SULFUR

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Sulfur, through its major derivative sulfuric acid, ranks as one of the more important elements utilized by humanity as an industrial raw material. It is of prime importance to every sector of the world's industrial and fertilizer complexes. Sulfuric acid production is the major end use for sulfur and sulfuric acid consumption has been regarded as one of the best indexes of a nation's industrial development. More sulfuric acid is produced in the United States every year than any other chemical; nearly 90 million tons were produced in 1994, 13% more than the previous year.[1]

Domestic production of sulfur increased in 1994 for the second consecutive year and consumption increased after 4 years of decline. The United States maintained its position as the leading producer and consumer of sulfur and sulfuric acid in the world. The quantity of sulfur recovered during the refining of petroleum and the processing of natural gas continued its upward trend established in 1938, the year the U.S. Bureau of Mines (USBM) started publishing data on the production of this type of sulfur. The production of sulfur through the Frasch process was significantly higher in 1994 although direct comparisons to 1993 data are not possible because listed production data reflected only 10 months of Frasch data to conform with proprietary data requirements. Frasch production data for 1994 were estimated based on reports published by the two remaining Frasch producers and the State of Texas. Total production of sulfur from all sources increased, shipments were higher than they had been since 1988, and stocks declined.

Byproduct sulfuric acid from the Nation's nonferrous smelters and roasters, essentially mandated by laws concerning sulfur dioxide emissions, supplied a significant quantity of sulfuric acid to the domestic merchant (commercial) acid market. Production has increased slightly since 1990.

Worldwide, sulfur production increased for the first time since 1988. Frasch production was 17% higher than in 1993, due to increased production in the United States and Poland. Elemental sulfur production from recovered sources, primarily during the processing of natural gas and petroleum products, was virtually unchanged. Nearly three-quarters of the world's elemental sulfur production came from recovered sources; the quantity of sulfur supplied from these sources was dependent on the world demand for fuels and petroleum products, not on the demand for sulfur.

World sulfur consumption was relatively unchanged. Consumption in fertilizer production increased, although consumption for a myriad of industrial uses continued to be pressured by environmental constraints placed on the products produced or effluents from the chemical processes utilizing sulfur or its major derivative, sulfuric acid.

World trade of elemental sulfur was virtually unchanged from the levels recorded in 1993. U.S. sulfur inventories increased about 16% during 1994, however, worldwide inventories of elemental sulfur increased 8%. *(See table 1 and figure 1.)*

Production

Elemental Sulfur.—Elemental sulfur production was about 4% higher in 1994 than it was the previous year; shipments were slightly higher in quantity and 13% higher in value. Increases in the average reported unit value of Frasch sulfur and byproduct sulfuric acid offset decreases in recovered sulfur values.

Production statistics are collected on a monthly basis and published in the USBM Sulfur Monthly Mineral Industry Survey. Of the 149 operations to which a survey request was sent, all responded, representing 100% of the total production shown in table 1.

Frasch.—Native sulfur associated with the cap rock of salt domes and in sedimentary deposits is mined by the Frasch hot-water method, in which the native sulfur is melted underground and brought to the surface by compressed air. In 1994, three Frasch mines operated in Louisiana and Texas, although one of the mines in Louisiana ceased production on January 15, leaving two Frasch operations throughout the remainder of the year. Freeport Sulphur Co. owned and operated two mines in Louisiana, the Caminada Pass Mine, 14 kilometers offshore in the Gulf of Mexico, and Main Pass, 27 kilometers offshore. Caminada was closed to take better advantage of the lower cost sulfur recovery at Main Pass, which had reached full production capacity near the end of 1993. The cost of producing sulfur from Caminada was significantly higher than at Main Pass, and Main Pass alone will supply the company's internal consumption and sales requirements.[2] Pennzoil Sulphur Co. operated at the Culberson Mine in Pecos County, TX.

In October, Pennzoil announced an agreement to sell virtually all of its sulfur assets to Freeport. The sale was effective, officially, January 3, 1995. The sulfur assets included in the sale are the Culberson Mine; sulfur forming and loading facilities in Galveston, TX and Tampa, FL; the charter of a marine sulfur tanker, two sulfur barges, 503 leased and owned sulfur rail cars; and associated commercial contracts and obligations.[3]

Recovered.—Recovered elemental sulfur, a nondiscretionary byproduct from petroleum refining, natural gas processing, and coking plants, was produced primarily to comply with environmental regulations that were applicable directly to emissions from the processing facility or indirectly by restricting the sulfur content of the fuels sold or used by the facility. Recovered elemental sulfur was produced by 59 companies at 150 plants in 26 States, 1 plant in Puerto Rico, and 1 plant in the U.S. Virgin Islands. Most of these plants were of relatively small size, with only 22 reporting an annual production exceeding 100,000 tons. By source, 69% was produced at 3 coking plants and 86 refineries or satellite plants treating refinery gases. The remainder was produced at 61 natural gas treatment plants. The six largest recovered-sulfur producers in 1994 were Exxon Co. U.S.A., Standard Oil Co. (California), Standard Oil Co. (Indiana), Mobil Oil Corp., Star Enterprises, and Shell Oil Co. The 51 plants owned by these companies accounted for 58% of recovered elemental sulfur output during the year. *(See tables 2 and 3.)*

Byproduct Sulfuric Acid.—Byproduct sulfuric acid at copper, lead, molybdenum, and zinc roasters and smelters amounted to 12% of the total domestic production of sulfur in all forms. Eight acid plants operated in conjunction with copper smelters, and eight were accessories to lead, molybdenum, and zinc smelting and roasting operations. The seven largest acid plants (all at copper mines) accounted for 85% of the output. The five largest producers of byproduct sulfuric acid were all copper producers. They were Phelps Dodge Corp., Magma Copper Co., ASARCO Incorporated, Kennecott Corp., and Cyprus Miami Mining Corp. Their eight plants

produced 87% of the 1993 total. *(See table 4.)*

Pyrites, Hydrogen Sulfide, and Sulfur Dioxide.—Because the total sulfur contained in these products has not constituted a significant portion of total domestic sulfur production for many years, the surveys that collected data on this production were discontinued for the 1994 canvass.

Consumption and Uses

Domestic consumption of sulfur in all forms was about 5% higher in 1994 than it was in 1993. In 1994, 85% of the sulfur consumed was obtained from domestic sources compared with 83% in 1993, 79% in 1992, 77% in 1991, and 80% in 1990. The sources of supply were domestic elemental sulfur, 76%, and domestic byproduct sulfuric acid, 11%. The remaining 13% was supplied by imports of recovered elemental sulfur.

The USBM collected end-use data on sulfur and sulfuric acid according to the Standard Industrial Classification of industrial activities. Shipments by end use of elemental sulfur were reported by 62 companies, and shipments of sulfuric acid were reported by 55 companies. Shipments of both elemental sulfur and sulfuric acid were reported by 14 companies.

Sulfur differs from most other major mineral commodities in that its primary use is as a chemical reagent rather than a component of a finished product. Its predominant use as a chemical reagent generally required that it first be converted to an intermediate chemical product prior to its initial use by industry. The largest sulfur end use, sulfuric acid, represented 84% of reported consumption with an identified end use. Some identified sulfur end uses were tabulated in the "Unidentified" category because these data were proprietary. Data collected from companies that did not identify shipment by end use also were tabulated as "Unidentified." Although there are no supporting data, it could be reasonably assumed that a significant portion of the sulfur in the "Unidentified" category was shipped to sulfuric acid producers or was exported.

Sulfuric acid, because of its desirable properties, retained its position, both domestically and worldwide, as the most universally used mineral acid and the largest volume inorganic chemical in terms of the quantity produced and consumed. Reported U.S. consumption of sulfur in sulfuric acid (100% basis) was slightly higher in 1994 owing to a 10% increase in demand for sulfuric acid in the production of the phosphoric acid used in the production of phosphate fertilizers, the largest single end use. Sulfuric acid demand for copper ore leaching, the second single largest end use, decreased slightly according to reports from sulfuric acid producers. Reported shipments of sulfur sulfuric acid for petroleum refining and other petroleum and coal products were down 20% from those of 1993.

According to the 1994 canvass reports, company receipt of spent or contaminated sulfuric acid for reclaiming totaled 2.7 million tons. The largest reported source for spent acid was chemical producers with 50% of the total returned. The second largest source of this spent acid was the petroleum refining industry, which accounted for 49% of the total returned. The remaining reclaimed acid was from unidentified sources.

The largest use of sulfur in all forms, for agricultural purposes, increased from 9.0 million tons in 1993 to about 9.9 million tons because of increases in consumption for the production of nitrogenous and phosphatic fertilizers and other agricultural chemicals. Consumption in phosphatic fertilizers was 10% higher than that in 1993, reflecting the improved condition of the phosphate industry. The estimated quantity of sulfur needed to manufacture exported phosphatic fertilizers increased 1 million tons to 5.4 million tons, indicating that consumption for fertilizers intended for domestic consumption was nearly 6% lower than it had been in 1993. *(See tables 5, 6, and 7.)*

Stocks

Yearend inventories held by Frasch and recovered elemental sulfur producers decreased 16% from those of 1993. Combined yearend stocks amounted to approximately a 34-day supply compared with a 43-day supply in 1993, a 23-day supply in 1992, a 34-day supply in 1991, and a 40-day supply in 1990, based on apparent consumption of all forms of sulfur. *(See table 1.)*

Prices

The posted price for Frasch sulfur exterminal Tampa, FL, began the year at $68 per ton, decreased to $65 in February, was quoted as $70 in March, and increased to $77 in October. This price was maintained through yearend. On the basis of total shipments and value reported to the USBM, the average value of shipments for all elemental sulfur was $28.60 per ton in 1994, about 10% lower than in 1993. It is no longer possible to publish average values for the two types of elemental sulfur because there were only two Frasch companies operating in 1994; however, reported Frasch prices increased in 1994 and reported recovered prices decreased. *(See table 8.)*

Foreign Trade

Exports of elemental sulfur from the United States, including the U.S. Virgin Islands, increased 37% in quantity and 22% in value. The average unit value of exported elemental sulfur decreased from $61 per metric ton to $54, a decrease of 11%. According to the Bureau of the Census, exports from the west coast were 611,000 tons or 68% of total U.S. exports.

The United States continued to be a net importer of sulfur; imports exceeded exports by 751,000 tons in 1994. Recovered sulfur from Canada and Mexico delivered to U.S. terminals and consumers in the liquid phase, furnished about 95% of all U.S. sulfur import requirements. Total elemental sulfur imports decreased about 20% in quantity; imports by rail from Canada decreased 27%, while waterborne shipments from Mexico were 11% lower than those in 1993. Imports from several other countries comprised about 5% of all imported sulfur. The value of import elemental sulfur imports increased 24%.

The United States also had significant trade in sulfuric acid. Sulfuric acid exports decreased slightly from those of 1993. Imports were significantly greater than exports, 79% of which were by rail from Canada, 16% waterborne from Europe, and the remainder from several other countries, primarily by ship. The tonnage decreased 13% from the quantity reported in 1993; the value of imported sulfuric acid increased 20%. *(See tables 9, 10, 11, and 12.)*

World Review

Although world production was slightly higher than that of 1993, consumption was down for the sixth consecutive year, and prices were lower in terms of constant dollars than they had been for at least 20 years and probably longer. Frasch production increased for the first time since 1989, recovered sulfur production was relatively unchanged, and byproduct sulfuric acid production grew. Low prices and weak demand prompted worldwide inventory increases, more than one-half of which has been stockpiled in Canada.

Industry Structure.—In 1994, the global sulfur industry remained divided into two sectors, discretionary and nondiscretionary. In one, the mining of sulfur or pyrites was the sole objective; this voluntary production of native sulfur or pyrites was based on the orderly mining of discrete deposits, with the objective of obtaining as nearly a complete recovery of the resource as economic conditions permit. In the other, sulfur or sulfuric acid was recovered as an involuntary byproduct, the quantity of

output subject to demand for the primary product irrespective of sulfur demand. In 1994, involuntary sources represented about 67% of the elemental sulfur produced worldwide.

Poland and the United States were the only countries that produced 1 million tons or more of native sulfur using either the Frasch method or conventional mining methods. Small quantities of native sulfur were produced in Asia, Europe, and North and South America. Pyrites have significantly decreased in importance to the world sulfur supply; China, South Africa, and Spain are the only countries in the top 15 sulfur producers whose prime sulfur source is pyrites. Nearly 80% of all pyrites production is in these countries.

Recovered elemental sulfur was the predominant sulfur source in Canada, France, Germany, Iran, Russia, Saudi Arabia, and the United States. Additionally, recovered elemental sulfur was an important source in Japan and Mexico.

International sulfur trade was dominated by a limited number of exporting countries; exports from Canada, Saudi Arabia, Poland, Germany, and Japan, in descending order of the quantity shipped, accounted for 82% of sulfur trade in 1994. Major sulfur importers in 1994 were Morocco, the United States, Tunisia, Brazil, and India, in descending order of importance, all with imports of more than 1 million tons.

Canada.—In 1994, Canada was the world's leading producer of recovered sulfur, primarily from sour gas deposits, and the largest sulfur exporter. Low prices prompted the Canadian export organization, Prism Sulphur Corp., to limit the amount of sulfur made available to the offshore market. This strategy was believed to be partially responsible for the apparent recovery in prices that began in the second half of 1994, but also caused the increase of stocks in Canada to almost 8 million tons. The three largest Canadian suppliers elected to withdraw from Prism at the end of the year to regain control of the marketing of their product. These producers continued to emphasize that their corporate strategy was to continue stockpiling sulfur rather than sell it at less than favorable prices.

Poland.—One of the few major native sulfur producing countries, Poland suffered from reduced sulfur demand and increased supplies since 1989. As Poland has become increasingly market-economy based, environmental concerns in Poland have necessitated increased compliance to environmental protection legislation and energy prices have increased, both factors that drive up the cost of producing sulfur. Poland has restructured its sulfur industry to remain a viable supplier in the world market. Actions have been taken to significantly reduce the cost of production by reducing the amount of hot water required, reducing the work force, and eliminating nonproductive assets, i.e., holiday homes and unused facilities. The responsibility for reclaiming the closed Machow Mine was turned over to the Government and plans exist to convert the mine pit into a recreational boating facility. Three mines remain in operation, Grzybów, Jeziórko, and Osiek. Osiek's first full year of production was 1994.[4] *(See table 13.)*

Current Research and Technology

The first stage of Clean Air Act Amendments (CAAA) of 1990 requires the Nation's largest electric utilities to reduce sulfur dioxide emissions significantly in 1995, and all power companies to limit sulfur dioxide emissions to 1990 levels by the year 2000. Coal-fired power plants are the focus of the acid rain legislation; however, any coal-fired industrial boilers will need to reduce emissions to meet provisions of the CAAA and any State and local requirements. Many companies were developing new and refining existing technologies to meet increasingly stringent environmental regulations.

The most common processes for removing sulfur dioxide from flue gas at existing powerplants have been wet scrubbing systems that produce high volume byproducts or waste materials. However, recent trends in research and development indicate that processes to recover salable byproducts are finding increasing favor as the cost of disposal of the more common waste products is expected to become more costly and more difficult for environmental reasons. Byproducts from new technologies include commercial grade elemental sulfur, sulfuric acid, liquid sulfur dioxide, ammonium sulfate, potassium sulfate, and wallboard-grade synthetic gypsum. Possible market sizes and locations are considered when determining the byproduct of choice. Low value materials, i.e., flue gas desulfurization gypsum, are usually marketed in close proximity to proven markets, while relatively higher value materials such as elemental sulfur may be shipped longer distances as is the case with much recovered sulfur.

A few small and demonstration facilities were producing sulfur products during 1994, and several larger projects should be operating by the end of 1996. The potential exists for significant growth of salable sulfur byproducts as power companies and other industrial coal-burners come into compliance with CAAA requirements and other environmental regulations.

Energy Biosystems Corp. (EBC), of Houston, TX, has developed a unique process for the lowcost removal of sulfur from petroleum products. EBC was building a pilot plant to test its biocatalytic desulfurization process for using genetically engineered microorganisms that remove the sulfur from petroleum products by eating it without consuming carbon and wasting valuable fuel. Construction costs of the biological desulfurizing units are expected to be significantly less expensive than those of the more traditional systems, and operating costs should be lower also. The technology was being piloted on a diesel feedstock supplied by a French petroleum company, and further research was ongoing to investigate the processes potential for desulfurizing crude oil.[5]

Outlook

Although the fortunes of the U.S. sulfur industry were showing signs of improvement in the second half of 1994, the longer term outlook changed little: increased output with slower growth in consumption resulting in variable prices and growing inventories. Specific details are much more difficult. Which producers will suffer most from the oversupply situation is a question that can only be answered over time.

World sulfur demand is forecast to increase at an annual rate of almost 2% per year for the next 10 years. World demand is projected to attain 55.5 million tons in 1999 and increase to just more than 60 million tons in the year 2004. Growth of sulfur consumption in the United States is expected to be modest. The phosphate fertilizer industry was operating near capacity and prospects for significant expansion in this area are low, with expectations for growth reflecting only slight increases to efficiency at operating plants and little chance for new facilities. Industrial consumption should remain fairly steady with the only serious possibility of increases in nonferrous ore leaching.

Almost two-thirds of sulfur consumption in the United States is for agricultural uses. More than 80% of U.S. agricultural sulfur demand and almost 60% of world agricultural sulfur consumption was for the manufacture of phosphoric acid in 1994. World demand for phosphate fertilizers is forecast to increase at an annual rate of about 2.7% for the next 10 years. This indicates improved growth over predictions of the past few years, but is based on the fact that the past few years have been unusually bad for fertilizer producers. It is assumed that more than 80% of the growth will be for the production of phosphoric acid to produce high-analysis fertilizers, which will directly affect world sulfur demand.

Consumption of sulfur for phosphate fertilizer manufacture in the United States is divided into two main components: (1) demand for phosphate fertilizers consumed by domestic farmers and (2) demand for exported phosphate fertilizers.

In 1994, an estimate of more than 5 million tons of sulfur was required to manufacture the phosphatic fertilizers exported from the United States compared with about 3.6 million tons of sulfur for domestic phosphoric fertilizer use, based on data reported in the USBM "Phosphate Rock Annual Report." Consumption in the U.S. fertilizer industry is expected to remain relatively steady.

The broad spectrum industrial or nonagricultural sulfur use category accounted for less than one-third of U.S. sulfur consumption and about 40% of world sulfur demand. Although significant variations in demand for the diverse elements within this broad category are expected in the United States and other geographic areas, world industrial demand is expected to average less than a 1% increase annually over the next 10 years, reaching about 23 million tons in the year 2004.

The necessity for the removal of sulfur from solid, liquid, and gaseous effluents for environmental protection has caused the production of sulfur and sulfur compounds from these sources to exceed production from primary sources of supply. The long-term prospect is that 85% or more of the world sulfur supply will come from environmentally regulated sources and that output from these sources will be produced regardless of world sulfur demand. As a result, it is probable that after the turn of the century, no new operation that produces sulfur as its primary product will be developed, except where it may be deemed necessary for political or social reasons and more voluntary operations will be curtailed. In 1980, voluntary sources of production—Frasch, native sulfur, and pyrites—accounted for 50% of world output, about 55 million tons. In 1994, these same sources supplied only 27% of world production, 51.0 million tons.

It is anticipated that in the short term, owing to steady production at Frasch operations and the reluctance of large recovered producers to sell at low prices, world sulfur market availability and demand will be closely balanced; supplies should remain relatively tight through 1995 and going into 1996. However, the number of new recovered facilities continues to grow and more are anticipated to further increase supply availability.

U.S. Frasch production was up in 1994 and is likely to maintain current levels as long as both mines continue to operate. Increases are expected when the United Nations sanctions against Iraq are lifted. The timing and speed of these developments are unknown. Other voluntary producers seem to be maintaining a relatively stable level of production with a slight downward trend. However, recovered sulfur production will continue to expand at a faster pace than demand, and as more countries enact and enforce environmental legislation on a par with North American and European laws, tremendous new quantities of sulfur could be recovered. More stringent regulation and compliance will be long-term developments and cannot be quantified at the current time, but changes are inevitable.

Statistics show that an oversupply situation existed in 1994; however, the decision by some producers to continue to build stocks rather than sell at unfavorable prices resulted in what appeared as tightened supplies and prices rose throughout the year. Material is expected to continue to be withheld from sale through 1995, but as prices rise, the incentive to build inventories lessens and prices could soften. World sulfur production is predicted to reach nearly 64 million tons in 1999 and 67 million tons in 2004.

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[1]Kirschner, E. M. Production of Top 50 Chemicals Increased Substantially in 1994. Chem. & Eng. News, v. 7, No. 15, 1995, p. 17.

[2]Green Markets. Freeport-McMoRan To Idle Caminada Sulfur Mine. V. 17, No. 42, pp. 1 and 10.

[3]Fertilizer Markets. Freeport to Buy Most of Pennzoil Sulphur. V. 5, No. 14, p. 1.

[4]Manser, R. Struggling to Stand Tall, Poland's Deep Restructuring. Sulphur (London), No. 232, 1994, pp. 21-29.

[5]Rhodes, A. K. Enzymes Desulfurizing Diesel Fuel in Pilot Plant Tests. Oil & Gas Journal, v. 93, No. 20, 1995.

OTHER SOURCES OF INFORMATION

U.S. Bureau of Mines Publications

Sulfur. Ch. in Mineral Commodity Summaries, annual.

Sulfur. Ch. in Minerals Yearbook, annual.

Sulfur. Reported monthly in Mineral Industry Surveys.

Other Sources

Chemical and Engineering News, weekly.

Chemical Engineering, weekly.

Chemical Marketing Reporter, weekly.

Chemical Week.

European Chemical News (London), weekly.

Fertilizer Focus (London).

Fertilizer International (London).

Fertilizer Markets, weekly.

Green Markets, weekly.

Industrial Minerals (London).

The Oil and Gas Journal, weekly.

Phosphorus & Potassium (London), bimonthly.

Sulphur (London), bimonthly.

Sulfur Newsletter—Fertecon North America Sulfur Service.

TABLE 1
SALIENT SULFUR STATISTICS 1/

(Thousand metric tons, sulfur content, and thousand dollars unless otherwise specified)

	1990	1991	1992	1993	1994
United States:					
Production:					
Frasch	3,730	2,870	2,320	1,900 2/	2,960 e/
Recovered 3/	6,540	6,650	7,050	7,720 r/ 4/	7,160 e/
Other forms	1,300	1,310	1,300	1,430 r/	1,380
Total	11,600	10,800	10,700	11,100 r/	11,500
Shipments:					
Frasch	3,680	3,120	2,600	1,480 2/	W
Recovered 3/	6,480	6,680	7,090	7,580 r/ 4/	10,300 5/
Other forms	1,300	1,310	1,300	1,430 r/	1,380
Total	11,500	11,100	11,000	10,500 r/	11,700
Exports, elemental 6/	972	1,200	966	656	899
Imports, elemental	2,570	3,020	2,730	2,040 r/	1,650
Consumption, all forms	13,100	12,900	12,700	11,800	12,400
Stocks, Dec. 31: Producer, Frasch and recovered	1,420	1,190	809	1,380	1,160
Value:					
Shipments, f.o.b. mine or plant:					
Frasch	$335,000	$272,000	$151,000	$101,000	W
Recovered 3/	$479,000	$429,000	$315,000	$189,000 r/	$293,000 5/
Other forms	$117,000	$112,000	$76,100	$63,100 r/	$86,100
Total	$931,000	$813,000	$543,000	$335,000	$379,000
Exports, elemental 6/ 7/	$109,000	$120,000	$69,700	$39,700	$48,400
Imports, elemental 7/	$206,000	$242,000	$130,000	$49,800 r/	$62,000
Price, elemental, dollars per metric ton, f.o.b. mine or plant	$80.14	$71.45	$48.14	$31.86	$28.60
World: Production, all forms (including pyrites)	57,800 r/	54,500 r/	48,500 r/	48,900 r/	51,000 e/

e/ Estimated. r/ Revised. W Withheld to avoid disclosing company proprietary data; included with "Recovered."

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Includes 10 months of Frasch sulfur data. Two remaining months of Frasch data included with recovered sulfur data to conform with proprietary data requirements.

3/ Includes Puerto Rico and the U.S. Virgin Islands.

4/ Includes corresponding Frasch sulfur data for November and December.

5/ Includes corresponding Frasch sulfur data.

6/ Includes exports from the U.S. Virgin Islands to foreign countries.

7/ Includes value of exports from the U.S. Virgin Islands to foreign countries.

TABLE 2
RECOVERED SULFUR PRODUCED AND SHIPPED IN THE UNITED STATES, BY STATE 1/

(Thousand metric tons and thousand dollars)

State	1993			1994		
		Shipments			Shipments	
	Production	Quantity	Value	Production	Quantity	Value
Alabama	397	397	14,400	406	405	10,600
California	755 r/	747 r/	4,350 r/	764	764	7,170
Illinois	297	295	8,340	303	305	5,200
Louisiana	1,250 2/	1,120 2/	45,000 2/	798 e/	2,930 4/	133,000 4/
Michigan and Minnesota	158	157	733	192	193	2,260
Mississippi	589	580	12,800	612	596	7,320
New Mexico	50	50	321	43	43	54
North Dakota	81	81	1,830	79	79	448
Ohio	54	54	2,420	51	51	859
Pennsylvania	71	71	2,130	98	96	1,780
Texas	2,310 2/	2,310 2/	67,400 2/	2,060	3,110 4/	96,700 4/
Washington	104	107	444	105	105	527
Wyoming	907	909	6,980	963	971	13,300
Other 3/	695	706	21,800	692	692	14,300
Total	7,720 r/	7,580 r/	189,000 r/	7,160 e/	10,300	293,000

e/ Estimated. r/ Revised.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Includes corresponding Frasch sulfur data for November and December.

3/ Includes Arkansas, Colorado, Delaware, Florida, Indiana, Kansas, Kentucky, Montana, New Jersey, Utah, Virginia, Wisconsin, Puerto Rico, and the U. S. Virgin Islands.

4/ Includes corresponding Frasch sulfur data.

TABLE 3
RECOVERED SULFUR PRODUCED AND SHIPPED IN THE UNITED STATES,
BY PETROLEUM ADMINISTRATION FOR DEFENSE (PAD) DISTRICT 1/

(Thousand metric tons)

District and source	1993		1994	
	Production	Shipments	Production	Shipments
PAD 1:				
Petroleum and coke	281	280	303	303
Natural gas	47	47	52	52
Total	328	327	355	354
PAD 2:				
Petroleum and coke	721	716	801	803
Natural gas	83	83	79	80
Total	804	799	880	883
PAD 3: 2/				
Petroleum	2,860	2,870	2,800	2,790
Natural gas	1,890 r/ 3/	1,750 r/ 3/	1,210	4,390 4/
Total	4,750 r/	4,620 r/	4,000	7,180
PAD 4 and 5:				
Petroleum	958	950	1,020	1,020
Natural gas	885	886	901	911
Total	1,840	1,840	1,920	1,930
Grand total	7,720 r/	7,580 r/	7,160	10,300

r/ Revised.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Includes Puerto Rico and the U.S. Virgin Islands.

3/ Includes corresponding Frasch sulfur data for November and December.

4/ Includes corresponding data from Frasch producers.

TABLE 4
BYPRODUCT SULFURIC ACID1/ PRODUCED
IN THE UNITED STATES 2/

(Thousand metric tons, sulfur content, and thousand dollars)

Type of plant	1993	1994
Copper 3/	1,230 r/	1,200
Zinc 4/	130	118
Lead and molybdenum 4/	66	66
Total	1,430 r/	1,380
Value	63,100 r/	86,100

r/ Revised.
1/ Includes acid from foreign materials.
2/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.
3/ Excludes acid made from pyrites concentrates.
4/ Excludes acid made from native sulfur.

TABLE 5
CONSUMPTION OF SULFUR 1/ IN THE UNITED STATES 2/

(Thousand metric tons)

	1993	1994
Frasch:		
Shipments	1,480 3/	W
Exports	246	--
Imports	100	--
Total	1,330	W
Recovered:		
Shipments 4/	7,520 5/	10,300 6/
Exports	410	899
Imports	1,940	1,650
Total	9,050	11,100
Total elemental	10,400	11,100
Pyrites, shipments	W	NA
Byproduct sulfuric acid, shipments	1,430 r/	1,380
Other forms, shipments 7/	4	NA
Total, all forms	11,800	12,400

NA Not Available. W Withheld to avoid disclosing company proprietary data; included with "other forms, shipments."
1/ Crude sulfur or sulfur content.
2/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.
3/ Includes 10 months of Frasch sulfur data. Two remaining months of Frasch data included with recovered data to conform with proprietary data requirements.
4/ Includes Puerto Rico and the U.S. Virgin Islands.
5/ Includes corresponding Frasch sulfur data for November and December.
6/ Includes data from Frasch producers.
7/ Includes consumption of hydrogen sulfide, liquid sulfur dioxide, and data indicated by symbol W.

TABLE 6
SULFUR AND SULFURIC ACID SOLD OR USED IN THE UNITED STATES, BY END USE 1/

(Thousand metric tons, sulfur content)

End use		Elemental sulfur 2/		Sulfuric acid (sulfur equivalent)		Total	
		1993	1994	1993	1994	1993	1994
102	Copper ores	--	--	696	787	696	787
1094	Uranium and vanadium ores	--	--	1	1	1	1
10	Other ores	--	--	49	34	49	34
20	Food and kindred products	(3/)	--	--	--	--	--
26, 261	Pulpmills and paper products	W	W	304	295	304	295
28, 285, 286, 2816	Inorganic pigments, paints and allied products, industrial organic chemicals, other chemical products 4/	74	26	317	240	391	266
281	Other inorganic chemicals	122	127	232	208	354	335
282, 2822	Synthetic rubber and other plastic materials and synthetics	64	W	259	256	323	256
2823	Cellulosic fibers, including rayon	--	--	51	51	51	51
283	Drugs	--	--	15	13	15	13
284	Soaps and detergents	W	8	45	46	45	54
286	Industrial organic chemicals	--	--	82	113	82	113
2873	Nitrogenous fertilizers	--	--	123	145	123	145
2874	Phosphatic fertilizers	--	--	7,910	8,700 p/	7,910	8,700 p/
2879	Pesticides	--	--	7	7	7	7
287	Other agricultural chemicals	914	990 p/	30	36	944	1,030 p/
2892	Explosives	--	--	9	9	9	9
2899	Water-treating compounds	--	--	94	110	94	110
28	Other chemical products	--	--	147	38	147	38
29, 291	Petroleum refining and other petroleum and coal products	571	529	388	236	959	765
30	Rubber and miscellaneous plastic products	W	542	--	--	W	542
331	Steel pickling	--	--	28	10	28	10
333	Nonferrous metals	--	--	26	31	26	31
33	Other primary metals	--	--	2	4	2	4
3691	Storage batteries (acid)	--	--	28	59	28	59
	Exported sulfuric acid	--	--	10	77	10	77
	Total identified	1,740	2,220	11,100	11,500	12,600 r/	13,700
	Unidentified	1,010	94	824	500	1,830	1,040
	Grand total	2,750	2,320	11,900	12,000	14,400 r/	14,800

p/ Preliminary. r/ Revised. W Withheld to avoid disclosing company proprietary data; included with "Unidentified."

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Does not include elemental sulfur used for production of sulfuric acid.

3/ Revised to zero.

4/ No elemental sulfur was used in inorganic pigments and paints and allied products.

TABLE 7
SULFURIC ACID FROM SMELTERS SOLD OR USED IN THE UNITED STATES, BY END USE 1/

(Thousand metric tons of 100% H_2SO_4)

SIC	Use	1993	1994
102	Copper ores	1,950	1,920
1094	Uranium and vanadium ores	--	5
10	Other ores	145	105
26, 261	Pulp mills and other paper products	337	51
2816	Inorganic pigments	W	W
281	Other inorganic chemicals	83	95
2823	Cellulosic fibers	W	W
283	Drugs	W	W
2873	Nitrogenous fertilizers	W	W
2874	Phosphatic fertilizers	286	410
287	Other agricultural chemicals	52	82
2899	Water-treating compounds	126	170
28	Other chemical products	16	12
291	Petroleum refining	11	11
331	Steel pickling	W	W
333	Nonferrous metals	12	12
3691	Storage batteries (acid)	16	32
	Unidentified	944	590
	Total domestic	3,980	3,500
	Exports	W	W
	Grand total	3,980	3,500

W Withheld to avoid disclosing company proprietary data; included with "Unidentified."
1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

TABLE 8
REPORTED SALES VALUES OF SHIPMENTS OF SULFUR F.O.B. MINE OR PLANT

(Dollars per metric ton)

	1993	1994
Frasch	51.60	W
Recovered	25.06	W
Average	31.86	28.60

W Withheld to avoid disclosing company proprietary data.

TABLE 9
U.S. EXPORTS1/ OF ELEMENTAL SULFUR, BY COUNTRY 2/

(Thousand metric tons and thousand dollars)

Country	1993		1994	
	Quantity	Value	Quantity	Value
Argentina	25	779	17	568
Australia	27	2,500	17	1,660
Brazil	116	5,410	157	6,970
Chile	56	2,400	6	280
India	29	1,590	48	1,820
Indonesia	20	1,130	52	2,680
Israel	85	2,660	33	1,720
Korea, Republic of	3	3,810	28	5,270
Mexico	90	6,170	63	3,740
Morocco	8	469	39	1,040
Philippines	6	403	43	2,480
Senegal	33	858	130	5,460
South Africa, Republic of	2	237	56	2,280
Tunisia	93	2,850	62	2,340
Other	63 r/	8,480 r/	148	10,100
Total	656	39,700	899	48,400

r/ Revised.
1/ Includes exports from the U.S. Virgin Islands.
2/ Previously published and 1994 data are rounded to three significant digits; may not add to totals shown.

Source: Bureau of the Census.

TABLE 10
U.S. EXPORTS 0F SULFURIC ACID (100% H_2SO_4), BY COUNTRY 1/

Country	1993		1994	
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
Belgium	3,600	$119	--	--
Canada	89,800	6,190	66,800	$4,690
China	2,130	164	6,220	279
Costa Rica	1,270	97	2,190	144
Dominican Republic	1,740	98	2,880	241
Guatemala	1,280	48	(2/)	17
Israel	3,430	375	6,230	488
Korea, Republic of	1,120	657	(2/)	460
Mexico	14,400	881	11,400	911
Netherlands Antilles	4,360	161	4,880	245
Panama	4,840	144	6,810	239
Singapore	1,060	182	937	201
Taiwan	2,730	606	2,510	769
Trinidad and Tobago	2,220	53	3,640	247
United Kingdom	2,200	126	1,650	54
Venezuela	(2/)	42	7,470	206
Other	8,800 r/	1,230 r/	16,500	1,860
Total	145,000 r/	11,200 r/	140,000	11,100

r/ Revised.
1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.
2/ Less than 1/2 unit.

Source: Bureau of the Census.

TABLE 11
U.S. IMPORTS OF ELEMENTAL SULFUR, BY COUNTRY 1/

(Thousand metric tons and thousand dollars)

Country	1993		1994	
	Quantity	Value 2/	Quantity	Value 2/
Canada	1,530	27,300	1,120	36,500
Mexico	504	21,300	450	20,900
Other 3/	39 r/	1,200 r/	81	4,640
Total	2,070 r/	49,800 r/	1,650	62,000

r/ Revised.
1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.
2/ Declared customs valuation.
3/ Includes France, Germany, Japan, the Netherlands, Netherlands Antilles, and the United Kingdom in 1993; France, Venezuela, the Netherlands, Japan, Brazil, British Virgin Islands, the Dominican Republic in 1994.

Source: Bureau of the Census.

TABLE 12
U.S. IMPORTS OF SULFURIC ACID (100% H_2SO_4), BY COUNTRY 1/

Country	1993		1994	
	Quantity (metric tons)	Value 2/ (thousands)	Quantity (metric tons)	Value 2/ (thousands)
Canada	1,380,000 r/	$52,600 r/	1,680,000	$72,900
Germany	369,000 r/	5,450 r/	264,000	5,680
Italy	23,100	503	--	--
Japan	224,000	4,080	103,000	2,880
Mexico	121,000 r/	2,450 r/	18,600	1,350
Netherlands	81,200	1,570	27,600	671
Spain	75,000	1,710	984	91
Sweden	59,100	1,360	29,700	1,130
United Kingdom	96,000 r/	876 r/	11,000	374
Other	9,980 r/	63 r/	73	23
Total	2,440,000 r/	70,700 r/	2,130,000	85,100

r/ Revised.
1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.
2/ Declared c.i.f. valuation.

Source: Bureau of the Census.

TABLE 13
SULFUR: WORLD PRODUCTION IN ALL FORMS, BY COUNTRY AND SOURCE 1/ 2/

(Thousand metric tons)

Country and source 3/	1990	1991	1992	1993	1994 e/
Canada: Byproduct:					
Metallurgy	899	872	931	897 r/	990 4/
Natural gas	5,180	5,490	5,770	6,500 e/	7,000
Petroleum e/	207 4/	230	235	350 r/	400
Tar sands	503	540	552	700 r/	750
Total e/	6,790	7,130	7,490	8,450 r/	9,140 4/
China: e/					
Native	320	320	320	330	330
Pyrites	4,400	4,940	4,500	5,000	5,000
Byproduct, all sources	650	650	650	700	700
Total	5,370	5,910	5,470	6,030	6,030
France: Byproduct:					
Natural gas	666	794	770	829 r/	700
Petroleum	233 e/	225	230	278 r/	250
Unspecified e/	150	180	150	150	150
Total e/	1,050	1,200	1,150	1,260 r/	1,100
Germany:					
Pyrites e/	150	95	25	--	--
Byproduct:					
Metallurgy	225 r/	23 r/	23	33 r/	35
Natural gas and petroleum	915 r/	1,080 r/	1,020	1,140 r/	1,200
Unspecified 5/	260 e/	84	100	XX	XX
Total e/	1,550	1,280	1,160	1,170 r/ 4/	1,240
Iran: Byproduct: e/					
Metallurgy	45	50	50	50	50
Natural gas and petroleum	635	650	700	750	830
Total	680	700	750	800	880 4/
Iraq: e/					
Frasch	800	250	500	600	600
Byproduct, natural gas and petroleum	380	50	100	200	200
Total	1,180	300	600	800	800
Japan:					
Pyrites	53	30	31	29	4 4/
Byproduct:					
Metallurgy	1,310 r/	1,350 r/	1,370 r/	1,380 r/	1,350
Petroleum	1,270	1,240	1,340 r/	1,510 r/	1,550
Total	2,630 r/	2,630 r/	2,750 r/	2,920 r/	2,900
Mexico:					
Frasch	1,440	1,040	710	102	--
Byproduct:					
Metallurgy e/	290	280	817	730 r/	2,010 4/
Natural gas and petroleum	682	754	775	804 r/	877 4/
Unspecified	--	20	--	30 e/	30
Total e/	2,410	2,094 r/	2,300	1,670 r/	2,920
Poland: 6/					
Frasch	4,030	3,300	2,280	1,850 r/	2,100
Native	637	633	635	40 r/	41
Byproduct: e/					
Metallurgy	200	200	200	200	200
Petroleum	28	28	25	25	25
Gypsum e/	10	10	10	10	10
Total e/	4,900	4,170	3,150	2,130 r/	2,380
Russia: e/ 7/					
Native	XX	XX	100	100	80
Byproducts:					
Metallurgy	XX	XX	250	200	150
Natural gas	XX	XX	1,800	1,700 r/	1,600
Total	XX	XX	2,150	2,000 r/	1,830
Saudi Arabia: Byproduct, natural gas and petroleum	1,435	2,000	1,630	1,600 e/	1,600

See footnotes at end of table.

TABLE 13--Continued
SULFUR: WORLD PRODUCTION IN ALL FORMS, BY COUNTRY AND SOURCE 1/ 2/

(Thousand metric tons)

Country and source 3/	1990	1991	1992	1993	1994 e/
South Africa, Republic of:					
Pyrites	452	293	296 r/	323 r/	252 4/
Byproduct:					
Metallurgy e/	21 r/	68 r/	56 r/	81 r/	82
Petroleum 8/	210 r/ e/	160 r/ e/	166 r/	171 r/	190 4/
Total	683	521 r/	518 r/	575 r/	524 4/
Spain:					
Pyrites	748	546	510	327 e/	350
Byproduct: e/					
Coal (lignite) gasification	2	2	2	2	2
Metallurgy	248	252	258	258	250
Petroleum	149	105	90	100	100
Total e/	1,150	905	860	687	702
U.S.S.R.: e/ 9/					
Frasch	1,000	900	XX	XX	XX
Native	2,000	1,800	XX	XX	XX
Pyrites	1,900	1,700	XX	XX	XX
Byproduct:					
Metallurgy	1,200	1,100	XX	XX	XX
Natural gas	2,500	2,200	XX	XX	XX
Petroleum	425	400	XX	XX	XX
Total	9,030	8,100	XX	XX	XX
United States:					
Frasch	3,730	2,870	2,320	1,900 10/	2,930
Pyrites	W	W	W	W	(11/)
Byproduct:					
Metallurgy	1,290	1,300	1,290	1,390	1,400
Natural gas	2,340	2,400	2,530	2,850 12/	2,240 4/
Petroleum	4,200	4,240	4,520	4,820	4,920 4/
Unspecified	4	4	3	3	(11/)
Total	11,600	10,800	10,700	11,000	11,500
Other countries:	7,410	6,780	7,810	7,840	7,430
Of which:					
Frasch	6	5	18	20	20
Native	97	94	960	790	622
Pyrites	2,330	1,920	1,740	1,600	1,480
' Byproduct:					
Coal (lignite) gasification	--	--	--	--	--
Metallurgy	1,940	2,000	2,140	2,250	2,010
Natural gas	272	246	277	299	303
Natural gas and petroleum, undifferentiated	597	370	486	490	531
Petroleum	1,230	1,270	1,370	1,550	1,620
Tar sands	--	--	--	--	--
Unspecified sources	934	880	817	839	840
Gypsum	--	--	--	--	--
Grand total:	57,800 r/	54,500 r/	48,500 r/	48,900 r/	51,000
Of which:					
Frasch	11,000	8,370	5,830 r	4,480 r/	5,650
Native	3,050	2,850	2,020 r/	1,260 r/	1,070
Pyrites	10,000 r/	9,520 r/	7,110 r/	7,280 r/	7,090
' Byproduct:					
Coal (lignite) gasification	2	2	2	2	2
Metallurgy	7,670 r/	7,500 r/	7,390 r/	7,470 r/	8,540
Natural gas	11,000	11,100	11,100 r/	12,200 r/	11,800
Natural gas and petroleum, undifferentiated	4,640 r/	4,900 r/	4,710	4,980 r/	5,240
Petroleum	7,950 r/	7,900	7,980 r/	8,800 r/	9,060
Tar sands	503	540	552	700 r/	750
Unspecified sources	2,000	1,820 r/	1,720	1,720 r/	1,720
Gypsum	10	10	10	10	10

e/ Estimated. r/ Revised. W Withheld to avoid disclosing company proprietary data; included with "Byproduct: Unspecified sources." XX Not applicable.
1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.
2/ Table includes data available through July 12, 1995.

TABLE 13--Continued
SULFUR: WORLD PRODUCTION IN ALL FORMS, BY COUNTRY AND SOURCE 1/ 2/

3/ The term "Source" reflects both the means of collecting sulfur and the type of raw material. Sources listed include the following: (1) Frasch recovery; (2) native, comprising all production of elemental sulfur by traditional mining methods (thereby excluding Frasch); (3) pyrites (whether or not the sulfur is recovered in the elemental form or as acid); (4) byproduct recovery, either as elemental sulfur or as sulfur compounds from coal gasification, metallurgical operations including associated coal processing, crude oil and natural gas extraction, petroleum refining, tar sand cleaning, and processing of spent oxide from stack-gas scrubbers; and (5) recovery from the processing of mined gypsum. Recovery of sulfur in the form of sulfuric acid from artificial gypsum produced as a byproduct of phosphatic fertilizer production is excluded because to include it would result in double counting. It should be noted that production of Frasch sulfur, other native sulfur, pyrites derived sulfur, mined gypsum-derived sulfur, byproduct sulfur from extraction of crude oil and natural gas, and recovery from tar sands are all credited to the country of origin of the extracted raw materials, in contrast, byproduct recovery from metallurgical operations, petroleum refineries, and spent oxides are credited to the nation where the recovery takes place, which in some instances is not the original source country of the crude product from which the sulfur is extracted.
4/ Reported figure.
5/ Data for 1990-92 represent byproduct production from the eastern states. Production data for 1993-94 represent those of the unified country.
6/ Official Polish sources report total Frasch and native mined elemental sulfur output annually, undifferentiated; this figure has been divided between Frasch and other native sulfur on the basis of information obtained from supplementary sources.
7/ Sulfur is believed to be produced from Frasch and pyrite, and as a petroleum byproduct, however information is inadequate to formulate reliable estimates.
8/ Estimates for 1990-94 include byproduct production from synthetic fuels.
9/ Dissolved in Dec. 1991.
10/ Includes 10 months of Frasch sulfur production data. Two remaining months of Frasch data included with byproduct: natural gas data to conform with proprietary data requirements.
11/ Survey discontinued for 1994; data not available.
12/ Includes Frasch sulfur production data for November and December.