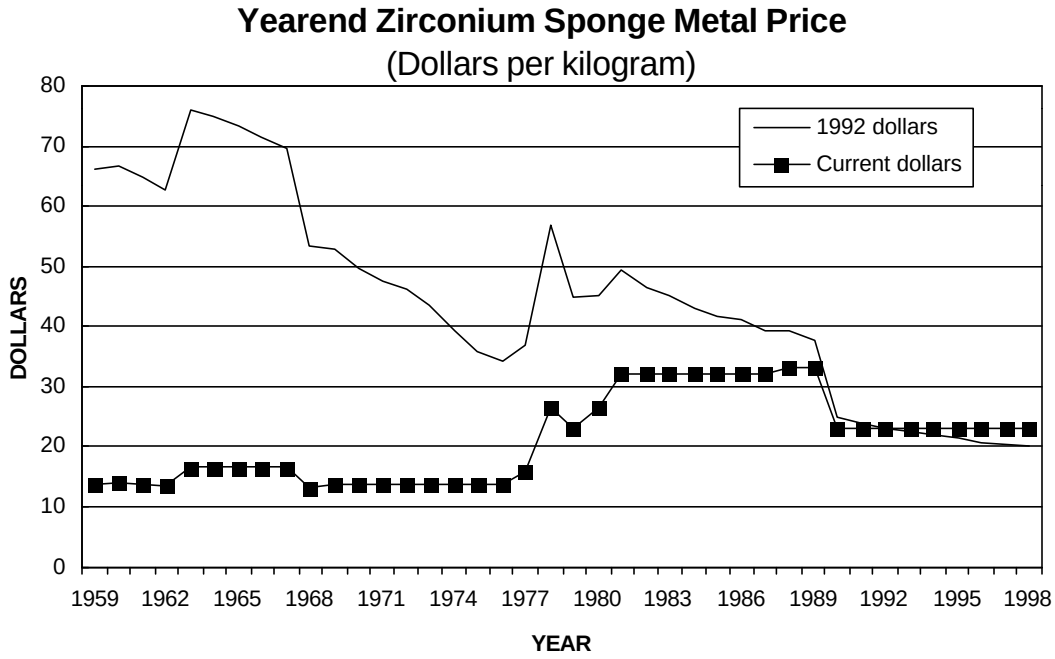
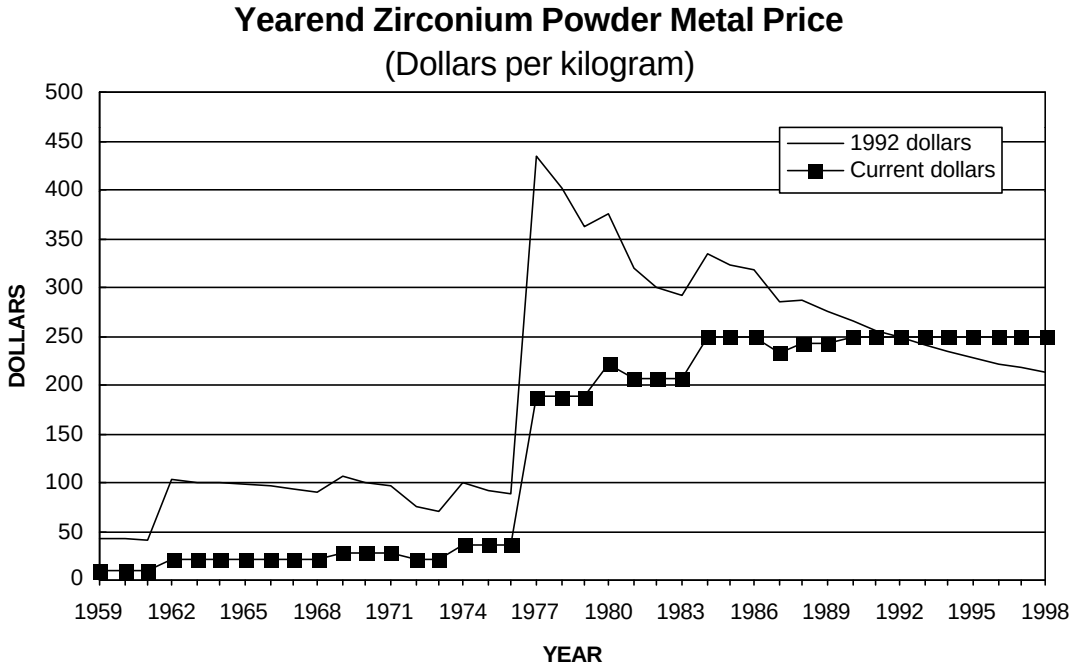
Zirconium

by James B. Hedrick





Significant events affecting zirconium prices

1957-62	Improved production methods and increased scale of operations and capacity led to declining prices
1977-78	Number of producers reduced to one; inflation, and lack of competition; demand increasing for high-purity specialty powders and metal

Zirconium metal is sold in three basic forms—powder, sponge, and crystal bar. Martin H. Klaproth discovered the element in Germany in 1789 by analyzing zircon (Weeks and Leicester, 1968). Production of the first impure zirconium metal was by Jöns Jakob Berzelius in 1824 (Berzelius, 1825). Commercial quantities of the ductile metal were not produced until 100 years later when Anton Eduard van Arkel and Jan Hedrik de Boer discovered the iodide, or crystal bar, process (van Arkel and de Boer, 1925). Powdered zirconium metal was available on domestic markets as early as 1930, when it was used primarily for its pyrophoric and alloying properties. Principal uses were for ammunition primers, vacuum-tube getters, flash powder used in photography, and corrosion-resistant steel alloys (Kalish, 1953). An economic process to produce zirconium metal sponge (Kroll, or magnesium-reduction, process) was developed in the mid-1940's and became commercially available in the early 1950's (Kroll, 1937; Kroll, Schlechten, and Yerkes, 1946; Kroll, Schlechten, and others, 1947; Kroll, Anderson, and others, 1948). Zirconium sponge is used in the production of zirconium metal and alloys, especially for use in nuclear fuel cladding, corrosion resistant piping in chemical processing plants, and heat exchangers. Crystal bar, which is a very high purity form of zirconium metal that is used mostly in research and special applications, is not covered in this report.

Zirconium Sponge

In January 1945, the U.S. Bureau of Mines (USBM) began research to develop a commercial process for making zirconium sponge metal (Etherington, Dalzell, and Lillie, 1955). By 1947, the USBM was operating a 27-kilogram (60-pound)-per-week pilot plant in Albany, OR, using the Kroll process. In response to the U.S. Navy's interest in zirconium for possible use in nuclear powered submarines, capacity at the pilot plant was expanded in 1949 (11,800 kilograms), 1950, and twice in 1951 (Shelton and others, 1956). By 1951, USBM capacity had reached about 136,000 kilograms (300,000 pounds) per year. That same year, commercial price quotations for zirconium sponge began at $22 per kilogram ($10 per pound). In 1952, the Atomic Energy Commission (AEC) contracted with Carborundum Metals Co., Akron, NY, to supply the metal for 5 years. By 1955, the Carborundum plant was producing more sponge than was needed for the U.S. Navy's nuclear submarine program. At this time, the USBM's zirconium plant was converted to a metallurgical research facility. From 1959 to 1977, the price of zirconium sponge remained fairly stable, averaging from about $14 to $17 per kilogram ($31-$37 per pound). The decline was also attributed to the slowing of the nuclear submarine program and the use of substitute materials for commercial powerplants. Beginning in 1978, prices for zirconium sponge increased, following the pattern of zirconium powder. The substantial price increase has been attributed primarily to the U.S. economy because lagging U.S. economic activity and double-digit inflation increased operating costs throughout the industry. The twofold price increase for zirconium sponge may have been associated with the 50% reduction in capacity by the sole domestic producer, the cost of implementing process environmental controls to regulate naturally occurring radioactive materials, and the continued demand for replacement fuel cladding and structural repairs at nuclear powerplants (Templeton, 1993).

In the 1980's and 1990's, the use of zirconium sponge in military and commercial nuclear powerplants, heat exchangers, and specialty chemical piping for corrosive environments eventually overshadowed the use of the metal in powder and crystal bar applications (Hedrick, 1989). With no new domestic construction of nuclear powerplants, demand for zirconium metal is expected to remain stable.

Zirconium Powder

In 1932, the price quoted for powdered metal of 98% purity was $13.23 per kilogram ($6 per pound) or less, depending on the quantity. The price remained stable throughout the next two decades, and the uses of the powder expanded to include applications in the ceramic, glass, and steel industries. The price for powdered zirconium declined to a record low of $8.82 per kilogram ($4 per pound) by 1957 as the Kroll process was commercialized and the demand and scale of operations increased. Increases in production and demand for zirconium sponge in the 1950's also probably contributed to the decline in the price of powder during this period. Beginning in 1977, prices for zirconium metal were tied to many factors, including the U.S. economy, as lagging U.S. economic activity and double-digit inflation increased operating costs throughout the industry. Increased energy costs were also a factor for the substantial price increases for zirconium powder and sponge. During the late 1970's, the number of zirconium powder producers declined to one for a short time, and requirements for high-grade powder started to increase. These events, including the development of the hydrogen embrittlement technique (hydride-dehydride

process) to facilitate the conversion of sponge to powder and improved demand for replacement fuel cladding and structural repairs at nuclear powerplants, contributed to the increasing prices during this period.

Prices for zirconium powder stabilized during the 1980's and 1990's as market growth decreased and demand leveled off.

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Yearend Zirconium Sponge Metal Price

(Dollars per kilogram[1])

Year	Price	Year	Price	Year	Price	Year	Price
1959	13.78	1969	13.78	1979	23.15	1989	33.07
1960	14.05	1970	13.78	1980	26.46	1990	23.15
1961	13.78	1971	13.78	1981	31.97	1991	23.15
1962	13.50	1972	13.78	1982	31.97	1992	23.15
1963	16.53	1973	13.78	1983	31.97	1993	23.15
1964	16.53	1974	13.78	1984	31.97	1994	23.15
1965	16.53	1975	13.78	1985	31.97	1995	23.15
1966	16.53	1976	13.78	1986	31.97	1996	23.15
1967	16.53	1977	15.98	1987	31.97	1997	23.15
1968	13.23	1978	26.46	1988	33.07	1998	23.15

[1] Prices are an average of a range and converted from dollars per pound.

Sources: American Metal Market (1959-62, 1969-98), Engineering & Mining Journal (1963-67), and Wah Chang Albany Corp., Albany, OR (1968).

Yearend Zirconium Powder Metal Price

(Dollars per kilogram[1])

Year	Price	Year	Price	Year	Price	Year	Price
1959	8.82	1969	27.56	1979	187.39	1989	242.51
1960	8.82	1970	27.56	1980	220.46	1990	248.02
1961	8.82	1971	27.56	1981	206.68	1991	248.02
1962	22.05	1972	22.05	1982	206.68	1992	248.02
1963	22.05	1973	22.05	1983	206.68	1993	248.02
1964	22.05	1974	35.27	1984	248.02	1994	248.02
1965	22.05	1975	35.27	1985	248.02	1995	248.02
1966	22.05	1976	35.27	1986	248.02	1996	248.02
1967	22.05	1977	187.39	1987	231.49	1997	248.02
1968	22.05	1978	187.39	1988	242.51	1998	248.02

[1] Prices are an average of a range and converted from dollars per pound.

Source: American Metal Market.