4. PRODUCTION, IMPORT/EXPORT, USE, AND DISPOSAL

4.1 PRODUCTION

Table 4-1 lists the facilities in each state that manufacture or process chromium, the intended use, and the range of maximum amounts of chromium that are stored on site. There are currently 3,391 facilities that produce or process chromium in the United States. The data listed in Table 4-1 are derived from the Toxics Release Inventory (TRI97 1999). Only certain types of facilities were required to report. Therefore, this is not an exhaustive list.

Chromium metal is commercially produced in the United States by the reduction of chromite ore with carbon, aluminum, or silicon, and subsequent purification. Sodium chromate and dichromate are produced by roasting chromite ore with soda ash. Most other chromium compounds are produced from sodium chromate and dichromate (Hartford 1979; Westbrook 1979). For example, basic chromic sulfate ($Cr(OH)SO_4$), commonly used in tanning, is commercially produced by the reduction of sodium dichromate with organic compounds (e.g., molasses) in the presence of sulfuric acid or by the reduction of dichromate with sulfur dioxide. Lead chromate, commonly used as a pigment, is produced by the reaction of sodium chromate with lead nitrate or by reaction of lead monoxide with chromic acid solution (IARC 1990).

In 1997, the major manufacturers of chromium compounds were: (1) chromic(VI) acid, including chromic(VI) anhydride and chromic(VI) trioxide (total capacity 76,000 metric tons): American Chrome & Chemicals Inc., Corpus Christi, Texas; Occidental Chemical Corporation Specialty Business Group, Castle Hayne, North Carolina; (2) chromium(III) sulfate: Blue Grass Chemical Specialties, L.P., New Albany, Indiana; Johnson Matthey, Inc., Ward Hill, Massachusetts; Wayne Chemical Corp., Amarillo, Texas, Dakota City, Nebraska, and Milwaukee, Wisconsin; (3) chromium(III) acetate: Blue Grass Chemical Specialties, L.P., McGean-Rohco, Inc., Cleveland, Ohio; The Shepard Chemical Company, Cincinnati, Ohio; (4) chromium acetylacetonate: MacKenzie Corporation, Bush, Louisiana; The Shepard Chemical Company, Cincinnati, Ohio; (5) chromium boride: Cerac Incorporated, Milwaukee, Wisconsin; Johnson Matthey, Inc., Alfa Aesar, Ward Hill, Massachusetts; (6) chromium(III) chloride: Blue Grass Chemical Specialties, LP, New Albany, Indiana, McGean-Rohco, Inc., Cleveland, Ohio; (7) chromium diboride: Johnson Matthey, Inc., Ward Hill, Massachusetts; (8) chromium dioxide: DuPont, DuPont Diversified Businesses, Newport, Delaware; (9) chromium 2-ethylhexanoate: OM Group, Inc., Franklin, Pennsylvania, The Shepherd Chemical Company, Cincinnati, Ohio; (10) chromium fluoride: Atotech

Table 4-1. Facilities that Manufacture or Process Chromium and Chromium Compounds

State[a]	Number of facilities	Range of maximum amounts on site in pounds[b]	Activities and uses[c]
AK	1	0-99999	11
AL	87	1000-999999	1,2,3,5,6,7,8,9,10,11,12,13
AR	49	100-999999	1,2,3,4,5,8,9,11,12,13
AZ	31	100-999999	1,2,3,4,5,6,8,9,11,12,13
CA	147	0-999999999	1,2,3,4,5,6,7,8,9,10,11,12,13
CO	33	100-999999	1,2,3,4,5,7,8,9,11,12
CT	66	100-9999999	1,2,3,4,5,7,8,9,10,11,12,13
DE	6	1000-999999	1,2,3,4,5,7,8,9
FL	45	100-9999999	5,7,8,9,10,11,13
GA	90	0-49999999	1,2,3,4,5,6,7,8,9,10,11,12,13
HI	2	0-99999	8
IA	55	100-9999999	1,2,3,5,7,8,9,10,12,13
ID	6	100000-49999999	1,5,7,9
IL	212	0-9999999	1,2,3,4,5,6,7,8,9,10,11,12,13
IN	199	0-99999999	1,2,3,4,5,6,7,8,9,10,11,12,13
KS	38	0-999999	2,3,7,8,9,11,12,13
KY	72	0-9999999	1,2,3,4,5,6,7,8,9,10,11,12,13
LA	34	100-9999999	1,2,3,4,5,7,8,9,10,11,12
MA	79	100-999999	1,2,3,4,5,7,8,9,10,11,12,13
MD	32	100-49999999	1,2,3,4,5,6,7,8,9,10,11
ME	18	1000-999999999	1,3,5,7,8,9,12,13
MI	162	0-9999999	1,2,3,4,5,6,7,8,9,10,11,12,13
MN	49	100-9999999	1,3,5,7,8,9,10,12,13
MO	74	100-9999999	1,2,5,7,8,9,10,11,12,13
MS	49	1000-999999	1,5,7,8,9,11,12,13
MT	4	10000-99999	7,8,13
NC	91	0-999999999	1,2,3,4,5,6,7,8,9,10,12,13
ND	5	1000-999999	2,3,9

Table 4-1. Facilities that Manufacture or Process Chromium and Chromium Compounds (*continued*)

State[a]	Number of facilities	Range of maximum amounts on site in pounds[b]	Activities and uses[c]
NE	22	1000-999999	1,2,3,5,8,9,11,12,13
NH	20	1000-99999	8,9,11,12
NJ	48	100-9999999	1,2,3,4,5,7,8,9,10,11,12,13
NM	7	1000-999999	1,2,3,5,6,8,9,12
NV	6	10000-99999	4,8,9,10
NY	94	0-9999999	1,2,3,4,5,6,7,8,9,10,11,12,13
OH	333	0-999999999	1,2,3,4,5,6,7,8,9,10,11,12,13
OK	67	100-49999999	1,2,3,4,5,6,8,9,10,11,12,13
OR	37	1000-999999	1,2,3,5,8,9,10,12,13
PA	316	0-999999999	1,2,3,4,5,6,7,8,9,10,11,12,13
PR	4	0-99999	1,5,9,11
RI	14	1000-999999	1,2,3,8,9,10,13
SC	72	0-999999999	1,2,3,4,5,7,8,9,10,11,12,13
SD	8	1000-99999	2,3,8,9
TN	81	0-9999999	1,2,3,4,5,6,7,8,9,10,11,12,13
TX	177	0-99999999	1,2,3,4,5,6,7,8,9,10,11,12,13
UT	28	0-999999	1,2,3,4,5,7,8,9,11,13
VA	51	0-9999999	1,2,4,5,7,8,9,10,12,13
VT	4	0-999999	3,4,9
WA	39	100-9999999	1,2,3,6,7,8,9,12,13
WI	197	0-9999999	1,2,3,4,5,6,7,8,9,10,11,12,13
WV	27	100-9999999	1,2,3,5,6,7,8,9,10,12,13
WY	3	0-99999	1,6,9

Source: TR197 1999

[a]Post office state abbreviations used
[b]Range represents maximum amounts on site reported by facilities in each state
[c]Activities/uses:

1. Produce
2. Import
3. Onsite use/processing
4. Sale/distribution
5. Byproduct
6. Impurity
7. Reactant
8. Formulation component
9. Article component
10. Repackaging
11. Chemical processing aid
12. Manufacturing aid
13. Ancillary/other uses

USA Inc., Cleveland, Ohio; (11) chromium hydroxy diacetate: McGean-Rohco, Inc., Cleveland, Ohio; (12) chromium naphthenate: OM Group, Inc., Franklin, Pennsylvania; (13) chromium nitrate: The Hall Chemical Co., Arab, Alabama; McGean-Rohco, Inc., Cleveland, Ohio; The Shepard Chemical Company, Cincinnati, Ohio; (14) chromium octoate: Dixie Chemical Company, Inc., Bayport, Texas; (15) chromium oxide: American Chrome & Chemicals Inc., Corpus Christi, Texas; Johnson Matthey, Inc., Ward Hill, Massachusetts; (16) chromium potassium sulfate: McGean-Rohco, Inc., Cleveland, Ohio; and (17) chromium-silicon monoxide: Cerac Incorporated, Milwaukee, Wisconsin (SRI 1997). Besides these producers of chromium metal alloys and chromium compounds, Table 4-1 reports the number of facilities in each state that manufacture and process chromium, the intended use of the products, and the range of maximum amounts of chromium products that are stored on site. The data reported in Table 4-1 are derived from the Toxic Release Inventory (TRI) of EPA (TRI97 1999). The TRI data should be used with caution since only certain types of facilities were required to report. Hence, this is not an exhaustive list.

4.2 IMPORT/EXPORT

Chromite ore has not been mined in the United States since 1961 (Stokinger 1981). Today, the United States receives all chromium ores from other countries. From 1993–1996, chromium contained in chromite ore and chromium ferroalloys and metal were imported from South Africa (37%), Turkey (13%), Russia (18%), Kazakstan (8%), Zimbabwe (7%), and other nations totaling 22% (USGS 1998).

According to NTDB (1998), the U.S. domestic exports of chromium trioxide rose from 5,236,260 kg in 1992 to 11,037,984 kg in 1996. The U.S. domestic exports of chromium oxide and hydride rose from 1,657,121 kg in 1992 to 2,127,153 kg in 1996. The U.S. imports of chromium oxide and hydride rose from 3,570,688 kg in 1992 to a peak of 5,803,207 kg in 1994 before declining to 4,462,076 kg in 1996. U.S. imports of chromium trioxide rose from 374,269 kg in 1992 to 3,796,267 kg in 1996.

4.3 USE

The metallurgical, refractory, and chemical industries are the fundamental users of chromium. In the metallurgical industry, chromium is used to produce stainless steels, alloy cast irons, nonferrous alloys, and other miscellaneous materials. Ferrochromiums are the main intermediates used by the metallurgical industry. Typical weight percent of chromium in stainless steel and chromium alloys ranges from 11.5% to 30%. In the refractory industry, chromium is a component in chrome and chrome-magnesite,

magnesite-chrome bricks, and granular chrome-bearing and granular chromite, which are used as linings for high temperature industrial furnaces. In the chemical industry, chromium is used primarily in pigments, both chromium(III) and chromium(VI); metal finishing, chromium(VI); leather tanning, chromium(III); and wood preservatives, chromium(VI). Table 4-2 lists the approximate distribution of use for chromium chemicals in the major applications in the United States and Western world in 1996 with a comparison to use in the United States for 1951 (Barnhart 1997). Smaller amounts are used in drilling muds, chemical manufacturing, textiles, toners for copying machines, magnetic tapes, and as catalysts (CMR 1988; EPA 1984a; IARC 1990; USDI 1988a). In the past, chromium was also used in cooling towers as a rust and corrosion inhibitor. Chromium alloys are also used in metal joint prostheses (Sunderman et al. 1989). In 1988, the U.S. chemical and metallurgical industries accounted for 83.9% and the refractory industry for 16.1% of the total domestic consumption of chromite (USDI 1988a). Chromium picolinate, a trivalent form of chromium complexed with picolinic acid, is used as a dietary supplement. It is also claimed to reduce symptoms of type II diabetes and hypoglycemia (Broadhurst et al. 1997).

4.4 DISPOSAL

Information regarding the disposal of finished products and wastes produced during the manufacturing of consumable items that contain chromium is limited. In 1987, 25% of the chromium demand in the United States was supplied by recycled stainless steel scrap. Although a large portion of the chromium wastes from plating operations is also recovered, large amounts of chromium-containing waste waters from plating, finishing, and textile industries are discharged into surface waters. A substantial amount of chromium enters sewage treatment plants from industrial and residential sources (Klein et al. 1974; TRI97 1999). Presently, slag from roasting/leaching of chromite ore is one of the materials excluded from regulation under the Resource Conservation and Recovery Act by the 1980 Bevill Amendment. However, emission control dust or sludge from ferrochromium and ferrochromium-silicon production is listed as hazardous waste by EPA (1988b). The processed wastes from several chromium chemical industries are designated as hazardous wastes as well (EPA 1981), and disposal of process wastes is regulated by the EPA. Land filling appears to be the most important method for the disposal of chromium wastes generated by chemical industries. Of the total chromium released in the environment by chemical industries, . 82.3% is released on land. An equally large amount of chromium waste is transferred off-site (see Section 5.2). It is anticipated that most of this off-site waste will be disposed of in landfills after proper treatment. It is important to convert chromium wastes into forms of chromium

Table 4-2. Historical Use of Chromium in the United States and Western World

Use	1996 Western world	1996 United States	1951 United States
Wood preservation	15%	52%	2%
Leather tanning	40%	13%	20%
Metals finishing	17%	13%	25%
Pigments	15%	12%	35%
Refractory	3%	3%	1%
Other	10%	7%	17%

Souce: Barnhart 1997

that have low mobilities in soils and low availabilities to plants and animals before land disposal. Chromium(III) oxide is one such form. Chromium in chemical industry wastes occurs predominately in the hexavalent form. The treatment of chromium(VI) waste often involves reduction to chromium(III) and precipitation as the hydrous oxide with lime or caustic soda. Chromium(III) waste can also be converted into hydrous oxide or may be incinerated to form the oxide before land disposal. In most cases, the pretreated sludge containing chromium(III) is disposed of by land burial or ocean dumping. There is not much known about the disposal method of waste refractory materials used as lining for metallurgical furnaces or the disposal practices for the finished products containing chromium, such as chromium-containing pigments (Fishbein 1981; Komori et al. 1990a; NRCC 1976; Polprasert and Charnapratheep 1989; USDI 1988b; Westbrook 1979).

Chromium is listed as a toxic substance under Section 313 of the Emergency Planning and Community Right to Know Act (EPCRA) under Title III of the Superfund Amendments and Reauthorization Act (SARA) (EPA 1995). Disposal of wastes containing chromium is controlled by a number of federal regulations (see Chapter 7).