# SCANDIUM[1]

(Data in metric tons of scandium oxide equivalent unless otherwise noted)

**Domestic Production and Use:** Domestically, scandium-bearing minerals were neither mined nor recovered from mine tailings in 2018. Previously, scandium was produced domestically primarily from the scandium-yttrium silicate mineral thortveitite and from byproduct leach solutions from uranium operations. Limited capacity to produce ingot and distilled scandium metal existed at facilities in Ames, IA; Tolleson, AZ; and Urbana, IL. The principal source for scandium metal and scandium compounds was imports from China. The principal uses for scandium in 2018 were in aluminum-scandium alloys and solid oxide fuel cells (SOFCs). Other uses for scandium included ceramics, electronics, lasers, lighting, and radioactive isotopes. In SOFCs, electricity is generated directly from oxidizing a fuel. For metal applications, scandium metal is typically produced by reducing scandium fluoride with calcium metal. Aluminum-scandium alloys are produced for sporting goods, aerospace, and other high-performance applications. Aluminum-magnesium-scandium alloys have been developed for use in additive manufacturing. Scandium is added to a zirconia-base electrolyte to improve the power density and to lower the reaction temperature of the SOFC. Scandium is used in small quantities in a number of electronic applications. Some lasers that contain scandium are used in defense applications and in medical treatments. In lighting, scandium iodide is used in high-intensity lights to simulate natural light. Scandium isotopes are used as a tracing agent in oil refining.

| **Salient Statistics—United States:** | **2014** | **2015** | **2016** | **2017** | **2018[e]** |
|---|---|---|---|---|---|
| Price, yearend, dollars: | | | | | |
| Compounds, per gram: | | | | | |
| Acetate, 99.9% purity, 5-gram sample size[2] | 43.00 | 43.00 | 44.00 | 44.00 | 44.00 |
| Chloride, 99.9% purity, 5-gram sample size[2] | 123.00 | 123.00 | 126.00 | 124.00 | 125.00 |
| Fluoride, 99.9% purity, 1-to-5-gram sample size | [2]263.00 | [2]263.00 | [3]270.00 | [3]277.00 | [3]206.00 |
| Iodide, 99.999% purity, 5-gram sample size[2] | 187.00 | 187.00 | 149.00 | 183.00 | 165.00 |
| Oxide, 99.99% purity, 5-kilogram lot size[4] | 5.00 | 5.10 | 4.60 | 4.60 | 4.60 |
| Metal: | | | | | |
| Scandium, distilled dendritic, per gram, 2-gram sample size[2] | 221.00 | 221.00 | 228.00 | 226.00 | 226.00 |
| Scandium, ingot, per gram, 5-gram sample size[2] | 134.00 | 134.00 | 107.00 | 132.00 | 132.00 |
| Scandium-aluminum alloy, per kilogram, metric-ton lot size[4] | 386.00 | 220.00 | 340.00 | 350.00 | 360.00 |
| Net import reliance[5] as a percentage of apparent consumption | 100 | 100 | 100 | 100 | 100 |

**Recycling:** None.

**Import Sources (2014–17):** Although no definitive data exist listing import sources, imported material is mostly from Europe, China, Japan, and Russia.

| **Tariff: Item** | **Number** | **Normal Trade Relations 12–31–18** |
|---|---|---|
| Rare-earth metals, unspecified, whether or not intermixed or interalloyed | 2805.30.0090 | 5.0% ad val. |
| Compounds of rare-earth metals: | | |
| Mixtures of oxides of yttrium or scandium as the predominant metal | 2846.90.2015 | Free. |
| Mixtures of chlorides of yttrium or scandium as the predominant metal | 2846.90.2082 | Free. |
| Mixtures of other rare-earth carbonates, including scandium | 2846.90.8075 | 3.7% ad val. |
| Mixtures of other rare-earth compounds, including scandium | 2846.90.8090 | 3.7% ad val. |

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

**Government Stockpile:** None.

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**Events, Trends, and Issues:** The global supply and consumption of scandium was estimated to be about 10 tons to 15 tons per year. Consumption of scandium contained in SOFCs and nonferrous alloys was reported to be within this same range. Prices quoted for most scandium products in the United States were generally unchanged or decreased compared with those in 2017. In China, ex-works prices for scandium oxide were significantly less than domestic quoted prices.

Although global exploration and development projects continued in anticipation of increased demand, the global scandium market remained small relative to most other metals. In the United States, following the completion of a feasibility study in 2017 for the polymetallic Elk Creek project in Nebraska, permitting and engineering studies were ongoing. Other domestic projects that included scandium recovery in their process plans were the Bokan project in Alaska and the Round Top project in Texas. The U.S. Department of Energy was funding the development of methods to separate scandium from coal and coal byproducts. In Australia, the Nyngan project and Syerston project in New South Wales were under development while seeking project financing and offtake agreements. Reserves at Nyngan were estimated to be 1.44 million tons containing about 590 tons of scandium using an effective cutoff grade of 155 parts per million scandium. Subject to financing, the developer expected to begin production in 2020 and was expected to produce as much as 38.5 tons per year of scandium oxide. The Syerston project's measured and indicated scandium resources increased 63% to 45.7 million tons containing 19,200 tons of scandium oxide equivalent using a 300-parts-per-million scandium cutoff grade. In Queensland, the Scandium-Cobalt-Nickel (SCONI) Project was nearing completion of a bankable feasibility study and updated resource estimate at yearend. The prior measured and indicated resources of the SCONI Project were estimated at 12 million tons containing about 3,000 tons of scandium oxide using a 162-parts-per-million scandium cutoff grade. In India, a project to construct a 2.4-ton-per-year scandium oxide plant awaited environmental approval. In the Philippines, a plant to recover 7.5 tons per year of scandium oxide equivalent was being commissioned at the Taganito high-pressure acid-leach nickel operation. Production of an intermediate concentrate was expected to increase in 2019. In Russia, an aluminum producer was commercializing a hybrid technology for producing scandium-aluminum master alloy and developing new aluminum alloy formulations for additive manufacturing. Feasibility studies for making scandium oxide as a byproduct of alumina refining in the Ural Mountains were ongoing. The pilot plant was reported to have produced scandium oxide with purity greater than 99%. Based on pilot test results, plans were in place for a 3-ton-per-year scandium oxide plant. In Dalur, Kurgan region, development of scandium recovery as a byproduct of uranium production continued, and a 1.5-ton-per-year plant produced finished scandium oxide in 2018. In the European Union, recovery methods were being developed to produce scandium compounds and aluminum alloys from ores and byproducts. Globally, several projects were underway to commercialize new aluminum-scandium alloys for casting and additive manufacturing.

In May 2018, the U.S. Department of the Interior, in coordination with other executive branch agencies, published a list of 35 critical minerals (83 FR 23295), including scandium. This list was developed to serve as an initial focus, pursuant to Executive Order 13817, ''A Federal Strategy to Ensure Secure and Reliable Supplies of Critical Minerals" (82 FR 60835).

**World Mine Production and Reserves:**[6] No scandium was mined in the United States. As a result of its low concentration, scandium is produced exclusively as a byproduct during processing of various ores or recovered from previously processed tailings or residues. In recent years, scandium was produced as byproduct material in China (iron ore, rare earths, titanium, and zirconium), Kazakhstan (uranium), Russia (apatite and uranium), and Ukraine (uranium). Foreign mine production data for 2018 were not available.

**World Resources:** Resources of scandium are abundant. Scandium's crustal abundance is greater than that of lead. Scandium lacks affinity for the common ore-forming anions; therefore, it is widely dispersed in the lithosphere and forms solid solutions with low concentrations in more than 100 minerals. There are identified scandium resources in Australia, Canada, China, Kazakhstan, Madagascar, Norway, the Philippines, Russia, Ukraine, and the United States.

**Substitutes:** Titanium and aluminum high-strength alloys, as well as carbon-fiber materials, may substitute in high-performance scandium-alloy applications. Light-emitting diodes displace mercury-vapor high-intensity lights in some industrial and residential applications. In some applications that rely on scandium's unique properties, substitution is not possible.

[e]Estimated.

[1]See also Rare Earths. Scandium is one of the 17 rare-earth elements.

[2]Prices from Alfa Aesar, a Johnson Matthey company.

[3]Prices from Sigma-Aldrich, a part of Millipore Sigma.

[4]Prices from Stanford Materials Corp.

[5]Defined as imports – exports. Quantitative data are not available.

[6]See Appendix C for resource and reserve definitions and information concerning data sources.