RHENIUM

(Data in kilograms of rhenium content unless otherwise noted)

Domestic Production and Use: During 2015, ores containing 8,500 kilograms of rhenium were mined at nine operations (six in Arizona, and one each in Montana, New Mexico, and Utah). Rhenium compounds are included in molybdenum concentrates derived from porphyry copper deposits, and rhenium is recovered as a byproduct from roasting such molybdenum concentrates. Rhenium-containing products included ammonium perrhenate (APR), metal powder, and perrhenic acid. The major uses of rhenium were in superalloys used in high-temperature turbine engine components and in petroleum-reforming catalysts, representing an estimated 70% and 20%, respectively, of end uses. Bimetallic platinum-rhenium catalysts were used in petroleum reforming for the production of high-octane hydrocarbons, which are used in the production of lead-free gasoline. Rhenium improves the high-temperature (1,000° C) strength properties of some nickel-based superalloys. Rhenium alloys were used in crucibles, electrical contacts, electromagnets, electron tubes and targets, heating elements, ionization gauges, mass spectrographs, metallic coatings, semiconductors, temperature controls, thermocouples, vacuum tubes, and other applications. The estimated value of rhenium consumed in 2015 was about $80 million.

Salient Statistics—United States:	**2011**	**2012**	**2013**	**2014**	**2015[e]**
Production[1]	8,610	7,910	7,100	8,500	8,500
Imports for consumption	33,500	40,800	27,600	24,800	32,600
Exports	NA	NA	NA	NA	NA
Consumption, apparent	42,100	48,700	34,700	33,300	41,000
Price,[2] average value, dollars per kilogram, gross weight:					
Metal pellets, 99.99% pure	4,670	4,040	3,160	3,000	2,900
Ammonium perrhenate	4,360	3,990	3,400	3,100	2,800
Employment, number	Small	Small	Small	Small	Small
Net import reliance[3] as a percentage of apparent consumption	80	84	80	74	79

Recycling: Nickel-based superalloy scrap and scrapped turbine blades and vanes continued to be recycled hydrometallurgically to produce rhenium metal for use in new superalloy melts. The scrapped parts were also processed to generate engine revert—a high-quality, lower cost superalloy meltstock—by a growing number of companies, mainly in the United States, Canada, Estonia, Germany, and Russia. Rhenium-containing catalysts were also recycled.

Import Sources (2011–14): Rhenium metal powder: Chile, 87%; Poland, 8%; Germany, 2%; and other, 3%. Ammonium perrhenate: Kazakhstan, 43%; Republic of Korea, 36%; Canada, 8%; Germany, 5%; and other, 8%.

Tariff: Item	**Number**	**Normal Trade Relations 12–31–15**
Salts of peroxometallic acids, other, ammonium perrhenate	2841.90.2000	3.1% ad val.
Rhenium (and other metals), waste and scrap	8112.92.0600	Free.
Rhenium (and other metals), unwrought and powders	8112.92.5000	3% ad val.
Rhenium (and other metals), wrought	8112.99.9000	4% ad val.

Depletion Allowance: 14% (Domestic and foreign).

Government Stockpile: None.

Prepared by **Désirée E. Polyak [(703) 648–4909, dpolyak@usgs.gov]**

RHENIUM

Events, Trends, and Issues: During 2015, the United States continued to rely on imports for much of its supply of rhenium. Chile, Germany, Kazakhstan, Poland, and the Republic of Korea supplied most of the imported rhenium. Rhenium imports for consumption increased by 31% from those of 2014. Primary rhenium production in the United States stayed the same as that of 2014. Operations at the Zhezkazgan smelter and refinery in Kazakhstan were temporarily suspended in mid-2013. The facility was being upgraded to process copper-molybdenum ore from the newly developed Bozshakol mining and concentrating complex also in Kazakhstan. Operations were expected to reopen by 2017. Therefore, during 2014 and 2015, Kazakhstan only produced a small amount of APR.

In 2015, both rhenium metal and catalytic-grade APR prices declined from those in 2014. In 2015, catalytic-grade APR prices averaged $2,800 per kilogram and rhenium metal pellet price averaged $2,900 per kilogram.

Consumption of catalyst-grade APR by the petroleum industry was expected to remain at high levels. Demand for rhenium in the aerospace industry, although more unpredictable, was expected to continue to increase. The major aerospace companies, however, were expected to continue testing superalloys that contain one-half the rhenium used in engine blades as currently designed, as well as testing rhenium-free alloys for other engine components. New technology continued to be developed to allow recycling of nickel-base superalloy scrap more efficiently. The processing of scrapped engine parts to generate engine revert increased worldwide and this increase in engine revert supply was expected to continue to have a significant impact on the rhenium market.

World Mine Production and Reserves:

	Mine production[4]		Reserves[5]
	2014	2015[e]	
United States	8,500	8,500	390,000
Armenia	351	350	95,000
Canada	—	—	32,000
Chile[6]	25,000	26,000	1,300,000
China	NA	NA	NA
Kazakhstan	300	200	190,000
Peru	—	—	45,000
Poland	7,600	7,800	NA
Russia	NA	NA	310,000
Uzbekistan	900	1,000	NA
Other countries	2,000	2,000	91,000
World total (rounded)	44,700	46,000	2,500,000

World Resources: Most rhenium occurs with molybdenum in porphyry copper deposits. Identified U.S. resources are estimated to be about 5 million kilograms, and the identified resources of the rest of the world are approximately 6 million kilograms. Rhenium also is associated with copper minerals in sedimentary deposits in Armenia, Kazakhstan, Poland, Russia, and Uzbekistan, where ore is processed for copper recovery and the rhenium-bearing residues are recovered at copper smelters.

Substitutes: Substitutes for rhenium in platinum-rhenium catalysts are being evaluated continually. Iridium and tin have achieved commercial success in one such application. Other metals being evaluated for catalytic use include gallium, germanium, indium, selenium, silicon, tungsten, and vanadium. The use of these and other metals in bimetallic catalysts might decrease rhenium's share of the existing catalyst market; however, this would likely be offset by rhenium-bearing catalysts being considered for use in several proposed gas-to-liquid projects. Materials that can substitute for rhenium in various end uses are as follows: cobalt and tungsten for coatings on copper x-ray targets, rhodium and rhodium-iridium for high-temperature thermocouples, tungsten and platinum-ruthenium for coatings on electrical contacts, and tungsten and tantalum for electron emitters.

[e]Estimated. NA Not available. — Zero.

[1]Based on 80% recovery of estimated rhenium contained in molybdenum disulfide concentrates. Secondary rhenium production not included.

[2]Average price per kilogram of rhenium in pellets or catalytic-grade ammonium perrhenate, from Metal Bulletin.

[3]Defined as imports – exports + adjustments for industry stock changes.

[4]Estimated amount of rhenium recovered in association with copper and molybdenum production. Secondary rhenium production not included.

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

[6]Estimated rhenium recovered from roaster residues from Belgium, Chile, and Mexico.