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. To achieve desired metallurgical properties, molybdenum, primarily in the form of molybdic oxide or ferromolybdenum, is frequently used in combination with/added to chromium, columbium, manganese, nickel, tungsten, or other alloy metals. 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 128,000 metric tons (molybdenum contained in concentrate), of which Canada, Chile, China, and the United States provided 65%. These four countries, led by the United States, are expected to continue to be 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.

Domestic production data for molybdenum are derived 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. All 14 operations to which surveys were sent responded, representing 100% of the total U.S. production shown in table 1.

Domestic mine production of molybdenum concentrate decreased to 54,900 tons of contained molybdenum, compared with 60,900 tons in 1995. This production was about 43% of world production. World mine production of molybdenum concentrate decreased from a total of 141,000 tons in 1995 to 128,000 tons. Production of molybdenum products was the same as in 1995. *(See tables 1, 2, and 3.)*

Consumption

Consumption of molybdenum concentrate decreased by 1,000 tons. Domestic mine production of molybdenum concentrate was either roasted, exported for conversion, or purified to lubrication-grade molybdenum disulfide. The consumption in 1996 of technical-grade molybdic oxide increased about 3% from that of 1995. Oxide is the chief form of molybdenum used by industry, particularly in stainless and alloy steel, cast irons, and superalloys. Some of the material is, however, also converted to other molybdenum products, such as ferromolybdenum, high-purity oxide, ammonium and sodium molybdate, and metal powder. *(See table 2.)*

Stocks

Total industry stocks, which include those of producers and consumers, decreased by about 1,600 tons of contained molybdenum. Inventories of molybdenum in concentrate at producer locations decreased about 2,920 tons. Producer stocks of molybdenum in products, such as oxide, ferromolybdenum, molybdate, metal powders, and other types, increased by about 960 tons. Domestic end-use consumer stocks of molybdenum increased 310 tons from that of 1995. Inventories of 10,800 tons represented about a 28-week supply, as measured by reported consumption.

Prices

Prices are from Platt's Metals Week (1996) and are in U.S. dollars per kilogram of contained molybdenum. The prices at the beginning of 1996 were molybdenum concentrates (MoCons), $6.172; molybdic oxide (MoX), $9.590; and ferromolybdenum (Femo), $12.952. The prices at the beginning of the second quarter were MoCons, $4.684; MoX, $8.157; and Femo, $11.574. The prices at the start of the third quarter were MoCons, $4.409; MoX, $7.385; and Femo, $10.251. The prices at the start of the fourth quarter were MoCons, $6.062; MoX, $11.574; and Femo, $12.456. The prices at the end of the fourth quarter were MoCons, $4.960; MoX, $9.479; and Femo, $11.464. The average prices were MoCons, $5.026; MoX, $8.291; and Femo, $11.248.

Foreign Trade

Exports of molybdenum in concentrate and in molybdic oxide were about the same as those of 1995; molybdenum concentrate exports were about 82% of domestic mine production. About 96% of reported exports went to Belgium, Chile, China, Japan, Mexico, the Netherlands, and the United Kingdom. The calculated molybdenum content of all exports was about 49,700 tons. Total value of exports decreased from $707 million in

1995 to $301 million.

About 20,700 tons of molybdenum in various forms were imported into the United States, about 2,400 tons more than in 1995. Total value of all forms of molybdenum imported decreased from $188 million in 1995 to $132 million. In terms of value, the major form imported was ferromolybdenum. *(See tables 5, 6, and 7.)*

World Review

Capacity.—As of December 31, 1996, the rated capacity for mines and mills 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 operating plants and plants temporarily closed that, in the judgment of the author, can be brought into production within a short period of time with minimum capital expenditure.

Reserves.—With a reserve base of molybdenum estimated at 5.4 million tons, the United States has 45% of the world molybdenum reserve base. About 90% of U.S. reserves are 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.

Most Canadian reserves of molybdenum are in British Columbia. Other Canadian reserves are associated with molybdenum and copper-molybdenum porphyry deposits in British Columbia and with minor sources in New Brunswick and Quebec.

Molybdenum reserves in Central America and South America are associates mainly with large copper porphyry deposits. Of several such deposits in Chile, the Chuquicamata and the El Teniente deposits are among the world's largest and account for 85% of total reserves in Chile. Mexico and Peru have substantial reserves. The La Caridad deposit in Mexico is a large producer. Numerous other copper porphyries that may contain recoverable quantities of molybdenum have been identified in Central America and South America. Many of these deposits are being actively explored and evaluated and could substantially add 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 increase about 3% in 1997. It is estimated that the demand in 1998 will be about the same as in 1997.

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[1]Prior to January 1996, published by the U.S. Bureau of Mines.

TABLE 1
SALIENT MOLYBDENUM STATISTICS 1/

(Metric tons of contained molybdenum unless otherwise specified)

	1992	1993	1994	1995	1996
United States:					
Concentrate:					
Production	49,700	36,800	46,800	60,900	54,900
Shipments	43,100 r/	39,200	40,000 r/	61,700	57,900
Value thousands	$190,000	$165,000	$284,000	$651,000	$456,000
Reported consumption	15,200	13,800	17,200	25,500 r/	24,500
Imports for consumption	831	3,400	2,280	5,570	5,480
Stocks, Dec. 31:					
Concentrate, mine and plant	11,900	11,200	5,510	5,390	2,470
Product producers 2/	7,480	6,150	3,940	4,820	5,780
Consumers, by end use	2,500	2,510 r/	2,080	2,210	2,520
Total	21,900	19,900	11,500	12,400	10,800
Primary products:					
Production	26,000	22,700	31,100	46,000	46,300
Shipments	17,300	16,000	21,400	24,000	24,100
Reported consumption, by end use	17,200	17,700	19,100	19,900 r/	20,300
World: Mine production	114,000 r/	99,500 r/	112,000 r/	141,000 r/	128,000 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)

	1995	1996	1995	1996	1995	1996
	Metal powder		Other 2/		Total	
Received from other producers	--	--	3,380	4,140	3,380	4,140
Gross production during year	4,680	4,830	41,300	41,500	46,000	46,300
Molybdenum products used to make other products	2,710	2,850	20,400	21,000	23,100	23,900
Net production	1,970 r/	1,970	20,900	20,400	22,900 r/	22,400
Shipments	452	481	23,500	23,600	24,000	24,100
Producer stocks, Dec. 31	221	223	4,590	5,560	4,820	5,780

r/ Revised.

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/	1992	1993	1994	1995	1996 e/
Armenia e/	1,000	500	500	800	900
Canada	9,405	9,700	10,250	9,113 r/	8,845 p/
Chile	14,500 r/	14,899	16,028	17,889	18,000
China e/	19,200	18,300	21,400 r/	32,000 r/	25,000
Iran e/	1,320 4/	1,000	1,000	1,200	1,200
Kazakstan e/	700	600	500	700	800
Korea, Republic of	5	--	2	-- r/	--
Mexico	1,458	1,705	2,610	3,810	3,900
Mongolia	1,610	2,050	2,100	1,830	2,200 4/
Peru	3,220	2,980	2,765	3,411 r/	3,711 4/
Russia e/	10,800 r/	10,300 r/	7,700 r/	8,800 r/	8,500
United States	49,700	36,800	46,800	60,900	54,900 4/
Uzbekistan e/	700	700	700	500	500
Total	114,000 r/	99,500 r/	112,000 r/	141,000 r/	128,000

e/ Estimated. p/ Preliminary. r/ Revised.

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 June 13, 1997.

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/ Reported figure.

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	Molyb-denum scrap	Other 3/	Total
1995:						
Steel:						
Carbon	604,000 r/	301,000	--	--	76,500	982,000 r/
Stainless and heat-resisting	3,230,000	344,000	--	--	74,800	3,650,000
Full alloy	2,450,000 r/	1,180,000 r/	--	--	45,200	3,680,000 r/
Electrical	--	W	--	--	--	W
High-strength, low-alloy	628,000 r/	298,000 r/	--	--	--	926,000 r/
Tool	1,080,000	W	--	--	28,600	1,110,000
Unspecified steel	W	W	--	--	2,100	2,100
Cast irons	214,000 r/	772,000 r/	--	--	14,100 r/	1,000,000 r/
Superalloys	W r/	W	--	W	547,000 r/	547,000 r/
Alloys:						
Welding materials (structural and hard facing)	--	86,600	--	W	6,770	93,300 r/
Other alloys 4/	W	W	--	--	79,000	79,000 r/
Mill products made from metal powder	--	W	--	--	2,200,000	2,200,000
Chemical and ceramic uses:						
Pigments	W	--	W	--	--	W
Catalysts	1,710,000	--	W	--	179,000	1,890,000
Other	W	--	W	--	290,000	290,000 r/
Miscellaneous and unspecified	1,180,000 r/	387,000 r/	1,260,000	451,000	146,000 r/	3,430,000 r/
Total	11,100,000 r/	3,370,000 r/	1,260,000	451,000	3,690,000 r/	19,900,000 r/
1996:						
Steel:						
Carbon	597,000	316,000	--	--	76,500	990,000
Stainless and heat-resisting	3,460,000	343,000	--	--	77,600	3,880,000
Full alloy	2,740,000	1,540,000	--	--	46,300	4,320,000
Electrical	--	W	--	--	--	W
High-strength, low-alloy	470,000	377,000	--	--	--	848,000
Tool	1,080,000	89,600	--	--	32,200	1,200,000
Unspecified steel	W	24,900			1,370	26,200
Cast irons	177,000	905,000	--	--	27,800	1,110,000
Superalloys	W	57,000	--	W	479,000	536,000
Alloys:						
Welding materials (structural and hard facing)	--	88,700	--	W	6,320	95,000
Other alloys 4/	W	W	--	--	73,800	73,800
Mill products made from metal powder	--	W	--	--	2,050,000	2,050,000
Chemical and ceramic uses:						
Pigments	W	--	W	--	--	W
Catalysts	1,700,000	--	W	--	179,000	1,880,000
Other	W	--	W	--	305,000	305,000
Miscellaneous and unspecified	1,160,000	66,200	1,130,000	513,000	121,000	2,990,000
Total	11,400,000	3,810,000	1,130,000	513,000	3,480,000	20,300,000

r/ Revised. W Withheld to avoid disclosing company proprietary data; included in "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.	1995 Quantity (metric tons)	1995 Value (thousands)	1996 Quantity (metric tons)	1996 Value (thousands)
Oxides and hydroxides, gross weight:	2825.70.0000				
Belgium		133	$2,070	45	$398
Brazil		1	16	--	--
Canada		1,160	12,800	848	5,820
India		2	28	--	--
Japan		345	6,360	582	4,780
Korea, Republic of		3	28	--	--
Mexico		121	2,700	79	1,060
Netherlands		909	15,700	210	1,860
Spain		153	2,210	--	--
United Kingdom		--	--	21	77
Venezuela		8 r/	121 r/	--	--
Other		9	142	1	3
Total		2,840	42,200	1,790	14,000
Molybdates all, contained weight:	2841.70.0000				
Argentina		--	--	(2/)	3
Australia		9	301	11	135
Brazil		34	408	3	54
Canada		377	2,640	395	2,290
China		4	66	21	191
Colombia		9	92	16	100
Honduras		2	28	2	26
Japan		144	2,810	159	1,610
Korea, Republic of		111 r/	1,800	70	668
Mexico		59 r/	328	68	349
Netherlands		1,220	26,300	260	1,590
Singapore		28	153	8	49
South Africa		18	183	18	115
Taiwan		23	193	80	194
Thailand		1	39 r/	211	175
Venezuela		116	390 r/	--	--
Other		28 r/	217 r/	15	60
Total		2,180 r/	36,000	1,340	7,620
Ferromolybdenum, contained weight: 3/	7202.70.0000				
Australia		1 r/	25	--	--
Canada		214 r/	3,740	420	2,900
Japan		105 r/	2,300	214	1,870
Korea, Republic of		2 r/	30	3	40
Malaysia		22 r/	1,270	62	252
Mexico		201 r/	4,040	192	1,610
Netherlands		74 r/	1,880	--	--
Singapore		(4/)	(4/)	89	3,220
Spain		23 r/	581 r/	1	17
Taiwan		48 r/	710	--	--
Venezuela		3 r/	40 r/	1	12
Other		2 r/	22 r/	3	3
Total		695 r/	14,600	985	9,930
Powder, gross weight:	8102.10.0000				
Brazil		7	286	3	102
Canada		19 r/	405	5	171
France		11	419 r/	11	330
Germany		95	3,200	9	555
India		32	957	32	1,110
Italy		(2/) r/	39 r/	(2/)	46
Japan		81 r/	3,610	74	2,930
Mexico		6	272 r/	3	149
Netherlands		3	135 r/	--	--
Spain		3	187 r/	2	131
Sweden		28	860 r/	4	130
Switzerland		--	33 r/	--	--
Taiwan		1	49 r/	4	94
United Kingdom		13	439	6	430
Other		7 r/	218 r/	57	2,080
Total		306 r/	11,100	210	8,260

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.	1995 Quantity (metric tons)	1995 Value (thousands)	1996 Quantity (metric tons)	1996 Value (thousands)
Molybdenum unwrought, gross weight:	8102.91.0000				
Australia		--	--	9	$219
Austria		58	$927	12	191
Brazil		(2/)	6	30	510
Canada		32 r/	702	26	698
China		62	633	52	650
France		(2/)	12	23	404
Germany		31 r/	579	38	665
India		7	183	23	390
Japan		375	4,550	324	2,800
Korea, Republic of		(2/)	15	--	--
Mexico		1 r/	19 r/	6	52
Netherlands		38 r/	1,780	39	214
Sweden		--	--	(2/)	16
United Kingdom		8	115	13	266
Other		17 r/	250 r/	6	29
Total		629 r/	9,770 r/	601	7,110
Molybdenum wrought, gross weight:	8102.92.0000				
Brazil		1	50	3	119
Canada		18	795	24	859
France		11	569	8	493
Germany		5	480	3	394
India		(2/)	26	1	447
Italy		(2/)	17	(2/)	42
Japan		72	6,970	74	4,750
Korea, Republic of		3	217	8	634
Mexico		(2/)	70	1	137
Netherlands		(2/)	78	4	181
United Kingdom		62	2,840	47	2,420
Other		10 r/	563 r/	12	505
Total		182 r/	12,700	185	11,000
Wire, gross weight:	8102.93.0000				
Argentina		(2/)	29	(2/)	45
Belgium		1	123	(2/)	17
Brazil		27	1,220	32	1,640
Canada		4	229 r/	1	69
France		28	1,510	14	806
Germany		56	3,250	19	1,280
Hungary		44	2,840	36	4,030
India		10	756	9	587
Indonesia		2	138	2	110
Italy		19	1,080	8	443
Japan		24	1,830	14	1,160
Korea, Republic of		14	963	8	472
Mexico		2	212	1	137
Netherlands		(2/) r/	25 r/	--	--
Singapore		4	205	--	--
South Africa		3	200	1	60
Spain		1	72	1	67
Sweden		23	1,330	9	450
Taiwan		17	1,030	5	293
United Kingdom		10	427	5	349
Other		14 r/	263 r/	9	280
Total		303 r/	17,700	174	12,300

r/ Revised.
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.
4/ Revised to zero.

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)

Country	1995 Quantity (contained molybdenum)	1995 Value (thousands)	1996 Quantity (contained molybdenum)	1996 Value (thousands)
Australia	65	$597	61	$588
Belgium	10,300	123,000	12,400	48,200
Brazil	157	2,740	20	138
Canada	759	9,640 r/	268	1,880
Chile	6,290	59,400	6,990	35,400
China	--	--	1,290	4,480
Germany	769	12,000	505	2,800
India	--	--	59	262
Italy	137	1,960 r/	384	2,370
Japan	5,490	86,300	5,140	31,900
Korea, Republic of	(2/)	3	10	135
Mexico	4,040	40,200	5,500	22,700
Netherlands	11,200	153,000	5,890	36,600
Sweden	636 r/	9,530 r/	473	4,190
Switzerland	32	680	--	--
United Kingdom	4,740	64,700	6,010	40,100
Other	14	187 r/	26	131
Total	44,600	564,000 r/	45,000	232,000

r/ Revised.
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.

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

Item	HTS No.	1995 Gross weight (metric tons)	1995 Contained molybdenum	1995 Value (thousands)	1996 Gross weight (metric tons)	1996 Contained molybdenum	1996 Value (thousands)
Molybdenum ore and concentrates, roasted	2613.10.0000	7,430 r/	4,780	$73,000	8,090	5,460	$40,900
Molybdenum ore and concentrates, other	2613.90.0000	1,500	793	7,990	36	21	169
Molybdenum oxides and hydroxides	2825.70.0000	918	NA	11,200	1,160	NA	8,670
Molydates of ammonium	2841.70.0000	345	185	2,810	665	368	5,230
Molybdates all others	2841.70.5000	54 r/	42 r/	279 r/	83	36	486
Molybdenum orange	3206.20.0000	673 r/	NA	2,250	1,840	NA	5,670
Mixtures of inorganic compounds	3823.90.3400	1 r/	(2/) r/	128 r/	1	1	214
Ferromolybdenum	7202.70.0000	6,550	4,190	73,700	7,870	4,960	54,300
Molybdenum powders	8102.10.0000	195	146	5,470	125	110	3,360
Molybdenum unwrought	8102.91.1000	131	102	3,430	91	84	2,360
Molybdenum waste and scrap	8102.91.5000	453	429	6,230	693	640	9,480
Molybdenum wire	8102.93.0000	1 r/	NA	272 r/	2	NA	309
Molybdenum other	8102.99.0000	3	NA	970	4	NA	1,030
Total		18,300 r/	10,700 r/	188,000 r/	20,700	11,700	132,000

r/ Revised. 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.