

## SELENIUM

(Data in metric tons of selenium content unless otherwise noted)

**Domestic Production and Use:** Primary selenium was refined from anode slimes recovered from the electrolytic refining of copper. Of the two electrolytic copper refineries operating in the United States, only one in Texas reported production of primary selenium.

In glass manufacturing, selenium is used to decolorize the green tint caused by iron impurities in container glass and other soda-lime silica glass and is used in architectural plate glass to reduce solar heat transmission. Cadmium sulfoselenide pigments are used in ceramics, glass, and plastics to produce a ruby-red color. Selenium is used in blasting caps; in catalysts to enhance selective oxidation; in copper, lead, and steel alloys to improve machinability; in the electrolytic production of manganese to increase yields; in gun bluing to improve cosmetic appearance and provide corrosion resistance; in plating solutions, where it improves appearance and durability; in rubber compounding chemicals to act as a vulcanizing agent; and in thin-film photovoltaic copper-indium-gallium-diselenide (CIGS) solar cells.

Selenium is an essential micronutrient and is used as a human dietary supplement, a dietary supplement for livestock, and as a fertilizer additive to enrich selenium-poor soils. Selenium is also used as an active ingredient in antidandruff shampoos.

Estimates for world consumption are as follows: metallurgy (including manganese production), 40%; glass manufacturing, 25%; agriculture, 10%; chemicals and pigments, 10%; electronics, 10%; and other uses, 5%.

<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, refinery	W	W	W	W	W
Imports for consumption:					
Selenium metal	467	444	411	450	390
Selenium dioxide	8	14	21	19	13
Exports, <sup>1</sup> metal	521	468	150	268	160
Consumption, apparent <sup>2</sup>	W	W	W	W	W
Price, average, dollars per pound <sup>3</sup>	26.78	22.09	23.69	10.78	20.00
Stocks, producer, refined, yearend	W	W	W	W	W
Net import reliance <sup>4</sup> as a percentage of apparent consumption	E	E	E	E	E

**Recycling:** Domestic production of secondary selenium was estimated to be very small because most scrap from older plain paper photocopiers and electronic materials was exported for recovery of the contained selenium.

**Import Sources (2014–17):** China, 19%; Philippines 13%; Germany, 13%; Japan, 12%; and other, 43%.

<b>Tariff: Item</b>	<b>Number</b>	<b>Normal Trade Relations 12–31–18</b>
Selenium metal	2804.90.0000	Free.
Selenium dioxide	2811.29.2000	Free.

**Depletion Allowance:** 14% (Domestic and foreign).

**Government Stockpile:** None.

**Events, Trends, and Issues:** The supply of selenium is directly affected by the supply of the materials from which it is a byproduct—copper and, to a lesser extent, nickel—and it is directly affected by the number of facilities that recover selenium. The estimated annual average price for selenium was \$20.00 per pound in 2018, about 86% more than the annual average price in 2017. In the first quarter of 2018, average monthly prices increased from \$12.50 per pound to \$20.00 per pound. Prices then increased slightly to \$20.50 per pound in June and remained level through September.

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Electrolytic manganese production was the main metallurgical end use for selenium in China, where selenium dioxide was used in the electrolytic process to increase current efficiency and the metal deposition rate. Selenium consumption in China was thought to have increased in recent years; 51 electrolytic manganese producers were reported to have been operating and consuming selenium in 2017 (latest information available), up from 47 reported in 2016.

### World Refinery Production and Reserves:

	Refinery production <sup>5</sup>		Reserves <sup>6</sup>
	<u>2017</u>	<u>2018<sup>e</sup></u>	
United States	W	W	10,000
Belgium	200	200	—
Canada	49	50	6,000
China	930	950	26,000
Finland	105	100	—
Germany	300	300	—
Japan	729	750	—
Peru	45	45	13,000
Poland	88	90	3,000
Russia	150	150	20,000
Sweden	20	20	—
Turkey	50	50	—
Other countries	<u>47</u>	<u>50</u>	<u>21,000</u>
World total (rounded)	<u>72,710</u>	<u>72,800</u>	<u>99,000</u>

**World Resources:** Reserves for selenium are based on identified copper deposits and average selenium content. Coal generally contains between 0.5 and 12 parts per million of selenium, or about 80 to 90 times the average for copper deposits. The recovery of selenium from coal fly ash, although technically feasible, does not appear likely to be economical in the foreseeable future.

**Substitutes:** Silicon is the major substitute for selenium in low- and medium-voltage rectifiers. Organic pigments have been developed as substitutes for cadmium sulfoselenide pigments. Other substitutes include cerium oxide as either a colorant or decolorant in glass; tellurium in pigments and rubber; bismuth, lead, and tellurium in free-machining alloys; and bismuth and tellurium in lead-free brasses. Sulfur dioxide can be used as a replacement for selenium dioxide in the production of electrolytic manganese metal, but it is not as energy efficient.

The selenium-tellurium photoreceptors used in some plain paper copiers and laser printers have been replaced by organic photoreceptors in newer machines. Amorphous silicon and cadmium telluride are the two principal competitors with CIGS in thin-film photovoltaic solar cells.

<sup>e</sup>Estimated. E Net exporter. W Withheld to avoid disclosing company proprietary data. — Zero.

<sup>1</sup>There was no exclusive domestic export classification code for selenium dioxide.

<sup>2</sup>Defined as production + imports – exports + adjustments for industry stock changes.

<sup>3</sup>U.S. spot market price for selenium metal powder, minimum 99.5% purity, in 5-ton lots. Source: Platts Metals Week.

<sup>4</sup>Defined as imports – exports + adjustments for industry stock changes; export data incomplete for common forms of selenium, and may be exported under unexpected or misidentified forms, such as copper selenide or zinc selenide.

<sup>5</sup>Insofar as possible, data relate to refinery output only; thus, countries that produced selenium contained in blister copper, copper concentrates, copper ores, and (or) refinery residues, but did not recover refined selenium from these materials indigenously, were excluded to avoid double counting.

<sup>6</sup>See Appendix C for resource and reserve definitions and information concerning data sources.

<sup>7</sup>Excludes U.S. production. Australia, Iran, Kazakhstan, Mexico, the Philippines, and Uzbekistan are known to produce refined selenium, but output was not reported, and information was inadequate to make reliable production estimates.