CHROMIUM

By John F. Papp

In 1995, chromium apparent consumption was about 566,000 tons of contained chromium. U.S. supply consisted of recycled and imported chromium materials. The United States recycled about 663,000 tons, gross weight, of stainless steel scrap and imported about 829,000 tons of chromite ore, and chromium ferroalloys, chemicals, and pigments valued at about $545 million. The United States exported about 67,000 tons of chromium materials valued at about $83 million.

Because the United States has no chromite ore reserves and a limited reserve base, domestic supply has been a concern during every national military emergency since World War I. World chromite resources, mining capacity, and ferrochromium production capacity are concentrated in the Eastern Hemisphere. The National Defense Stockpile (NDS) contains chromium in various forms, including chromite ore, chromium ferroalloys, and chromium metal in recognition of the vulnerability of long supply routes during a military emergency. Recycling is the only domestic supply source of chromium. As a result of reduced threat to the territory of the United States, stockpile goals have been reduced and stockpiled materials are being sold. World chromite ore reserves are more than adequate to meet anticipated world demand.

Chromium is an essential trace element for human health. However, some chromium compounds are acutely toxic, chronically toxic, and/or carcinogenic. Chromium releases into the environment are regulated by the Environmental Protection Agency (EPA). Workplace exposure is regulated by the Occupational Safety and Health Administration.

Legislation and Government Programs

Congress, through the National Materials Advisory Board, assessed high-purity chromium metal.[1] The review was prompted by the fact that high-purity chromium metal is a critical alloying element in superalloys used in gas-turbine engines, and only one supplier of this material remains in the Western World (i.e., Elkem Metals Co.). The report found that supply was adequate and economically secure, and that the NDS was adequate to meet emergency demand. The review committee recommended that the Defense Logistics Agency (DLA) continually upgrade its stocks to meet industry standards, that no special supplier support program was necessary, and that industry make chromium-metal specifications independent from the production methodology. (As currently structured, the airplane manufacturing industry requires that only certified metals be used in engine manufacturing. Certification includes supplier, material sources, and processes. Thus, a supplier, once certified, can not change his process without recertification.)

The DLA disposed of chromium materials under its Fiscal year (FY) 1995 (October 1, 1994 through September 30, 1995) Annual Materials Plan (AMP). The AMP identified chromium materials for disposal. DLA's FY95 revised AMP set maximum disposal goals for chromium materials at 45,400 tons for chemical grade chromite ore; 318,000 tons of metallurgical grade chromite ore; and 90,700 tons of refractory grade chromite ore. DLA also developed its FY96 AMP which called for the disposal of 45,400 tons of chemical grade chromite ore; 318,000 tons of metallurgical grade chromite ore; and 22,700 tons of chromium ferroalloy.

The Department of Commerce completed a review of the countervailing duties applied to South African ferrochromium. The review covered ferrochromium imports from South African companies during 1991. The preliminary results were made in 1989. The final assessment was zero against Consolidated Metallurgical Industries (CMI) and 0.81 % against all other South African producers' materials.[2]

The Food and Drug Administration, Department of Health and Human Services, is amending its regulations to add chromium to labeling for reference daily intakes and to add chromium to the factors in determining whether a substitute food is inferior.[3]

The EPA regulated chromium emissions from hard and decorative chromium plating operations.[4] It was estimated that over 5,000 facilities nationwide, which were collectively emitting about 175 tons of chromium per year, would be required by regulation to reduce their emission by 99%. Hard chrome platers and anodizers were given 2 years and decorative chromium platers 1 year to comply with the new regulations. The regulation results from the 1990 Clean Air Act and specifies emission limits, work practices, initial performance testing, ongoing compliance monitoring, recordkeeping, and reporting requirements.

The EPA published a retrospective study on effluent guidelines, leather tanning, and pollution prevention.[5] The report found that industry met the chromium limitations by modifying the tanning process to get more chromium out of the tanning wastewater and into the leather. By changing chromium formulations, raising process temperature and time, and reducing bath water, industry increased chromium fixation from about 50% to about 90%. Recycling was also done to meet guidelines.

Production

The major marketplace chromium materials are chromite ore and chromium ferroalloys, metal, and chemicals. In 1995, the United States produced chromium ferroalloys, metal, and

chemicals, but no chromite ore.

Domestic production data for chromium ferroalloys and metal are developed by the U.S. Geological Survey by means of two separate surveys, the monthly "Chromite Ores and Chromium Products" and the annual "Ferroalloys." Production by the metallurgical companies listed in table 4 represented 100% of the domestic production shown in the current year of table 5.

Oregon Resources Corp., a subsidiary of Rare Earth Resources Ltd. (Canada), evaluated the potential use of a chromite mineral sand deposit south of Coos Bay, OR. Small-scale casting tests of chromite sand derived from the deposit found it acceptable for use as a foundry sand. The deposit covers 2,300 acres of terraced mineral sands containing proven resources of about 2.5 million tons of material averaging 13% chromite. Geological resources of the area were estimated at an additional 7 million tons. Oregon Resources planned to continue development of the deposit by testing bulk samples of foundry sand in commercial foundry operations.[6]

Consumption

Domestic consumption of chromite ore and concentrate was 351,000 tons in 1995. Chromium has a wide range of uses in the three primary consumer groups. In the metallurgical industry, its principal use was in stainless steel. In the refractory industry, its principal use was in the form of chromite to make refractory bricks to line metallurgical furnaces.

The chemical industry consumed chromite for manufacturing sodium bichromate, chromic acid, and other chromium chemicals and pigments. Sodium bichromate is the material from which a wide range of chromium chemicals are made. *(See tables 6 and 7.)*

World Review

In 1995, chromite ore and ferrochromium prices increased. Ferrochromium production capacity was increased in South Africa through the renovation of idle equipment and the startup of new furnaces. Construction of new capacity was started. Chromite mine capacity was increased or planned to meet demand from current and planned ferrochromium consumers. Vertical integration of the chromium industries of Finland and South Africa were implemented resulting in increased stainless steel production capacity in those countries. By yearend, world demand for stainless steel weakened as did ferrochromium prices.

Industry Structure.—The chromium industry is composed primarily of producers of chromite ore, ferrochromium, and stainless steel. Other industry components are chemical and refractory producers. A variety of vertical integration schemes were practiced.

Capacity.—Rated capacity is defined as the maximum quantity of product that can be produced in a period of time at 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 judgment of the author, can be brought into production within a short period of time with minimum capital expenditure. Because not all countries or producers make production capacity information available, historical chromium trade data have been used to estimate production capacity. Therefore, rated production capacity changes result from changes in facilities and changes in knowledge about facilities. Capacities have been rated for the chromite ore, ferrochromium, chromium chemical, and chromium metal industries.

Production.—World chromite ore production in 1995 was estimated at about 12.1 million tons, a 28% increase over that of 1994. World ferrochromium production in 1995 was estimated at about 2.37 million tons, a 14% increase over that of 1994.

Albania.—Albania continued negotiations for a joint venture with foreign investors to develop its chromium industry. Albania and Japan made a joint-venture agreement wherein Japan will assist Albania to survey the chromite resources in the Shebinik area of Albania over a 3-year period. The Shebinik area has relatively shallow resources, is near the coast, and has relatively good transportation infrastructure. Albania reported chromite ore reserves of 37.3 million tons of chromite ore containing about 12 million tons of chromium.

The chromium resources of Albania were reviewed.[7] Mines, production capacities, and the grade of ore produced were reported.

Australia.—Dragon Mining started a feasibility study for mining high-iron chromite in Western Australia. Dragon resources estimated resources at 500,000 tons; reserves at 270,000 tons of chromite ore. The reduction of chromite ore from the Coobina deposit was studied.[8] The ore was found to be suitable for the production of ferrochromium using direct prereduction followed by electric furnace smelting.

China.—China reported record imports of chromite ore in 1995 at 1,370,434 ton and record exports of ferrochromium at 320,969 tons.

Ferrochromium.—Jilin Ferroalloy Works reported negotiating with North West Province Development Corp. (South Africa) to put up a ferrochromium smelter at the Dilokong Mine (South Africa). The smelter was planned to have an annual ferrochromium production capacity of 50,000 tons.

Zunyi Ferroalloy Works, Guizhou Province, installed a furnace of 31.5 megavolt-ampere electrical capacity for the production of ferrochromium.

Chemicals.—China's chromium chemical industry is made of over 30 chromium chemical plants of widely varying production capacity. Only about seven plants accounted for an annual capacity of 4,000 tons-sodium dichromate or more each. The two major chromium chemical plants are the Chongqing Plant, Sichuan Province, and the Jinan Plant, Shangdong Province, each of which has an annual production capacity of about 15,000 tons.

Chromium Metal.—China produced chromium metal at three plants each of which produces by the aluminothermic method from chromic oxide produced at the plant site. Each chromium metal plant is part of a ferroalloy plant. Hunan Plant produced about 1,000 tons of chromium metal from an annual capacity of 1,300 tons. Nanjing Plant closed due to environmental problems. Jinzhou Plant produced about 3,000 tons which is its annual capacity. Hunan and Jinzhou chromium metal production capacity was limited by chromic oxide production capacity.

Stainless Steel.—China reported production of stainless steel from an annual production capacity of 300,000 tons. China planned to modernize its stainless steel production facilities and to increase production capacity to the range of 600,000 tons to 800,000 tons by the year 2000.

Finland.—Outokumpu Polarit, the stainless steel-producing division of Outokumpu Oy, planned to increase its stainless steel annual production capacity from 400,000 tons to 500,000 tons in 1996 then to 540,000 tons in 1997 by increasing use of molten ferrochromium. Outokumpu was using about 40% of its ferrochromium needs in liquid form, the remainder being crushed material. In order to increase the amount of ferrochromium used in liquid form, Outokumpu constructed a ferrochromium converter which refines the ferrochromium and melts scrap steel (ferrochromium-to-scrap ration of 2 to 1). Liquid ferrochromium was transported by ladle from the ferrochromium smelter to the stainless steel melt shop where it was mixed with steel scrap in the ferrochromium converter. The converted holds from 30 tons to 120 tons of molten metal. About 41 tons of material from the converter was to be mixed in a ladle with an equal amount of material from an electric-arc furnace. The mixture was to be fed into an argon-oxygen decarburisation (AOD) converter. The large capacity of the ferrochromium converter relative to the amount of material required by the AOD converter was designed to permit the ferrochromium converter to be used as a holding vessel to balance the production rates of ferrochromium and stainless steel.

Germany.—Bayer A.G. planned to close its remaining German chromium chemicals plant at Leverkusen. Closure is scheduled for 1998. Bayer closed its chromium chemicals plant at Oerdingen in 1992. The company planned to select a new plant site near chromite ore resources to which to transfer its production. Bayer's other plants in Argentina, Brazil, and South Africa were not expected to be affected.

India.—**National**.—A dispute over access to chromite ore reserves in Orissa State resulted in litigation. Tata Iron and Steel sought to renew its chromite ore mining lease covering 1,261 hectars of land in Sukinda Valley, Orissa State, in 1992 after holding that lease for 20 years. The High Court of Orissa State awarded 406 hectars to Tata Iron and Steel and the remaining 855 hectars to Orissa Mining Corp (OMC). Tata Iron and Steel appealed the decision to India's Supreme Court. Before the redistribution of resources, OMC held 5,000 hectars of land which accounted for 70% of the mining leases. (Tata's 1,261 hectars accounted for 17%. The remainder was held in smaller parcels by Facor and other companies.) Based on chromite ore resources, Tata held 39% of chromite ore down to 100 meters and 66% down to 300 meters.

India reduced its import duty on ferroalloys from 50% to 30%. This reduction followed a reduction from 85% to 50% in the preceding fiscal year. Orissa State experienced floods which interrupted chromite ore mining. Andhra Pradesh and Karnataka States reported power shortages of up to 70%.

Indian Bureau of Mines (IBM) reported chromite ore total geological resources of 182 million tons, 96% of which was in Cuttack district of Orissa State. Reserves were 88.351 million tons (98% in Orissa, 1% in Karnataka, and the remainder in Andhra Pradesh, Bihar, Maharashtra, Manipur, and Tamil Nadu). The major chromite mining companies were; Tata Iron and Steel Co. Ltd., Orissa Mining Corp. Ltd., Ferro Alloys Corp. Ltd., and Mysore Minerals Ltd. Chromite production was 939,597 tons 1990-91; 1,082,069 in 1991-92; and 1,069,603 tons in 1992-93. India reported domestic chromite ore consumption of 527,900 tons in 1991-92. The distribution of consumption was 88% to chromium ferroalloy production, 7% to refractory production, and 5% to chemical production. IBM reported ferrochromium (i.e., ferrochrome plus charge chrome) production of 149,966 tons in 1990-91, 192,674 tons in 1991-92, and 201,902 tons in 1992-93. Ferrochromium consumption reported over the same time period was 21,750 tons, 90% of which went into alloy steel. The major ferrochromium producers included; Deepak Ferro-Alloys, Eastern Metals and Ferro-Alloys, Ferro Alloys Corp., IDC Orissa, Indian Metals and Ferro Alloys, Ispat Alloys, Nav Bharat Ferro Alloys, Tata Iron and Steel, VBC Alloys, and Visvesvaraya Iron and Steel.

Chromite.—Chromite ore production was estimated at 1,230,000 tons in 1995. Tata Iron and Steel Co. estimated their production at 750,000 tons of which 650,000 tons was friable ore and 100,000 tons was concentrate. Tata Iron and Steel Co., a major chromite ore producer, experienced chromite ore export problems in March and April when inland transportation firms experienced a labor dispute.

Refractories.—Associated Cement Co., Katni, Madhya Pradesh State started production of mag-chrome bricks with annual capacity of 5,000 tons. The plant manufactured bricks under license from Refractechnik GmbH (Germany) for use in the burning zone of rotary cement kilns.

Ferrochromium.—The Indian ferrochromium industry was reviewed.[9] It was reported that India held 2.63% of world chromite ore resources valued at 182 million tons which was being mined at the rate of about 1 million tons per year. About 70% of chromite production was for domestic use. Metallurgical industry consumption accounted for about 86% of domestic chromite consumption. Ferrochromium was produced in electric arc furnaces at temperatures in the range of 1,500 to 1,800° C. Mostly open furnaces of former U.S.S.R. design were used. However, closed furnaces of Scandinavian design which are more energy efficient were also used. Recently, domestically designed furnaces in the 2 to 5 megavolt-ampere electrical rating range had been introduced. Pollution control was not an integral part of open or domestic furnaces. Because

of economic regulation at the National and State level, the industry has developed into small unlicensed plants serving mostly local demand, and large licensed plants serving national needs and export markets. Export oriented plants are permitted to import materials and equipment at international prices. Electrical power supply is a major problem for ferrochromium producers because ferrochromium production is electrical-energy intensive; electrical energy is in short supply; supply is unreliable; cost exceeds international prices; and accounts for about 45% of the ferrochromium producers variable cost. Export oriented producers had installed captive powerplants to alleviate some of their power supply problems. Domestic ferrochromium supply moved from scarcity to abundance recently. The ferrochromium industry today was reported to have an annual production capacity of about 200,000 tons at domestically oriented plants and an additional 200,000 tons at export oriented plants. Only about 50% of this capacity was being utilized. Ferrochromium production is mostly cast, crushed, and sized manually. As a result, only 80% to 84% of hot metal production was marketable domestically because the remainder did not meet consumer size requirements. Over 80% of domestic ferrochromium consumption was used by the stainless steel industry, and over 90% of that stainless steel was used in utensil grade. The remaining 10% of stainless steel production was for industrial consumption. Domestic ferrochromium meets domestic stainless steel industry standards required to meet their end-use engineering requirements. Export oriented ferrochromium meets international stainless steel industry quality requirements. Domestic ferrochromium demand was in the range 80,000 to 90,000 tons among 18 to 20 major consumers.

The high price of ferrochromium early in 1995 lead many of India's 71 ferromanganese producers to consider conversion to ferrochromium production or to add furnaces. Lower import duties resulted in increased imports of low-carbon ferrochromium.

Ferroalloys Corp. produced ferrochromium at Shreeramnagar, Andhra Pradesh (domestic oriented) and Randia, Orissa (export oriented), both of which have captive power generating plants. Hira Ferro Alloys contracted with Tata Iron and Steel Co. to supply chromite ore for two 12 megavolt-ampere furnaces to produce ferrochromium. Industrial Development Corp. reported idle low-carbon ferrochromium production capacity owing to increased imports.

Indian Charge Chrome Corp. (ICCL), Choudwar, Orissa State, restarted chromite ore and ferrochromium production after closure since the first quarter of 1994. ICCL stopped production after a conversion agreement with Tata Iron and Steel broke down. Tata was to supply chromite ore; ICCL was to smelt the ore. ICCL restarted production because of the high price of ferrochromium. The company reported that they could produce profitably when the ferrochromium price is $0.48 per pound. They planned to source their chromite ore from Orissa Mining Corp. and from foreign sources. ICCL also operated a captive 100 megawatt electrical powerplant.

Ispat Alloys Ltd. operated five electric furnaces at its Balgopalpur, Balasore District, Orissa State plant. The plant has been producing silicomanganese, but switched to ferrochromium.

Jindal Ferro Alloys Ltd. is a member of the Jindal Group, an integrated stainless steel producer. Jindal produced ferrochromium at Vizakhapatanam, Madhya Pradesh State, with an annual capacity of about 40,000 tons. Jindal planned a green field ferrochromium plant and captive powerplant for startup in 1998. Jindal sought mining leases to assure access to chromite ore. The new ferrochromium plant was planned to be part of Jindal's stainless steel production expansion with excess ferrochromium production capacity.

Nav Bharat Ferro Alloys Ltd. reported ferrochromium production from two of its three furnaces. Nav Bharat reported purchasing two Russian electric furnaces with electrical power rating of 15.5 megavolt-amperes with which to produce ferrochromium. Nav Bharat planned to construct an export oriented ferrochromium plant with an annual capacity of 50,000 tons with the furnaces. The new plant was planned to be completed in 1996. Navchrome, a subsidiary of Nav Bharat, reported converting one furnace to ferrochromium production. G.M.R. Vasavi (formerly Sarada Ferro Alloys) reported ferrochromium production from an annual capacity of 10,700 tons. Vasavi planned to add an additional 15,000 tons of ferrochromium production capacity.

Sandur Manganese and Iron Ores Ltd. of Bangalore, Karnataka State, made a conversion deal with Tata Iron and Steel to convert one of its three 24-megavolt-ampere furnaces to ferrochromium production with an annual capacity of 24,000 tons.

Standard Chrome, a joint venture between Tata Iron and Steel and Jalans, operated three furnaces with electrical power ratings of 5 megavolt-amperes. Tata held 32% of the joint venture and was to supply chromite ore and coke. Standard reported production of 10,635 tons for ferrochromium in the 1994-95 fiscal year. Standard planned to add two more furnaces.

Tata Iron and Steel converted one electric furnace at its Joda Plant to ferrochromium production increasing annual ferrochromium production capacity at the plant by 10,000 tons. Tata made contracts with several ferroalloy producers in which Tata was to supply them with chromite ore.

VBC Ferro Alloys Ltd. reported making a contract to produce ferrochromium for Tata Iron and Steel.

Stainless Steel.—India's stainless steel unit consumption (i.e., per person) was reported to have been 300 grams compared with unit consumptions of 3,500 grams in the United States and 6,000 grams in Japan. In India, the production of stainless steel has been increasing (from 32,000 tons in 1980 to 500,000 tons in 1994-95). Stainless steel production by grade was about 70% in 200 series grades; by form about 85% was flat products and 15% tubular and long products.[10]

Tata Iron and Steel and Jindal Group reported long-range plans to put up an integrated stainless steel producing plant. The plan included ferrochromium production, stainless steel production, and hot and cold rolling mills. Stainless steel

production in India was reported growing 18.9%.

Chemicals.—Lord Chemicals Ltd., West Bengal State, started commercial production of sodium dichromate and chrome oxide green. The plant had a production capacity of 3,300 tons of sodium dichromate and 30 tons of chrome oxide green. Ispat Alloys Ltd studied the possibility of chromium chemical production.

Japan.—Japan planned to reduce its ferrochromium import duty of 7.2% by one-third in accordance with the Uruguay Round GATT agreement. Japan's planned ferrochromium import duty reduction schedule is as follows: 1995, 7.2%; 1996, 6.9%; 1997, 6.4%; 1998, 5.8%; and 1999, 5.3%.

Japan operated a two-part stockpiling program, Government and private. Japan's long-term goal was to acquire a stockpile of chromium materials adequate to serve the needs of Japanese industry for 60 days. Japan planned to have the Government finance and stockpile 70% of the material; private sector was to hold the remaining 30% and to reach the 60 day-supply target in 1995. Metal Mining Agency of Japan, under the supervision of the Ministry of International Trade and Industry, operated the Government stockpile, while Japan Rare Metals Stockpiling Association operated the private stockpile. Japan appropriated money to continue stockpile purchases through FY95 (April 1995--March 1996).

Japan imported 607,268 tons of chromite ore, 825,718 tons of ferrochromium, 2,082 tons of chromium metal, and 218,725 tons of stainless steel scrap. Japan's ferroalloy industry produced about 236,373 tons of ferrochromium, an increase of 10% compared with that of 1994. (Japan's annual ferrochromium production has ranged about from 216,000 tons to 360,000 tons in the 1980-95 time period with the lower limit set in 1994.) Japan reported hot rolled stainless steel production of 3,242,705 tons in 1995, an increase of 13% compared with that of 1994. Japan exported 1,347 tons of ferrochromium and 1,220,212 tons of stainless steel. Chromium metal imports had shown substantial increases in recent years owing to the closure of Japan's largest and only electrolytic chromium metal producer: 44% in 1991; 25% in 1992; 48% in 1993; 38% increase in 1994; and 3% in 1995. The small increase in 1995 chromium metal imports suggests that the Japanese domestic chromium metal market has adjusted to the closure. Japan has become the world's second largest importer of chromium metal. Ferrochromium imports represented 78% of market share (up 4% over that of 1994), while stainless steel exports represented 38% of production. Based on chromite ore, ferrochromium, and chromium metal trade, chromium apparent consumption of Japan was about 638,000 tons-contained chromium in 1995. Ferrochromium stocks at steel plants were 161,250 tons (153,775 tons of high-carbon and 7,475 tons of low-carbon ferrochromium) at yearend representing 2.36 months of high-carbon ferrochromium supply and 2.01 months of low-carbon ferrochromium supply. Japan reported chromite ore consumption directly by converters at steel mills of 78,229 tons in 1995; electric furnaces, 139 tons. Kawasaki Steel (Chiba Steel Works) and NKK Corp. (Fukuyama Steel Works) operate stainless steel production processes that used chromite ore directly.

Japan continued to buy into foreign ferrochromium operations as it rationalized its domestic ferrochromium industry. In 1993, Tubatse Ferrochrome (Samancor, South Africa) and Nippon Denko formed NST Ferrochrome to produce high-carbon ferrochromium. In 1995, two new joint ventures were formed between Japanese and South African companies for the production of ferrochromium in South Africa. Mitsui and Co. bought a share of Lydenburg ferrochrome plant (CMI, South Africa) to get a share of its high-carbon ferrochromium production. Mitsui carried out its acquisition via its newly formed wholly owned subsidiary in South Africa, Mitsui Minerals Development of South Africa Pty. Ltd. Mitsui chose this method instead of a joint venture, possibly positioning itself for further investments in the South African minerals industry. Showa Denko and Marubeni formed Technochrome, a joint venture with Middelburg Ferrochrome (Samancor, South Africa), to produce low-carbon ferrochromium in South Africa. In addition to investments in South Africa, Japan invested in Zimbabwe. Japan Metals and Chemicals (JMC) and Mitsui and Co. planned a joint venture with Zimbabwe Alloys to utilize an idle furnace for the production of low-carbon ferrochromium in Zimbabwe. Low-carbon ferrochromium production in Zimbabwe was expected to eventually displace JMC's Oguni plant low-carbon ferrochromium production. Japan also invested in Kazakstan via Japan Chrome Corp., the consortium that purchased controlling interest in Kramds, the holding company for the Kazakstani chromium industry. (*See Kazakstan*.)

Kazakstan.—Chromite ore production at Donskoy Ore Dressing Complex (Aqtöbe Oblys), the sole producer in Kazakstan, has been declining. Annual production peaked in 1992 at 3.5 million tons. Since then, production declined to 2.9 million tons in 1993 and to about 2 million tons in 1994. Aktyubinsk Ferroalloy Plant (Aqtöbe Oblys) reported three idle furnaces, while Yermakovsky Ferroalloy Plant (Pavlodar Oblys) reported operating at 30% to 35% of capacity. In order to reverse this trend, Kazakstan sought to reorganize the domestic chromium industry by accepting investment capital and outside management in exchange for privatizing the industry for a 5-year period. To this end, Japan Chrome Corp. (JCC) invested in and took management control of Kazakstan's chromium industry in May. JCC's strategy was to further vertically integrate the chromium industry, to move from supplying chromite ore to supplying ferrochromium, a value added product. To improve delivery, JCC planned to set up ferrochromium stocks at Vanino Port, Siberia, for deliveries to the East and at Ventspirus Port, Latvia, for deliveries to the West. Donskoy planned to complete construction of a second concentrating line at its Centralyna Mine bringing its annual output capacity up to 2 million tons.

Yermakovsky Ferroalloys Plant reported production of ferrochromiumsilicon. Aktyubinsk Ferroalloys Plant reported production of chromium ferroalloys. Kazakstani chromium ferroalloy production dropped from 416.4 tons in 1990 to 326.4 tons in 1994, a 22% decline. Production in 1990 was oriented

to the internal needs of the former U.S.S.R. In 1994, chromium ferroalloys were marketed worldwide. Kazakstani chromium ferroalloy producers planned to convert their production facilities to meet world demand. Yermakovsky planned to convert furnaces to ferrochromium production up to an annual capacity of 300,000 tons. Aktyubinsk stopped low-carbon ferrochromium production in favor of high-carbon ferrochromium production.[11]

Korea, Republic of.—Pohang Iron and Steel Co. planned to increase its stainless steel production capacity from its current 550,000 tons to 1.15 million tons in 1997.

Madagascar.—Kraomita Malagasy reported chromite ore production in 1994 of 200,000 tons run-of-mine which was beneficiated to 150,000 tons of marketable product including 90,000 tons of lumpy ore and 60,000 tons of concentrate. Kraomita reported that hurricane damage from 1994 had been repaired and that a new mine, Bemanevika, was being planned for startup in 1996. Bemanevika Mine was reported to have reserves of 3 million tons.

Norway.—Elkem reported planning to add one furnace to its two currently producing furnaces at the Mo-I-Rana Plant. Elkem reported shifting its chromite ore supplier from Kazakstan to Turkey as a result of reduced availability from Kazakstan.

Pakistan.—Pakistan Chrome Mines near Muslimbagh northeast of Quetta, Balochistan Province, was reported to have been auctioned off to pay creditors. The mine was the largest in Pakistan, producing about 10,000 tons of chromite ore in 1993, of which 5,000 tons was metallurgical grade. Pakistan reported chromite ore production in 1994 of 6,240 tons and estimated 1995 production at 17,000 tons.

Philippines.—In 1995, abundant rainfall resulted in abundant hydroelectric power supply for the ferrochromium producing plants. However, chromite supply limited production.

Russia.—**Chromite Ore**.—Saranovsk chromite ore mining complex, Perm Oblast, reported 1994 chromite ore production of 129,000 tons. Russian ore supply was inadequate to meet ferroalloy plant demand in 1995 owing to reduced imports from Kazakstan, Russia's traditional supplier. Russia considered two options, diversifying ore suppliers and developing domestic deposits. Deposits identified for potential prospecting and appraisal include Sopch-Yavr lake region (Murmansk Oblast), Ray-Iz (polar region of Ural Mountains), and Agan-Ozero (Karilea Autonomous Republic) chromite ore deposits. The patterns of distribution, composition, and lithological and facial peculiarities of Precambrian chromium sandy deposits of the Ugui Graben, Olekma-Vitim Province, Chita Oblast, were reported.[12] Two deposits containing up to 14% Cr_2O_3 were reported. Chromite ore reserves in Russia were reported to have been 700 million tons. The Agan-Ozero and the Ray-Iz deposits were identified as having high development potential.[13]

Ferrochromium.—Chromium ferroalloy production in Russia was reported to have declined from 481,800 tons in 1990 to 313,800 tons in 1994, a drop of 35%. Chromium ferroalloy consumption in 1994 was reported to have been 123,000 tons. Producers in 1994 were JSC Chelyabinsky Electrometallurgical Works (Chelyabinsk, Chelyabinsk Oblast), JSC Serovsky Ferroalloys Plant (Serov, Sverdlovsk Oblast), JSC Klyuchevsky Ferroalloys Plant (Dvurechensk, Sverdlovsk Oblast), Ferroalloys Shop (Tula, Tula Oblast), and NIIM Pilot Shop (Chelyabinsk, Chelyabinsk Oblast).

Chelyabinsk reported 1994 production of 164,600 tons of ferrochromium and 1995 production of 120,000 tons to 240,000 tons of high-carbon ferrochromium and 24,000 tons to 48,000 tons of low-carbon ferrochromium. Chromite ore supply shortages were experienced. The B&D Group (USA) expanded its investment in the Russian metallurgical industry by purchasing an undisclosed share of Chelyabinsk for which it was to take exclusive marketing rights through TDR International (Belgium). Chelyabinsk planned to join with Chelyabinsk Steel Works to construct a power station and develop stainless steel ingot production capacity of 380,000 tons.

Serov reported annual production capacity of 121,500 tons of low-carbon ferrochromium, 90,500 tons of high-carbon ferrochromium, and 125,800 tons of ferrochromiumsilicon. However, Serov was unable to produce at capacity owing to inadequate chromite ore supply. Serov planned a briqueting plant to permit greater flexibility in chromite ore supply. Serov sold shares to raise $21 million in order to invest in chromite mine development and gas filtering pollution control equipment. Serov planned to invest in the development of the Yuzhno-Saranovskoye (southern Saranovsk) deposits.

A new ferroalloy production facility was being planned by TDR International (Belgium) for startup in 1996. The new producer was to be named North East Ferroalloy Plant; to operate four 16.5 megavolt-ampere renovated electric-arc furnaces; to have an annual high-carbon ferrochromium (62% to 63% chromium, 8% carbon) production capacity of 140,000 tons; and to be located at Tihvin, Leningrad Oblast. The location was chosen for its abundant electrical energy supply with cost at $0.02 per kilowatthour.

Chromium Chemicals.—Russia reported closing two of its sodium bichromate producing plants.

Slovak Republic.—Oravske FeroZria Inarske Zavody reported operating two of its four furnaces at Istebne to produce high-carbon ferrochromium during 1995. Each furnace was shut down for about a month for repairs.

South Africa.—According to the Minerals Bureau, South Africa in 1994 produced 3.599 million tons of chromite ore of which 74% was locally sold, and 1.104 million tons of ferrochromium of which 6% was sold locally.

Chromite Ore.—Chromite ore resources were studied in the Erst Gaelic area (24° 45′ south, 30° 10′ east) in the eastern section of the Bushveld Complex near Steelpoort. The area was found to have reserves of 25 million tons of chromite ore at depths of 180 meters to 550 meters. Deeper resources add 100 million tons of chromite ore resources in the area. The average width of the reef is 1.95 meters.[14]

Samancor operated chromite mines under its Eastern and Western Chrome Mines Divisions. Eastern Chrome Mines operated Montrose, Steelpoort (Winterveld), and Tweefontein

sections, restarted Doornbosch section, and kept Jagdlust and Mooihoek sections idle in Northern Province and Mpumalanga Provinces. Samancor entered into a joint venture with Lavino (Anglovaal) amalgamating Lavino with Annex Grootboom Mine and renaming the operation Lannex under its Eastern Chrome Mines Division. Western Chrome Mines operated Millsell, Elandsdrift, and Mooinooi sections, restarted Buffelsfontein, started opencast mining at Elandsdrift, and kept Waterkloof idle in North-West Province. Samancor reported mining 3.17 million tons; 1.65 million tons in the east and 1.52 million tons in the west.

Chrome Resources, a subsidiary of Chrome Corp. Holdings Ltd., operated the Chroombronne Mine with an annual run-of-mine production capacity of 1.7 million tons of chromite ore which yields 800,000 tons of marketable product. Chrome Resources planned to double capacity. Chrome Resources operated two sections, Kroondal and Waterval. Reserves were reported at 15.92 million tons (12.50 million tons at Kroondal and 3.42 million tons at Waterval) and were being extracted at the rate of one shift per day, 5 days per week. Each section operates its own concentration plant. The Kroondal section produces lumps, pebbles, and fines from the LG6 seam exclusively for the Chromecorp Technology smelter at Rustenburg and produced chemical grade chromite from the MG3 seam. Kroondal's run-of-mine chromite ore monthly production rate was about 110,000 tons, of which about 68% was marketable product. The marketable product was about 53% fines, 30% lump, and 17% pebbles. The concentrator plant consists of a jaw crusher to reduce ore size to below 150 millimeters after which it is separated via a double deck screen into lumps (150 millimeters to 20 millimeters), pebbles (20 millimeters to 0.08 millimeters), and fines (less than 0.08 millimeters). The lumps and pebbles are processed by heavy media separation to separate ore from gangue, while fines are mixed with water to form a slurry which is passed through spirals to separate ore from tailings. Metallurgical grades run 44.5% Cr_2O_3, 2.5% SiO_2; chemical grades, 46% Cr_2O_3, under 1% SiO_2. Reserves at Kroondal were estimated at about 16 million tons in the LG6 seam and an additional 16 million tons of reserve base contained in the MG3 seam. The LG6 seam is about 1.3 meters thick and is subdivided by about 500 millimeters of waste. The MG3 is about 1.5 meters thick. Waterval produced at the run-of-mine chromite ore monthly rate of about 35,000 tons, with reserves of about 3.42 million tons. Chrome Resources also reported acquiring surface and mineral rights to the Brakspruit and Spruitfontein Farms near the Kroondal section.[15]

Chrome Chemicals, a subsidiary of Bayer AG (Germany), reported capacity production of 72,000 tons of metallurgical grade (40% Cr_2O_3) and 180,000 tons of chemical grade (36% Cr_2O_3) chromite ore in 1994. Dilokong Chrome Mine reported annual chromite ore production with a capacity of 420,000 tons at Mooihoek. Lavino, a subsidiary of Anglovaal, reported annual production of about 400,000 tons, of which 50,000 to 80,000 tons was of foundry sand quality. Marico Chrome Corp., a joint venture between Samancor and Verref Minerals in the western Bushveld, was reported to have had an annual production capacity of 72,000 tons. Most of production was of metallurgical grade; however, from 12,000 to 18,000 tons was of refractory grade. Samancor held 60% of South Africa's chromite ore reserves.[16]

CMI developed its chromite ore resources and production capacity in order to assure itself a secure chromite ore supply. Thorncliff Mine reported annual production of 150,000 to 200,000 tons from open pit mining for which it has about 1.5 years of reserves. Thorncliff has underground reserves adequate for 20 years operation at an annual marketable production rate of 600,000 tons. The chromite seam at Thorncliff is about 1.8 meters thick. Purity Mine reported extending its reserves through the purchase of chromite mineral rights contiguous to its property from Anglo American Platinum Corp. CMI reported annual chromite ore production of 480,000 tons run-of-mine to yield 330,000 tons of marketable product.

Ferrochromium.—The South African ferrochromium industry is dynamic and innovative. Vertical integration of the chromium industry has resulted in the expansion and planned expansion of ferrochromium production in South Africa using abundant supplies of domestic chromite ore and coal-based electrical energy. Japan continued to buy into the South African ferrochromium industry this year joined by China. South Africa's ferrochromium industry was expanding to meet world demand driven by a growing stainless steel market and to meet local demand driven by newly installed or expanded stainless steel production facilities. Expansions and/or new plants by Chrome Resources and Ferrometals added an annual ferrochromium production capacity in excess of 100,000 tons in 1995. Additional expansions and/or new plants were planned by Chrome Corp. Holdings, Hernic Ferrochrome, Rhoex, and Samancor to come into production in or after 1996, accounting for an additional annual ferrochromium production capacity of about 670,000 tons.

Batlhako Ferrochrome, a Samancor subsidiary, planned to restart its 12.5 megavolt-ampere furnace with annual ferrochromium production capacity of 25,000 tons.

Chromecorp Holdings Ltd. resulted from the reorganization of Chromecorp Technology which went public with the sale of stock to raise money to pay off debts and expand operations. Chromecorp Technology was a wholly owned subsidiary of Südelektra (Switzerland). Chrome Resources was created as a subdivision of Chromecorp Holdings responsible for chromite mining and ferrochromium smelting. Chromecorp operated a smelter at Rustenburg. Completion of its fourth furnace of 39 megavolt-ampere electrical capacity and 80,000 tons per year of ferrochromium production capacity gave the Rustenburg Plant a total annual electric furnace ferrochromium production capacity of 260,000 tons. In addition to its furnaces, Chrome Resources operated a ferrochromium from slag recovery plant which added annual ferrochromium production capacity of 20,000 tons. Chrome Resources planned to increase its production capacity by constructing a new smeltes. Chrome Resources planned a mine site smelter consisting of two furnaces with electrical capacity of 44 megavolt-amperes and

annual ferrochromium production capacity of 160,000 tons to 170,000 tons. Chrome Resources made a long-term purchase agreement with Platinum Mines to purchase chromite-containing tailings for the production of ferrochromium at one of its new plants. Chrome Resources would grind, beneficiate by flotation and spiral separation, and agglomerate by sintering the chromite concentrate before smelting it to a high-carbon ferrochromium containing about 48% chromium. These chromite rich tailings from platinum mining of the Bushweld Complex UG2 seam contain about 38% Cr_2O_3 and have a chromium-to-iron ration of 1.3. As a result, it produces a 48% chromium ferrochromium, a nonstandard grade. Chrome Resources planned to introduce this new grade through its exclusive supply agreement with Iscor Ltd. and thereby demonstrate the utility of the new grade to the stainless steel industry in general.

CMI sold 12.5% of its Lydenburg Plant to Mitsui Minerals Development of South Africa, a subsidiary of Mitsui (Japan) for about $27 million. CMI planned construction of a fourth furnace at its Lydenburg plant. The new furnace was planned to be completed by September 1996 and to add 70,000 tons to CMI's current annual production capacity of about 330,000 tons. CMI planned to acquire the Thorncliff chromite deposit to supply its new furnace with lump ore.

Feralloys, an Anglovaal subsidiary, reported capacity production of high-carbon ferrochromium at an annual rate of 120,000 tons from its three 24 megavolt-ampere furnaces at Machadodorp. Feralloys reported no longer producing low-carbon ferrochromium.

Hernic Ferrochrome (Pty.) Ltd. started construction in April of a new ferrochromium smelter near Brits. The project was reportedly financed 11.0% by Nittetsu Shoji Co., Ltd. (Japan), 16.5% by ELG Haniel GmbH (Germany), and the remaining 72.5% by Hernic (Pty.) Ltd. The project cost was estimated at $130 million. The plant was planned to consist of two 37 megavolt-ampere electric-arc furnaces each capable of producing 65,000 tons of ferrochromium per year. The furnaces were to be producing in May and June of 1996. Hernic planned to use ore from its Brits area operations reported to have 15 million tons of chromite ore reserves including 5 million tons at Elandskraal Mine. To meet its ferrochromium needs and export market demand, Hernic planned production of 1 million tons run-of-mine chromite ore, which would yield 750,000 tons of marketable product for its smelter (250,000 tons) and for export (500,000 tons).

Ferrometals, a Samancor subsidiary, started production from a ferrochromium-from-slag recovery plant. The new recovery plant adds an annual ferrochromium production capacity of 50,000 tons to Ferrometals annual ferrochromium production capacity of 320,000 tons from five furnaces. The recovery plant is based on Mintek developed technology that, at pilot-plant stage, demonstrated over 90% recovery of metal liberated from slag. The process consists of first crushing slag to less than 25 millimeters then separating over 1 millimeter from under 1 millimeter sizes. The undersize fraction is processed through spiral separators, while the oversize is treated by a jig (a pulsed water bed activated by compressed air). The system was reported to be quite economical because both capital and operating costs were about 40% of that of an electric furnace of about the same production capacity. The recovery plant cost about $7.7 million.[17] Ferrometals had 10 million tons of slag stockpiled and was generating slag at an annual rate of 450,000 tons.

Tubatse Ferrochrome, a subsidiary of Samancor, started construction of its sixth electric furnace with electrical capacity of 37 megavolt-amperes, an annual ferrochromium production capacity of 55,000 tons, and at a cost of $27 million.[18] Construction was to be completed in 1996. With five furnaces in operation, Tubatse's electric furnace ferrochromium production capacity was 300,000 tons. An additional annual capacity of 20,000 tons was to become available in 1996 upon completion of a ferrochromium-from-slag recovery plant which cost $6.3 million.[19]

Middelburg Ferrochrome, a Samancor subsidiary, inaugurated its Technochrome joint venture with Showa Denko (20.7%) and Marubeni (13.8%). As a result of this joint venture, Middelburg planned to upgrade its production facilities and practices and to start production for the export market, ultimately displacing Showa Denko's production in Japan. Special grades of low-carbon ferrochromium will require Middelburg to supplement its domestic chromite ore supply with imported ore having a chromium-to-iron ratio greater than that available from local sources. Middelburg started construction of a direct current (DC) plasma arc furnace with electrical capacity of 56 megavolt-amperes for the chrome direct reduction kiln. The furnace was expected to be completed in 1996 at a cost of $18 million.[20] Upon completion, the 100,000 tons of idle capacity represented by the chrome direct reduction process could be brought into production. The new DC-arc furnace was designed to provide liquid ferrochromium to Columbus' stainless steel producing furnaces. The furnace can also smelt ore directly when the kiln is out of service for routine maintenance.

A joint venture was planned between Northern Province Development Council and Eastern Asia Metal Investment Corp. (China) to develop the Dilokong chromite mine. The plan included mine expansion and smelter development at a cost of about $70 million. The mine had chromite ore reserves of 25 million tons and was to be developed to an annual chromite ore production capacity of 400,000 tons. A ferrochromium smelter was to be constructed at the mine site with annual ferrochromium production capacity of 100,000 tons. China was to supply smelting technology and process equipment. Eastern Asia Metal Investment Corp., a subsidiary of the state-owned China Iron and Steel Industry and Trade Group Corp., and Jilin Ferroalloy Works (China) was to hold 60% of the joint venture.

Stainless Steel.—Columbus Joint Venture and Iscor developed stainless steel production facilities. Columbus is a joint venture among Samancor, Highveld Steel, and Industrial Development Corp. (Government), each with one-third interest. Production at the Middelburg plant site started. Columbus' 1995 calendar year production was estimated at 250,000 tons.

Columbus planned to reach its target annual production capacity of 600,000 tons in 1997. Iscor proceeded to convert its Pretoria and Durban steel plants to stainless steel production. Iscor planned to start production in 1996 and to meet its annual stainless steel production capacity of 480,000 tons at the Pretoria plant in 1998 and 120,000 tons at Durban. The Columbus Plant will produce flat products; the Iscor Pretoria Plant, slabs; Durban, billets.

Zimbabwe.—Zimbabwe reported chromite ore production of 514,000 tons in 1994, up from 252,000 tons in 1993. Zimbabwe reported 1994 ferrochromium production of 182,000 tons (153,000 tons of high-carbon ferrochromium and 29,000 tons of low-carbon ferrochromium). Zimbabwe also produced 36,000 tons of ferrochromiumsilicon.

Chromite Ore.—Zimbabwe Alloys reported improving its Inyala chromite mine by opening a new production area and by installing a new heavy media separation plant. An additional heavy media separation plant was planned for startup in 1996.

Ferrochromium.—Two ferrochromium producers operated in Zimasco and Zimbabwe Alloys. Union Carbide (United States) sold its shares in Zimbabwe Mining and Smelting to a management holding company. It produces high-carbon ferrochromium at Kwe Kwe with an annual capacity of about 178,000 tons from six electric furnaces. Zimbabwe Alloys, a subsidiary of Anglo American (South Africa), produced low-carbon ferrochromium with an annual capacity of about 34,000 tons and ferrochromiumsilicon at Gweru. Zimbabwe Alloys operated a 17.5 megavolt-ampere furnace with an annual ferrochromiumsilicon production capacity of 15,000 tons.

Both Zimbabwean ferrochromium producers started ferrochromium from slag recovery processes in 1995. Zimasco built a plant to recover ferrochromium from slag. It has about 200 million tons of slag from which it planned to recover about 60,000 tons of ferrochromium over the next 5 years. Zimbabwe Alloys began trial operation of a ferrochromium from slag recovery process. The process was planned to have an annual production capacity of about 8,000 tons of ferrochromium.

Zimbabwe Alloys planned a joint venture with Japan Metals and Chemicals (Japan) and Mitsui (Japan) to produce low-carbon ferrochromium. The joint venture, to be called JM Alloys (Private) Ltd., is intended to supply low-carbon ferrochromium to Japanese consumers replacing that produced by Japan Metals and Chemicals as it closes down its plant in Japan. Additional furnace capacity was planned to be added to Zimbabwe Alloys as production increases consume current excess production capacity. Zimbabwe Alloys reported the results of implementing a furnace control system for ferrochromiumsilicon production. They found that furnace operation improved as did alloy quality. With the automated control system, they produced ferrochromiumsilicon at an energy cost of 6,400 kilowatthours and at a material cost of 1.26 tons of chromite ore, 0.72 tons of coke, and 1.15 tons of quartz per ton of hot metal tapped.[21]

The Zimbabwean Institute of Mining Research (IMR) studied the recovery and processing of chromite ore from the Great Dyke. IMR applied a wire cutting technique developed originally for stone quarrying and recently applied to mining gold tabular ore bodies. The technique was applied at the Great Dyke Mine. IMR studied chromite ore refining by slag-metal reaction, or smelting, to optimize the slag composition. They found that initially bulk transport followed by chemical control were the rate controlling factors in the slag-metal refining process. IMR set up a data bank for its chromite ore data. IMR studied the remelting of ferrochromium fines and found that the induction furnace remelting could be used to enhance the product by increasing chromium and decreasing carbon content.

Current Research and Technology

Mineral Processing and Industrial Applications.—The former U.S. Bureau of Mines (USBM) studied the effect of oxidation on the flotation of chromite and associated minerals.[22] The effect of oxidation on chromite and olivine was studied in an effort to improve chromite recovery from domestic deposits. It was found that oxidation affected chromite but not olivine flotation. A procedure was developed and demonstrated to improve chromite recovery.

Environmental.—It was reported that as a result of EPA's encouragement to reduce or eliminate current surface finishing processes that use chromium, there has been a surge in research for the development of new environmentally conscious protection schemes.[23] All three branches of the military were working on alternatives to conventional chromium coatings for corrosion prevention. However, although results were promising, a completely satisfactory process has not been found. Chromium contamination from a chromite mine was studied.[24] It was found that there had been a small but steady flux of chromium from Sukinda into the principal river Bramhani and further to the Dhamra region where enrichment of chromium had been noticed in water, suspended solids, and sediments.

The environmental aspects of ferrochromium production were studied.[25] Chromite ore was subject to Toxicity Characteristic Leaching Procedure (TCLP) as specified by the EPA. The TCLP extract contained less chromium than that required by the EPA to classify the material as hazardous. The greatest risk from smelting was found to be dust from the bag filter or sludge from the gas cleaning system. Closed furnace operation was found to yield less water soluble chromium in furnace dust than open furnace operation. It was found that environmental impact of ferrochromium production could be effectively contained using existing techniques and processes.

Ferrochromium.—Ferrochromium production technology as a process step in stainless steel production was reviewed.[26] The ferrochromium production process was found to be mature and therefore in need of technological renovation or replacement to make further gains in economic efficiency and product quality. The strengths and weaknesses of the traditional submerged electric arc and the plasma transfered arc and heater, along with variations on those processes including preheating and prereduction were described. Direct stainless steelmaking was also mentioned.

Stainless Steel.—NKK (Fukuyama Works, Japan) and

Kawaski (Chiba Works, Japan) reported direct stainless steel production albeit by different processes.[27] Kawaski uses a process wherein prereduced pelletized chromite ore is added to molten iron in a converter. To complete the process, supplemental heat is supplied by injection and combustion of coke and oxygen. NKK uses a process wherein chromite ore is added directly to iron in a converter. These processes reduce the use of ferrochromium in favor of chromite ore.

Columbus Stainless Steel (South Africa) reported preproduction development of a nickel-free austenitic stainless steel grade which it has named Cromanite. The new grade contains chromium and nitrogen and is high in manganese. Adequate supplies of chromium and manganese are locally available, whereas nickel is not. Cromanite contains 19% chromium, 10% manganese, and 0.5% nitrogen.[28]

Outlook

On average (from 1983 through 1992) in the United States chromium consumption by end use industry has been: 87%, metallurgical; 10%, chemical; and 3%, refractory.[29] About 70% of metallurgical industry chromium consumption is as feed material for stainless steel production. Thus, stainless steel production accounts for about 60% of the chromium consumed in the United States. The remainder of metallurgical industry consumption is for the production of other ferrous and nonferrous alloys. Some chemical and refractory products are consumed in the steel production process. The average chromium content of stainless steel produced in the United States from 1962 through 1983 was 17%.[30] Stainless steel, by definition, contains at least 1% chromium but may contain up to 36% chromium.

It was estimated in 1989 that on average internationally, about 79% of chromium is consumed by the metallurgical industry, 13% by the chemical industry, and 8% by the refractory industry.[31] Of the chromium consumed in the metallurgical industry, about 60% was consumed in stainless steel. Thus, stainless steel production accounted for about one-half of the chromium consumed internationally. It was estimated in 1993 that on average internationally within market economy countries that about 77% of chromium was consumed by the metallurgical industry, 14% by the chemical industry, and 9% in the refractory industry (including foundry sand).[32]

The outlook for chromium consumption in the United States and internationally is the same as that for stainless steel. Stainless steel is the major end use for chromium worldwide. Thus, stainless steel industry performance determines chromium industry demand worldwide.

The trend to supply chromium in the form of ferrochromium by chromite mining countries is expected to continue. With new, efficient ferrochromium production facilities and excess capacity in chromite-producing countries, both production and capacity are expected to diminish in traditional ferrochromium-producing countries and by small, less efficient producers, except where domestic industries are protected by quotas and tariffs. Further vertical integration of the chromium industry is expected as chromite-producing countries expand ferrochromium or stainless steel production capacity.

Stainless Steel.—Stainless steel production showed two consecutive years of strong growth, i.e., in excess of 10% per year for two consecutive years. Growth was expected again in 1996. Stainless growth was attributed to restocking and increasing market share. This kind of strong growth is difficult for suppliers to cope with. It was reported that 90% to 95% of high-carbon ferrochromium goes into stainless steel which also drives chromium units from stainless scrap. Stainless steel scrap was estimated to consist of about 50% old scrap which has a 15 to 20 year life cycle, 35% revert scrap which has a 3 month life cycle, and 15% industrial scrap which has a 6 month life cycle. As a result, scrap is generally in short supply when stainless production is growing and in excess supply when stainless production is decreasing.[33] An analysis of the world ferroalloy industry found that the structure of the industry changed drastically over the 1980 to 1992 time period.[34] It was anticipated that ferroalloy production would decline further in Europe and North America while increasing in Asia, Africa, Latin America, and the Middle East. Ferrochromium production is likely to follow this trend modified by the availablity of chromite ore and electrical energy. Production will be rationalized in China, Eastern Europe, India, and Japan leaving a substantial share of production in the hands of major producers in India and Africa.

World production of chromite ore which has been declining since 1989 made a major comeback in 1995 owing to continued strong demand for ferrochromium from the stainless steel industry. Projected stainless steel production growth will turn around the decline in world chromite ore production. The projected addition of stainless steel capacity of about 3.2 million tons compared to 1994 world capacity of 16 million tons, when utilized will, compared with 1994 industry performance, increase demand for ferrochromium by about 900,000 tons (25% of 1994 production) and demand for chromite ore by 2.3 million tons (24% of 1994 production).

Stainless steel demand is price sensitive, and an important part of stinless steel cost is nickel cost (about 70% of stainless steel requires nickel). Nickel availability and cost has been viewed as a potential limitation to increased stainless steel production. The discovery and development of new nickel deposits projected to produce at near one-half the cost of that of current producers mitigates this potential limitation to stainless steel production growth.

Chromium Chemicals.—Chromium chemical production is geographically concentrated in developed economies. Major producing countries where large plants (capacity in excess of 100,000 tons-sodium bichromate per year) operate include Germany, Kazakstan, Russia, the United Kingdom, and the United States. Small-scale local producers operate worldwide but especially in China and India.

Sodium dichromium apparent consumption in 1994 was estimated at 110,000 tons in the United States, 137,000 tons in Western Europe, and 42,000 tons in Japan.[35] In the United States, most sodium dichromate is converted to chromic acid.

However, sodium dichromate is also used directly by several industries. In the United States, major end-use markets for sodium dichromate were wood preservation, leather tanning, and metal finishing are mature markets showing slow growth. Other end uses showing declining use include chromate pigments, corrosion control agents, and water treatment chemicals. Newer, faster growing markets include magnetic recording media and catalysts and represent a small part of the market. In Europe, leather tanning was a major end use. In Japan, electroplating and metal finishing were major end uses.

Chrome yellow was found to dominate the market for traffic paint but was loosing market share to organic pigments.[36]

---

[1]High-Purity Chromium Metal: Supply Issues for Gas-Turbine Superalloys. National Materials Advisory Board, National Academy Press, Report NMAB-480, 1995, 60 pp.

[2]Federal Register. V. 60, No. 24, Feb. 6, 1995, pp. 7043-7046.

[3]_____. v. 60, No. 249, Dec. 28, 1995, pp. 67164-67175.

[4]_____. V. 60, No. 16, Jan. 25, 1995, pp. 4948-4993.

A Guidebook on How to Comply with the Chromium Electroplating and Anodizing National Emission Standards for Hazardous Air Pollutants. Evironmental Protection Agency Report EPA-453/B-95-001, Apr. 1995, 154 pp.

[5]Environmental Protection Agency. Effluent Guidelines, Leather Tanning, and Pollution Prevention: A Retrospective Study. EPA Report EPA-820-R-95-006, 1995, 5 pp.

[6]Private Communication. Jim Dingman, Pacific Industrial Minerals, telephone (360) 376-4272.

[7]Steblez, W. The Chromium Resources of Albania. International Geology Review, v. 36, 1994, pp. 785-795.

[8]Duong, H. V., and R. F. Johnston. Solid State Reduction of Australian Chromite With Coal. Australasion Institute of Mining and Metallurgy, AusIMM Proceedings, v. 299, No. 2, pp. 63-68, 1994.

[9]Chakravortty, S. Presentation at Indian Metals Conference, Bombay, Mar. 1994. Surplus Situation, Minerals & Metals Review Annual, 1994, pp. 251-252, 255, 257, and 259.

[10]Work cited in footnote 9.

[11]Serov, G. V. Ferroalloy Industry on CIS Countries. Paper in INFACON 7, ed. by J. Kr. Tuset, H. Tveit, and I. G. Page, Trodheim, Norway, June 11-17, 1995, pp. 87-96.

[12]Bogdanov, Y. V., and P. V. Berlyand-Kozhevnikov. Chromium Sandy Deposits of The Precambrian of the Ugui Graben. Litologiya i Poleznye Iskopaemye, No. 2, pp. 41-48, Mar.-Apr. 1992.

[13]Serov, G. V. Ferroalloy Industry on CIS Countries. Paper in INFACON 7, ed. by J. Kr. Tuset, H. Tveit, and I. G. Page, Trodheim, Norway, June 11-17, 1995, pp. 87-96.

[14]Scoon, R. N., and B. Teigler. A New LG-6 Chromite Reserve at Erst Gaelic n Boundary Zone Between Central and Sourn Sectors of Eastern Bushveld Complex. Economic Geology, v. 90, pp. 969-982, 1995.

[15]Skillen, A. Welcome to the New South Africa. Industrial Minerals, No. 333, June 1995, pp. 30, 32, and 53.

Tex Report. V. 27, No. 6369, June 7, 1995, p. 5.

Mining Weekly (South Africa). V. 1, No. 31, Aug. 11, 1995, pp. 1-2.

Business Day. Sept.7, 1995, p. 10.

[16]Skillen, A. Welcome to the New South Africa. Industrial Minerals, No. 333, pp. 30, 32, and 53, June 1995.

[17]Value converted from South African Rand (R) to U.S. dollars (US$) at the rate of R1=US$0.27451 (US$1=R3.6429).

[18]Work cited in footnote 17.

[19]Work cited in footnote 17.

[20]Work cited in footnote 17.

[21]Ngwenya, B. A., L. Mabiza, I. J. Barker, A. de Waal, M. S. Rennie, and P. Mailer. The Performance of a Resistance-Based Furnace Control System on a Submerged Arc Furnace. Paper in INFACON 7, ed. by J. Kr. Tuset, H. Tveit, and I. G. Page, Trodheim, Norway, June 11-17, 1995, pp. 529-534.

[22]Kotlyar, D. G., W. K. Tolley, and D. A. Rice. The Effect of Oxidation on the Flotation of Chromite and Associated Minerals. U.S. Bureau of Mines Report of Investigation 9575, 1995, 10 pp.

[23]Glip, B. Alternatives to Conventional Chromium Coatings. MIAC Newsletter, v. 5, No. 3, June 1995, pp. 529-534.

[24]Godgul, G. and K. C. Sahu. Chromium Contamination from Chromite Mine. Environmental Geology, v. 25, 1995, pp. 251-257.

[25]Gericke, W. A. Environmental Aspects of Ferrochrome Production. Article in INFACON 7 ed. by J. Kr. Tuset, H. Tveit, and I. G. Page, Proceedings of the 7th International Ferroalloys Congress, Trodheim, Norway, June 11, 1995, pp. 131-140.

[26]Slatter, D. D. Technological Trends in Chromium Unit Production and Supply. Article in INFACON 7 ed. by J. Kr. Tuset, H. Tveit, and I. G. Page, Proceedings of the 7th International Ferroalloys Congress, Trodheim, Norway, June 11, 1995, pp. 249-262.

[27]Tex Report. V. 27, No. 6357, May 22, 1995, p. 2.

Mining Journal. V. 325, No. 8353.

American Metal Market. July 18, 1995, p. 4.

[28]Engineering News. Nov. 10, 1995, p. 7.

[29]Papp, J. F. Chromium Life Cycle Study. U.S. Bureau of Mines Information Circular 9411, 1994, 94 pp.

[30]_____. Chromium, Nickel, and Other Alloying Elements in U.S.-Produced Stainless and Heat-Resisting Steel. U.S. Bureau of Mines Information Circular 9275, 1991, 41 pp.

[31]Granville, A. and E. F. Statham. Profits From Processing. Mintek, Nov. 1989, pp. 10-11.

[32]Boyle, E. H., Jr., D. J. Shields, and L. A. Wagner. Chromium Availability in Market Economy Countries and Network Flow Analysis of World Chromium Supply. USBM IC 9337, 1993, p. 28.

[33]Metal Bulletin. No. 8032, Nov. 23, 1995, p. 11.

[34]Avery, P. Futute Localization and Structure of the Ferroalloy Industry. Article in INFACON 7 ed. by J. Kr. Tuset, H. Tveit, and I. G. Page, Proceedings of the 7th International Ferroalloys Congress, Trodheim, Norway, June 11, 1995, pp. 1-20.

[35]Chromium Products in Chemical Economics Handbook.

[36]American Paint & Coatings Journal. Apr. 10, 1995, p. 27.

OTHER SOURCES OF INFORMATION

U.S. Geological Survey Publications

Chromium. Ch. in Mineral Commodity Summaries, annual.
Chromium. Ch. in Minerals Yearbook, annual.
Mineral Industry Surveys, monthly.

Other Sources

American Iron and Steel Institute.
American Metal Market.
Ceramic Bulletin.
Chemical Market Reporter.
Chemical Week.
Chemical and Engineering News.
Chromite. Ch. in Industrial Rocks and Minerals.
Chromite. Ch. in Indian Minerals Yearbook.

CRU Metal Monitor.
Defense Logistics Agency, Stockpile Reports.
The Economics of Chromium (Roskill Information Services, London).
Engineering and Mining Journal.
Federal Register.
Ferro-Alloy Directory and Databook (Metal Bulletin, London).
Ferro-alloys. Ch. in Indian Minerals Yearbook.
Ferro Alloys Manual (The TEX Report, Tokyo).
Ferrous Mineral Commodities Produced in the Republic of South Africa 1992. (South African Department of Mineral and Energy Affairs Directory D8/93).
Indian Minerals Yearbook 1993, Chromite and Ferro-alloys Chapters, (Indian Bureau of Mines).
Industrial Minerals (London).
International Chromium Development Association (Paris).
Japan Chemical Week (Tokyo).
MEED (Middle East Economic Digest, London).
Metal Bulletin (London).
Mineral Exporters Assoc. (Turkey).
Mining Annual Review (London).
Mining Engineering.
Mining Journal (London).
Mining Magazine.
Outokumpu News.
Platt's Metals Week.
Raw Materials Report (Stockholm).
Samancor Annual Report.
South Africa's Minerals Industry 1993/94 (Minerals Bureau, South Africa).
Stainless Steel Databook (Metal Bulletin Books, London).
Sumàrio Mineral 1994 (Department of National Mineral Production, Brazil).
The TEX Report (Tokyo).

TABLE 1
SALIENT CHROMIUM STATISTICS 1/

(Metric tons, contained chromium unless otherwise specified)

		1991	1992	1993	1994	1995
World production:						
Chromite ore (mine) 2/		4,020,000	3,310,000 r/	2,830,000 r/	2,860,000 r/	3,630,000 e/
Ferrochromium (smelter) 3/		2,210,000	2,100,000	1,870,000	2,010,000 r/	2,370,000 e/
Stainless steel 4/		2,240,000 r/	2,180,000 r/	2,150,000 r/	2,350,000 r/	2,580,000 e/
U.S. supply:						
Components of U.S. supply:						
Domestic mines		--	--	--	--	--
Secondary		96,100	102,000	92,000	99,000	113,000
Imports:						
Chromite ore		64,500	67,700	84,300	59,600	81,400
Chromium ferroalloy		234,000	247,000	233,000	198,000	319,000
Chromium metal		5,770	5,450	6,170	6,520	7,040
Chromium chemicals		5,330	4,320	6,210	9,210	8,360
Stocks, Jan. 1:						
Government		1,270,000	1,250,000	1,280,000	1,210,000	1,170,000
Industry		126,000	118,000	118,000	103,000	101,000
Total U.S. supply		1,800,000	1,800,000	1,820,000	1,690,000	1,790,000
Distribution of U.S. supply:						
Exports:						
Chromite ore		2,660	2,180	3,310	14,000	5,740
Chromium ferroalloy and metal		6,570	6,530	9,420	7,600	6,260
Chromium chemicals		9,000	9,270	8,170	11,700	14,700
Stocks, Dec. 31:						
Government		1,250,000	1,280,000	1,210,000	1,170,000	1,120,000
Industry		118,000	118,000	103,000 r/	101,000	80,400
Total U.S. distribution		1,390,000	1,420,000	1,340,000	1,300,000	1,230,000
Apparent industry demand		413,000	378,000	484,000	390,000	566,000
Industrial releases and transfers: 5/						
Released		12,400	11,600	11,300	10,500	NA
Transferred		41,900	55,300	69,600	76,400	NA
Total		54,300	66,900	80,900	86,900	NA
Value of trade:						
Exports	thousands	$56,400	$56,200	$64,900	$69,900	$83,200
Imports	do.	$328,000	$330,000	$279,000	$254,000	$545,000
Net trade 6/	do.	($271,000)	($274,000)	($214,000)	($185,000)	($461,000)

e/ Estimated. r/ Revised. NA Not available.

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

2/ Calculated assuming chromite ore to average 44% Cr_2O_3 that is 68.42% chromium.

3/ Calculated assuming chromium content of ferrochromium to average 57%.

4/ Calculated assuming chromium content of stainless steel to average 17%.

5/ Data on industrial release and transfers from Environmental Protection Agency, Toxic Release Inventory (July 1996.)

6/ Number in parenthesis indicate that imports are greater than exports.

TABLE 2
MANUFACTURING INDUSTRY CHROMIUM 1/ RELEASE TO THE ENVIRONMENT
AND TRANSFER BY MODE AND BY YEAR 2/

Mode	1992 Kilograms contained chromium	1992 Percent	1993 Kilograms contained chromium	1993 Percent
Releases: 3/				
To air	451,000 r/	4	388,000	3
To water	136,000 r/	1	115,000	1
To underground	14,700	(4/)	19,400	(4/)
To land:				
Fill	1,730,000 r/	15	1,480,000	13
Treatment	111,000	1	61,300	1
Impoundment	9,020,000 r/	77	9,140,000	81
Other	177,000 r/	2 r/	86,800	1
Total releases 5/	11,600,000	17	11,300,000	14
Transfers: 6/				
To POTW	435,000	1	206,000	(4/)
To off-site location:				
Disposal	6,680,000	12	7,870,000	11
Recycling	46,200,000	84	59,900,000	86
Treatment	1,730,000	3	1,560,000	2
Other	269,000	(4/)	28,200	(4/)
Total transfers 5/	55,300,000	83	69,600,000	86
Total releases plus transfers	66,900,000	XX	80,900,000	XX

r/ Revised. XX Not applicable
1/ Chromium contained in EPA categories chromium and chromium compounds.
2/ Data are rounded to three significant digits; may not add to totals shown.
3/ Releases as percent of total releases.
4/ Less than 1/2 unit.
5/ Totals as percent of total releases plus transfers.
6/ Transfers as percent of total transfers.

NOTE: Air included point and nonpoint (i.e. stack and fugitive) sources. POTW is publicly owned treatment works.

Source: Environmental Protection Agency, Toxic Release Inventory (July 1996).

TABLE 3
CHROMIUM 1/ RELEASED TO THE ENVIRONMENT AND TRANSFERRED BY INDUSTRY 2/

(Kilograms, contained chromium)

SIC 3/	Industry	1992 Released	1992 Transferred	1992 Total	1993 Released	1993 Transferred	1993 Total
20	Food products	5,150	35,900	41,100	3,940	72,200	76,100
21	Tobacco products	--	113	113	--	113	113
22	Textile mill products	2,230	63,200	65,500	4,730	29,000	33,700
23	Apparel	--	--	--	--	--	--
24	Lumber and wood products	2,570	61,100	63,700	2,330	70,200	72,500
25	Furniture	20,500	704,000	724,000	14,900	298,000	313,000
26	Paper and allied products	95,300	19,000	114,000	62,400	5,690	68,100
27	Printing and publishing	113	4,400	4,510	113	3,650	3,770
28	Chemical and allied products	8,580,000	886,000	9,470,000	8,720,000	997,000	9,710,000
29	Petroleum and coal	182,000	83,800	266,000	92,000	84,000	176,000
30	Rubber and plastic	6,180	162,000	168,000	3,660	426,000	430,000
31	Leather and leather products	18,100	1,110,000	1,120,000	6,130	1,020,000	1,030,000
32	Stone, clay, glass, and concrete	85,000	1,140,000	1,220,000	85,300	1,870,000	1,960,000
33	Primary metals	2,370,000	26,400,000	28,800,000	2,070,000	37,200,000	39,300,000
34	Fabricated metals	190,000	8,480,000	8,670,000	98,600	10,400,000	10,500,000
35	Machinery and computer equipment	30,100	8,250,000	8,280,000	60,300	6,800,000	6,860,000
36	Electrical and electronic equipment	5,060	912,000	917,000	21,200	847,000	868,000
37	Transportation equipment	36,200	6,350,000	6,390,000	40,500	7,950,000	7,990,000
38	Instruments	2,700	419,000	422,000	3,190	483,000	486,000
39	Miscellaneous manufacturing	1,300	60,800	62,100	2,130	949,000	951,000
	Other	1,280	85,300	86,500	1,110	92,900	94,000
	Total	11,600,000	55,300,000	66,900,000	11,300,000	69,600,000	80,900,000

1/ Chromium contained in EPA categories chromium and chromium compounds.
2/ Data are rounded to three significant digits; may not add to totals shown.
3/ Standard industrial classification code.

Source: Environmental Protection Agency, Toxic Release Inventory (July 1994).

TABLE 4
PRINCIPAL U.S. PRODUCERS OF CHROMIUM PRODUCTS IN 1995, BY INDUSTRY

Industry and company	Plant
Metallurgical:	
Elkem AS, Elkem Metals Co.	Marietta, OH.
Macalloy Corp.	Charleston, SC.
Refractory:	
General Refractories Co.	Lehi, UT.
Harbison-Walker Refractories, a division of Dresser Industries Inc.	Hammond, IN.
National Refractories & Mining Corp.	Moss Landing, CA and Columbiana, OH.
North American Refractories Co. Ltd.	Womelsdorf, PA.
Chemical:	
American Chrome & Chemicals Inc.	Corpus Christi, TX.
Occidental Chemicals Corp.	Castle Hayne, NC.

TABLE 5
PRODUCTION, SHIPMENTS, AND STOCKS OF CHROMIUM FERROALLOYS AND METAL, AND OTHER CHROMIUM MATERIALS IN THE UNITED STATES 1/

(Metric tons)

	Net production			
Year	Gross weight	Chromium content	Net shipments	Producer stocks, Dec. 31
1994	67,400	45,800	63,900	8,070
1995	72,500	49,500	72,100	8,430

1/ Data are rounded to three significant digits.

TABLE 6
CONSUMPTION OF CHROMITE AND TENOR OF ORE USED BY PRIMARY CONSUMER GROUPS IN THE UNITED STATES 1/

	Chemical and metallurgical industry		Refractory industry		Total	
Year	Gross weight (metric tons)	Average Cr_2O_3 (percentage)	Gross weight (metric tons)	Average Cr_2O_3 (percentage)	Gross weight (metric tons)	Average Cr_2O_3 (percentage)
1994	302,000	47.8	20,100	40.0	322,000	47.3
1995	W	43.9	W	42.1	351,000	43.8

W Withheld to avoid disclosing company proprietary data; included in "Total."
1/ Data are rounded to three significant digits; may not add to totals shown.

TABLE 7
U.S. CONSUMPTION OF CHROMIUM FERROALLOYS AND METAL, BY END USE 1/

(Metric tons, gross weight unless noted)

End use	Ferrochromium		Ferro-chromium-silicon	Other	Total
	Low-carbon 2/	High-carbon 3/			
1994:					
Steel:					
Carbon	4,520	6,950	199	W	11,700
Stainless and heat-resisting	8,180	252,000	14,800	41	275,000
Full-alloy	3,200	23,000	1,370	W	27,600
High-strength, low-alloy and electric	1,820	2,030	7,230	--	11,100
Tool	W	2,980	W	W	2,980
Cast irons	1,050	3,890	W	406 r/	5,340 r/
Superalloys	2,090	4,280	--	3,080	9,450
Welding materials 4/	15	122	--	W	137
Other alloys 5/	731	340	--	1,350	2,420
Miscellaneous and unspecified	1,580	228 r/	985	797	3,590
Total 6/	23,200	296,000	24,600	5,670 r/ 7/	350,000 r/
Chromium content	15,700	176,000	8,910	4,900 r/	206,000 r/
Stocks, December 31, 1994	1,990 r/	12,000	527	523 r/ 8/	15,000 r/
1995:					
Steel:					
Carbon	4,360	7,560	165	W	12,100
Stainless and heat-resisting	7,980	209,000	32,800	W	250,000
Full-alloy	4,250	27,800	1,380	W	33,400
High-strength, low-alloy and electric	1,580	2,150	7,280	--	11,000
Tool	W	4,140	W	W	4,140
Cast irons	935	3,230	W	384	4,550
Superalloys	2,380	4,940	--	3,430	10,700
Welding materials 4/	W	89	W	W	89
Other alloys 5/	621	363	--	1,530	2,510
Miscellaneous and unspecified	1,720	223	5,840	1,470	9,250
Total 6/	23,800	260,000	47,500	6,800 9/	338,000
Chromium content	16,000	153,000	18,100	5,420	193,000
Stocks, December 31, 1995	2,030	16,700	3,870	514 10/	23,200

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/ Low-carbon ferrochromium contains less than 3% carbon.

3/ High-carbon ferrochromium contains 3% or more carbon.

4/ Includes structural and hard-facing welding material.

5/ Includes cutting materials and magnetic, aluminum, copper, nickel, and other alloys.

6/ Includes estimates.

7/ Includes 3,960 tons of chromium metal.

8/ Includes 292 tons of chromium metal.

9/ Includes 4,240 tons of chromium metal.

10/ Includes 240 tons of chromium metal.

TABLE 8
U.S. CONSUMER STOCKS OF CHROMITE, CHROMIUM FERROALLOYS, AND METAL, DECEMBER 31 1/

(Metric tons, gross weight)

Industry	1994	1995
Chromite:		
Chemical and metallurgical	250,000	194,000
Refractory	16,500	10,900
Total	266,000	205,000
Chromium ferroalloy and metal:		
Low-carbon ferrochromium	1,990 r/	2,030
High-carbon ferrochromium	12,000	16,700
Ferrochromium-silicon	527	3,870
Other 2/	523 r/	514
Total	15,000 r/	23,200

r/ Revised.

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

2/ Includes chromium briquets, chromium metal, exothermic chromium additives, and other miscellaneous chromium alloys.

TABLE 9
U.S. GOVERNMENT STOCKPILE YEAREND INVENTORIES 1/ AND CHANGE FOR CHROMIUM 2/

(Metric tons, gross weight)

Material	1994	1995	Change 3/ Quantity	Change 3/ Percent
Chromite:				
Chemical	220,000	220,000	--	--
Metallurgical	905,000	773,000	(133,000)	(17%)
Refractory	345,000	328,000	(17,100)	(5%)
Chromium ferroalloys:				
Ferrochromium-silicon	52,900	52,900	--	--
High-carbon ferrochromium	740,000	738,000	(2,490)	(4/)
Low-carbon ferrochromium	283,000	283,000	--	--
Chromium metal:				
Aluminothermic	2,670	2,670	--	--
Electrolytic	5,020	5,020	--	--

1/ Includes specification- and nonspecification-grade material.
2/ Data are rounded to three significant digits.
3/ Number in parenthesis indicates decrease.
4/ Less than 1/2 unit.

Source: Defense Logistics Agency.

TABLE 10
TIME-VALUE 1/ RELATIONSHIPS FOR CHROMITE ORE

(Average annual value, dollars per metric ton)

	Not more than 40% chromic oxide		More than 40% but less than 46% chromic oxide		46% or more chromic oxide		Total, all grades	
Year	Contained chromium	Gross weight	Contained chromium	Gross weight	Contained chromium	Gross weight	Contained chromium	Gross weight
1994	574	88	219	69	205	66	233	69
1995	630	153	262	74	232	76	247	80

1/ Customs value per ton of chromium contained in imported material.

TABLE 11
TIME-VALUE 1/ RELATIONSHIPS FOR FERROCHROMIUM AND CHROMIUM METAL 2/

(Average annual value, dollars per metric ton)

	Ferrochromium						Chromium metal
	Low-carbon 3/		High-carbon 4/		Total, all grades		
Year	Contained chromium	Gross weight	Contained chromium	Gross weight	Contained chromium	Gross weight	gross weight
1994	1,190 r/	776	638	379	767	465	6,030
1995	1,880	1,230	1,220	731	1,320	805	6,450

r/ Revised.
1/ Customs value per ton of chromium contained in imported material.
2/ Data are rounded to three significant digits.
3/ Carbon not more than 4%.
4/ More than 4% carbon.

TABLE 12
PRICE QUOTATIONS FOR CHROMIUM MATERIALS AT BEGINNING AND END OF 1995

Material	January	December	Year average
Dollars per metric ton of product:			
Chromite ore:			
South Africa	50 - 60	70 - 80	61
Turkey	105 - 110	220 - 230	144
Cents per pound of chromium:			
High-carbon ferrochromium:			
Imported:			
50% to 55% chromium	43 - 45	62 - 64	70
60% to 65% chromium	47 - 49	66 - 70	74
Low-carbon:			
Domestic:			
0.05% carbon	95	95	95
0.015% carbon (Simplex)	166	166	166
Imported:			
0.05% carbon	81 - 83	119 - 123	112
0.10% carbon	68 - 72	110 - 112	104
Cents per pound of product:			
Chromium metal (domestic):			
Electrolytic	370.0	415.0	397.0
Elchrome	450.0	490.0	473.0

Source: Platt's Metals Week.

TABLE 13
U.S. EXPORTS OF CHROMIUM MATERIALS, BY TYPE 1/

Type	1994 Gross weight (metric tons)	1994 Value (thousands)	1995 Gross weight (metric tons)	1995 Value (thousands)	Principal destinations, 1995
Chromite ore and concentrate	47,100	$3,550	17,800	$3,430	Canada (90%); Mexico (7%).
Metal and alloys:					
Chromium metal 2/	446	4,150	714	7,820	Japan (47%); Canada (22%).
Chromium ferroalloys:					
High-carbon ferrochromium 3/	6,220 4/	5,260	6,610 5/	8,120	Mexico (68%); Canada (29%).
Low-carbon ferrochromium 6/	5,320 7/	6,450	2,010 8/	3,490	Canada (35%); Mexico (31%); Netherlands (11%); United Kingdom (10%).
Ferrochromium-silicon	499 9/	554	741 10/	860	Canada (87%); Mexico (13%).
Total ferroalloys	12,000 11/	12,300	9,360 12/	12,500	
Chemicals:					
Chromium oxides:					
Chromium trioxide	5,940	11,200	7,590	14,500	Canada (35%); Japan (12%); Australia (10%); Mexico (9%); Korea, Republic of (9%); Taiwan (4%).
Other	2,450	14,700	2,460	14,600	Canada (39%); Netherlands (16%); Korea, Republic of (13%); Japan (7%); United Kingdom (6%).
Chromium sulfates	10	45	187	412	Canada (92%); Mexico (6%).
Salts of oxometallic or peroxometallic acids:					
Zinc and lead chromate	938	3,150	969	3,280	Canada (99%).
Sodium dichromate	19,600	13,000	25,800	18,900	Mexico (36%); Thailand (21%); China (10%); Peru (5%).
Potassium dichromate	45	121	35	102	Canada (75%); Japan (20%).
Other chromates, dichromates, and peroxochromates	470	1,750	410	1,620	Canada (53%); Australia (29%); Brazil (13%).
Pigments and preparations	1,310	6,010	1,260	6,020	Philippines (31%); Mexico (8%); Canada (7%); Japan (7%); Netherlands (6%); South Africa (6%).

1/ Data are rounded to three significant digits; may not add to totals shown.
2/ Articles thereof and waste and scrap.
3/ More than 4% carbon.
4/ Contained 3,700 tons of chromium.
5/ Contained 4,060 tons of chromium.
6/ Not more than 4% carbon.
7/ Contained 3,280 tons of chromium.
8/ Contained 1,220 tons of chromium.
9/ Contained 174 tons of chromium.
10/ Contained 259 tons of chromium.
11/ Contained 7,150 tons of chromium.
12/ Contained 5,540 tons of chromium.

Source: Bureau of the Census.

TABLE 14
U.S. IMPORTS FOR CONSUMPTION OF CHROMITE ORE, BY COUNTRY 1/

	Not more than 40% Cr_2O_3			More than 40% but less than 46% Cr_2O_3			46% or more Cr_2O_3			Total		
Country	Gross weight (metric tons)	Cr_2O_3 content (metric tons)	Value (thousands)	Gross weight (metric tons)	Cr_2O_3 content (metric tons)	Value (thousands)	Gross weight (metric tons)	Cr_2O_3 content (metric tons)	Value (thousands)	Gross weight (metric tons)	Cr_2O_3 content (metric tons)	Value (thousands)
1994:												
Philippines	8,060	2,620	$1,250	450	187	$84	--	--	--	8,510	2,810	$1,340
South Africa	19,900	3,650	1,210	18,300	8,410	1,200	155,000	72,300	$10,200	193,000	84,400	12,600
Total	27,900	6,270	2,470	18,700	8,600	1,290	155,000	72,300	10,200	201,000	87,200	13,900
1995:												
Canada	--	--	--	--	--	--	39	24	9	39	24	9
India	--	--	--	--	--	--	25,400	12,400	4,090	25,400	12,400	4,090
Philippines	11,100	4,000	1,700	--	--	--	--	--	--	11,100	4,000	1,700
South Africa	171	39	27	14,800	6,110	1,100	201,000	96,400	13,200	216,000	103,000	14,300
Venezuela	321	80	49	--	--	--	--	--	--	321	80	49
Total	11,600	4,120	1,780	14,800	6,110	1,100	226,000	109,000	17,200	253,000	119,000	20,100

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

Source: Bureau of the Census.

TABLE 15
U.S. IMPORTS FOR CONSUMPTION OF FERROCHROMIUM, BY COUNTRY 1/

Country	Low-carbon (not more than 3% carbon)			Medium-carbon (more than 3% carbon but not more than 4% carbon)			High-carbon (more than 4% carbon)			Total (all grades)		
	Gross weight (metric tons)	Chromium content (metric tons)	Value (thou-sands)	Gross weight (metric tons)	Chromium content (metric tons)	Value (thou-sands)	Gross weight (metric tons)	Chromium content (metric tons)	Value (thou-sands)	Gross weight (metric tons)	Chromium content (metric tons)	Value (thou-sands)
1994:												
Albania	--	--	--	--	--	--	7,690	4,800	$3,250	7,690	4,800	$3,250
China	3,010	1,970	$2,770	--	--	--	370	222	146	3,380	2,190	2,920
Croatia	--	--	--	--	--	--	21,200	13,100	7,820	21,200	13,100	7,820
Estonia	--	--	--	--	--	--	2,000	1,350	804	2,000	1,350	804
Finland	--	--	--	--	--	--	13,800	7,670	5,680	13,800	7,670	5,680
France	60	41	75	--	--	--	3	2	4	63	43	78
Germany	4,420	3,160	9,060	--	--	--	53	36	33	4,470	3,200	9,090
India	--	--	--	--	--	--	7,250	4,460	3,040	7,250	4,460	3,040
Japan	580	400	1,580	--	--	--	86	57	169	666	456	1,750
Kazakstan	9,100	6,380	5,650	1,800	1,210	$613	18,300	11,800	6,970	29,200	19,300	13,200
Macedonia	324	220	269	--	--	--	--	--	--	324	220	269
Mexico	--	--	--	397	281	179	--	--	--	397	281	179
Poland	--	--	--	--	--	--	386	263	243	386	263	243
Russia	30,700	20,800	23,700	--	--	--	25,700	16,700	11,000	56,500	37,500	34,700
Slovakia	2,060	1,450	934	--	--	--	--	--	--	2,060	1,450	934
South Africa	10,800	5,940	5,010	2,600	1,310	954	67,200	34,100	22,400	80,600	41,300	28,400
Sweden	--	--	--	--	--	--	120	80	65	120	80	65
Turkey	1,720	1,190	1,520	30	19	21	62,500	38,800	24,000	64,300	40,000	25,500
Ukraine	303	222	451	--	--	--	--	--	--	303	222	451
United Kingdom	17	13	30	--	--	--	198	133	230	215	146	260
Former U.S.S.R.	--	--	--	--	--	--	3,320	2,290	1,060	3,320	2,290	1,060
Zimbabwe	1,310	694	946	--	--	--	18,000	11,500	7,070	19,300	12,200	8,020
Total	64,500	42,500	52,000	4,830	2,820	1,770	248,000	147,000	94,000	317,000	193,000	148,000
1995:												
Albania	--	--	--	--	--	--	8,700	5,240	5,170	8,700	5,240	5,170
Argentina	70	51	107	--	--	--	--	--	--	70	51	107
Brazil	--	--	--	--	--	--	7,000	3,690	4,660	7,000	3,690	4,660
Canada	--	--	--	--	--	--	19	11	22	19	11	22
China	5,240	3,350	6,830	227	151	127	12,400	8,020	11,000	17,800	11,500	17,900
Croatia	--	--	--	6	4	9	14,300	8,820	10,800	14,300	8,820	10,800
Estonia	123	87	140	--	--	--	--	--	--	123	87	140
Finland	--	--	--	--	--	--	8,610	4,850	5,270	8,610	4,850	5,270
France	--	--	--	--	--	--	7	5	9	7	5	9
Germany	6,830	4,770	14,600	--	--	--	7	5	15	6,840	4,780	14,600
India	--	--	--	--	--	--	11,600	6,970	10,300	11,600	6,970	10,300
Japan	525	348	1,350	--	--	--	269	169	309	793	517	1,660
Kazakstan	7,040	4,370	7,730	5,840	3,840	5,750	34,300	22,800	28,000	47,200	31,000	41,500
Latvia	1,120	727	1,150	--	--	--	15,500	10,700	13,300	16,600	11,500	14,500
Netherlands	5	3	7	--	--	--	--	--	--	5	3	7
Norway	--	--	--	--	--	--	6,170	3,850	5,200	6,170	3,850	5,200
Philippines	--	--	--	--	--	--	2,580	1,530	2,390	2,580	1,530	2,390
Poland	--	--	--	--	--	--	1,410	801	1,020	1,410	801	1,020
Russia	28,100	19,500	37,200	--	--	--	68,300	45,800	57,800	96,400	65,300	95,000
Slovenia	--	--	--	--	--	--	1,250	750	1,140	1,250	750	1,140
South Africa	14,300	8,050	10,900	--	--	--	118,000	60,000	58,900	132,000	68,000	69,800
Sweden	--	--	--	--	--	--	38	26	49	38	26	49
Turkey	956	699	1,240	1,500	930	1,170	82,400	51,000	69,000	84,800	52,600	71,400
Ukraine	185	131	237	--	--	--	--	--	--	185	131	237
United Kingdom	61	46	132	--	--	--	162	107	201	224	153	332
Zimbabwe	1,340	716	1,320	--	--	--	29,000	18,400	24,000	30,300	19,100	25,300
Total	65,800	42,800	82,900	7,570	4,930	7,060	422,000	254,000	309,000	495,000	301,000	399,000

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

Source: Bureau of the Census.

TABLE 16
U.S. IMPORTS FOR CONSUMPTION OF CHROMIUM MATERIALS, BY TYPE 1/

Type	1994 Gross weight (metric tons)	1994 Value (thousands)	1995 Gross weight (metric tons)	1995 Value (thousands)	Principal sources, 1995
Metals and alloys:					
Chromium metal:					
Waste and scrap	366	$1,730	109	$542	China (79%); Russia (14%).
Other than waste and scrap	6,160	37,600	6,930	44,900	China (27%); France (26%); Russia (20%); United Kingdom (19%).
Ferrochromium-silicon	15,100 2/	7,790	49,600 3/	32,500	Russia (57%); China (17%); Zimbabwe (12%).
Chemicals:					
Chromium oxides and hydroxides:					
Chromium trioxide	2,540	4,820	4,060	7,270	Kazakstan (44%); China (22%); Germany (21%); Italy (4%).
Other	5,740	13,900	5,030	14,500	Germany (27%); Japan (18%); United Kingdom (17%); China (14%).
Sulfates of chromium	241	166	170	127	South Africa (42%); Mexico (34%); Germany (12%); Turkey (12%).
Salts of oxometallic or peroxometallic acids:					
Chromates of lead and zinc	281	861	396	925	Canada (67%); Japan (16%); Norway (12%).
Sodium dichromate	10,500	5,920	7,000	4,660	United Kingdom (87%); Argentina (6%).
Potassium dichromate	396	693	377	661	United Kingdom (64%); Russia (23%); Mexico (6%).
Other chromates and dichromates; peroxochromates	708	1,570	919	2,040	United Kingdom (80%); France (13%).
Chromium carbide	151	1,320	200	1,970	Japan (48%); United Kingdom (34%); Germany (16%).
Pigments and preparations based on chromium:					
Chrome yellow	5,080	11,400	4,700	10,400	Canada (53%); Mexico (23%); Poland (11%).
Molybdenum orange	616	1,870	673	2,250	Canada (98%).
Zinc yellow	218	435	136	314	Norway (100%).
Other	481	2,730	805	3,060	Canada (40%); France (29%); Germany (12%).

1/ Data are rounded to three significant digits; may not add to totals shown.
2/ Contained 5,260 tons of chromium.
3/ Contained 17,300 tons of chromium.

Source: Bureau of the Census.

TABLE 17
PRINCIPAL WORLD CHROMITE PRODUCERS, 1995

Country 1/	Company
Albania	Albchrome (Government owned).
Brazil	Bayer AG (Germany).
	Coitezeiro Mineração S.A.
	Cia. de Ferro-Ligas da Bahia S.A.
	Cia. de Mineração Serra de Jacobina S.A.
	Mineração Vale do Jacurici S.A.
	Indústria e Comércio de Minérios S.A.
	Invituruí Mineração S.A.
	Magnesita S.A.
	Piunhiense Mineração Ltda.
	Rada Mineração Ltda.
Finland	Outokumpu Chrome Oy (Government owned).
India	Ferro Alloys Corp. Ltd.
	Mysore Mineral Ltd.
	Orissa Mining Corp. Ltd. (Government owned).
	Tata Iron and Steel Co. Ltd.
Indonesia	PT. Palabim Mining-PT. Bituminuse
Japan	Japan Chrome Industry Co. Ltd.
Kazakstan	Donskoy Ore Dressing Complex.
Philippines	Acoje Mining Co. Inc.
	Benguet Corp.
	Philchrome Mining Corp.
	Velore Mining Corp.
Russia	Saranov Complex.
South Africa 2/	African Mining and Trust Co. Ltd.
	Rustenburg Minerals Development Co. (Pty.) Ltd.
	Zeerust Chrome Mine Ltd.
	Bayer (Germany).
	Bayer (Pty.) Ltd.
	Canadian Gold S.A. (Pty.) Ltd.
	Goudini Chrome (Pty.) Ltd.
	Chromecorp Holdings (Pty.) Ltd.
	Chrome Resources (Pty.) Ltd.
	Consolidated Metallurgical Industries Ltd.
	Hernic Chrome
	Hernic Mining (Pty.) Ltd.
	Lebowa Development Corp. Ltd.
	Dilokong Chrome Mine (Pty.) Ltd.
	Pilanesberg Chrome (Pty.) Ltd.
	Rooderand Chrome Mine (Pty.) Ltd.
	Samancor Ltd.
	Batlhako Mining Ltd.
	Eastern Chrome Mines.
	Doornbosch Mines.
	Lannex Joint Venture.
	Montrose Mine.
	Groothoek Section.
	Jagdlust Section.
	Montrose Section.
	Mooihoek Mine.
	Steelpoort Mine.
	Tweefontein Mine.
	Western Chrome Mines.
	Buffelsfontein Section.
	Elandsdrift Section.
	Henery Gould Section.
	Millsell Section.
	Mooinooi Section.
	Waterloof Section.
	Vereeniging Refractories Ltd.
	Bophuthatswana Chrome Co. (Pty.) Ltd.
	Marico Chrome Corp. Ltd.
Sudan	Advanced Mining Works Ltd.
	Blue Nile Mines Co. Ltd.

See footnotes at end of table.

TABLE 17 - Continued
PRINCIPAL WORLD CHROMITE PRODUCERS, 1995

Country 1/	Company
Turkey	Aycan Madencilik Ltd. Sti.
	Bilfer Madencilik A.S.
	Birlik Madencilik Sanayi ve Ticaret A.S.
	Cevher Madencilik ve Ticaret A.S.
	Dedeman Madencilik Turzim Sanayi ve Ticaret A.S.
	Ege Metal Endüstri A.S.
	Etibank General Management (Government owned).
	Hayri Ögelman Madencilik Ltd. Sti.
	Tekfen Dis. Ticaret A.S.
	Tevfik Refik Bayoglu Madencilik.
	Tut. Gen. Ticaret Ltd. Sti.
	Turk Maadin Sti. A.S.
Zimbabwe	Zimbabwe Alloys Ltd.
	Zimasco (Pvt.) Ltd.

1/ Other chromite-producing countries included Burma, China, Cuba, Egypt, Iran, Macedonia, Madagascar, Morocco, Oman, and Pakistan.

2/ Includes Bophuthatswana.

TABLE 18
PRINCIPAL WORLD FERROCHROMIUM PRODUCERS, 1995

Country 1/	Company
Albania	Albchrome Ltd. (Government owned).
Brazil	Cia. de Ferro-Ligas da Bahia S.A.
China	Chongqing Ferroalloy Works (Government owned).
	Emei Ferroalloy Works (Government owned).
	Hanzhong Ferroalloy Works (Government owned).
	Hengshan Iron and Steel Works (Government owned).
	Hunan Ferroalloy Works Government owned).
	Jiangyin Ferroalloy Factory (Government owned).
	Jilin Ferroalloy Works (Government owned).
	Jinzhou Ferroalloy Works (Government owned).
	Liaoyang Ferroalloy Works (Government owned).
	Nanjing Ferroalloy Plant (Government owned).
	Shanghai Ferroalloy Works (Government owned).
	Xibei Ferroalloy Works (Government owned).
Croatia	Dalmacija Ferro-Alloys Works.
Finland	Outokumpu Chrome Oy (Government owned).
Germany	Elektrowerk Weisweiler GmbH.
India	Deepak Ferro-Alloys Ltd.
	Eastern Metals & Ferro-Alloys Ltd.
	Ferro Alloys Corp. Ltd.
	Charge Chrome Works.
	Ferroalloys Works.
	GMR Vasavi Industries Ltd.
	Hi-Tech Electrothermics (Pvt.) Ltd.
	Indian Metals & Ferro Alloys Ltd.
	Indian Charge Chrome Ltd.
	Industrial Development Corp.
	Ispat Alloys Ltd.
	Jindal Ferro Alloys Ltd.
	Mandsaur Ferro Alloys Ltd.
	Monnet Industries Ltd.
	Nav Chrome Ltd.
	Nava Bharat Ferro Alloys Ltd.
	Standard Chrome Ltd.
	Tata Iron and Steel Co. Ltd.
	Bamnipal Plant.
	Joda Plant.
	VBC Ferro-Alloys Ltd.
	Visvesvaraya Iron & Steel Ltd. (State owned).
	V.K. Ferroalloys (Pvt.) Ltd.
Italy	Acciaierie e Ferriere Lombarde Falck SpA.
	Darfo s.r.l.
	Ferroleghe SpA.

See footnotes at end of table.

TABLE 18--Continued
PRINCIPAL WORLD FERROCHROMIUM PRODUCERS, 1995

Country 1/	Company
Japan	Japan Metals and Chemicals Co. Ltd.
	Nippon Denko Co. Ltd.
	NKK Corp.
	Pacific Metals Co. Ltd.
	Showa Denko K.K.
Kazakstan	Aktubinsk Ferroalloy Works.
	Yermakovsky Ferroalloy Plant.
Norway	Elkem A/S.
Philippines	Ferrochrome Philippines Inc.
	Integrated Chrome Corp.
	Philippine Mineral & Alloy Corp.
Poland	Huta "Laziska" Ferroalloy Plant.
Romania	S.C. Ferom S.A.
Russia	Chelyabinsk Electrometallurgical Works.
	Klutchevsk Ferroalloy Plant.
	Serovsk Ferroalloy Works.
Slovakia	Oravske Ferozliatinarske Zavody.
Slovenia	Tovarna Dusika Ruse-Metalurgija d.o.o.
South Africa	Assoc. Manganese Mines of South Africa Ltd.
	Feralloys Ltd.
	Chromecorp Holdings Ltd.
	Chrome Resources (Pty.) Ltd.
	Ferrochrome Division.
	Johannesburg Consolidated Investment Co. Ltd.
	Consolidated Metallurgical Industries Ltd.
	Lydenburg Works.
	Rustenburg Works.
	Purity Ferrochrome (Pty.) Ltd.
	Samancor Ltd.
	Batlhako Ferrochrome Ltd.
	Ferrometals Division.
	Middelburg Ferrochrome Division.
	Palmiet Ferrochrome Division.
	Tubatse Ferrochrome Division.
Sweden	Vargön Alloy AB.
Turkey	Etibank General Management (Government owned).
United States	Elkem Metals Co.
	Macalloy Corp.
Zimbabwe	Zimbabwe Alloys Ltd.
	Zimasco (Pvt.) Ltd.

1/ Other ferrochromium-producing countries include Chile, Mexico, Spain and Taiwan.

TABLE 19
CHROMITE: WORLD PRODUCTION, BY COUNTRY 1/ 2/

(Metric tons, gross weight)

Country 3/	1991	1992	1993	1994	1995 e/
Albania	587,000	322,000	282,000	222,879	250,000
Brazil 4/	340,000	448,980	307,577	359,788	360,000
Burma e/	1,000	6,200	1,000	1,000	--
China e/	25,000	25,000	54,000	62,000 r/	70,000
Cuba e/	50,000	50,000	50,000	50,000	50,000
Egypt e/	649 5/	600	600	600	600
Finland	473,000	499,000	511,000	572,747	610,000
Greece 6/	37,169	4,000 e/	2,500 r/ e/	-- r/	--
India	939,597	1,158,050 r/	1,026,024 r/	1,021,846 r/	1,230,000
Indonesia e/	1,950 5/	2,000	2,500	2,500	2,500
Iran 7/	90,119	130,265	130,000 e/	129,000	129,000
Japan e/	8,000	8,000	7,000	7,000	7,000
Kazakstan	XX	3,500,000	2,900,000	2,020,000	2,400,000
Macedonia e/ 8/	XX	6,000	5,000	5,000	5,000
Madagascar 7/	149,400	160,700	144,200	90,200	90,000
Morocco	500	500	500 e/	500 e/	500
New Caledonia	--	8,169	--	--	--
Oman	--	1,764	10,000 e/	6,166 r/	5,300 5/
Pakistan	31,474	22,852	22,154	6,240 r/	17,000
Philippines	191,484	80,509 r/	58,436 r/	74,956 r/	95,000
Russia e/	XX	121,000	121,000	143,000 5/	151,400 5/
South Africa 9/	5,100,299	3,363,481	2,826,652	3,641,994 r/	5,104,026 5/
Sudan e/	10,000	10,000	11,500 r/	25,000 r/	25,000
Turkey 10/	940,000 e/	531,112	642,376 r/	501,851 r/	800,000
U.S.S.R. 11/	3,800,000 e/	XX	XX	XX	XX
United Arab Emirates e/	--	1,000	20,000	25,000	25,000
Yugoslavia 8/ 12/	6,000 e/	XX	XX	XX	XX
Zimbabwe	563,634	522,013	252,033	516,801	631,382 5/
Total	13,300,000	11,000,000	9,390,000 r/	9,490,000 r/	12,100,000

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

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

2/ Table includes data available through July 26, 1996.

3/ Figures for all countries represent marketable output unless otherwise noted.

4/ Reported figure.

5/ Average Cr2O3 content was as follows: 1991--41.9%; 1992--44.1%; 1993--41.0%; 1994--41.3%; and 1995--41.3%.

6/ Direct-shipping ore plus concentrate.

7/ Concentrate.

8/ All production in Yugoslavia for 1991 came from Macedonia.

9/ Includes production by Bophuthatswana.

10/ Salable product: direct-shipping lump ore plus concentrate.

11/ Dissolved in Dec. 1991.

12/ Dissolved in Apr. 1992.

TABLE 20
FERROCHROMIUM: WORLD PRODUCTION, BY COUNTRY 1/ 2/

(Metric tons)

Country	1991	1992	1993	1994	1995 e/
Albania	25,000	22,000	36,000	34,000	43,000
Brazil 3/	82,225	91,100	83,892	77,163 r/	95,840 4/
Chile	2,509	2,110	680	1,579	2,730 4/
China e/	380,000	410,000	372,000	370,000	400,000
Croatia	XX	56,456	27,336	31,700 r/	26,000 4/
Czechoslovakia 3/ 5/	41,200	52,500	XX	XX	XX
Finland	190,000	187,100	218,370	254,000 r/	232,000 4/
France e/	23,100	6,694 4/	--	--	--
Germany	38,327	26,520	16,400	17,283	22,000 4/
Greece	10,500 e/	--	--	--	--
India 6/	229,477	256,831	234,500	251,459	300,000
Iran 7/	--	--	--	5,000 e/	5,000
Italy	47,192	60,315	53,504	22,650	51,017 4/
Japan 3/	278,522	275,615	211,102	204,181 r/	221,425 4/
Kazakstan	XX	400,000 e/	327,896	200,000 r/ e/	350,000
Macedonia	XX	3,958	4,376	3,164	3,765 4/
Mexico	72	70 e/	--	--	-- 4/
Norway	83,000	102,000	80,000	120,000	148,000 4/
Philippines	23,700	27,400	11,908	16,186	50,500
Poland	1,928	35,322	38,449	7,000 e/	18,334 4/
Romania	20,380	6,977	3,907	3,885 r/	15,053 4/
Russia	XX	400,000 e/	255,900	265,525	200,000
Slovakia 3/ 5/	XX	XX	50,600	48,555 r/	65,260 4/
Slovenia	XX	17,104	9,000	12,592 r/	18,876 4/
South Africa 8/	1,149,200	770,600	833,600	1,103,612	1,341,267 4/
Spain	6,000 e/	--	2,390	2,300 r/	1,320 4/
Sweden	120,884	133,300	127,543	134,076	130,000
Turkey	84,651	85,755	90,030	97,585	88,809 4/
U.S.S.R. e/ 9/	700,000	XX	XX	XX	XX
United States 10/	68,300	60,900	63,000	67,400	72,500 4/
Yugoslavia 11/	91,000	XX	XX	XX	XX
Zimbabwe 3/	186,774	190,994	124,000 r/	182,852 r/	254,142 4/
Total	3,880,000	3,680,000	3,280,000	3,530,000 r/	4,160,000

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 26, 1996.

3/ Includes high- and low-carbon ferrochromium.

4/ Reported figure.

5/ Czechoslovakia was dissolved on Dec. 31, 1992. All production in Czechoslovakia for 1991-92 came from Slovakia.

6/ Includes ferrochrome and charge chrome.

7/ Production began in 1994. Plant capacity is estimated at 7,000 tons per day.

8/ Includes high- and low-carbon ferrochromium and ferrochromium-silicon.

9/ Dissolved in Dec. 1991.

10/ Includes high- and low-carbon ferrochromium, ferrochromium-silicon, chromium metal, and other chromium materials.

11/ Dissolved in Apr. 1992.

TABLE 21
WORLD CHROMIUM ANNUAL PRODUCTION CAPACITY OF CHROMITE ORE,
FERROCHROMIUM, CHROMIUM METAL, CHROMIUM CHEMICALS, AND STAINLESS STEEL IN 1995 1/

(Thousand metric tons, contained chromium)

	Ore	Ferro-chromium	Metal	Chemicals	Stainless steel
Albania	150	32	--	--	--
Argentina	--	--	--	6	NA
Austria	--	--	--	--	12
Bangladesh	--	--	--	--	3
Belgium	--	--	--	--	75
Brazil	135	89	(2/)	12	37
Burma	(2/)	--	--	--	--
Canada	--	--	--	--	32
Chile	--	2	--	--	--
China	13	200	5	21	68
Croatia	--	42	--	--	--
Cuba	14	--	--	--	11
Czech Republic	--	--	--	--	NA
Egypt	1	--	--	--	--
Finland	211	115	--	--	73
France	--	--	5	--	156
Germany	--	76	4	20	255
Greece	21	--	--	--	--
India	309	195	(2/)	8	83
Indonesia	20	--	--	--	--
Iran	34	8	--	2	--
Italy	--	64	--	--	146
Japan	3	146	1	21	595
Kazakstan	1,100	330	--	42	--
Korea, North	--	32	--	--	--
Korea, Republic of	--	--	--	--	102
Macedonia	3	7	--	5	--
Madagascar	21	--	--	--	--
Mexico	--	2	--	--	NA
Norway	--	88	--	--	--
Oman	6	--	--	--	--
Pakistan	10	--	--	3	--
Philippines	60	60	--	--	--
Poland	--	16	--	7	NA
Romania	--	26	--	5	NA
Russia	40	233	18	58	330
Slovakia	--	30	--	--	--
Slovenia	--	8	--	--	NA
South Africa	1,700	958	--	--	50
Spain	--	--	--	--	112
Sudan	2	--	--	--	--
Sweden	--	97	--	--	105
Taiwan	--	1	--	--	28
Thailand	(2/)	--	--	--	--
Turkey	580	103	--	10	54
Ukraine	--	--	--	--	33
United Arab Emirates	8	--	--	--	--
United Kingdom	--	--	5	52	94
United States	--	83	3	55	330
Zimbabwe	170	148	--	--	--
Total	4,610	3,190	41	330	2,780

NA Not available.

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

2/ Less than 1/2 unit.