# Magnesium

***Patrick Chevalier***

*The author is with the Minerals and Metals Sector, Natural Resources Canada.*
*Telephone: (613) 992-4401*
*E-mail: pchevali@nrcan.gc.ca*

The tightness in magnesium markets experienced in 1995 eased somewhat in 1996 as world production increased and shipments to some key sectors weakened. According to the International Magnesium Association (IMA), primary magnesium shipments for the first nine months of 1996 were down 5400 t compared to the same period in 1995, for a total of 222 000 t. The main reason for the decrease was reduced shipments to the aluminum alloy market, which dropped 13%. Markets for desulphurization and die casting were higher than last year (up 23% and 11% respectfully), but not enough to offset the losses in the aluminum alloy market. Primary production in the first three quarters of the year increased by 1700 t over the same period in 1995 to 186 500 t, primarily as the result of increased production in North America. Exports from Russia, China and Ukraine continued to be strong and now account for roughly 20% of the Western markets.

## CANADIAN DEVELOPMENTS

Production at Norsk Hydro Canada Inc.'s (NHC) 40 000-t/y Bécancour smelter in Quebec continued to operate at close to full capacity in 1996. The process technology used at Bécancour involves leaching magnesite imported from China with hydrochloric acid to produce a brine of magnesium chloride ($MgCl_2$), dehydration, and then reducing the $MgCl_2$ granules in electrolytic cells to produce metallic magnesium.

In June, NHC announced a $20 million investment for the Bécancour smelter. The plan includes the construction of a new 15 000-t/y alloy ingot casting line to meet growing demand. The plan also includes a second project to reprocess and recycle production residues normally left unused. The residues will be converted to saleable products or fed back into the magnesium production process, leaving only 20% of the original residues for landfilling as non-hazardous material. Both projects are expected to be fully operational by the fourth quarter of 1997.

NHC also completed a main expansion study at Bécancour in November. The study demonstrated the technical viability and economic attractiveness of a series of multiple-step expansions of 10 000-15 000 t each. The project is now into a technology assessment phase with no announced date for expansion.

The U.S. Department of Commerce (DOC) provisionally cut to zero from 21% the anti-dumping duty on imports of pure magnesium into the United States from Norsk Hydro's Canadian operations. The 21% anti-dumping rate had been in place since November 1993. Two more review periods are expected before any final dumping duty ruling will be made. In a separate review in October, the DOC announced its preliminary finding for the administrative review of the countervailing duty orders on both pure and alloy magnesium from NHC. The countervailing duties were lowered to 4.01% ad valorem for the period January 1 to December 31, 1994. The duty had been set at 7.61% before the review. Final results of the 1994 review period are expected in early 1997.

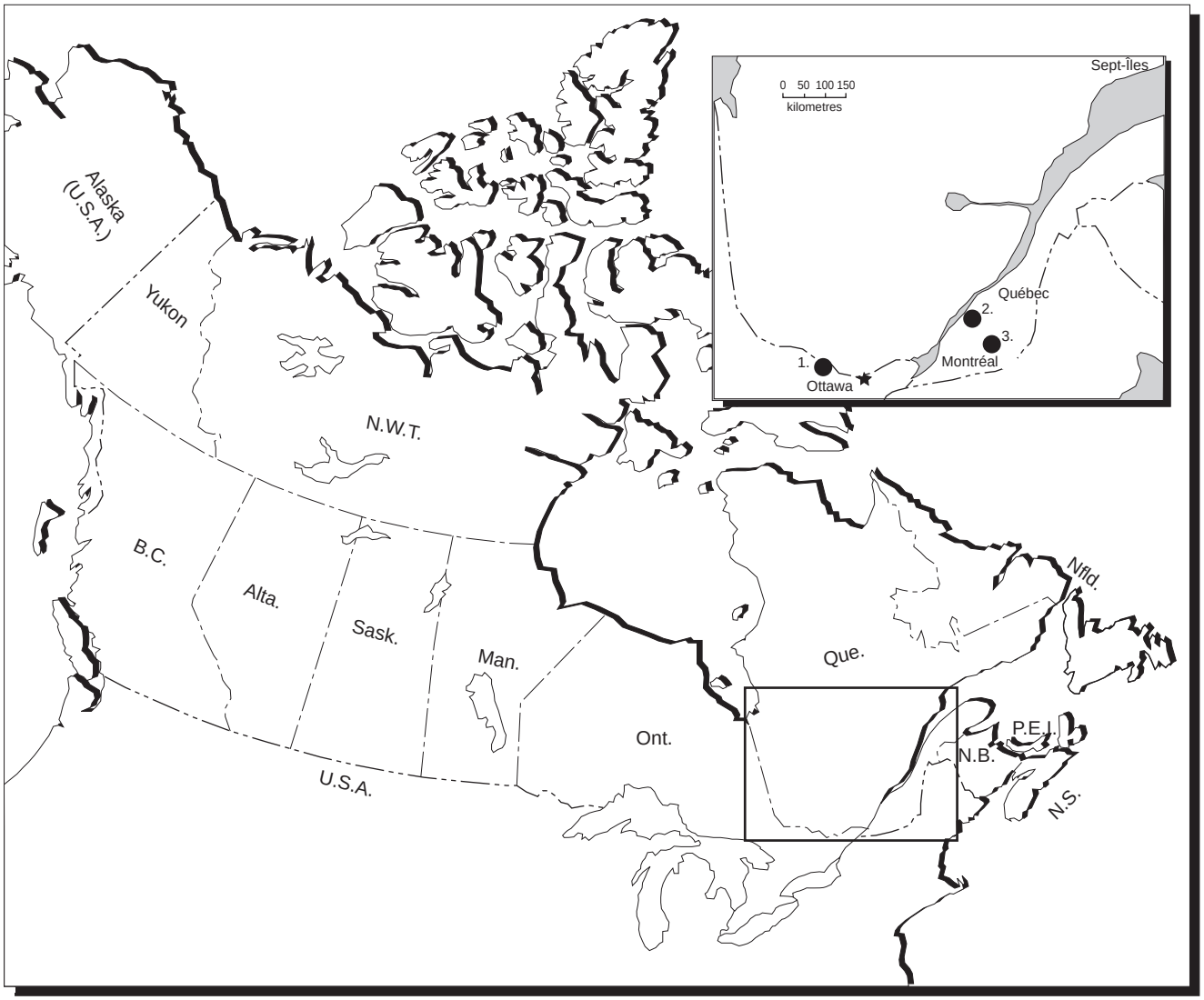
Timminco Metals, a division of Timminco Limited, produces high-purity metal (up to 99.98% pure) for specialized market applications at its 6000-t/y magnesium plant at Haley Station, Ontario. The company also produces highly corrosion-resistant magnesium die-casting alloys and extruded anode rods for hot-water heaters. Timminco's magnesium products are used for a variety of applications such as an alloying agent for aluminum and calcium, in Grignard reagents for the pharmaceutical industry, and in electronic products. Timminco uses the Pidgeon magnesium process in which calcined dolomite is reduced by ferrosilicon in a vacuum retort. Timminco mines the dolomite at the plant site but purchases the ferrosilicon feed on the open market.

Magnola Metallurgy announced plans to locate its future magnesium plant near the town of Asbestos in the Estrie region of Quebec. Work continued in 1996 to further refine Magnola's proprietary process at a pilot plant on the Canadian Electrolytic Zinc property in Valleyfield, Quebec. A decision on whether to proceed with a 58 500-t/y magnesium smelter, using a process based on the tailings from local asbestos mines, is expected to be made in 1998 with full

production by the year 2000. Noranda Metallurgy Inc. owns 52% of Magnola, while the remainder is shared between Japanese automotive parts manufacturers Aisin Seiki Company Limited, Aisin Takaoka Company Limited and Aisin World Corporation of America (16%), the Montréal-based engineering firm SNC Lavalin Inc. (16%), and the Société générale de financement du Québec (SGF) (16%).

Magnesium Services (Canada) Inc. (MSI), together with the Alberta Research Council, established a research program for the development of secondary magnesium manufacturing and recovery technologies. The $1.2 million program is expected to provide MSI with secondary magnesium production technologies, processes and techniques for the high-yield recovery of magnesium scrap.

**Figure 1**
**Magnesium Smelters, 1996**

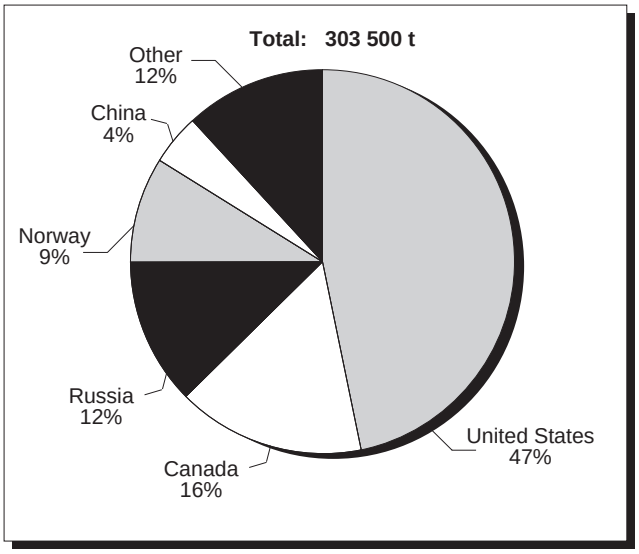



| SMELTER | COMPANY | CAPACITY (t/y) |
|---|---|---|
| 1. Haley Station, Ontario | Timminco | 6 000 |
| 2. Bécancour, Quebec | Norsk Hydro | 40 000 |
| 3. Asbestos, Quebec (proposed) | Magnola Metallurgy | 58 500 |

# WORLD DEVELOPMENTS

Western World primary magnesium production increased to 186 500 t for the first nine months of 1996 compared to 184 800 t for the same period in 1995. The increased production, coupled with an estimated 26% rise in exports from Russia and China totalling 51 100 t, helped to ease the market tightness experienced in 1995 and to suppress prices throughout 1996. While shipments in North America remained strong, total shipments of 222 000 t for the first three quarters of 1996 were lower that the 227 400 t shipped in the same period in 1995. The lower shipments reflected the weaker demand in some of magnesium's key market sectors, particularly in Europe and Asia.

**Figure 2**
**World Primary Magnesium Production, 1995**




Source: Natural Resources Canada.

## United States

The United States, which is the world's largest magnesium producer, has three primary magnesium smelters. The Dow Chemical Company, the largest U.S. producer, operates a 65 000-t/y electrolytic magnesium plant at Freeport, Texas. Magnesium chloride feedstock for the plant is derived from a seawater-dolomite process. Magnesium Corporation of America (Magcorp) operates a 38 000-t/y electrolytic plant in Rowley, Utah. Northwest Alloys Inc., a subsidiary of the Aluminum Company of America (Alcoa), operates a 38 000-t/y magnesium plant in Addy, Washington. The plant uses the Magnetherm silicothermic process in which magnesium is produced by reducing dolomite with ferrosilicon. The bulk of Northwest Alloy's production is shipped for use by subsidiaries of Alcoa.

## Europe

The European Commission (EC) retained anti-dumping duties on imports of unwrought pure magnesium from Russia and Ukraine following a review. The minimum import duties for Russian magnesium were lowered from 2735 ECU (European currency units)/t to 2602 ECU/t, and from 2701 ECU/t to 2568 ECU/t for Ukrainian magnesium. The EC imposed provisional anti-dumping duties in December 1995 following a complaint by the European industry. The duties were extended for a further two months in April while the Commission completed an anti-dumping inquiry. The Commission dropped the complaint against imports of alloyed magnesium since neither the exporters nor the European industry sold alloyed magnesium. The complaint against imports from Kazakstan was also dropped since the quantities in question were considered to be too small. Exempt from the duties are the two primary magnesium-producing companies in Russia (Avisma Titanium-Magnesium Works and Solikamsk Magnesium Works) and the sole producer in Ukraine (Concern Chlorvinil, Kaluzh Works). The companies were exempted after promising to resolve the dispute with the EC, but the duties remain to prevent third parties from undermining efforts by the three producers.

In Iceland, participants in the Icelandic Magnesium Project formed a joint-venture company, Icelandic Magnesium Corporation Limited, for the construction of a new magnesium smelter. Partners in the project include Iceland's Sudurnes Regional Heating Corporation, Salzgitter Anlagenbau GmbH of Germany, and Consortium Magniy of Russia. The partners in the project approved an agreement to complete the feasibility phase of the project by the end of 1996. Following completion of the study, a decision will be made on whether to go ahead with a two-part project to build a 25 000-t/y smelter by the second half of 1999 that would eventually be expanded to 50 000 t/y.

In June, General Motors Corporation (GM) and Norsk Hydro A/S announced an agreement to work towards the increased use of magnesium alloys in automotive applications and a long-term agreement for the supply of magnesium metal. With this new agreement, GM will be able to make a range of magnesium alloys available to both first- and second-tier suppliers for fabrication into a variety of automotive parts.

## Russian Federation

Metallurg Inc. acquired a minority equity stake in Solikamsk Magnesium Works, the Russian magnesium and rare metals producer. Solikamsk produces tantalum and niobium (columbium) oxides, titanium dioxide, and rare earth compounds, and is a major producer of magnesium. In a separate transaction, Minmet Financing Co. of Switzerland also bought a

15% equity stake in Solikamsk earlier in the year. Solikamsk produces between 17 000 and 18 000 t of pure and alloyed magnesium annually, and this year began construction of a magnesium granules plant. The plant was expected to start production by year-end. Production will begin at about 2000 t/y and will supply Russia's domestic desulphurization sector. Solikamsk is also looking to eventually build a new plant with a production capacity of 25 000 t/y.

### Middle East

Dead Sea Magnesium, a joint venture between Israel's Dead Sea Works Limited and Volkswagen AG of Germany, started magnesium production in December from the plant's first electrolytic cell. The plant is scheduled to begin commercial production in early 1997 and to produce up to 10 000 t for the rest of the year during the start-up phase. Eventually the plant is expected to increase its production capacity to 55 000 t/y.

Elsewhere in the Middle East, The Arab Potash Company announced plans to build a magnesium plant using the brines from the Dead Sea as its feed source. Arab Potash signed a memorandum of understanding with Russia to construct a 50 000-t/y plant on the Jordanian side of the Dead Sea.

### China

China has been slowly but steadily increasing its magnesium production over the past few years, largely with the assistance of Japanese investment. China may seek additional opportunities to expand even further in an effort to double its production capacity to about 80 000 t/y over the next few years. There are currently some 100 plus small-scale plants operating in China, many of which are operating at only half capacity using the Pidgeon process.

Nippon Kinzoku Co. Ltd. established a US$1.8 million magnesium smelting venture with China's Ningxia Huayuan Metallurgical Import and Export Trade Corporation. The joint venture, called Silver River Corporation, is located in the Ningxia Hui autonomous region and was scheduled to start production in March 1996 with a capacity of 1000 t/y of refined magnesium. The plant will use local sources of dolomite and produce high-grade magnesium ingots.

Taiyuan East-United Smelt Magnesium Co. Ltd., a joint-venture project between China's Zhao Jia Fort Enterprise Group and U.S.-based Shenwei Industrial Holdings Limited, began magnesium production in 1996. The smelter, located in Qinxu County, Shanxi Province, began operation in June with a production capacity of 10 000 t/y. In addition to primary magnesium ingot, the plant also produces a variety of magnesium alloys that target the die-cast market as well.

### India

India continued to review the possibility of developing its large reserves of dolomite and increasing its magnesium metal production to meet growing demand. Total recoverable reserves of dolomite in India are currently an estimated 5 billion t. There are two magnesium producers in India employing the Pidgeon process: Tamil Nadu Magnesium Limited and Southern Magnesium and Chemicals Limited (SMCL). SMCL announced that it will increase its magnesium production to up to 700 t in 1997 from just under 520 t in 1996. The company is working towards increasing capacity from its current 600 t/y to 2000 t/y. In addition to primary ingot production, SMCL plans to expand its capacity to produce magnesium powders, granules, alloys and extrusions.

### Australia

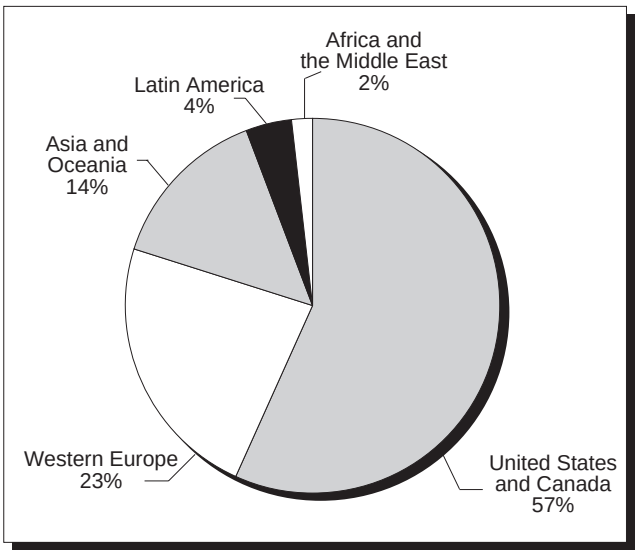
Queensland Metals Corp. Ltd. announced in May that it was close to finalizing a joint-venture deal to build an A$640 million magnesium metal smelter in Queensland. The company declined to specifically name the joint-venture parties involved in the discussions; however, a major automotive manufacturer is believed to be a likely equity partner in what would be Australia's first magnesium-producing project. The smelter, to be built near Gladstone in central Queensland, is expected to produce a minimum of 60 000 t/y of magnesium, with a possible expansion to 90 000 t/y. An official announcement outlining the details of the joint venture is expected sometime in early 1997.

## CONSUMPTION AND USES

Total world consumption of primary magnesium reached 303 700 t in 1995, compared to 298 000 t in 1994. In Canada, reported magnesium consumption in 1995 increased by 3667 t to 27 230 t as the result of a rise in consumption for castings and wrought products, which increased by 28% to 12 488 t, outpacing demand for the production of aluminum alloys for the first time. Demand for aluminum alloys increased slightly to 12 413 t.

Magnesium is the eighth most abundant element in the earth's crust, comprising over 2% of the total. It is the third most abundant element dissolved in seawater with a concentration averaging 0.14% by weight. Unlike many major elements, magnesium does not occur in its native state, but is found in over 60 different minerals. The principal sources of magnesium are as a carbonate in dolomite and magnesite; as a silicate in olivine and brucite; as an oxide in serpentine; and as a chloride in seawater, natural brines and evaporites, and salt deposits. Magnesium metal is currently produced from three major sources: dolomite/magnesite, seawater, and brines and bitterns.

**Figure 3**
**Magnesium Shipments by World Zone, 1996**




Source: International Magnesium Association.

Magnesium is best known for its light weight and high strength-to-weight ratio, making it suitable for a wide range of applications. When used as a structural material, magnesium is alloyed with several other elements including aluminum, manganese, rare-earth metals, silver, thorium, zinc and zirconium. When alloyed with one or a number of these elements, the resulting alloys can have unusually high strength-to-weight ratios. Magnesium-aluminum alloys are the most common and are principally used in die-cast applications.

The main application of magnesium is as an alloying agent for aluminum, accounting for 48% of Western World consumption in 1996. According to the IMA, Western World magnesium shipments for this application reached 138 200 t in 1996, compared to 157 100 t in 1995. Magnesium consumption for this application is forecast to increase by 2% annually.

The second largest use of magnesium is in structural applications where high-pressure die-cast products are the most important use. The IMA reported that shipments of magnesium in 1996 for die-cast applications totalled 72 300 t. Total consumption of magnesium for this application is expected to exceed 100 000 t/y within the next five years. During the next decade, high-pressure die casting is expected to be the fastest growing sector, particularly in the United States and Europe.

The increased interest in magnesium metal in the automotive market is largely due to weight savings of about 33% compared to aluminum. Magnesium also has good vibration-dampening characteristics. Its lower heat of solidification, which increases die-casting production capacity by 25%, results in major process energy savings. In addition, magnesium dies are reported to have more than twice the life of aluminum dies. Furthermore, at a magnesium-to-aluminum price ratio of 1.7:1.0, many magnesium metal parts can be fabricated at a lower cost than those made from aluminum.

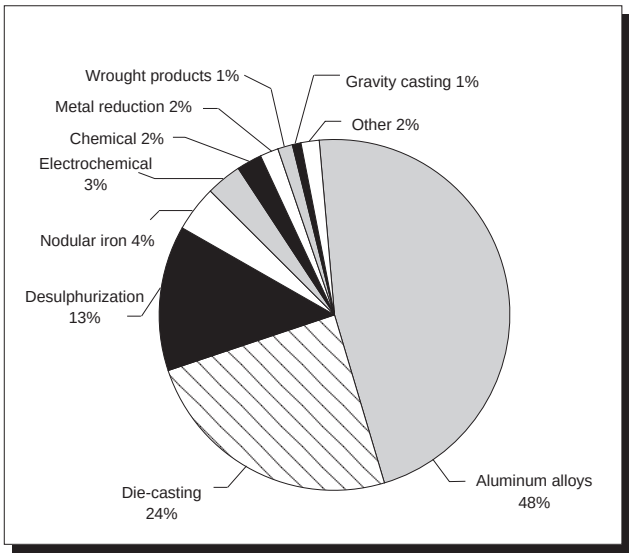
The enforcement of stricter fuel efficiency and emissions standards is encouraging many auto manufacturers to reduce their vehicles' weight. Increased consumer demand for cars with added luxury items is also driving manufacturers to find ways to reduce automobile curb-weight. Many automobile manufacturers in both the United States and Japan are looking to magnesium to help reduce total vehicle weight without sacrificing consumer demand for larger vehicles.

Besides automotive applications, die-cast magnesium products are widely used in the manufacture of portable tools and sporting goods. The use of magnesium in electronics equipment, particularly computer housings and components, has grown substantially. This trend is expected to continue. Magnesium's advantages for these applications are its good strength-to-weight ratio, heat dissipation, electromagnetic field containment, and radio frequency interference dissipation.

The third largest use of magnesium is as a desulphurizing agent in the ferrous industry. Magnesium shipments in 1996 for desulphurization, as reported by the IMA, totalled 39 600 t. This sector, which grew at an average rate of 15%/y in the late 1980s, should see a more moderate growth rate because of the rationalization that took place in the steel industry.

Magnesium is introduced into the melt during the production of nodular iron, which is used primarily for the production of ductile iron pipes and die-cast parts for use in automobiles and farm equipment. Shipments in 1996 totalled 12 500 t, down from 14 500 t in 1995. This application is expected to continue to face stiff competition as plastics increasingly penetrate the water pipe market. Magnesium is also used as a reducing agent in the production of titanium, beryllium, zirconium, hafnium and uranium. Electrochemical applications account for about 4% of magnesium consumption for use in the manufacture of batteries and in anodes for the cathodic protection of gas pipelines and water heaters. As with nodular iron, plastics in the gas pipeline market continue to penetrate this market. Chemical applications include the manufacture of pharmaceutical products, perfumes and pyrotechnics. Wrought products mainly include extruded products, except anodes, sheets and plates; gravity casting includes the production of complex or large parts by sand casting or casting with other materials.

**Figure 4**
**Magnesium Shipments by Use, 1996**




Source: International Magnesium Association.

## RECYCLING

The anticipated growth for magnesium die-cast parts in the automotive sector should provide greater opportunities for magnesium recycling. Norsk Hydro Canada and Dow Chemical collect magnesium scrap from their clients. This source of supply is expected to increase as magnesium metal further penetrates the automobile market.

Like aluminum, recycled magnesium only requires about 5% of the energy required to produce primary magnesium. The recycling of magnesium is expected to increase with the expected growth in the use of magnesium die-cast automobile parts.

Norsk Hydro began operating its new 10 000-t/y recycling facility at Porsgrunn, Norway. Initially, the plant will accept metal from magnesium casting operations, but it will eventually accept other magnesium residues and old or used parts. Norsk Hydro also operates a 10 000-t/y recycling plant at its Bécancour smelter in Canada.

In the United States, a number of new recycling facilities are either under construction or in the planning phase. The need for more recycling capacity in the United States is growing as the use of magnesium for automotive parts continues to grow. Four companies recycle magnesium scrap in the United States: Garfield Alloys Inc., IMCO Recycling Inc., Halaco, and Spectrulite Consortium Inc.

In July, Garfield Alloys Inc. began construction of a 13 600-t/y magnesium recycling plant in Bellevue, Ohio. The plant, which will operate under the name MagReTech Inc., is expected to come on stream sometime in the second quarter of 1997 and will process high-grade Type 1 scrap. Lower grades of magnesium scrap, including post-consumer scrap, will continue to be recycled at the company's plant in Garfield Heights near Cleveland, Ohio. Type 1 scrap comprises scrap material from diecasters who use magnesium alloys to make components for the automotive and other sectors.

Spectrulite Consortium Inc. of Illinois brought the first phase of its magnesium recycling expansion on stream at the beginning of the year to recycle Type 1 scrap in the United States. The company brought 5000 t of new capacity on stream in January, and its capacity was expected to reach 20 000 t by year-end. Spectrulite also operates a separate 20 000-t/y recycling plant that has been running at the rate of 12 000 t/y, and it may be upgraded to take Type 1 scrap as well.

MSI Magnesium Services (US) Inc. still plans to build a 20 000-t/y plant to recycle Type 1 scrap at a site in Indiana. Last year MSI more than tripled its original capacity plans to build a magnesium scrap refining and alloy production facility in the state of Indiana by late 1996. The new plant will take in scrap from diecasters and producers and recycle it into 24 000 t/y of high-purity alloy ingots for die casting and another 8000 t/y of magnesium chips for desulphurization. In addition, the plant design provides for an additional expansion to 56 000 t/y depending on market conditions.

## PRICES AND STOCKS

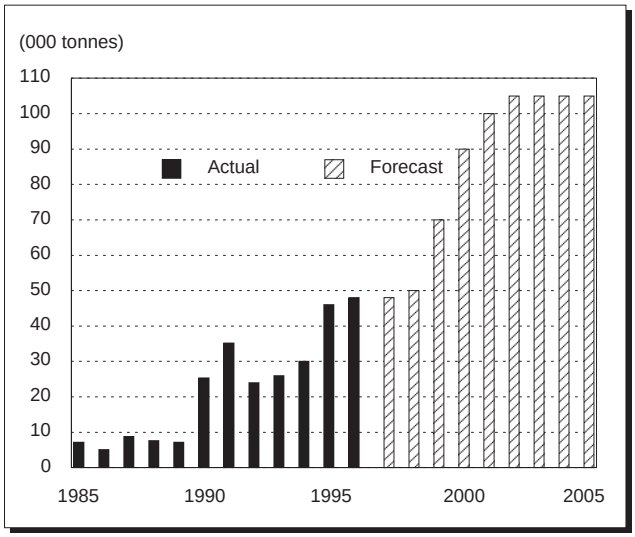
According to the IMA, total magnesium stocks increased steadily throughout the year, rising from 22 800 t at the end of 1995 to 33 400 t in June 1996, only to rise again to 38 400 t by the end of September.

Prices for primary magnesium continued on a downward trend for most of the year as the market tightness experienced last year eased somewhat, particularly outside North America. Prices for U.S. die-cast alloy and primary ingot remained stable, while spot prices eased towards the end of the summer to finish the year in the US$1.70-$1.80/lb range. Norsk Hydro cut its European producer price for pure magnesium several times in 1996 to end the year at 5.95 Deutsche Marks (DM)/kg, down from 6.95 DM/kg at the start of the year. The downward pressure on prices in Europe was attributed to relatively weak demand in magnesium's principal markets (aluminum alloying and steel desulphurization). European Free Market prices were also weaker, finishing the year in the US$2600-$2700/t range, down from $3900-$4000/t at the start of the year. Norsk Hydro's North American list price of US$1.94/lb was unchanged, reflecting the better market conditions there compared to those in Europe.

## OUTLOOK

Canadian production of magnesium increased dramatically at the start of the decade with the opening of Norsk Hydro's 40 000-t/y Bécancour smelter in 1989. It subsequently dropped in 1993 with the closing of Magcan and the U.S. trade action against Norsk Hydro's exports. Production is expected to remain stable in 1997 as both producers continue to operate at or near capacity to meet demand. In the longer term, Magnola Metallurgy Inc.'s 58 500-t/y magnesium smelter to be built near Asbestos, Quebec, will increase Canada's magnesium production capacity to close to 105 000 t/y by the end of the decade. World magnesium production is expected to reach 360 000 t/y in 2000, and to increase further to 500 000 t/y by 2005.

**Figure 5**
**Canadian Magnesium Production, 1985-2005**



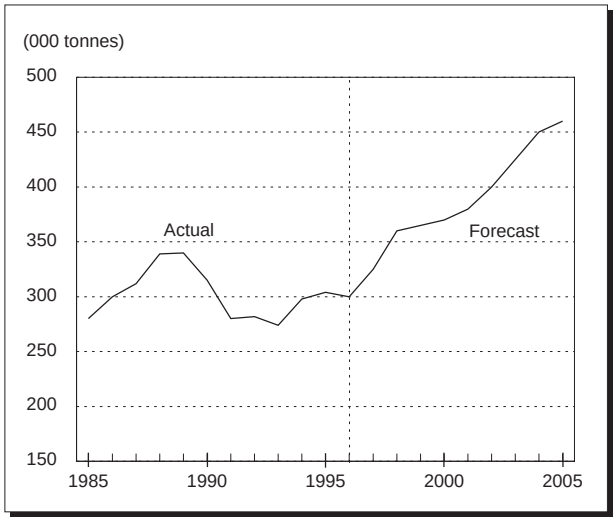

Source: Natural Resources Canada.

World primary magnesium consumption is forecast to increase to 375 000 t/y by the end of the decade and to 495 000 t/y by 2005. The Western World's primary magnesium annual growth in demand for this period is forecast to reach 5% in North America, 4% in Western Europe, and 9% in the Far East. This growth will be primarily fed by strong demand for magnesium in aluminum alloys, die-cast automotive parts and, to a lesser extent, desulphurization applications in the steel industry. Magnesium continues to face stiff competition from other materials, including aluminum and plastics, in the all-important automotive parts sector. New applications and increased awareness of the advantages of magnesium in certain applications are growing, particularly in the North American automotive industry.

A major factor that will affect magnesium prices over the next decade will be the growth in supply from expansions or new capacity in Canada, the Middle East, Australia, and possibly China. This newer, low-cost supply is forecast to eventually cause prices to decline slightly, in constant dollar terms, over the next decade. Prices, in constant 1996 dollars, are forecast to average in the US$1.80-$1.90/lb range in 1997, and to gradually decline to the $1.50-$1.60/lb range in the longer term.

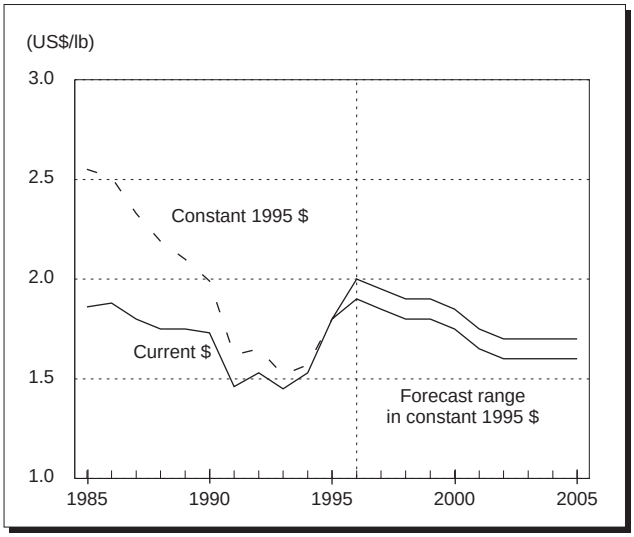
*Notes: (1) For definitions and valuation of mineral production, shipments and trade, please refer to Chapter 70. (2) Information in this review was current as of February 19, 1997.*

**Figure 6**
**World Primary Magnesium Consumption, 1985-2005**




Source: Natural Resources Canada.

**Figure 7**
**Magnesium Prices, 1985-2005**




Source: Natural Resources Canada.

**TARIFFS**

| Item No. | Description | Canada | | | United States | EU | Japan[1] |
|---|---|---|---|---|---|---|---|
| | | MFN | GPT | USA | Canada | MFN | GATT |
| 8104.11 | Magnesium unwrought, containing by weight at least 99.8% of magnesium | 3.2% | Free | 0.4% | 0.8% | 5.3% | 5.1% |
| 8104.19 | Magnesium unwrought, n.e.s. | 3.2% | Free | 0.4% | 0.6% | 4.5% | 5.1% |
| 8104.20 | Magnesium waste and scrap | Free | Free | Free | Free | Free | 2.8% |
| 8104.30 | Magnesium raspings, turnings and granules, graded according to size; powders | | | | | | |
| 8104.30.10 | Raspings, turnings and granules; powders, alloyed | 5.9% | 3% | 1% | 0.6% | 4.5% | 5.5% |
| 8104.30.20 | Powders, not alloyed | 3.2% | Free | 0.4% | 0.6% | 4.5% | 5.5% |
| 8104.90 | Other magnesium | | | | | | |
| 8104.90.10 | Bars, rods, plates, sheets, strip, foil, tubes and pipes, alloyed | 3.2% | Free | 0.4% | [a] | 4.5% | 5.5% |
| 8104.90.90 | Other | 5.9% | 3% | 1% | [a] | 4.5% | 5.5% |

Sources: Customs Tariff, effective January 1997, Revenue Canada; Harmonized Tariff Schedule of the United States 1997; The "Bulletin International des Douanes," Journal Number 14 (18th Edition), European Union, 1995-1996, "Conventional" column; Custom Tariff Schedules of Japan, 1996.
n.e.s. Not elsewhere specified.
[a] 1.4¢/kg on magnesium content plus 0.3%.
[1] GATT rate is shown; lower tariff rates may apply circumstantially.

**TABLE 1. CANADA, MAGNESIUM EXPORTS AND IMPORTS BY COMMODITY AND COUNTRY, 1995 AND 1996**

| Item No. | | 1995 | | 1996[p] | |
|---|---|---|---|---|---|
| | | (tonnes) | ($000) | (tonnes) | ($000) |
| **EXPORTS** | | | | | |
| 8104.11 | Magnesium unwrought, containing by weight at least 99.8% of magnesium | | | | |
| | Japan | 4 285[r] | 20 097[r] | 2 209 | 12 162 |
| | Germany | 1 326 | 6 047 | 1 913 | 9 805 |
| | United States | 766 | 3 884 | 1 265 | 7 404 |
| | United Kingdom | 1 247 | 7 474 | 744 | 4 788 |
| | Norway | 514 | 2 414 | 1 151 | 3 315 |
| | Switzerland | 350 | 1 751 | 404 | 2 066 |
| | France | 211 | 972 | 325 | 1 689 |
| | Venezuela | 387 | 1 863 | 207 | 1 218 |
| | Brazil | – | – | 205 | 1 008 |
| | Other countries | 2 666 | 11 864 | 326 | 1 721 |
| | Total | 11 752[r] | 56 366[r] | 8 749 | 45 176 |
| 8104.19 | Magnesium unwrought, other | | | | |
| | United States | 13 890 | 58 270 | 19 986 | 91 081 |
| | Australia | 620 | 3 530 | 558 | 3 278 |
| | Italy | 178 | 1 127 | 288 | 2 057 |
| | Netherlands | 209 | 2 171 | 165 | 1 402 |
| | Singapore | – | – | 36 | 781 |
| | Germany | – | – | 78 | 454 |
| | Other countries | 496[r] | 2 426[r] | 215 | 1 617 |
| | Total | 15 393[r] | 67 524[r] | 21 326 | 100 670 |
| 8104.20 | Magnesium waste and scrap | | | | |
| | Norway | 116 | 415 | 3 723 | 15 303 |
| | United States | 8 565 | 26 631 | 1 458 | 4 454 |
| | Other countries | 887 | 3 530 | 6 | 19 |
| | Total | 9 568 | 30 576 | 5 187 | 19 776 |
| 8104.30 | Magnesium raspings, turnings or granules, graded according to size and powders | | | | |
| | United States | 629 | 3 756 | 2 377 | 11 228 |
| | Ireland | 231 | 1 435 | 327 | 2 350 |
| | South Korea | – | – | 265 | 1 541 |
| | Other countries | 120 | 813 | 144 | 934 |
| | Total | 980 | 6 004 | 3 113 | 16 053 |
| 8104.90 | Magnesium and articles thereof, other | | | | |
| | United States | 1 031[r] | 5 763[r] | 1 092 | 7 457 |
| | Norway | – | – | 171 | 248 |
| | Argentina | – | – | 7 | 61 |
| | Other countries | 115 | 869 | 18 | 137 |
| | Total | 1 146[r] | 6 632[r] | 1 288 | 7 903 |
| | Total exports | 38 839[r] | 167 102[r] | 39 663 | 189 578 |

**TABLE 1** (cont'd)

| Item No. | | 1995 | | 1996p | |
|---|---|---|---|---|---|
| | | (tonnes) | ($000) | (tonnes) | ($000) |
| **IMPORTS** | | | | | |
| 8104.11 | Magnesium unwrought, containing by weight at least 99.8% of magnesium | | | | |
| | China | 337 | 1 826 | 2 121 | 9 240 |
| | Ukraine | 752 | 4 019 | 103 | 445 |
| | United States | 222 | 1 049 | 26 | 117 |
| | Other countries | 1 931 | 10 011 | 11 | 27 |
| | Total | 3 242 | 16 905 | 2 261 | 9 829 |
| 8104.19 | Magnesium unwrought, other | | | | |
| | United States | 3 749 | 12 867 | 4 508 | 21 795 |
| | Norway | 1 659 | 7 281 | 3 888 | 18 451 |
| | Russia | 935 | 4 172 | 1 305 | 6 014 |
| | United Kingdom | 119 | 825 | 247 | 1 443 |
| | China | 52 | 263 | 250 | 1 104 |
| | Other countries | 741 | 3 470 | 315 | 1 603 |
| | Total | 7 255 | 28 878 | 10 513 | 50 410 |
| 8104.20 | Magnesium waste and scrap | | | | |
| | United States | 3 697 | 10 873 | 8 574 | 26 829 |
| | Norway | 1 | 4 | 208 | 1 017 |
| | Other countries | 140 | 326 | 157 | 333 |
| | Total | 3 838 | 11 203 | 8 939 | 28 179 |
| 8104.30 | Magnesium raspings, turnings or granules, graded according to size and powders | | | | |
| | United States | 270 | 1 108 | 287 | 1 266 |
| | Other countries | 3 | 9 | 7 | 39 |
| | Total | 273 | 1 117 | 294 | 1 305 |
| 8104.90 | Magnesium and articles thereof, other | | | | |
| | United States | 930r | 5 864r | 866 | 6 469 |
| | Mexico | – | – | 28 | 197 |
| | China | – | – | 31 | 184 |
| | Australia | – | – | 21 | 184 |
| | Norway | 1 | 6 | 1 | 6 |
| | United Kingdom | 1 | 5 | . . . | 2 |
| | Austria | . . . | 2 | – | – |
| | Total | 932r | 5 878r | 947 | 7 042 |
| | Total imports | 15 540r | 63 981r | 22 954 | 96 765 |

Source: Statistics Canada.
– Nil; . . . Amount too small to be expressed; p Preliminary; r Revised.
Note: Numbers may not add to totals due to rounding.

**TABLE 2. CANADA, CONSUMPTION[1] OF MAGNESIUM, 1989-95**

| | 1989a | 1990 | 1991a | 1992a | 1993a | 1994 | 1995a,p |
|---|---|---|---|---|---|---|---|
| | | | | (tonnes) | | | |
| Castings and wrought products[2] | 5 661 | 5 849 | 4 604 | 6 915 | 7 678 | 8 940 | 12 488 |
| Aluminum alloys | 7 761 | 7 672 | 9 215 | 9 203 | 10 174 | 12 389r | 12 413 |
| Other uses[3] | 1 985 | 1 603 | 1 926 | 2 005 | 2 162 | 2 234 | 2 329 |
| Total | 15 407 | 15 125 | 15 745 | 18 123 | 20 014 | 23 563r | 27 230 |

Source: Natural Resources Canada.
p Preliminary; r Revised.
a Increase in number of companies being surveyed.
1 Available data as reported by consumers. 2 Die, permanent mould and sand castings, structural shapes, tubings, forgings, sheet and plate. 3 Cathodic protection, reducing agents, desulphurizers and other alloys.

## TABLE 3. WORLD MAGNESIUM PRODUCTION, 1992-95

| Country | 1992 | 1993 | 1994 | 1995p |
|---|---|---|---|---|
| | | (tonnes) | | |
| Austria (secondary) | 100 | 100 | 100 | 100 |
| Brazil | 7 300 | 9 600 | 8 800 | 8 000 |
| Brazil (secondary) | 1 600 | 1 600 | 1 600 | 1 600 |
| Canada[e] | 25 800 | 23 000 | 28 900 | 48 000 |
| China[e] | 10 500 | 11 800 | 13 200 | 13 000 |
| France | 13 700 | 10 900 | 12 500 | 12 000 |
| India | 1 000 | 1 000 | 1 000 | 1 000 |
| Italy | 1 200 | – | – | – |
| Japan | 7 100 | 7 500 | 3 400 | – |
| Japan (secondary) | 13 000 | 13 200 | 19 000 | 11 800 |
| Kazakstan[e] | 3 500 | 2 000 | – | – |
| Norway | 30 400 | 27 300 | 27 600 | 27 000 |
| Russia[e] | 32 900 | 32 200 | 35 400 | 37 500 |
| Ukraine[e] | 17 100 | 14 900 | 12 000 | 13 000 |
| United Kingdom (secondary) | 800 | 500 | 500 | 500 |
| United States | 136 900 | 132 100 | 128 500 | 142 000 |
| United States (secondary) | 57 000 | 58 900 | 62 100 | 65 000 |
| Ex-Yugoslavia | 4 100 | – | 2 000 | 2 000 |
| Total (primary) | 291 500 | 272 300 | 273 300 | 303 500 |
| Total (secondary) | 72 500 | 74 300 | 83 300 | 79 000 |
| Total | 364 000 | 346 600 | 356 600 | 382 500 |

Sources: Natural Resources Canada; International Consultative Group on Nonferrous Metals Statistics.
– Nil; e Estimated; p Preliminary.

**TABLE 4. WORLD CONSUMPTION OF MAGNESIUM, 1992-95**

| Country | 1992 | 1993 | 1994 | 1995p |
|---|---|---|---|---|
| | | | (tonnes) | |
| Argentina | 400 | 400 | 400 | 400 |
| Australia | 3 500 | 4 000 | 4 000 | 4 000 |
| Austria | 4 300 | 3 500 | 3 500 | 3 500 |
| Belgium/Luxembourg | 2 600 | 2 200 | 4 400 | 4 000 |
| Brazil | 8 500 | 10 000 | 10 500 | 10 000 |
| Cameroon | 200 | 100 | 100 | 100 |
| Canada | 18 100 | 20 000 | 23 600 | 27 100 |
| China[e] | 17 000 | 18 000 | 20 000 | 22 000 |
| Denmark | 200 | 200 | 200 | 200 |
| Egypt[e] | 1 000 | 1 000 | 1 000 | 1 000 |
| France | 13 800 | 12 000 | 16 100 | 16 000 |
| Germany | 21 300 | 14 900 | 12 600 | 14 900 |
| Ghana | 100 | 100 | 100 | 100 |
| Greece | 600 | 1 000 | 1 000 | 1 000 |
| Hungary[e] | 200 | 200 | 200 | 200 |
| India | 1 600 | 1 800 | 1 800 | 1 800 |
| Italy | 5 500 | 3 800 | 4 700 | 5 400 |
| Japan (primary) | 26 900 | 25 100 | 27 500 | 28 600 |
| Japan (secondary) | 13 000 | 13 100 | 14 300 | 17 100 |
| Mexico | 1 300 | 1 000 | 1 000 | 1 000 |
| Netherlands | 1 000 | 1 000 | 1 000 | 1 000 |
| New Zealand[e] | 400 | 400 | 400 | 400 |
| Norway[e] | 8 000 | 5 800 | 6 000 | 6 000 |
| Poland[e] | 300 | 700 | 500 | 500 |
| Romania[e] | 500 | 500 | 400 | 300 |
| Slovakia[e] | 1 000 | 1 000 | – | – |
| South Africa | 600 | 500 | 800 | 800 |
| South Korea | 1 800 | 2 100 | 2 200 | 2 000 |
| Spain | 1 500 | 1 500 | 1 700 | 1 500 |
| Sweden | 1 700 | 1 800 | 1 800 | 1 800 |
| Switzerland | 2 600 | 1 800 | 2 300 | 3 000 |
| Taiwan | 1 700 | 1 600 | 1 900 | 1 900 |
| Turkey | 500 | 600 | 600 | 500 |
| Ex-U.S.S.R.[e] | 30 000 | 25 000 | 25 000 | 25 000 |
| United Kingdom | 5 800 | 6 300 | 6 000 | 6 000 |
| United States (primary) | 93 800 | 101 100 | 111 800 | 109 000 |
| United States (secondary) | 57 000 | 58 900 | 62 100 | 65 000 |
| Venezuela | 700 | 600 | 600 | 500 |
| Ex-Yugoslavia | 1 000 | 500 | 400 | 200 |
| Other[e] | 1 800 | 1 900 | 1 900 | 2 000 |
| Total (primary) | 281 800 | 274 000 | 298 000 | 303 700 |
| Total (secondary) | 70 000 | 72 000 | 76 400 | 82 100 |
| Total | 351 800 | 346 000 | 374 400 | 385 800 |

Sources: Natural Resources Canada; International Consultative Group on Nonferrous Metals Statistics.
– Nil; [e] Estimated; [p] Preliminary.

**TABLE 5. WORLD PRIMARY MAGNESIUM SMELTER CAPACITY, 1996**

| Country | Smelter Location | Company | Capacity |
|---|---|---|---|
| | | | (t/y) |
| Brazil | Bocaiuva | Rima Industrial S.A. | 12 000 |
| Canada | Bécancour | Norsk Hydro Canada Inc. | 40 000 |
| | Haley Station | Timminco Metals | 6 000 |
| China | Baotou | Nei Mongol Province | 3 500 |
| | Dancheng | Henan Province | 1 000 |
| | Fushun | CNNC | 5 000 |
| | Guigang | Gaungxi Province | 1 000 |
| | Hengyang | Hunan Province | 3 000 |
| | Huinong | Ningxia Province | 1 000 |
| | Jinzhou | Liaoning Province | 1 000 |
| | Minhe | CNNC | 4 000 |
| | Nanjing | Nanjing Ube Magnesium | 14 000 |
| | Ningxia Hui | Silver River Corporation | 1 000 |
| | Shanxi (7 plants) | Shanxi Province | 1 900 |
| | Taiyuan | Taiyuan East United Smelt | 10 000 |
| | Tongxin | Ningxia Province | 1 700 |
| | Yinchuan | Ningxia Province | 1 000 |
| | Yunnan | Yunnan Province | 200 |
| France | Maringnac | Pechiney | 18 000 |
| India | Valinokkam | Tamil Nadu | 600 |
| | Hyderabad | Southern Magnesium | 600 |
| Kazakstan | Ust Kamenogorsk | Ust Kamenogorsk Works | 40 000 |
| Norway | Porsgrunn | Norsk Hydro AS | 55 000 |
| Russia | Solikamsk | Solikamsk Magnesium Works | 20 000 |
| | Berezniki | Avisma | 25 000 |
| Ukraine | Kaluzh | Kaluzh Works | 24 000 |
| | Zaporozhyre | Zaporozhyre Works | 45 000 |
| United States | Freeport | Dow Chemical | 65 000 |
| | Addy | Northwest Alloys | 38 000 |
| | Rowley | Magnesium Corp of America | 38 000 |
| Yugoslavia | Bela Stena | Magnohrom | 9 000 |
| Total | | | 485 500 |

Source: Natural Resources Canada.
CNNC China National Nonferrous Metals Industry Corporation.

**TABLE 6. PRIMARY MAGNESIUM SHIPMENTS BY WORLD ZONE, 1986-96**

| Period | Area 1 United States and Canada | Area 2 Latin America | Area 3 Western Europe | Area 4 Africa and Middle East | Area 5 Asia and Oceania | Area 6 COMECON C.I.S. & PRC | Total |
|---|---|---|---|---|---|---|---|
| | | | | (000 tonnes) | | | |
| 1986 | 103.3 | 11.3 | 73.6 | 3.2 | 35.0 | – | 226.4 |
| 1987 | 113.7 | 8.3 | 66.9 | 5.2 | 28.7 | 13.2 | 236.0 |
| 1988 | 125.0 | 11.7 | 70.6 | 3.8 | 33.8 | 6.2 | 251.2 |
| 1989 | 127.9 | 9.4 | 69.5 | 2.6 | 33.7 | 4.1 | 246.2 |
| 1990 | 127.3 | 11.6 | 68.7 | 4.0 | 37.6 | 2.8 | 252.0 |
| 1991 | 121.3 | 10.3 | 66.6 | 4.5 | 40.1 | 0.7 | 243.5 |
| 1992 | 139.5 | 10.3 | 67.9 | 3.8 | 35.0 | 0.8 | 257.3 |
| 1993 | 143.1 | 12.3 | 58.1 | 3.6 | 35.0 | – | 252.1 |
| 1994 | 152.7 | 14.5 | 76.0 | 4.6 | 39.6 | – | 287.4 |
| 1995 | 165.4 | 12.9 | 74.0 | 4.9 | 46.8 | – | 304.0 |
| 1996 | 167.6 | 11.7 | 68.4 | 5.3 | 42.4 | – | 295.4 |

Source: International Magnesium Association.
– Nil.

**TABLE 7. PRIMARY MAGNESIUM SHIPMENTS BY WORLD ZONE AND CATEGORY, 1996**

| Use | Area 1 United States and Canada | Area 2 Latin America | Area 3 Western Europe | Area 4 Africa and Middle East | Area 5 Asia and Oceania | Area 6 Other | Total |
|---|---|---|---|---|---|---|---|
| | | | | (000 tonnes) | | | |
| Aluminum alloying | 66.0 | 3.7 | 32.4 | 4.5 | 31.6 | – | 138.2 |
| Die casting | 50.6 | 6.4 | 12.2 | 0.1 | 3.0 | – | 72.3 |
| Desulphurization | 26.4 | 0.2 | 11.8 | 0.6 | 0.6 | – | 39.6 |
| Nodular iron | 6.5 | 0.5 | 3.7 | – | 1.8 | – | 12.5 |
| Electrochemical applications | 6.1 | 0.6 | 1.6 | – | 1.3 | – | 9.6 |
| Chemical applications | 1.1 | – | 2.6 | – | 3.2 | – | 6.9 |
| Metal reduction | 3.4 | – | 1.6 | – | – | – | 5.0 |
| Wrought products | 3.6 | – | 0.1 | – | 0.3 | – | 4.0 |
| Gravity casting | 0.7 | – | 1.6 | – | 0.1 | – | 2.4 |
| Other | 3.2 | 0.3 | 0.8 | 0.1 | 0.5 | – | 4.9 |
| Total | 167.6 | 11.7 | 68.4 | 5.3 | 42.4 | – | 295.4 |

Source: International Magnesium Association.
– Nil.

**TABLE 8. PRIMARY MAGNESIUM SHIPMENTS BY CATEGORY, 1986-96**

| | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | (000 tonnes) | | | | | |
| Aluminum alloying | 122.1 | 122.1 | 134.3 | 130.8 | 130.6 | 137.9 | 133.8 | 126.0 | 143.0 | 157.1 | 138.2 |
| Die casting | 26.8 | 26.6 | 28.5 | 28.6 | 36.3 | 30.7 | 34.5 | 38.6 | 51.2 | 64.1 | 72.3 |
| Desulphurization | 20.3 | 21.9 | 28.6 | 32.3 | 28.0 | 28.1 | 36.6 | 40.6 | 42.5 | 36.3 | 39.6 |
| Nodular iron | 12.3 | 14.2 | 15.8 | 16.9 | 14.4 | 13.7 | 13.3 | 13.4 | 16.2 | 14.5 | 12.5 |
| Electrochemical applications | 8.3 | 8.0 | 8.0 | 8.1 | 9.6 | 9.2 | 9.5 | 9.4 | 11.7 | 10.6 | 9.6 |
| Chemical applications | 8.0 | 7.2 | 8.1 | 5.5 | 7.1 | 7.1 | 7.3 | 6.5 | 6.2 | 6.5 | 6.9 |
| Metal reduction | 9.6 | 8.8 | 10.2 | 9.4 | 8.8 | 5.6 | 7.4 | 5.1 | 3.8 | 3.9 | 5.0 |
| Wrought products | 5.4 | 8.4 | 7.4 | 6.2 | 6.7 | 5.7 | 6.8 | 5.8 | 5.3 | 4.2 | 4.0 |
| Gravity casting | 1.6 | 1.8 | 2.1 | 2.5 | 3.3 | 2.2 | 2.6 | 1.5 | 1.8 | 1.8 | 2.4 |
| Other | 10.0 | 17.0 | 8.2 | 6.9 | 7.2 | 3.3 | 5.5 | 5.2 | 5.7 | 5.0 | 4.9 |
| Total | 226.4 | 236.0 | 251.2 | 247.2 | 252.0 | 243.5 | 257.3 | 252.1 | 287.4 | 304.0 | 295.4 |

Source: International Magnesium Association.