

## THORIUM

[Data in kilograms unless otherwise noted]

**Domestic Production and Use:** The world's primary source of thorium is the rare-earth and thorium phosphate mineral monazite. In 2018, monazite may have been produced as a separated concentrate or included as an accessory mineral in heavy-mineral concentrates. Essentially, all thorium compounds and alloys consumed by the domestic industry were derived from imports. The number of companies that processed or fabricated various forms of thorium for commercial use was not available. Thorium's use in most products was generally limited because of concerns over its naturally occurring radioactivity. Imports of thorium compounds are sporadic owing to changes in consumption and fluctuations in consumer inventory levels. The estimated value of thorium compounds imported for consumption by the domestic industry in 2018 was about \$260,000, compared with \$731,000 in 2017.

<b>Salient Statistics—United States:</b>	<b>2014</b>	<b>2015</b>	<b>2016</b>	<b>2017</b>	<b>2018<sup>e</sup></b>
Production, mine <sup>1</sup>	—	—	NA	NA	NA
Imports for consumption:					
Thorium ore and concentrates (monazite), gross weight	—	—	16,000	—	1,000
Thorium ore and concentrates (monazite) <sup>e</sup>	—	—	800	—	50
Thorium compounds (oxide, nitrate, etc.), gross weight	11,000	2,740	3,120	8,510	3,800
Thorium compounds (oxide, nitrate, etc.) <sup>e</sup>	5,200	1,400	1,600	4,200	1,800
Exports:					
Thorium ore and concentrates (monazite), gross weight	—	—	—	—	1,000
Thorium ore and concentrates (monazite) <sup>e</sup>	—	—	—	—	50
Thorium compounds (oxide, nitrate, etc.), gross weight	<sup>2</sup> 14,800	2,160	<sup>2</sup> 63,900	<sup>2</sup> 88,600	<sup>2</sup> 12,000
Thorium compounds (oxide, nitrate, etc.) <sup>e</sup>	<sup>3</sup> 7,000	1,600	<sup>3</sup> 3,400	<sup>3</sup> 1,100	2,000
Consumption, apparent <sup>4</sup>	(5)	(5)	(5)	3,100	(5)
Value, thorium compounds, gross weight, dollars per kilogram, <sup>6</sup>					
India	65	63	65	73	72
Net import reliance <sup>7</sup> as a percentage of apparent consumption	100	100	100	100	100

**Recycling:** None.

**Import Sources (2014–17):** Monazite: Canada, 100%. Thorium compounds: India, 96%; United Kingdom, 3%; and other, 1%.

<b>Tariff:</b>	<b>Item</b>	<b>Number</b>	<b>Normal Trade Relations 12–31–18</b>
	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, and 14% on rare-earth and yttrium content (Domestic); 14% (Foreign).

**Government Stockpile:** None.

**Events, Trends, and Issues:** Domestic demand for thorium alloys, compounds, and metals was limited. Imports and existing stocks supplied essentially all thorium consumed in the United States in 2018. In addition to research purposes, various commercial uses of thorium included catalysts, high-temperature ceramics, magnetrons in microwave ovens, metal-halide lamps, nuclear medicine, optical coatings, tungsten filaments, and welding electrodes.

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Estimated imports of unspecified thorium compounds were thought to contain about 1,800 kilograms of ThO<sub>2</sub> equivalent in 2018. India maintained its position as the primary source of imported thorium compounds in 2018. The unit value of imports from India decreased slightly to \$72 per kilogram compared with \$73 per kilogram in 2017.

Exports of unspecified thorium compounds were 12,000 kilograms in 2018; however, 83% of the exports were reported to have a unit value less than \$50 per kilogram and may have been misclassified. Owing to potentially misclassified material and variations in the type and purity of thorium compound, the unit value of exports varied widely by month and exporting district, from a low of \$7 per kilogram to a high of \$9,100 per kilogram.

Globally, monazite was produced primarily for its rare-earth-element content, and only a small fraction of the byproduct thorium produced was consumed. India was the leading producer of monazite. Thorium consumption worldwide is relatively small compared with that of most other mineral commodities. In regard to international trade, China was the leading importer of monazite, and Brazil and Thailand were China's leading import sources. Some concentrates from Thailand may be beneficiated concentrates from other sources. According to export statistics from Australia, 17,500 tons of thorium ores and concentrates, with a unit value of \$122 per ton, were exported from Australia to Thailand in 2017.

Several companies and countries were active in the pursuit of commercializing thorium as a fuel material for a new generation of nuclear reactors. Thorium-based nuclear research and development programs have been or are underway in Belgium, Brazil, Canada, China, Czechia, France, Germany, India, Israel, Japan, the Netherlands, Norway, Russia, the United Kingdom, and the United States.

The U.S. Environmental Protection Agency (EPA) withdrew proposed revisions to the EPA's "Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings." The new standards would have been applicable to byproduct materials produced by uranium in situ recovery.

**World Refinery Production and Reserves:**<sup>8</sup> Production and reserves are associated with the recovery of monazite in heavy-mineral-sand deposits. Without demand for the rare earths, monazite would probably not be recovered for its thorium content under current market conditions.

**World Resources:** The world's leading thorium resources are found in placer, carbonatite, and vein-type deposits. Thorium is found in several minerals, including monazite, thorite, and thorianite. According to a report by the Organisation for Economic Co-operation and Development's Nuclear Energy Agency and the International Atomic Energy Agency, worldwide thorium resources were estimated to total more than 6 million tons of thorium. Thorium resources are found throughout the world, most notably in Australia, Brazil, and India. India's Department of Atomic Energy estimated that 12 million tons of monazite was contained in heavy-mineral sands in India. India's monazite was reported to have an average thorium oxide content of 9% to 10%. Geoscience Australia estimated Australia's inferred resources to be about 0.6 million tons of thorium. Most of the identified thorium resources in Australia are within heavy-mineral-sand deposits. None of Australia's thorium resources were classified as economically recoverable. Brazil's thorium resources were estimated to be 0.6 million tons.

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

<sup>0</sup>Estimated. NA Not Available.— Zero.

<sup>1</sup>All domestically consumed thorium was thought to be derived from imported materials; however, monazite may have been produced as a separate concentrate or included as an accessory mineral in heavy-mineral concentrates.

<sup>2</sup>Includes material that may have been misclassified.

<sup>3</sup>Low unit-value exports were excluded from ThO<sub>2</sub> content estimate because they were believed to have been misclassified.

<sup>4</sup>Defined as production + imports – exports. Excludes ores and concentrates.

<sup>5</sup>The apparent consumption calculation yields a negative value from 2014 through 2016 and 2018.

<sup>6</sup>Based on U.S. Census Bureau customs value.

<sup>7</sup>Defined as imports – exports; however, all exports of refined compounds and alloys were derived from imported materials, and net import reliance is assumed to be 100%.

<sup>8</sup>See Appendix C for resource and reserve definitions and information concerning data sources.