MOLYBDENUM

By John W. Blossom

Molybdenum is a refractory metallic element used principally as an alloying agent in steels, cast irons, and superalloys to enhance hardenability, strength, toughness, and wear and corrosion resistance. Primarily added in the form of molybdic oxide or ferromolybdenum, it is frequently used in combination with chromium, columbium, manganese, nickel, tungsten, or other alloy metals to achieve desired metallurgical properties. The versatility of molybdenum has ensured it a significant role in contemporary industrial technology, which increasingly requires materials that are serviceable under higher stresses, greater temperature ranges, and more corrosive environments. Moreover, molybdenum finds significant usage as a refractory metal in numerous chemical applications, including catalysts, lubricants, and pigments. The variety of uses for molybdenum materials, few of which afford acceptable substitutions, has resulted in a demand that is expected to grow at a greater rate than most other ferrous metals.

Distribution of molybdenum reserves and productive capacity is concentrated in a few countries of the world. World mine output was an estimated 126,000 metric tons (molybdenum contained in concentrate) in 1995, of which Canada, Chile, China, and the United States provided 85%. These four countries, led by the United States, are expected to continue as the principal mine producers for the rest of this century. These countries also possess about 90% of the estimated 12 million metric tons of molybdenum in world reserve base.

The metric system is the official system of measurement of most countries. The U.S. Geological Survey (USGS), in an effort to provide statistical data on molybdenum that are consistent with international usage, reports data in kilograms and metric tons.

Domestic production data for molybdenum are developed by the USGS by means of three separate, voluntary surveys. These surveys are Molybdenum Ore and Concentrate (annual), Molybdenum Concentrate (monthly), and Molybdenum Products and Molybdenum Concentrates (monthly). Surveys are sent to all operations that produce molybdenum ore and products. Out of 14 operations to which surveys were sent, all responded, representing 100% of the total U.S. production shown in table 1.

Domestic mine production of molybdenum concentrate increased to a total of 60,900 tons of contained molybdenum compared with 46,800 tons in 1994. This production was about 49% of world production. World mine production of molybdenum concentrate increased from a total of 105,000 tons in 1994 to 126,000 tons in 1995. Production of molybdenum products increased 48% in 1995. *(See tables 1, 2, and 3.)*

Consumption

Consumption of molybdenum concentrate decreased 3,500 tons in 1995. Domestic mine production of molybdenum concentrate was either roasted, exported for conversion, or purified to lubrication-grade molybdenum disulfide. The consumption in 1995 of technical-grade molybdic oxide increased about 8% from that of 1994. Oxide is the chief form of molybdenum utilized by industry, particularly in stainless and alloy steels, cast irons, and superalloys. However, some of the material is also converted to other molybdenum products, such as ferromolybdenum, high-purity oxide, ammonium and sodium molybdate, and metal power. *(See table 1.)*

Stocks

Total industry stocks, which include those of producers and consumers, increased by about 900 tons of contained molybdenum. Inventories of molybdenum in concentrate at producer locations decreased about 120 tons. Producer stocks of molybdenum in products, such as oxide, ferromolybdenum, molybdate, metal powers, and other types, increased by about 880 tons. Domestic end use consumer stocks of molybdenum increased 130 tons from that in 1994. Inventories of 2,210 tons represented approximately a 10-week supply as measured by the average monthly reported consumption.

Prices

Prices are from Platt's Metals Week and are in U.S. dollars per kilogram of contained molybdenum. The prices at the beginning of 1995 were: molybdenum concentrates (MoCons), $8.708; molybdic oxide (MoX), $34.172; and ferromolybdenum (Femo), $30.865. The prices at the beginning of the second quarter were: MoCons, $8,708; MoX, $14.872; and Femo, $25.133. The prices at the start of the third quarter were: MoCons, $11.850; MoX, $12.677; and Femo, $17,196. The prices at the start of the fourth quarter were MoCons, $6.173; MoX, $9.370; and Femo $16.810. The prices at the end of the fourth quarter were: MoCons, $6.173; MoX, $9.920; and Femo, $14.606. The average prices for 1995 were: MoCons, $8.273; MoX, $17.467; and Femo, $21.176.

Foreign Trade

Export of molybdenum in concentrate and in molybdic oxide increased about 33% when compared with those of 1994.

Molybdenum concentrate exports were about 73% of domestic mine production. Approximately 92% of reported exports of concentrate and oxides was made by Belgium, Canada, Chile, Japan, the Netherlands, and the United Kingdom. The calculated molybdenum content of all exports was about 51,300 tons in 1995. Total value of exports increased from $247 million in 1994 to $707 million in 1995.

Approximately 106,000 tons of molybdenum in various forms was imported into the United States, about 4,000 tons more than in 1994. Total value of all forms of molybdenum imported increased from $59 million in 1994 to $187 million in 1995. In terms of value, the major form imported was ferromolybdenum. (See tables 5, 6, and 7.)

World Review

Capacity.—The rated capacity for mines and mills as of December 31, 1995, was 125,000 tons per year of contained metal. Rated capacity is defined as the maximum quantity of product that can be produced in a period of time on a normally sustainable long-term operating rate, based on the physical equipment of the plant, and given acceptable routine operating procedures involving labor, energy, materials, and maintenance. Capacity includes both operating plants and plants temporarily closed that, in the judgement of the author, can be brought into production within a short period of time with minimum capital expenditure. Mine capacity for molybdenum is based on published reports, production statistics, and estimates.

Reserves.—The definitions of reserves and reserve base are published in U.S. Geological Survey Circular 831, "Principles of a Resource/Reserve Classification for Minerals," which is reprinted in the USGS/USBM Mineral Commodity Summaries, 1996.

The United States, with a reserve base of molyddenum estimated at 5.4 million tons, has 45% of the world molybdenum reserve base. About 90% of U.S. reserves occur in large porphyry or disseminated deposits mined, or anticipated to be mined, primarily for molybdenum. These deposits are in Alaska, Colorado, Idaho, Nevada, New Mexico, and Utah. Other molybdenum sources contribute insignificantly to U.S. reserves.

Canadian reserves of primary molybdenum are in British Columbia, including 30% of the total in the Endako deposit. Other Canadian reserves are associated with molybdenum and copper-molybdenum porphyry deposits in British Columbia and in relatively minor sources in New Brunswick and Quebec.

Molybdenum reserves in Central America and South America are mainly with large porphyry copper deposits. Of several such deposits in Chile, the Chuquicamata and El Teniente deposits are among the world's largest and account for 85% of total molybdenum reserves in Chile. Mexico and Peru have substantial reserves. The La Caridad deposit in Mexico is a large producer. Numerous other porphyry copper deposits that may contain recoverable quantities of molybdenum have been identified in Central America and South America. Many of these deposits are actively being explored and evaluated and could add substantially to reserves in the future.

Reserves of molybdenum in China and the former Soviet Union are estimated to be substantial, but definitive information about the current sources of supply or prospects for future development in the two countries is lacking.

Outlook

The world demand for molybdenum contained in alloy and stainless steel and also for chemicals/catalysts is expected to decrease about 5% in 1996. It is estimated that the demand in 1997 will be about the same as in 1996. Projecting into 1998, molybdenum demand may see a slight increase.

OTHER SOURCES OF INFORMATION

U.S. Geological Survey Publications

King, R.U., Shaine, D. R., and Mackevett, E.M., Jr., 1973, Molybdenum in Brobst, D. A., and Pratt, W.P., United States mineral resources: U.S. Geological Survey Professional Paper 820, p. 425-435.

Molybdenum. Ch in Mineral Commodity Summaries, annual.

Molybdenum. Ch. in Mineral Yearbook, annual.

Molybdenum. Reported monthly and annually in Mineral Industry surveys.

Other Sources

American Bureau of Metal Statistics. Nonferrous Metal Data.

American Metal Market (daily paper).

Canadian Mining Journal (Canada). Annual reports of various companies.

Engineering and Mining Journal.

Metal Bulletin (London).

Metals Week.

Mining Congress Journal.

Mining Engineering.

Mining Journal (London).

Skillings Mining Review.

The Northern Miner (Canada).

TABLE 1
SALIENT MOLYBDENUM STATISTICS 1/

(Metric tons of contained molybdenum unless otherwise specified)

	1991	1992	1993	1994	1995
United States:					
Concentrate:					
Production	53,400	49,700	36,800	46,800	60,900
Shipments	53,600	45,100	39,200	46,000	61,700
Value thousands	$250,000	$190,000	$165,000	$284,000	$651,000
Reported consumption	33,000	15,200	13,800	17,200	13,700
Imports for consumption	161	831	3,400	2,280	5,570
Stocks, Dec. 31:					
Concentrate, mine and plant	5,290	11,900	11,200	5,510	5,390
Product producers 2/	9,420	7,480	6,150	3,940	4,820
Consumers, by end use	2,590	2,500	2,520	2,080	2,210
Total	17,300	21,900	19,900	11,500	12,400
Primary products:					
Production	33,700	26,000	22,700	31,100	46,000
Shipments	19,100	17,300	16,000	21,400	24,000
Reported consumption, by end use	16,900	17,200	17,700	19,100 r/	20,200
World: Mine production	115,000	108,000	94,000 r/	105,000 r/	126,000 e/

e/ Estimated. r/ Revised.

1/ Data are rounded to three significant digits; may not add to totals shown.

2/ Includes technical and purified molybdic oxide, briquets, ferromolybdenum, phosphomolybdic acid, molybdenum disulfide, molybdic acid, ammonium molybdate, sodium molybdate, calcium molybdate, molybdenum metal, pellets, molybdenum pentachloride, and molybdenum hexacarbonyl.

TABLE 2
PRODUCTION, SHIPMENTS, AND STOCKS OF MOLYBDENUM PRODUCTS IN THE UNITED STATES 1/

(Metric tons of contained molybdenum)

	Metal powder		Other 2/		Total	
	1994	1995	1994	1995	1994	1995
Received from other producers	--	--	4,030	3,380	4,030	3,380
Gross production during year	2,570	4,680	28,600	41,300	31,100	46,000
Molybdenum products used to make other products	1,500	2,710	13,600	20,400	15,100	23,100
Net production	1,070	1,070	14,900	20,900	16,000	22,000
Shipments	214	452	21,200	23,500	21,400	24,000
Producer stocks, Dec. 31	124	221	3,820	4,590	3,940	4,820

1/ Data are rounded to three significant digits; may not add to totals shown.

2/ Includes ferromolybdenum, molybdic oxides, phosphomolybdic acid, molybdenum disulfide, molybdic acid, ammonium molybdate, calcium molybdate, sodium molybdate, molybdenum metal, pellets, molybdenum pentachloride, and molybdenum hexacarbonyl.

TABLE 3
MOLYBDENUM: WORLD MINE PRODUCTION, BY COUNTRY 1/ 2/

(Metric tons of contained molybdenum)

Country 3/	1991	1992	1993	1994	1995 e/
Armenia e/	XX	1,000	500	500	800
Bulgaria 4/	-- r/	-- r/	-- r/	-- r/	--
Canada	11,329	9,405	9,700	10,250 r/	9,536 5/
Chile	14,434	14,840	14,899	16,028	17,889 5/
China e/	13,200	19,200	18,300	17,500	17,500
Iran	395	1,320 r/	1,000 e/	1,000 e/	1,200
Kazakstan e/	XX	700	600	500	700
Korea, Republic of	144	5 r/	--	2 r/	2
Mexico	1,716	1,458	1,705	2,610	3,810 5/
Mongolia	1,716	1,610 r/	2,050 r/	2,100 r/	1,830 5/
Niger e/	10	--	--	--	--
Peru	3,030	3,220	2,980	2,765 r/	3,630 5/
Russia e/	XX	5,000	4,800	4,500	7,300
U.S.S.R. e/ 6/	16,000	XX	XX	XX	XX
United States	53,400	49,700	36,800	46,800	60,900 5/
Uzbekistan e/	XX	700	700	700	500
Total	115,000	108,000	94,000 r/	105,000 r/	126,000

e/ Estimated. r/ Revised. XX Not applicable.

1/ World totals, U.S. data, and estimated data are rounded to three significant digits; may not add to totals shown.

2/ Table includes data available through July 12, 1996.

3/ In addition to the countries listed, North Korea, Romania, and Turkey are believed to produce molybdenum but output is not reported quantitatively, and available general information is inadequate to make reliable estimates of output levels.

4/ Molybdenum not recovered.

5/ Reported figure.

6/ Dissolved in Dec. 1991.

TABLE 4
U.S. REPORTED CONSUMPTION OF MOLYBDENUM, BY END USE 1/

(Kilograms, contained molybdenum)

End use	Molybdic oxides	Ferro-molybdenum 2/	Ammonium and sodium molybdate	Molybdenum scrap	Other 3/	Total
1994:						
Steel:						
Carbon	668,000	303,000	--	--	76,900	1,050,000
Stainless and heat-resisting	3,310,000	550,000 r/	--	--	65,700 r/	3,920,000 r/
Full alloy	2,460,000	1,180,000	--	--	31,300	3,670,000
High-strength low-alloy	518,000	307,000	--	--	--	825,000
Tool	788,000	129,000	--	--	18,400	935,000
Cast irons	199,000	773,000	--	--	14,200	986,000
Superalloys	W	47,600	--	W	618,000	666,000
Alloys:						
Welding materials (structural and hard facing)	--	88,200	--	--	6,900	95,100
Other alloys 4/	W	52,900	--	W	W	52,900 r/
Mill products made from metal powder	W	W	--	--	1,630,000	1,630,000
Chemical and ceramic uses:						
Pigments	W	--	W	--	--	W
Catalysts	1,710,000	--	W	--	W	1,710,000
Other	W	--	W	--	8,700 r/	8,700 r/
Miscellaneous and unspecified	1,100,000 r/	23,100 r/	1,280,000	481,000	683,000 r/	3,570,000 r/
Total	10,800,000 r/	3,450,000 r/	1,280,000	481,000	3,150,000 r/	19,100,000 r/
1995:						
Steel:						
Carbon	631,000	301,000	--	--	76,500	1,010,000
Stainless and heat-resisting	3,230,000	344,000	--	--	74,800	3,650,000
Full alloy	2,740,000	1,190,000	--	--	45,200	3,970,000
High-strength low-alloy	540,000	323,000	--	--	--	862,000
Tool	1,080,000	W	--	--	W	1,080,000
Cast irons	180,000	835,000	--	--	37,300	1,050,000
Superalloys	930,000	W	--	W	622,000	1,550,000

See footnotes at end of table.

TABLE 4--Continued
U.S. REPORTED CONSUMPTION OF MOLYBDENUM, BY END USE 1/

(Kilograms, contained molybdenum)

End use	Molybdic oxides	Ferro-molybdenum 2/	Ammonium and sodium molybdate	Molybdenum scrap	Other 3/	Total
1995--Continued:						
Alloys:						
Welding materials (structural and hard facing)	--	86,600	--	--	5,850	92,400
Other alloys 4/	W	W	--	W	W	W
Mill products made from metal powder	--	W	--	--	2,200,000	2,200,000
Chemical and ceramic uses:						
Pigments	152	--	W	--	--	152
Catalysts	1,710,000	--	W	--	W	1,710,000
Other	10,700	--	W	--	W	10,700
Miscellaneous and unspecified	245,000	391,000	1,260,000	451,000	703,000	3,050,000
Total	11,300,000	3,470,000	1,260,000	451,000	3,770,000	20,200,000

r/ Revised. W Withheld to avoid disclosing company proprietary data; included with "Miscellaneous and unspecified."

1/ Data are rounded to three significant digits; may not add to totals shown.

2/ Includes calcium molybdate.

3/ Includes purified molybdenum disulfide, molydenite concentrate added directly to steel, molybdenum metal powder, molybdenum metal, pellets and other molybdenum materials.

4/ Includes magnetic and nonferrous alloys.

TABLE 5
U.S. EXPORTS OF MOLYBDENUM PRODUCTS, BY PRODUCT AND COUNTRY 1/

Product and country	HTS No.	1994 Quantity (metric tons)	1994 Value (thousands)	1995 Quantity (metric tons)	1995 Value (thousands)
Oxides and hydroxides, gross weight:	2825.70.0000				
Belgium		164	$787	133	$2,070
Brazil		34	168	1	16
Canada		414	3,330	1,160	12,800
China		183	429	--	--
India		38	154	2	28
Japan		505	3,380	345	6,360
Korea, Republic of		--	--	3	28
Mexico		10	278	121	2,700
Netherlands		558	3,330	909	15,700
Netherlands Antilles		109	821	--	--
Spain		--	--	153	2,210
United Kingdom		225	1,030	--	--
Venezuela		(2/)	9	7	120
Other		--	--	9	142
Total		2,240	13,700	2,840	42,200
Molybdates all, contained weight:	2841.70.0000				
Canada		437	2,200	377	2,640
Honduras		5	33	2	28
Jamaica		1	8	--	--
Japan		156	751	144	2,810
Korea, Republic of		113	552	110	1,800
Mexico		45	300	58	328
Netherlands		779	5,170	1,220	26,300
Netherlands Antilles		178	658	--	--
Philippines		12	18	--	--
Singapore		1	9	28	153
South Africa		--	--	18	183
Taiwan		66	234	23	193
Thailand		6	44	1	38
Venezuela		--	--	116	389
Other		3	15	73	1,070
Total		1,800	10,000	2,170	36,000

See footnotes at end of table.

TABLE 5--Continued
U.S. EXPORTS OF MOLYBDENUM PRODUCTS, BY PRODUCT AND COUNTRY 1/

Product and country	HTS No.	1994 Quantity (metric tons)	1994 Value (thousands)	1995 Quantity (metric tons)	1995 Value (thousands)
Ferromolybdenum, contained weight: 3/	7202.70.0000				
Argentina		17	$179	--	--
Canada		113	1,260	357	$3,740
Japan		93	1,090	177	2,300
Malaysia		6	92	144	1,270
Mexico		152	1,350	325	4,040
Netherlands		56	452	122	1,880
Singapore		12	338	--	--
Spain		--	--	36	580
Taiwan		28	408	80	710
Venezuela		2	26	4	39
Other		(2/)	6	5	75
Total		479	5,200	1,250	14,600
Powder, gross weight:	8102.10.0000				
Belgium		13	443	--	--
Brazil		3	106	7	286
Canada		7	231	18	405
France		14	432	11	418
Germany		7	391	95	3,200
India		16	268	32	957
Italy		1	58	80	3,610
Japan		11	232	--	--
Mexico		9	284	6	271
Netherlands		3	117	3	134
Spain		2	123	3	186
Sweden		5	77	28	859
Switzerland		5	110	--	--
Taiwan		66	1,250	1	48
Turkey		(2/)	12	--	--
United Kingdom		3	113	13	439
Other		3	78	4	286
Total		168	4,320	301	11,100
Molybdenum unwrought, gross weight:	8102.91.0000				
Australia		10	102	--	--
Austria		38	598	58	927
Canada		23	403	31	702
China		--	--	62	633
France		4	117	--	--
Germany		--	--	30	579
Hong Kong		6	72	--	--
India		2	22	7	183
Japan		85	1,050	375	4,550
Korea, Republic of		3	51	--	--
Mexico		1	35	--	--
Netherlands		170	2,020	37	1,780
Netherlands Antilles		36	290	--	--
Sweden		9	71	--	--
United Kingdom		9	141	8	115
Other		(2/)	15	14	296
Total		396	4,980	622	9,760
Molybdenum wrought, gross weight:	8102.92.0000				
Brazil		2	82	1	50
Canada		9	409	18	795
France		18	782	11	569
Germany		3	283	5	480
India		1	114	--	26
Italy		1	80	--	17
Japan		34	2,510	72	6,970
Korea, Republic of		2	220	3	217
Mexico		1	125	--	70
Netherlands		1	20	--	78
United Kingdom		26	1,190	62	2,840
Other		3	245	2	569
Total		101	6,050	174	12,700

See footnotes at end of table.

TABLE 5--Continued
U.S. EXPORTS OF MOLYBDENUM PRODUCTS, BY PRODUCT AND COUNTRY 1/

Product and country	HTS No.	1994 Quantity (metric tons)	1994 Value (thousands)	1995 Quantity (metric tons)	1995 Value (thousands)
Wire, gross weight:	8102.93.0000				
Argentina		3	$130	--	$29
Belgium		1	50	1	123
Brazil		21	744	27	1,220
Canada		2	105	4	228
Czech Republic		3	85	--	--
France		25	911	28	1,510
Germany		51	1,890	56	3,250
Hungary		31	1,790	44	2,840
India		11	673	10	756
Italy		13	544	19	1,080
Japan		12	747	24	1,830
Korea, Republic of		14	621	14	963
Mexico		6	501	2	212
Netherlands		1	14	--	--
Poland		1	47	--	--
Singapore		3	102	4	205
Spain		5	155	1	72
Sweden		5	162	23	1,330
Taiwan		7	301	17	1,030
United Kingdom		5	239	10	427
Other		2	234	7	631
Total		221	10,000	291	17,700

1/ Data are rounded to three significant digits; may not add to totals shown.
2/ Less than 1/2 unit.
3/ Ferromolybdenum contains about 60% to 65% molybdenum.

Source: Bureau of the Census.

TABLE 6
U.S. EXPORTS OF MOLYBDENUM ORE AND CONCENTRATES (INCLUDING ROASTED AND OTHER CONCENTRATES), BY COUNTRY 1/

(Metric tons)

	1994		1995	
Country	Quantity (contained molybdenum)	Value (thousands)	Quantity (contained molybdenum)	Value (thousands)
Argentina	1	$6	--	--
Australia	23	118	65	$597
Austria	11	80	--	--
Belgium	11,500	78,300	10,300	123,000
Brazil	445	3,030	157	2,740
Canada	1,300	7,070	759	8,640
Chile	2,160	11,900	6,290	59,400
China	224	800	--	--
Germany	635	3,820	769	12,000
India	127	781	--	--
Italy	78	640	137	1,950
Japan	3,860	24,800	5,490	86,300
Korea, Republic of	7	41	2	3
Malta	53	198	--	--
Mexico	519	6,410	4,040	40,200
Netherlands	8,670	35,300	11,200	153,000
Netherlands Antilles	554	2,910	--	--
Russia	53	1,160	--	--
Singapore	2	13	--	--
Sweden	107	581	630	9,520
Switzerland	16	249	32	680
United Kingdom	3,290	21,000	4,740	64,700
Other	--	--	14	199
Total	33,600	199,000	44,600	563,000

1/ Data are rounded to three significant digits; may not add to totals shown.

Source: Bureau of the Census.

TABLE 7
U.S. IMPORTS FOR CONSUMPTION OF MOLYBDENUM 1/

		1994			1995		
Item	HTS No.	Gross weight (metric tons)	Contained molybdenum	Value (thousands)	Gross weight (metric tons)	Contained molybdenum	Value (thousands)
Molybdenum ore and concentrates, roasted	2613.10.0000	3,110	1,870	$12,700	7,440	4,780	$73,000
Molybdenum ore and concentrates, other	2613.90.0000	682	411	3,190	1,500	793	7,990
Molybdenum oxides and hydroxides	2825.70.0000	628	NA	3,950	918	NA	11,200
Molydates of ammonium	2841.70.0000	608	321	2,340	345	185	2,810
Molybdates all others	2841.70.5000	76	41	288	673	NA	2,250
Molybdenum orange	3206.20.0000	616	NA	1,880	(2/)	(2/)	127
Mixtures of inorganic compounds	3823.90.3400	3	2	235	--	--	--
Ferromolybdenum	7202.70.0000	4,590	2,960	23,200	6,550	4,190	73,700
Molybdenum powders	8102.10.0000	113	89	2,770	195	146	5,470
Molybdenum unwrought	8102.91.1000	70	52	1,060	131	102	3,430
Molybdenum waste and scrap	8102.91.5000	791	777	6,560	453	429	6,230
Molybdenum wire	8102.93.0000	2	NA	304	(2/)	NA	271
Molybdenum other	8102.99.0000	5	NA	738	3	NA	970
Total		11,300	6,520	59,300	18,200	10,600	187,000

NA Not available.
1/ Data are rounded to three significant digits; may not add to totals shown.
2/ Less than 1/2 unit.

Source: Bureau of the Census.