

## ZIRCONIUM AND HAFNIUM

(Data in metric tons of zirconium oxide (ZrO<sub>2</sub>) equivalent, unless otherwise noted)

**Domestic Production and Use:** Zircon sand was produced at two mines in Florida and one mine in Virginia. Zirconium and hafnium metal were produced from zircon sand by two domestic producers, one each in Oregon and Utah. Both metals are present in the ore typically in a Zr to Hf ratio of 50:1. Primary zirconium chemicals were produced by the Oregon metal producer and at a plant in New Jersey. Secondary zirconium chemicals were produced by 10 other companies as well. Zirconia (ZrO<sub>2</sub>) was produced from zircon sand at plants in Alabama, New Hampshire, New York, and Ohio, and the metal producer in Oregon. Zircon ceramics, opacifiers, refractories, and foundry applications are the largest end uses for zirconium. Other end uses of zirconium include abrasives, chemicals, metal alloys, welding rod coatings, and sandblasting. The largest market for hafnium metal is an addition in superalloys.

<b>Salient Statistics—United States:</b>	<b>1994</b>	<b>1995</b>	<b>1996</b>	<b>1997</b>	<b>1998<sup>e</sup></b>
Production: Zircon (ZrO <sub>2</sub> content) <sup>1</sup>	W	W	W	W	W
Imports:					
Zirconium, ores and concentrates (ZrO <sub>2</sub> content)	53,300	60,800	60,100	40,600	70,000
Zirconium, alloys, waste and scrap (ZrO <sub>2</sub> content)	837	884	836	929	1,400
Zirconium oxide (ZrO <sub>2</sub> content) <sup>2</sup>	2,400	4,370	5,240	4,220	4,000
Hafnium, unwrought, waste and scrap	5	5	9	8	13
Exports:					
Zirconium ores and concentrates (ZrO <sub>2</sub> content)	20,800	26,200	22,780	28,800	24,000
Zirconium, alloys, waste and scrap (ZrO <sub>2</sub> content)	301	221	184	188	200
Zirconium oxide (ZrO <sub>2</sub> content) <sup>2</sup>	1,220	1,680	1,480	1,970	1,700
Consumption, zirconium ores and concentrates, apparent (ZrO <sub>2</sub> content)	W	W	W	W	W
Prices:					
Zircon, dollars per metric ton (gross weight):					
Domestic <sup>3</sup>	306	352	462	462	462
Imported, f.o.b. U.S. east coast <sup>4</sup>	220	325	400	400	353
Zirconium sponge, dollars per kilogram <sup>5</sup>	20-26	20-26	20-26	20-26	20-26
Hafnium sponge, dollars per kilogram <sup>5</sup>	165-209	165-209	165-209	165-209	165-209
Net import reliance <sup>6</sup> as a percent of apparent consumption:					
Zirconium	W	W	W	W	W
Hafnium	NA	NA	NA	NA	NA

**Recycling:** Zirconium metal was recycled by four companies, one each in California, Michigan, New York, and Texas. The majority of the zirconium recycled came from scrap generated during metal production and fabrication. Zircon foundry mold cores and spent or rejected zirconia refractories are often recycled. Recycling of hafnium metal was insignificant.

**Import Sources (1994-97):** Zirconium ores and concentrates: Australia, 51%; South Africa, 48%; and other, 1%. Zirconium, wrought, unwrought, waste and scrap: France, 39%; Germany, 24%; Canada, 12%; Japan, 10%; and other, 15%. Hafnium, unwrought, waste and scrap: France, 69%; Australia, 21%; Germany, 8%; and United Kingdom, 2%.

<b>Tariff: Item</b>	<b>Number</b>	<b>Normal Trade Relations (NTR)</b>	<b>Non-NTR<sup>7</sup></b>
		<b>12/31/98</b>	<b>12/31/98</b>
Zirconium ores and concentrates	2615.10.0000	Free	Free.
Germanium oxides and ZrO <sub>2</sub>	2825.60.0000	3.7 ad val.	25% ad val.
Ferrozirconium	7202.99.1000	4.2% ad val.	25% ad val.
Zirconium, waste and scrap	8109.10.3000	Free	Free.
Zirconium, other unwrought, powders	8109.10.6000	4.2% ad val.	25% ad val.
Zirconium, other wrought, alloys	8109.90.0000	4.1% ad val.	45% ad val.
Unwrought hafnium, waste and scrap	8112.91.2000	Free	25% ad val.

**Depletion Allowance:** 22% (Domestic), 14% (Foreign)

**Government Stockpile:** In addition to 15,800 tons of baddeleyite ore held in the National Defense Stockpile, the U.S. Department of Energy (DOE) held over 500 tons of zirconium in various forms. DOE also maintained a supply of approximately 35 tons of hafnium.

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Material	Uncommitted inventory	Stockpile Status—9-30-98 <sup>8</sup>		Disposal plan FY 1998	Disposals FY 1998
		Committed inventory	Authorized for disposal		
Baddeleyite	15,800	—	—	—	—

**Events, Trends, and Issues:** The global supply and demand of zirconium mineral concentrates was largely in balance in 1998 and this trend is expected to continue over the next few years. However, long term supply shortages may occur unless new production sources of zirconium concentrates are developed. U.S. imports of zirconium concentrates were estimated to have increased 73% while exports decreased 16% compared with 1997. A new mining operation at Stony Creek, VA, began production of zircon and other heavy minerals in 1998. Initial capacity was expected to include up to 30,000 tons per year of zircon. Availability of hafnium continued to exceed supply. Surpluses were stockpiled in the form of hafnium oxide. The demand for nuclear-grade zirconium metal, the production of which necessitates hafnium's removal, produces more hafnium than can be consumed by the metal's uses.

Zirconium and hafnium exhibit nearly identical properties and are not separated for most applications. However, zirconium and hafnium are separated for certain nuclear applications. Zirconium-clad fuel rods in nuclear reactors are hafnium-free to improve reactor efficiency because hafnium is a strong absorber of thermal neutrons. At the same time, hafnium is used in reactor control rods to regulate the fission process through neutron absorption.

**World Refinery Production, Reserves, and Reserve Base:** World primary hafnium production statistics are not available. Hafnium occurs with zirconium in the minerals zircon and baddeleyite.

	Zirconium			Hafnium		
	Mine production <sup>e</sup> (thousand metric tons)	Reserves <sup>9</sup> (million metric tons, ZrO <sub>2</sub> )	Reserve base <sup>9</sup>	Reserves <sup>9</sup> (thousand metric tons, HfO <sub>2</sub> )	Reserve base <sup>9</sup>	
	<u>1997</u>	<u>1998<sup>e</sup></u>				
United States	W	W	3.4	5.3	68	97
Australia	424	500	9.1	29.8	182	596
Brazil	17	17	.4	.4	7	7
China <sup>e</sup>	15	15	.5	1.0	NA	NA
India	19	20	3.4	3.8	42	46
South Africa	360	265	14.3	14.3	259	259
Ukraine <sup>e</sup>	65	60	4.0	6.0	NA	NA
Other countries	<u>26</u>	<u>30</u>	<u>.9</u>	<u>4.1</u>	<u>NA</u>	<u>NA</u>
World total (rounded)	<sup>10</sup> 926	<sup>10</sup> 907	36	65	558	1,000

**World Resources:** Resources of zircon in the United States included about 14 million tons associated with titanium resources in heavy-mineral sand deposits. Phosphate and sand and gravel deposits have the potential to yield substantial amounts of zircon as a future byproduct. Eudialyte and gittinsite are zirconium silicate minerals that have a potential for zirconia production. Identified world resources of zircon exceed 60 million tons.

Resources of hafnium in the United States are estimated to be about 130,000 tons, available in the 14-million ton domestic resources of zircon. World resources of hafnium are associated with those of zircon and baddeleyite and exceed 1 million tons.

**Substitutes:** Chromite and olivine can be used instead of zircon for some foundry applications. Dolomite and spinel refractories can also substitute for zircon in certain high-temperature applications. Columbium (niobium), stainless steel, and tantalum provide limited substitution in nuclear applications, while titanium and synthetic materials may substitute in some chemical plant uses.

Silver-cadmium-indium control rods are used in lieu of hafnium at numerous nuclear powerplants. Zirconium can be used interchangeably with hafnium in certain superalloys; in others, only hafnium produces the desired or required grain boundary refinement.

<sup>e</sup>Estimated. NA Not available. W Withheld to avoid disclosing company proprietary data.

<sup>1</sup>Less than 250 micron, 99.9% purity, 1994 through 1998 prices converted from 0.5 gram price, from Alfa Aesar.

<sup>2</sup>Lump, sublimed dendritic 99.99% purity, from Alfa Aesar.

<sup>3</sup>Bromide, chloride, and fluoride in crystalline or crystalline aggregate form and scandium iodide as ultradry powder from Alfa Aesar.

<sup>4</sup>Defined as imports - exports + adjustments for Government and industry stock changes.

<sup>5</sup>See Appendix B.

<sup>6</sup>See Appendix D for definitions.