ	Austria	0.01	Plates	90	-	-	
19	MNR	Canada	2	Plates	93	-	20	
20	Slowpoke Alberta	Canada	0.02	Pin Bundle	93	-	-	
21	Slowpoke Halifax	Canada	0.02	Pin Bundle	93	-	-	
22	Slowpoke Montreal	Canada	0.02	Pin Bundle	93	-	-	
23	Slowpoke Saskatchwan	Canada	0.02	Pin Bundle	93	-	-	

Table A1. (cont'd) Foreign Research and Test Reactors That Possess Only Aluminum-Based Fuel Containing HEU and LEU of United States Origin.

	Reactor	Country	Power, MW	Fuel Geometry	Initial Enrichments* Wt-% U-235, U.S. Origin Enr.1	Enr.2	Enr.3	
24	Slowpoke Toronto	Canada	0.02	Pin Bundle	93	-	-	
25	LA REINA	Chile	5	Plates	80	-	-	
26	IAN-R1	Columbia	0.03	Plates	90	-	-	
27	EOLE	France	0.01	Plates	93	-	-	
28	MINERVE	France	0.003	Plates	93	-	-	
29	SCARABEE	France	20	Plates	93	-	-	
30	Strasbourg - Cronenbourg	France	0.1	Plates	90	-	-	
31	Ulyssee - Saclay	France	0.1	Plates	90	-	-	
32	BER-II	Germany	10	Plates	93	-	20	(3)
33	FRJ-2	Germany	23	Tubes	80	-	20	(3)
34	FRM	Germany	4	Plates	93	45	-	
35	IRR-1	Israel	5	Plates	93	-	20	(3)
36	Slowpoke	Jamaica	0.02	Pin Bundle	93	-	-	
37	JMTRC	Japan	0	Plates	93	45	-	
38	JRR-4	Japan	3.5	Plates	93	-	20	(3)
39	KUCA	Japan	0	Plates	93	45	-	
40	KUR	Japan	5	Plates	93	-	20	(3)
41	UTR Kinki	Japan	0	Plates	90	-	-	
42	HFR Petten	Netherlands	45	Plates	93	-	20	(3)
43	LFR	Netherlands	0.03	Plates	93	-	-	
44	RPI	Portugal	1	Plates	93	-	20	
45	SAFARI	S. Africa	20	Plates	93	-	-	(4)
46	R2-0	Sweden	1	Plates	90	-	-	
47	ZPRL	Taiwan	0.01	Plates	93	-	20	
HEU Operating Reactors That Cannot Be Converted With Current Technology								
48	BR-2	Belgium	60	Tubes	90 - 93	-	-	
49	ORPHEE	France	14	Plates	93	-	-	
50	RHF	France	57	Involute Plates	93	-	-	

Table A1. Foreign Research and Test Reactors That Possess Only Aluminum-Based Fuel Containing HEU and LEU of United States Origin. (cont'd)

	Reactor	Country	Power, MW	Fuel Geometry	Initial Enrichments* Wt-% U-235, U.S. Origin Enr.1	Enr.2	Enr.3	
HEU Operating Reactors Announced To Be Shutdown								
51	SILOE	France	35	Plates	93	45	20	
52	SILOETTE	France	0.1	Plates	93	-	-	
53	FMRB	Germany	1	Plates	93	-	-	
54	FRG-2	Germany	15	Plates	90 - 93	-	20	
55	JRR-2	Japan	10	Plates	93	45	-	
56	UTR 300	U K	0.3	Plates	90	-	-	
Shutdown Reactors Possessing HEU Fuel								
57	BR-02	Belgium	-	Tubes	90	-	-	
58	NRX	Canada	-	Pin Cluster	93	-	-	
59	PTR	Canada	-	Plates	93	-	-	
60	Slowpoke Kanata	Canada	-	Pin Bundle	93	-	-	
61	MELUSINE	France	-	Plates	93	-	-	
62	GALILEO	Italy	-	Plates	89	-	-	
63	ISPRA-1	Italy	-	Plates	90	-	-	
64	RANA	Italy	-	Plates	90	-	20	
65	JEN-1	Spain	-	Plates	79	-	20	(5)
66	SAPHIR	Switzerland	-	Plates	93	45	20	

Table A1. Foreign Research and Test Reactors That Possess Only Aluminum-Based (cont'd) Fuel Containing HEU and LEU of United States Origin.

	Reactor	Country	Power, MW	Fuel Geometry	Initial Enrichments* Wt-% U-235, U.S. Origin Enr.1	Enr.2	Enr.3	
LEU Operating Reactors Possessing Only LEU Fuel								
67	RA-0	Argentina	0.01	Plates	-	-	20	
68	Argonauta	Brazil	0.2	Plates	-	-	20	
69	RSG-GAS30	Indonesia	30	Plates	-	-	20	
70	JRR-3M	Japan	20	Plates	-	-	20	
71	TTR-1	Japan	0.1	Plates	-	-	20	
72	RP-10	Peru	10	Plates	-	-	20	
73	KMRR	S. Korea	30	Pin Cluster	-	-	20	(6)
74	RV-1	Venezuela	3	Plates	-	-	20	
LEU Shutdown Reactors Possessing Only LEU Fuel								
75	THAR	Taiwan	-	Plates	-	-	20	
76	RU-1	Uruguay	-	Plates	-	-	20	

* Initial enrichments, in weight-% U-235, of the fuels possessed or anticipated to be possessed by each reactor. Only fuels containing uranium of United States origin are included.

Notes

(1) Converted to LEU fuel of Soviet origin.
(2) Converted to LEU fuel of Chinese origin.
(3) Use of fuel containing LEU of United States origin is anticipated to begin before 2001.
(4) Currently uses HEU of South African origin.
(5) JEN-1 fuel is currently being stored in Dounreay, Scotland.
(6) The KMRR reactor in South Korea is anticipated to begin operation using LEU aluminum-based fuel in January 1995.

Table A2. Foreign Research and Test Reactors That Possess Only TRIGA Fuel Containing HEU and LEU of United States Origin.

	Reactor	Country	Power, MW	Fuel Geometry	Initial Enrichments* Wt-% U-235, U.S. Origin Enr.1	Enr.2	Enr.3
Reactors Possessing HEU Fuel							
1	Vienna	Austria	0.25	Rods	70	-	20
2	Salazar	Mexico	1	Rods	70	-	20
3	SSR	Romania	14	Rods	93	-	20
4	Ljubljana	Slovenia	0.25	Rods	70	-	20
5	Seoul #2	S. Korea	2	Rods	70	-	20
Reactors Possessing LEU Fuel							
6	Dhaka	Bangladesh	3	Rods	-	-	20
7	Belo Horiz.	Brazil	-	Rods	-	-	20
8	Helsinki	Finland	0.25	Rods	-	-	20
9	Hannover	Germany	-	Rods	-	-	20
10	Heidelberg	Germany	0.25	Rods	-	-	20
11	Mainz	Germany	0.1	Rods	-	-	20
12	Bandung	Indonesia	1	Rods	-	-	20
13	Yogyakarta	Indonesia	0.1	Rods	-	-	20
14	Pavia	Italy	0.25	Rods	-	-	20
15	Rome	Italy	1	Rods	-	-	20
16	Mushashi Inst	Japan	0.1	Rods	-	-	20
17	NSRR-Tokai	Japan	0.3	Rods	-	-	20
18	Rikkyo U.	Japan	0.1	Rods	-	-	20
19	Kuala Lumpur	Malaysia	1	Rods	-	-	20
20	ACPR	Romania	0.5	Rods	-	-	20
21	Seoul #1	S. Korea	0.25	Rods	-	-	20
22	Istanbul	Turkey	0.25	Rods	-	-	20
23	Imp Chem Ind.	U K	0.25	Rods	-	-	20
24	TRICO II	Zaire	1	Rods	-	-	20
Shutdown Reactors							
25	TRICO I	Zaire	-	Rods	-	-	20

* Initial enrichments, in weight-% U-235, of the fuels possessed by each reactor. Only fuels containing uranium of United States origin are included.

Table A3. Foreign Research and Test Reactors That Possess Both Aluminum-Based and TRIGA Fuel Containing HEU and LEU of United States Origin.

	Reactor	Country	Power, MW	Fuel Geometry	Initial Enrichments* Wt-% U-235, U.S. Origin Enr.1	Enr.2	Enr.3
1	PRR-1	Philippines	3	TRIGA Rods	-	-	20
			-	Plates	93	-	20
2	THOR	Taiwan	1	TRIGA Rods	-	-	20
			-	Plates	93	-	-
3	TRR-1	Thailand	2	TRIGA Rods	-	-	20
			-	Plates	90	-	-

* Initial enrichments, in weight-% U-235, of the fuels possessed by each reactor. Only fuels containing uranium of United States origin are included.

Notes

All three of these reactors have been converted from plate-type, aluminum-based HEU fuel to TRIGA LEU fuel. The PRR-1 reactor in the Philippines possess both HEU and LEU cores of plate-type aluminum-based fuel elements.

ATTACHMENT B

Estimates by Country of Irradiated Fuel Inventories of Foreign Research and Test Reactors Using Aluminum-Based and TRIGA Fuels Containing Uranium of United States Origin

Table B1. Estimates (December 1, 1994) of Irradiated HEU and LEU Aluminum-Based Fuel of US-Origin
1996 Possessed by Foreign Research Reactors in January 1996

ALUMINUM-BASED FUELS

	January 1996 HEU Fuel in Core			January 1996 HEU Spent Fuel			Total HEU Fuel Spent+ in Core			January 1996 LEU Fuel in Core			January 1996 LEU Spent Fuel			Total LEU Fuel Spent+ in Core		
Country	No.	Kg HEU*	Kg Tot Weight	No.	Kg HEU*	Kg Tot Weight	No.	Kg HEU*	Kg Tot Weight	No.	Kg LEU*	Kg Tot Weight	No.	Kg LEU*	Kg Tot Weight	No.	Kg LEU*	Kg Tot Weight
Argentina (a)	28	5.8	120	225	46.7	968	253	53	1,088	30	18.8	129	0	0.0	0	30	19	129
Australia	37	10.4	109	624	120.1	1,390	661	131	1,499	0	0.0	0	0	0.0	0	0	0	0
Austria	6	2.3	27	38	12.6	181	44	15	208	23	37.7	147	14	24.0	90	37	62	237
Belgium	32	13.8	122	1,134	458.0	4,407	1,166	472	4,529	0	0.0	0	0	0.0	0	0	0	0
Brazil (a)	0	0.0	0	43	7.5	194	43	8	194	29	28.5	155	43	32.7	198	72	61	352
Canada	51	12.4	181	1,176	605.9	5,430	1,227	618	5,611	91	225.2	599	337	837.8	2,224	428	1,063	2,824
Chile (a)	9	1.9	45	49	10.0	245	58	12	290	0	0.0	0	0	0.0	0	0	0	0
Columbia (a)	16	2.4	59	0	0.0	0	16	2	59	0	0.0	0	0	0.0	0	0	0	0
Denmark	0	0.0	0	88	14.6	237	88	15	237	26	23.4	86	195	175.5	644	221	199	729
France	224	66.8	1,316	405	399.2	5,192	629	466	6,508	35	86.9	260	86	211.1	637	121	298	897
Germany	117	29.8	519	377	73.5	1,808	494	103	2,327	23	34.9	149	42	61.1	263	65	96	412
Greece (a)	28	5.1	137	126	22.0	617	154	27	755	8	7.9	46	0	0.0	0	8	8	46
Indonesia (a)	. 0	0.0	0	0	0.0	0	0	0	0	48	57.2	348	30	35.7	218	78	93	566
Iran (a)	0	0.0	0	29	5.5	119	29	6	119	0	0.0	0	0	0.0	0	0	0	0
Israel	26	5.7	125	108	23.7	518	134	29	643	0	0.0	0	0	0.0	0	0	0	0
Italy	0	0.0	0	117	21.4	485	117	21	485	0	0.0	0	33	21.7	145	33	22	145
Jamaica (a)	2	0.9	5	0	0.0	0	2	1	5	0	0.0	0	0	0.0	0	0	0	0
Japan	113	45.1	597	1,273	669.4	6,984	1,386	715	7,581	86	114.2	601	330	524.1	2,412	416	638	3,013
Netherlands	80	25.3	362	696	281.4	3,170	776	307	3,532	0	0.0	0	0	0.0	0	0	0	0
Pakistan (a)	0	0.0	0	82	15.9	336	82	16	336	0	0.0	0	0	0.0	0	0	0	0
Peru (a)	0	0.0	0	0	0.0	0	0	0	0	29	38.5	174	0	0.0	0	29	39	174
Philippines (a)	0	0.0	0	20	3.3	82	20	3	82	0	0.0	0	30	20.6	135	30	21	135
Portugal (a)	14	3.3	65	0	0.0	0	14	3	65	13	11.3	63	44	34.7	219	57	46	282
South Africa (a)	0	0.0	0	50	9.8	215	50	10	215	0	0.0	0	0	0.0	0	0	0	0
South Korea (a)	0	0.0	0	0	0.0	0	0	0	0	28	53.4	166	0	0.0	0	28	53	166

Table B1. (cont'd) 1996 Estimates (December 1, 1994) of Irradiated HEU and LEU Aluminum-Based Fuel of US-Origin Possessed by Foreign Research Reactors in January 1996

ALUMINUM-BASED FUELS

Country	January 1996 HEU Fuel in Core			January 1996 HEU Spent Fuel			Total HEU Fuel Spent+ in Core			January 1996 LEU Fuel in Core			January 1996 LEU Spent Fuel			Total LEU Fuel Spent+ in Core		
	No.	Kg HEU*	Kg Tot Weight	No.	Kg HEU*	Kg Tot Weight	No.	Kg HEU*	Kg Tot Weight	No.	Kg LEU*	Kg Tot Weight	No.	Kg LEU*	Kg Tot Weight	No.	Kg LEU*	Kg Tot Weight
Spain (b)	0	0.0	0	32	10.0	134	32	10	134	0	0.0	0	8	5.8	34	8	6	34
Sweden	38	4.9	163	404	103.9	1,858	442	109	2,022	50	95.6	310	132	252.2	818	182	348	1,128
Switzerland	0	0.0	0	124	55.8	498	124	56	498	0	0.0	0	35	72.4	192	35	72	192
Taiwan (c)	27	3.7	139	34	4.9	173	61	9	313	0	0.0	0	58	56.7	249	58	57	249
Thailand (a)	0	0.0	0	31	5.3	130	31	5	130	0	0.0	0	0	0.0	0	0	0	0
Turkey (a)	19	5.2	91	8	2.2	38	27	7	130	3	6.3	20	0	0.0	0	3	6	20
Uruguay (a)	0	0.0	0	0	0.0	0	0	0	0	0	0.0	0	19	18.1	95	19	18	95
Venezuela (a)	0	0.0	0	0	0.0	0	0	0	0	40	27.0	240	80	54.0	480	120	81	720
United Kingdom	12	4.0	78	0	0.0	0	12	4	78	0	0.0	0	0	0.0	0			
Total for All Countries	879	249	4,261	7,293	2,983	35,411	8,172	3,231	39,672	562	867	3,493	1,516	2,438	9,051	2,078	3,305	12,544
Subtotal for Developing Countries Only	116	25	523	663	128	2,945	779	153	3,467	228	249	1,341	246	196	1,344	474	445	2,684

* Initial weight of uranium before insertion into reactor.

(a) Considered a developing country, defined as a country which is classified as a Low-Income or Middle-Income Economy by the World Bank Development Report 1994, published for the World Bank by Oxford University Press, pages 162 and 163.

(b) Fuel assemblies are currently stored at Dounreay, Scotland.

(c) For purposes of this report, Taiwan, with an estimated per capita Gross Domestic Product of $10,900 (1994), is considered to be a High-Income Economy and does not qualify as a developing country.

Table B2. Estimates (December 1, 1994) of Irradiated HEU and LEU TRIGA Fuel of US-Origin
1996 Possessed by Foreign Research Reactors in January 1996
TRIGA FUEL

Country	January 1996 HEU Fuel in Core			January 1996 HEU Spent Fuel			Total HEU Fuel Spent+ in Core			January 1996 LEU Fuel in Core			January 1996 LEU Spent Fuel			Total LEU Fuel Spent+ in Core		
	No.	Kg HEU*	Kg Tot Weight	No.	Kg HEU*	Kg Tot Weight	No.	Kg HEU*	Kg Tot Weight	No.	Kg LEU*	Kg Tot Weight	No.	Kg LEU*	Kg Tot Weight	No.	Kg LEU*	Kg Tot Weight
Austria	9	1.6	32	1	0.2	4	10	2	36	70	13.3	252	18	3.4	65	88	17	317
Bangladesh (a)	0	0.0	0	0	0.0	0	0	0	0	100	49.0	360	0	0.0	0	100	49	360
Brazil (a)	0	0.0	0	0	0.0	0	0	0	0	0	0.0	0	75	14.3	270	75	14	270
Finland	0	0.0	0	0	0.0	0	0	0	0	77	14.6	277	17	3.2	61	94	18	338
Germany	0	0.0	0	0	0.0	0	0	0	0	132	25.1	475	146	27.7	526	278	53	1,001
Indonesia (a)	0	0.0	0	0	0.0	0	0	0	0	149	28.3	536	72	13.7	259	221	42	796
Italy	0	0.0	0	0	0.0	0	0	0	0	183	34.0	659	154	28.9	554	337	63	1,213
Japan	0	0.0	0	0	0.0	0	0	0	0	301	56.8	1,084	15	2.9	54	316	60	1,138
Malaysia (a)	0	0.0	0	0	0.0	0	0	0	0	84	41.6	302	0	0.0	0	84	42	302
Mexico (a)	29	5.5	93	0	0.0	0	29	6	93	71	13.5	227	64	12.2	205	135	26	432
Philippines (a)	0	0.0	0	0	0.0	0	0	0	0	120	73.8	420	0	0.0	0	120	74	420
Romania (a)	782	34.7	508	96	4.3	62	878	39	571	175	41.6	328	0	0.0	0	175	42	328
Slovenia (a)	25	4.8	80	1	0.2	3	26	5	83	75	14.3	240	192	36.5	614	267	51	854
South Korea (a)	100	19.0	320	0	0.0	0	100	19	320	91	17.3	291	113	21.5	362	204	39	653
Taiwan (b)	0	0.0	0	0	0.0	0	0	0	0	112	67.2	392	12	7.2	42	124	74	434
Thailand (a)	0	0.0	0	0	0.0	0	0	0	0	110	25.1	350	26	10.1	83	136	35	433
Turkey (a)	0	0.0	0	0	0.0	0	0	0	0	69	13.1	219	0	0.0	0	69	13	219
United Kingdom	0	0.0	0	0	0.0	0	0	0	0	89	16.9	320	0	0.0	0	89	17	320
Zaire (c)	0	0.0	0	0	0.0	0	0	0	0	70	13.3	252	58	11.0	209	128	24	461
Total for All	945	66	1,034	98	5	69	1,043	70	1,103	2,078	559	6,986	962	193	3,304	3,040	751	10,289
Subtotal for Developing Countries Only	936	64	1,001	97	5	66	1,033	69	1,067	1,226	398	3,918	612	127	2,044	1,838	525	5,962

* Initial weight of uranium before insertion into reactor.

(a) Considered a developing country, defined as a country which is classified as a Low-Income or Middle-Income Economy by the World Bank Development Report 1994, published for the World Bank by Oxford University Press, pages 162 and 163.

(b) For purposes of this report, Taiwan, with an estimated per capita Gross Domestic Product of $10,900 (1994), is considered to be a High-Income Economy and does not qualify as a developing country.

(c) For purposes of this report, Zaire is considered to be a Low-Income Economy, and does qualify as a developing country.

Table B3. Estimates (December 1, 1994) of Irradiated HEU and LEU Aluminum-Based Fuel of US-Origin
2001 Possessed by Foreign Research Reactors in January 2001

ALUMINUM-BASED FUELS

Country	January 2001 HEU Fuel in Core			January 2001 HEU Spent Fuel			Total HEU Fuel Spent+ in Core			January 2001 LEU Fuel in Core			January 2001 LEU Spent Fuel			Total LEU Fuel Spent+ in Core		
	No.	Kg HEU*	Kg Tot Weight	No.	Kg HEU*	Kg Tot Weight	No.	Kg HEU*	Kg Tot Weight	No.	Kg LEU*	Kg Tot Weight	No.	Kg LEU*	Kg Tot Weight	No.	Kg LEU*	Kg Tot Weight
Argentina (a)	15	3.1	65	238	49.4	1,023	253	53	1,088	30	18.8	129	0	0.0	0	30	19	129
Australia	12	3.3	52	674	134.2	1,505	686	138	1,557	25	25.0	58	84	84.0	193	109	109	251
Austria	6	2.3	27	38	12.6	181	44	15	208	23	37.7	147	41	67.7	262	64	105	410
Belgium	32	13.8	122	1,359	554.8	5,262	1,391	569	5,384	0	0.0	0	0	0.0	0	0	0	0
Brazil (a)	0	0.0	0	43	7.5	194	43	8	194	24	24.0	132	48	37.2	220	72	61	352
Canada	41	7.9	158	1,222	617.3	5,592	1,263	625	5,750	91	225.2	599	889	2,208.0	5,865	980	2,433	6,464
Chile (a)	0	0.0	0	58	11.9	290	58	12	290	0	0.0	0	0	0.0	0	0	0	0
Columbia (a)	0	0.0	0	16	2.4	59	16	2	59	0	0.0	0	0	0.0	0	0	0	0
Denmark	0	0.0	0	88	14.6	237	88	15	237	26	23.4	86	371	333.9	1,224	397	357	1,310
France	168	47.1	989	763	831.7	10,668	931	879	11,656	35	86.9	260	486	1,189.5	3,597	521	1,276	3,857
Germany	23	13.5	134	900	184.7	3,654	923	198	3,788	84	115.6	502	104	156.7	681	188	272	1,184
Greece (a)	0	0.0	0	154	27.1	755	154	27	755	33	33.7	188	12	12.3	68	45	46	257
Indonesia (a)	0	0.0	0	0	0.0	0	0	0	0	48	57.2	348	90	107.2	653	138	164	1,001
Iran (a)	0	0.0	0	29	5.5	119	29	6	119	0	0.0	0	0	0.0	0	0	0	0
Israel	26	5.7	125	127	27.8	610	153	34	734	0	0.0	0	0	0.0	0	0	0	0
Italy	0	0.0	0	117	21.4	485	117	21	485	0	0.0	0	33	21.7	145	33	22	145
Jamaica (a)	2	0.9	5	0	0.0	0	2	1	5	0	0.0	0	0	0.0	0	0	0	0
Japan	69	29.8	353	1,420	717.5	7,746	1,489	747	8,099	79	116.7	546	833	1,355.4	5,977	912	1,472	6,522
Netherlands	9	2.1	45	993	403.5	4,523	1,002	406	4,568	71	128.7	353	68	143.8	314	139	273	667
Pakistan (a)	0	0.0	0	82	15.9	336	82	16	336	0	0.0	0	0	0.0	0	0	0	0
Peru (a)	0	0.0	0	0	0.0	0	0	0	0	29	38.5	174	0	0.0	0	29	39	174
Philippines (a)	0	0.0	0	20	3.3	82	20	3	82	0	0.0	0	30	20.6	135	30	21	135
Portugal (a)	20	5.0	92	2	0.3	10	22	5	102	7	5.9	34	50	40.1	248	57	46	282
South Africa (a)	0	0.0	0	50	9.8	215	50	10	215	0	0.0	0	0	0.0	0	0	0	0
South Korea (a)	0	0.0	0	0	0.0	0	0	0	0	28	53.4	166	70	133.6	416	98	187	582

Table B3. (cont'd) 2001 **Estimates (December 1, 1994) of Irradiated HEU and LEU Aluminum-Based Fuel of US-Origin Possessed by Foreign Research Reactors in January 2001**

ALUMINUM-BASED FUELS

Country	January 2001 HEU Fuel in Core			January 2001 HEU Spent Fuel			Total HEU Fuel Spent+ in Core			January 2001 LEU Fuel in Core			January 2001 LEU Spent Fuel			Total LEU Fuel Spent+ in Core		
	No.	Kg HEU*	Kg Tot Weight	No.	Kg HEU*	Kg Tot Weight	No.	Kg HEU*	Kg Tot Weight	No.	Kg LEU*	Kg Tot Weight	No.	Kg LEU*	Kg Tot Weight	No.	Kg LEU*	Kg Tot Weight
Spain (b)	0	0.0	0	32	10.0	134	32	10	134	0	0.0	0	8	5.8	34	8	6	34
Sweden	38	4.9	163	404	103.9	1,858	442	109	2,022	50	95.6	310	372	710.2	2,306	422	806	2,616
Switzerland	0	0.0	0	124	55.8	498	124	56	498	0	0.0	0	35	72.4	192	35	72	192
Taiwan (c)	0	0.0	0	69	9.7	354	69	10	354	0	0.0	0	58	56.7	249	58	57	249
Thailand (a)	0	0.0	0	31	5.3	130	31	5	130	0	0.0	0	0	0.0	0	0	0	0
Turkey (a)	0	0.0	0	28	7.6	134	28	8	134	22	43.5	140	0	0.0	0	22	44	140
Uruguay (a)	0	0.0	0	0	0.0	0	0	0	0	0	0.0	0	19	18.1	95	19	18	95
Venezuela (a)	0	0.0	0	0	0.0	0	0	0	0	40	27.0	240	90	60.8	540	130	88	780
United Kingdom	0	0.0	0	12	4.0	78	12	4	78	0	0.0	0	0	0.0	0			
Total for All Countries	461	139	2,329	9,093	3,850	46,732	9,554	3,989	49,061	745	1,157	4,413	3,791	6,836	23,414	4,536	7,993	27,827
Subtotal for Developing Countries Only	37	9	161	751	146	3,348	788	155	3,509	261	302	1,552	409	430	2,375	670	732	3,927

* Initial weight of uranium before insertion into reactor.

(a) Considered a developing country, defined as a country which is classified as a Low-Income or Middle-Income Economy by the World Bank Development Report 1994, published for the World Bank by Oxford University Press, pages 162 and 163.

(b) Fuel assemblies are currently stored at Dounreay, Scotland.

(c) For purposes of this report, Taiwan, with an estimated per capita Gross Domestic Product of $10,900 (1994), is considered to be a High-Income Economy and does not qualify as a developing country.

Table B4. Estimates (December 1, 1994) of Irradiated HEU and LEU TRIGA Fuel of US-Origin
2001 Possessed by Foreign Research Reactors in January 2001
TRIGA FUEL

	January 2001 HEU Fuel in Core			January 2001 HEU Spent Fuel			Total HEU Fuel Spent+ in Core			January 2001 LEU Fuel in Core			January 2001 LEU Spent Fuel			Total LEU Fuel Spent+ in Core		
Country	No.	Kg HEU*	Kg Tot Weight	No.	Kg HEU*	Kg Tot Weight	No.	Kg HEU*	Kg Tot Weight	No.	Kg LEU*	Kg Tot Weight	No.	Kg LEU*	Kg Tot Weight	No.	Kg LEU*	Kg Tot Weight
Austria	9	1.6	32	1	0.2	4	10	2	36	70	13.3	252	22	4.2	79	92	18	331
Bangladesh (a)	0	0.0	0	0	0.0	0	0	0	0	100	49.0	360	0	0.0	0	100	49	360
Brazil (a)	0	0.0	0	0	0.0	0	0	0	0	0	0.0	0	75	14.3	270	75	14	270
Finland	0	0.0	0	0	0.0	0	0	0	0	77	14.6	277	94	17.9	338	171	33	616
Germany	0	0.0	0	0	0.0	0	0	0	0	132	25.1	475	206	39.1	742	338	64	1,217
Indonesia (a)	0	0.0	0	0	0.0	0	0	0	0	149	28.3	536	84	16.0	302	233	44	839
Italy	0	0.0	0	0	0.0	0	0	0	0	183	34.0	659	160	30.0	576	343	64	1,235
Japan	0	0.0	0	0	0.0	0	0	0	0	228	43.3	821	93	17.3	335	321	61	1,156
Malaysia (a)	0	0.0	0	0	0.0	0	0	0	0	84	41.6	302	5	2.5	18	89	44	320
Mexico (a)	29	5.5	93	3	0.6	10	32	6	102	71	13.5	227	72	13.7	230	143	27	458
Philippines (a)	0	0.0	0	0	0.0	0	0	0	0	120	73.8	420	0	0.0	0	120	74	420
Romania (a)	257	11.4	167	621	27.6	404	878	39	571	573	149.8	678	0	0.0	0	573	150	678
Slovenia (a)	25	4.8	80	26	4.9	83	51	10	163	75	14.3	240	192	36.5	614	267	51	854
South Korea (a)	100	19.0	320	16	3.0	51	116	22	371	91	17.3	291	113	21.5	362	204	39	653
Taiwan (b)	0	0.0	0	0	0.0	0	0	0	0	112	67.2	392	22	13.2	77	134	80	469
Thailand (a)	0	0.0	0	0	0.0	0	0	0	0	0	0.0	0	136	35.2	433	136	35	433
Turkey (a)	0	0.0	0	0	0.0	0	0	0	0	69	13.1	219	0	0.0	0	69	13	219
United Kingdom	0	0.0	0	0	0.0	0	0	0	0	89	16.9	320	0	0.0	0	89	17	320
Zaire (a)	0	0.0	0	0	0.0	0	0	0	0	70	13.3	252	62	11.8	223	132	25	475
Total for All	420	42	692	667	36	551	1,087	79	1,243	2,293	628	6,723	1,336	273	4,600	3,629	902	11,323
Subtotal for Developing Countries Only	411	41	660	666	36	548	1,077	77	1,207	1,402	414	3,527	739	152	2,453	2,141	566	5,979

* Initial weight of uranium before insertion into reactor.

(a) Considered a developing country, defined as a country which is classified as a Low-Income or Middle-Income Economy by the World Bank Development Report 1994, published for the World Bank by Oxford University Press, pages 162 and 163.

(b) For purposes of this report, Taiwan, with an estimated per capita Gross Domestic Product of $10,900 (1994), is considered to be a High-Income Economy and does not qualify as a developing country.

(c) For purposes of this report, Zaire is considered to be a Low-Income Economy, and does qualify as a developing country.

Table B5. Estimates (December 1, 1994) of Irradiated HEU and LEU Aluminum-Based Fuel of US-Origin
2006 Possessed by Foreign Research Reactors in January 2006

ALUMINUM-BASED FUELS

Country	January 2006 HEU Fuel in Core			January 2006 HEU Spent Fuel			Total HEU Fuel Spent+ in Core			January 2006 LEU Fuel in Core			January 2006 LEU Spent Fuel			Total LEU Fuel Spent+ in Core		
	No.	Kg HEU*	Kg Tot Weight	No.	Kg HEU*	Kg Tot Weight	No.	Kg HEU*	Kg Tot Weight	No.	Kg LEU*	Kg Tot Weight	No.	Kg LEU*	Kg Tot Weight	No.	Kg LEU*	Kg Tot Weight
Argentina (a)	0	0.0	0	253	52.5	1,088	253	53	1,088	30	18.8	129	0	0.0	0	30	19	129
Australia	12	3.3	52	674	134.2	1,505	686	138	1,557	25	25.0	58	264	264.0	607	289	289	665
Austria	6	2.3	27	38	12.6	181	44	15	208	23	37.7	147	68	111.3	435	91	149	582
Belgium	32	13.8	122	1,734	716.1	6,687	1,766	730	6,809	0	0.0	0	0	0.0	0	0	0	0
Brazil (a)	0	0.0	0	43	7.5	194	43	8	194	24	24.0	132	48	37.2	220	72	61	352
Canada	0	0.0	0	1,261	624.8	5,743	1,261	625	5,743	125	270.7	780	1,445	3,582.8	9,526	1,570	3,854	10,306
Chile (a)	0	0.0	0	58	11.9	290	58	12	290	0	0.0	0	0	0.0	0	0	0	0
Columbia (a)	0	0.0	0	16	2.4	59	16	2	59	0	0.0	0	0	0.0	0	0	0	0
Denmark	0	0.0	0	88	14.6	237	88	15	237	26	23.4	86	546	491.4	1,802	572	515	1,888
France	168	47.1	989	893	1,184.9	14,818	1,061	1,232	15,806	35	86.9	260	886	2,167.9	6,557	921	2,255	6,817
Germany	23	13.5	134	930	201.8	3,830	953	215	3,964	84	115.6	502	467	578.5	2,437	551	694	2,939
Greece (a)	0	0.0	0	154	27.1	755	154	27	755	33	33.7	188	52	51.8	296	85	86	485
Indonesia (a)	0	0.0	0	0	0.0	0	0	0	0	48	57.2	348	150	178.6	1,088	198	236	1,436
Iran (a)	0	0.0	0	29	5.5	119	29	6	119	0	0.0	0	0	0.0	0	0	0	0
Israel	0	0.0	0	153	33.5	734	153	34	734	26	51.9	125	13	25.7	62	39	78	187
Italy	0	0.0	0	117	21.4	485	117	21	485	0	0.0	0	33	21.7	145	33	22	145
Jamaica (a)	0	0.0	0	2	0.9	5	2	1	5	0	0.0	0	0	0.0	0	0	0	0
Japan	42	25.1	230	1,450	726.6	7,911	1,492	752	8,141	106	142.4	687	1,383	2,239.9	9,764	1,489	2,382	10,452
Netherlands	9	2.1	45	994	403.7	4,528	1,003	406	4,573	71	128.7	353	414	869.7	1,913	485	998	2,266
Pakistan (a)	0	0.0	0	82	15.9	336	82	16	336	0	0.0	0	0	0.0	0	0	0	0
Peru (a)	0	0.0	0	0	0.0	0	0	0	0	29	38.5	174	0	0.0	0	29	39	174
Philippines (a)	0	0.0	0	20	3.3	82	20	3	82	0	0.0	0	30	20.6	135	30	21	135
Portugal (a)	27	7.0	124	4	0.6	20	31	8	143	0	0.0	0	57	45.9	282	57	46	282
South Africa (a)	0	0.0	0	50	9.8	215	50	10	215	0	0.0	0	0	0.0	0	0	0	0
South Korea (a)	0	0.0	0	0	0.0	0	0	0	0	28	53.4	166	140	267.1	832	168	321	998

Table B5. (cont'd) 2006 **Estimates (December 1, 1994) of Irradiated HEU and LEU Aluminum-Based Fuel of US-Origin Possessed by Foreign Research Reactors in January 2006**

ALUMINUM-BASED FUELS

Country	January 2006 HEU Fuel in Core			January 2006 HEU Spent Fuel			Total HEU Fuel Spent+ in Core			January 2006 LEU Fuel in Core			January 2006 LEU Spent Fuel			Total LEU Fuel Spent+ in Core		
	No.	Kg HEU*	Kg Tot Weight	No.	Kg HEU*	Kg Tot Weight	No.	Kg HEU*	Kg Tot Weight	No.	Kg LEU*	Kg Tot Weight	No.	Kg LEU*	Kg Tot Weight	No.	Kg LEU*	Kg Tot Weight
Spain (b)	0	0.0	0	32	10.0	134	32	10	134	0	0.0	0	8	5.8	34	8	6	34
Sweden	0	0.0	0	451	110.0	2,061	451	110	2,061	50	95.6	310	612	1,168.1	3,794	662	1,264	4,104
Switzerland	0	0.0	0	124	55.8	498	124	56	498	0	0.0	0	35	72.4	192	35	72	192
Taiwan (c)	0	0.0	0	69	9.7	354	69	10	354	0	0.0	0	58	56.7	249	58	57	249
Thailand (a)	0	0.0	0	31	5.3	130	31	5	130	0	0.0	0	0	0.0	0	0	0	0
Turkey (a)	0	0.0	0	28	7.6	134	28	8	134	22	43.5	140	19	37.7	121	41	81	262
Uruguay (a)	0	0.0	0	0	0.0	0	0	0	0	0	0.0	0	19	18.1	95	19	18	95
Venezuela (a)	0	0.0	0	0	0.0	0	0	0	0	40	27.0	240	100	67.5	600	140	95	840
United Kingdom	0	0.0	0	12	4.0	78	12	4	78	0	0.0	0	0	0.0	0			
Total for All Countries	319	114	1,722	9,790	4,414	53,209	10,109	4,528	54,931	825	1,274	4,826	6,847	12,380	41,187	7,672	13,654	46,013
Subtotal for Developing Countries Only	27	7	124	770	150	3,427	797	157	3,550	254	296	1,518	615	725	3,669	869	1,021	5,187

* Initial weight of uranium before insertion into reactor.

(a) Considered a developing country, defined as a country which is classified as a Low-Income or Middle-Income Economy by the World Bank Development Report 1994, published for the World Bank by Oxford University Press, pages 162 and 163.

(b) Fuel assemblies are currently stored at Dounreay, Scotland.

(c) For purposes of this report, Taiwan, with an estimated per capita Gross Domestic Product of $10,900 (1994), is considered to be a High-Income Economy and does not qualify as a developing country.

Table B6. Estimates (December 1, 1994) of Irradiated HEU and LEU TRIGA Fuel of US-Origin
2006 Possessed by Foreign Research Reactors in January 2006

TRIGA FUEL

Country	January 2006 HEU Fuel in Core			January 2006 HEU Spent Fuel			Total HEU Fuel Spent+ in Core			January 2006 LEU Fuel in Core			January 2006 LEU Spent Fuel			Total LEU Fuel Spent+ in Core		
	No.	Kg HEU*	Kg Tot Weight	No.	Kg HEU*	Kg Tot Weight	No.	Kg HEU*	Kg Tot Weight	No.	Kg LEU*	Kg Tot Weight	No.	Kg LEU*	Kg Tot Weight	No.	Kg LEU*	Kg Tot Weight
Austria	9	1.6	32	1	0.2	4	10	2	36	70	13.3	252	26	4.9	94	96	18	346
Bangladesh (a)	0	0.0	0	0	0.0	0	0	0	0	0	0.0	0	100	49.0	360	100	49	360
Brazil (a)	0	0.0	0	0	0.0	0	0	0	0	0	0.0	0	75	14.3	270	75	14	270
Finland	0	0.0	0	0	0.0	0	0	0	0	77	14.6	277	94	17.9	338	171	33	616
Germany	0	0.0	0	0	0.0	0	0	0	0	132	25.1	475	226	42.9	814	358	68	1,289
Indonesia (a)	0	0.0	0	0	0.0	0	0	0	0	149	28.3	536	96	18.2	346	245	47	882
Italy	0	0.0	0	0	0.0	0	0	0	0	183	34.0	659	203	37.9	731	386	72	1,390
Japan	0	0.0	0	0	0.0	0	0	0	0	228	43.3	821	98	18.3	353	326	62	1,174
Malaysia (a)	0	0.0	0	0	0.0	0	0	0	0	84	41.6	302	10	5.0	36	94	47	338
Mexico (a)	29	5.5	93	6	1.1	19	35	7	112	71	13.5	227	80	15.2	256	151	29	483
Philippines (a)	0	0.0	0	0	0.0	0	0	0	0	120	73.8	420	8	4.9	28	128	79	448
Romania (a)	257	11.4	167	621	27.6	404	878	39	571	573	149.8	678	0	0.0	0	573	150	678
Slovenia (a)	25	4.8	80	26	4.9	83	51	10	163	75	14.3	240	267	50.7	854	342	65	1,094
South Korea (a)	100	19.0	320	32	6.1	102	132	25	422	91	17.3	291	113	21.5	362	204	39	653
Taiwan (b)	0	0.0	0	0	0.0	0	0	0	0	112	67.2	392	32	19.2	112	144	86	504
Thailand (a)	0	0.0	0	0	0.0	0	0	0	0	0	0.0	0	136	35.2	433	136	35	433
Turkey (a)	0	0.0	0	0	0.0	0	0	0	0	69	13.1	219	10	1.9	32	79	15	251
United Kingdom	0	0.0	0	0	0.0	0	0	0	0	0	0.0	0	90	17.1	324	90	17	324
Zaire (a)	0	0.0	0	0	0.0	0	0	0	0	70	13.3	252	66	12.5	238	136	26	490
Totals	420	42	692	686	40	612	1,106	82	1,304	2,104	563	6,043	1,730	387	5,979	3,834	949	12,022
Subtotal for Developing Countries Only	411	41	660	685	40	609	1,096	80	1,268	1,302	365	3,167	961	228	3,214	2,263	593	6,380

* Initial weight of uranium before insertion into reactor.

(a) Considered a developing country, defined as a country which is classified as a Low-Income or Middle-Income Economy by the World Bank Development Report 1994, published for the World Bank by Oxford University Press, pages 162 and 163.

(b) For purposes of this report, Taiwan, with an estimated per capita Gross Domestic Product of $10,900 (1994), is considered to be a High-Income Economy and does not qualify as a developing country.

(c) For purposes of this report, Zaire is considered to be a Low-Income Economy, and does qualify as a developing country.