

# INDIUM

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Indium production in the United States during 1999 was confined to the upgrading of imported metal and the recycling of scrap. Two refiners, one each in New York and Rhode Island, were the major producers of indium metal and indium products in 1999. A number of smaller firms also produced high-purity indium alloys, compounds, solders, indium-tin oxide (ITO) coatings, and related products.

Domestic consumption was estimated by the U.S. Geological Survey to have increased moderately to about 52 metric tons. Estimated uses were about the same as those in 1998: coatings, 50%; solder and alloys, 33%; batteries and electronic uses, 12%; and other uses, 5%. The value of primary metal consumed in the United States in 1999 was \$13.2 million at an average producer price of \$7.90 per troy ounce, calculated from prices published in Platt's Metals Week.

World consumption was believed to have increased slightly in 1999. World refinery production was estimated at 230 tons, a 4.5% increase compared with the 220 tons (revised) produced in 1998. The six major producing countries were Belgium, Canada, China, France, Japan, and Russia. The recycling of indium, which became significant for the first time in 1996, was not significant domestically in 1999. However, recycling remained important in Japan (Roskill's Letter from Japan, 1999b). The increase in world consumption despite increased efficiency in the manufacture of ITO coatings with thin film transistor (TFT) technology was due to increased demand for display devices.

Japan and the Republic of Korea were the leading producers of TFT liquid crystal displays (LCD's). The greatest expansion in production was in Taiwan (Roskill's Letter from Japan, 1999a). World reserves are sufficient to meet anticipated demand beyond the first decade of this century. Canada has greater resources of indium than any other country—about 27% of world reserves totaling 2,600 tons. The United States holds about 12% of world reserves.

## Legislation and Government Programs

The original National Defense Stockpile (NDS) goal for indium, set in 1989, was 41,990 kilograms (kg). In 1992, when the first purchase of indium was made for the stockpile, the goal was reduced to 7,740 kg. By 1996, as for many other commodities, the Annual Materials Plan for the NDS called for the elimination of indium from the stockpile. No sales were made in 1996, but stockpile disposals of indium amounted to 1,118 kg (35,956 troy ounces) in 1997. The last 443 kg (14,248 troy ounces) of NDS indium were sold in 1998. From that point on, the United States became completely dependent on imports for primary indium (American Metal Market,

1998).

## Production

U.S. production of primary indium in 1999 consisted of upgrading lower-grade and standard-grade indium (99.97% and 99.99%) into higher purity metal. Indium can be refined to purities up to 99.99999%. All the indium to be upgraded was imported. Secondary production was mainly from new (unused) scrap and certain types of old (used) scrap. Nevertheless, only a small amount of indium was recycled domestically. Indium was produced in various forms, such as ingot, foil, powder, ribbon, shot, and wire.

## Consumption

Domestic consumption in 1999 was estimated at about 52 tons, a moderate increase from the 1998 level. Consumption in the various end uses held steady. Thin-film coatings on glass, which included indium oxide and indium-tin-oxide, constituted one-half of total domestic indium use in 1999. The coatings, produced by sputtering the material onto a glass substrate, have been the largest area of research, development, and growth for indium in the past several years.

There are two kinds of indium-containing coatings—electrically conductive coatings and infrared-reflecting coatings. Electrically conductive coatings, the more commercially significant group, are used primarily in LCD's for watches, television screens, portable computer screens, and video monitors. They are also used to defog aircraft and locomotive windshields and to keep glass doors on commercial refrigerators and freezers frost-free. In addition, infrared-reflecting indium coatings on window glass limit the transfer of radiant heat through the glass, helping to make the heating and cooling of buildings more energy efficient.

About 33% of the indium consumed was used as an addition to combinations of bismuth, cadmium, lead, and tin to form low-melting-point alloys. These alloys are used in such applications as electrical fuses, fusible links, or as gripping material for the grinding of optical glass. Indium is used as a strengthening agent for lead solders and also as the base material for many low-melting-point solders. Indium-based solders have a number of advantages over ordinary solders: lower melting points, flexibility over a greater temperature range, and negligible leaching of gold components from electronic assemblies. Lead-free solders have been developed starting with indium-based alloys.

Indium is used in alkaline batteries to prevent the buildup of hydrogen gas in the sealed battery casing. These batteries are

available in popular small consumer sizes, and together with electronic uses, including semiconductors, accounted for about 12% of the indium consumed domestically.

## Prices

The domestic producer price as reported by Platt's Metals Week for 99.97%- to 99.99%-pure indium decreased from \$8.63 per troy ounce to \$6.22 per troy ounce in 1999; prices for higher grades of metal were not published. The price decline was a reflection of the world supply and demand situation. The anticipated expansion of Asian LCD manufacturing was overshadowed by plentiful supply from China and concerns over possible releases from the Ukrainian stockpile. The average producer price was \$8.63 per troy ounce at the beginning of the year. It held steady until July, when it was lowered to \$7.85 per troy ounce. The price fell again in October and November, reaching \$6.99 and \$6.22 per troy ounce, respectively. The price remained steady well into 2000. The price had been nearly constant throughout 1998. It fluctuated moderately in 1997, following a steady increase in 1995 and a steady decrease in 1996.

## Foreign Trade

Imports increased 3% by weight but decreased 22% in value. Canada retained its position as the top supplier; but with an 85% increase in exports to the United States, China became a close second supplier. The top two provided 78% of the total. Next, in order of importance, were France, Russia, Peru, and Belgium. U.S. exports to Japan were 9 tons in 1997, 7 tons in 1998, and 2 tons for the first half of 1999 (Roskill's Letter from Japan, 1999a). Data on other U.S. exports of indium were unavailable, but total exports were estimated at about 25 tons.

## World Review

**Asia.**—The world indium market in 1999 was again dominated by Japanese buyers and Chinese sellers (Metal Bulletin, 1999a). Japan remained the world's largest consumer of indium, with two-thirds of it going for ITO coatings. Low-priced indium was so readily available from China, that temporary reductions in output at two of China's main producers did not significantly affect the market (Mining Journal, 1999c). Market observers were relieved when Japanese imports reached a very high level (11.5 tons) in September (Mining Journal, 1999a). New LCD plants in Japan, the Republic of Korea, and Taiwan provided optimism for a larger indium market, but such startups require indium demand surges that are not expected to be sustained over the long term (Metal Bulletin, 1999e).

**Canada.**—Cominco, Ltd. announced plans to begin processing a stockpile of lead smelter slag at its Trail, British Columbia, plant at the end of 1999. The 215,000-ton stockpile contains 35,000 tons of zinc and significant amounts of indium and germanium. The prospect of processing the slag helped hold indium prices down in 1999 (Metal Bulletin, 1999b, f).

Two interruptions of indium production at the Kidd Creek,

Ontario, plant of Falconbridge, Ltd. failed to lift spot prices. The first interruption was a strike from July 8 until August 3, and the second was due to a runout at a copper furnace in December. Both stoppages lasted about 6 weeks and could have decreased production by as much as 6 tons, but no effect on prices was apparent (Metal Bulletin, 1999c, d).

**Ukraine.**—The indium world market continued to be concerned by the availability of more than 25 tons of indium from the Ukrainian stockpile. The market has been aware of this material for several years and was disturbed that the equivalent of 12% of annual world production could be sold abruptly. As the price declined through 1999, it was believed that a major participant in the market would make an offer for the entire stockpile, but the Ukrainians were apparently unwilling to sell at the prevailing low prices. This situation resulted in higher spot prices during the first half of 1999 (Mining Journal, 1999b).

## Current Research and Technology

In 1999, the conversion from the older technology, the supertwisted nematic (STN) LCD; to the thin film transistor LCD continued. The TFT-LCD requires only one-third as much indium per unit as the STN-LCD (Roskill's Letter from Japan, 1999c). Since more than one-half of the world's indium consumption is for ITO coatings, the conversion to a more efficient technology has the same effect as would an increase in indium reserves.

## Outlook

Consumption of indium is expected to increase throughout the next decade, especially for LCD's, high-definition television, semiconductor materials, batteries, and low-temperature solders for military and electronic applications. The main driving force for this increase will continue to be Japanese production of LCD's.

Roskill has predicted a world demand of 250 tons by 2005 (Roskill Information Services, 1999). Demand for other uses, such as replacement nuclear control rods and fusible alloys, should remain steady. If indium prices rise significantly, conversion to TFT-LCD's will be further accelerated, and research into substitutes for ITO in LCD's will be stimulated. Zinc-tin-oxide could possibly be used as a substitute, but currently its properties are not as good as those of ITO. However, another substitution scenario is possible: light emitting plastic screens are being developed in England. These could someday compete for display applications (Wired News, July 3, 2000, Plastic coming to screens soon, accessed July 4, 2000, at URL <http://wired.com/news/print/0,129437375,00>). If the price of indium is sufficiently high, recycling becomes economically attractive and will tend to limit upward movements in price as long as there is a supply of appropriate scrap. Stocks of scrap increase when little recycling is occurring—as in recent years. World reserves, together with increases in production capacity (achieved through new plants and increased yields in primary recovery and improvements in manufacturing and recycling technology) are expected to be

sufficient to meet the demand for indium through the first decade of the 21st century.

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- 1999c, Furnace run-out halts production at Kidd: Metal Bulletin, no. 8437, December 23, p. 4.
- 1999d, Indium market shrugs off Kidd closure: Metal Bulletin, no. 8393, July 15, p. 7.
- 1999e, More positive indium market looks ahead: Metal Bulletin, no. 8424, November 8, p. 9.
- 1999f, US antimony prices move ahead: Metal Bulletin, no. 8382, June 7, p. 12.
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- 1999b, Minor metals in February: Mining Journal, v. 332, no. 8521, March 5, p. 163.
- 1999c, Mixed month for minor metals: Mining Journal, v. 332, no. 8530, May 7, p. 341.
- Roskill Information Services, 1999, Economics of Indium: Roskill Information Services, London, 113 p.

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- 1999b, Indium—Japanese demand is forecast to recover in 1999: Roskill's Letter from Japan, no. 279, July, p. 2.
- 1999c, Indium—Japanese imports drop by 20% in 1998: Roskill's Letter from Japan, no. 273, January, p. 2.

## GENERAL SOURCES OF INFORMATION

### U.S. Geological Survey Publications

- Indium. Ch. in Mineral Commodity Summaries, annual.
- Indium. Ch. in Minerals Yearbook, annual.<sup>1</sup>
- Gallium, germanium, and indium. Ch. in United States Mineral Resources, Professional Paper 820, 1973.

### Other

- Indium. Ch. in Minerals Facts and Problems, U.S. Bureau of Mines Bulletin 675, 1985.<sup>1</sup>

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<sup>1</sup>Prior to January 1996, published by the U.S. Bureau of Mines.

TABLE 1  
U.S. IMPORTS FOR CONSUMPTION OF INDIUM, BY CLASS AND COUNTRY 1/

Class and country	1998		1999	
	Quantity (kilograms)	Value (thousands)	Quantity (kilograms)	Value (thousands)
Unwrought and waste and scrap:				
Belgium	3,080	\$795	1,850	\$343
Canada	31,100	7,060	31,800	6,390
China	15,500	3,690	28,700	4,690
Finland	--	--	--	--
France	7,610	2,030	5,780	1,230
Germany	207	60	80	12
Hong Kong	714	202	396	54
Japan	861	312	634	226
Netherlands	91	22	--	--
Peru	2,520	691	2,100	382
Romania	18	4	--	--
Russia	11,500	3,160	5,100	984
Singapore	360	99	30	3
Switzerland	--	--	500	93
United Kingdom	1,410	478	410	137
Total	75,000	18,600	77,400	14,500

-- Zero.

1/ Data are rounded to no more than three significant digits; may not add to totals shown.

Source: U. S. Census Bureau.