

CESIUM

(Data in metric tons of cesium oxide unless otherwise noted)

Domestic Production and Use: In 2019, no cesium was mined domestically, and the United States was 100% import reliant for cesium minerals. Pollucite, mainly found in association with lithium-rich, lepidolite-bearing or petalite-bearing zoned granite pegmatites, is the principal cesium ore mineral. Cesium minerals are used as feedstocks to produce a variety of cesium compounds and cesium metal. The primary application for cesium, by gross weight, is in cesium formate brines used for high-pressure, high-temperature well drilling for oil and gas production and exploration.

Cesium metal is used in the production of cesium compounds and potentially in photoelectric cells. Cesium bromide is used in infrared detectors, optics, photoelectric cells, scintillation counters, and spectrophotometers. Cesium carbonate is used in the alkylation of organic compounds and in energy conversion devices, such as fuel cells, magneto-hydrodynamic generators, and polymer solar cells. Cesium chloride is used in analytical chemistry applications as a reagent, in high-temperature solders, as an intermediate in cesium metal production, in isopycnic centrifugation, as a radioisotope in nuclear medicine, as an insect repellent in agricultural applications, and in specialty glasses. Cesium hydroxide is used as an electrolyte in alkaline storage batteries. Cesium iodide is used in fluoroscopy equipment—Fourier-transform infrared spectrometers—as the input phosphor of x-ray image intensifier tubes, and in scintillators. Cesium nitrate is used as a colorant and oxidizer in the pyrotechnic industry, in petroleum cracking, in scintillation counters, and in x-ray phosphors. Cesium sulfates are soluble in water and are thought to be used primarily in water treatment, fuel cells, and to improve optical quality for scientific instruments.

Cesium isotopes, which are obtained as a byproduct in nuclear fission or formed from other isotopes, such as barium-131, are used in electronic, medical, metallurgical, and research applications. Cesium isotopes are used as an atomic resonance frequency standard in atomic clocks, which plays a vital role in aircraft guidance systems, global positioning satellites, and internet and cellular telephone transmissions. Cesium clocks monitor the cycles of microwave radiation emitted by cesium's electrons and use these cycles as a time reference. Owing to the high accuracy of the cesium atomic clock, the international definition of 1 second is based on the cesium atom. The U.S. civilian time and frequency standard is based on a cesium fountain clock at the National Institute of Standards and Technology in Boulder, CO. The U.S. military frequency standard, the United States Naval Observatory Time Scale, is based on 48 weighted atomic clocks, including 25 cesium fountain clocks.

A company in Richland, WA, produced a range of cesium-131 medical products for treatment of various cancers. Cesium-137 may be used in industrial gauges, in mining and geophysical instruments, and for sterilization of food, sewage, and surgical equipment. Because of the danger posed by the radiological properties of cesium-137, efforts to find substitutes in its applications continued.

Salient Statistics—United States: Consumption, import, and export data for cesium have not been available since the late 1980s. Because cesium metal is not traded in commercial quantities, a market price is unavailable. Only a few thousand kilograms of cesium chemicals are thought to be consumed in the United States every year. The United States was 100% import reliant for its cesium needs.

In 2019, one company offered 1-gram ampoules of 99.8% (metal basis) cesium for \$63.00, a slight increase from \$61.80 in 2018, and 99.98% (metal basis) cesium for \$81.10, a 3% increase from \$78.70 in 2018.

In 2019, the prices for 50 grams of 99.9% (metal basis) cesium acetate, cesium bromide, cesium carbonate, cesium chloride, and cesium iodide were \$118.20, \$71.90, \$101.80, \$103.60, and \$117.00 respectively, a 3% increase from prices in 2018. The price for a cesium-plasma standard solution (10,000 micrograms per milliliter) was \$81.90 for 50 milliliters and \$125.00 for 100 milliliters, and the price for 25 grams of cesium formate, 98% basis, was \$39.90.

Recycling: Cesium formate brines are typically rented by oil and gas exploration clients. After completion of the well, the used cesium formate brine is returned and reprocessed for subsequent drilling operations. The formate brines are recycled with an estimated recovery rate of 85%, which can be reprocessed for further use.

Import Sources (2015–18): No reliable data have been available to determine the source of cesium ore imported by the United States since 1988. Previously, Canada was thought to be the primary supplier of cesium ore.

CESIUM

| Tariff: Item | Number | Normal Trade Relations |
|----------------------|---------------|-------------------------------|
| | | <u>12-31-19</u> |
| Alkali metals, other | 2805.19.9000 | 5.5% ad val. |
| Chlorides, other | 2827.39.9000 | 3.7% ad val. |
| Bromides, other | 2827.59.5100 | 3.6% ad val. |
| Iodides, other | 2827.60.5100 | 4.2% ad val. |
| Sulfates, other | 2833.29.5100 | 3.7% ad val. |
| Nitrates, other | 2834.29.5100 | 3.5% ad val. |
| Carbonates, other | 2836.99.5000 | 3.7% ad val. |
| Cesium-137, other | 2844.40.0021 | Free |

Depletion Allowance: 14% (Domestic and foreign).

Government Stockpile: None.

Events, Trends, and Issues: Domestic cesium occurrences will likely remain uneconomic unless market conditions change. No known human health issues are associated with naturally occurring cesium, and its use has minimal environmental impact. Radioactive isotopes of cesium have been known to cause adverse health effects. Certain cesium compounds may be toxic if consumed. Food that has been irradiated using the radioisotope Cesium-137 has been found to be safe by the U.S. Food and Drug Administration.

During 2019, projects that were primarily aimed at developing lithium resources with cesium content were at various stages of development. One United States-based company sold its cesium mine in Manitoba, Canada, and its specialty fluids division, including cesium formate, in Norway, Scotland, and Singapore to a company in China. Operations commenced at a pollucite mine in Western Australia in December 2018, with cesium being exported to the United States as contracted with a cesium chemical producer. The company reported that the first stage of mining produced 19,000 tons of pollucite with an average grade of 9.1% cesium oxide. The U.S. Food and Drug Administration issued a notice of significant health and safety risks associated with compounded cesium chloride, which had been used as an alternative cancer treatment. In May 2019, a blood irradiator that used cesium-137 spilled while being moved from a medical research center to a secure disposal site. The National Nuclear Security Administration managed the cleanup efforts and an investigation. Congressional budget proposals recommended increased funding for the National Nuclear Security Administration's Cesium Irradiator Replacement Project to assist in replacing cesium-137 blood irradiators.

World Mine Production and Reserves: There were no official sources for cesium production data. In addition to production of pollucite in Australia, Namibia and Zimbabwe were thought to have produced cesium in small quantities as a byproduct of lithium mining operations. Cesium reserves are, therefore, estimated based on the occurrence of pollucite, which is mined as a byproduct of the lithium mineral lepidolite. Most pollucite contains 5% to 32% cesium oxide. Reserves data for Australia and Canada were added based on industry information.

| | Reserves¹ |
|-----------------------|-----------------------------|
| Australia | 7,100 |
| Canada | 120,000 |
| Namibia | 30,000 |
| Zimbabwe | <u>60,000</u> |
| World total (rounded) | 220,000 |

World Resources: Cesium is associated with lithium-bearing pegmatites worldwide, and cesium resources have been identified in Australia, Canada, Namibia, the United States, and Zimbabwe. In the United States, pollucite occurs in pegmatites in Alaska, Maine, and South Dakota. Lower concentrations occur in brines in Chile and China and in geothermal systems in Germany, India, and Tibet. China was thought to have cesium-rich deposits of geyserite, lepidolite, and pollucite, with concentrations highest in Yichun, Jiangxi Province, although no resource, reserves, or production estimates were available.

Substitutes: Cesium and rubidium can be used interchangeably in many applications because they have similar physical properties and atomic radii. Cesium, however, is more electropositive than rubidium, making it a preferred material for some applications. However, rubidium is mined from similar deposits, in relatively smaller quantities, as a byproduct of cesium production in pegmatites and as a byproduct of lithium production from lepidolite (hard-rock) mining and processing, making it no more readily available than cesium.

¹See Appendix C for resource and reserve definitions and information concerning data sources.