THORIUM

(Data in metric tons of thorium oxide (ThO_2) equivalent, unless otherwise noted)

Domestic Production and Use: The primary source of the world's thorium is the rare-earth and thorium phosphate mineral monazite. Monazite was not recovered as a salable product during processing of heavy mineral sands in 2000. Past production had been as a byproduct of titanium and zirconium mineral processing during which monazite was recovered for its rare-earth content. Essentially all thorium compounds and alloys consumed by the domestic industry were derived from imports, stocks of previously imported materials, or materials shipped from U.S. Government stockpiles. About eight companies processed or fabricated various forms of thorium for nonenergy uses, such as high-temperature ceramics, catalysts, and welding electrodes. The value of thorium metal, alloys, and compounds used by the domestic industry was estimated to be about $420,000.

Salient Statistics—United States:	1996	1997	1998	1999	2000[e]
Production, refinery[1]	—	—	—	—	—
Imports for consumption:					
Thorium ore and concentrates (monazite), gross weight	101	20	—	—	—
Thorium ore and concentrates (monazite), ThO_2 content	7.07	1.40	—	—	—
Thorium compounds (oxide, nitrate, etc.), gross weight	26.30	13.50	7.45	5.29	15.10
Thorium compounds (oxide, nitrate, etc.), ThO_2 content	19.45	10.00	5.51	3.91	11.10
Exports:					
Thorium ore and concentrates (monazite), gross weight	2	—	—	—	—
Thorium ore and concentrates (monazite), ThO_2 content	.14	—	—	—	—
Thorium compounds (oxide, nitrate, etc.), gross weight	.06	.24	1.13	2.52	4.04
Thorium compounds (oxide, nitrate, etc.), ThO_2 content	.04	.18	.84	.79	2.98
Shipments from Government stockpile excesses ($ThNO_3$)	—	.82	—	—	—
Consumption: Reported, (ThO_2 content[e])	4.9	13.0	7.0	7.0	NA
Apparent	26.3	12.0	4.7	3.1	8.2
Price, yearend, dollars per kilogram:					
Nitrate, welding-grade[2]	5.46	5.46	5.46	5.46	5.46
Nitrate, mantle-grade[3]	14.32	27.00	27.00	27.00	27.00
Oxide, yearend: 99.9% purity[4]	88.50	82.50	82.50	82.50	82.50
99.99% purity[4]	107.25	107.25	107.25	107.25	107.25
Stocks, industrial, yearend	35.2	12.8	NA	NA	NA
Net import reliance[5] as a percent of apparent consumption	NA	100	100	100	100

Recycling: None.

Import Sources (1996-99): Monazite: Australia, 67%; and France, 33%. Thorium compounds: France, 99.4%; and other, 0.6%.

Tariff:

Item	Number	Normal Trade Relations 12/31/00
Thorium ores and concentrates (monazite)	2612.20.0000	Free.
Thorium compounds	2844.30.1000	5.5% ad val.

Depletion Allowance: Monazite, 22% on thorium content, 14% on rare-earth and yttrium content (Domestic); 14% (Foreign).

Government Stockpile:

Stockpile Status—9-30-00[6]

Material	Uncommitted inventory	Committed inventory	Authorized for disposal	Disposal plan FY 2000	Disposals FY 2000
Thorium nitrate (gross weight)	3,218	—	2,944	2,946	—

Events, Trends, and Issues: Domestic mine production of thorium-bearing monazite ceased at the end of 1994 as world demand for ores containing naturally occurring radioactive thorium declined. Imports and existing stocks supplied essentially all thorium consumed in the United States in 2000. Domestic demand for thorium ores, compounds, metals, and alloys has exhibited a long-term declining trend. Thorium consumption in the United States remained level in 1999 at 7.0 tons, however, most material was consumed in a nonrecurring application. In 2000, thorium consumption, primarily for use in catalyst applications, is estimated to increase. On the basis of data through July 2000, the average value of imported thorium compounds decreased to $47.76 per kilogram from the 1999 average of $53.15 per kilogram (gross weight).

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THORIUM

A thorium research company announced that it had obtained its fourth and final U.S. patent in February for a thorium-based nonproliferative seed-and-blanket nuclear facility assembly.[7]

A researcher from the University of Vienna's Institute for Experimental Physics presented a paper on the nonproliferative commercial Radkowsky thorium-fuel concept. The reactor was initially designed to use a seed of enriched uranium-zirconium alloy to initiate the thorium fuel cycle. The thorium-fueled reactor design, however, can also be adapted to "burn" plutonium by using a plutonium-zirconium alloy. The design is adaptable to many existing pressurized water reactors (PWR) or Russian-designed Vodo Vodyanyi Energeticheskiy Reaktor (VVER) reactors with either minor or no changes to the existing designs especially because the thorium fuel installs in the same space as the uranium cores. Conventional uranium fueled reactors produce approximately 50 times more plutonium than those using thorium.[8]

The use of thorium in the United States has decreased significantly since the 1980's when consumption averaged 45 tons per year. Increased costs to monitor and dispose of thorium have caused the domestic processors to switch to thorium-free materials. Real and potential costs related to compliance with State and Federal regulations, proper disposal, and monitoring of thorium's radioactivity have limited its commercial value. Use of thorium has been forecast to decline unless a low-cost disposal process is developed or new technology creates renewed demand.

World Refinery Production, Reserves, and Reserve Base:

	Refinery production		Reserves[9]	Reserve base[9]
	1999	2000		
United States	—	—	160,000	300,000
Australia	—	—	300,000	340,000
Brazil	NA	NA	16,000	18,000
Canada	NA	NA	100,000	100,000
India	NA	NA	290,000	300,000
Malaysia	—	—	4,500	4,500
Norway	—	—	170,000	180,000
South Africa	NA	NA	35,000	39,000
Other countries	NA	NA	90,000	100,000
World total (rounded)	NA	NA	1,200,000	1,400,000

Reserves and reserve base are contained primarily in monazite. Without demand for the rare earths, monazite would probably not be recovered for its thorium content. Other ore minerals with higher thorium contents, such as thorite, would be more likely sources if demand significantly increased. No new demand that could not be met from existing stockpiles is expected. Reserves exist primarily in recent and ancient placer deposits. Lesser quantities of thorium-bearing monazite reserves occur in vein deposits and carbonatites.

World Resources: Thorium resources occur in provinces similar to those of reserves. The largest share are contained in placer deposits. Resources of more than 500,000 tons are contained in placer, vein, and carbonatite deposits. Disseminated deposits in various other alkaline igneous rocks contain additional resources of more than 2 million tons. Large thorium resources are found in Australia, Brazil, Canada, Greenland, India, South Africa, and the United States.

Substitutes: Nonradioactive substitutes have been developed for many applications for thorium. Yttrium compounds have replaced thorium compounds in incandescent lamp mantles. A magnesium alloy containing lanthanides, zirconium, and yttrium can substitute for magnesium-thorium alloys in aerospace applications.

[e]Estimated. NA Not available.
[1]All domestically consumed thorium was derived from imported materials.
[2]U.S. Department of Defense, Defense Logistics Agency. Based on sales from the National Defense Stockpile.
[3]Rhodia Canada, Inc., f.o.b. port of entry, duty paid, ThO_2 basis.
[4]Rhodia Rare Earths, Inc., 1 to 950 kilogram quantities, f.o.b. port of entry, duty paid.
[5]Defined as imports - exports + adjustments for Government and industry stock changes.
[6]See Appendix B for definitions.
[7]Radkowsky Thorium Power Corporation news release, 2000, RTPC's fourth and final patent issued for non-proliferative seed-and-blanket fuel assembly. RTPC news, Washington, DC, February 15, 1 p.
[8]Higatsberger, Michael, 1999, The non-proliferative commercial Radkowsky thorium fuel concept: International Atomic Energy Agency Technical Committee on "Utilisation Options in Emerging Nuclear Energy Systems," Vienna, November 15-17, 28 p.
[9]See Appendix C for definitions.