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 1998. Past production had been as a byproduct during processing for titanium and zirconium minerals and 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 $600,000.

Salient Statistics—United States:	1994	1995	1996	1997	1998[e]
Production, refinery[1]	—	—	—	—	—
Imports for consumption:					
Thorium ore and concentrates (monazite), gross weight	—	40	101	20	—
Thorium ore and concentrates (monazite), ThO_2 content	—	2.80	7.07	1.40	—
Thorium compounds (oxide, nitrate, etc.), gross weight	3.12	20.51	26.30	13.50	10.50
Thorium compounds (oxide, nitrate, etc), ThO_2 content	2.31	15.16	19.45	10.00	7.77
Exports:					
Thorium ore and concentrates (monazite), gross weight	33	—	2	—	—
Thorium ore and concentrates (monazite), ThO_2 content	2.31	—	.14	—	—
Thorium compounds (oxide, nitrate, etc.), gross weight	.01	.08	.06	.24	1.15
Thorium compounds (oxide, nitrate, etc.), ThO_2 content	.01	.06	.04	.18	.85
Shipments from Government stockpile excesses ($ThNO_3$)	—	—	—	.82	—
Consumption: Reported, (ThO_2 content[e])	3.6	5.4	4.9	13.0	5.0
Apparent	NA	NA	NA	33.6	6.9
Price, yearend, dollars per kilogram:					
Nitrate, welding-grade[2]	5.46	5.46	5.46	5.46	5.46
Nitrate, mantle-grade[3]	23.30	23.30	14.32	27.00	27.00
Oxide, yearend: 99.0% purity[4]	63.80	NA	64.45	65.55	65.55
99.9% purity[4]	NA	88.50	90.00	90.00	90.00
99.99% purity[4]	107.25	107.25	107.25	107.25	107.25
Stocks, industrial, yearend	NA	NA	35.2	12.8	NA
Net import reliance[5] as a percent of apparent consumption	NA	NA	NA	100	100

Recycling: None.

Import Sources (1994-97): Monazite: Australia, 50%; and France, 50%. Thorium compounds: France, 99%; and other, 1%.

Tariff: Item	Number	Normal Trade Relations (NTR) 12/31/98	Non-NTR[6] 12/31/98
Thorium ores and concentrates (monazite)	2612.20.0000	Free	Free.
Thorium compounds	2844.30.1000	6.0% ad val.	35% ad val.

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

Government Stockpile:

Stockpile Status—9-30-98[7]

Material	Uncommitted inventory	Committed inventory	Authorized for disposal	Disposal plan FY 1998	Disposals FY 1998
Thorium nitrate (gross weight)	3,217	—	2,945	454	—

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 1998. Domestic demand for thorium ores, compounds, metals, and alloys has exhibited a long term declining trend. Thorium consumption in the United States increased in 1997 to 13.0 tons, however, most material was consumed in a nonrecurring application. Thorium consumption in 1998 is estimated to decrease. Based on data through July 1998, the average value of imported thorium compounds decreased to $23.00 per kilogram from the 1997 average of $42.46 per kilogram (gross weight).

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THORIUM

A theory developed by Italian physicist and past director of the European Laboratory for Particle Physics (CERN) to create a fuel cycle using subatomic particles and thorium gained support in Europe. The theory advanced that thorium should produce 140 times more energy than uranium using accelerated subatomic particles. The process would involve accelerating the subatomic particles to speeds of several million kilometers per hour in particle accelerators and then firing them at thorium.[8] Fission would occur based on a nuclear cascade generated by the particle accelerator instead of the conventional chain reaction generated from the neutron bombardment from uranium or plutonium fuel. Several European industrial companies were reportedly preparing to fund a prototype of the energy amplifier needed to demonstrate the process.[9]

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 thorium's commercial value. It is forecast that thorium's use will continue 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[10]	Reserve base[10]
	1997	1998		
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 the rare-earth ore mineral, 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, however, 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]Source: U.S. Department of Defense, Defense Logistics Agency. Based on sales from the National Defense Stockpile.
[3]Source: Rhône-Poulenc Basic Chemical Co., f.o.b. port of entry, duty paid, ThO_2 basis. Rhône-Poulenc Basic Chemicals Co., Shelton, CT, 1994-98.
[4]Source: Rhône-Poulenc Basic Chemicals Co., f.o.b. port of entry, duty paid.
[5]Defined as imports - exports + adjustments for Government and industry stock changes.
[6]See Appendix B.
[7]See Appendix C for definitions.
[8]The Washington Post, Reuters, 1993, In theory, a new route to nuclear energy: November 24, p. A18.
[9]Sacks, Tony, 1997, Nuclear nirvana?: Electrical Review, v. 230 no. 12, June 10, p. 24-26.
[10]See Appendix D for definitions.