THORIUM

(Data in metric tons of thorium oxide (ThO₂) equivalent, unless otherwise noted)

<u>Domestic Production and Use</u>: 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 1999. 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 \$400,000.

Salient Statistics—United States:	<u> 1995</u>	<u>1996</u>	<u> 1997</u>	<u>1998</u>	<u>1999</u> °
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	20.51	26.30	13.50	7.45	6.77
Thorium compounds (oxide, nitrate, etc.), ThO ₂ content	15.16	19.45	10.00	5.51	5.00
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	.08	.06	.24	1.13	1.07
Thorium compounds (oxide, nitrate, etc.), ThO ₂ content	.06	.04	.18	.84	.79
Shipments from Government stockpile excesses (ThNO ₃)		_	.82		
Consumption: Reported, (ThO ₂ content ^e)	5.4	4.9	13.0	7.0	NA
Apparent	NA	NA	33.6	6.9	4.1
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	14.32	27.00	27.00	27.00
Oxide, yearend: 99.9% purity ⁴	88.50	88.50	82.50	82.50	82.50
99.99% purity ⁴	107.25	107.25	107.25	107.25	107.25
Stocks, industrial, yearend	NA	35.2	12.8	NA	NA
Net import reliance ⁵ as a percent of apparent consumption	NA	NA	100	100	100

Recycling: None.

Import Sources (1995-98): Monazite: Australia, 75%; and France, 25%. Thorium compounds: France, 99.7%; and other, 0.3%.

Tariff: Item	Number	Normal Trade Relations 12/31/99
Thorium ores and concentrates (monazite)	2612.20.0000	Free.
Thorium compounds	2844.30.1000	5.5% ad val.

<u>Depletion Allowance</u>: Percentage method: Monazite, 23% on thorium content, 15% on rare-earth and yttrium content (Domestic); 14% (Foreign).

Government Stockpile:

Stockpile Status—9-30-99 ⁶					
	Uncommitted	Committed	Authorized	Disposal plan	Disposals
Material	inventory	inventory	for disposal	FY 1999	FY 1999
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 1999. Domestic demand for thorium ores, compounds, metals, and alloys has exhibited a long-term declining trend. Thorium consumption in the United States decreased in 1998 to 7.0 tons, however, most material was consumed in a nonrecurring application. Thorium consumption in 1999 is estimated to decrease. Based on data through July 1999, the average value of imported thorium compounds increased to \$53.15 per kilogram from the 1998 average of \$23.00 per kilogram (gross weight).

THORIUM

A team of researchers from a university in Massachusetts, a U.S. Government research laboratory, a university in Israel, a nuclear research facility in Moscow, Russia, and a nuclear fuel manufacturer in Russia, have joined with a U.S. company in Washington, DC, to study the commercialization of nonproliferative thorium energy. The researchers in Massachusetts will assess the application of "seed-blanket" thorium fuel to Light Water Reactors with regard to neutronics and fission control. A study of the toxicity of various nuclear fuels determined that after 100 to 200 years, thorium produces only one sixth of the actinide toxicity produced by other nuclear fuels, such as uranium. The toxicity, measured in conjunction with the uranium used in the Th/U fuel cycle, still was reduced by a factor of 3 compared to the other actinides.

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. 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 p	Refinery production		Reserve base ⁹	
	<u>1998</u>	<u>1999</u>			
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	<u>NA</u>	<u>NA</u>	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.

<u>World Resources</u>: 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.

<u>Substitutes</u>: 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.

^eEstimated. NA Not available.

¹All domestically consumed thorium was derived from imported materials.

²Source: U.S. Department of Defense, Defense Logistics Agency. Based on sales from the National Defense Stockpile.

³Source: Rhodia Canada, Inc., f.o.b. port of entry, duty paid, ThO₂ basis.

⁴Source: Rhodia Rare Earths, Inc., 1-950 kilogram quantities, f.o.b. port of entry, duty paid.

⁵Defined as imports - exports + adjustments for Government and industry stock changes.

⁶See Appendix B for definitions.

⁷Radkowsky Thorium Power Corporation news release, 1999, MIT joins Radkowsky thorium fuel team—findings to be presented at Global 99 International Conference on Future Nuclear Systems: RTPC news, Washington, D.C., July 8, 2 p.

⁸Radkowsky Thorium Power Corporation news release, 1999, Environmental advantages achieved in reduced toxicity of new thorium fuel: RTPC news, Washington, D.C., August 2, 2 p.

⁹See Appendix C for definitions.