SECTION 5
ACQUISITIONS

The total HEU acquisitions for the period between 1945 and September 30, 1996, were **1,055.4** MTU containing **864.4** MTU-235. For the purpose of this report, total HEU acquisitions consist of the following:

- Production from uranium enrichment processes
- Production from blending LEU to HEU
- Receipts from foreign countries

U.S. production from uranium enrichment processes accounts for approximately 99 percent of all acquisitions with a total of **1,045.4** MTU. Approximately **3.1** MTU was produced from blending, and **6.9** MTU was received from foreign countries.

U.S. HEU PRODUCTION

From 1945 through 1996, a total of **1,045.4** MTU containing **859.2** MTU-235 was produced in the United States at three facilities utilizing two different production technologies. Total U.S. HEU production is provided in **Table 5-1** with annual production presented in four distinct ranges of uranium-235 percentages (in kilograms) along with total kilograms of uranium and uranium-235.

U.S. HEU Production

Location	*MTU*
Y-12 Plant Calutrons	1.4
Oak Ridge Gaseous Diffusion Plant	491.8
Portsmouth Gaseous Diffusion Plant	552.2
Total	1,045.4

Figure 5-1 shows that the majority of HEU was produced from 1956 through 1964. During these years, the Oak Ridge and Portsmouth Gaseous Diffusion Plants produced HEU concurrently. This period accounts for approximately 70 percent of the total amount of HEU produced by the U.S. Site details are discussed later in this section.

Shown in **Figure 5-2** are the quantities of HEU produced by assay range.

- Approximately 19 percent of the total HEU produced was enriched in the assay range greater than or equal to 96 percent. All of this HEU was produced at the Portsmouth Gaseous Diffusion Plant. The average assay of this material is approximately 97 percent.
- The largest quantity of HEU produced was in the assay range from 90 percent to less than 96 percent enriched. This material accounted for approximately 58 percent of the total quantity of HEU produced and was used in nuclear weapons, Savannah River Site production reactors, military reactors, research reactors, and space propulsion reactors. The average assay of this HEU is approximately 93 percent.

- HEU enriched in the assay range from 20 to less than 90 percent accounts for the remaining quantity of HEU produced.

Openness Press Conference

At the June 27, 1994, Openness Press Conference, the DOE released 994 metric tons as an estimate of HEU produced in the U.S. between 1945 and 1992 (DOE 1994a). This report updates the June 1994 production estimate from 994 to 1,045 metric tons HEU. Several factors account for the 51 metric ton increase in production. First, the 994 quantity relied on readily available existing reports that proved to be incomplete. In support of the June 1994 Openness Press Conference, there was insufficient time to research historical production reports, reconcile data to site accountability records, or to review plant operating records. In addition, the June 1994 production quantity did not recognize or adjust for changes in definitions, terminology, and reporting that have occurred over the last 50 years. Furthermore, the June 1994 quantity did not include:

- HEU produced in the Y-12 Plant calutrons,
- HEU produced below 90 percent uranium-235 at the Oak Ridge Gaseous Diffusion Plant from 1945 to 1954, and
- HEU produced at the Portsmouth Gaseous Diffusion Plant after July 1991.

Most importantly, the June 1994 release did not include a material balance, and, therefore, these early oversights were not discovered until the preparation of the current material balance contained in this report.

Table 5-1 Total U.S. HEU Production

Year	Percent U-235[a]								Totals[a]	
	20 to <70%		70 to <90%		90 to <96%		≥96%			
	U	U-235	U	U-235	U	U-235	U	U-235	U	U-235
1945[b]	1,529	391	--	--	--	--	--	--	1,529	391
1946[b]	3,127	905	73	61	603	571	--	--	3,804	1,538
1947	118	36	--	--	1,746	1,637	--	--	1,864	1,673
1948	--	--	--	--	1,391	1,296	--	--	1,391	1,296
1949	25	14	87	65	1,582	1,473	--	--	1,694	1,552
1950	370	158	10	9	1,687	1,570	--	--	2,068	1,737
1951	--	--	--	--	1,091	1,016	--	--	1,091	1,016
1952	110	35	12	10	4,163	3,877	--	--	4,284	3,923
1953	--	--	1	1	7,261	6,765	--	--	7,262	6,766
1954	1,379	518	--	--	14,302	13,333	--	--	15,681	13,851
1955	16,812	6,600	--	--	17,364	16,209	--	--	34,176	22,809
1956	26,362	9,983	2,991	2,380	30,707	28,641	--	--	60,060	41,004
1957	21,520	8,073	72	64	43,357	40,454	--	--	64,950	48,591
1958	15,663	5,874	-13	-12	61,715	57,612	--	--	77,364	63,475
1959	37,142	13,353	68	59	64,686	60,632	--	--	101,896	74,045
1960	23,364	8,354	150	134	72,312	68,068	--	--	95,826	76,557
1961	9,454	3,455	132	117	79,015	73,702	--	--	88,601	77,274
1962	16,451	6,267	450	404	74,589	69,533	521	508	92,012	76,712
1963	19,738	8,423	7,538	5,328	58,261	54,357	--	--	85,537	68,109
1964	10,125	5,262	10,246	7,289	32,228	30,046	11,967	11,652	64,566	54,248
1965	1,828	643	233	209	12,808	11,930	6,484	6,333	21,353	19,115
1966	753	224	165	148	6,382	5,945	4,578	4,471	11,879	10,788
1967	2,375	752	260	234	2,314	2,156	5,710	5,576	10,660	8,718
1968	2,302	1,187	200	180	2,340	2,180	3,455	3,374	8,297	6,921
1969	2,613	1,302	600	533	5,697	5,306	8,270	8,076	17,181	15,217
1970	1,250	519	100	78	264	240	5,167	5,046	6,782	5,884
1971	1,041	248	109	98	94	85	4,108	4,009	5,352	4,440
1972	83	24	142	127	1,932	1,796	7,788	7,605	9,945	9,552
1973	44	10	18	16	2,239	2,081	8,562	8,361	10,862	10,467
1974	404	128	--	--	626	583	7,818	7,634	8,848	8,345
1975	46	14	1	1	1,260	1,174	7,323	7,152	8,631	8,341
1976	1,049	472	102	74	218	203	12,885	12,582	14,254	13,331
1977	39	11	--	--	555	517	11,850	11,565	12,443	12,092
1978	4	2	84	70	1	1	9,541	9,284	9,631	9,356
1979	825	496	54	38	227	211	4,777	4,648	5,883	5,392
1980	28	9	2	1	275	256	2,317	2,254	2,621	2,521
1981	66	27	7	6	28	26	4,983	4,849	5,084	4,908
1982	55	22	11	9	681	635	12,297	11,965	13,044	12,630
1983	104	41	31	24	2	1	8,958	8,716	9,095	8,783
1984	113	38	-3	-1	-16	-15	5,837	5,680	5,931	5,702
1985	166	55	-15	-10	34	32	5,902	5,744	6,088	5,821
1986	40	6	29	21	331	307	3,778	3,675	4,177	4,010
1987	143	58	28	21	5	4	5,056	4,912	5,231	4,995
1988	55	21	21	17	7	7	7,395	7,191	7,478	7,237
1989	32	13	15	13	8	7	9,071	8,817	9,125	8,849
1990	182	83	8	7	63	59	5,929	5,740	6,183	5,888
1991	-26	-18	40	31	499	476	1,581	1,527	2,093	2,017
1992	1	--	101	88	1,105	1,032	177	170	1,384	1,290
1993[c]	30	16	-1	-1	--	--	-2	-3	27	12
1994[c]	15	3	--	--	1	1	--	--	16	5
1995[c]	60	24	6	5	--	--	1	1	67	29
1996[c]	77	13	3	2	4	3	1	1	85	19
Total	**219,087**	**84,144**	**24,171**	**17,949**	**608,044**	**568,031**	**194,085**	**189,115**	**1,045,387**	**859,242**

Note: Totals may not add due to rounding.

a Quantities are in kilograms.

b Calutron production for 1945 is combined with production for 1946 and included only in the data for 1946.

c HEU production was suspended in 1992. Quantities reported for 1993 through 1996 reflect the removal of residual holdup.

Figure 5-1 U.S. HEU Production by Year

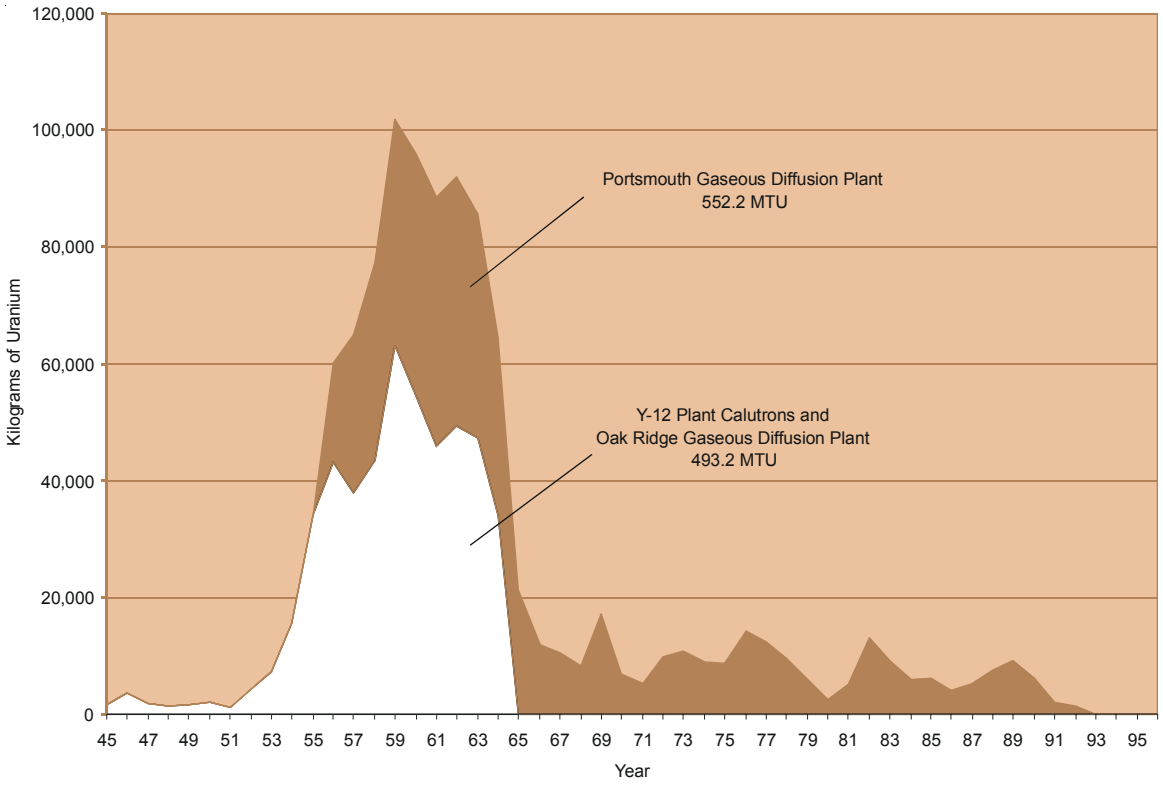
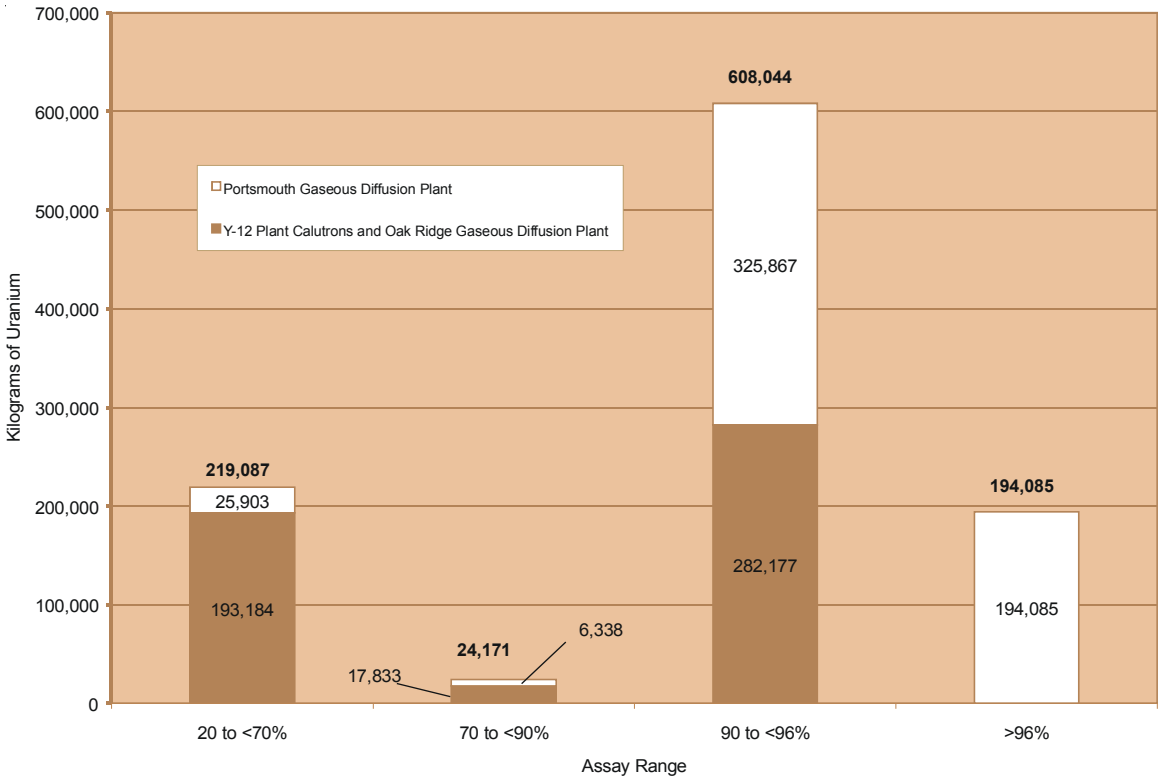


Figure 5-2 U.S. HEU Production by Assay



Y-12 Plant Calutrons

The Y-12 Plant calutrons produced **1.4** MTU containing **1.2** MTU-235 from 1945 through 1947 using the electromagnetic separation process. HEU production from the Y-12 Plant calutrons is provided in **Table 5-2** and is presented in four distinct ranges of uranium-235 percentages (in kilograms) along with total kilograms of uranium and uranium-235.

HEU Production at the Y-12 Plant Calutrons

- ✓ Located in Oak Ridge, Tennessee, the Y-12 Plant calutrons produced the **first quantities of HEU in the U.S**.
- ✓ Using the electromagnetic separation process, a total of **1.4** MTU containing **1.2** MTU-235 was produced from 1945 through 1947.

General Site History

Site selection for the production of HEU was accomplished in the fall of 1942 when the U.S. Army Corps of Engineers' Manhattan Engineer District, under the direction of General Leslie R. Groves, purchased 54,000 acres of land near the towns of Knoxville and Clinton, Tennessee. A portion of the site became the Oak Ridge Reservation with a primary mission to produce uranium-235 on a scale sufficient to support production of atomic weapons. Proposed technologies for accomplishing this objective included: gaseous diffusion; thermal diffusion; centrifuge separation; and electromagnetic separation. Additionally, the process had to be implemented quickly enough to enable the United States to produce an atomic weapon ahead of Germany. The site chosen for the electromagnetic separation process, called the Y-12 site, was about 825 acres. Groundbreaking for the construction of the huge electromagnetic complex took place on February 18, 1943.

The electromagnetic separation process was, like many World War II projects, based on a simple concept. The process used a device called a calutron. Calutrons use magnetic fields to separate a stream of ions (atoms carrying electrical charges). The different masses of the isotopes give each a different radius of curvature in a magnetic field, causing the stream to divide into separate streams. Ninety-six calutrons were to be grouped into racetracks, named for their oval shape. The major items required for efficient calutron operation were well-designed magnets and associated power supplies, high-voltage triodes for close current control, a special high-voltage, high-current x-ray cable, and large vacuum systems. Also needed were huge quantities of copper (or other electrical conductors) to be fabricated into large coils that would produce the magnetic fields in the calutrons. As a result of a wartime shortage of copper, the Army borrowed almost 14,600 tons of pure silver from the U.S. Treasury as a substitute for copper.

In August 1943, the first racetrack began to operate successfully but soon failed as a result of a leaky vacuum, shorted coils, and warped tanks from the powerful magnet. By April 1944, four alpha racetracks were functioning, including the repaired first racetrack.

During 1944, the alpha calutrons continued to be improved while a second generation of calutrons, called beta, was being built. The beta calutrons further enriched the uranium produced in the alpha calutrons and accepted enriched uranium feed from the gaseous diffusion and thermal diffusion separation processes. Since the beta calutrons used only enriched uranium as feed, they processed proportionally less material. As a result, beta calutron beams did not have to be as broad or as large as those in alpha calutrons.

The first beta units were tested at Oak Ridge in late February 1944 but were soon redesigned to overcome technical problems in recovering the precious enriched uranium scattered throughout the calutron. Ultimately, nine alpha tracks and six beta tracks operated at Oak Ridge. Some of the uranium-235 produced in the beta calutrons was sent by train to the Los Alamos National Laboratory, where the material was fabricated as part of the "Little Boy" atomic weapon and detonated in World War II.

Table 5-2 HEU Production at the Y-12 Plant Calutrons

Year	Percent U-235[a]								Totals[a]	
	20 to <70%		70 to <90%		90 to <96%		≥96%			
	U	U-235	U	U-235	U	U-235	U	U-235	U	U-235
1946	238	63	73	61	603	571	--	--	915	695
1947	--	--	--	--	482	456	--	--	482	456
Total	**238**	**63**	**73**	**61**	**1,085**	**1,027**	**--**	**--**	**1,396**	**1,151**

Note: Totals may not add due to rounding.

[a] Quantities are in kilograms.

[b] Includes HEU produced in 1945 and 1946.

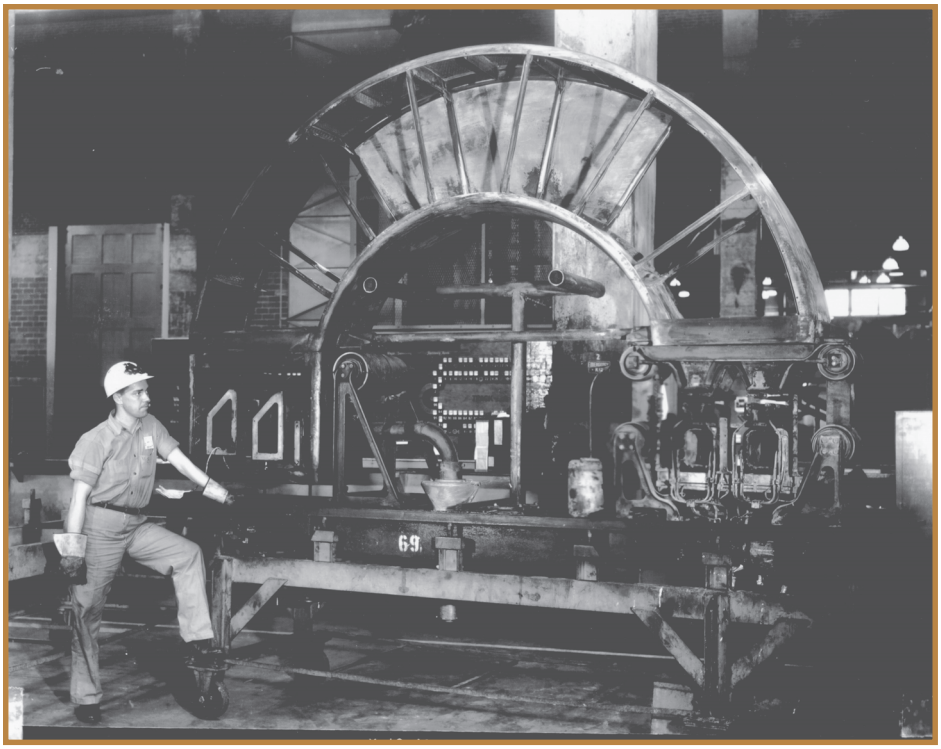
The major advantages of the calutron process were a very low loss of uranium-235 and the ability to reach very high enrichments in a simple, highly efficient step. The major constraint on electromagnetic separation efficiency was the recycling, handling, and chemical separation of enriched uranium deposited on the walls of the calutrons themselves and just about everything else in the process buildings. Because of these factors, calutrons used an inordinate amount of manpower.

The Y-12 Plant calutrons remained the mainstay of the U.S. uranium enrichment effort through 1947, when the HEU production capability was terminated in favor of the more cost-effective gaseous diffusion process.

Current Status

As of the date of this report, only one racetrack of calutrons is preserved at Oak Ridge. It is maintained and operated for the production and sale of stable isotopes that are important to industry, medicine, and scientific research.

Using the electromagnetic separation process, the "alpha" calutrons at the Y-12 Plant produced enriched uranium that was fed to the "beta" calutrons for further enrichment. Pictured is the Y-12 Plant Alpha 1 racetrack.



A total of nine "alpha" and six "beta" racetracks produced enriched uranium at the Y-12 Plant from 1943 through 1947. Pictured is the Alpha Type 1 "D" Unit removed for maintenance.

Oak Ridge Gaseous Diffusion Plant

From 1945 through 1964, the Oak Ridge Gaseous Diffusion Plant produced **491.8** MTU containing **348.9** MTU-235. HEU production from the Oak Ridge Gaseous Diffusion Plant is provided in **Table 5-3** and is presented in four distinct ranges of uranium-235 percentages (in kilograms) along with total kilograms of uranium and uranium-235.

HEU Production at the Oak Ridge Gaseous Diffusion Plant

- ✓ Located in Oak Ridge, Tennessee, the Oak Ridge Gaseous Diffusion Plant **was the first gaseous diffusion plant to produce HEU**.
- ✓ A total of **491.8** MTU containing **348.9** MTU-235 was produced from 1945 through 1964.
- ✓ The Oak Ridge Gaseous Diffusion Plant continued to produce LEU until 1985 when it was placed in standby status.

General Site History

The Oak Ridge Gaseous Diffusion Plant was the first gaseous diffusion plant to perform large-scale enrichment of uranium-235. It was selected in September 1942 because of its comparatively isolated location and the availability of electrical power (from the Tennessee Valley Authority) and water. Construction started in 1943 with the first process building designated as K-25. The first shipment of enriched uranium from K-25 was made in 1945, and a subsequent process building addition, K-27, was placed in full operation in February 1946.

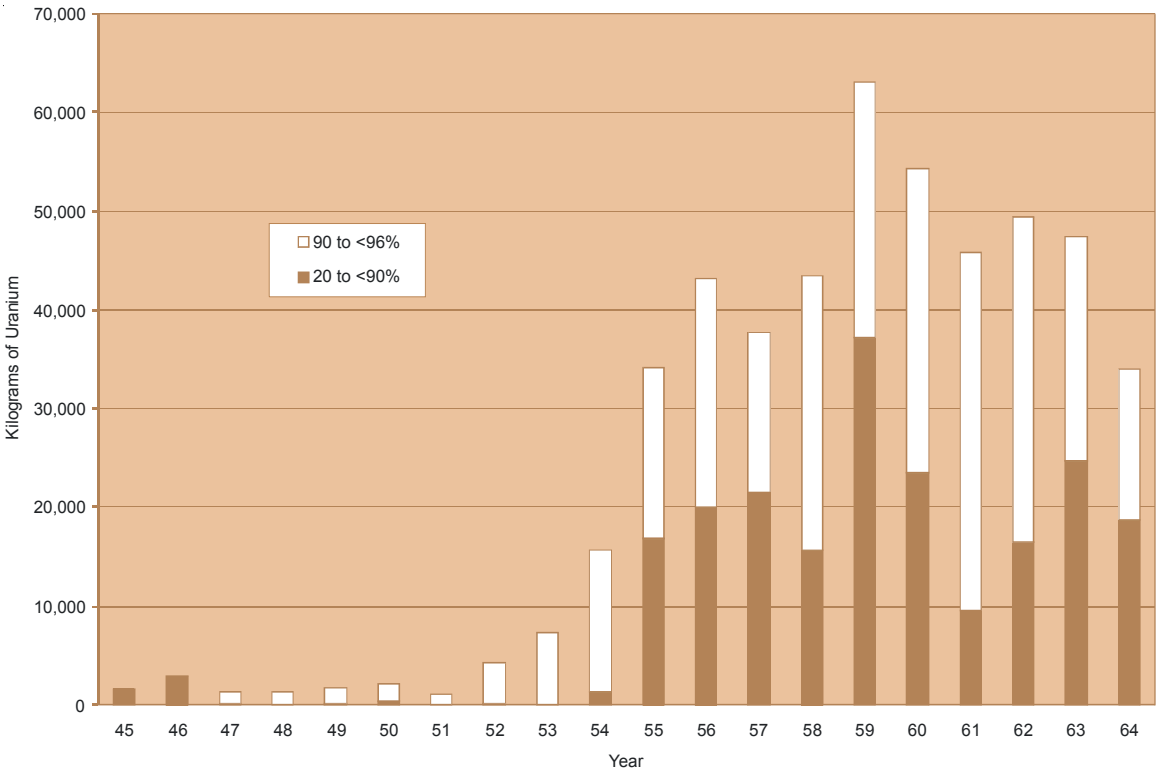
Increasing production demands and concerns over the possibility of sabotage prompted AEC to approve an additional building for Oak Ridge, K-29, in March 1949. With the outbreak of the Korean War in June 1950, less than a year after the first Russian nuclear detonation, additional production capacity was required. As a result, buildings K-31 and K-33 were approved for construction. Once constructed, this five-building complex was commonly referred to as the Oak Ridge Gaseous Diffusion Plant (ORGDP).

By the mid-1950s, all five of the process buildings were interconnected to form one long continuous cascade of approximately 5,000 stages capable of furnishing a "top product" of 93.15 percent uranium-235. The K-25 building operated at the top of the plant cascade and received uranium hexafluoride at approximately 20 percent enriched from the K-27 building. This material was further enriched to above 90 percent at K-25. By 1964, defense needs for HEU had been satisfied, and the first two buildings, K-25 and K-27, were shut down and placed in standby. The remaining buildings continued to produce LEU with a maximum enrichment of about 5 percent uranium-235, adequate for civilian nuclear power plants. These LEU operations continued until 1985, when the remaining process buildings were placed on standby. In December 1987, buildings K-29, K-31, and K-33 and the associated enrichment operations buildings were officially shut down.

Current Status

The Oak Ridge Gaseous Diffusion Plant is today known as the East Tennessee Technology Park (previously K-25 Site). The mission of the plant includes environmental restoration, waste management, technology development and demonstration, education and training, and technology transfer for the DOE, other agencies, and the public.

Table 5-3 HEU Production at the Oak Ridge Gaseous Diffusion Plant

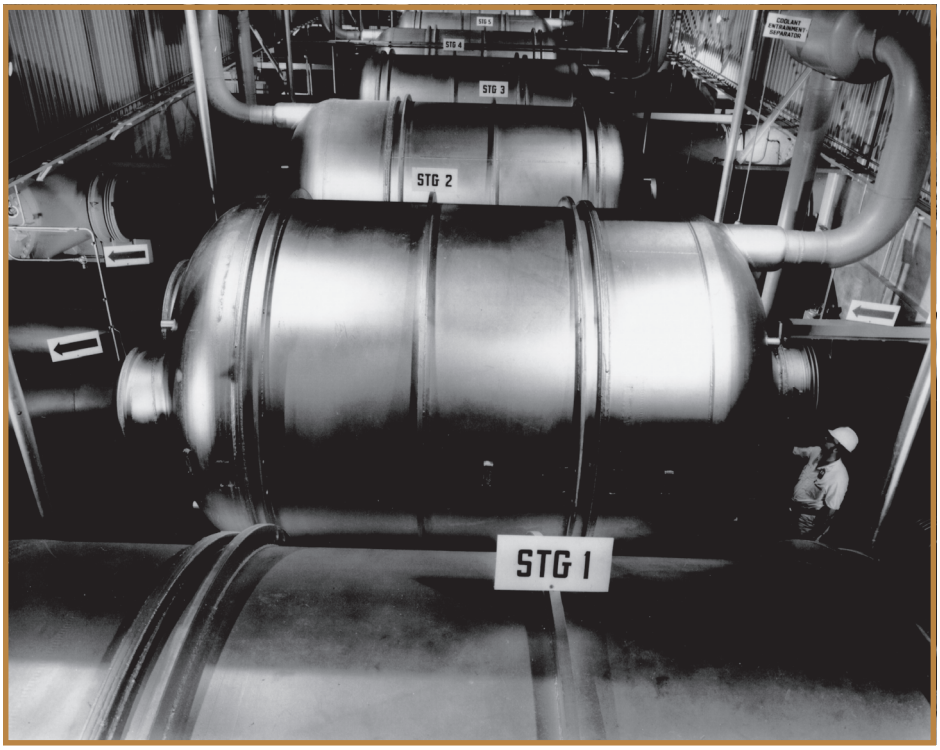


Year	Percent U-235 [a]								Totals [a]	
	20 to <70%		70 to <90%		90 to <96%		≥96%			
	U	U-235	U	U-235	U	U-235	U	U-235	U	U-235
1945	1,529	391	--	--	--	--	--	--	1,529	391
1946	2,889	842	--	--	--	--	--	--	2,889	842
1947	118	36	--	--	1,264	1,181	--	--	1,383	1,218
1948	--	--	--	--	1,391	1,296	--	--	1,391	1,296
1949	25	14	87	65	1,582	1,473	--	--	1,694	1,552
1950	370	158	10	9	1,687	1,570	--	--	2,068	1,737
1951	--	--	--	--	1,091	1,016	--	--	1,091	1,016
1952	110	35	12	10	4,163	3,877	--	--	4,284	3,923
1953	--	--	1	1	7,261	6,765	--	--	7,262	6,766
1954	1,379	518	--	--	14,302	13,333	--	--	15,681	13,851
1955	16,812	6,600	--	--	17,364	16,209	--	--	34,176	22,809
1956	20,001	7,493	6	6	23,124	21,565	--	--	43,131	29,064
1957	21,520	8,073	15	13	16,231	15,144	--	--	37,767	23,231
1958	15,663	5,874	10	8	27,712	25,867	--	--	43,384	31,750
1959	37,142	13,353	68	59	25,860	24,236	--	--	63,070	37,649
1960	23,353	8,352	136	122	30,833	29,007	--	--	54,322	37,482
1961	9,396	3,436	111	100	36,358	33,912	--	--	45,865	37,447
1962	16,008	6,005	450	404	32,976	30,740	--	--	49,434	37,149
1963	17,211	7,656	7,527	5,318	22,616	21,095	--	--	47,354	34,070
1964	9,419	4,790	9,325	6,643	15,277	14,240	--	--	34,021	25,673
Total	**192,946**	**73,628**	**17,760**	**12,758**	**281,092**	**262,528**	--	--	**491,797**	**348,915**

Note: Totals may not add due to rounding.

[a] Quantities are in kilograms.

The Oak Ridge Gaseous Diffusion Plant was the first gaseous diffusion plant to produce HEU. Ultimately, there were five process buildings at the plant that were interconnected to form one long, continuous cascade.



To enrich uranium using the gaseous diffusion process, uranium hexafluoride gas must be cycled and recycled through various stages of equipment, such as the arrangement at the Oak Ridge Gaseous Diffusion Plant (ORGDP). By the mid-1950s, the ORGDP had approximately 5,000 stages capable of furnishing a top product of 93 percent uranium-235.

Paducah Gaseous Diffusion Plant

The Paducah Gaseous Diffusion Plant produced LEU for weapons production beginning in the early 1950s. No HEU was produced at Paducah; however, the plant was constructed to operate in conjunction with the Oak Ridge Gaseous Diffusion Plant.

General Site History

The Paducah Gaseous Diffusion Plant, located on a 750-acre site near Paducah, Kentucky, was the second gaseous diffusion plant to be constructed. Prior to the outbreak of the Korean War, the entire U.S. gaseous diffusion capacity was concentrated at Oak Ridge. Additional gaseous diffusion complexes were located at sites other than Oak Ridge to increase production and enhance security through dispersion.

Paducah Gaseous Diffusion Plant

- ✓ Located near Paducah, Kentucky, it was the **second gaseous diffusion plant built**.
- ✓ **No HEU was produced** at the Paducah Gaseous Diffusion Plant. Only LEU was produced.
- ✓ Paducah currently produces LEU for the commercial nuclear power industry.

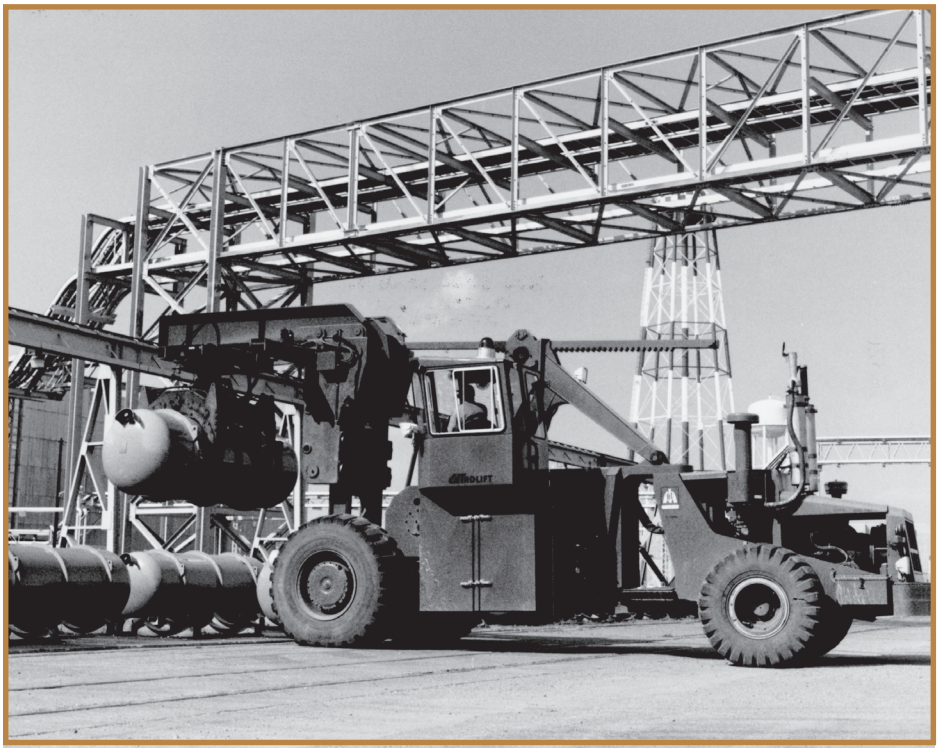
Construction of the Paducah Gaseous Diffusion Plant began in 1951, and production of LEU began in 1952 before construction was completed. The plant was constructed in two steps. The first step consisted of two process buildings, C-331 and C-333, with a total of 880 stages and ground coverage of about 36 acres. The second step consisted of another two process buildings, C-335 and C-337, duplicating the first two buildings.

Paducah produced an intermediate enriched product that was fed to the Oak Ridge and Portsmouth Gaseous Diffusion Plants for further enrichment. The nominal product enrichment of Paducah is limited to 2 percent uranium-235.

Current Status

In October 1992, the Energy Policy Act of 1992 was passed creating the United States Enrichment Corporation (USEC). This corporation, which officially began operations on July 1, 1993, is responsible for all uranium enrichment activities in the United States. As part of these activities, Paducah enriches uranium for commercial customers, primarily nuclear power utilities.

The Paducah Gaseous Diffusion Plant began producing LEU in 1952. Even though HEU was never produced at Paducah, the LEU product was shipped as feed material to the Oak Ridge and Portsmouth Gaseous Diffusion Plants.



Pictured is a uranium hexafluoride cylinder handler at the Paducah Gaseous Diffusion Plant. This piece of equipment is used to handle 4-foot diameter, 10- and 14-ton uranium hexafluoride cylinders.

PORTSMOUTH GASEOUS DIFFUSION PLANT

The Portsmouth Gaseous Diffusion Plant produced **552.2** MTU containing **509.2** MTU-235 from 1956 through 1992, when HEU production was terminated. HEU production from the Portsmouth Gaseous Diffusion Plant is provided in **Figure 5-3** and **Table 5-4**. Data in Table 5-4 is presented in four distinct ranges of uranium-235 percentages (in kilograms) along with total kilograms of uranium and uranium-235.

HEU Production at the Portsmouth Gaseous Diffusion Plant

- ✓ Located near Portsmouth, Ohio, the Portsmouth Gaseous Diffusion Plant **was the largest producer of HEU.**
- ✓ A total of **552.2** MTU containing **509.2** MTU-235 was produced from 1956 through 1992.
- ✓ Portsmouth currently produces LEU for the commercial nuclear power industry.

GENERAL SITE HISTORY

The Portsmouth Gaseous Diffusion Plant was the last gaseous diffusion plant constructed. Construction of the plant began in 1952, and the first process building, designated as X-330, started production in September 1954. The last two process buildings, designated as X-333 and X-326, were placed in full operation in November 1955 and February 1956, respectively. By the mid-1950s, all three process buildings were interconnected to form one long continuous cascade of approximately 4,000 stages capable of furnishing a "top product" of 97.65 percent uranium-235. Because of the length of the cascade, a large amount of uranium is contained within the process piping and equipment of the various stages. While a small portion of this uranium is HEU, it is not counted as part of HEU production or as part of the U.S. HEU inventory until it has been withdrawn from the cascades. This amount can vary depending on how the cascades are being operated and the desired product. For example, in September 1990, the "uranium in cascades" was approximately 328.0 MTU containing 4.4 MTU-235.

Until the mid-1960s, the plant produced HEU for nuclear weapons, the Naval Nuclear Propulsion Program, and other defense needs. With defense needs satisfied, the U.S. ceased the production of HEU for weapons in 1964. After 1964, the U.S. continued to make HEU at Portsmouth for naval, space and research reactors. As commercial nuclear power reactor programs expanded in the 1970s and defense requirements dropped, an increasing portion of the plant's production was a low assay product in the range of 2 to 5 percent uranium-235.

In November 1991, the DOE announced that production of HEU at Portsmouth would be suspended. The decision was later modified to indicate that production of HEU would be permanently shut down. The process equipment in the X-326 building was modified to produce LEU. At the same time, a comprehensive program was initiated to perform chemical treatments on cells in X-326 to remove residual HEU holdup in process equipment. All of the gas phase HEU

in the cascade was removed by February 1993. Top enrichment is now approximately 5 to 6 percent uranium-235. As the solid HEU holdup is recovered, it is refed to the operating cascade where it is blended with LEU to yield the desired LEU product.

Current Status

In October 1992, the Energy Policy Act of 1992 was passed creating USEC. In accordance with this Act, the diffusion cascade and support facilities at the plant have been leased to USEC. This corporation, which officially began operations on July 1, 1993, is responsible for all uranium enrichment activities in the U.S. As part of these activities, Portsmouth enriches uranium for commercial customers, primarily nuclear power utilities.

Figure 5-3 HEU Production at the Portsmouth Gaseous Diffusion Plant

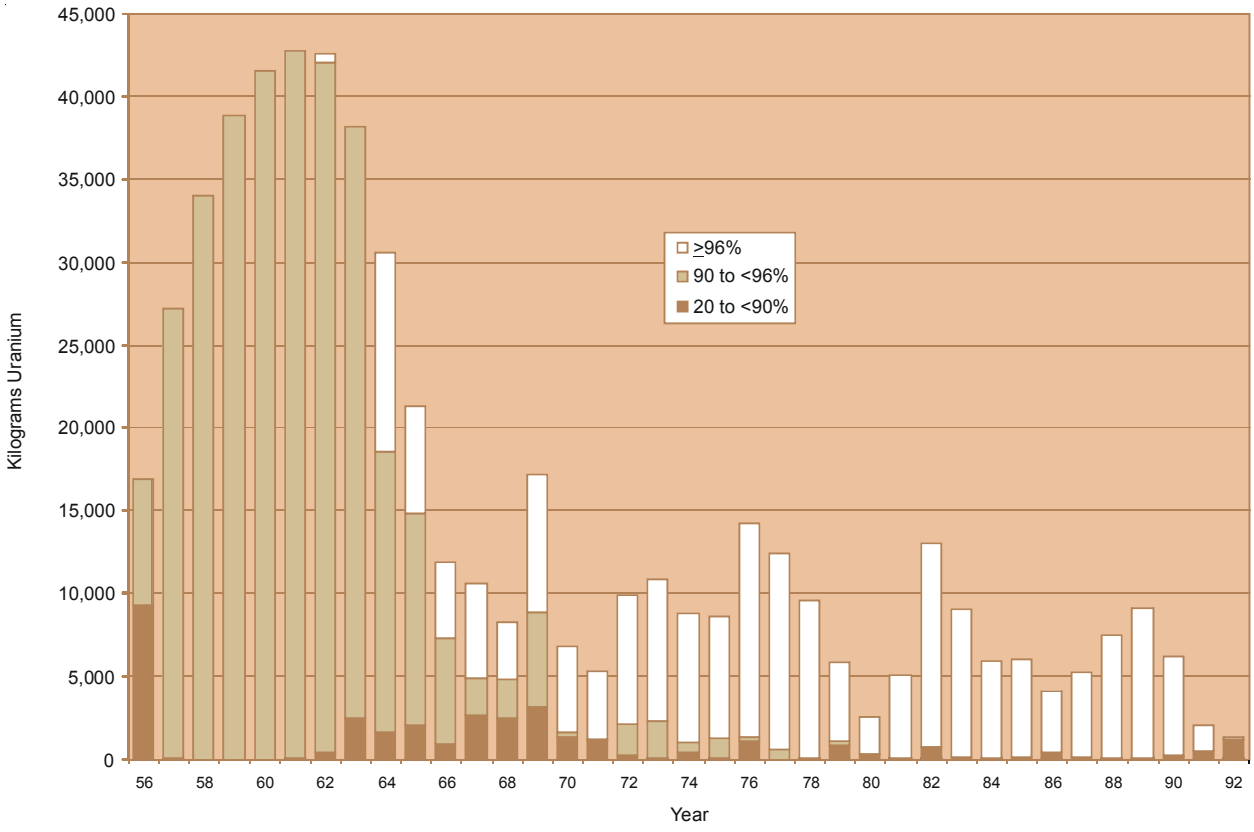


Table 5-4 HEU Production at the Portsmouth Gaseous Diffusion Plant

Year	Percent U-235[a]								Totals[a]	
	20 to <70%		70 to <90%		90 to <96%		≥96%			
	U	U-235	U	U-235	U	U-235	U	U-235	U	U-235
1956	6,361	2,490	2,985	2,374	7,583	7,076	–	–	16,929	11,940
1957	–	–	57	51	27,126	25,310	–	–	27,183	25,360
1958	–	–	-23	-20	34,003	31,745	–	–	33,980	31,725
1959	–	–	–	–	38,826	36,396	–	–	38,826	36,396
1960	11	2	14	12	41,479	39,061	–	–	41,504	39,075
1961	58	19	21	17	42,657	39,790	–	–	42,736	39,827
1962	443	262	–	–	41,613	38,793	521	508	42,578	39,563
1963	2,527	767	11	10	35,645	33,262	–	–	38,183	34,039
1964	706	472	921	646	16,951	15,806	11,967	11,652	30,545	28,575
1965	1,828	643	233	209	12,808	11,930	6,484	6,333	21,353	19,115
1966	753	224	165	148	6,382	5,945	4,578	4,471	11,879	10,788
1967	2,375	752	260	234	2,314	2,156	5,710	5,576	10,660	8,718
1968	2,302	1,187	200	180	2,340	2,180	3,455	3,374	8,297	6,921
1969	2,613	1,302	600	533	5,697	5,306	8,270	8,076	17,181	15,217
1970	1,250	519	100	78	264	240	5,167	5,046	6,782	5,884
1971	1,041	248	109	98	94	85	4,108	4,009	5,352	4,440
1972	83	24	142	127	1,932	1,796	7,788	7,605	9,945	9,552
1973	44	10	18	16	2,239	2,081	8,562	8,361	10,862	10,467
1974	404	128	–	–	626	583	7,818	7,634	8,848	8,345
1975	46	14	1	1	1,260	1,174	7,323	7,152	8,631	8,341
1976	1,049	472	102	74	218	203	12,885	12,582	14,254	13,331
1977	39	11	–	–	555	517	11,850	11,565	12,443	12,092
1978	4	2	84	70	1	1	9,541	9,284	9,631	9,356
1979	825	496	54	38	227	211	4,777	4,648	5,883	5,392
1980	28	9	2	1	275	256	2,317	2,254	2,621	2,521
1981	66	27	7	6	28	26	4,983	4,849	5,084	4,908
1982	55	22	11	9	681	635	12,297	11,965	13,044	12,630
1983	104	41	31	24	2	1	8,958	8,716	9,095	8,783
1984	113	38	-3	-1	-16	-15	5,837	5,680	5,931	5,702
1985	166	55	-15	-10	34	32	5,902	5,744	6,088	5,821
1986	40	6	29	21	331	307	3,778	3,675	4,177	4,010
1987	143	58	28	21	5	4	5,056	4,912	5,231	4,995
1988	55	21	21	17	7	7	7,395	7,191	7,478	7,237
1989	32	13	15	13	8	7	9,071	8,817	9,125	8,849
1990	182	83	8	7	63	59	5,929	5,740	6,183	5,888
1991	-26	-18	40	31	499	476	1,581	1,527	2,093	2,017
1992[b]	1	–	101	88	1,105	1,032	177	170	1,384	1,290
1993[b]	30	16	-1	-1	–	–	-2	-3	27	12
1994[b]	15	3	–	–	1	1	–	–	16	5
1995[b]	60	24	6	5	–	–	1	1	67	29
1996[b]	77	13	3	2	4	3	1	1	85	19
Total	**25,903**	**10,454**	**6,338**	**5,129**	**325,867**	**304,478**	**194,085**	**189,115**	**552,193**	**509,176**

[a] Quantities are in kilograms.

[b] HEU production was suspended in 1992. Quantities reported for 1993 through 1996 are not a result of HEU production. These quantities reflect the removal of holdup during cleanup of the cascades.

The Portsmouth Gaseous Diffusion Plant was the largest producer of HEU. By the mid-1950s, all three of the process buildings at Portsmouth were interconnected to form one long continuous cascade of approximately 4,000 stages capable of furnishing a "top product" of 97.65 percent uranium-235.

Pictured is a storage yard of cylinders at the Portsmouth Gaseous Diffusion Plant. The cylinders contain cascade tails material with a uranium-235 content between 0.3 and 0.55 percent.

Production from Blending

Through September 30, 1996, a total quantity of **3.1** MTU containing **0.3** MTU-235 was produced from blending LEU to HEU. Production from blending occurred primarily at the Oak Ridge Y-12 Plant, the Oak Ridge Gaseous Diffusion Plant, and the Portsmouth Gaseous Diffusion Plant. It is important to note that these values may be somewhat understated since data for fiscal year 1977 and all fiscal years prior to 1976 were not available for the Oak Ridge Y-12 Plant.

For the purpose of this report, HEU production from blending occurs when HEU is mixed with either depleted, natural, or LEU to form a new product. The resulting product will be the average of all of the materials mixed. If the resulting mixture has an isotopic concentration of 20 percent or greater uranium-235, the quantity of the depleted, natural, or LEU used in the blending operation is added to the HEU inventory as production. However, if the new mixture has an isotopic concentration of less than 20 percent uranium-235, the HEU used in the blending operation is removed from the HEU inventory as down blending. Quantities removed from the inventory as a result of down blending are provided in Section 6.

Production from Blending

- ✓ **Total Production** – **3.1** MTU (3,058 kilograms) containing **0.3** MTU-235 (261 kilograms). This is the amount of LEU blended to HEU.
- ✓ **Primary Blending Sites** – Oak Ridge Y-12 Plant, Oak Ridge Gaseous Diffusion Plant, and Portsmouth Gaseous Diffusion Plant.

- ✓ **Example:** If 1 kilogram of LEU at a 10 percent enrichment is mixed with 1 kilogram of HEU at a 90 percent enrichment, the resultant mixture will contain 2 kilograms of HEU at an enrichment of 50 percent.

Receipts from Foreign Countries

- ✓ **Total Receipts** – **6.9** MTU containing **4.9** MTU-235.

- ✓ **Return of U.S.-Origin HEU** – Approximately **6.3** MTU containing **4.3** MTU-235 was received in accordance with Agreements for Cooperation for the Peaceful Uses of Atomic Energy.
- ✓ **Kazakhstan: Project Sapphire –** A total of **0.65** MTU containing **0.58** MTU-235 was obtained from the former Soviet Union.

HEU Receipts from Foreign Countries

From 1958 through 1996, the U.S. received **6.9** MTU containing **4.9** MTU-235 from foreign countries. **Figure 5-4** provides the annual quantities of HEU received by the U.S. from foreign countries through September 30, 1996. **Tables 5-5** and **5-6** provide the location and quantities of HEU returned to the U.S. from Euratom and non-Euratom countries.

RETURN OF U.S.-ORIGIN HEU

A total of **6.3** MTU containing **4.3** MTU-235 was received from foreign countries in accordance with Agreements for Cooperation for the Peaceful Uses of Atomic Energy, primarily Euratom countries, Canada, Japan, and South Africa. Most of this material was of U.S.-origin in the form of spent nuclear fuel.

The acceptance of spent nuclear fuel from foreign countries was originally authorized by the Atomic Energy Act of 1954, as amended, and the NNPA. The Atoms for Peace Program provided the framework for these activities. Under this program, nuclear fuel was sold or leased for use in foreign power, research, and experimental reactors. The details of these shipments are provided in Section 6, Removals.

The Atoms for Peace Program also allowed for the subsequent return of this material for reprocessing in the U.S. In July 1963, the first shipment of irradiated (spent) reactor fuel was received from abroad for reprocessing at the Idaho Chemical Processing Plant in Idaho Falls, Idaho. The fuel had been leased to Sweden in 1961 for use in the materials testing and research reactor, "R-2," near Stockholm. In 1964, the U.S. offered to accept the delivery of highly enriched spent fuel from foreign research reactors for chemical processing at the Savannah River Site. Previously, such shipments were restricted to the Idaho Chemical Processing Plant.

Reducing the threat of the proliferation of nuclear weapons is one of the foremost goals of the United States. Proper management of spent nuclear fuel from foreign research reactors is essential to achieving these goals since much of the fuel contains HEU, which could be used in simple nuclear weapons.

The concern over appropriate management of foreign research reactor spent nuclear fuel was reiterated in the Presidential Directive on Nonproliferation and Export Controls, issued by President Clinton on September 27, 1993. In particular, the Presidential Directive included steps to accelerate the return of U.S.-origin spent fuels from foreign research reactors.

Figure 5-4 HEU Received from Foreign Countries

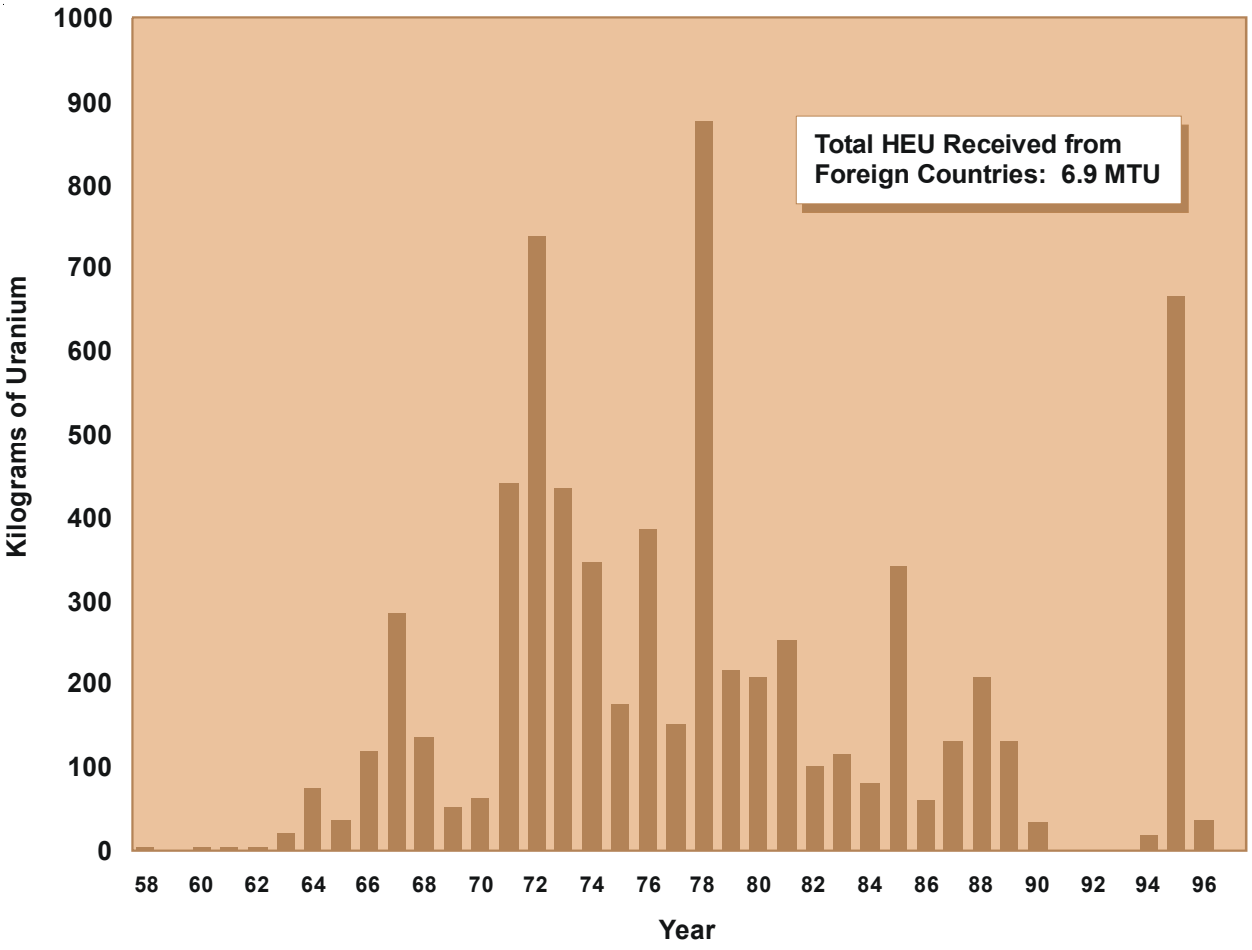
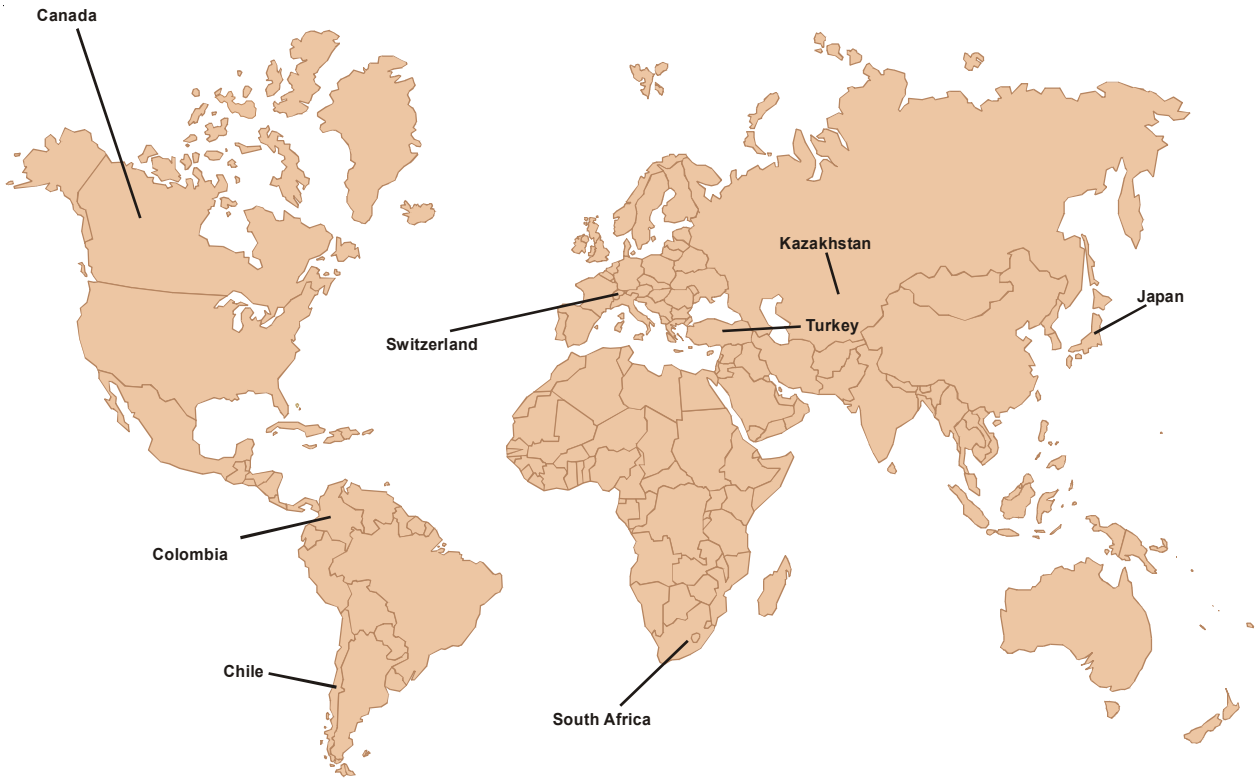


Table 5-5 HEU Received from Euratom Countries

Country	Percent U-235[a]				Totals[a]	
	20 to <90%		≥90%			
	U	U-235	U	U-235	U	U-235
Austria	11	7			11	7
Belgium	500	390	3	2	503	392
Denmark	72	51			72	51
France	2,767	2,015	35	32	2,802	2,047
Germany	940	348	75	70	1,015	418
Greece	9	8			9	8
Italy	75	61			75	61
Netherlands	223	172			223	172
Spain	7	6			7	6
Sweden	306	230			306	230
United Kingdom	150	118			150	118
Total	**5,060**	**3,406**	**113**	**105**	**5,173**	**3,512**

[a] Quantities are in kilograms.

Table 5-6 HEU Received from Non-Euratom Countries



Country	Percent U-235[a]				Totals[a]	
	20 to <90%		³ 90%			
	U	U-235	U	U-235	U	U-235
Canada	651	441	51	48	702	489
Chile	4	2			4	2
Colombia			3	3	3	3
Japan	342	299			342	299
Kazakhstan	568	506	84	76	652	581
South Africa	34	26			34	26
Switzerland	18	12			18	12
Turkey	5	4			5	4
Others	1	1			1	1
Total	**1,623**	**1,291**	**138**	**127**	**1,761**	**1,417**

[a] Quantities are in kilograms.

KAZAKHSTAN-"PROJECT SAPPHIRE"

In November 1994, in response to the President's Nonproliferation and Export Control Policy, the DOE acquired approximately **652** kilograms of HEU from the former Soviet Republic of Kazakhstan. The purchase was conducted as a classified operation under the code name "Project Sapphire."

When the U.S. acquired the HEU from the Republic of Kazakhstan, in consultation with the Russian Federation, the purpose of both governments was to prevent this HEU from falling into the hands of those who might use it to produce nuclear weapons. Central to this action was the need to ensure understanding and confidence that the material would not be used in the United States' nuclear arsenal. Therefore, it was important to blend the Kazakhstan-origin HEU to a nonweapons-usable form that would ultimately result in the peaceful use of this material as fuel for commercial nuclear reactors. In this manner, the U.S. hoped to encourage other nations to reduce their stockpiles of weapons-usable fissile materials and to advance global nonproliferation goals.

The Kazakhstan material was received and placed in safe, secure, interim storage at the Oak Ridge Y-12 Plant. In May 1995, the DOE conducted an environmental assessment to determine the disposition of the HEU. Based upon the analyses in the environmental assessment, the DOE awarded a contract to Babcock and Wilcox in Lynchburg, Virginia, to blend the Kazakhstan-origin HEU to LEU (DOE 1995a).

Conversion of this HEU to LEU was also in direct response to President Clinton's Nonproliferation and Export Control Policy, which mandates that the United States will:

- Seek to eliminate, where possible, the accumulation of stockpiles of HEU; and
- Pursue the purchase of HEU from the former Soviet Union and other countries and the conversion of that HEU to peaceful use as reactor fuel.

Kazakhstan HEU was packaged into 55-gallon "6M" shipping containers by DOE personnel for shipment to the U.S.

Kazakhstan HEU was then loaded onto a U.S. Air Force C-5 Galaxy Aircraft at the UST-Kamenogorsk airport in Kazakhstan. The material was then transported to the Oak Ridge Y-12 Plant for safekeeping.

Established in 1943, the Oak Ridge Y-12 Plant's mission includes the purification and processing of HEU into useable products or forms for use in the U.S. as well as foreign countries. These processes result in normal operating losses, blending, and inventory differences.

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